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CORRECTIVE MEASURES PROPOSAL SOLID WASTE MANAGEMENT UNIT 3 (SWMU 3) AMMUNITION BURNING GROUNDS/OLD JEEP TRAIL VOLUME II APPENDICES NSA CRANE IN
6/1/2011
TETRA TECH

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Corrective Measures Proposal
for
Solid Waste Management Unit 3 - Ammunition Burning Grounds / Old Jeep Trail

Volume II - Appendices

NAVAL SUPPORT ACTIVITY CRANE
CRANE, INDIANA

NAVFAC
Naval Facilities Engineering Command
Midwest

Naval Facilities Engineering Command Midwest

Contract Number N62467-04-D-0055
Contract Task Order 21

June 2011

REVISION 3
JUNE 2011

CORRECTIVE MEASURES PROPOSAL FOR SOLID WASTE MANAGEMENT UNIT 3 - AMMUNITION BURNING GROUNDS/OLD JEEP TRAIL

VOLUME II – APPENDICES

NAVAL SUPPORT ACTIVITY CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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CONTRACT NUMBER N62467-04-D-0055
CONTRACT TASK ORDER 21

JUNE 2011

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APPENDIX A

SAIC GROUNDWATER MONITORING REPORT
FOR
SWMU 3 – AMMUNTION BURNING GROUNDS

(CALENDAR YEARS 2000, 2001, 2002, AND 2003)

APPENDIX A-1

SAIC GROUNDWATER MONITORING REPORT
FOR
SWMU 3 – AMMUNTION BURNING GROUNDS

(CALENDAR YEAR 2000)

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2000

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: December 16, 2002

Prepared By:
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Table 8.1 Ammunition Burning Ground Monitoring Points with results exceeding an established RBTL and statistically higher than background. [C, Compliance; Cl, Closure; CA, Corrective Action; NA, Natural Attenuation; K, Karst]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
EXPLOSIVES						
1,3,5-Trinitrobenzene	03C09P2	C,Cl,K	X			
	03C20	C,Cl,K	X	X	X	X
RDX	03C02P2	C,Cl,K		X	X	
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C09P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	X	X
	03C11	NA,K	X	X	X	X
	03C12	C,Cl,NA,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
METALS						
Barium	03C02P2	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	X	X
	03C12	C,Cl,NA,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Barium (filtered)	03C02P2	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	X	X
	03C12	C,Cl,NA,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Selenium	03C11	NA,K			X	
Zinc (filtered)	03C07	C,Cl,K	X			
	03C15	C,Cl,K	X			
Manganese	03C04	C,Cl,NA,K	X	X		X
Manganese (filtered)	03C04	C,Cl,NA,K	X	X	X	X
VOLATILE ORGANIC COMPOUNDS						
1,2-Dichloroethane	03C10	NA,K	X	X	X	X
Carbon Tetrachloride	03C09P2	C,Cl,K		X		
	03C10	NA,K	X	X	X	X
Chloroform	03C09P2	C,Cl,K		X		
	03C10	NA,K	X	X	X	X
	03C11	NA,K	X	X	X	X
	03C20	C,Cl,K		X		
cis-1,2-Dichloroethene	03C20	C,Cl,K	X	X	X	X
Trichloroethene	03C11	NA,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X

9.0 Conclusions

Results from the 2000 quarterly monitoring at the ABG generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek aquifer, often at concentrations above the respective RBTL. RBTLs were commonly exceeded in points of compliance wells. Barium, TCE, and RDX were the most frequently detected compounds at the site. TCE and RDX were both found at concentrations above the RBTL in multiple wells on the site. RDX was detected above the RBTL for every sampling round of both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and a nitro-toluene daughter product of the explosives were also found exiting the site in Spring A.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POCs. Constituents that exceeded an RBTL and were statistically significant in one or more POCs include 1,3,5-Trinitrobenzene, RDX, barium, zinc, manganese, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, and trichloroethene (TCE).

Barium and RDX were the two constituents with the highest number of significant exceedances in ABG POCs. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POCs. RDX may pose the most serious potential problem of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in six ABG POC wells as well as Spring A.

Barium exceeded both thresholds in five POC wells and both springs. The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than those found base wide.

Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2000 were limited to TNT in only one well. Detection of explosives in 2000 was predominantly nitro-toluene daughter products in one well. Detected constituents at the ORR were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the ABG, the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POCs include arsenic, barium, cadmium, zinc, iron, and manganese. Barium and manganese were the constituents with the highest number of significant exceedances in ORR POCs. Barium and manganese both exceeded the RBTL and statistical threshold in

four POC wells and the downgradient well 06C19. All of the other metals listed above exceeded the RBTL and met the statistical threshold in no more than two POCs.

APPENDIX A-2

SAIC GROUNDWATER MONITORING REPORT
FOR
SWMU 3 – AMMUNTION BURNING GROUNDS

(CALENDAR YEAR 2001)

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2001

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: December 16, 2002
Binder 2 of 2

Prepared By:
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Bloomfield, IN 47424
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Table 8.1 Ammunition Burning Ground Monitoring Points with results exceeding an established RBTL and statistically higher than background. [C = Compliance; Cl = Closure; CA = Corrective Action; NA = Natural Attenuation; K = Karst; ND = No Data]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
EXPLOSIVES						
1,3,5-Trinitrobenzene	03C20	C,Cl,K	X	X	X	X
RDX	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C09P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	ND	ND
	03C11	NA,K	X	X	ND	ND
	03C12	C,Cl,NA,K	X	X	ND	ND
	03C20	C,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
METALS						
Barium	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	ND	ND
	03C12	C,Cl,NA,K	X	X	ND	ND
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Barium (filtered)	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	ND	ND
	03C11	NA,K	X	X	ND	ND
	03C12	C,Cl,NA,K	X	X	ND	ND
	03C15	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Selenium	03C11	NA,K	X		ND	ND
Zinc	03C07	C,Cl,K			X	
Zinc (filtered)	03C02P2	C,Cl,K				X

Table 8.1 (Cont.) Ammunition Burning Ground Monitoring Points with results exceeding an established RBTL and statistically higher than background. [C = Compliance; Cl = Closure; CA = Corrective Action; NA = Natural Attenuation; K = Karst; ND = No Data]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
VOLATILE ORGANIC COMPOUNDS						
1,2-Dichloroethane	03C09P2	C,Cl,K		X		
	03C10	NA,K		X	ND	ND
Carbon Tetrachloride	03C09P2	C,Cl,K		X		
	03C10	NA,K		X	ND	ND
Chloroform	03C09P2	C,Cl,K		X		
	03C10	NA,K		X	ND	ND
	03C11	NA,K		X	ND	ND
	03C20	C,Cl,K		X		
cis-1,2-Dichloroethene	03C20	C,Cl,K	X	X	X	X
Trichloroethene	03C02P2	C,Cl,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C09P2	C,Cl,K	X	X	X	X
	03C10	NA,K	X	X	ND	ND
	03C11	NA,K	X	X	ND	ND
	03C12	C,Cl,NA,K	X	X	ND	ND
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	X	X	X	X

Wells 03C10, 03C11, and 03C12 were not sampled in the third and fourth quarters because the Groundwater Monitoring Plan called for the cessation of sampling after eight rounds.

CY 2001

9.0 Conclusions

Results from the 2001 quarterly monitoring at the ABG generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek aquifer, often at concentrations above the respective RBTL. Risk-Based Target Limits were commonly exceeded in points of compliance. Barium, TCE, and RDX were the most frequently detected compounds at the site. TCE and RDX were both found at concentrations above the RBTL in multiple wells on the site. RDX was detected above the RBTL for every sampling round of both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and a nitro-toluene daughter product of the explosives were also found exiting the site in Spring A.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POCs. Constituents that exceeded an RBTL and were statistically significant in one or more POCs include 1,3,5-Trinitrobenzene, RDX, barium, zinc, 1,2-Dichloroethane, Carbon Tetrachloride, Chloroform, Cis-1,2-dichloroethene, and Trichloroethene (TCE).

Barium, RDX, and TCE were the constituents with the highest number of significant exceedances in ABG POC wells. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POC wells. RDX and TCE may pose the most serious threat of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in six ABG POC wells as well as Spring A. TCE exceeded both thresholds in ten wells, including eight POC wells. The high number of POC wells with TCE concentrations exceeding both thresholds was stable for both 2000 and 2001.

Barium exceeded both thresholds in five POC wells and both springs. The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than found basewide.

Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2000 were limited to TNT in only one well. Detection of explosives in 2001 was predominantly nitro-toluene daughter products in one well. Detected constituents at the ORR were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the ABG, the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POCs include arsenic, barium, zinc, and manganese. Manganese was the

constituent with the highest number of significant exceedances in ORR POC wells. Manganese exceeded the RBTL and statistical threshold in eight POC wells and the downgradient wells, 06C19 and 06C19P2.

Samples were collected from the DR monitoring wells only twice per year in 2000 and 2001. Consequently, results from 2000 and 2001 were combined for this report. Previous work at the DR showed the persistence of metals. Results at the DR generally agree with the historic data. Detections in DR monitoring wells were predominately metals. Similar to the ABG and ORR, elevated barium concentrations were ubiquitous in both well networks at the DR. As is the case with the other sites, the results may be due to natural or background conditions.

Constituents that exceeded an RBTL and were statistically significant in one or more DR POCs include arsenic, barium, cadmium, copper, and manganese. Historically, as noted in the Groundwater Monitoring Plan, wells 06C06 and 06C07 were found to have the highest number of statistical exceedances. Results from 2000 and 2001 indicate that POC wells 06C02 and 06C03 exhibited the most exceedances of both the concentration and statistical thresholds. Barium was the constituent with the highest number of significant exceedances in DR POC wells. Point of compliance wells with barium concentrations that exceeded both thresholds includes 06C03P2, 06C04P2, 06C02, 06C03, 06C04, 06C05, and 06C07. Manganese exceeded the RBTL and statistical threshold in four POC wells, including 06C02, 06C03, 06C04, and 06C06.

APPENDIX A-3

SAIC GROUNDWATER MONITORING REPORT
FOR
SWMU 3 – AMMUNTION BURNING GROUNDS

(CALENDAR YEAR 2002)

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2002

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: 31 October 2003
Binder 2 of 2

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Table 8.1.2 Ammunition Burning Ground Monitoring Points with results exceeding an established RBTL and statistically higher than background. [C = Compliance; Cl = Closure; CA = Corrective Action; NA = Natural Attenuation; K = Karst; ND = No Data]

Parameter	Well	MP Objective	2002 BTL Exceedances by Quarter			
			1st	2nd	3rd	4th
EXPLOSIVES						
1,3,5-Trinitrobenzene	*03C20*	*C,Cl,K*	*X*	*X*	*X*	*X*
RDX	*03C07*	*G,Cl,K*	*X*	*X*	*X*	*X*
	03C08P2	*C,Cl,K*	*X*	*X*	*X*	*X*
	03C09P2	*C,Cl,K*	*X*	*X*	*X*	*X*
	03C20	*C,Cl,K*	*X*	*X*	*X*	*X*
	SPA	*C,Cl,NA,K*	*X*	*X*	*X*	*X*
METALS						
Barium	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	03C15	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Barium (filtered)	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C15	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	X	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Zinc (filtered) Outliers Removed	03C09P2	C,Cl,K		X		X
VOLATILE ORGANIC COMPOUNDS						
1,2-Dichloroethane	03C09P2	C,Cl,K		X		
Carbon Tetrachloride	03C09P2	C,Cl,K		X		
Chloroform	03C09P2	C,Cl,K		X		
	03C20	C,Cl,K		X		
Cis-1,2-Dichloroethene	03C20	C,Cl,K	X	X		
Trichloroethene	03C09P2	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X		X	X

2002

9.0 Conclusions

Results from the 2002 quarterly monitoring at the ABG generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek aquifer, often at concentrations above the respective RBTL. Risk-Based Target Limits were commonly exceeded in points of compliance wells. Barium, TCE, and RDX were the most frequently detected compounds at the site. Barium, TCE, and RDX were all found at concentrations above the RBTL in multiple wells on the site. Explosives are migrating offsite by way of the springs. RDX was commonly detected above the RBTL in both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and nitro-toluene daughter products of the explosives were also found exiting Spring A. The presence of the degradation products indicates that some natural attenuation of explosives is occurring in the system.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POCs. Constituents that exceeded an RBTL and were statistically significant in one or more POCs include 1,3,5-trinitrobenzene, RDX, barium, zinc, 1,2-dichloroethane, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, and, TCE.

Barium and RDX were the constituents with the highest number of significant exceedances in ABG POC wells. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POC sites. RDX and TCE may pose the most serious threat of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in four ABG POC wells as well as Spring A. However, the number of sites exceeding both thresholds for RDX has decreased each year from 2000 to 2002. TCE exceeded both thresholds in only two POC wells in 2002. The number of ABG wells exceeding both thresholds for TCE decreased sharply from 2001 when ten wells were found to have concentrations that exceeded both the concentration and statistical threshold. The decrease in the number of wells exceeding both thresholds for RDX and TCE evident in the 2002 data may be due to natural attenuation.

Barium exceeded both thresholds in nine POC wells and both springs. Historic activities at the ABG could have contributed to the elevated presence of barium in groundwater underlying the site. Items have been burned at the unit that contained barium sulfate, an inert filler for projectiles and flares, known as "Salt-Load". The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than found basewide.

Detected constituents at the ORR were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the ABG,

the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic. Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2002 were limited to TNT in well 06C15. In addition, nitro-toluene daughter products were also detected in well 06C15.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POCs include arsenic, barium, manganese, zinc, lead, selenium, and silver. Manganese and barium were the constituents with the highest number of significant exceedances in ORR POC wells. Manganese exceeded the RBTL and statistical threshold in POC wells 06C11P2, 06C13P2, 06C18P2, 06C11, 06C12, 06C13, 06C14, and 06C18 as well as the downgradient wells, 06C19 and 06C19P2. Barium exceeded the RBTL and statistical threshold in POC wells 06C13P2, 06C18P2, 06C11, 06C12, 06C13, 06C16, 06C18. Barium exceeded the RBTL and statistical threshold in POC well 06C19 but only when the statistical analysis was performed with the outliers removed.

Previous work at the DR showed the persistence of metals. Results at the DR generally agree with the historic data. Detections in DR monitoring wells were predominately metals. Similar to the ABG and ORR, elevated barium concentrations were ubiquitous in both well networks at the DR. As is the case with the other sites, the results may be due to natural or background conditions.

Constituents that exceeded an RBTL and were statistically significant in one or more DR POCs include arsenic, barium, and manganese. Historically, as noted in the Groundwater Monitoring Plan, wells 06C06 and 06C07 were found to have the highest number of statistical exceedances. Results from 2002 indicate that POC well 06C03 exhibited the most exceedances of both the concentration and statistical thresholds. Barium was the constituent with the highest number of significant exceedances in DR POC wells. Point of compliance wells with barium concentrations that exceeded both thresholds includes 06C03P2, 06C04P2, 06C06P2, 06C02, 06C03, 06C04, 06C05, and 06C07. Manganese exceeded the RBTL and statistical threshold in three POC wells, including 06C02, 06C03, and 06C04.

APPENDIX A-4

SAIC GROUNDWATER MONITORING REPORT
FOR
SWMU 3 – AMMUNTION BURNING GROUNDS

(CALENDAR YEAR 2003)

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2003

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

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Table 8.1.1 Ammunition Burning Ground Monitoring Points with results exceeding an established RBTL and statistically higher than background. [C = Compliance; Cl = Closure; CA = Corrective Action; NA = Natural Attenuation; K = Karst; ND = No Data]

Parameter	Well	MP Objective	2003 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
EXPLOSIVES						
1,3,5-Trinitrobenzene	03C20	C,Cl,K	X	X	X	X
2,4,6-Trinitrobenzene	SPA	C,Cl,NA,K		X	X	
RDX	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C09P2	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
METALS						
Barium	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C15	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	ND	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Barium (filtered)	03C02P2	C,Cl,K	X	X	X	X
	03C04	C,Cl,NA,K	X	X	X	X
	03C07	C,Cl,K	X	X	X	X
	03C08P2	C,Cl,K	X	X	X	X
	03C15	C,Cl,K	X	X	X	X
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X	X	X
	03C27	C,Cl,K	ND	X	X	X
	03C30	C,CA,Cl,K	X	X	X	X
	SPA	C,Cl,NA,K	X	X	X	X
	SPC	C,Cl,NA,K	X	X	X	X
Zinc (filtered)	03C20	C,Cl,K		X		X
	SPA	C,Cl,NA,K		X		
VOLATILE ORGANIC COMPOUNDS						
1,2-Dichloroethane	03C09P2	C,Cl,K		X		
Carbon Tetrachloride	03C09P2	C,Cl,K		X		
Chloroform	03C09P2	C,Cl,K		X		
	03C20	C,Cl,K		X		
Cis-1,2-Dichloroethene	03C20	C,Cl,K		X	X	X
Tetrachloroethene	03C20	C,Cl,K		X		
Trichloroethene	03C02P2	C,Cl,K	X	X	X	X
	03C07	C,Cl,K	X		X	X
	O3C08P2	C,Cl,K	X	X	X	X
	03C09P2	C,Cl,K	X	X	X	
	03C20	C,Cl,K	X	X	X	X
	03C26	C,Cl,K	X	X		X
	O3C27	C,Cl,K	ND	X	X	X

9.0 Conclusions

Results from the 2003 quarterly monitoring at the Ammunition Burning Grounds generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek Aquifer, often at concentrations above the respective RBTL. Risk-Based Target Limits were commonly exceeded in points of compliance wells. Barium, TCE, and RDX were the most frequently detected compounds at the site. Barium, TCE, and RDX were all found at concentrations above the RBTL in multiple wells on the site. Explosives are migrating offsite by way of the springs. RDX was commonly detected above the RBTL in both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and nitro-toluene daughter products of the explosives were also found exiting Spring A in two of the four quarters. The presence of the degradation products indicates that some natural attenuation of explosives is occurring in the system.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POC wells. Constituents that exceeded an RBTL and were statistically significant in one or more POC wells include 1,3,5-trinitrobenzene, 2,4,6-trinitrobenzene, RDX, barium, zinc, 1,2-dichloroethane, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, tetrachloroethene, and TCE.

Barium, Trichloroethene, and RDX were the constituents with the highest number of significant exceedances in ABG POC wells. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POC sites. RDX and TCE may pose the most serious threat of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in four ABG POC wells as well as Spring A. However, the number of sites exceeding both thresholds for RDX has decreased each year from 2000 to 2002, but remained the same for 2003. The number of ABG wells exceeding both thresholds for TCE decreased sharply from 2001 when ten wells were found to have concentrations that exceeded both the concentration and statistical threshold. The decrease in the number of wells exceeding both thresholds for RDX and TCE evident in the 2003 data may be due to natural attenuation.

Barium exceeded both thresholds in nine POC wells and both springs. Historic activities at the ABG could have contributed to the elevated presence of barium in groundwater underlying the site. Items have been burned at the unit that contained barium sulfate, an inert filler for projectiles and flares, known as "Salt-Load". The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than found basewide.

Detected constituents at the Old Rifle Range were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the

ABG, the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic. Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2003 were limited to TNT in Well 06C15, as was the case in 2002. In addition, nitro-toluene daughter products were also detected in Well 06C15.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POC wells include arsenic, barium, manganese, zinc, and lead. Manganese and barium were the constituents with the highest number of significant exceedances in ORR POC wells. Manganese exceeded the RBTL and statistical threshold in POC Wells 06C11P2, 06C13P2, 06C18P2, 06C12, 06C13, 06C14, and 06C18 as well as the downgradient Wells 06C19 and 06C19P2. Barium exceeded the RBTL and statistical threshold in POC wells 06C13P2, 06C18P2, 06C11, 06C13, 06C16, 06C18. Barium exceeded the RBTL and statistical threshold in POC Well 06C19 but only when the statistical analysis was performed with the outliers removed.

Previous work at the Demolition Range showed the persistence of metals. Results at the DR generally agree with the historic data. Detections in DR monitoring wells were predominately metals. Similar to the ABG and ORR, elevated barium concentrations were ubiquitous in both well networks at the DR. As is the case with the other sites, the results may be due to natural or background conditions.

Constituents that exceeded an RBTL and were statistically significant in one or more DR POC wells include arsenic, barium, and manganese. Historically, as noted in the Groundwater Monitoring Plan, Wells 06C06 and 06C07 were found to have the highest number of statistical exceedances. Results from 2003 indicate that POC Well 06C03 exhibited the most exceedances of both the concentration and statistical thresholds. Barium was the constituent with the highest number of significant exceedances in DR POC wells. Point of compliance wells with barium concentrations that exceeded both thresholds includes 06C03P2, 06C04P2, 06C06P2, 06C02, 06C03, 06C04, 06C05, and 06C07. Manganese exceeded the RBTL and statistical threshold in three POC wells, including 06C02, 06C03, and 06C04.

APPENDIX B

HUMAN HEALTH SCREENING RISK EVALUATION

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-03-D-0057

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HUMAN HEALTH RISK SCREENING EVALUATION
for
SOLID WASTE MANAGEMENT UNIT 3 (AMMUNITION BURNING GROUNDS)

Naval Surface Warfare Center
Crane, Indiana

Contract Task Order 0311

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ACRONYMS

2,4,6-TNT	2,4,6-trinitrotoluene
2-Amino-4,6-DNT	2-amino-4,6-dinitrotoluene
4-Amino-2,6-DNT	4-amino-2,6-dinitrotoluene
ABG	Ammunition Burning Ground
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
CCCRA	Current Contamination Conditions Risk Assessment
CMS	Corrective Measures Study
COPC	chemicals of potential concern
EPC	exposure point concentration
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HHRSE	Human Health Risk Screening Evaluation
HI	Hazard Index
HMX	hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
mg/kg	milligram per kilogram
mg/M^3	milligram per cubic meter
MRL	Minimal Risk Levels
NIOSH	National Institute for Occupational Safety and Health
NSWC	Naval Surface Warfare Center
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Level
PRG	preliminary remediation goals
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
REL	Recommended Exposure Level
SWMU	Solid Waste Management Unit
SWMU 3	Ammunition Burning Ground
TCE	trichloroethylene
TNT	2,4,6-trinitrotoluene

TtNUS	Tetra Tech NUS, Incorporated
TWA	Time-weighted Average
UCL	upper confidence limit
U.S. EPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
WRS	Wilcoxin Rank Sum

1.0 HUMAN HEALTH SCREENING EVALUATION

This section presents the results of the Human Health Risk Screening Evaluation (HHRSE) of chemical concentrations detected in surface soils [generally 0 to 24 inches below ground surface (bgs)] and subsurface soils (generally greater than 24 inches bgs) collected at solid waste management unit (SWMU) 3, the Ammunition Burning Ground (ABG). Analytical data available for samples collected in 1993, 1995, and 2004 are evaluated in this HHRSE. The U.S. EPA conducted a review of the historical data for three SWMUs at Naval Surface Warfare Center (NSWC) Crane including SWMU 3. After their review was conducted, a procedural memorandum (U.S. EPA, 1997) was issued that listed the historical data that is acceptable for use in risk assessments. With respect to SWMU 3, only the explosives data was found to be acceptable for use in risk assessments. All data available for soil samples collected in 1995 and 2004 are assessed. The current and anticipated future land use for SWMU 3 is industrial. At the request of U.S. EPA Region 5, this HHRSE evaluates direct-contact risk to the potential current receptors (i.e., the typical SWMU/industrial worker, the construction worker, and the trespasser only). At the request of U.S. EPA Region 5, this HHRSE also evaluates risk to a future resident child hypothetically exposed to lead concentrations in the surface soils at SWMU 3. Risks incurred by other hypothetical future receptors typically evaluated for Naval Surface Warfare Center (NSWC) Crane will be considered in the risk assessments conducted in support of the eventual closure of the unit. This HHRSE does not evaluate risk associated with receptor exposure to groundwater, surface water, or sediments at the ABG. The assessment also does not evaluate the migration of contaminants from soils to groundwater.

Information on the selection of chemicals of potential concern (COPC), exposure assessment, characterization of estimated potential human health risks, uncertainty analysis, and summary and conclusions for the risk screening are contained in Sections 1.0, 2.0, 3.0, 4.0, and 5.0, respectively.

1.1 CHEMICALS OF POTENTIAL CONCERN SELECTION

COPCs are target analytes detected in an environmental media that are selected for evaluation in a risk assessment. A chemical was selected as a COPC for the ABG surface or subsurface soils if the maximum detected concentration exceeded screening criteria based on the U.S. EPA Region 9 preliminary remediation goals (PRGs). The PRGs are chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1 for non-carcinogenic chemicals or a lifetime cancer risk of 1E-06 for carcinogenic chemicals). One-tenth the PRG is typically recommended by U.S. EPA Region 5 as the COPC screening criteria for non-carcinogenic compounds to account for the potential cumulative effects of multiple compounds affecting the same target organ or producing the same target effect. The

PRG is the COPC screening criteria recommended by U.S. EPA Region 5 for carcinogens. Conservatively, Region 9 PRGs based on the residential land use scenario are the basis of the COPC screening criteria.

Tables 1-1 and 1-2 present the results of the COPC selection conducted for the ABG surface and subsurface soils, respectively. The following chemicals were selected as COPCs based on a comparison of maximum detected concentrations to the COPC screening criteria:

Chemical	Maximum Surface (mg/kg)	Maximum Subsurface (mg/kg)	Background UTL[1] (mg/kg)	Background Screening Value[2] (mg/kg)
TCE	ND	19,000	NA	NA
2,4,6-TNT	400	2,030	NA	NA
2-Amino-4,6-DNT	12.	1.24	NA	NA
4-Amino-2,6-DNT	10.	2.16	NA	NA
HMX	1,100	232	NA	NA
RDX	1,820	274	NA	NA
Aluminum	26,600	47,200	17,400	7,937
Antimony	32	32.6	2.8	9.9
Arsenic	27.9	22	9.6	8.7
Barium	4,120	595	147	295
Cadmium	38.5	3.5	2.05	ND
Chromium	56.6	65.3	29.1	14.6
Copper	10,700	508	21.4	10.7
Iron	68,900	86,000	34,500	27,381
Lead	14,600	524	19.7	43.5
Manganese	5,390	7,380	3,270	2,323
Mercury	5.5	1.5	0.072	ND
Vanadium	29.6	39.5	45.8	20.7
Zinc	11,100	1,430	54	67.6

NA - Not Applicable
ND - Non Detection
TCE - trichloroethylene
mg/kg - milligram per kilogram
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
4-Amino-2,6-DNT - 4,amino-2,6-dinitrotoluene
2-Amino-4,6-DNT - 2,amino-4,6-dinitrotoluene
2,4,6-TNT - 2,4,6-trinitrotoluene
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
UTL - Upper Tolerance Limit

1 - 95 percent Upper Tolerance Limit (UTL) value calculated for complete background soil dataset as presented in Table 4-1 Tetra Tech NUS, Inc. (TtNUS) of the Final Basewide Background Soil Investigation Report, Naval Surface Warfare Center Crane, Crane, Indiana, January, 2001 (TtNUS, 2001).
2 - Tables E-6 and E-7 of the Current Conditions Risk Assessment Report (TtNUS, 1999).

Although the ABG soil data set was not compared to the background soil data set using formal statistical tests [e.g., the Wilcoxin Rank Sum (WRS) Test], the data summary presented in the preceding table and the background comparison analysis presented in the Current Contamination Conditions Risk Assessment (CCCRA) report (TtNUS, 1999) suggests that most (if not all) of the inorganics listed above are present in the ABG soils at concentrations exceeding background. This is particularly true for the metals determined to be the risk drivers for the ABG soils (e.g., lead and barium; see Section 3.0 below).

TABLE 1-1

SUMMARY OF DESCRIPTIVE STATISTICS
SURFACE SOIL - SWMU 3 (AMMUNITION BURNING GROUND)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Arithmetic Mean Concentration[1]	Average of Positive Detects[1]	Sample of Maximum Detects	Region 9 PRG for Soil - Residential[2]	Region 9 PRG for Soil - Industrial[2]	IDEM Default Direct Contact Closure Levels for Soil - Residential[3]	IDEM Default Direct Contact Closure Levels for Soil - Industrial[3]	Maximum Detection > Residential Criteria?[4]	Maximum Detection > Industrial Criteria?[4]
Dioxins (ng/kg)													
1,2,3,4,6,7,8,9-OCDD	3/3	256 J	1170 J	---	750	750	CR95-03SS-A06-01	39000[5]	160000[5]	---	---	---	---
1,2,3,4,6,7,8,9-OCDF	3/3	13.4 J	31.1 J	---	23.3	23.3	CR95-03SS-A07-01	39000[5]	160000[5]	---	---	---	---
1,2,3,4,6,7,8-HPCDD	3/3	30 J	38.7 J	---	34.1	34.1	CR95-03SS-A08-01	390[5]	1600[5]	---	---	---	---
1,2,3,4,6,7,8-HPCDF	3/3	7.09 J	11.4 J	---	9.15	9.15	CR95-03SS-A07-01	390[5]	1600[5]	---	---	---	---
1,2,3,4,7,8-HXCDF	1/3	2.45	2.45	1.03 - 11	2.82	2.45	CR95-03SS-A07-01	39[5]	160[5]	---	---	---	---
1,2,3,6,7,8-HXCDD	2/3	1.11	2.39	1.04	1.34	1.75	CR95-03SS-A08-01	39[5]	160[5]	---	---	---	---
1,2,3,7,8,9-HXCDD	3/3	1.86	3.69	---	2.48	2.48	CR95-03SS-A08-01	39[5]	160[5]	---	---	---	---
2,3,7,8-TCDF	2/3	1.81 J	2.23	0.14	1.37	2.02	CR95-03SS-A08-01	39[5]	160[5]	---	---	---	---
Volatile Organic Compounds (µg/kg)													
2-BUTANONE	1/1	7 J	7 J	---	7.00	7.00	03SS1080002	2200000	11000000	44000000	70000000	---	---
ACETONE	1/1	66 J	66 J	---	66.0	66.0	03SS1080002	1400000	5400000	4800000	6300000	---	---
Energetics (mg/kg)													
1,3,5-TRINITROBENZENE	28/131	0.065 J	14	0.25	0.330	1.09	03SS1200002	180	1800	---	---	---	---
1,3-DINITROBENZENE	8/131	0.25	0.25	0.25	0.133	0.250	8 Samples	0.61	6.2	---	---	---	---
2,4,6-TRINITROTOLUENE	43/131	0.04 J	400	0.25	5.14	15.4	03SS1200002	3.1[6]	31[6]	---	---	RES	IND
2,4-DINITROTOLUENE	27/131	0.015 J	11.6	0.25	0.277	0.863	03/10-12-93-1	12	120	---	---	---	---
2,6-DIAMINO-4-NITROTOLUENE	1/23	0.47 J	0.47 J	0.25	0.140	0.470	03SS1200002	---	---	---	---	---	---
2,6-DINITROTOLUENE	15/131	0.1 J	0.575	0.25 - 0.26	0.144	0.270	03/10-49-93-1	6.1	62	---	---	---	---
2-AMINO-4,6-DINITROTOLUENE	34/131	0.01 J	12	0.25	0.336	0.936	03SS1200002	1.2[7]	12[7]	---	---	---	---
3,5-DINITROANILINE	1/23	1.1	1.1	0.25	0.167	1.10	03SS1200002	---	---	---	---	---	---
4,4'-TN-AZOXY	1/23	0.61 J	0.61 J	0.5	0.266	0.610	03SS1200002	---	---	---	---	---	---
4-AMINO-2,6-DINITROTOLUENE	38/131	0.06 J	10	0.25	0.346	0.886	03SS1200002	1.2[7]	12[7]	---	---	RES	---
HMX	57/131	0.105 J	1100	0.25 - 2.2	17.2	39.0	03SS1200002	310	3100	---	---	RES	---
MNX	1/23	0.62 J	0.62 J	0.25	0.147	0.620	03SS1200002	---	---	---	---	---	---
RDX	36/131	0.035 J	1820	0.25 - 1	22.0	79.3	03/10-61-93-1	4.4	16	---	---	RES	IND
TETRYL	8/123	0.65	0.65	0.25 - 65	0.512	0.650	8 Samples	61	620	---	---	---	---
Inorganics (mg/kg)													
ALUMINUM	35/35	4500	26600	---	9529	9529	03SS1160002	7600	100000	---	---	RES	---
ANTIMONY	19/35	0.34 J	32 J	0.23 - 0.73	2.54	4.51	03SS0880002	3.1	41	140	620	RES	---
ARSENIC	35/35	4.3 J	27.9 J	---	8.69	8.69	03SS1160002	0.39	1.6	3.9	20	RES	IND
BARIUM	35/35	25.5 J	4120 J	---	415	415	03SS1160002	540	6700	23000	98000	RES	---
BERYLLIUM	33/35	0.29 J	1.8	0.57	0.763	0.792	03SS0780002	15	190	680	2900	---	---
CADMIUM	20/35	0.22 J	38.5	0.17 - 0.56	2.70	4.63	03SS1200002	3.7	45	12	990	RES	---
CALCIUM	35/35	177 J	78200 J	---	14023	14023	03SS1200002	---	---	---	---	---	---
CHROMIUM	35/35	10.4 J	56.6 J	---	18.2	18.2	03SS1160002	30[8]	64[8]	430[8]	650[8]	RES	---
COBALT	35/35	3.6 J	20.6 J	---	11.7	11.7	03SS0700002	900	1900	---	---	---	---
COPPER	35/35	5 J	10700 J	---	573	573	03SS1160002	310	4100	13000	57000	RES	IND
IRON	35/35	10800 J	68900 J	---	25429	25429	03SS1200002	2300	31000[9]	---	---	RES	---
LEAD	35/35	9.8 J	14600 J	---	681	681	03SS1200002	400	800	400	1300	RES	IND
MAGNESIUM	35/35	500 J	11300 J	---	2665	2665	03SS0700002	---	---	---	---	---	---
MANGANESE	35/35	57.1 J	5390 J	---	930	930	03SS1160002	180	1900	---	---	RES	IND
MERCURY	26/35	0.012 J	5.5	0.018 - 0.061	0.257	0.339	03SS1200002	2.3	31	100	470	RES	---
NICKEL	35/35	4.8 J	67.6 J	---	22.0	22.0	03SS1200002	160	2000	6900	31000	---	---
POTASSIUM	35/35	325 J	3080 J	---	1044	1044	03SS1010002	---	---	---	---	---	---
SELENIUM	11/35	0.27 J	0.53 J	0.14 - 0.4	0.199	0.365	03SS1000002	39	510	1700	7800	---	---
SILVER	9/35	0.11 J	15.7	0.041 - 0.57	0.854	3.18	03SS1160002	39	510	1700	7800	---	---
SODIUM	19/35	52.4 J	684 J	14 - 67.9	100	170	03SS1120002	---	---	---	---	---	---
THALLIUM	8/35	0.08 J	0.12 J	0.06 - 0.21	0.0701	0.101	03SS0780002, 03SS1030002	0.52	6.7	24	110	---	---
TIN	11/35	0.44 J	44.2 J	0.29 - 1.8	3.81	11.3	03SS1160002	4700	61000[9]	---	---	---	---
VANADIUM	35/35	8.8 J	29.6 J	---	18.0	18.0	03SS0680002	7.8	100	---	---	RES	---
ZINC	34/35	15 J	11100 J	148	703	722	03SS1160002	2300	31000[9]	100000	470000	RES	---

TABLE 1-1

SUMMARY OF DESCRIPTIVE STATISTICS
SURFACE SOIL - SWMU 3 (AMMUNITION BURNING GROUND)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Arithmetic Mean Concentration[1]	Average of Positive Detects[1]	Sample of Maximum Detects	Region 9 PRG for Soil - Residential[2]	Region 9 PRG for Soil - Industrial[2]	IDEM Default Direct Contact Closure Levels for Soil - Residential[3]	IDEM Default Direct Contact Closure Levels for Soil - Industrial[3]	Maximum Detection > Residential Criteria?[4]	Maximum Detection > Industrial Criteria?[4]
Miscellaneous Parameters													
CATION EXCHANGE CAPACITY (MEQ/1)	2/2	14	19	---	16.5	16.5	03SS0780002	---	---	---	---	---	---
PERCHLORATE (µg/kg)	5/23	70 J	300 J	42 - 54	69.2	234	03SS0590002, 03SS0670002, 03SS0910002	5500[10]	72000[10]	---	---	---	---
PERCHLORATE-8321 (µg/kg)	2/6	0.53 J	0.69 J	1.1 - 1.2	0.595	0.610	03SS0610002	5500[10]	72000[10]	---	---	---	---
PH (S.U.)	2/2	7.6	8	---	7.80	7.80	03SS1160002	---	---	---	---	---	---
TOTAL ORGANIC CARBON (mg/kg)	2/2	1700	15000	---	8350	8350	03SS1160002	---	---	---	---	---	---

Footnotes

1 - Duplicates were averaged prior to the calculation of the "Arithmetic Mean Concentration" for all data and "Average of Positive Detection" values. The "Arithmetic Mean Concentration" calculated using 1/2 the sample quantitation limit as a surrogate for non-detect results.
2 - Value presented is the screening level based on U.S. EPA Region 9 Preliminary Remediation Goal (PRG) for residential or industrial soils (U.S. EPA Region 9, October 2004, Updated December 2004). The screening level for noncarcinogenic compounds are 1/10th the PRG presented in the Region 9 PRG Table.
3 - Indiana Department of Environmental Management (IDEM) , Risk Integrated System of Closure (RISC) residential or industrial default closure levels for soil (IDEM, January 2004). Values added to table as a point of comparison.
4 - "RES" and "IND" indicate maximum concentration detected exceeds COPC screening levels for the residential and industrial level land use scenario, respectively.
5 - Value is derived by multiplying criteria for 2,3,7,8-TCDD by World Health Organization Toxicity Equivalent Factor.
6 - One tenth of the noncarcinogenic PRG is less than the carcinogenic PRG, therefore the one tenth noncarcinogenic PRG is presented.
7 - The values for aminodinitrotoluene are used as a surrogate for 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene.
8 - The values for hexavalent chromium are presented.
9 - The printed PRG table lists a ceiling limit of 100,000 mg/kg as the PRG. The value presented is 1/10 of the actual risk-based PRG presented in the electronic version of the PRG table.
10 - No Region 9 PRG is available, value presented in the U.S. EPA Region 3 Risk-Based Concentration (RBC) (April 7, 2005).

µg/kg - microgram per kilogram
COPC - chemical of potential concern
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
IDEM - Indiana Department of Environmental Management
IND - industrial
mg/kg - milligram per kilogram
MNX - monomitroxylene
ng/kg - nanogram per kilogram
PRG - Preliminary Remediation Goal
RBC - Risk-Based Concentration
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
RES - residential
RISC - Risk Integrated System of Closure
TETRYL - methyl-2,4,6-trinitrophenylnitramine
U.S. EPA - United States Environmental Protection Agency

Parameter detected at maximum detected concentrations exceeding COPC selection criteria are shaded.

TABLE 1-2

SUMMARY OF DESCRIPTIVE STATISTICS
SUBSURFACE SOIL - SWMU 3 (AMMUNITION BURNING GROUND)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Arithmetic Mean Concentration[1]	Average of Positive Detects[1]	Sample of Maximum Detects	Region 9 PRG for Soil - Residential[2]	Region 9 PRG for Soil - Industrial[2]	IDEM Default Direct Contact Closure Levels for Soil - Residential[3]	IDEM Default Direct Contact Closure Levels for Soil - Industrial[3]	Maximum Detection > Residential Criteria?[4]	Maximum Detection > Industrial Criteria?[4]
Volatile Organic Compounds (µg/kg)													
1,1,2-TRICHLOROETHANE	3/92	3 J	14 J	0.917 - 2.05	0.895	9.67	03SB0610206	730	1600	9400	15000	—	—
1,1-DICHLOROETHENE	4/92	2 J	7 J	0.917 - 2.05	0.748	4.00	03SB1030610	12000	41000	310000	410000	—	—
2-BUTANONE	27/47	3 J	36 J	0.917 - 2.05	5.89	9.78	03SB1021014	2200000	11000000	44000000	70000000	—	—
4-METHYL-2-PENTANONE	2/92	2 J	10 J	0.917 - 2.05	0.718	6.00	03SB1021014	530000	4700000	12000000	29000000	—	—
ACETONE	58/87	4 J	7200 J	0.965 - 37	108	160	03SB1021014	1400000	5400000	4800000	6300000	—	—
BENZENE	7/92	2 J	31	0.917 - 2.05	1.07	6.86	03SB0700610	640	1400	7800	13000	—	—
BROMOMETHANE	4/92	2 J	8	0.917 - 2.05	0.760	4.25	03SB1191014	390	1300	9900	13000	—	—
CARBON DISULFIDE	11/92	2 J	8	0.917 - 2.05	0.931	3.36	03SB1090610	36000	720000	900000	1200000	—	—
CHLOROFORM	6/92	2 J	7	0.917 - 2.05	0.811	3.83	03SB0920610	220	470	910	1200	—	—
CHLOROMETHANE	1/92	4	4	0.917 - 2.05	0.638	4.00	03SB1191014	4700	16000	—	—	—	—
CIS-1,2-DICHLOROETHENE	16/92	2 J	3100 J	0.917 - 2.05	88.4	505	03SB1030610	4300	15000	110000	140000	—	—
ETHYLBENZENE	6/92	2 J	1200 J	0.917 - 2.05	14.3	211	03SB1030610	400000	400000	4600000	6800000	—	—
METHYL IODIDE	1/54	15 J	15 J	0.917 - 2.05	0.869	15.0	03SB1191014	—	—	4300	14000	—	—
STYRENE	1/91	33	33	0.917 - 2.05	0.957	33.0	03SB1020610	1700000	1700000	11000000	16000000	—	—
TOLUENE	11/92	2 J	160	0.917 - 2.05	3.96	28.7	03SB1021014	520000	520000	1700000	2200000	—	—
TOTAL XYLENES	8/92	2 J	2000 J	0.917 - 2.05	23.5	264	03SB1030610	27000	420000	690000	890000	—	—
TRANS-1,2-DICHLOROETHENE	10/92	2 J	250 J	0.917 - 2.05	4.42	35.7	03SB0610610	6900	23000	180000	230000	—	—
TRICHLOROETHENE	15/92	2 J	19000	0.917 - 2.05	337	2065	03SB0610206	**53**	**110**	710	1100	RES	IND
TRICHLOROFLUOROMETHANE	2/92	2 J	2 J	0.917 - 2.05	0.629	2.00	03SB0731014, 03SB0900610	39000	2000000	—	—	—	—
VINYL CHLORIDE	9/92	2 J	20	0.917 - 2.05	1.40	8.78	03SB1011014	79	750	1500	3100	—	—
Energetics (mg/kg)													
1,3,5-TRINITROBENZENE	4/183	0.34 J	37.5	0.25	0.350	10.4	03/10-35-93-2	180	1800	—	—	—	—
2,4,6-TRINITROTOLUENE	9/183	0.02 J	2030	0.25	11.8	238	03/10-35-93-2	**3.1[5]**	**31[5]**	—	—	RES	IND
2,4-DINITROTOLUENE	2/183	0.03 J	0.075 J	0.25 - 25	0.192	0.0525	03/10-17-93-2	12	120	—	—	—	—
2,6-DINITROTOLUENE	3/183	0.33 J	0.41 J	0.25 - 26	0.200	0.360	03SB0821014	6.1	62	—	—	—	—
2-AMINO-4,6-DINITROTOLUENE	4/183	0.085 J	1.24	0.25 - 25	0.200	0.450	03/10-17-93-2	**1.2[6]**	12[6]	—	—	RES	—
4-AMINO-2,6-DINITROTOLUENE	6/183	0.02 J	2.16	0.25 - 25	0.203	0.448	03/10-17-93-2	**1.2[6]**	12[6]	—	—	RES	—
HMX	30/183	0.08 J	232	0.25 - 2.2	2.07	11.4	03/10-35-93-2	310	3100	—	—	—	—
RDX	12/183	0.265	274	0.1 - 1	2.10	29.6	03/10-17-93-2	**4.4**	**16**	—	—	RES	IND
Inorganics (mg/kg)													
ALUMINUM	82/82	20.4 J	47200 J	—	9215	9215	03SB0601014	**7600**	100000	—	—	RES	—
ANTIMONY	42/82	0.27 J	32.6 J	0.12 - 0.74	0.952	1.68	03SB1000610	**3.1**	41	140	620	RES	—
ARSENIC	81/82	1.3 J	22 J	0.13	8.59	8.69	03SB0681014	**0.39**	**1.6**	3.9	20	RES	IND
BARIUM	81/82	18.3 J	595 J	0.59	122	124	03SB1000610	**540**	6700	23000	98000	RES	—
BERYLLIUM	70/82	0.23 J	2.3 J	0.018 - 0.88	0.954	1.07	03SB0820206	15	190	680	2900	—	—
CADMIUM	33/82	0.18 J	3.5	0.034 - 0.84	0.375	0.711	03SB1000610	3.7	45	12	990	—	—
CALCIUM	80/82	81.2 J	129000 J	8.6 - 951	8625	8835	03SB0701014	—	—	—	—	—	—
CHROMIUM	81/82	6.7 J	65.3 J	0.25	19.5	19.7	03SB1000610	**30[7]**	**64[7]**	430[7]	650[7]	RES	IND
COBALT	81/82	0.2 J	39.9 J	2.6	14.6	14.8	03SB0660610	900	1900	—	—	—	—
COPPER	81/82	3.9 J	508 J	0.18	24.0	24.3	03SB1000610	**310**	4100	13000	57000	RES	—
IRON	81/82	7170 J	86000 J	44.1	32666	33069	03SB1211014	**2300**	31000[8]	—	—	RES	—
LEAD	81/82	7.6 J	524 J	0.05	28.1	28.4	03SB1000610	**400**	800	**400**	1300	RES	—
MAGNESIUM	81/82	334 J	23900 J	3	1939	1963	03SB0700206	—	—	—	—	—	—
MANGANESE	81/82	46.4	7380	1.3	936	948	03SB1000610	**180**	**1900**	—	—	RES	IND
MERCURY	45/82	0.008 J	1.5 J	0.007 - 0.077	0.0541	0.0862	03SB0600206	2.3	31	100	470	—	—
NICKEL	82/82	0.25 J	48.4 J	—	24.1	24.1	03SB0681014	160	2000	6900	31000	—	—
POTASSIUM	81/82	312 J	8980 J	3.5	1267	1283	03SB0601014	—	—	—	—	—	—
SELENIUM	18/82	0.25 J	0.56 J	0.026 - 1	0.164	0.364	03SB0740610	39	510	1700	7800	—	—
SILVER	4/82	0.05 J	16.8	0.041 - 0.29	0.245	4.38	03SB1000610	39	510	1700	7800	—	—
SODIUM	40/82	44.8 J	520 J	3.47 - 59.3	67.4	122	03SB1000610	—	—	—	—	—	—
THALLIUM	15/82	0.08 J	0.14 J	0.012 - 0.27	0.0655	0.101	03SB0940610	0.52	6.7	24	110	—	—
TIN	22/82	0.26 J	58.6 J	0.31 - 3.4	1.70	5.31	03SB1211014	4700	61000[8]	—	—	—	—
VANADIUM	82/82	0.21 J	39.5 J	—	18.6	18.6	03SB1101014	**7.8**	100	—	—	RES	—
ZINC	81/82	13.4 J	1430 J	1.13	88.0	89.0	03SB1000610	2300	31000[8]	100000	470000	—	—

TABLE 1-2

SUMMARY OF DESCRIPTIVE STATISTICS
SUBSURFACE SOIL - SWMU 3 (AMMUNITION BURNING GROUND)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Arithmetic Mean Concentration[1]	Average of Positive Detects[1]	Sample of Maximum Detects	Region 9 PRG for Soil - Residential[2]	Region 9 PRG for Soil - Industrial[2]	IDEM Default Direct Contact Closure Levels for Soil - Residential[3]	IDEM Default Direct Contact Closure Levels for Soil - Industrial[3]	Maximum Detection > Residential Criteria?[4]	Maximum Detection > Industrial Criteria?[4]
Miscellaneous Parameters													
BULK DENSITY (G/CM3)	4/4	1.57	1.81	—	1.69	1.69	03ST0990204	—	—	—	—	—	—
CATION EXCHANGE CAPACITY (MEQ/1)	4/4	10	31	—	19.5	19.5	03SB0780206	—	—	—	—	—	—
PERCHLORATE (µg/kg)	9/51	50 J	800	41 - 53	64.0	252	03SB0670610	5500[9]	72000[9]	—	—	—	—
PERCHLORATE-8321 (µg/kg)	2/13	3	9	1.1 - 1.3	1.43	6.00	03SB0890206	5500[9]	72000[9]	—	—	—	—
PH (S.U.)	4/4	7.6	8	—	7.75	7.75	03SB1160610	—	—	—	—	—	—
POROSITY (%)	4/4	31.9	40.1	—	36.1	36.1	03ST0770608	—	—	—	—	—	—
SPECIFIC GRAVITY (S.U.)	4/4	2.63	2.66	—	2.64	2.64	03ST0990204	—	—	—	—	—	—
TOTAL ORGANIC CARBON (mg/kg)	4/4	3700	9300	—	5850	5850	03SB0780610	—	—	—	—	—	—

Footnotes

1 - Duplicates were averaged prior to the calculation of the "Arithmetic Mean Concentration" for all data and "Average of Positive Detection" values. The "Arithmetic Mean Concentration" calculated using 1/2 the sample quantitation limit as a surrogatefor non-detect results.
2 - Value presented is the screening level based on U.S. EPA Region 9 Preliminary Remediation Goal (PRG) for residential or industrial soils (U.S. EPA Region 9, October 2004, Updated December 2004). The screening level for noncarcinogenic compounds are 1/10th the PRG presented in the Region 9 PRG Table.
3 - Indiana Department of Environmental Management (IDEM), Risk Integrated System of Closure (RISC) residential or industrial default closure levels for soil (IDEM, January 2004). Values added to table as a point of comparison.
4 - "RES" and "IND" indicate maximum concentration detected exceeds COPC screening levels for the residential and industrial level land use scenario, respectively.
5 - One tenth of the noncarcinogenic PRG is less than the carcinogenic PRG, therefore the one tenth noncarcinogenic PRG is presented.
6 - The values for aminodinitrotoluene are used as a surrogate for 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene.
7 - The values for hexavalent chromium are presented.
8 - The printed PRG table lists a ceiling limit of 100,000 mg/kg as the PRG. The value presented is 1/10 of the actual risk-based PRG presented in the electronic version of the PRG table.

µg/kg - microgram per kilogram
COPC - chemical of potential concern
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
IDEM - Indiana Department of Environmental Management
IND - industrial
mg/kg - milligram per kilogram
MNX - monomitroxylene
ng/kg - nanogram per kilogram
PRG - Preliminary Remediation Goal
RBC - Risk-Based Concentration
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
RES - residential
RISC - Risk Integrated System of Closure
U.S. EPA - United States Environmental Protection Agency

Parameter detected at maximum detected concentrations exceeding COPC selection criteria are shaded.

2.0 EXPOSURE ASSESSMENT

This section presents the exposure assessment for the ABG soils at SWMU 3. Receptors evaluated in the risk assessment are identified. The methodology used to determine the exposure point concentration (i.e., the concentration to which a receptor is exposed) is presented.

The ABG covers approximately 20 acres of the facility and is located near the east center boundary in a remote area within the valley of Little Sulphur Creek. The ABG is currently used for the open burning of explosives and explosives-containing materials. There are no buildings at the ABG; the structures that do exist on-site are associated with the treatment of ordnance to be disposed. There are no plans to further develop or close the unit at this time. Consequently, under current and anticipated future land use, the following receptors are the most likely individuals to be exposed to COPCs in soils at the site.

- Base personnel (typical SWMU workers) specifically assigned work tasks at the ABG
- Construction workers periodically assigned work at the ABG
- Trespassers

Typical maintenance work at SWMU 3 consists of ground maintenance (i.e., mechanical non-contact grass mowing) where exposure to soils is less than the exposure for the base personnel. Therefore, for the purposes of this HHRSE, the maintenance worker exposure and risk is considered equivalent to the base personnel. However, there are no construction/excavation activities currently planned for the site and, given the active nature of the facility, trespass at SWMU 3 is unlikely. The construction worker and trespasser are included in this analysis primarily for purposes of completeness. Additionally, at the request of U.S. EPA Region 5, this HHRSE includes a risk evaluation of a future resident child hypothetically exposed to lead concentrations in the surface soils at SWMU 3.

Typical SWMU workers, construction workers, and trespassers may be exposed to COPCs in soils via direct contact (i.e., incidental ingestion, dermal contact) or via inhalation of airborne soil particulates from the site. The exposure assessment assumptions (e.g., soil ingestion rates, etc) used in this HHRSE for the typical SWMU worker are those specified in the calculation of the U.S. EPA Region 9 PRGs for the typical industrial worker. The exposure assessment assumptions for the construction worker are those specified in the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (U.S. EPA, 2002)*. The exposure assumptions for the trespasser are those specified in Appendix A and are similar to those typically used by TtNUS to conduct baseline human health risk assessments (HHRAs)

for NSWC Crane. The exposure assumptions specifically utilized for the evaluation of typical worker, construction worker, or hypothetical future child resident exposure to lead concentrations in the SWMU 3 surface soils are detailed in the risk assessment worksheets presented in Appendix A and further discussed in Section 3 of this HHSRE. The assumptions are typical of those recommended in the following two risk assessments models utilized for the evaluation of human exposure to lead:

- The U.S. Technical Review Workgroup (TRW) for Lead Model (U.S. EPA, 2003). (This model is often referred to as the Adult Lead Model.)
- The U.S. EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model (U.S. EPA, 1994).

The exposure point concentration (EPC) is the COPC concentration to which the receptor is exposed. Per U.S. EPA guidance, the arithmetic mean concentration is recommended as the EPC for lead and the 95 percent upper confidence limit (UCL) on the arithmetic mean is recommended as the EPC for other chemicals. EPCs are calculated following *U.S. EPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (U.S. EPA, 2002) and using TtNUS software based on the U.S. EPA Pro-UCL software.

3.0 RISK CHARACTERIZATION

The risk characterization of all chemicals in soils except lead is conducted using the simple risk-ratio technique described in the following paragraphs. The risk characterization for lead is conducted by a qualitative comparison of arithmetic mean lead concentrations in soils to the U.S. EPA risk benchmarks for the residential and industrial land use scenarios (400 mg/kg and 800 mg/kg, respectively, as presented in the U.S. EPA Region 9 PRG table), and a risk-based concentration (RBC) developed for the construction worker (Appendix A). At the request of the U.S. EPA, the risk characterization of lead is also conducted using the aforementioned EPA TRW and IEUBK models specifically designed for the risk evaluation of lead exposure.

The risk characterizations of chemicals other than lead are presented in Tables 3-1 through 3-6. Cancer and non-cancer risk estimates were developed for the typical SWMU worker, the construction worker, and the trespasser using the EPC concentrations calculated for COPC concentrations in soils (as described above), and available U.S. EPA Region 9 PRGs for industrial workers or RBCs calculated using the receptor exposure assumptions described above and detailed in Appendix A. It should be noted that the Region 9 PRGs used in the risk calculations were updated to reflect guidance presented in Risk Assessment Guidance for Superfund (RAGS) Part E (published post the most recent U.S. EPA Region 9 table) and updated toxicity criteria. The U.S. EPA Region 9 PRGs and Appendix A RBCs for noncarcinogens represent a Hazard Index (HI) of 1 (i.e., the no adverse effect concentration). The U.S. EPA Region 9 PRGs and Appendix A RBCs for carcinogens represent the 1E-06 cancer risk level. (It should be noted that PRGs/RBCs for both cancer and noncancer effects are available for chemicals that have both cancer slope factors and reference doses.) Thus, risk estimates were developed using the following simple ratio-ing technique:

$$\frac{\text{EPA Region 9 PRG or RBC}}{\text{EPC for COPC}} = \frac{\text{Hazard Index of 1 or Cancer Risk Estimate of 1E-06}}{\text{?? Hazard Index or Cancer risk Estimate}}$$

Risk estimates (e.g., hazard indices) for the hypothetical future resident, the typical industrial worker, and the trespasser are summarized below:

Receptor	Hazard Index for Surface Soil	Hazard Index for Subsurface Soil	Cancer Risk Estimate for Surface Soil	Cancer Risk Estimate for Subsurface Soil
Typical Industrial Worker	0.6	0.5	1E-05	8E-06
Construction Worker	10 Risk Driver(1) = Barium, Manganese	10 Risk Driver = Manganese	2E-06	2E-06
Trespasser	0.08	0.08	8E-07	6E-07

1 - A non-carcinogenic risk driver is a chemical that contributes substantially to a target organ specific HI that exceeds 1.

The cancer risk estimates presented of the all three receptors are less than or within the U.S. EPA's target cancer risk range (1E-04 to 1E-06).

Total Hazardous Indices (HIs) calculated for the typical site worker and the trespasser do not exceed 1 indicating that adverse non-carcinogenic health affects are not anticipated for these receptors. However, total HIs, chemical specific HIs for barium (surface soil only) and manganese (surface and subsurface soils), and target organ specific HIs for the central nervous system (surface and subsurface soils), and the kidney (surface soil only) calculated for construction worker exposure exceed 1 indicating a potential for adverse non-carcinogenic health effects. As discussed below, the spatial distribution of the metals contamination at the ABG, the nature of the work activities currently occurring at the ABG, and the uncertainty attached to available toxicity criteria (i.e., inhalation reference doses) for barium and manganese should be considered when interpreting these results. The risk evaluation of lead concentrations in soils is also discussed below.

Risk Characterization of Construction Worker Exposure to Barium

The EPC calculated for construction worker exposure to barium concentrations across the whole ABG site (EPC = 1,890 mg/kg) marginally exceeds the RBC developed for the construction worker in Appendix A (RBC = 1,800 mg/kg). The HI associated with this EPC (1.1) also marginally exceeds the U.S. EPA HI benchmark of 1 and would not result in the selection of barium for further consideration in a Corrective Measures Study (CMS). Additionally, the RBC developed for the construction worker is conservatively based on a ***chronic*** inhalation reference dose presented in the U.S. EPA's Health Effects Assessment Summary Tables (HEAST) and published in the U.S. EPA Region 9 PRG tables because ***sub-chronic*** inhalation toxicity criteria are not available on the U.S. EPA's Integrated Risk Information System (IRIS) database and because the toxicity information in HEAST is dated (1997). However, per U.S. EPA

recommendations, construction worker exposures as a result of short-term construction projects (e.g., a project lasting one year or less) are classified as ***sub-chronic*** and should be evaluated using ***sub-chronic toxicity values*** (U.S. EPA, 2002). The toxicity information presented in the 1997 HEAST tables also indicates that a sub-chronic inhalation reference for barium may be an order of magnitude greater than (less restrictive than) the chronic reference dose used to calculate the RBC developed in Appendix A. The RBC calculated for the construction worker using the sub-chronic inhalation reference dose presented in HEAST is 18,000 mg/kg. None of the barium concentrations detected in the ABG surface or subsurface soils exceed this RBC.

Risk Characterization of Receptor Exposure to Lead

The arithmetic mean lead concentration for surface soils at the ABG (681 mg/kg) exceeds the current U.S. EPA Region 9 soil PRG for residential land use scenario (400 mg/kg) but does not exceed the soil PRG for the industrial land use scenario (800 mg/kg). However, the U.S. EPA Region 9 soil PRG for the industrial land use scenario was calculated assuming ***typical*** industrial worker exposure to soil. Because typical industrial workers are exposed to soils ***less intensely*** than are construction workers, a screening-level of 540 mg/kg was specifically calculated for the construction worker scenario as detailed in Appendix A. The arithmetic mean lead concentration for soils across the ABG does exceed this screening level. Although lead concentrations exceeding the aforementioned PRGs/screening levels were only reported for ***two*** soil samples collected in the southeast quadrant of the ABG (See Figure 3-1), historical data discussed in the CCCRA also indicate the presence of elevated lead concentrations in this area. The arithmetic mean lead concentration for the area also demonstrating the elevated barium concentrations (locations 03SB086, 03SB120, 03SB121, and 03SB116, see Figure 3-2) is 5,600 mg/kg. This value is an order of magnitude greater than any of the PRGs or screening levels presented for lead in this HHRSE. A review of the spatial distribution of data available for the ABG (Figures 3-1 through 3-6) indicates that lead, barium, and/or several other metals (e.g., zinc, copper, cadmium, arsenic, and antimony) and organics are present in the vicinity of locations 03SB086, 03SB120, 03SB121, and 03SB116 and at location 03SB088 (immediately to the southwest of the area) at concentrations that are elevated when compared to chemical concentrations reported at most other locations at the ABG. This sub-area is approximately one-half acre in size.

Exposures to lead in surface soil by construction workers and industrial workers were also evaluated using the aforementioned slope-factor approach developed by the U.S. EPA TRW for Lead (U.S. EPA, 2003c). As recommended by the adult lead model, the average lead concentration in surface soil was used as the exposure point concentration for construction workers and typical workers. Three cases

were evaluate, the entire site (681 mg/kg), the "Hot Spot" (5,600 mg/kg) (locations 03SB086, 03SB116, 03SB120, and 03SB121), and the entire site minus the "Hot Spot" (40 mg/kg). As noted above, ILCRs and HIs were calculated for non-lead compounds using RME assumptions; however, the adult lead model guidance recommends the use of CTE assumptions in evaluating adult exposures to lead in soil (U.S. EPA, 2003c). Therefore, the incidental soil ingestion rate was assumed to be 100 mg/day for the construction worker and 50 mg/day for industrial workers (U.S. EPA, 2003a). The exposure frequency was assumed to be 219 days/year for both the construction worker and industrial worker. Values of 2.18 and 1.53 µg/dL were used for the standard deviation and baseline blood lead concentration, respectively, which are the recommended values for the mid-western United States (U.S. EPA, 2002g). Default parameters were used for all the remaining model input parameters. Results of the model runs are included in Appendix A.

The fetus of a pregnant worker is the receptor of concern for the TRW model. For construction workers exposed to soils across the entire site, the lead concentration of 681 mg/kg results in 6.9 percent of the receptors (fetuses) having a blood lead level greater than 10 µg/dL and a geometric mean blood lead level of 3.5 µg/dL. For construction workers exposed to the "Hot Spot" , the lead concentration of 5,600 mg/kg results in 72 percent of the receptors (fetuses) having a blood lead level greater than 10 µg/dL and a geometric mean blood lead level of 17.7 µg/dL. These results exceed the U.S. EPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 10 µg/dL blood lead level. For construction workers exposed to the entire site minus the "Hot Spot", the lead concentration of 40 mg/kg results in 0.7 percent of the receptors (fetuses) having a blood lead level greater than 10 µg/dL and a geometric mean blood lead level of 1.6 µg/dL. These results do not exceed the U.S. EPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 10 µg/dL blood lead level.

For industrial workers exposed to soils across the entire site, the lead concentration of 681 mg/kg results in 2.8 percent of the receptors (fetuses) having a blood lead level greater than 10.0 µg/dL and a geometric mean blood lead level of 2.5 µg/dL. For industrial workers exposed to soils across the entire site minus the "Hot Spot", the lead concentration of 40 mg/kg results in 0.6 percent of the receptors (fetuses) having a blood lead level greater than 10.0 µg/dL and a geometric mean blood lead level of 1.6 µg/dL. These results do not exceed the U.S. EPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 10 µg/dL blood lead level. For industrial workers exposed to lead concentration in soils in the "Hot Spot", the lead concentration of 5,600 mg/kg results in 43 percent of the receptors (fetuses) having a blood lead level greater than 10.0 µg/dL and a geometric mean blood lead level of 9.6 µg/dL. These results do exceed the U.S. EPA goal of no more than 5 percent of children (fetuses of exposed women) exceeding a 10 µg/dL blood lead level.

At the request of U.S. EPA Region 5, hypothetical residential exposures to lead in surface soil were also evaluated using the most recent version of the IEUBK lead model (USEPA, 1994b). As previously noted current and expected future land use for SWMU 3 is military/industrial. Future residential development of the site is unlikely to occur. Consequently, this residential evaluation is presented for informational purposes only. As recommended by the IEUBK model, the average lead concentration of in surface soil was used as the EPC. As with the adult lead model, three cases were evaluate, soils across the entire site (681 mg/kg), soils in the "Hot Spot" (5,600 mg/kg) (locations 03SB086, 03SB116, 03SB120, and 03SB121), and soils across the entire site minus the "Hot Spot" (40 mg/kg). Default model values were used for the remaining model input parameters. IEUBK model outputs are included in Appendix A. The evaluation of the average lead concentration for the entire site of 681 mg/kg results in 24.7 percent of hypothetical on-site child residents having a blood lead level greater than 10 µg/dL and results in a geometric mean blood lead level of 7.3 µg/dL. The evaluation of average lead concentration for the "Hot Spot" of 5,600 mg/kg results in 98.7 percent of hypothetical on-site child residents having a blood lead level greater than 10 µg/dL and results in a geometric mean blood lead level of 28.7 µg/dL. These results exceed the USEPA goal as described in the 1994 OSWER Directive of no more than 5 percent of children exceeding a 10 µg/dL blood lead level. The evaluation of the average lead concentration for the entire site minus the "Hot Spot" of 40 mg/kg results in 0.025 percent of hypothetical on-site child residents having a blood lead level greater than 10 µg/dL and results in a geometric mean blood lead level of 1.95 µg/dL. This result is within the USEPA goal as described in the 1994 OSWER Directive of no more than 5 percent of children exceeding a 10 µg/dL blood lead level.

Risk Characterization of Construction Worker Exposure to Manganese

Manganese detections exceeding the RBC calculated for a construction worker (180 mg/kg) are scattered across the ABG; they are not limited to the southeast quadrant sub-area as described for other metals contamination (e.g., barium, lead). However, as displayed in Figures 3-7 and 3-8, concentrations exceeding the background UTL listed in Section 3.1 (3,270 mg/kg) occur at very few locations. Site-data to background-data comparisons presented in Appendix A suggest that, with few exceptions, manganese concentrations in the surface soils reflect background conditions while manganese concentrations in the subsurface soil may exceed background conditions. Although HIs calculated based on the EPCs for ABG surface and subsurface soils exceed 1, HIs calculated for a construction worker exposed to maximum and average background manganese concentrations reported in the Final Basewide Background Soil Investigation Report (TtNUS, 2001) would also exceed 1 suggesting a potential for adverse non-carcinogenic heath effects even at background concentrations. The HIs predicted in this HHSRE for the construction worker are likely overestimated for the following reasons:

- *A sub-chronic inhalation reference dose is not available for the evaluation of construction worker exposure to manganese.* As noted above, exposures to construction workers as a result of short-term construction projects (e.g., a project lasting one year or less) are classified as sub-chronic and should be evaluated using sub-chronic toxicity values (U.S. EPA, 2002). Unfortunately, sub-chronic reference doses are not currently available for manganese in the IRIS database, in HEAST, or in the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) databases. Consequently, the very low (relative to other chemicals) chronic inhalation reference dose available on the U.S. EPA's IRIS for manganese was used in this HHRSE. Although sub-chronic reference doses are not available for manganese, a review of sub-chronic versus chronic toxicity criteria in the aforementioned HEAST and the ATSDR tables for other chemicals indicates that sub-chronic toxicity criteria and screening levels are often 5 times to 10 times greater than (less restrictive than) chronic toxicity criteria and screening levels.

- *The chronic inhalation reference dose for manganese is based primarily on epidemiological studies of workers exposed to manganese oxide compounds in an occupation setting.* The construction worker at the ABG is hypothetically exposed to manganese compounds that are components of a soil matrix. The worker is not exposed to pure manganese compounds fumes or dusts as occurs in an occupational setting. The soil matrix may impact the extent to which the manganese compounds are deposited and absorbed into the lungs.

It should be noted that manganese concentrations predicted for construction workers using the fate and transport modeling presented in the *U.S. EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (U.S. EPA, 2002) [i.e., 0.00012 milligrams per cubic meter (mg/M^3)] are several orders of magnitude less than available Occupational Safety and Health Administration (OSHA) or National Institute for Occupational Safety and Health (NIOSH) standards or criteria for worker exposure to manganese compounds:

OSHA Permissible Exposure Levels (PEL)	5 mg/M^3(Mn compounds and fumes) (Ceiling Limit)
	5 mg/M^3(Mn_3O_4) (Ceiling Limit)
NIOSH Recommended Exposure Level (REL)	1 mg/M^3(Mn compounds and fumes) (Time-weighted Average [TWA])

A review of both U.S. EPA and OSHA documentation regarding the toxicity of manganese indicates that different toxicity/epidemiological studies were used by these two agencies as the basis of toxicity criteria and standards. Additionally, the U.S. EPA applies an uncertainty factor of 1,000 to underlying toxicity data in the development of the recommended U.S. EPA inhalation reference dose; OSHA does not.

TABLE 3-1

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Industrial[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
2,4,6-TNT	25 [6]	7.9E+01	3.2E-07	Liver	4.2E+02	6.0E-02
2-A-4,6-DNT	0.8 [7]	NA	NA	NA	1.9E+03	4.2E-04
4-A-2,6-DNT	0.8 [7]	NA	NA	NA	1.9E+03	4.2E-04
RDX	110 [6]	2.4E+01	4.6E-06	Prostate	2.8E+03	3.9E-02
HMX	73 [6]	NA	NA	Liver	4.9E+04	1.5E-03
Aluminum	10900 [8]	NA	NA	CNS[13]	9.2E+05	1.2E-02
Antimony	13.9 [9]	NA	NA	Blood	4.1E+02	3.4E-02
Arsenic	9.8 [10]	1.6E+00	6.1E-06	Skin, CVS	2.6E+02	3.8E-02
Barium	1890 [9]	NA	NA	Kidney	1.7E+05	1.1E-02
Cadmium	15.6 [9]	3.0E+03	5.2E-09	Kidney	4.5E+02	3.5E-02
Chromium[5]	20.9 [8]	4.5E+02	4.6E-08	None reported (ingestion)	2.5E+03	8.4E-03
Cooper	4150 [9]	NA	NA	GI[14]	4.1E+04	1.0E-01
Iron	29000 [8]	NA	NA	None reported[13]	3.1E+05	9.4E-02
Lead	681 [11]	8.0E+02	[12]	CNS[15]	8.0E+02	[12]
Manganese	1790 [7]	NA	NA	CNS	2.0E+04	9.2E-02
Mercury	1.8 [9]	NA	NA	CNS	3.1E+02	5.8E-03
Vanadium	19.5 [10]	NA	NA	Kidney[13]	1.0E+03	2.0E-02
Zinc	4550 [9]	NA	NA	Blood	3.1E+05	1.5E-02
		Total Carcinogenic Risk	1E-05		Total HI	6E-01

Target Organ HIs

Total Kidney HI =	6.5E-02	Total Liver HI =	6.1E-02
Total CNS HI =	1.1E-01	Total Prostate HI =	3.9E-02
Total CVS HI =	3.8E-02	Total Blood HI =	4.9E-02
Total GI HI =	1.0E-01	Total Skin HI =	3.8E-02

TABLE 3-1

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - U.S. EPA Region 3 - Preliminary Remediation Goals (PRGs) Tables, October 2004, updated December 28, 2004. The carcinogenic PRGs for 2,4,6-TNT and RDX and the noncarcinogenic PRGs for 2,4,6-TNT, the aminodinitrotoluenes, RDX, HMX, and barium are different from those presented in the Region IX PRG Table as a result of changes in toxicity criteria or updated dermal absorption factors.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds the carcinogenic and/or 1/10th the noncarcinogenic PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - The carcinogenic PRG is based on total chromium; the noncarcinogenic PRG is based on hexavalent chromium.
6 - 97.5% Chebyshev (Mean, Std) UCL
7 - 95% Chebyshev (Mean, Std) UCL
8 - Student-t UCL
9 - 99% Chebyshev (Mean, Std) UCL
10 - Approximate Gamma 95% UCL
11 - Arithmetic mean
12 - Lead is evaluated qualitatively.
13 - NCEA paper, available upon request.
14 - State of Florida, Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida Dept. of Environmental Protection, February 2005.
15 - Guidance Manual for the IEUBK Model for lead in children. U.S. EPA. NTIS# PB93-963510. OSWER# 9285.7-15-1. February 1994.

Abbreviations:

CNS - Central Nervous System
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

TABLE 3-2

SUMMARY OF CONSTRUCTION HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Construction[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Construction[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
2,4,6-TNT	25 [6]	1.1E+03	2.3E-08	Liver	2.4E+02	1.1E-01
2-A-4,6-DNT	0.8 [7]	NA	NA	NA	1.0E+03	8.0E-04
4-A-2,6-DNT	0.8 [7]	NA	NA	NA	1.0E+03	8.0E-04
RDX	110 [6]	3.1E+02	3.5E-07	Prostate	1.5E+03	7.3E-02
HMX	73 [6]	NA	NA	Liver	2.5E+04	2.9E-03
Aluminum	10900 [8]	NA	NA	CNS[13]	1.7E+04	6.3E-01
Antimony	13.9 [9]	NA	NA	Blood	2.1E+02	6.7E-02
Arsenic	9.8 [10]	1.6E+01	6.1E-07	Skin, CVS	1.4E+02	6.9E-02
Barium	1890 [9]	NA	NA	Kidney	1.8E+03	1.1E+00
Cadmium	15.6 [9]	1.4E+02	1.1E-07	Kidney	1.8E+02	8.6E-02
Chromium[5]	20.9 [8]	2.2E+01	9.6E-07	None reported (ingestion)	3.0E+02	7.0E-02
Cooper	4150 [9]	NA	NA	GI[14]	2.1E+04	2.0E-01
Iron	29000 [8]	NA	NA	None reported[13]	1.6E+05	1.9E-01
Lead	681 [11]	8.0E+02	[12]	CNS[15]	8.0E+02	[12]
Manganese	1790 [7]	NA	NA	CNS	1.8E+02	1.0E+01
Mercury	1.8 [9]	NA	NA	CNS	1.6E+02	1.2E-02
Vanadium	19.5 [10]	NA	NA	Kidney[13]	5.2E+02	3.8E-02
Zinc	4550 [9]	NA	NA	Blood	1.6E+05	2.9E-02
		Total Carcinogenic Risk	2E-06		Total HI	1E+01

Target Organ HIs

Total Kidney HI =	1.2E+00	Total Liver HI =	1.1E-01
Total CNS HI =	1.1E+01	Total Prostate HI =	7.3E-02
Total CVS HI =	6.9E-02	Total Blood HI =	9.7E-02
Total GI HI =	2.0E-01	Total Skin HI =	6.9E-02

TABLE 3-2

SUMMARY OF CONSTRUCTION HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - The PRGs for the construction worker were derived following the methodology used to calculate the U.S. EPA Region IX PRGs.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds the carcinogenic and/or 1/10th the noncarcinogenic PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - Hexavalent Chromium
6 - 97.5% Chebyshev (Mean, Std) UCL
7 - 95% Chebyshev (Mean, Std) UCL
8 - Student-t UCL
9 - 99% Chebyshev (Mean, Std) UCL
10 - Approximate Gamma 95% UCL
11 - Arithmetic mean
12 - Lead is evaluated qualitatively.
13 - NCEA paper, available upon request.
14 - State of Florida, Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida Dept. of Environmental Protection, February 2005.
15 - Guidance Manual for the IEUBK Model for lead in children. U.S. EPA. NTIS# PB93-963510. OSWER# 9285.7-15-1. February 1994.

Abbreviations:

% - percent
CNS - Central Nervous System
CTL - Cleanup Target Level
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
NCEA - National Center for Environmental Assessment
NTIS - National Technical Information Service
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

TABLE 3-3

SUMMARY OF TRESPASSER HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Trespasser[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Trespasser[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
2,4,6-TNT	25 [6]	1.1E+03	2.3E-08	Liver	2.5E+03	1.0E-02
2-A-4,6-DNT	0.8 [7]	NA	NA	NA	1.1E+04	7.3E-05
4-A-2,6-DNT	0.8 [7]	NA	NA	NA	1.1E+04	7.3E-05
RDX	110 [6]	3.2E+02	3.4E-07	Prostate	1.6E+04	6.9E-03
HMX	73 [6]	NA	NA	Liver	2.9E+05	2.5E-04
Aluminum	10900 [8]	NA	NA	CNS[13]	5.9E+06	1.9E-03
Antimony	13.9 [9]	NA	NA	Blood	2.4E+03	5.8E-03
Arsenic	9.8 [10]	2.1E+01	4.6E-07	Skin, CVS	1.5E+03	6.5E-03
Barium	1890 [9]	NA	NA	Kidney	1.2E+06	1.6E-03
Cadmium	15.6 [9]	1.7E+05	9.3E-11	Kidney	2.7E+03	5.8E-03
Chromium[5]	20.9 [8]	2.6E+04	8.1E-10	None reported (ingestion)	1.8E+04	1.2E-03
Copper	4150 [9]	NA	NA	GI[14]	2.4E+05	1.7E-02
Iron	29000 [8]	NA	NA	None reported[13]	1.8E+06	1.6E-02
Lead	681 [11]	4.0E+02	[12]	CNS[15]	4.0E+02	[12]
Manganese	1790 [7]	NA	NA	CNS	3.7E+05	4.9E-03
Mercury	1.8 [9]	NA	NA	CNS	1.8E+03	9.9E-04
Vanadium	19.5 [10]	NA	NA	Kidney[13]	6.0E+03	3.2E-03
Zinc	4550 [9]	NA	NA	Blood	1.8E+06	2.5E-03
		Total Carcinogenic Risk	8E-07		Total HI	8E-02

Target Organ HIs

Total Kidney HI =	1.1E-02	Total Liver HI =	1.0E-02
Total CNS HI =	7.7E-03	Total Prostate HI =	6.9E-03
Total CVS HI =	6.5E-03	Total Blood HI =	8.3E-03
Total GI HI =	1.7E-02	Total Skin HI =	6.5E-03

TABLE 3-3

SUMMARY OF TRESPASSER HUMAN HEALTH RISKS AND HAZARDS
SURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - The PRGs for the adolescent trespasser were derived following the methodology used to calculate the U.S. EPA Region IX PRGs.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds the carcinogenic and/or 1/10th the noncarcinogenic PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - Hexavalent Chromium
6 - 97.5% Chebyshev (Mean, Std) UCL
7 - 95% Chebyshev (Mean, Std) UCL
8 - Student-t UCL
9 - 99% Chebyshev (Mean, Std) UCL
10 - Approximate Gamma 95% UCL
11 - Arithmetic mean
12 - Lead is evaluated qualitatively.
13 - NCEA paper, available upon request.
14 - State of Florida, Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida Dept. of Environmental Protection, February 2005.
15 - Guidance Manual for the IEUBK Model for lead in children. U.S. EPA. NTIS# PB93-963510. OSWER# 9285.7-15-1. February 1994.

Abbreviations:

% - percent
CNS - Central Nervous System
CTL - Cleanup Target Level
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
NCEA - National Center for Environmental Assessment
NTIS - National Technical Information Service
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

TABLE 3-4

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Industrial[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
Trichloroethene	3 [6]	6.0E+00	5.0E-07	NA	2.8E+03	1.1E-03
2,4,6-TNT	81 [7]	7.9E+01	1.0E-06	Liver	4.2E+02	1.9E-01
2-A-4,6-DNT	0.3 [8]	NA	NA	NA	1.9E+03	1.6E-04
4-A-2,6-DNT	0.3 [8]	NA	NA	NA	1.9E+03	1.6E-04
RDX	9 [9]	2.4E+01	3.8E-07	Prostate	2.8E+03	3.2E-03
HMX	10 [7]	NA	NA	Liver	4.9E+04	2.0E-04
Aluminum	12600 [9]	NA	NA	CNS[12]	9.2E+05	1.4E-02
Antimony	3.5 [7]	NA	NA	Blood	4.1E+02	8.6E-03
Arsenic	10.7 [9]	1.6E+00	6.7E-06	Skin, CVS	2.6E+02	4.2E-02
Barium	173 [9]	NA	NA	Kidney	1.7E+05	1.0E-03
Cadmium	0.64 [9]	3.0E+03		Kidney	4.5E+02	1.4E-03
Chromium[5]	24.5 [9]	4.5E+02	5.4E-08	None reported (ingestion)	2.5E+03	9.8E-03
Copper	52.4 [9]	NA	NA	GI[13]	4.1E+04	1.3E-03
Iron	41400 [9]	NA	NA	None reported[12]	3.1E+05	1.3E-01
Lead	55.5 [10]	8.0E+02	[11]	CNS[14]	8.0E+02	[11]
Manganese	1660 [7]	NA	NA	CNS	2.0E+04	8.5E-02
Mercury	0.14 [9]	NA		CNS	3.1E+02	4.5E-04
Vanadium	20.1 [8]	NA	NA	Kidney[12]	1.0E+03	2.0E-02
Zinc	169 [9]	NA		Blood	3.1E+05	5.5E-04
		Total Carcinogenic Risk	8E-06		Total HI	5E-01

Target Organ HIs

Total Kidney HI =	2.3E-02	Total Liver HI =	1.9E-01
Total CNS HI =	9.9E-02	Total Prostate HI =	3.2E-03
Total CVS HI =	4.2E-02	Total Blood HI =	9.1E-03
Total GI HI =	1.3E-03	Total Skin HI =	4.2E-02

TABLE 3-4

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 2004, updated December 28, 2004. The carcinogenic PRGs for 2,4,6-TNT and RDX and the noncarcinogenic PRGs for 2,4,6-TNT, the aminodinitrotoluenes, RDX, HMX, and barium are different from those presented in the Region IX PRG Table as a result of changes intoxicity criteria or updated dermal absorption factors.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds the carcinogenic and/or 1/10th the noncarcinogenic PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - The carcinogenic PRG is based on total chromium; the noncarcinogenic PRG is based on hexavalent chromium.
6 - 99% (Mean, Std) Chebyshev UCL
7 - 97.5% (Mean, Std) Chebyshev UCL
8 - Student-t UCL
9 - 95% Chebyshev (Mean, Std) UCL
10 - Arithmetic mean
11 - Lead is evaluated qualitatively.
12 - NCEA paper, available upon request.
13 - State of Florida, Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida Dept. of Environmental Protection, February 2005.
14 - Guidance Manual for the IEUBK Model for lead in children. USEPA. NTIS# PB93-963510. OSWER# 9285.7-15-1. February 1994.

Abbreviations:

% - percent
CNS - Central Nervous System
CTL - Cleanup Target Level
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
NCEA - National Center for Environmental Assessment
NTIS - National Technical Information Service
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

TABLE 3-5

SUMMARY OF CONSTRUCTION HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Construction[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Construction[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
Trichloroethene	3 [6]	5.5E+01	5.5E-08	NA	9.5E+02	3.2E-03
2,4,6-TNT	81 [7]	1.1E+03	7.4E-08	Liver	2.4E+02	3.4E-01
2-A-4,6-DNT	0.3 [8]	NA	NA	NA	1.0E+03	3.0E-04
4-A-2,6-DNT	0.3 [8]	NA	NA	NA	1.0E+03	3.0E-04
RDX	9 [9]	3.1E+02	2.9E-08	Prostate	1.5E+03	6.0E-03
HMX	10 [7]	NA	NA	Liver	2.5E+04	4.0E-04
Aluminum	12600 [9]	NA	NA	CNS[12]	1.7E+04	7.3E-01
Antimony	3.5 [7]	NA	NA	Blood	2.1E+02	1.7E-02
Arsenic	10.7 [9]	1.6E+01	6.6E-07	Skin, CVS	1.4E+02	7.5E-02
Barium	173 [9]	NA	NA	Kidney	1.8E+03	9.9E-02
Cadmium	0.64 [9]	1.4E+02	4.5E-09	Kidney	1.8E+02	3.5E-03
Chromium[5]	24.5 [9]	2.2E+01	1.1E-06	None reported (ingestion)	3.0E+02	8.2E-02
Copper	52.4 [9]	NA	NA	GI[13]	2.1E+04	2.5E-03
Iron	41400 [9]	NA	NA	None reported[12]	1.6E+05	2.7E-01
Lead	55.5 [10]	8.0E+02	[11]	CNS[14]	8.0E+02	[11]
Manganese	1660 [7]	NA	NA	CNS	1.8E+02	9.4E+00
Mercury	0.14 [9]	NA	NA	CNS	1.6E+02	9.0E-04
Vanadium	20.1 [8]	NA	NA	Kidney[12]	5.2E+02	3.9E-02
Zinc	169 [9]	NA	NA	Blood	1.6E+05	1.1E-03
		Total Carcinogenic Risk	2E-06		Total HI	1E+01

Target Organ HIs

Total Kidney HI =	1.4E-01	Total Liver HI =	3.5E-01
Total CNS HI =	1.0E+01	Total Prostate HI =	6.0E-03
Total CVS HI =	7.5E-02	Total Blood HI =	1.8E-02
Total GI HI =	2.5E-03	Total Skin HI =	7.5E-02

TABLE 3-5

SUMMARY OF CONSTRUCTION HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - The PRGs for the construction worker were derived following the methodology used to calculate the USEPA Region IX PRGs.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds 1/10th the PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - Hexavalent Chromium
6 - 99% (Mean, Std) Chebyshev UCL
7 - 97.5% (Mean, Std) Chebyshev UCL
8 - Student-t UCL
9 - 95% (Mean, Std) Chebyshev UCL
10 - Arithmetic mean
11 - Lead is evaluated qualitatively.
12 - NCEA paper, available upon request.
13 - State of Florida, Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C. Prepared for the Division of Waste Management, Florida Dept. of Environmental Protection, February 2005.
14 - Guidance Manual for the IEUBK Model for lead in children. USEPA. NTIS# PB93-963510. OSWER# 9285.7-15-1. February 1994.

Abbreviations:

% - percent
CNS - Central Nervous System
CTL - Cleanup Target Level
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
NCEA - National Center for Environmental Assessment
NTIS - National Technical Information Service
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

TABLE 3-6

SUMMARY OF TRESPASSER HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter[4]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Trespasser[1,3]	Estimated ILCR	Primary Target Organs[2]	PRG - Trespasser[1,3]	Estimated HQ
	(mg/kg)	(mg/kg)			(mg/kg)	
Trichloroethene	3 [6]	3.3E+02	9.1E-09	NA	6.7E+04	4.5E-05
2,4,6-TNT	81 [7]	1.1E+03	7.4E-08	Liver	2.5E+03	3.2E-02
2-A-4,6-DNT	0.3 [8]	NA	NA	NA	1.1E+04	2.7E-05
4-A-2,6-DNT	0.3 [8]	NA	NA	NA	1.1E+04	2.7E-05
RDX	9 [9]	3.2E+02	2.8E-08	Prostate	1.6E+04	5.6E-04
HMX	10 [7]	NA	NA	Liver	2.9E+05	3.4E-05
Aluminum	12600 [9]	NA	NA	CNS[12]	5.9E+06	2.1E-03
Antimony	3.5 [7]	NA	NA	Blood	2.4E+03	1.5E-03
Arsenic	10.7 [9]	2.1E+01	5.0E-07	Skin, CVS	1.5E+03	7.1E-03
Barium	173 [9]	NA	NA	Kidney	1.2E+06	1.5E-04
Cadmium	0.64 [9]	1.7E+05	3.8E-12	Kidney	2.7E+03	2.4E-04
Chromium[5]	24.5 [9]	2.6E+04	9.5E-10	None reported (ingestion)	1.8E+04	1.4E-03
Copper	52.4 [9]	NA	NA	GI[13]	2.4E+05	2.2E-04
Iron	41400 [9]	NA	NA	None reported[12]	1.8E+06	2.3E-02
Lead	55.5 [10]	4.0E+02	[11]	CNS[14]	4.0E+02	[11]
Manganese	1660 [7]	NA	NA	CNS	3.7E+05	4.5E-03
Mercury	0.14 [9]	NA	NA	CNS	1.8E+03	7.7E-05
Vanadium	20.1 [8]	NA	NA	Kidney[12]	6.0E+03	3.3E-03
Zinc	169 [9]	NA	NA	Blood	1.8E+06	9.3E-05
		Total Carcinogenic Risk	6E-07		Total HI	8E-02

Target Organ HIs

Total Kidney HI =	3.7E-03	Total Liver HI =	3.2E-02
Total CNS HI =	6.8E-03	Total Prostate HI =	5.6E-04
Total CVS HI =	7.1E-03	Total Blood HI =	1.5E-03
Total GI HI =	2.2E-04	Total Skin HI =	7.1E-03

TABLE 3-6

SUMMARY OF TRESPASSER HUMAN HEALTH RISKS AND HAZARDS
SUBSURFACE SOIL
AMMUNITION BURNING GROUND
NSWC CRANE
CRANE, INDIANA

Footnotes:

1 - The PRGs for the adolescent trespasser were derived following the methodology used to calculate the USEPA Region IX PRGs.
2 - Primary Target Organs - Integrated Risk Information System (IRIS), unless otherwise noted.
3 - PRG is shaded if EPC exceeds 1/10th the PRG.
4 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
5 - Hexavalent Chromium
6 - 99% Chebyshev (Mean, Std) UCL
7 - 97.5% Chebyshev (Mean, Std) UCL
8 - Student-t UCL
9 - 95% Chebyshev (Mean, Std) UCL
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11 - Lead is evaluated qualitatively.
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Abbreviations:

% - percent
CNS - Central Nervous System
CTL - Cleanup Target Level
CVS - Cardiovascular System
DNT - 2,4-dinitrotoluene
EPC - Exposure Point Concentration
F.A.C. - Florida Administrative Code
GI - Gastrointestinal
HI - Hazard Index
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
HQ - Hazard Quotient
ILCR - Incremental Lifetime Cancer Risk
NA - Not Applicable - these COPCs are not carcinogens
NCEA - National Center for Environmental Assessment
NTIS - National Technical Information Service
PRG - Preliminary Remediation Goal
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6 trinitrotoluene
U.S. EPA - United States Environmental Protection Agency
UCL - Upper Confidence Level

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DRAWING NO. FIGURE 3 - 1

REV –

LEAD CONCENTRATIONS IN SURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY L. SINAGOGA DATE 7/20/05

COST/SCHED-AREA

SCALE AS NOTED

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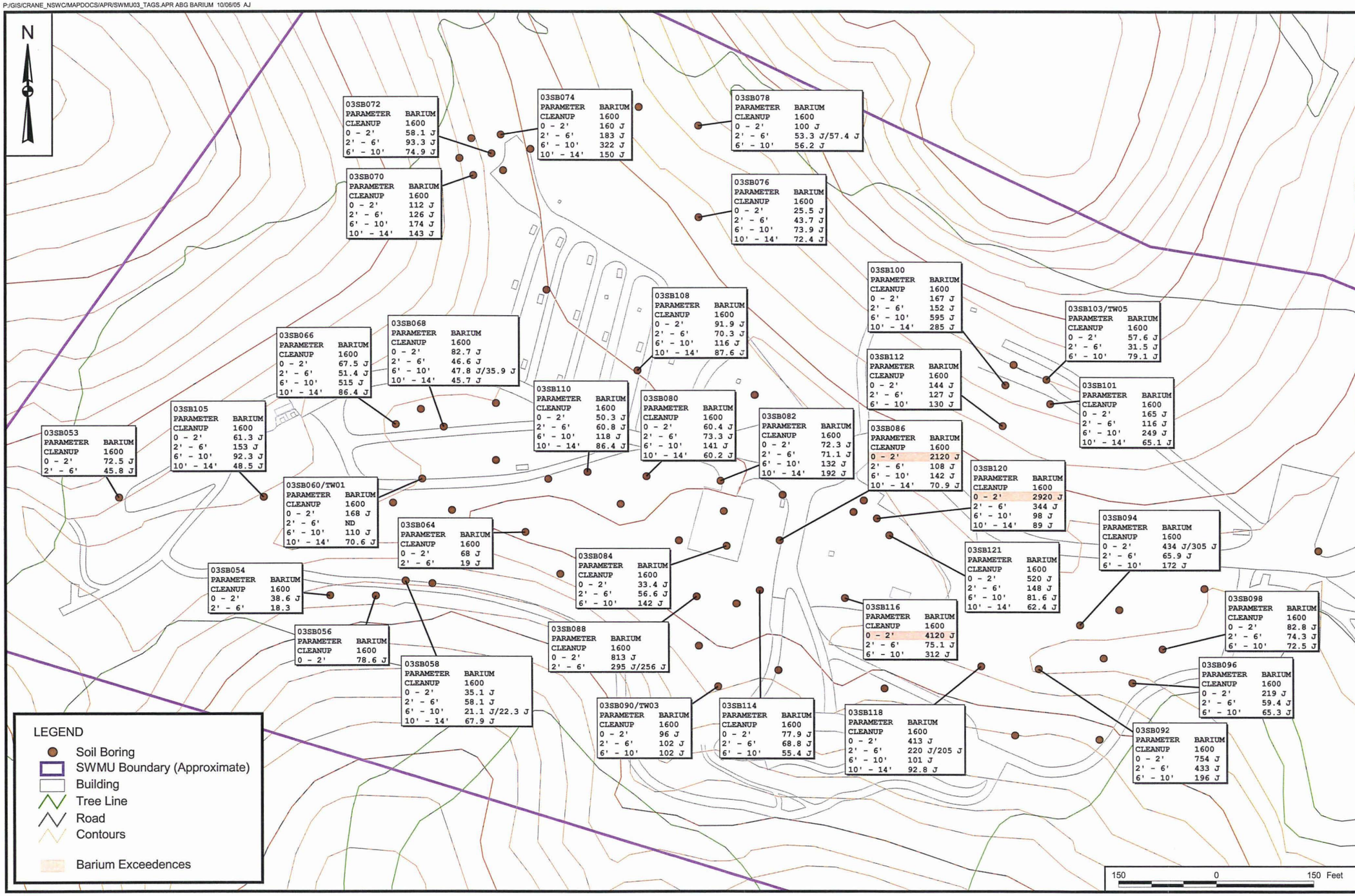

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DRAWING NO. FIGURE 3 - 2

REV 0

BARIUM CONCENTRATIONS IN SURFACE AND SUBSURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY L. SINAGOGA DATE 9/15/05

COST/SCHED-AREA

SCALE AS NOTED

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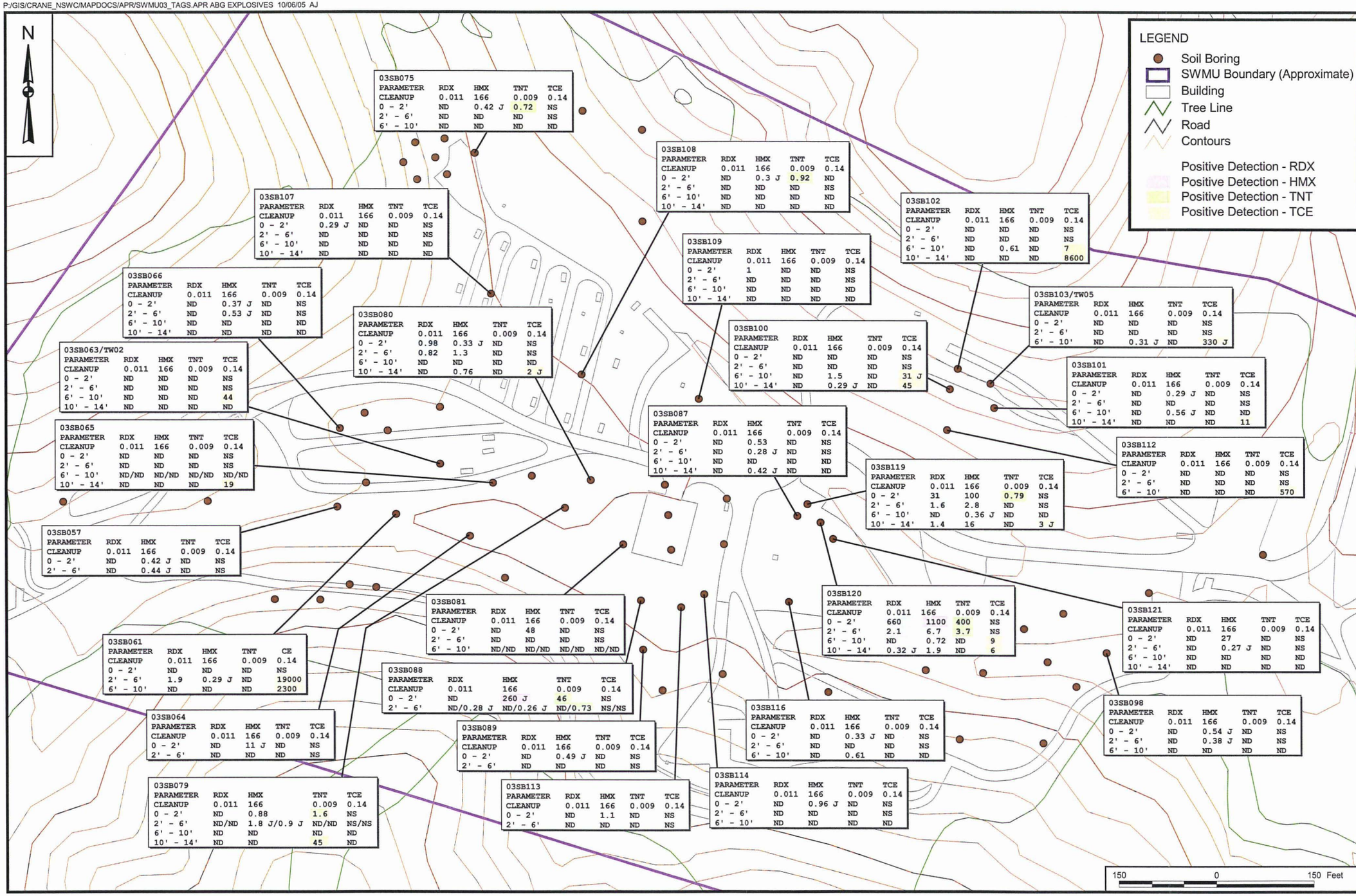

03SB075

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.42 J	0.72	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	ND

03SB107

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	0.29 J	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	ND	ND

03SB066

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.37 J	ND	NS
2' - 6'	ND	0.53 J	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	ND	ND

03SB063/TW02

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	44
10' - 14'	ND	ND	ND	ND

03SB065

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND/ND	ND/ND	ND/ND	ND/ND
10' - 14'	ND	ND	ND	19

03SB057

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.42 J	ND	NS
2' - 6'	ND	0.44 J	ND	NS

03SB061

PARAMETER	RDX	HMX	TNT	CE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	1.9	0.29 J	ND	19000
6' - 10'	ND	ND	ND	2300

03SB064

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	11 J	ND	NS
2' - 6'	ND	ND	ND	NS

03SB079

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.88	1.6	NS
2' - 6'	ND/ND	1.8 J/0.9 J	ND/ND	NS/NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	45	ND

03SB080

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	0.98	0.33 J	ND	NS
2' - 6'	0.82	1.3	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	0.76	ND	2 J

03SB081

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	48	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND/ND	ND/ND	ND/ND	ND/ND

03SB088

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	260 J	46	NS
2' - 6'	ND/0.28 J	ND/0.26 J	ND/0.73	NS/NS

03SB089

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.49 J	ND	NS
2' - 6'	ND	ND	ND	NS

03SB113

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	1.1	ND	NS
2' - 6'	ND	ND	ND	NS

03SB108

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.3 J	0.92	ND
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	ND	ND

03SB109

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	1	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	ND	ND

03SB100

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	1.5	ND	31 J
10' - 14'	ND	0.29 J	ND	45

03SB087

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.53	ND	NS
2' - 6'	ND	0.28 J	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	0.42 J	ND	ND

03SB119

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	31	100	0.79	NS
2' - 6'	1.6	2.8	ND	NS
6' - 10'	ND	0.36 J	ND	ND
10' - 14'	1.4	16	ND	3 J

03SB120

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	660	1100	400	NS
2' - 6'	2.1	6.7	3.7	NS
6' - 10'	ND	0.72	ND	9
10' - 14'	0.32 J	1.9	ND	6

03SB116

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.33 J	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	0.61	ND	ND

03SB114

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.96 J	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	ND

03SB102

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	0.61	ND	7
10' - 14'	ND	ND	ND	8600

03SB103/TW05

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	0.31 J	ND	330 J

03SB101

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.29 J	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	0.56 J	ND	ND
10' - 14'	ND	ND	ND	11

03SB112

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	ND	ND	NS
2' - 6'	ND	ND	ND	NS
6' - 10'	ND	ND	ND	570

03SB121

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	27	ND	NS
2' - 6'	ND	0.27 J	ND	NS
6' - 10'	ND	ND	ND	ND
10' - 14'	ND	ND	ND	ND

03SB098

PARAMETER	RDX	HMX	TNT	TCE
CLEANUP	0.011	166	0.009	0.14
0 - 2'	ND	0.54 J	ND	NS
2' - 6'	ND	0.38 J	ND	NS
6' - 10'	ND	ND	ND	ND

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DRAWING NO. FIGURE 3 - 3

REV 0

PRIMARY ORGANIC CONTAMINANTS IN SURFACE AND SUBSURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY L. SINAGOGA DATE 9/15/05

COST/SCHED-AREA

SCALE AS NOTED

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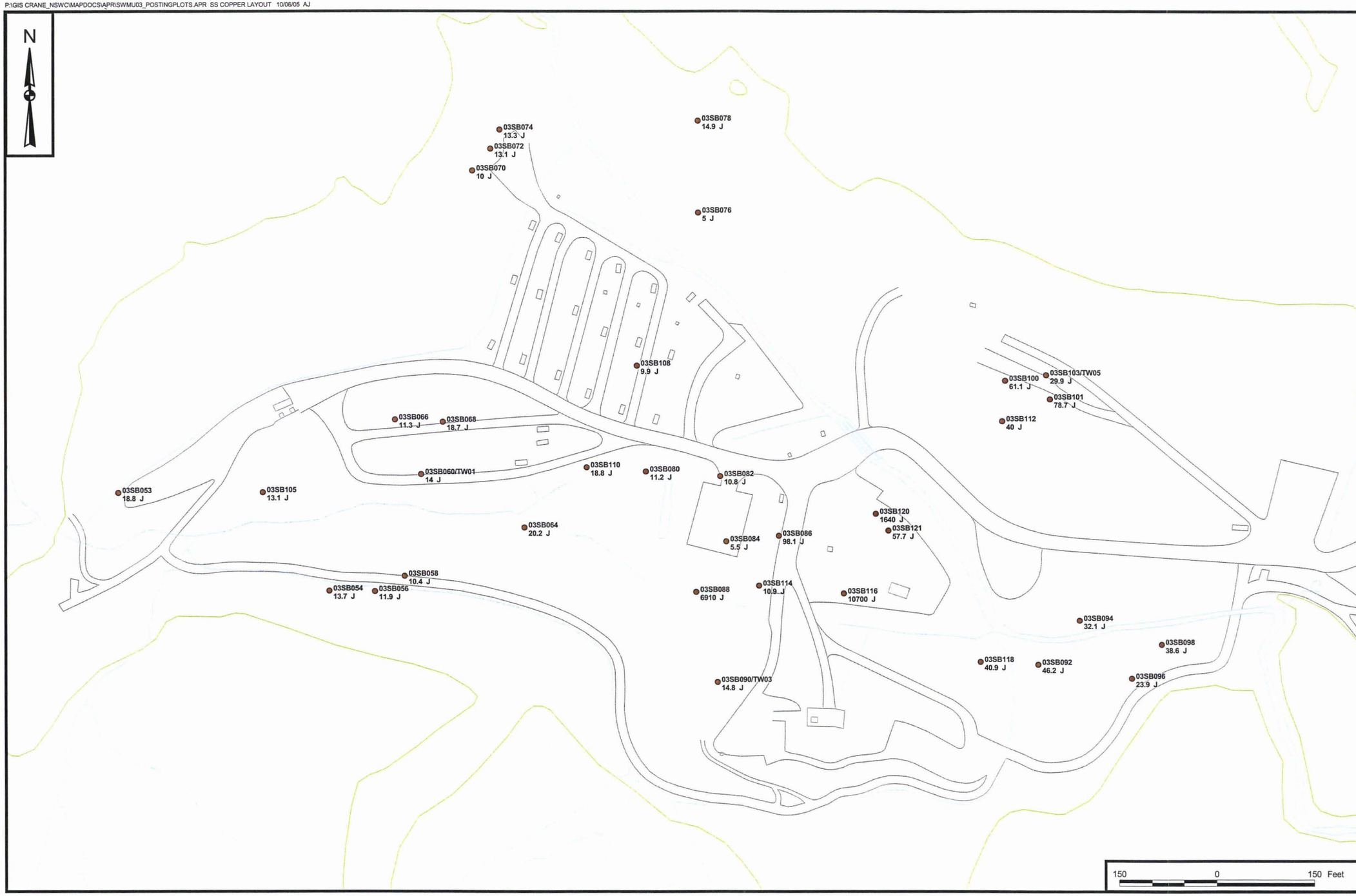

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8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 3 - 4

REV –

COPPER CONCENTRATIONS IN SURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY L. SINAGOGA DATE 7/20/05

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS CRANE_NSWC\MAPDOCS\APR\SWMU03_POSTINGPLOTS.APR SS ZINC LAYOUT 10/06/05 AJ

CONTRACT NO.
8383

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 5

REV –

ZINC CONCENTRATIONS IN SURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

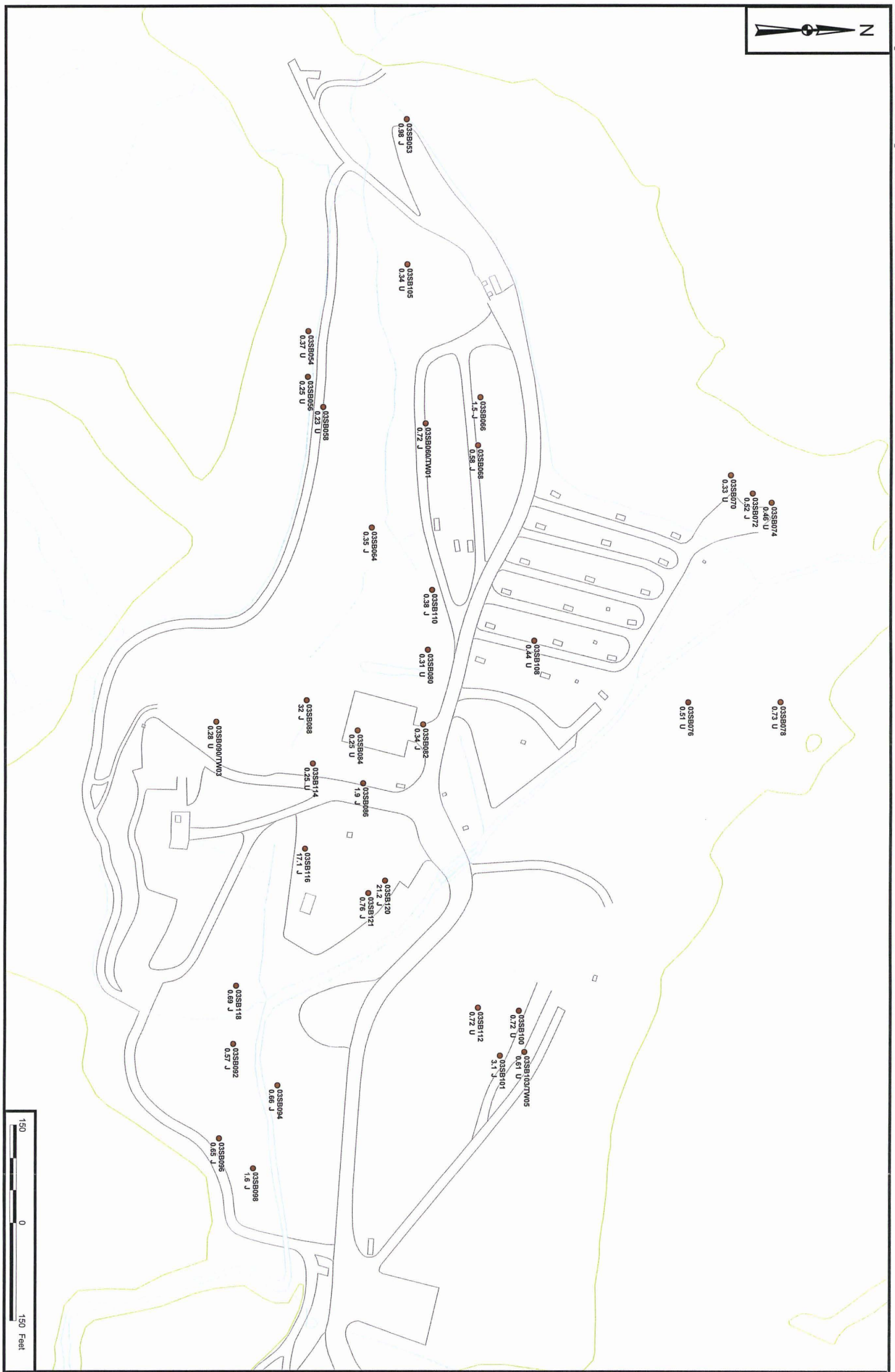
DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY L. SINAGOGA DATE 9/15/05

COST/SCHED-AREA

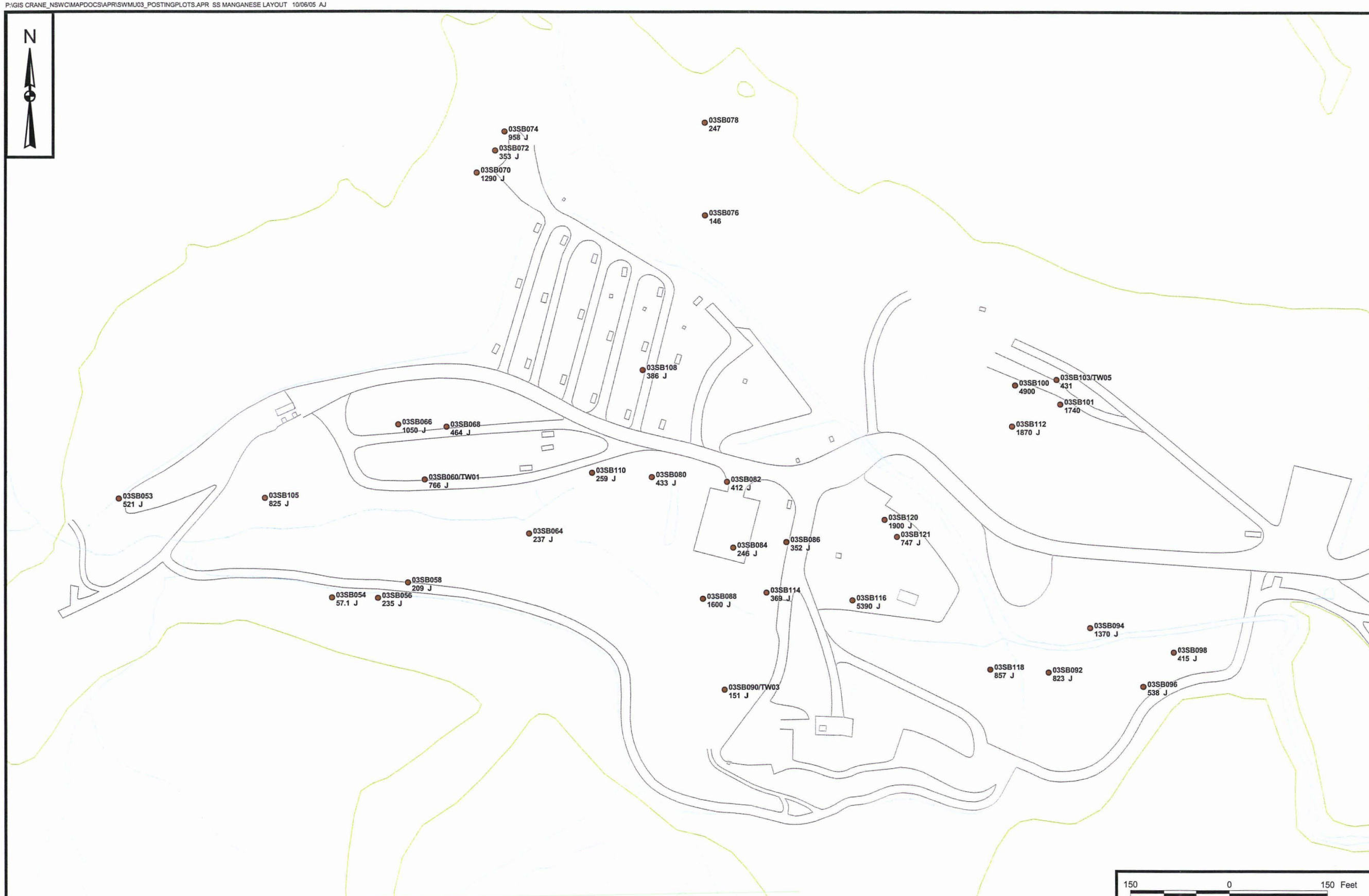
SCALE AS NOTED

P:\GIS CRANE_NSWC\MAPDOCS\APR\SWMU03_POSTINGPLOTS.APR SS ANTIMONY LAYOUT 10/06/05 AJ



DRAWN BY C. FOSTER	DATE 7/20/05	ANTIMONY CONCENTRATIONS IN SURFACE SOILS (MG/KG) SWMU 3 - AMMUNITION BURNING GROUNDS (MAIN TREATMENT AREA) NSWC CRANE CRANE, INDIANA	CONTRACT NO. 8383
CHECKED BY L. SINAGOGA	DATE 7/20/05		APPROVED BY ___ DATE ___
COST/SCHED-AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 3 - 6 REV –

P:\GIS CRANE_NSWC\MAPDOCS\APR\SWMU03_POSTINGPLOTS.APR SS MANGANESE LAYOUT 10/06/05 AJ



CONTRACT NO.
8383

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 3 - 7

REV –

MANGANESE CONCENTRATIONS IN SURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY L. SINAGOGA DATE 7/20/05

COST/SCHED-AREA

SCALE AS NOTED

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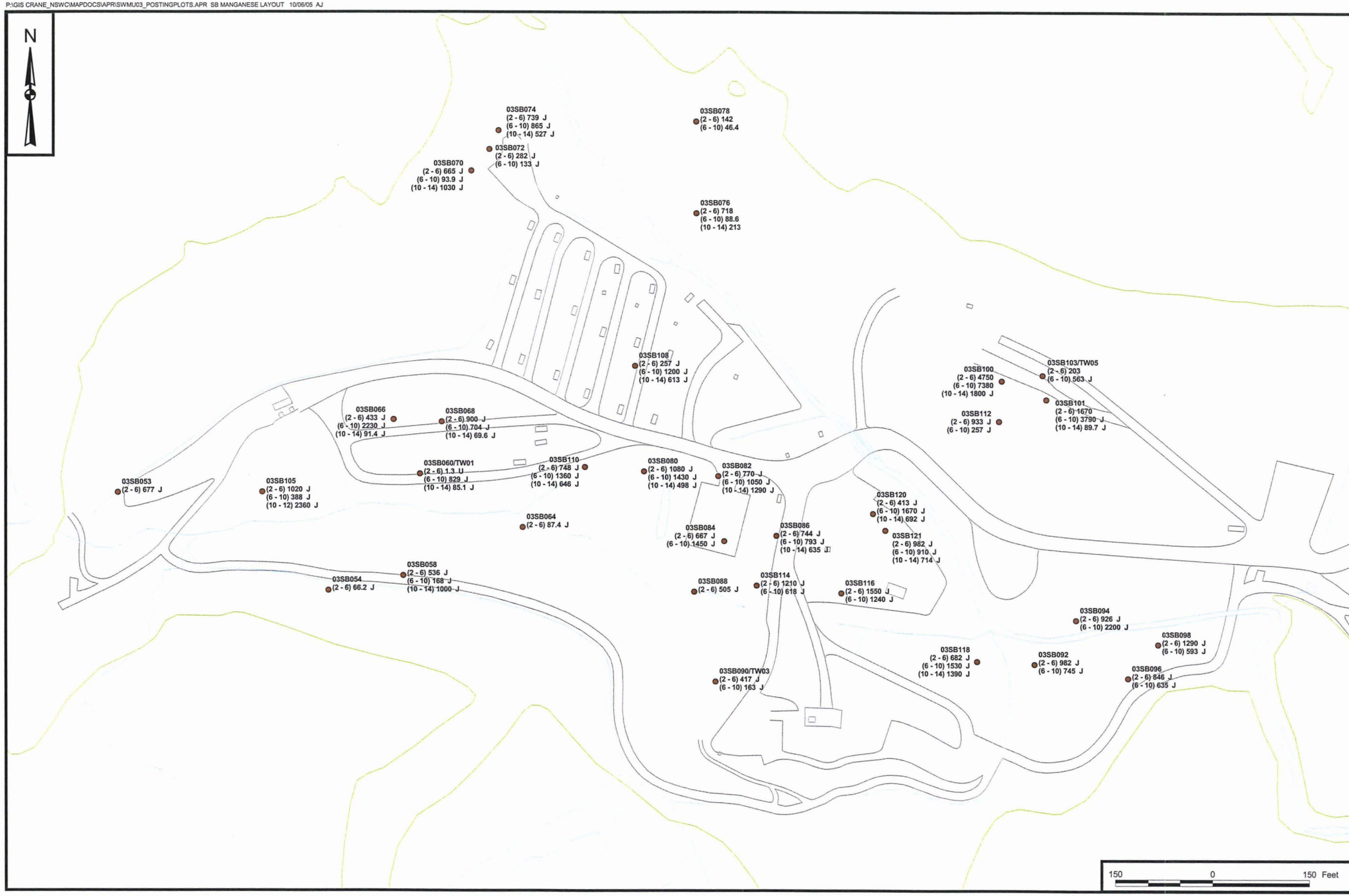

CONTRACT NO.
8383

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 3 - 8

REV –

MANGANESE CONCENTRATIONS IN
SUBSURFACE SOILS (MG/KG)
SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY L. SINAGOGA DATE 7/20/05

COST/SCHED-AREA

SCALE AS NOTED

4.0 UNCERTAINTY ANALYSIS

The following significant sources of uncertainty should be considered when interpreting the results of this HHRSE:

- In the absence of specific information regarding the nature of construction activities that may occur at the ABG, conservative modeling assumptions were used to predict dust emissions occurring during a construction project. For example, the modeling (Appendix A) assumed that construction vehicles would generate dust by traversing unpaved areas of a ½ acre construction area 30 times per day (i.e., 30 vehicles per day). Given that there are no significant buildings/infrastructure at the ABG and no substantial construction is anticipated to be needed because of current site use, this assumed level of activity may overpredict the potential for emissions and construction worker exposure at the ABG.

- Based on the ***currently available data***, the size of the metals "hot spot" area in the southeast quadrant of the ABG may be no larger than ½ acre. When compared to the size of the area likely to be contacted by a receptor over the course of a long-term construction event, the area of metals contamination may only be a ***portion*** of the exposure unit for the construction worker. Also, given current operations at the ABG which generally require the SWMU worker to traverse the whole site (as opposed to working in the southeast quadrant only), the area of metals contamination in the southeast quadrant is also a portion of the exposure unit for the SWMU worker who is typically coming on site only to load materials to be burned, etc. The potential for receptor risk is mitigated by the limited size of the "hot spot" in the southeast quadrant.

- In counter-balance to the uncertainty discussed in the preceding bullet, it must be noted that the available data for the area of metals contamination in the southeast quadrant of the site is limited and the extent of contamination has not been completely defined (see Figures 1 through 6). Consequently, although the current data suggests a limited "hot spot" area (i.e., approximately ½ acre), sampling at some time in the future may indicate a larger area of contamination. The potential for receptor risk would increase if the size of the "hot spot" area were to increase.

- Buildings do not exist in the main treatment area (MTA) of the ABG and no buildings are planned for this area because it is used for the open burning of explosives and explosives-containing materials. However, it should be noted that volatile organic chemicals (primarily TCE) have been detected in

both soils and groundwater underlying the MTA. Consequently, the potential for vapor intrusion into future buildings that may be constructed on site should be investigated in the risk assessment prepared to support the eventual closure of the unit.

- The RBC for construction worker exposure to lead (see Appendix A) assumes that the receptor is a pregnant worker exposed to soils at the ABG for extended period of time (at least 90 days). The RBC is actually calculated to be protective of the worker's fetus. A RBC that is protective of this most-sensitive receptor is assumed to be protective of all other workers at the ABG. While the potential for receptor risk is somewhat mitigated the fact that a pregnant worker is not likely to be assigned soil-contact-intensive work tasks at the ABG, it should be noted that lead stored in the body of a worker may be transferred to the fetus subsequent to the time of the actual exposure. Consequently, lead exposures occurring prior to pregnancy still have the potential to adversely impact the fetus during pregnancy.

- The U.S. EPA IRIS database does not include an inhalation reference dose for barium. Consequently, the inhalation reference dose published in the 1997 HEAST and listed in the U.S. EPA Region 9 PRG table was used in this HHRSE.

It should be noted that the HHRSE presented in this report was prepared using human health risk assessment guidelines published for the U.S. EPA CERCLA and RCRA programs. Although certain OSHA standards are presented as a point of reference, the assessment was not prepared to demonstrate compliance with OSHA.

5.0 SUMMARY AND CONCLUSIONS

A HHRSE was conducted for current land use receptors hypothetically exposed to chemical concentrations detected in the surface and subsurface soils at the ABG. The following chemicals were selected as COPCs based on a comparison of maximum detected chemical concentrations to the U.S. EPA Region 9 soil PRGs for the residential land use scenario:

TCE	2,4,6-TNT	2-Amino-4,6-DNT	4-Amino-2,6-DNT
HMX	RDX	Aluminum	Antimony
Arsenic	Barium	Cadmium	Chromium
Copper	Iron	Lead	Manganese
Mercury	Vanadium	Zinc	

The typical industrial worker, the construction worker, and the trespasser were evaluated as receptors potentially exposed to surface and subsurface soils at the ABG. Cancer risk estimates for these receptors are less than or within the U.S. EPA target cancer risk range (1E-04 to 1E-06). Non-cancer risk estimates for the typical industrial worker and the trespasser do not exceed the U.S. EPA HI benchmark of 1. Non-cancer risk estimates for the construction worker are 10 for COPC concentrations in both surface and subsurface soils; the primary risk drivers are barium, lead, and manganese. Barium is not recommended for further evaluation in the CMS for SWMU 3 because non-cancer risk estimates based on ***sub-chronic*** inhalation reference doses available in HEAST (but not in the IRIS database) indicated that construction worker exposure to on-site barium concentrations would not result in HIs exceeding 1. Manganese is not recommended for further evaluation in the CMS for SWMU 3 because the non-cancer risk estimates for the construction worker are based on a ***chronic*** inhalation reference dose (a sub-chronic inhalation reference dose is not available) developed using toxicity data reflective of a workers exposure to manganese oxide compounds in an occupation setting (not incidental exposure to soils). These factors and a comparison of the predicted manganese air concentrations to available OSHA and NIOSH standards/criteria indicate that the HIs presented in the HHRSE over estimate the potential for non-cancer risk. ***Lead is recommended for further evaluation in the CMS for SWMU 3***. The area of concern is a sub-area of the southeast quadrant of the ABG which demonstrates arithmetic mean lead concentrations exceeding the U.S. EPA Region 9 soil PRGs for residential and industrial land use scenarios, and RBCs developed specifically for the construction worker. Although the area appears to be limited in size, lead and several other metals (e.g., zinc, copper, cadmium, arsenic, and antimony) were

detected in this area at concentrations often an order of magnitude greater than those detected at other locations across the ABG.

REFERENCES

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APPENDIX A

HUMAN HEALTH RISK ASSESSMENT CALCULATIONS

TABLE A-1
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
SURFACE SOIL - SWMU 3 (AMMUNITION BURNING GROUND)
NSWC CRANE
CRANE, INDIANA

Version 1.42

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use Adjusted		Reason for Adjustment	Comments
	Frequency of Detection		Minimum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Variance	Coefficient of Variation	Outlier?					
	Number	Percent															
Dioxins (ng/kg)																	
1,2,3,4,6,7,8,9-OCDD	3/3	100%	256 J	1170 J	CR95-03SS-A06-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,4,6,7,8,9-OCDF	3/3	100%	13.4 J	31.1 J	CR95-03SS-A07-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,4,6,7,8-HPCDD	3/3	100%	30 J	38.7 J	CR95-03SS-A08-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,4,6,7,8-HPCDF	3/3	100%	7.09 J	11.4 J	CR95-03SS-A07-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,4,7,8-HXCDF	1/3	33%	2.45	2.45	CR95-03SS-A07-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,6,7,8-HXCDD	2/3	67%	1.11	2.39	CR95-03SS-A08-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
1,2,3,7,8,9-HXCDD	3/3	100%	1.86	3.69	CR95-03SS-A08-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
2,3,7,8-TCDF	2/3	67%	1.81 J	2.23	CR95-03SS-A08-01	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
Volatile Organics (µg/kg)																	
2-BUTANONE	1/1	100%	7 J	7 J	03SS1080002	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
ACETONE	1/1	100%	66 J	66 J	03SS1080002	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
Energetics (mg/kg)																	
1,3,5-TRINITROBENZENE	28/131	21%	0.065 J	14	03SS1200002	0.330	1.09	0.125	1.26	1.59	3.81	NA(7)	Non-parametric	0.810	95% Chebyshev(Mean, Std) UCL		
1,3-DINITROBENZENE	8/131	6%	0.25	0.25	8 Samples	0.133	0.250	0.125	0.030	0.0009	0.227	NA(7)	Non-parametric	0.137	Student-t or Modified-t UCL		
2,4,6-TRINITROTOLUENE	43/131	33%	0.04 J	400	03SS1200002	5.14	15.4	0.125	37.0	1370	7.21	NA(7)	Non-parametric	25.3	97.5% Chebyshev(Mean, Std) UCL		
2,4-DINITROTOLUENE	27/131	21%	0.015 J	11.6	03/10-12-93-1	0.277	0.863	0.125	1.07	1.14	3.86	NA(7)	Non-parametric	0.684	95% Chebyshev(Mean, Std) UCL		
2,6-DIAMINO-4-NITROTOLUENE	1/23	4%	0.47 J	0.47 J	03SS1200002	0.140	0.470	0.125	0.072	0.005	0.514	Yes	Non-parametric	0.166	Student-t or Modified-t UCL		
2,6-DINITROTOLUENE	15/131	11%	0.1 J	0.575	03/10-49-93-1	0.144	0.270	0.125	0.059	0.003	0.412	NA(7)	Non-parametric	0.152	Student-t or Modified-t UCL		
2-AMINO-4,6-DINITROTOLUENE	34/131	26%	0.01 J	12	03SS1200002	0.336	0.936	0.125	1.16	1.36	3.47	NA(7)	Non-parametric	0.779	95% Chebyshev(Mean, Std) UCL		
3,5-DINITROANILINE	1/23	4%	1.1	1.1	03SS1200002	0.167	1.10	0.125	0.203	0.041	1.21	Yes	Non-parametric	0.240	Student-t or Modified-t UCL		
4,4'-DN-AZOXY	1/23	4%	0.61 J	0.61 J	03SS1200002	0.266	0.610	0.250	0.075	0.006	0.283	Yes	Non-parametric	0.293	Student-t or Modified-t UCL		
4-AMINO-2,6-DINITROTOLUENE	38/131	29%	0.06 J	10	03SS1200002	0.346	0.886	0.125	1.14	1.30	3.30	NA(7)	Non-parametric	0.779	95% Chebyshev(Mean, Std) UCL		
HMX	57/131	44%	0.105 J	1100	03SS1200002	17.2	39.0	0.490	101	10286	5.89	NA(7)	Non-parametric	72.6	97.5% Chebyshev(Mean, Std) UCL		
MNX	1/23	4%	0.62 J	0.62 J	03SS1200002	0.147	0.620	0.125	0.103	0.011	0.704	Yes	Non-parametric	0.183	Student-t or Modified-t UCL		
RDX	36/131	27%	0.035 J	1820	03/10-61-93-1	22.0	79.3	0.235	169	28660	7.71	NA(7)	Non-parametric	114	97.5% Chebyshev(Mean, Std) UCL		
TETRYL	8/123	7%	0.65	0.65	8 Samples	0.512	0.650	0.325	2.91	8.48	5.69	NA(7)	Non-parametric	0.65	Maximum Concentration	FOD, No Variation b/t Pos Hits	UCL > Max, Max ND > Max & UCL
Inorganics (mg/kg)																	
ALUMINUM	35/35	100%	4500 J	26600	03SS1160002	9529	9529	8250	4626	21403914	0.486	Yes	Non-parametric	10851	Student-t or Modified-t UCL		- -
ANTIMONY	19/35	54%	0.34 J	32 J	03SS0880002	2.54	4.51	0.365	6.78	46.0	2.67	Yes	Non-parametric	13.9	99% Chebyshev(Mean, Std) UCL		- -
ARSENIC	35/35	100%	4.3 J	27.9 J	03SS1160002	8.69	8.69	7.30	4.26	18.2	0.490	Yes	Gamma	9.76	Approximate Gamma 95% UCL		- -
BARIUM	35/35	100%	25.5 J	4120 J	03SS1160002	415	415	91.9	876	767608	2.11	Yes	Non-parametric	1889	99% Chebyshev(Mean, Std) UCL		- -
BERYLLIUM	33/35	94%	0.29 J	1.8	03SS0780002	0.763	0.792	0.780	0.292	0.085	0.383	Yes	Non-parametric	0.847	Student-t or Modified-t UCL		- -
CADMIUM	20/35	57%	0.22 J	38.5	03SS1200002	2.70	4.63	0.500	7.69	59.1	2.84	Yes	Non-parametric	15.6	99% Chebyshev(Mean, Std) UCL		- -
CALCIUM	35/35	100%	177 J	78200 J	03SS1200002	14023	14023	7130	20983	440287254	1.50	Yes	Non-parametric	49313	99% Chebyshev(Mean, Std) UCL		- -
CHROMIUM	35/35	100%	10.4 J	56.6 J	03SS1160002	18.2	18.2	15.6	9.34	87.2	0.513	Yes	Non-parametric	20.9	Student-t or Modified-t UCL		- -
COBALT	35/35	100%	3.6 J	20.6 J	03SS0700002	11.7	11.7	11.8	4.28	18.3	0.365	- -	Gamma	13.2	Approximate Gamma 95% UCL		- -
COPPER	35/35	100%	5 J	10700 J	03SS1160002	573	573	18.7	2124	4513469	3.71	Yes	Non-parametric	4146	99% Chebyshev(Mean, Std) UCL		- -
IRON	35/35	100%	10800 J	68900 J	03SS1200002	25429	25429	21800	12379	153227983	0.487	Yes	Non-parametric	28967	Student-t or Modified-t UCL		- -
LEAD	35/35	100%	9.8 J	14600 J	03SS1200002	681	681	20.4	2764	7640829	4.06	Yes	Non-parametric	5330	99% Chebyshev(Mean, Std) UCL		- -
MAGNESIUM	35/35	100%	500 J	11300 J	03SS0700002	2665	2665	1590	2483	6166870	0.932	Yes	Non-parametric	4495	95% Chebyshev(Mean, Std) UCL		- -
MANGANESE	35/35	100%	57.1 J	5390 J	03SS1160002	930	930	464	1172	1373678	1.26	Yes	Non-parametric	1793	95% Chebyshev(Mean, Std) UCL		- -
MERCURY	26/35	74%	0.012 J	5.5	03SS1200002	0.257	0.339	0.033	0.935	0.875	3.64	Yes	Non-parametric	1.83	99% Chebyshev(Mean, Std) UCL		- -
NICKEL	35/35	100%	4.8 J	67.6 J	03SS1200002	22.0	22.0	19.5	12.5	156	0.568	Yes	Gamma	25.7	Approximate Gamma 95% UCL		- -
POTASSIUM	35/35	100%	325 J	3080 J	03SS1010002	1044	1044	823	631	398552	0.604	Yes	Gamma	1226	Approximate Gamma 95% UCL		- -
SELENIUM	11/35	31%	0.27 J	0.53 J	03SS1000002	0.199	0.365	0.145	0.125	0.016	0.624	- -	Non-parametric	0.291	95% Chebyshev(Mean, Std) UCL		
SILVER	9/35	26%	0.11 J	15.7	03SS1160002	0.854	3.18	0.035	2.75	7.56	3.22	Yes	Non-parametric	5.48	99% Chebyshev(Mean, Std) UCL		- -
SODIUM	19/35	54%	52.4 J	684 J	03SS1120002	100	170	72.4	135	18171	1.35	Yes	Non-parametric	327	99% Chebyshev(Mean, Std) UCL		- -
THALLIUM	8/35	23%	0.08 J	0.12 J	03SS0780002, 03SS1030002	0.070	0.101	0.065	0.026	0.0007	0.373	- -	Gamma	0.078	Approximate Gamma 95% UCL		Max ND > Max & UCL
TIN	11/35	31%	0.44 J	44.2 J	03SS1160002	3.81	11.3	0.415	9.48	89.9	2.49	Yes	Non-parametric	19.8	99% Chebyshev(Mean, Std) UCL		
VANADIUM	35/35	100%	8.8 J	29.6 J	03SS0680002	18.0	18.0	17.6	4.75	22.6	0.264	- -	Gamma	19.5	Approximate Gamma 95% UCL		- -
ZINC	34/35	97%	15 J	11100 J	03SS1160002	703	722	53.9	2287	5228982	3.25	Yes	Non-parametric	4549	99% Chebyshev(Mean, Std) UCL		- -
Miscellaneous Parameters																	
CATION EXCHANGE CAPACITY (MEQ/1)	2/2	100%	14	19	03SS0780002	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
PERCHLORATE (µg/kg)	5/23	22%	70 J	300 J	03SS0590002, 03SS0670002, 03SS0910002	69.2	234	23.5	98.8	9762	1.43	- -	Non-parametric	159	95% Chebyshev(Mean, Std) UCL		
PERCHLORATE-8321 (µg/kg)	2/6	33%	0.53 J	0.69 J	03SS0610002	0.595	0.610	0.600	0.055	0.003	0.093	- -	Normal	0.641	Student-t		Min ND & Max ND > Max & UCL
PH (S.U.)	2/2	100%	7.6	8	03SS1160002	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)
TOTAL ORGANIC CARBON (mg/kg)	2/2	100%	1700	15000	03SS1160002	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)		NA(1)

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
B qualified data were evaluated as positive detections.
NA(1) - Not applicable, there are an insufficient number of samples to calculate statistics.
NA(7) - There are more than 50 samples, therefore, the Discordance Test could not be performed.

µg/kg - microgram per kilogram
COPC - chemical of potential concern
HMX - hexahydro-1,3,5-trinitro-1,3,5-trizine
IDEM - Indiana Department of Environmental Management
IND - industrial
mg/kg - milligram per kilogram
NA - not applicable
ng/kg - nanogram per kilogram
PRG - Preliminary Remediation Goal
RBC - Risk-Based Concentration

RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
RES - residential
RISC - Risk Integrated System of Closure
TETRYL
U.S. EPA - United States Environmental Protection Agency
UCL - upper confidence limit.

TABLE A-2
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
SUBSURFACE SOIL - AMMUNITION BURNING GROUND
SWMU 3 - CRANE

Version 1.42 Chemical	Raw Statistics: Frequency of Detection Number	Frequency of Detection Percent	Minimum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?	Data Distribution	EPA's ProUCL Recommended UCL to Use Adjusted		Reason for Adjustment	Comments
Volatile Organics (ug/kg)																	
1,1,2-TRICHLOROETHANE	3/92	3%	3 J	140 J	03SB0610206	0.895	9.67	0.580	1.84	2.06	6.53	NA(7)	Non-parametric	1.73	95% Chebyshev(Mean, Std) UCL		- -
1,2-DICHLOROETHENE	4/92	4%	2 J	3 J	03SB1090610	0.748	4.00	0.583	0.833	1.11	5.30	NA(7)	Non-parametric	0.893	Student-t or Modified-t UCL		- -
2-BUTANONE	27/47	57%	3 J	36 J	03SB1021014	5.89	9.78	5.00	7.23	1.23	2.33	Yes	Non-parametric	16.4	99% Chebyshev(Mean, Std) UCL		- -
4-METHYL-2-PENTANONE	2/82	2%	2 J	10 J	03SB1021014	0.718	6.00	0.580	0.995	1.38	8.95	NA(7)	Non-parametric	0.890	Student-t or Modified-t UCL		- -
ACETONE	58/87	67%	4 J	7200 J	03SB1021014	108	160	18.0	770	7.13	9.31	NA(7)	Non-parametric	623	97.5% Chebyshev(Mean, Std) UCL		- -
BENZENE	7/92	8%	2 J	91 J	03SB0700610	1.07	6.86	0.585	3.22	3.00	9.05	NA(7)	Non-parametric	2.54	95% Chebyshev(Mean, Std) UCL		- -
BROMOMETHANE	4/92	4%	2 J	8 J	03SB1191014	0.760	4.25	0.583	0.918	1.21	6.67	NA(7)	Non-parametric	0.919	Student-t or Modified-t UCL		- -
CARBON DISULFIDE	11/92	12%	2 J	8 J	03SB1090610	0.931	3.36	0.588	1.16	1.24	4.57	NA(7)	Non-parametric	1.46	95% Chebyshev(Mean, Std) UCL		- -
CHLOROFORM	6/92	7%	2 J	7 J	03SB0920610	0.811	3.83	0.585	0.928	1.14	4.99	NA(7)	Non-parametric	0.972	Student-t or Modified-t UCL		- -
CHLOROMETHANE	1/92	1%	4	4	03SB1191014	0.638	4.00	0.580	0.369	0.579	6.48	NA(7)	Non-parametric	0.702	Student-t or Modified-t UCL		- -
CIS-1,2-DICHLOROETHENE	16/92	17%	2 J	3100 J	03SB1030610	88.4	505	0.600	413	4.68	5.80	NA(7)	Non-parametric	517	99% Chebyshev(Mean, Std) UCL		- -
ETHYLBENZENE	6/92	7%	2 J	1200 J	03SB1030610	14.3	211	0.585	125	8.73	9.58	NA(7)	Non-parametric	45.7	97.5% Chebyshev(Mean, Std) UCL		- -
METHYLIODIDE	1/54	2%	15 J	15 J	03SB1191014	0.869	15.0	0.588	1.96	2.26	7.32	NA(7)	Non-parametric	1.32	Student-t or Modified-t UCL		- -
STYRENE	1/91	1%	33	33	03SB1020610	0.957	33.0	0.580	3.40	3.55	9.53	NA(7)	Non-parametric	1.55	Student-t or Modified-t UCL		- -
TOLUENE	11/92	12%	2 J	160	03SB1021014	3.96	28.7	0.590	19.1	4.82	7.19	NA(7)	Non-parametric	16.4	97.5% Chebyshev(Mean, Std) UCL		- -
TOTAL XYLENES	8/92	9%	2 J	2000 J	03SB1030610	23.5	264	0.588	208	8.87	9.58	NA(7)	Non-parametric	159	97.5% Chebyshev(Mean, Std) UCL		- -
TRANS-1,2-DICHLOROETHENE	10/92	11%	2 J	250 J	03SB0610610	4.42	35.7	0.593	26.5	5.99	9.02	NA(7)	Non-parametric	21.6	97.5% Chebyshev(Mean, Std) UCL		- -
TRICHLOROETHENE	15/92	16%	2 J	19000	03SB0610206	337	2065	0.598	2174	6.45	7.72	NA(7)	Non-parametric	2593	99% Chebyshev(Mean, Std) UCL		- -
TRICHLOROFLUOROMETHANE	2/82	2%	2 J	2 J	03SB0731014, 03SB0900610	0.629	2.00	0.580	0.230	0.365	4.83	NA(7)	Non-parametric	0.669	Student-t or Modified-t UCL		Max ND > Max, Min ND & Max ND > UCL
VINYL CHLORIDE	9/92	10%	2 J	20 J	03SB1011014	1.40	8.78	0.590	3.05	2.18	4.40	NA(7)	Non-parametric	2.79	95% Chebyshev(Mean, Std) UCL		- -
Energetics (mg/kg)																	
1,3,5-TRINITROBENZENE	4/183	2%	0.34 J	37.5	03/10-35-93-2	0.350	10.4	0.125	2.77	7.91	13.4	NA(7)	Non-parametric	1.24	95% Chebyshev(Mean, Std) UCL		- -
2,4,6-TRINITROTOLUENE	9/183	5%	0.02 J	2030	03/10-35-93-2	1.18	238	0.125	150	12.7	13.5	NA(7)	Non-parametric	81.1	97.5% Chebyshev(Mean, Std) UCL		- -
2,4-DINITROTOLUENE	2/183	1%	0.03 J	0.075 J	03/10-17-93-2	0.192	0.053	0.125	0.915	4.77	13.5	NA(7)	Non-parametric	0.075	Maximum Concentration	FOD	UCL > Max, Min ND & Max ND > Max, Max ND > UCL
2,6-DINITROTOLUENE	3/183	2%	0.33 J	0.41 J	03SB0821014	0.200	0.360	0.125	0.952	4.76	13.5	NA(7)	Non-parametric	0.316	Student-t or Modified-t UCL		Max ND > Max & UCL
2-AMINO-4,6-DINITROTOLUENE	4/183	2%	0.085 J	124	03/10-17-93-2	0.200	0.450	0.125	0.918	4.60	13.4	NA(7)	Non-parametric	0.312	Student-t or Modified-t UCL		Max ND > Max & UCL
4-AMINO-2,6-DINITROTOLUENE	6/183	3%	0.02 J	2.16	03/10-17-93-2	0.203	0.448	0.125	0.926	4.56	13.0	NA(7)	Non-parametric	0.316	Student-t or Modified-t UCL		Max ND > Max & UCL
HMX	30/183	16%	0.08 J	232	03/10-35-93-2	2.07	11.4	0.125	12.7	6.56	12.3	NA(7)	Non-parametric	10.2	97.5% Chebyshev(Mean, Std) UCL		- -
RDX	12/183	7%	0.265	274	03/10-17-93-2	2.10	29.6	0.125	20.7	9.86	12.7	NA(7)	Non-parametric	8.77	95% Chebyshev(Mean, Std) UCL		- -
Inorganics (mg/kg)																	
ALUMINUM	82/82	100%	20.4 J	47200 J	03SB0601014	9215	9215	7640	6970	0.756	3.35	NA(7)	Non-parametric	12570	95% Chebyshev(Mean, Std) UCL		- -
ANTIMONY	42/82	51%	0.27 J	32.6 J	03SB1000610	0.952	1.68	0.330	3.62	3.81	8.45	NA(7)	Non-parametric	3.45	97.5% Chebyshev(Mean, Std) UCL		- -
ARSENIC	81/82	99%	1.3 J	22 J	03SB0681014	8.59	8.69	7.65	4.45	0.518	0.908	NA(7)	Non-parametric	10.7	95% Chebyshev(Mean, Std) UCL		- -
BARIUM	81/82	99%	18.3 J	595 J	03SB1000610	122	124	87.0	105	0.860	2.43	NA(7)	Non-parametric	173	95% Chebyshev(Mean, Std) UCL		- -
BERYLLIUM	70/82	85%	0.23 J	2.3 J	03SB0820206	0.954	1.07	0.940	0.465	0.487	0.335	NA(7)	Normal	1.04	Student-t		- -
CADMIUM	33/82	40%	0.18 J	3.5	03SB1000610	0.375	0.711	0.205	0.549	1.46	4.39	NA(7)	Non-parametric	0.640	95% Chebyshev(Mean, Std) UCL		- -
CALCIUM	80/82	98%	81.2 J	129000 J	03SB0701014	8625	8835	3155	18040	2.09	4.90	NA(7)	Lognormal	17985	H-UCL		- -
CHROMIUM	81/82	99%	6.7 J	65.3 J	03SB1000610	19.5	19.7	16.4	10.5	0.537	1.57	NA(7)	Non-parametric	24.5	95% Chebyshev(Mean, Std) UCL		- -
COBALT	81/82	99%	0.2 J	39.9 J	03SB0660610	14.6	14.8	14.4	5.98	0.408	0.745	NA(7)	Normal	15.7	Student-t		- -
COPPER	81/82	99%	3.9 J	508 J	03SB1000610	24.0	24.3	12.3	58.9	2.46	7.24	NA(7)	Non-parametric	52.4	95% Chebyshev(Mean, Std) UCL		- -
IRON	81/82	99%	7170 J	86000 J	03SB1211014	32666	33069	27250	18076	0.553	0.904	NA(7)	Non-parametric	41367	95% Chebyshev(Mean, Std) UCL		- -
LEAD	81/82	99%	7.6 J	524 J	03SB1000610	28.1	28.4	18.8	57.0	2.03	8.33	NA(7)	Non-parametric	55.5	95% Chebyshev(Mean, Std) UCL		- -
MAGNESIUM	81/82	99%	334 J	23900 J	03SB0700206	1939	1963	1080	2868	1.48	5.89	NA(7)	Non-parametric	3917	97.5% Chebyshev(Mean, Std) UCL		- -
MANGANESE	81/82	99%	46.4 J	7380	03SB1000610	936	948	716	1049	1.12	3.78	NA(7)	Non-parametric	1659	97.5% Chebyshev(Mean, Std) UCL		- -
MERCURY	45/82	55%	0.008 J	1.5 J	03SB0600206	0.054	0.086	0.022	0.180	3.33	7.16	NA(7)	Non-parametric	0.141	95% Chebyshev(Mean, Std) UCL		- -
NICKEL	82/82	100%	0.25 J	48.4 J	03SB0681014	24.1	24.1	21.5	11.4	0.471	0.341	NA(7)	Non-parametric	29.6	95% Chebyshev(Mean, Std) UCL		- -
POTASSIUM	81/82	99%	312 J	8980 J	03SB0601014	1267	1283	771	1412	1.11	3.28	NA(7)	Non-parametric	2240	97.5% Chebyshev(Mean, Std) UCL		- -
SELENIUM	18/82	22%	0.25 J	0.56 J	03SB0740610	0.164	0.364	0.120	0.133	0.808	1.27	NA(7)	Lognormal	0.203	H-UCL		Max ND > Max & UCL
SILVER	4/82	5%	0.05 J	16.2	03SB1000610	0.245	4.38	0.024	1.85	7.57	9.04	NA(7)	Non-parametric	1.14	95% Chebyshev(Mean, Std) UCL		- -
SODIUM	40/82	49%	44.8 J	520 J	03SB1000610	67.4	122	28.8	88.0	1.30	2.94	NA(7)	Non-parametric	128	97.5% Chebyshev(Mean, Std) UCL		- -
THALLIUM	15/82	18%	0.08 J	0.14 J	03SB0940610	0.066	0.101	0.058	0.029	0.447	0.741	NA(7)	Lognormal	0.071	Student's-t, modified-t or H-UCL		Max ND > Max & UCL
TIN	22/82	27%	0.26 J	58.6 J	03SB1211014	1.70	6.31	0.358	7.82	4.60	6.53	NA(7)	Non-parametric	5.47	95% Chebyshev(Mean, Std) UCL		- -
VANADIUM	82/82	100%	0.21 J	39.5 J	03SB1101014	18.6	18.6	17.8	8.39	0.451	0.505	NA(7)	Normal	20.1	Student-t		- -
ZINC	81/82	99%	13.4 J	1430 J	03SB1000610	88.0	89.0	51.2	169	1.92	6.55	NA(7)	Non-parametric	169	95% Chebyshev(Mean, Std) UCL		- -
Miscellaneous Parameters																	
BULK DENSITY (G/CM3)	4/4	100%	1.57	1.81	03ST0990204	1.69	1.69	1.69	0.106	0.063	5.03	- -	Normal	1.81	Maximum Concentration	N < 10	UCL > Max
CATION EXCHANGE CAPACITY (MEQ/1)	4/4	100%	10	31	03SB0780206	19.5	19.5	18.5	10.6	0.544	0.181	- -	Normal	31	Maximum Concentration	N < 10	UCL > Max
PERCHLORATE (ug/kg)	9/51	18%	50 J	800	03SB0670610	64.0	252	24.0	132	2.07	4.30	NA(7)	Non-parametric	145	95% Chebyshev(Mean, Std) UCL		- -
PERCHLORATE-8321 (ug/kg)	2/13	15%	3	91	03SB0890206	1.43	6.00	0.600	2.37	1.56	3.19	Yes	Non-parametric	4.30	95% Chebyshev(Mean, Std) UCL		- -
PH (S.U.)	4/4	100%	7.6	8	03SB1160610	7.75	7.75	7.70	0.173	0.022	1.54	- -	Normal	7.95	Student-t		- -
POROSITY (%)	4/4	100%	31.9	40.1	03ST0770608	36.1	36.1	36.2	3.60	0.100	-0.123	- -	Normal	40.1	Maximum Concentration	N < 10	UCL > Max
SPECIFIC GRAVITY (S.U.)	4/4	100%	2.63	2.66	03ST0990204	2.64	2.64	2.64	0.015	0.006	0.370	- -	Normal	2.66	Maximum Concentration	N < 10	UCL > Max
TOTAL ORGANIC CARBON (mg/kg)	4/4	100%	3700	9300	03SB0780610	5850	5850	5200	2541	0.434	1.08	- -	Normal	8840	Student-t		- -

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
B qualified data were evaluated as positive detections.
NA(7) - There are more than 50 samples, therefore, the Discordance Test could not be performed.

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: INDUSTRIAL WORKERS
MEDIA: SURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

RELEVANT EQUATION:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

WHERE:

Cs = :		Concentration in soil (mg/kg)
TCR = :	1.0E-06	Target Cancer Risk
THI = :	1	Target Hazard Index
IR = :	100	Soil Ingestion Rate (mg/day)
CF = :	1.0E-06	Conversion Factor (kg/mg)
FI = :	1	Fraction from contaminated source (unitless)
SA = :	3300	Skin surface available for contact (cm^2/event)
AF = :	0.2	Soil to skin adherence factor (mg/cm^2)
ABS = :	Chemical Specific	Absorption factor (unitless)
InR = :	2.5	Inhalation rate (m^3/hr)
ET = :	8	Exposure time (hr/day)
EF = :	250	Exposure Frequency (days/year)
ED = :	25	Exposure Duration (years)
BW = :	70	Body Weight (kg)
ATc = :	25,550	Averaging time for carcinogenic exposures (days)
ATn = :	9,125	Averaging time for noncarcinogenic exposures (days)
PEF = :	1.32E+09	Particulate emission factor (m^3/kg)
VF = :	Chemical Specific	Volatilization Factor (m^3/kg)

CHEMICAL	ABS	Cancer Slope Factor			Reference Dose			Source:
		Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Inhalation $(mg/kg/day)^{-1}$	Oral (mg/kg/day)	Dermal (mg/kg/day)	Inhalation (mg/kg/day)	
Trichloroethene	0	1.3E-02	1.3E-02	7.0E-03	5.0E-01	5.0E-01	1.7E-01	Cal-EPA
2,4,6-Trinitrotoluene	0.032	3.0E-02	3.0E-02	NA	5.0E-04	5.0E-04	NA	IRIS
Aminodinitrotoluenes	0.009	NA	NA	NA	2.0E-03	2.0E-03	NA	IRIS
RDX	0.015	1.1E-01	1.1E-01	NA	3.0E-03	3.0E-03	NA	IRIS
HMX	0.006	NA	NA	NA	5.0E-02	5.0E-02	NA	IRIS
Aluminum	0	NA	NA	NA	1.0E+00	1.0E+00	1.4E-03	NCEA
Antimony	0	NA	NA	NA	4.0E-04	6.0E-05	NA	IRIS
Arsenic	0.03	1.5E+00	1.5E+00	1.5E+01	3.0E-04	3.0E-04	NA	IRIS
Barium	0	NA	NA	NA	2.0E-01	1.4E-02	1.4E-04	IRIS/NCEA
Chromium	0	NA	NA	4.1E+01	3.0E-03	7.5E-05	2.9E-05	IRIS
Cadmium	0.001	NA	NA	6.3E+00	5.0E-04	2.5E-05	5.7E-05	IRIS
Copper	0	NA	NA	NA	4.0E-02	4.0E-02	NA	HEAST
Iron	0	NA	NA	NA	3.0E-01	3.0E-01	NA	NCEA
Lead	0	NA	NA	NA	NA	NA	NA	--
Manganese	0	NA	NA	NA	7.2E-02	2.9E-03	1.4E-05	IRIS
Mercury	0	NA	NA	NA	3.0E-04	2.1E-05	NA	IRIS
Vanadium	0	NA	NA	NA	1.0E-03	2.6E-05	NA	NCEA
Zinc	0	NA	NA	NA	3.0E-01	3.0E-01	NA	IRIS

1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Cancer slope factors and reference doses were obtained from the following sources:
CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
IRIS = Integrated Risk Information System. http://www.epa.gov/iris/
HEAST= Health Effects Assessment Summary Tables, USEPA, July 1997.
NCEA - National Center for Environmental Assessment - Provisional Peer Reviewed Toxicity Values (PPRTVs).

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: INDUSTRIAL WORKERS
MEDIA: SURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

CHEMICAL	Carcinogenic Intakes			Noncarcinogenic Intakes		
	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)
Trichloroethene	3.49E-07	0.00E+00	2.17E-05	9.78E-07	0.00E+00	6.08E-05
2,4,6-Trinitrotoluene	3.49E-07	7.38E-08	5.31E-11	9.78E-07	2.07E-07	1.49E-10
Aminodinitrotoluenes	3.49E-07	2.08E-08	5.31E-11	9.78E-07	5.81E-08	1.49E-10
RDX	3.49E-07	3.46E-08	5.31E-11	9.78E-07	9.69E-08	1.49E-10
HMX	3.49E-07	1.38E-08	5.31E-11	9.78E-07	3.87E-08	1.49E-10
Aluminum	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Antimony	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Arsenic	3.49E-07	6.92E-08	5.31E-11	9.78E-07	1.94E-07	1.49E-10
Barium	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Chromium	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Cadmium	3.49E-07	2.31E-09	5.31E-11	9.78E-07	6.46E-09	1.49E-10
Copper	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Iron	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Lead	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Manganese	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Mercury	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Vanadium	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10
Zinc	3.49E-07	0.00E+00	5.31E-11	9.78E-07	0.00E+00	1.49E-10

CHEMICAL	Soil Concentration		Risk-Based(1)
	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)	Cleanup Level (mg/kg)
Trichloroethene	6.38	2779	6.38
2,4,6-Trinitrotoluene	78.8	422	78.8
Aminodinitrotoluenes	NA	1929	1929
RDX	23.7	2790	23.7
HMX	NA	49154	49154
Aluminum	NA	921922	921922
Antimony	NA	409	409
Arsenic	1.59	256	1.59
Barium	NA	167939	167939
Chromium	459	3019	459
Cadmium	2989	451	451
Copper	NA	40880	40880
Iron	NA	306600	306600
Lead	NA	NA	NA
Manganese	NA	41302	41302
Mercury	NA	307	307
Vanadium	NA	1022	1022
Zinc	NA	306600	306600

Notes:
(1) - Risked-based cleanup level is the lower of the carcinogenic soil concentration and noncarcinogenic soil concentration.

CALCULATION OF AMBIENT AIR CONCENTRATION
SOURCE: U.S. EPA SOIL SCREENING GUIDANCE

Purpose: To calculate ambient air concentrations resulting from fugitive dust and volatilization from soil.

Relevant Equations:

$$Cair = Cs \times (1/PEF + 1/VF)$$

$$PEF = \frac{3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

$$VF = \frac{Q/C \times (3.14 \times DA \times T)^{1/2} \times 10^{-4}\ m^2/cm^2}{2 \times pb \times DA}$$

$$DA = \frac{[(\theta a^{10/3} \times Di \times H + \theta w^{10/3} \times Dw)/n^2)]}{pb \times Kd + \theta w + \theta a \times H}$$

$$Csat = S/pb \times (Kd \times pb + \theta w + H \times \theta a)$$

INPUT PARAMTERS		
Parameter	**Value**	**Definition**
Q/C = :	68.81	Inverse of mean conc. at center of source (g/m^2-s per kg/m^3).
T = :	9.5E+08	Exposure interval (seconds).
pb = :	1.5	Dry soil bulk density (g/cm^3).
ps = :	2.65	soil particle density (g/cm^3).
n = :	0.434	Total soil porosity (L_{pore}/L_{soil}).
θw = :	0.15	Water-filled soil porosity (L_{pore}/L_{soil}).
θa = :	0.284	Air-filled soil porosity (L_{air}/L_{soil}).
Di = :	Chemical specific	Diffusivity in air (cm^2/sec).
H' = :	Chemical specific	Dimensionless Henry's Law Constant.
Dw = :	Chemical specific	Diffusivity in water (cm^2/sec).
DA = :	Chemical specific	Apparent diffusivity (cm^2/sec).
Kd = :	Chemical specific	Soil-water partition coefficient (cm^3/g).
Koc = :	Chemical specific	Soil organic carbon partition coefficient (cm^3/g).
foc = :	0.006	Fraction organic carbon in soil (g/g).

Chemical	Volatile	Chemical Properties					Intermediate Calculations			
		Koc (cm^3/g)	Di (cm^2/sec)	Dw (cm^2/sec)	S (mg/L)	H'	Kd (cm^3/g)	Da (cm^2/sec)	VF (m^3/kg)	Csat (mg/kg)
Surface Soil										
Trichloroethene	Y	1.66E+02	7.90E-02	9.10E-06	1.10E+03	4.22E-01	9.96E-01	1.51E-03	3.22E+03	1.29E+03
2,4,6-Trinitrotoluene	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aminodinitrotoluenes	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
RDX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
HMX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aluminum	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Antimony	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Arsenic	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Barium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Chromium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Cadmium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Copper	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Iron	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Lead	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Manganese	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Mercury	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Vanadium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Zinc	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: CONSTRUCTION WORKERS
MEDIA: SURFACE/SUBSURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

RELEVANT EQUATION:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

WHERE:

Cs = :		Concentration in soil (mg/kg)
TCR = :	1.0E-06	Target Cancer Risk
THI = :	1	Target Hazard Index
IR = :	330	Soil Ingestion Rate (mg/day)
CF = :	1.0E-06	Conversion Factor (kg/mg)
FI = :	1	Fraction from contaminated source (unitless)
SA = :	3300	Skin surface available for contact (cm^2/event)
AF = :	0.3	Soil to skin adherence factor (mg/cm^2)
ABS = :	Chemical Specific	Absorption factor (unitless)
InR = :	2.5	Inhalation rate (m^3/hr)
ET = :	8	Exposure time (hr/day)
EF = :	150	Exposure Frequency (days/year)
ED = :	1	Exposure Duration (years)
BW = :	70	Body Weight (kg)
ATc = :	25,550	Averaging time for carcinogenic exposures (days)
ATn = :	365	Averaging time for noncarcinogenic exposures (days)
PEF = :	1.49E+06	Particulate emission factor (m^3/kg)
VF = :	Chemical Specific	Volatilization Factor (m^3/kg)

CHEMICAL	ABS[1]	Cancer Slope Factor[2]			Reference Dose[2]			Source:
		Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Inhalation $(mg/kg/day)^{-1}$	Oral (mg/kg/day)	Dermal (mg/kg/day)	Inhalation (mg/kg/day)	
Trichloroethene	0	1.3E-02	1.3E-02	7.0E-03	5.0E-01	5.0E-01	1.7E-01	Cal-EPA
2,4,6-Trinitrotoluene	0.032	3.0E-02	3.0E-02	NA	5.0E-04	5.0E-04	NA	IRIS
Aminodinitrotoluenes	0.009	NA	NA	NA	2.0E-03	2.0E-03	NA	IRIS
RDX	0.015	1.1E-01	1.1E-01	NA	3.0E-03	3.0E-03	NA	IRIS
HMX	0.006	NA	NA	NA	5.0E-02	5.0E-02	NA	IRIS
Aluminum	0	NA	NA	NA	1.0E+00	1.0E+00	1.4E-03	NCEA
Antimony	0	NA	NA	NA	4.0E-04	6.0E-05	NA	IRIS
Arsenic	0.03	1.5E+00	1.5E+00	1.5E+01	3.0E-04	3.0E-04	NA	IRIS
Barium	0	NA	NA	NA	2.0E-01	1.4E-02	1.4E-04	IRIS/NCEA
Chromium	0	NA	NA	4.1E+01	3.0E-03	7.5E-05	2.9E-05	IRIS
Cadmium	0.001	NA	NA	6.3E+00	5.0E-04	2.5E-05	5.7E-05	IRIS
Copper	0	NA	NA	NA	4.0E-02	4.0E-02	NA	HEAST
Iron	0	NA	NA	NA	3.0E-01	3.0E-01	NA	NCEA
Lead	0	NA	NA	NA	NA	NA	NA	–
Manganese	0	NA	NA	NA	7.2E-02	2.9E-03	1.4E-05	IRIS
Mercury	0	NA	NA	NA	3.0E-04	2.1E-05	NA	IRIS
Vanadium	0	NA	NA	NA	1.0E-03	2.6E-05	NA	NCEA
Zinc	0	NA	NA	NA	3.0E-01	3.0E-01	NA	IRIS

1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Cancer slope factors and reference doses were obtained from the following sources:
CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
IRIS = Integrated Risk Information System. http://www.epa.gov/iris/
HEAST= Health Effects Assessment Summary Tables, USEPA, July 1997.
NCEA - National Center for Environmental Assessment - Provisional Peer Reviewed Toxicity Values (PPRTVs).

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: CONSTRUCTION WORKERS
MEDIA: SURFACE/SUBSURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

CHEMICAL	Carcinogenic Intakes			Noncarcinogenic Intakes		
	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)
Trichloroethene	2.77E-08	0.00E+00	2.54E-06	1.94E-06	0.00E+00	1.78E-04
2,4,6-Trinitrotoluene	2.77E-08	2.66E-09	1.13E-09	1.94E-06	1.86E-07	7.88E-08
Aminodinitrotoluenes	2.77E-08	7.47E-10	1.13E-09	1.94E-06	5.23E-08	7.88E-08
RDX	2.77E-08	1.25E-09	1.13E-09	1.94E-06	8.72E-08	7.88E-08
HMX	2.77E-08	4.98E-10	1.13E-09	1.94E-06	3.49E-08	7.88E-08
Aluminum	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Antimony	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Arsenic	2.77E-08	2.49E-09	1.13E-09	1.94E-06	1.74E-07	7.88E-08
Barium	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Chromium	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Cadmium	2.77E-08	8.30E-11	1.13E-09	1.94E-06	5.81E-09	7.88E-08
Copper	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Iron	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Lead	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Manganese	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Mercury	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Vanadium	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08
Zinc	2.77E-08	0.00E+00	1.13E-09	1.94E-06	0.00E+00	7.88E-08

CHEMICAL	Soil Concentration		Risk-Based[1] Cleanup Level (mg/kg)
	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)	
Trichloroethene	55	952	55.1
2,4,6-Trinitrotoluene	1099	235	235
Aminodinitrotoluenes	NA	1005	1005
RDX	314	1482	314
HMX	NA	25352	25352
Aluminum	NA	17175	17175
Antimony	NA	206	206
Arsenic	16.1	142	16.1
Barium	NA	1747	1747
Chromium	21.7	297	21.7
Cadmium	141	182	141
Copper	NA	20646	20646
Iron	NA	154848	154848
Lead	NA	NA	NA
Manganese	NA	177	177
Mercury	NA	155	155
Vanadium	NA	516	516
Zinc	NA	154848	154848

Notes:
(1) - Risked-based cleanup level is the lower of the carcinogenic soil concentration and noncarcinogenic soil concentration.

CALCULATION OF AMBIENT AIR CONCENTRATION
SOURCE: U.S. EPA SOIL SCREENING GUIDANCE

Purpose: To calculate ambient air concentrations resulting from fugitive dust and volatilization from soil.

Relevant Equations:

$$Cair = Cs \times (1/PEF + 1/VF)$$

$$VF = \frac{1/F_D \times Q/C \times (3.14 \times DA \times T)^{1/2} \times 10^{-4}\ m^2/cm^2}{2 \times pb \times DA}$$

$$DA = \frac{[(\theta a^{10/3} \times Di \times H + \theta w^{10/3} \times Dw)/n^2)]}{pb \times Kd + \theta w + \theta a \times H}$$

$$Csat = S/pb \times (Kd \times pb + \theta w + H \times \theta a)$$

INPUT PARAMTERS		
Parameter	**Value**	**Definition**
Q/C = :	14.31	Inverse of mean conc. at center of source (g/m^2-s per kg/m^3).
T = :	3.2E+07	Exposure interval (seconds).
pb = :	1.5	Dry soil bulk density (g/cm^3).
ps = :	2.65	soil particle density (g/cm^3).
n = :	0.434	Total soil porosity (L_{pore}/L_{soil}).
θw = :	0.15	Water-filled soil porosity (L_{pore}/L_{soil}).
θa = :	0.284	Air-filled soil porosity (L_{air}/L_{soil}).
Di = :	Chemical specific	Diffusivity in air (cm^2/sec).
H' = :	Chemical specific	Dimensionless Henry's Law Constant.
Dw = :	Chemical specific	Diffusivity in water (cm^2/sec).
DA = :	Chemical specific	Apparent diffusivity (cm^2/sec).
Kd = :	Chemical specific	Soil-water partition coefficient (cm^3/g).
Koc = :	Chemical specific	Soil organic carbon partition coefficient (cm^3/g).
foc = :	0.006	Fraction organic carbon in soil (g/g).
F_D = :	0.185	dispersion correction factor

Chemical	Volatile	Chemical Properties					Intermediate Calculations			
		Koc (cm^3/g)	Di (cm^2/sec)	Dw (cm^2/sec)	S (mg/L)	H'	Kd (cm^3/g)	Da (cm^2/sec)	VF (m^3/kg)	Csat (mg/kg)
Surface Soil										
Trichloroethene	Y	1.66E+02	7.90E-02	9.10E-06	1.10E+03	4.22E-01	9.96E-01	1.51E-03	6.60E+02	1.29E+03
2,4,6-Trinitrotoluene	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aminodinitrotoluenes	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
RDX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
HMX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aluminum	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Antimony	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Arsenic	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Barium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Chromium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Cadmium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Copper	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Iron	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Lead	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Manganese	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Mercury	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Vanadium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Zinc	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: ADOLESCENT TRESPASSERS
MEDIA: SURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

RELEVANT EQUATION:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

Where:

Cs = :		Concentration in soil (mg/kg)
TCR = :	1.0E-06	Target Cancer Risk
THI = :	1	Target Hazard Index
IR = :	100	Soil Ingestion Rate (mg/day) (USEPA, 1993)
CF = :	1.0E-06	Conversion Factor (kg/mg)
FI = :	1	Fraction from contaminated source (unitless)
SA = :	3280	Skin surface available for contact (cm^2/event) (1)
AF = :	0.2	Soil to skin adherence factor (mg/cm^2) (USEPA, 2004)
ABS = :	Chemical Specific	Absorption factor (unitless)
InR = :	1.2	Inhalation rate (m^3/hr) (USEPA, 1997)
ET = :	4	Exposure time (hr/day)
EF = :	26	Exposure Frequency (days/year)
ED = :	11	Exposure Duration (years)
BW = :	43	Body Weight (kg) (USEPA, 1997)
ATc = :	25,550	Averaging time for carcinogenic exposures (days)
ATn = :	4,015	Averaging time for noncarcinogenic exposures (days)
PEF = :	1.32E+09	Particulate emission factor (m^3/kg)
VF = :	Chemical Specific	Volatilization Factor (m^3/kg)

1 - Assumes that the lower arms, hands, lower legs, and feet are exposed. (Values based on Exposure Factors Handbook 1997.)
USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
USEPA, 1997: Exposure Factors Handbook. U.S. EPA/600/8-95/002FA.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

CHEMICAL	ABS	Cancer Slope Factor			Reference Dose			Source:
		Oral $(mg/kg/day)^{-1}$	Dermal $(mg/kg/day)^{-1}$	Inhalation $(mg/kg/day)^{-1}$	Oral (mg/kg/day)	Dermal (mg/kg/day)	Inhalation (mg/kg/day)	
Trichloroethene	0	1.3E-02	1.3E-02	7.0E-03	5.0E-01	5.0E-01	1.7E-01	Cal-EPA
2,4,6-Trinitrotoluene	0.032	3.0E-02	3.0E-02	NA	5.0E-04	5.0E-04	NA	IRIS
Aminodinitrotoluenes	0.009	NA	NA	NA	2.0E-03	2.0E-03	NA	IRIS
RDX	0.015	1.1E-01	1.1E-01	NA	3.0E-03	3.0E-03	NA	IRIS
HMX	0.006	NA	NA	NA	5.0E-02	5.0E-02	NA	IRIS
Aluminum	0	NA	NA	NA	1.0E+00	1.0E+00	1.4E-03	NCEA
Antimony	0	NA	NA	NA	4.0E-04	6.0E-05	NA	IRIS
Arsenic	0.03	1.5E+00	1.5E+00	1.5E+01	3.0E-04	3.0E-04	NA	IRIS
Barium	0	NA	NA	NA	2.0E-01	1.4E-02	1.4E-04	IRIS/NCEA
Chromium	0	NA	NA	4.1E+01	3.0E-03	7.5E-05	2.9E-05	IRIS
Cadmium	0.001	NA	NA	6.3E+00	5.0E-04	2.5E-05	5.7E-05	IRIS
Copper	0	NA	NA	NA	4.0E-02	4.0E-02	NA	HEAST
Iron	0	NA	NA	NA	3.0E-01	3.0E-01	NA	NCEA
Lead	0	NA	NA	NA	NA	NA	NA	--
Manganese	0	NA	NA	NA	7.2E-02	2.9E-03	1.4E-05	IRIS
Mercury	0	NA	NA	NA	3.0E-04	2.1E-05	NA	IRIS
Vanadium	0	NA	NA	NA	1.0E-03	2.6E-05	NA	NCEA
Zinc	0	NA	NA	NA	3.0E-01	3.0E-01	NA	IRIS

1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Cancer slope factors and reference doses were obtained from the following sources:
CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
IRIS = Integrated Risk Information System. http://www.epa.gov/iris/
HEAST= Health Effects Assessment Summary Tables, USEPA, July 1997.
NCEA - National Center for Environmental Assessment - Provisional Peer Reviewed Toxicity Values (PPRTVs).

CALCULATION OF RISK-BASED PRELIMINARY CLEANUP LEVELS

SITE NAME: NSWC CRANE, CRANE INDIANA
EXPOSURE SCENARIO: ADOLESCENT TRESPASSERS
MEDIA: SURFACE SOIL
DATE: AUGUST 17, 2005

THIS SPREADSHEET CALCULATES RISK-BASED CLEANUP GOALS FOR EXPOSURES TO SOIL THROUGH INCIDENTAL INGESTION, DERMAL CONTACT, AND INHALATION ARE CONSIDERED.

CHEMICAL	Carcinogenic Intakes			Noncarcinogenic Intakes		
	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)	Oral (kg/kg/day)	Dermal (kg/kg/day)	Inhalation (kg/kg/day)
Trichloroethene	2.60E-08	0.00E+00	3.88E-07	1.66E-07	0.00E+00	2.47E-06
2,4,6-Trinitrotoluene	2.60E-08	5.46E-09	9.49E-13	1.66E-07	3.48E-08	6.04E-12
Aminodinitrotoluenes	2.60E-08	1.54E-09	9.49E-13	1.66E-07	9.78E-09	6.04E-12
RDX	2.60E-08	2.56E-09	9.49E-13	1.66E-07	1.63E-08	6.04E-12
HMX	2.60E-08	1.02E-09	9.49E-13	1.66E-07	6.52E-09	6.04E-12
Aluminum	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Antimony	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Arsenic	2.60E-08	5.12E-09	9.49E-13	1.66E-07	3.26E-08	6.04E-12
Barium	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Chromium	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Cadmium	2.60E-08	1.71E-10	9.49E-13	1.66E-07	1.09E-09	6.04E-12
Copper	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Iron	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Lead	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Manganese	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Mercury	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Vanadium	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12
Zinc	2.60E-08	0.00E+00	9.49E-13	1.66E-07	0.00E+00	6.04E-12

CHEMICAL	Soil Concentration		Risk-Based(1) Cleanup Level (mg/kg)
	Carcinogenic (mg/kg)	Noncarcinogenic (mg/kg)	
Trichloroethene	327	67237	327
2,4,6-Trinitrotoluene	1058	2495	1058
Aminodinitrotoluenes	NA	11400	11400
RDX	318	16487	318
HMX	NA	290397	290397
Aluminum	NA	5883262	5883262
Antimony	NA	2415	2415
Arsenic	21.4	1513	21.4
Barium	NA	1147515	1147515
Chromium	25688	18042	18042
Cadmium	167173	2667	2667
Copper	NA	241462	241462
Iron	NA	1810962	1810962
Lead	NA	NA	NA
Manganese	NA	365980	365980
Mercury	NA	1811	1811
Vanadium	NA	6037	6037
Zinc	NA	1810962	1810962

Notes:
(1) - Risked-based cleanup level is the lower of the carcinogenic soil concentration and noncarcinogenic soil concentration.

CALCULATION OF AMBIENT AIR CONCENTRATION
SOURCE: U.S. EPA SOIL SCREENING GUIDANCE

Purpose: To calculate ambient air concentrations resulting from fugitive dust and volatilization from soil.

Relevant Equations:

$$Cair = Cs \times (1/PEF + 1/VF)$$

$$PEF = \frac{3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

$$VF = \frac{Q/C \times (3.14 \times DA \times T)^{1/2} \times 10^{-4}\ m^2/cm^2}{2 \times pb \times DA}$$

$$DA = \frac{[(\theta a^{10/3} \times Di \times H + \theta w^{10/3} \times Dw)/n^2)]}{pb \times Kd + \theta w + \theta a \times H}$$

$$Csat = S/pb \times (Kd \times pb + \theta w + H \times \theta a)$$

INPUT PARAMTERS		
Parameter	**Value**	**Definition**
Q/C = :	68.81	Inverse of mean conc. at center of source (g/m^2-s per kg/m^3).
T = :	9.5E+08	Exposure interval (seconds).
pb = :	1.5	Dry soil bulk density (g/cm^3).
ps = :	2.65	soil particle density (g/cm^3).
n = :	0.434	Total soil porosity (L_{pore}/L_{soil}).
θw = :	0.15	Water-filled soil porosity (L_{pore}/L_{soil}).
θa = :	0.284	Air-filled soil porosity (L_{air}/L_{soil}).
Di = :	Chemical specific	Diffusivity in air (cm^2/sec).
H' = :	Chemical specific	Dimensionless Henry's Law Constant.
Dw = :	Chemical specific	Diffusivity in water (cm^2/sec).
DA = :	Chemical specific	Apparent diffusivity (cm^2/sec).
Kd = :	Chemical specific	Soil-water partition coefficient (cm^3/g).
Koc = :	Chemical specific	Soil organic carbon partition coefficient (cm^3/g).
foc = :	0.006	Fraction organic carbon in soil (g/g).

Chemical	Volatile	Chemical Properties					Intermediate Calculations			
		Koc (cm^3/g)	Di (cm^2/sec)	Dw (cm^2/sec)	S (mg/L)	H'	Kd (cm^3/g)	Da (cm^2/sec)	VF (m^3/kg)	Csat (mg/kg)
Surface Soil										
Trichloroethene	Y	1.66E+02	7.90E-02	9.10E-06	1.10E+03	4.22E-01	9.96E-01	1.51E-03	3.22E+03	1.29E+03
2,4,6-Trinitrotoluene	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aminodinitrotoluenes	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
RDX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
HMX	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Aluminum	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Antimony	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Arsenic	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Barium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Chromium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Cadmium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Copper	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Iron	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Lead	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Manganese	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Mercury	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Vanadium	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA
Zinc	N	NA	NA	NA	NA	NA	NA	NA	1.00E+99	NA

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR A CONSTRUCTION WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Schlber	DATE: 09/13/2005

PURPOSE: This spreadsheet calculates risk-based cleanup goals for exposures to soil. Exposures through incidental ingestion, dermal contact, and inhalation are considered.

RELEVANT EQUATIONS:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR A CONSTRUCTION WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY:	DATE: 09/13/2005

INPUT ASSUMPTIONS:

	Parameter	Value	Definition
General	PRGsoil = :		Screening level in soil (mg/kg)
	TCR = :	1.0E-06	Target Cancer Risk
	THI = :	1	Target Hazard Index
	CF = :	1.0E-06	Conversion Factor (kg/mg)
	EF = :	150	Exposure Frequency (days/year)
	ED = :	1	Exposure Duration (years)
	BW = :	70	Body Weight (kg)
	ATc = :	25,550	Averaging time for carcinogenic exposures (days)
	ATn = :	365	Averaging time for noncarcinogenic exposures (days)
Incidental Ingestion	IR = :	330	Soil Ingestion Rate (mg/day)
	FI = :	1	Fraction from contaminated source (unitless)
Dermal Contact	SA = :	3300	Skin surface available for contact (cm^2/event)
	AF = :	0.3	Soil to skin adherence factor (mg/cm^2)
	ABS = :	0	Absorption factor (unitless) Chemical Specific
Inhalation	InR = :	2.5	Inhalation rate (m^3/hr)
	ET = :	8	Exposure time (hr/day)
	PEF = :	1.32E+09	Particulate emission factor (m^3/kg)
	VF = :	6.6E+02	Volatilization Factor (m^3/kg)
Toxicity Values	CSForal = :	1.3E-02	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDoral = :	5.0E-01	oral noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFderm = :	1.3E-02	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDderm = :	5.0E-01	dermal noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFinh = :	7.0E-03	inhalation carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDinh = :	1.7E-01	inhalation noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR A CONSTRUCTION WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Schlox	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - CARCINOGENS

$$Intake_{oral} = \frac{330\ mg/day \times 150\ days/year \times 1\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 25550\ days}$$

$Intake_{oral}$ = 2.77E-08 kg/kg-day

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - NONCARCINOGENS

$$Intake_{oral} = \frac{330\ mg/day \times 150\ days/year \times 1\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 365\ days}$$

$Intake_{oral}$ = 1.94E-06 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - CARCINOGENS

$$Intake_{derm} = \frac{3300\ cm2/event \times 0.3\ mg/cm2 \times 0 \times 150\ events/year \times 1\ years \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 25550\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - NONCARCINOGENS

$$Intake_{derm} = \frac{3300\ cm2/event \times 0.3\ mg/cm2 \times 0 \times 150\ events/year \times 1\ years \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 365\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR A CONSTRUCTION WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Sellock	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INHALATION - CARCINOGENS

$$Intake_{inh} = \frac{2.5\ m3/hr \times 150\ days/year \times 1\ years \times 8\ hr/day \times (1/6.6E{+}02\ m3/kg + 1/1.3E{+}09\ m3/kg)}{70\ kg \times 25550\ days}$$

$Intake_{inh}$ = 2.54E-06 kg/kg-day

EXAMPLE CALCULATION FOR INHALATION - NONCARCINOGENS

$$Intake_{inh} = \frac{2.5\ m3/hr \times 150\ days/year \times 1\ years \times 8\ hr/day \times (1/6.6E{+}02\ m3/kg + 1/1.3E{+}09\ m3/kg)}{70\ kg \times 365\ days}$$

$Intake_{inh}$ = 1.78E-04 kg/kg-day

EXAMPLE CALCULATION OF PRGsoil - CARCINOGENS

$$PRG_{soil} = \frac{1.0E{-}06}{(2.77E{-}08\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (0.00E{+}00\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (2.54E{-}06\ kg/kg\text{-}day \times 7.0E{-}03\ kg\text{-}day/mg)}$$

PRG_{soil} = 55 mg/kg

EXAMPLE CALCULATION OF PRGsoil - NONCARCINOGENS

$$PRG_{soil} = \frac{1}{(1.94E{-}06\ kg/kg/day / 5.0E{-}01\ mg/kg\text{-}day) + (0.00E{+}00\ kg/kg/day / 5.0E{-}01\ mg/kg\text{-}day) + (1.78E{-}04 kg/kg\text{-}day / 1.7E{-}01\ mg/kg/day)}$$

PRG_{soil} = 952 mg/kg

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN ADOLESCENT TRESPASSER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Schlosser	DATE: 09/13/2005

PURPOSE: This spreadsheet calculates risk-based cleanup goals for exposures to soil. Exposures through incidental ingestion, dermal contact, and inhalation are considered.

RELEVANT EQUATIONS:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN ADOLESCENT TRESPASSER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Schlor	DATE: 09/13/2005

INPUT ASSUMPTIONS:

	Parameter	Value	Definition
General	PRGsoil = :		Screening level in soil (mg/kg)
	TCR = :	1.0E-06	Target Cancer Risk
	THI = :	1	Target Hazard Index
	CF = :	1.0E-06	Conversion Factor (kg/mg)
	EF = :	26	Exposure Frequency (days/year)
	ED = :	11	Exposure Duration (years)
	BW = :	43 ✓	Body Weight (kg) (USEPA, 1997)
	ATc = :	25,550	Averaging time for carcinogenic exposures (days)
	ATn = :	4,015	Averaging time for noncarcinogenic exposures (days)
Incidental Ingestion	IR = :	100	Soil Ingestion Rate (mg/day) (USEPA, 1993)
	FI = :	1	Fraction from contaminated source (unitless)
Dermal Contact	SA = :	3280	Skin surface available for contact (cm^2/event)(1)
	AF = :	0.2	Soil to skin adherence factor (mg/cm^2) (USEPA, 2004)
	ABS = :	0	Absorption factor (unitless) Chemical Specific (USEPA, 2004)
Inhalation	InR = :	1.2	Inhalation rate (m^3/hr) (USEPA, 1997)
	ET = :	4	Exposure time (hr/day)
	PEF = :	1.32E+09	Particulate emission factor (m^3/kg)
	VF = :	3.2E+03	Volatilization Factor (m^3/kg)
Toxicity Values	CSForal = :	1.3E-02	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDoral = :	5.0E-01	oral noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFderm = :	1.3E-02	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDderm = :	5.0E-01	dermal noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFinh = :	7.0E-03	inhalation carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDinh = :	1.7E-01	inhalation noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
1 - Assumes that the lower arms, hands, lower legs, and feet are exposed. (Values based on Exposure Factors Handbook 1997.)
USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.
USEPA, 1997: Exposure Factors Handbook. U.S. EPA/600/8-95/002FA.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN ADOLESCENT TRESPASSER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Selber	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - CARCINOGENS

$$Intake_{oral} = \frac{100\ mg/day \times 26\ days/year \times 11\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{43\ kg \times 25550\ days}$$

$Intake_{oral}$ = 2.60E-08 kg/kg-day

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - NONCARCINOGENS

$$Intake_{oral} = \frac{100\ mg/day \times 26\ days/year \times 11\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{43\ kg \times 4015\ days}$$

$Intake_{oral}$ = 1.66E-07 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - CARCINOGENS

$$Intake_{derm} = \frac{3280\ cm2/event \times 0.2\ mg/cm2 \times 0 \times 26\ events/year \times 11\ years \times 1.0E\text{-}06\ kg/mg}{43\ kg \times 25550\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - NONCARCINOGENS

$$Intake_{derm} = \frac{3280\ cm2/event \times 0.2\ mg/cm2 \times 0 \times 26\ events/year \times 11\ years \times 1.0E\text{-}06\ kg/mg}{43\ kg \times 4015\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN ADOLESCENT TRESPASSER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY:	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INHALATION - CARCINOGENS

$$Intake_{inh} = \frac{1.2\ m3/hr \times 26\ days/year \times 11\ years \times 4\ hr/day \times (1/3.2E{+}03\ m3/kg + 1/1.3E{+}09\ m3/kg)}{43\ kg \times 25550\ days}$$

$Intake_{inh}$ = 3.88E-07 kg/kg-day

EXAMPLE CALCULATION FOR INHALATION - NONCARCINOGENS

$$Intake_{inh} = \frac{1.2\ m3/hr \times 26\ days/year \times 11\ years \times 4\ hr/day \times (1/3.2E{+}03\ m3/kg + 1/1.3E{+}09\ m3/kg)}{43\ kg \times 4015\ days}$$

$Intake_{inh}$ = 2.47E-06 kg/kg-day

EXAMPLE CALCULATION OF PRGsoil - CARCINOGENS

$$PRG_{soil} = \frac{1.0E{-}06}{(2.60E{-}08\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (0.00E{+}00\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (3.88E{-}07\ kg/kg\text{-}day \times 7.0E{-}03\ kg\text{-}day/mg)}$$

PRG_{soil} = 327 mg/kg

EXAMPLE CALCULATION OF PRGsoil - NONCARCINOGENS

$$PRG_{soil} = \frac{1}{(1.66E{-}07\ kg/kg/day\ /\ 5.0E{-}01\ mg/kg\text{-}day) + (0.00E{+}00\ kg/kg/day\ /\ 5.0E{-}01\ mg/kg\text{-}day) + (2.47E{-}06 kg/kg\text{-}day\ /\ 1.7E{-}01\ mg/kg/day)}$$

PRG_{soil} = 67237 mg/kg

CALCULATION WORKSHEET

CLIENT: NSWC CRANE, INDIANA		**JOB NUMBER:** 8383
SUBJECT: CALCULATION OF PRG FOR AN INDUSTRIAL WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 09/13/2005

PURPOSE: This spreadsheet calculates risk-based cleanup goals for exposures to soil. Exposures through incidental ingestion, dermal contact, and inhalation are considered.

RELEVANT EQUATIONS:

Carcinogens

$$PRG_{soil} = \frac{TCR}{Intake_{oral} \cdot CSF_{oral} + Intake_{derm} \cdot CSF_{derm} + Intake_{inh} \cdot CSF_{inh}}$$

NonCarcinogens

$$PRG_{soil} = \frac{THI}{\left(\frac{Intake_{oral}}{RfD_{oral}}\right) + \left(\frac{Intake_{derm}}{RfD_{derm}}\right) + \left(\frac{Intake_{inh}}{RfD_{inh}}\right)}$$

$$Intake_{oral} = \frac{IR \times EF \times ED \times FI \times ET \times CF}{BW \times AT}$$

$$Intake_{derm} = \frac{SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$$Intake_{inh} = \frac{InR \times EF \times ED \times ET \times (1/VF + 1/PEF)}{BW \times AT}$$

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN INDUSTRIAL WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D Schloen	DATE: 09/13/2005

INPUT ASSUMPTIONS:

	Parameter	Value	Definition
General	PRGsoil = :		Screening level in soil (mg/kg)
	TCR = :	1.0E-06	Target Cancer Risk
	THI = :	1	Target Hazard Index
	CF = :	1.0E-06	Conversion Factor (kg/mg)
	EF = :	250	Exposure Frequency (days/year)
	ED = :	25	Exposure Duration (years)
	BW = :	70	Body Weight (kg)
	ATc = :	25,550	Averaging time for carcinogenic exposures (days)
	ATn = :	9,125	Averaging time for noncarcinogenic exposures (days)
Incidental Ingestion	IR = :	100	Soil Ingestion Rate (mg/day)
	FI = :	1	Fraction from contaminated source (unitless)
Dermal Contact	SA = :	3300	Skin surface available for contact (cm^2/event)
	AF = :	0.2	Soil to skin adherence factor (mg/cm^2)
	ABS = :	0	Absorption factor (unitless) Chemical Specific
Inhalation	InR = :	2.5	Inhalation rate (m^3/hr)
	ET = :	8	Exposure time (hr/day)
	PEF = :	1.32E+09	Particulate emission factor (m^3/kg)
	VF = :	3.2E+03	Volatilization Factor (m^3/kg)
Toxicity Values	CSForal = :	1.3E-02	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDoral = :	5.0E-01	oral noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFderm = :	1.3E-02	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDderm = :	5.0E-01	dermal noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)
	CSFinh = :	7.0E-03	inhalation carcinogenic slope factor ($(mg/kg/day)^{-1}$) (Cal EPA, 2002)
	RfDinh = :	1.7E-01	inhalation noncarcinogenic reference dose (mg/kg/day) (Cal EPA, 2002)

CA EPA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN INDUSTRIAL WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY: D. Sellon	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - CARCINOGENS

$$Intake_{oral} = \frac{100\ mg/day \times 250\ days/year \times 25\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 25550\ days}$$

$Intake_{oral}$ = 3.49E-07 kg/kg-day

EXAMPLE CALCULATION FOR INCIDENTAL INGESTION OF SOIL - NONCARCINOGENS

$$Intake_{oral} = \frac{100\ mg/day \times 250\ days/year \times 25\ years \times 1 \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 9125\ days}$$

$Intake_{oral}$ = 9.78E-07 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - CARCINOGENS

$$Intake_{derm} = \frac{3300\ cm2/event \times 0.2\ mg/cm2 \times 0 \times 250\ events/year \times 25\ years \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 25550\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

EXAMPLE CALCULATION FOR DERMAL CONTACT WITH SOIL - NONCARCINOGENS

$$Intake_{derm} = \frac{3300\ cm2/event \times 0.2\ mg/cm2 \times 0 \times 250\ events/year \times 25\ years \times 1.0E\text{-}06\ kg/mg}{70\ kg \times 9125\ days}$$

$Intake_{derm}$ = 0.00E+00 kg/kg-day

CLIENT: NSWC CRANE, INDIANA		JOB NUMBER: 8383
SUBJECT: CALCULATION OF PRG FOR AN INDUSTRIAL WORKER EXPOSED TO TRICHLOROETHENE IN SOIL		
BASED ON: USEPA, DEC. 1989		
BY: R. JUPIN	CHECKED BY:	DATE: 09/13/2005

EXAMPLE CALCULATION FOR INHALATION - CARCINOGENS

$$Intake_{inh} = \frac{2.5\ m3/hr \times 250\ days/year \times 25\ years \times 8\ hr/day \times (1/3.2E{+}03\ m3/kg + 1/1.3E{+}09\ m3/kg)}{70\ kg \times 25550\ days}$$

$Intake_{inh}$ = 2.17E-05 kg/kg-day

EXAMPLE CALCULATION FOR INHALATION - NONCARCINOGENS

$$Intake_{inh} = \frac{2.5\ m3/hr \times 250\ days/year \times 25\ years \times 8\ hr/day \times (1/3.2E{+}03\ m3/kg + 1/1.3E{+}09\ m3/kg)}{70\ kg \times 9125\ days}$$

$Intake_{inh}$ = 6.08E-05 kg/kg-day

EXAMPLE CALCULATION OF PRGsoil - CARCINOGENS

$$PRG_{soil} = \frac{1.0E{-}06}{(3.49E{-}07\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (0.00E{+}00\ kg/kg\text{-}day \times 1.3E{-}02\ kg\text{-}day/mg) + (2.17E{-}05\ kg/kg\text{-}day \times 7.0E{-}03\ kg\text{-}day/mg)}$$

PRG_{soil} = 6.38 mg/kg

EXAMPLE CALCULATION OF PRGsoil - NONCARCINOGENS

$$PRG_{soil} = \frac{1}{(9.78E{-}07\ kg/kg/day / 5.0E{-}01\ mg/kg\text{-}day) + (0.00E{+}00\ kg/kg/day / 5.0E{-}01\ mg/kg\text{-}day) + (6.08E{-}05 kg/kg\text{-}day / 1.7E{-}01\ mg/kg/day)}$$

PRG_{soil} = 2779 mg/kg

SITE NAME: SWMU 3
LOCATION: NSWC CRANE, CRANE, INDIANA
RECEPTOR: CONSTRUCTION WORKER
MEDIA: SURFACE SOIL (SITE)
DATE: FEBRUARY 1, 2007

Calculations of Preliminary Remediation Goals (PRGs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PRG Equations[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1: Construction Worker		Using Equation 2: Construction Worker	
$PbB_{fetal,\,0.95}$	X	X	95th percentile PbB in fetus	ug/dL	10		10	
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9		0.9	
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4		0.4	
GSD_i	X	X	Geometric standard deviation PbB	--	2.18		2.18	
PbB_0	X	X	Baseline PbB	ug/dL	1.53		1.53	
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100		--	
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--		0.100	
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--		1.0	
K_{SD}		X	Mass fraction of soil in dust	--	--		0.7	
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12		0.12	
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219		219	
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365		365	
PRG			Preliminary Remediation Goal	ppm	539		539	

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same PRG.

***Equation 1, based on Eq. 4 in USEPA (1996).**

$$PRG = \frac{([PbB_{95}fetal/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*(IR_{S+D}*AF_{S,D}*EF_{S,D})}$$

****Equation 2, alternate approach based on Eq. 4 and Eq. A-19 in USEPA (1996).**

$$PRG = \frac{([PbB_{fetal,0.95}/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])}$$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

APPENDIX C

ECOLOGICAL RISK ASSESSMENT (BARIUM)

OFF-SITE RECEPTORS

Barium

Barium was eliminated as a chemical of potential concern (COPC) for sediments for the following reasons:

- Barium concentrations are greatest in samples collected within the Ammunition Burning Ground (ABG) Main Treatment Area (MTA). Barium concentrations decreased further downngradient although they remained above the Apparent Effects Threshold (AET) and exceeded concentrations in samples collected upgradient of the MTA.

- Portions of Little Sulphur Creek (LSC) upgradient of Spring C are poor habitat for aquatic receptors and significant impacts are unlikely because of the number of receptors is limited by the poor habitat.

- Perennial portions of LSC (Below Spring C) are currently supporting a variety of aquatic receptors indicating impacts from barium are not significant.

Barium AET (48 mg/kg) toxic effects to the benthic organisms

Although the Apparent Effects Threshold (AET) is defined as the concentration above which toxic effects are expected to occur; the value of 48 mg/kg for barium is conservative. The co-author of the briefing report to the "EPA SAB: the apparent effects threshold approach" was contacted in order to better understand the source of the barium AET as well as any uncertainties that may be associated with its use. The original AET values were developed from the Commencement Bay Superfund project in 1984 and later updated with data collected from projects in Puget Sound. The co-author indicated that the AETs are site-specific data and that care should be used when applying at other project locations, in particular, that AETs "should not be considered off-the-shelf numbers". Therefore, although barium concentrations in sediment at SWMU 3 exceed the AET of 48 mg/kg, it does not appear that the AET is the most appropriate value in which to base risk conclusions, particularly because site-specific macro invertebrate samples have been collected in LSC.

In addition, barium concentrations from Wente (1994) were reviewed in order to further evaluate the conservative nature of the barium AET. Wente (1994) identifies background concentrations of 172 potential pollutants across the state of Indiana by county. The report identifies background concentrations as chemical concentrations that are present in sediment in the absence of any particular pollutant source; therefore, the background concentration can be useful in determining whether point

sources of pollutions have potentially contributed to a given sediment concentration. The maximum 95th percentile barium concentration for Martin County is 250 mg/kg, which is greater than five times the AET. The AET of 48 mg/kg implies that the naturally occurring barium concentrations throughout the state of Indiana are causing toxic effects to benthic organisms, which is unlikely.

With these considerations and the considerations discussed below, it does not appear that the AET is the most appropriate value for comparing sediment concentrations at SWMU 3 when site-specific data are available (Tetra Tech NUS, Inc., 1999). For these reasons, although barium concentrations are elevated at SWMU 3 with respect to the AET, the AET is a conservative value. Barium in the sediment does not appear to be causing adverse toxicity to aquatic invertebrates and concentrations in SWMU 3 sediments do not warrant retaining barium as a COPC for further evaluation.

Barium concentrations in shallow and deep sediments effects on benthic macro invertebrates

Three macro invertebrate samples were collected in LSC along the OJT during the Current Contamination Conditions Risk Assessment (TtNUS, 1999). One sample was co-located with a sediment sample analyzed for barium. The sediment sample is 03SD13 and the macro invertebrate sample is identified as that collected from Spring C, the riffle area. The barium concentration at 03SD13 was 262 mg/kg. The barium concentration at the next upstream sample, 03SD12, was 373 mg/kg. These concentrations are similar to those found in samples collected within this vicinity during the SWMU 3 RFI (TtNUS, 2005). Barium concentrations in shallow sediment (0 to 6 inches) at locations 03SD12 and 03SD13 collected during the SWMU 3 RFI were 353 mg/kg and 326 mg/kg.

Four species were found in the macro invertebrate sample collected from Spring C, the riffle area. Of these, two were EPT (pollution sensitive) species. The Current Contamination Conditions Risk Assessment concluded that the low flow conditions of LSC at the time of the survey contributed to the observed species composition. However, because pollution sensitive species were found in the riffle area, it does not appear that chemicals in the sediment are impacting sediment invertebrates. The barium concentrations have not significantly changed (i.e., increased) since samples were collected for the Current Contamination Conditions Risk Assessment. Therefore, there is no reason to believe that the macro invertebrate community in LSC is now being adversely impacted by barium in the sediment when it was previously concluded that the macro invertebrate community is diverse and pollution sensitive species are represented in this area.

During a site visit in June 2004, it was observed that the creek becomes perennial downstream of Spring C, where the flow of water increases. Halfway downstream to the next bridge, it was noted that the substrate was rocky with gravel with very little sediment. There were a few deeper pools/runs in this

portion of the creek that were several feet deep. Various aquatic insects were observed under rocks, and fish, crayfish, and frogs were present in the water; some of the fish were three to five inches long. Also, a few salamanders were observed under the rocks. Therefore, little viable habitat exists for aquatic receptors upstream of Spring C; LSC does support a variety of aquatic species downstream of Spring C. As such, from further qualitative observations, it does not appear that barium concentrations (or metals concentration in general) are adversely impacting the aquatic community downstream of Spring C where barium concentrations in the sediment samples (03SD15 through 03SD19) were elevated (ranging from 57.3 to 353 mg/kg) when compared to the conservative AET (48 mg/kg).

Barium a non-bioaccumulative chemical food-chain

It is not clear how food-chain modeling would provide evidence to support dropping barium from further consideration as a COPC for aquatic invertebrates. However, barium should be dropped as a COPC based upon the reasons which were previously discussed.

Endangered Species impacts for Sulphur Creek and the East Fork of the White River from metals transport (barium, cadmium, copper, lead, zinc)

After reviewing the data for barium, cadmium, copper, lead, and zinc, it does not appear that the greatest concentrations were detected in samples collected downstream of Spring C. For most of the metals identified, the greatest concentrations are in samples collected upstream of Spring C. For example, the greatest detected concentrations of lead in shallow sediment (i.e., those that were greater than the PEC) were all found in samples upstream of Spring C (see figure 5-8 of the SWMU 3 RFI). Although barium was detected at a concentration of 353 mg/kg at location 03SD15 (which is just downstream of Spring C) in deep sediments, the greatest concentrations of barium in deep sediment were detected upstream of Spring C. For example, barium was detected in deep sediments at concentrations of 981 mg/kg (location 03SD11), 744 mg/kg (location 03SD12), and 419 mg/kg (location 03SD10). Similarly, zinc was detected in deep sediments at a concentration of 319 mg/kg at location 03SD15; however, the greatest concentrations were detected at locations upstream of Spring C at 412 mg/kg, 1,120 mg/kg, and 421 mg/kg (locations 03SD10, 03SD11, and 13SD12, respectively). These are just a few examples; however, this is generally the case for most of the metals.

When comparing concentrations in samples 03SD15 through 03SD19, it appears that the greatest concentrations of metals in these samples are found at the most upstream location (13SD15). For example, copper was detected at 198 mg/kg at location 13SD15 and decreased to less than the consensus-based TEC of 31.6 mg/kg in the furthest downstream samples. In the case of lead, the greatest concentration in these samples was also detected at location 13SD15 with generally decreasing

concentrations downstream. In most cases, the concentrations of metals in the furthest downstream sediment samples were less than or just slightly greater than the TEC. Therefore the Navy does not believe that it is necessary to collect additional downstream samples to better define the spatial extent of these metals.

Macro invertebrate samples have been previously collected at SWMU 3 as a part of the Current Contamination Conditions Risk Assessment report (see Response to Comment RFI Eco 1). Three macro invertebrate samples were collected in LSC. The sediment location collocated with one of the macro invertebrate samples had metals concentrations greater than or similar to those found in samples collected downstream of Spring C; therefore, the Navy does not believe that additional field studies are needed.

The comment regarding "barium...is not generally associated with significant toxicity" was based on the fact that barium is likely to precipitate out of solution as an insoluble salt in aquatic media and that barium in sediments is typically found in the form of barium sulfate (ATSDR, 1992). Additionally, the insoluble salts are typically less toxic than the soluble barium salts (US EPA, http://www.epa.gov/safewater/dwh/c-ioc/barium.html).

Water hardness is typically used to adjust water quality criteria for evaluating surface water concentrations for certain metals. It is unclear how water hardness can be used to evaluate metals concentrations in sediment.

Calculation of the barium site-specific soil screening value for protection of groundwater

The site-specific barium screening value for protection of groundwater was calculated for the groundwater MCL of 2 mg/l as described in the following.

The actual screening concentration is 1,648 mg/kg. A copy of the calculation sheet is included below.

Equation B-13
Soil Screening Level Partitioning Equation for Migration to Ground Water

$$\text{Screening Level in Soil (mg/kg)} = C_w \left[K_D + \frac{(\theta_w + \theta_a H')}{\rho_b} \right]$$

Parameter/Definition (units)	Default
C_w/target soil leachate concentration (mg/L)	(nonzero MCLG, MCL, or HBL)[a] × dilution factor
K_d/soil-water partition coefficient (L/kg)	organics = $K_{oc} \times f_{oc}$ inorganics = see Appendix C[b]
K_{oc}/soil organic carbon/water partition coefficient (L/kg)	chemical-specific[c]
f_{oc}/fraction organic carbon in soil (g/g)	0.002 (0.2%)
θ_w/water-filled soil porosity (L_{water}/L_{soil})	0.3
θ_a/air-filled soil porosity (L_{air}/L_{soil})	$n - \theta_w$
ρ_b/dry soil bulk density (kg/L)	1.5
n/soil porosity (L_{pore}/L_{soil})	$1 - (\rho_b/\rho_s)$
ρ_s/soil particle density (kg/L)	2.65
H'/dimensionless Henry's law constant	chemical-specific[c] (assume to be zero for inorganic contaminants except mercury)

[a] Chemical-specific (see Appendix C).
[b] Assume a pH of 6.8 when selecting default K_d values for metals.
[c] See Appendix C.

Input Parameters:

DAF	=	20		
Cw	=	2	mg/L	(US EPA MCL)
		40	mg/L	
Kd	=	4.10E+01	L/kg	
Koc	=	NA	L/kg	
foc	=	NA	g/g	
□w	=	0.3	L/L	
□a	=	0.134	L/L	
Pb	=	1.5	kg/L	
n	=	0.434	L/L	
Ps	=	2.65	kg/L	
H'	=	0.00E+00		

SSL = 40 mg/L x [41 L/kg + (0.3 L/L + 0.134 L/L x 0)/1.5 kg/L]
SSL = 1,648 mg/kg

References:

US EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Office of Solid Waste and Emergency Response, Washington, D.C., December.

Air deposition of barium from OB/OD operations at the ABG/OJT and DBG

Air deposition was estimated in the AEHHRA using the US EPA approved mass-balance approach. This approach was used to estimate the accumulation of barium in soil over time for the Current and Future Land Use Scenarios. The estimated soil concentration for the Current Land Use Scenario is shown in Table 6-3 from the AEHHRA for a receptor location at the ABG. The estimated barium concentration in soil is 0.0048 mg/kg. The result for the same receptor in the Future Land Use Scenario is given in Table 6-4 from the AEHHRA. The estimated barium concentration in soil is also 0.0048 mg/kg.

All 35 surface soil samples analyzed at the MTA contained barium, which was expected, because barium is naturally occurring in soils. The soils background study (TtNUS 2000) showed that naturally occurring barium concentrations ranged form 46 to 153 mg/kg. Based on the results of the AEHHRA potential air deposition of barium (0.0048 mg/kg) would be insignificant compared to concentrations naturally occurring in soils.

The April 2004 sampling data showed that surface soil barium concentrations ranged from a low of 25.5 mg/kg to a high of 4,120 mg/kg. Subsurface soil barium concentrations ranged from a low of 18.3 to 652 mg/kg. As shown in Figure 1-22 from the Conceptual Site Model, the locations where the highest surface soil barium concentrations were found (2,120 mg/kg at 03SB086, 2,920 mg/kg at 03SB120, and 4,120 mg/kg at 03SB116) were all found in the same general area.

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX)

RDX above RBTLs in LSC surface waters

Evaluations have been conducted to determine risks to off-site receptors. Indiana water quality standards (WQS) for surface waters were used as the basis for evaluating risks to off-site receptors resulting from the presence of RDX in LSC surface waters. Based on this evaluation it was determined that even under worst-case conditions RDX concentrations LSC resulting from Spring A and Spring C discharges do not present any risk to off-site receptors. Following is the detailed evaluation.

Title 327 Water Pollution Control Board establishes regulations applicable to surface waters in the state of Indiana. 327 IAC 2-1-3 (Surface water use designations; multiple uses) Sec. 3(a) states the following:

(1) Surface waters of the state are designated for full-body contact recreation as provided in section 6(d) of this rule.

(2) All waters, except as described in subdivision (5), will be capable of supporting a well balanced, warm water aquatic community and, where natural temperatures will permit, will be capable of supporting put-and-take trout fishing. All waters capable of supporting the natural reproduction of trout as of February 17, 1977, shall be so maintained.

(3) All waters which are used for public or industrial water supply must meet the standards for those uses at the points where the water is withdrawn. This used designating and its corresponding water quality standards are not to be construed as imposing a user restriction on those exercising a desire to exercise the use.

(4) All waters which are used for agricultural purposes must, at a minimum, meet the standards established in section 6(a) of this rule.

(5) All waters in which naturally poor physical characteristics (including lack of sufficient flow), naturally poor chemical quality, or irreversible man-induced conditions, ... Specific waters of the state designated for exceptional use are listed in section 11(a) of this rule.

(6) All waters which provide unusual aquatic habitat, which are an integral .... Specific waters of the state designated for exceptional use are listed in section 11(b) of this rule.

LSC and the East Fork White River between LSC and Shoals are not listed in either 327 IAC 2-1-3 Sections 11(a) or 11(b).

Based on the above, RDX concentrations in LSC must be limited, at a minimum, to concentrations which would ensure maintenance of a balanced warm water aquatic community, and to protect public water supplies, wherever water is withdraw for drinking water or industrial use. These uses require the most stringent criterion.

327 IAC 2-1-6 (Minimum surface water quality standards) states the following in 327 IAC 2-1-6(a)(2):

(2) At all times, all surface waters outside of mixing zones shall be free of substances in concentrations that on the basis of available scientific data are believed to be sufficient to injure, be chronically toxic to or be carcinogenic, mutagenic, or tetratogenic to humans, animals, aquatic life, or plants. To assure protection against the adverse effects identified in this subdivision, the following requirements are established:

(A) A toxic substance or pollutant shall not be present in such waters in concentrations that exceed the most stringent of the following continuous criterion concentrations (CCCs):

(i) A chronic aquatic criterion (CAC) to protect aquatic life from chronic toxic effects.

(ii) A terrestrial life cycle safe concentration (TLSC) to protect terrestrial organisms from toxic effects that may result form the consumption of aquatic organisms or water from the waterbody.

(iii) A human health life cycle safe concentration (HLSC) to protect human health from toxic effects that may result from the consumption of aquatic organisms or drinking water from the waterbody.

(iv) For carcinogenic substances, a criterion to protect human health from unacceptable cancer risk of greater than one (1) additional occurrence of cancer per one hundred thousand (100,000) population.

327 IAC 2-1-6(a)(2)(B) references Table 6-1, which contains a list of surface water quality criteria for specific substances. Criteria are listed for aquatic life (4-day average) and for human health (30-day average) and at the point of water intake (30-day average). RDX is not one of the substances that are listed.

327 IAC 2-1-6(a)(2)(C) references procedures for calculation of criterion for substances which are not listed in Table 6-1. 327 IAC 2-1-8.3 [Determination of chronic aquatic criteria (CAC)] contains procedures for the development of water quality criteria for protection of aquatic receptors. The water quality criterion of 3,070 µg/L was determined by a methodology in accordance with these procedures. A terrestrial life cycle safe concentration (TLSC) was also calculated. The calculated TLSC was 2,800 µg/L. Attachment 1 contains the details.

327 IAC 2-1-6(a)(2)(E) states the following:

(E) The CAC and TLSC for a substance apply in all surface waters outside a mixing zone for a discharge of that substance. Similarly, in waters where a public water system intake is not present or is unaffected by the discharge of a substance, the HLSC and the carcinogenic criterion for that substance based on consumptions of organisms from the waterbody and only incidental ingestion of water shall apply to all surface waters outside the mixing zone for a discharge of that substance. In surface waters where a public water system intake is present, the HLSC and the carcinogenic criterion for a substance based on consumption of organisms and potable water from the waterbody shall apply at the point of the public water system intake.

327 IAC 2-1-8.6 (Determination of concentration providing an acceptable degree of protection to public health for cancer) contains procedures for the development of water quality criteria for protection of public water supply at the point of intake. For public water supply, the water quality criterion, 3.0 µg/L, was determined in accordance with these procedures. For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 240 µg/L. Attachment 2 contains the detailed calculations. Note that a WQS could also be calculated according to 327 IAC 2-1-8-5 for the noncarcinogenic health effects of RDX (on the prostate). However, calculations show that the

noncarcinogenic WQS would be approximately 35 times greater than WQS based on cancer. Only the more conservative carcinogenic WQS (3 µg/L) is presented.

In accordance with Indiana requirements, these surface water quality criteria must be met at the location of the point of use. For protection of aquatic receptors, this location would be below Spring C, where LSC becomes a perennial stream. For carcinogenic substances this location would be LSC outside of the location where Springs A and C mix with LSC. For protection of public water supplies, this location would be the closest location, where LSC surface waters are withdrawn for public water supply.

The discharges from Springs A and C can be considered to be equivalent to National Pollution Discharge Elimination System (NPDES) discharge points. Indiana regulations contain provisions for calculation of water quality based effluent limitations. 327 IAC 5-2-11.1 (Establishment of water quality-based effluent limitations for dischargers not discharging to waters within the Great Lakes system) was used to determine the water quality-based effluent limit (WQBEL) for RDX. 327 IAC 5-2-11.1 states the following:

> *(b)(4) The criterion to provide an acceptable degree of protection for public health for cancer effects shall apply outside of the mixing zone if the criterion is based on the consumption of organisms and incidental water intake and at the point of the public water system intake if based on the consumption of organisms and drinking water, if this would not cause the criterion based on the consumption of organisms and incidental water intake to be exceeded outside of the mixing zone. For calculation of allowable dilution, one-fourth (1/4) of the fiftieth percentile flow of the receiving stream shall be used if the criterion is based on consumption of organisms and incidental water intake, and the fiftieth percentile flow of the receiving stream at the point of the public water system intake can be used if the criterion is based on the consumption of organisms and drinking water.*

The surface water features of LSC and the streams into which it flows after it exits NSWC Crane property are shown in Figure 1. LSC flows into Sulphur Creek, which in turn flows into Indian Creek. Indian Creek flows into the East Fork of the White River. IDEM databases were used to determine location of public water supply intakes. No public water supply intakes were identified on Sulphur Creek, or Indian Creek.

United States Geological Survey (USGS) databases were used to obtain stream flow data. The closest stream gauging information, that was available from the USGS, was at the East Fork White River at Shoals. Attachment 3 contains the monthly average flow rate in terms of gallons per minute (gpm) for the last ten years (1993 through 2003). The monthly flow rates at this location ranged from a low of 142,279 gpm (November 1999) to a high of 15,762,951 gpm (May 1996).

All RDX in LSC originates from Spring A (from Main Treatment Area) and Spring C (from Jeep Trail). As noted previously, under base flow conditions, all of the surface waters in LSC are comprised of Springs A and C discharges. Attachment 4 contains information regarding concentrations of RDX in LSC below Springs A and C. The information presented in this attachment demonstrates that RDX concentrations generally decrease with increasing flow. The worst-case combination of RDX concentrations and flow rates was a Spring A RDX concentration of 120 µg/L at an estimated flow rate of 4 gpm. This is well below the aquatic life criterion of 3,070 µg/L and the public health criterion (incidental water intake only) of 240 µg/L. However, it is above the public water supply intake criterion of 3 µg/L which applies at the point of intake.

RDX concentrations at the nearest downstream gauging location (East Fork White River at Shoals), were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- Spring C RDX concentrations are 63 µg/L for 30 days
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of RDX occurs.

Under these assumptions, which are more stringent than allowed by IDEM regulations, RDX concentrations at Shoals would be 0.0026 µg/L. This concentration is well below the applicable Indiana RDX criterion for protection of public water supply of 3.0 µg/L.

Based on the above evaluation RDX concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the Little Sulphur Creek.

SOIL REMOVAL AND TREATMENT

The MTA is an active operating RCRA-permitted hazardous waste treatment facility. All RCRA-permitted facilities are subject to RCRA closure requirements for permitted facilities. At the end of the active life of the MTA, it will either be clean closed or closed as a RCRA landfill.

Human Health Risk Assessment: A screening level health risk assessment has being conducted for current actual/potential receptors that could occur under the existing land use (open burning facility). These receptors include the site worker, construction worker, and trespasser. The results are as follows:

- Barium is not recommended for further evaluation.
- Manganese is not recommended for further evaluation.

- Lead is recommended for further evaluation.

Ecological Risk Assessment: Currently, and for the foreseeable future, OB/OD operations occur at the active portion of ABG. As seen from Figure 2, the site consists of roads and other areas covered by gravel, pavement, concrete, etc., which is surrounded by mowed grass. The active area is surrounded by a heavily wooded area as seen in Figure 2. With the exception of soil invertebrates, grass and other herbaceous plants, few ecological receptors would be present in the active area except in passing, because of the industrial nature of the site. Therefore, there is not an ecologically significant ecological community that would be impacted by site contaminants under these conditions. After activities cease at the site, a risk-based closure plan would need to be prepared, and risks to ecological receptors will be evaluated at that time for the uses that will be designated in the closure plan.

OLD JEEP TRAIL — RDX, TRICHLOROETHENE (TCE), AND BARIUM CONTAMINATION

As previously stated, the MTA is an active operating RCRA-permitted hazardous waste treatment facility. All RCRA-permitted facilities are subject to RCRA closure requirements for permitted facilities. At the end of the active life of the MTA it will either be clean closed or closed as a RCRA landfill.

The TCE contamination in groundwater presents a risk to users of the groundwater. TCE in soils appears to be a continuing source of contamination in groundwater. However, groundwater from the contaminated Beech Creek aquifer will not be used for as long as the MTA is an active treatment area and/or under control of the Navy. Groundwater from the MTA and the OJT discharges into LSC from Springs A and C, respectively. TCE is generally not detected or only detected at trace concentrations in the springs and LSC surface waters. The TCE appears to be volatizing in the Karst System and any TCE that would be present in the springs would volatize in LSC. Therefore, TCE in groundwater does not present any risk to existing onsite or offsite receptors whether it originates in the MTA or the OJT.

Barium has been detected in wells, springs, and surface waters in excess of the RBTL (3.9 µg/L) established in the Permit. The most likely media cleanup standard (MCS) for protection of human health that would be established in the CMS is the Maximum Concentration Level (MCL), which is 2,000 µg/L. Groundwater data for the Old Jeep Trail, Main Treatment Area, and Springs A and C was evaluated to determine whether this MCL was exceeded.

Old Jeep Trail: Groundwater barium data (2001 and 2004) and Spring C (2001, 2002, 2003, and 2004) is available from samples collected during RFI and RCRA-Permit monitoring programs.

The following table summarizes the average and maximum sampling results for barium.

Calendar Year	Filtered Results (µg/L)				Unfiltered Results (µg/L)			
	Average Value	Maximum			Average Value	Maximum		
		Value	Location	Date		Value	Location	Date
2001	48.3	58.3	Spring C	9/17/2001	71.1	132.	03C02P2	9/18/2000
2002	53.9	63.3	Spring C	6/24/2002	55.3	66.7	Spring C	6/24/2002
2003	47.3	63.3	Spring C	9/9/2003	46.6	60.7	Spring C	9/9/2003
2004	55.2	67.5	Spring C	9/16/2004	54.8	66.1	Spring C	9/16/2004

The data from 1994 through 2004 indicates that the barium MCL, 2,000 µg/L, has never been exceeded at the Old Jeep Trail monitoring wells or in Spring C.

Main Treatment Area: Groundwater wells and springs at the Main Treatment Area are routinely analyzed for metals including barium in accordance with the RCRA Permit for open burning operations. The following table summarizes the average and maximum sampling results for barium from 1998 through 2004:

Calendar Year	Filtered Results (µg/L)				Unfiltered Results (µg/L)			
	Average Value	Maximum			Average Value	Maximum		
		Value	Location	Date		Value	Location	Date
1998	44.2	94.8	03C02P2	11/9/1998	43.9	96.2	03C02P2	11/9/1998
1999	50.9	154.	Spring A	9/13/1999	47.1	142.	Spring A	9/13/1999
2000	46.8	123.	03C02P2	9/18/2000	48.4	132.	03C02P2	9/18/2000
2001	42.3	131.	Spring A	9/17/2001	43.	130.	Spring A	9/17/2001
2002	36.5	105.	03C02P2	11/7/2002	38.7	106.	Spring A	6/20/2002
						106.	03C02P2	11/7/2002
2003	36.1	142.	Spring A	9/9/2003	37.7	134.	Spring A	9/9/2003
2004	37.2	133.	Spring A	9/16/2004	39.8	130.	Spring A	9/16/2004

The data from 1998 through 2004 demonstrates that the barium MCL of 2,000 µg/L has never been exceeded at the Main Treatment Area monitoring wells or Spring A.

Little Sulphur Creek: Surface water samples have also been collected from Little Sulphur Creek for metals analysis during the MNA monitoring program and during RFI investigations since 1998. The following table summarizes the average and maximum sampling results for barium from 1998 through 2004:

Calendar Year	Filtered Results (µg/L)				Unfiltered Results (µg/L)			
	Average Value	Maximum			Average Value	Maximum		
		Value	Location	Date		Value	Location	Date
1998	113.4	146.	Creek A	11/5/1998	117.1	158.	Creek A	11/5/1998
1999	63.4	158.	Creek B	9/13/1999	63.	158.	Creek B	9/13/1999
2000	69.	128.	Creek B	6/9/2000	54.7	70.7	Creek A	3/8/2000

The data from 1998 through 2004 demonstrates that the barium MCL of 2,000 µg/L has never been exceeded in Little Sulphur Creek in samples collected at locations below the discharge points of Springs A and C.

Based on the above data, the MCL for barium is attained under current conditions at SWMU 3.

Therefore, no remedial actions are necessary to address barium in groundwater.

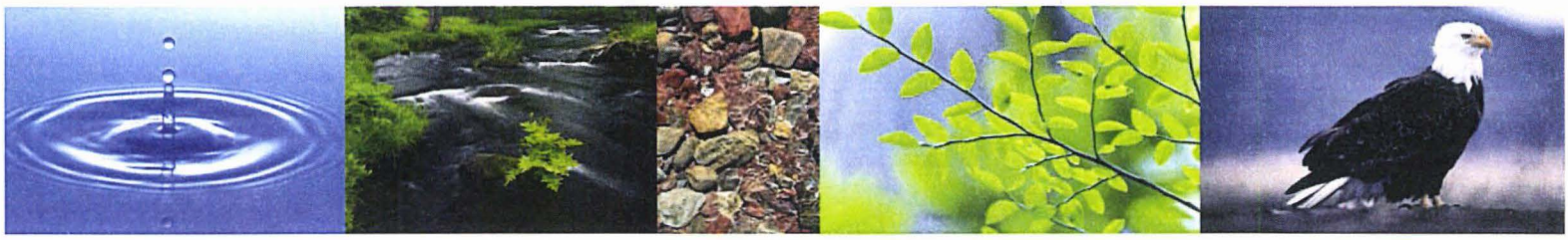
APPENDIX D

TITLE 37 INDIANA ADMINISTRATIVE CODE (IAC)

ALTERNATIVE WATER QUALITY CRITERIA
FOR
SWMU 3 (AMMUNITION BURNING GROUNDS)

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-03-D-0057



Rev. 2
07/09

Alternative Water Quality Criteria
for
Solid Waste Management Unit 3 (Ammunition Burning Grounds)

Naval Surface Warfare Center
Crane, Indiana

Contract Task Order 0311

July 2009

NAVFAC
Naval Facilities Engineering Command
Southeast
2155 Eagle Drive
North Charleston, South Carolina 29406

TETRA TECH NUS, Inc.

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1 - Surface Water Features Associated with Little Sulphur Creek

ACRONYMS

2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
ACR	Acute-to-chronic ratio
Amino-dinotrotoluene	2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene
2-A-DNT	2-amino-4,6-dinitrotoluene
4-A-DNT	4-amino-2,6-dinitrotoluene
COCs	Chemicals of concern
CAC	Chronic aquatic criterion
CLEAN 3	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
CCCs	Continuous criterion concentrations
gpm	Gallons per minute
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
HLSC	Human health life cycle safe concentration
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
kg/day	Kilograms per day
L/day	Liters per day
LSC	Little Sulphur Creek
MTA	Main Treatment Area
µg/L	Micrograms per liter
NPDES	National Pollution Discharge Elimination System
NSWC	Naval Surface Warfare Center
NAVFAC	Navy Southern Division Naval Facilities Engineering Command
OJT	Old Jeep Trail
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
RCRA	Resource Conservation and Recovery Act
SWMU	Solid waste management unit
SWMU 3	Ammunition Burning Grounds
TLSC	Terrestrial life cycle safe concentration
TNT	2,4,6-Trinitrotoluene
U.S.	United States
USGS	United States Geological Survey

U.S. EPA	United States Environmental Protection Agency
WQC	Water quality criteria
WQS	Water quality standards
WQBEL	Water quality-based effluent limit

EXECUTIVE SUMMARY

Alternative Water Quality Standards (WQS) for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (TNT), and amino-dinitrotoluenes [2-amino-4,6-dinitrotoluene (2-A-DNT) and 4-amino-2,6-dinitrotoluene (4-A-DNT)] in surface waters were developed to determine the impact to off-site human and ecological receptors based upon the Indiana WQS for surface waters.

The main surface water conduit evaluated was Little Sulfur Creek (LSC). The headwaters of LSC are primarily Springs A and C which are located at Naval Surface Warfare Center (NSWC) Crane. The location of the nearest "sport-fishing" location down stream of NSWC Crane is on Indian Creek immediately below the point where Sulfur Creek enters Indian Creek. This is approximately 5 miles south of the NSWC Crane boundary.

Indiana Administrative Code (IAC) Title 327 Water Pollution Control Board establishes regulations applicable to surface waters in the state of Indiana for the protection of public health and ecological receptors. Because neither RDX, 2,4-DNT, 2,6-DNT, TNT, nor amino-dinitrotoluenes are listed in Table 6-1 of Article 2 (Water Quality Standards), procedures in Title 327 IAC 2-1-8.6 were used to develop alternative water quality criteria (WQC) for the protection of public water supplies.

The discharges from Springs A and C can be considered to be equivalent to National Pollution Discharge Elimination System (NPDES) discharge points. Indiana regulations contain provisions for calculation of water quality based effluent limitations. Because neither RDX, 2,4-DNT, 2,6-DNT, TNT, nor amino-dinitrotoluenes are listed in Title 327 IAC 5-2-11.1 (Establishment of water quality-based effluent limitations for dischargers not discharging to waters within the Great Lakes system) was used to determine the water quality-based effluent limit (WQBEL) for these chemicals.

United States Geological Survey (USGS) databases were used to obtain stream flow data. The closest stream gauging information, based on USGS database, was at the East Fork White River at Shoals. The monthly average flow rate of the East Fork White River at Shoals ranged from a low of 142,279 gallons per minute (gpm) (November 1999) to a high of 15,762,951 gpm (May 1996).

RDX

The following summarizes the RDX findings and data:

- For public water supply, the RDX water quality criterion of 3.0 micrograms per liter (µg/L) was calculated.
- For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 240 µg/L.
- The maximum potential RDX concentration at Shoals is 0.00027 µg/L.
- For an exceedance of the RDX alternative WQS to occur at the Shoals water intake, the fenceline RDX concentration would need to be 106,707 µg/L.
- The maximum RDX concentration for either Spring A or Spring C was 140 µg/L (Spring A) on September 10, 2002.

Based on the above information RDX concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,4-DNT

The following summarized the 2,4-DNT findings and data:

- For public water supply, the 2,4-DNT water quality criterion of 52 µg/L was calculated.
- For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 195 µg/L.
- The maximum potential 2,4-DNT concentration at Shoals is 0.00007 µg/L.
- For an exceedance of the 2,4-DNT alternative WQS to occur at the Shoals water intake, the fenceline RDX concentration would need to be 1,849,000 µg/L.
- The maximum 2,4-DNT concentration for either Spring A or Spring C was 1.6 U µg/L (Spring C) on February 28, 1999.

Based on the above information 2,4-DNT concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,6-DNT

The following summarized the 2,6-DNT findings and data:

- For public water supply, the 2,6-DNT water quality criterion of 29 µg/L was calculated.
- For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 150 µg/L.
- The maximum potential 2,6-DNT concentration at Shoals is 0.00007 µg/L.
- For an exceedance of the 2,6-DNT alternative WQS to occur at the Shaols water intake, the fenceline RDX concentration would need to be 1,029,000 µg/L.
- The maximum 2,6-DNT concentration for either Spring A or Spring C was 1.6 U µg/L (Spring C) on February 28, 1999.

Based on the above information 2,6-DNT concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,4,6-TNT

The following summarized the TNT findings and data:

- For public water supply, the TNT water quality criterion of 10 µg/L was calculated.
- For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 84 µg/L.
- The maximum potential TNT concentration at Shoals is 0.00024 µg/L.

- For an exceedance of the TNT alternative WQS to occur at the Shoals water intake, the fenceline RDX concentration would need to be 1,030,000 µg/L.

- The maximum TNT concentration for either Spring A or Spring C was 5.6 µg/L (Spring A) on September 16, 2004.

Based on the above information TNT concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

AMINO-DINITROTOLUENES

The following summarized the amino-dinitrotoluenes findings and data:

- Based upon the procedures in Title 327 IAC 2-1-8.6, for public water supply, the amino-dinitrotoluenes water quality criterion, 67 µg/L, was determined.

- For surface waters at locations where public water supply intakes are not located, the calculated water quality criterion is 1,359 µg/L.

- The maximum amino-dinitrotoluenes concentrations for Spring A and Spring C is 70 and 1.6 µg/L, respectively.

- The maximum potential amino-dinitrotoluene concentration at Shoals is 0.00295 µg/L.

- For an exceedance of the amino-dinitrotoluene alternative WQC to occur at the Shoals water intake, the fenceline amino-dinitrotoluene concentration would need to be 2,380,000 µg/L.

- The impact to human receptors from incidental ingestion of surface water and consumption of stream fish alternative WQC is 1,359 µg/L.

- The maximum amino-dinitrotoluene concentration for either Spring A or Spring C was 70 µg/L (Spring A) (September 29, 2000).

Based on the above information amino-dinitrotoluenes concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Alternative WQC Report was prepared for the solid waste management unit (SWMU) 3 [Ammunition Burning Grounds (ABG)] at the NSWC facility located in Crane, Indiana, through the United States (U.S.) Navy Southern Division Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0311, for the Comprehensive Long-Term Environmental Action Navy (CLEAN 3), Contract Number N62467-94-D-0888. For the purposes of this report, SWMU 3 consists of the Main Treatment Area (MTA), the Old Jeep Trail (OJT), and Little Sulphur Creek (LSC).

This document is a supplement to the Phase 3 Resource Conservation and Recovery Act (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS). The Indiana Department of Environmental Management (IDEM) is the lead oversight agency. However, under a work-sharing agreement, U.S. Environmental Protection Agency (U.S. EPA) Region 5 is responsible for the RFI/CMS phases at SWMU 3.

This document presents the development and analysis of alternative WQC for off-site chemicals of concern (COCs) for surface water discharges associated with NSWC Crane. Evaluations were conducted for human and ecological receptors associated with RDX (hexahydro-1,3-5-trinitro-1,3,5-triazine), 2,4-dinitrotluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 2,4,6-trinitrotoluene (TNT), and amino-dinitrotoleunes [2-amino-4,6-dinitrotoluene (2-A-DNT) and 4-amino-2,6-dinitrotoluene (4-A-DNT)]. The basis for developing alternative WQC to off-site receptors was the Indiana WQS for surface waters.

The main surface water conduit evaluated was LSC. The headwaters of LSC are primarily Springs A and C which are located at NSWC Crane. The maximum concentrations of RDX, 2,4-DNT, 2,6-DNT, TNT, and amino-dinitrotoluenes' concentrations at low flow (e.g., worst case) for both Spring A and Spring C were evaluated. Based on this evaluation, it was determined that, even under worst-case, the concentrations in LSC do not present any risk to off-site receptors. The following presents the regulatory basis for the evaluation.

1.2 ORGANIZATION OF THE WQC REPORT

This WQC Report consists of five sections and supporting appendices. Section 1.0 is the introduction section. Section 2.0 provides a regulatory applicability determination for the development of alternative WQS. Section 3.0 presents the alternative WQC and human health impact summary. Section 4.0

presents the alternative WQC and ecological impact summary. Section 5.0 presents a summary of the conclusions.

Appendix A is Surface Water Data. Appendix B presents Surface Water Concentration Calculations. Appendix C presents Alternative WQC Calculations for Surface Water (LSC). Appendix D presents the Spring A and Spring C Data. Appendix E presents the Surface Water Criterion for RDX Aquatic Receptors. Appendix F presents the RDX Concentration Data Plots.

2.0 REGULATORY APPLICABILITY DETERMINATION

Title 327 of the IAC Water Pollution Control Board establishes regulations applicable to surface waters in the state of Indiana. Title 327 IAC 2-1-3 (Surface water use designations; multiple uses) Sec. 3(a) states the following:

(1) Surface waters of the state are designated for full-body contact recreation as provided in section 6(d) of this rule.

(2) All waters, except as described in subdivision (5), will be capable of supporting a well balanced, warm water aquatic community and, where natural temperatures will permit, will be capable of supporting put-and-take trout fishing. All waters capable of supporting the natural reproduction of trout as of February 17, 1977, shall be so maintained.

(3) All waters which are used for public or industrial water supply must meet the standards for those uses at the points where the water is withdrawn. This used designating and its corresponding water quality standards are not to be construed as imposing a user restriction on those exercising a desire to exercise the use.

(4) All waters which are used for agricultural purposes must, at a minimum, meet the standards established in section 6(a) of this rule.

(5) All waters in which naturally poor physical characteristics (including lack of sufficient flow), naturally poor chemical quality, or irreversible man-induced conditions,... Specific waters of the state designated for exceptional use are listed in section 11(a) of this rule.

(6) All waters which provide unusual aquatic habitat, which are an integral .... Specific waters of the state designated for exceptional use are listed in section 11(b) of this rule.

LSC and the East Fork White River between LSC and Shoals are not listed in either Title 327 IAC 2-1-11 Sections 11(a) or 11(b).

Based on the above, RDX concentrations in LSC must be limited, at a minimum, to concentrations which would ensure maintenance of a balanced warm water aquatic community, and to protect public water

supplies, wherever water is withdrawn for drinking water or industrial use. These uses require the most stringent criterion.

Title 327 IAC 2-1-6 (Minimum surface water quality standards) states the following in Title 327 IAC 2-1-6(a)(2):

> *(2) At all times, all surface waters outside of mixing zones shall be free of substances in concentrations that on the basis of available scientific data are believed to be sufficient to injure, be chronically toxic to or be carcinogenic, mutagenic, or tetratogenic to humans, animals, aquatic life, or plants. To assure protection against the adverse effects identified in this subdivision, the following requirements are established:*
>
> *(A) A toxic substance or pollutant shall not be present in such waters in concentrations that exceed the most stringent of the following continuous criterion concentrations (CCCs):*
>
> *(i) A chronic aquatic criterion (CAC) to protect aquatic life from chronic toxic effects.*
>
> *(ii) A terrestrial life cycle safe concentration (TLSC) to protect terrestrial organisms from toxic effects that may result form the consumption of aquatic organisms or water from the waterbody.*
>
> *(iii) A human health life cycle safe concentration (HLSC) to protect human health from toxic effects that may result from the consumption of aquatic organisms or drinking water from the waterbody.*
>
> *(iv) For carcinogenic substances, a criterion to protect human health from unacceptable cancer risk of greater than one (1) additional occurrence of cancer per one hundred thousand (100,000) population.*

Title 327 IAC 2-1-6(a)(2)(B) references Table 6-1, which contains a list of surface WQC for specific substances. Criteria are listed for aquatic life (4-day average), for human health (30-day average), and at the point of water intake (30-day average).

Title 327 IAC 2-1-6(a)(2)(C) references procedures for calculation of criterion for substances which are not listed in Table 6-1. Title 327 IAC 2-1-8.3 (Determination of CAC) contains procedures for the development of WQC for protection of aquatic receptors.

Title 327 IAC 2-1-6(a)(2)(E) states the following:

> *(E) The CAC and TLSC for a substance apply in all surface waters outside a mixing zone for a discharge of that substance. Similarly, in waters where a public water system intake is not present or is unaffected by the discharge of a substance, the HLSC and the carcinogenic criterion for that substance based on consumptions of organisms from the waterbody and only incidental ingestion of water shall apply to all surface waters outside the mixing zone for a discharge of that substance. In surface waters where a public water system intake is present, the HLSC and the carcinogenic criterion for a substance based on consumption of organisms and potable water from the waterbody shall apply at the point of the public water system intake.*

Title 327 IAC 2-1-8.6 (Determination of concentration providing an acceptable degree of protection to public health for cancer) contains procedures for the development of WQC for protection of public water supply at the point of intake.

In accordance with Indiana requirements, these surface WQC must be met at the location of the point of use. For protection of aquatic receptors, this location would be below Spring C, where LSC becomes a perennial stream. For carcinogenic substances, this location would be LSC outside of the location where Springs A and C mix with LSC. For protection of public water supplies, this location would be the closest location where LSC surface waters are withdrawn for public water supply.

The discharges from Springs A and C can be considered to be equivalent to NPDES discharge points. Indiana regulations contain provisions for calculation of WQBELs. Title 327 IAC 5-2-11.1 (Establishment of WQBELs for dischargers not discharging to waters within the Great Lakes system) was used to determine the WQBEL for RDX, 2,4-DNT, 2,6-DNT, TNT, and amino-dinitrotoluenes. Title 327 IAC 5-2-11.1 states the following:

> *(b)(4) The criterion to provide an acceptable degree of protection for public health for cancer effects shall apply outside of the mixing zone if the criterion is based on the consumption of organisms and incidental water intake and at the point of the public water system intake if based on the consumption of organisms and drinking water, if this would not cause the criterion based on the consumption of organisms and incidental water intake to be exceeded outside of the mixing zone. For calculation of allowable dilution, one-fourth (1/4) of the fiftieth percentile flow of the receiving stream shall be used if the criterion is based on consumption of organisms and incidental water intake, and the fiftieth percentile flow of the receiving stream at the point of the*

public water system intake can be used if the criterion is based on the consumption of organisms and drinking water.

The surface water features of LSC and the streams into which it flows after it exits NSWC Crane property are shown in Figure 1. LSC flows into Sulphur Creek, which in turn flows into Indian Creek. Indian Creek flows into the East Fork of the White River. IDEM databases were used to determine location of public water supply intakes. No public water supply intakes were identified on Sulphur Creek or Indian Creek.

USGS databases were used to obtain stream flow data. The closest stream gauging information, that was available from the USGS, was at the East Fork White River at Shoals (Appendix A). Appendix A contains the monthly average flow rate in terms of gallons per minute (gpm) for the last ten years (1993 through 2003). The monthly flow rates at this location ranged from a low of 142,279 gpm (November 1999) to a high of 15,762,951 gpm (May 1996).

All RDX, 2,4-DNT, 2,6-DNT, TNT, and amino-dinitrolotuenes in LSC originates from Spring A (from MTA) and Spring C (from OJT). Under base flow conditions, all of the surface waters in LSC are comprised of Springs A and C discharges. Appendix D contains information regarding concentrations of RDX, 2,4-DNT, 2,6-DNT, TNT, and amino-dinitrotoluenes in LSC below Springs A and C.

The location of the nearest "sport-fishing" location down stream of NSWC Crane is on Indian Creek immediately below the point where Sulfur Creek enters Indian Creek. This is approximately 5 miles south of the NSWC Crane boundary.

3.0 HUMAN RECEPTORS

3.1 RDX

Based upon the procedures in Title 327 IAC 2-1-8.6, for public water supply, the RDX WQC, 3.0 µg/L, was calculated (Appendix C.1). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 86 µg/L (Appendix C.1). Note that a WQC could also be calculated according to Title 327 IAC 2-1-8-5 for the non-carcinogenic health effects. However, calculations show that the non-carcinogenic WQC would be, approximately, 35 times greater than WQC based on cancer. Only the more conservative carcinogenic WQC (3 µg/L) is presented.

The information presented in Attachment F demonstrates that RDX concentrations generally decrease with increasing flow. The worst-case combination of RDX concentrations and flow rates was a Spring A RDX concentration of 140 µg/L at an estimated flow rate of 4 gpm. This is greater than the public health WQC (incidental water intake only) of 86 µg/L. However, this low flow condition (4 gpm) would preclude recreational use due to the lack of water in LSC. Additionally, 140 µg/L is greater than the public water supply intake WQC of 3 µg/L, which applies at the point of intake.

RDX concentrations at the nearest downstream gauging location (East Fork White River at Shoals), were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- Spring C RDX concentration is 6.4 µg/L for 30 days
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of RDX occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, RDX concentrations at Shoals would be 0.00027 µg/L (Appendix B.1). This concentration is well below the applicable Indiana RDX WQC for protection of public water supply of 3.0 µg/L. Furthermore, to exceed the RDX WQC for protection of public water supply (3.0 µg/L) at the Shoals water intake would require a fence line RDX concentration of 106,707 µg/L (Appendix B.1). The maximum RDX concentration for either Spring A or Spring C was 140 µg/L (Spring C) on September 10, 2002 (Appendix D, Tables D-1.1 and D-1.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulfur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 86 µg/L included the incidental ingestion of surface water [0.01 liters per day (L/day)] and consumption of stream fish [0.0065 kilograms of fish per day (kg/day)]. The maximum RDX concentration at either Spring A or Spring C (140 µg/L) is above this WQC (Appendix D, Tables D-1.1 and D-1.2). The worst-case combination of RDX concentrations and flow rates was a Spring A RDX concentration of 140 µg/L at an estimated flow rate of 4 gpm. However, this low flow condition (4 gpm) would preclude recreation use due to the lack of water in LSC. Additionally, 140 µg/L is above the public water supply intake WQC of 3 µg/L, which applies at the point of intake.

Based on the above evaluation, RDX concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

3.2 2,4-DNT

Based upon the procedures in Title 327 IAC 2-1-8.6 for public water supply, the 2,4-DNT WQC, 52 µg/L, was determined (Appendix C.2.1). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 195 µg/L (Appendix C.2).

There is no information available to correlate the 2,4-DNT concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum 2,4-DNT concentrations for Spring A and Spring C are 1.2 U and 1.6 U µg/L, respectively (Appendix D, Tables D-2.1 and D-2.2). The spring C 2,4-DNT concentration of 1.6 U µg/L (i.e., not detected) is well below the public health WQC (incidental water intake only) of 195 µg/L and the public water supply intake WQC of 52 µg/L, which applies at the point of intake.

2,4-DNT concentrations at the nearest downstream gauging location (East Fork White River at Shoals) were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- Spring C 2,4-DNT concentration is 1.6 µg/L for 30 days
- LSC flow rate is 6 gpm for 30 days

- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of 2,4-DNT occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, 2,4-DNT concentrations at Shoals would be 0.00007 µg/L (Appendix B.2.1). This concentration is well below the applicable Indiana 2,4-DNT WQC for protection of public water supply of 52 µg/L. Furthermore, to exceed the 2,4-DNT WQC for protection of public water supply (52 µg/L) at the shoals water intake would require a fence line 2,4-DNT concentration of 1,849,000 µg/L (Appendix B.2.1). The maximum 2,4-DNT concentration for either Spring A or Spring C was 1.6 U µg/L (Spring C) on February 28, 1999 (Appendix D, Tables D-2.1 and D-2.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulphur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 195 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish [0.0065 kilogram (kg) of fish per day]. The maximum 2,4-DNT concentration at either Spring A or Spring C (1.6 U µg/L) is below this WQC (Appendix D, Tables D-2.1 and D-2.2). Therefore, "sport-fishing" could take place at the NSWC facility fence line (Appendix C.2).

Based on the above evaluation, 2,4-DNT concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

3.3 2,6-DNT

Based upon the procedures in Title 327 IAC 2-1-8.6 for public water supply, the 2,6-DNT WQC, 29 µg/L, was determined (Appendix C.2.2). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 150 µg/L (Appendix C.2).

There is no information available to correlate the 2,6-DNT concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum 2,6-DNT concentrations for Spring A and Spring C are 1.2 U and 1.6 U µg/L, respectively (Appendix D, Tables D-2.3 and D-2.4). The Spring C 2,6-DNT concentration of 1.6 U µg/L is well below the public

health WQC (incidental water intake only) of 150 µg/L and the public water supply intake WQC of 29 µg/L, which applies at the point of intake.

2,6-DNT concentrations at the nearest downstream gauging location (East Fork White River at Shoals) were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- Spring C 2,6-DNT concentration is 1.6 µg/L for 30 days
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of 2,6-DNT occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, 2,6-DNT concentrations at Shoals would be 0.00007 µg/L (Appendix B.2.2). This concentration is well below the applicable Indiana 2,6-DNT WQC for protection of public water supply of 29 µg/L. Furthermore, to exceed the 2,6-DNT WQC for protection of public water supply (29 µg/L) at the Shoals water intake would require a fence line 2,6-DNT concentration of 1,029,000 µg/L (Appendix B.2.2). The maximum 2,6-DNT concentration for either Spring A or Spring C was 1.6 U µg/L (Spring C) on February 28, 1999 (Appendix D, Tables D-2.3 and D-2.4).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulphur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 150 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish [0.0065 kg of fish per day (kg/day)]. The maximum 2,6-DNT concentration at either Spring A or Spring C (1.6 U µg/L) is below this WQC (Appendix B.2, Table B-4). Therefore, "sport-fishing" could take place at the NSWC facility fence line (Appendix C.2).

Based on the above evaluation, 2,6-DNT concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

3.4 TNT

Based upon the procedures in Title 327 IAC 2-1-8.6 for public water supply, the TNT WQC, 10 µg/L, was determined (Appendix C.3). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 84 µg/L (Appendix C.3). Note that a WQC could also be calculated according to Title 327 IAC 2-1-8-5 for the non-carcinogenic health effects. However, calculations show that the non-carcinogenic WQC would be, approximately, 8 times greater than WQC based on cancer. Only the more conservative carcinogenic WQC (10 µg/L) is presented.

There is no information available to correlate the TNT concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum TNT concentrations for Spring A and Spring C are 5.6 and 1.6 µg/L, respectively (Appendix D, Tables D-3.1 and D-3.2). The Spring C TNT concentration of 5.6 µg/L is well below the public health WQC (incidental water intake only) of 84 µg/L and the public water supply intake WQC of 10 µg/L, which applies at the point of intake.

TNT concentrations at the nearest downstream gauging location (East Fork White River at Shoals) were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- Spring C TNT concentration is 5.6 µg/L for 30 days
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of TNT occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, TNT concentrations at Shoals would be 0.00024 µg/L (Appendix B.3). This concentration is well below the applicable Indiana TNT WQC for protection of public water supply of 10 µg/L. Furthermore, to exceed the TNT WQC for protection of public water supply (10 µg/L) at the Shoals water intake would require a fence line TNT concentration of 355,000 µg/L (Appendix B.3). The maximum TNT concentration for either Spring A or Spring C was 5.6 U µg/L (Spring A) on September 16, 2004 (Appendix D, Tables D-3.1 and D-3.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulphur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 84 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish (0.0065 kg/day). The maximum TNT concentration at either Spring A or Spring C (5.6 µg/L) is below this WQC (Appendix D, Tables D-3.1 and D-3.2). Therefore, "sport-fishing" could take place at the NSWC facility fence line (Appendix C.3).

Based on the above evaluation, TNT concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

3.5 AMINO-DINITROTOLUENES

Based upon the procedures in Title 327 IAC 2-1-8.6, for public water supply, the amino-dinitrotoluenes WQC, 67 µg/L, was determined (Appendix C.4). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 1,359 µg/L (Appendix C.4).

There is no information available to correlate the amino-dinitrotoluenes concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum amino-dinitrotoluenes concentrations for Spring A and Spring C is 70 and 1.6 U µg/L, respectively (Appendix D, Tables D-4.1 and D-4.2, respectively). The Spring A amino-dinitrotoluene concentration of 70 µg/L is above the public water supply intake WQC of 67 µg/L which applies at the point of intake (e.g., Shoals water intake).

Amino-dinitrotoluenes concentration at the nearest downstream gauging location (East Fork White River at Shoals), were calculated under the following assumptions:

- Spring A comprises the entire flow of LSC for 30 days
- Spring A amino-dinitrotoluenes concentration is 70 µg/L for 30 days
- LSC flow rate is 4 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of amino-dinitrotoluenes occurs.

The worst-case combination of amino-dinitrotoluene concentrations and flow rates was a Spring A amino-dinitrotoluene concentration of 0.00295 µg/L at an estimated flow rate of 4 gpm (Appendix B.4).

Under these assumptions, which are more stringent than specified by IDEM regulations, amino-dinitrotoluenes concentrations at Shoals would be 0.00295 µg/L (Appendix B.4). This concentration is well below the applicable Indiana amino-dinitrotoluenes WQC for protection of public water supply of 67 µg/L (Appendix C.4). Furthermore, to exceed the amino-dinitrotoluene WQC for protection of public water supply (67 µg/L) at the Shoals water intake would require a fence line RDX concentration of 2,380,000 µg/L (Appendix B.4). The maximum amino-dinitrotoluene concentration for either Spring A or Spring C was 70 µg/L (Spring A) on September 29, 2000 (Appendix D, Tables D-4.1 and D-4.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulfur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 1.359 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish (0.0175 kg/day) (Appendix C.2). The maximum amino-dinitrotoluenes concentration at either Spring A or Spring C (70 µg/L) is below this WQC (Appendix D, Tables D-4.1 and D-4.2). Therefore, "sport-fishing" could take place at the NSWC facility fence line.

Based on the above evaluation, amino-dinitrotoluenes concentrations in LSC are not presenting significant risks to off-site human receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

3.6 TNT DEGRADATION PRODUCTS

2,2-6,6'-Tetranitro-4,4'-Azoxytoluene (4,4'-TN-AZOXY)

Based upon the procedures in Title 327 IAC 2-1-8.6 for public water supply, the TNT degradation product 4,4'-TN-AZOXY as 1,3,5-trinitrobenzene WQC, 1,000 µg/L, was determined (Appendix C.5). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 19,000 µg/L (Appendix C.5). Note that a WQC could also be calculated according to Title 327 IAC 2-1-8-5 for the non-carcinogenic health effects. However, calculations show that the non-carcinogenic WQC would be, approximately, 8 times greater than WQC based on cancer. Only the more conservative carcinogenic WQC (1,000 µg/L) is presented.

There is no information available to correlate the 4,4'-TN-AZOXY concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum 4,4'-TN-AZOXY concentrations for Spring A and Spring C are 5.6 and 1.6 µg/L, respectively (Appendix D, Tables D-3.1 and D-3.2). The Spring C 4,4'-TN-AZOXY concentration of 5.6 µg/L is well below the public health WQC (incidental water intake only) of 19,000 µg/L and the public water supply intake WQC of 1,000 µg/L, which applies at the point of intake.

TNT concentrations at the nearest downstream gauging location (East Fork White River at Shoals) were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- No 4,4'-TN-AZOXY was detected in Spring; therefore TNT was used as a surrogate for C 4,4'-TN-AZOXY Spring C concentration (5.6 µg/L for 30 days)
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of 4,4'-TN-AZOXY occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, 4,4'-TN-AZOXY concentrations at Shoals would be 0.00024 µg/L (Appendix B.5). This concentration is well below the applicable Indiana 4,4'-TN-AZOXY WQC for protection of public water supply of 1,000 µg/L. Furthermore, to exceed the 4,4'-TN-AZOXY WQC for protection of public water supply (1,000 µg/L) at the Shoals water intake would require a fence line TNT concentration of 35,500,000 µg/L (Appendix B.5). The maximum TNT concentration for either Spring A or Spring C was 5.6 U µg/L (Spring A) on September 16, 2004 (Appendix D, Tables D-3.1 and D-3.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulphur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 19,000 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish (0.0065 kg/day). The maximum 4,4'-TN-AZOXY concentration at either Spring A or Spring C (5.6 µg/L using TNT as the surrogate) is below this WQC (Appendix D, Tables D-3.1 and D-3.2). Therefore, "sport-fishing" could take place at the NSWC facility fence line (Appendix C.3).

Based on the above evaluation, 4,4'-TN-AZOXY concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,6-diamino-4-nitrotoluene (2,6-D-4-NT) / 2,4-diamino-6-nitrotoluene (2,4-D-6-NT)

Based upon the procedures in Title 327 IAC 2-1-8.6 for public water supply, the TNT degradation product 24-D-4-NT / 26-D-4-NT as aminodinitrotoluene WQC, 1,000 µg/L, was determined (Appendix C.4.2). For surface waters at locations where public water supply intakes are not located, the calculated WQC is 1,350 µg/L (Appendix C.4.2). Note that a WQC could also be calculated according to Title 327 IAC 2-1-8-5 for the non-carcinogenic health effects. However, calculations show that the non-carcinogenic WQC would be, approximately, 8 times greater than WQC based on cancer. Only the more conservative carcinogenic WQC (67 µg/L) is presented.

There is no information available to correlate the 24-D-4-NT / 26-D-4-NT concentrations and LSC (e.g., Spring A and Spring C) flowrate; therefore, the following information from the RDX correlation in Section 3.1 was used for worst-case Spring A and Spring C flow conditions (4 and 6 gpm, respectively). The maximum 24-D-4-NT / 26-D-4-NT concentrations for Spring A and Spring C are 5.6 and 0.4 µg/L, respectively (Appendix D, Tables D-3.1 and D-3.2). The Spring C 24-D-4-NT / 26-D-4-NT concentration of 5.6 µg/L is well below the public health WQC (incidental water intake only) of 1,350 µg/L and the public water supply intake WQC of 67 µg/L, which applies at the point of intake.

TNT concentrations at the nearest downstream gauging location (East Fork White River at Shoals) were calculated under the following assumptions:

- Spring C comprises the entire flow of LSC for 30 days
- No 24-D-4-NT / 26-D-4-NT was detected in Spring; therefore TNT was used as a surrogate for C 24-D-4-NT / 26-D-4-NT Spring C concentration (5.6 µg/L for 30 days)
- LSC flow rate is 6 gpm for 30 days
- Public water supply intake is located on East Fork White River at Shoals
- Monthly flow rate at Shoals is 142,279 gpm
- No photolytic or biological degradation of 24-D-4-NT / 26-D-4-NT occurs.

Under these assumptions, which are more stringent than specified by IDEM regulations, 24-D-4-NT / 26-D-4-NT concentrations at Shoals would be 0.00024 µg/L (Appendix B.6). This concentration is well below the applicable Indiana 24-D-4-NT / 26-D-4-NT WQC for protection of public water supply of

1,000 µg/L. Furthermore, to exceed the 24-D-4-NT / 26-D-4-NT WQC for protection of public water supply (1,350 µg/L) at the Shoals water intake would require a fence line TNT concentration of 46,860,000 µg/L (Appendix B.6). The maximum TNT concentration for either Spring A or Spring C was 5.6 U µg/L (Spring A) on September 16, 2004 (Appendix D, Tables D-3.1 and D-3.2).

Additionally, the impact to human receptors from incidental ingestion of surface water and consumption of stream fish (i.e., "sport-fishing" on Indian Creek immediately below the point where Sulphur Creek enters Indian Creek) was evaluated by development of a WQC. This WQC of 1,350 µg/L included the incidental ingestion of surface water (0.01 L/day) and consumption of stream fish (0.0065 kg/day). The maximum 24-D-4-NT / 26-D-4-NT concentration at either Spring A or Spring C (5.6 µg/L using TNT as the surrogate) is below this WQC (Appendix D, Tables D-3.1 and D-3.2). Therefore, "sport-fishing" could take place at the NSWC facility fence line (Appendix C.4.2).

Based on the above evaluation, 24-D-4-NT / 26-D-4-NT concentrations in LSC are not presenting significant risks to off-site receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

4.0 ECOLOGICAL RECEPTORS

4.1 RDX

Title 327 IAC 2-1-6(a)(2)(C) references procedures for calculation of criterion for substances which are not listed in Table 6-1. Title 327 IAC 2-1-8.3 (Determination of CAC) contains procedures for the development of WQC for protection of aquatic receptors.

However, a water quality screening level for RDX using water quality standard methodology which is equivalent to IDEM procedures described in Title 327 IAC 2-1-8.3 (Determination of CAC) has recently been developed for the U.S. Army (Parametrix and ENSR, 2005) (see Appendix E). Note that although the title of this document indicates that it is for marine organisms, WQC developed, for both marine and freshwater organisms, are presented in the document. Acute and chronic WQCs were developed for RDX as 3,100 and 3,070 µg/L, respectively (Parametrix and ENSR, 2005). However, U.S. EPA Region 5 indicated that there was an error in the way that the chronic value was calculated. U.S. EPA Region 5 noted that the authors incorrectly applied the toxicity test RDX solubility concentration of 17 mg/L from one of the studies (Peters et al., 1991) to represent an acute value and inappropriately generated an acute-to-chronic ratio (ACR) of 3.6325. The correct freshwater ACR in Table 7-2 of ENSR (2005), should be the geometric mean of the two freshwater fish (Pimephales promelas) ACR values in Table 6-2 of ENSR (2005) which is 3.3047. This would result in a chronic RDX water screening value of 1.87 mg/L. Therefore, a chronic value of 1,870 µg/L will be used as the screening level for RDX in surface water at NSWC Crane.

A terrestrial life cycle safe concentration (TLSC) was also calculated utilizing (ENSR, 2005). The calculated TLSC was 2,800 µg/L. Appendix E contains a detailed discussion of the justification as well as the calculations for the terrestrial life TLSC.

Additionally, the impact to aquatic receptors was developed based upon the entire impacted waterway. The aquatic water quality for any location along LSC, Sulfur Creek, and East Fork White River indicates that RDX concentrations will not exceed the TLSC of 2,800 µg/L or chronic WQC for freshwater organisms of 1,870 µg/L.

Figures F-1 through F-4 (Appendix F) demonstrate that RDX concentrations generally decrease with increasing flow. The worst-case combination of RDX concentrations and flow rates was a Spring A RDX concentration of 120 µg/L at an estimated flow rate of 4 gpm. This is well below the aquatic life criterion

of 3,100 µg/L, TSCL of 2,800 µg/L, and the public health criteria (incidental water intake only) of 240 µg/L (Appendix E; Appendix C.1.1).

Based on the above evaluation RDX concentrations in LSC are not presenting significant risks to off-site aquatic receptors and are not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

5.0 CONCLUSIONS

RDX

The maximum potential RDX concentration at Shoals of 0.00027 µg/L is below the calculated RDX public water supply WQC of 3.0 µg/L

The maximum Spring A or Spring C concentration of 140 µg/L exceeds the surface WQC for locations where there is no public water supply of 86 µg/L.

The RDX concentration in surface waters is not presenting significant risks to off-site human receptors and is not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,4-DNT

The maximum potential 2,4-DNT concentration at Shoals of 0.00007 µg/L is below the calculated 2,4-DNT public water supply WQC of 52 µg/L.

The maximum Spring A or Spring C concentration of 1.6 U µg/L is below the surface WQC for locations where there is no public water supply of 195 µg/L.

The 2,4-DNT concentration in surface waters is not presenting significant risks to off-site human receptors and is not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

2,6-DNT

The maximum potential 2,6-DNT concentration at Shoals of 0.00007 µg/L is below the calculated 2,6-DNT public water supply WQC of 52 µg/L.

The maximum Spring A or Spring C concentration of 1.6 U µg/L is below the surface WQC for locations where there is no public water supply of 150 µg/L.

The 2,6-DNT concentration in surface waters is not presenting significant risks to off-site human receptors and is not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

TNT

The maximum potential TNT concentration at Shoals of 0.00024 µg/L is below the calculated TNT public water supply WQC of 10 µg/L.

The maximum Spring A or Spring C concentration of 5.6 µg/L is below the surface WQC for locations where there is no public water supply of 84 µg/L.

The TNT concentration in surface waters is not presenting significant risks to off-site human receptors and is not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

AMINO-DINITROTOLUENES

The maximum potential amino-dinitrotoluenes concentration at Shoals of 0.00295 µg/L is below the calculated amino-dinitrotoluenes public water supply WQC of 67 µg/L.

The maximum Spring A or Spring C concentration of 70 µg/L is below the surface WQC for locations where there is no public water supply of 1,359 µg/L.

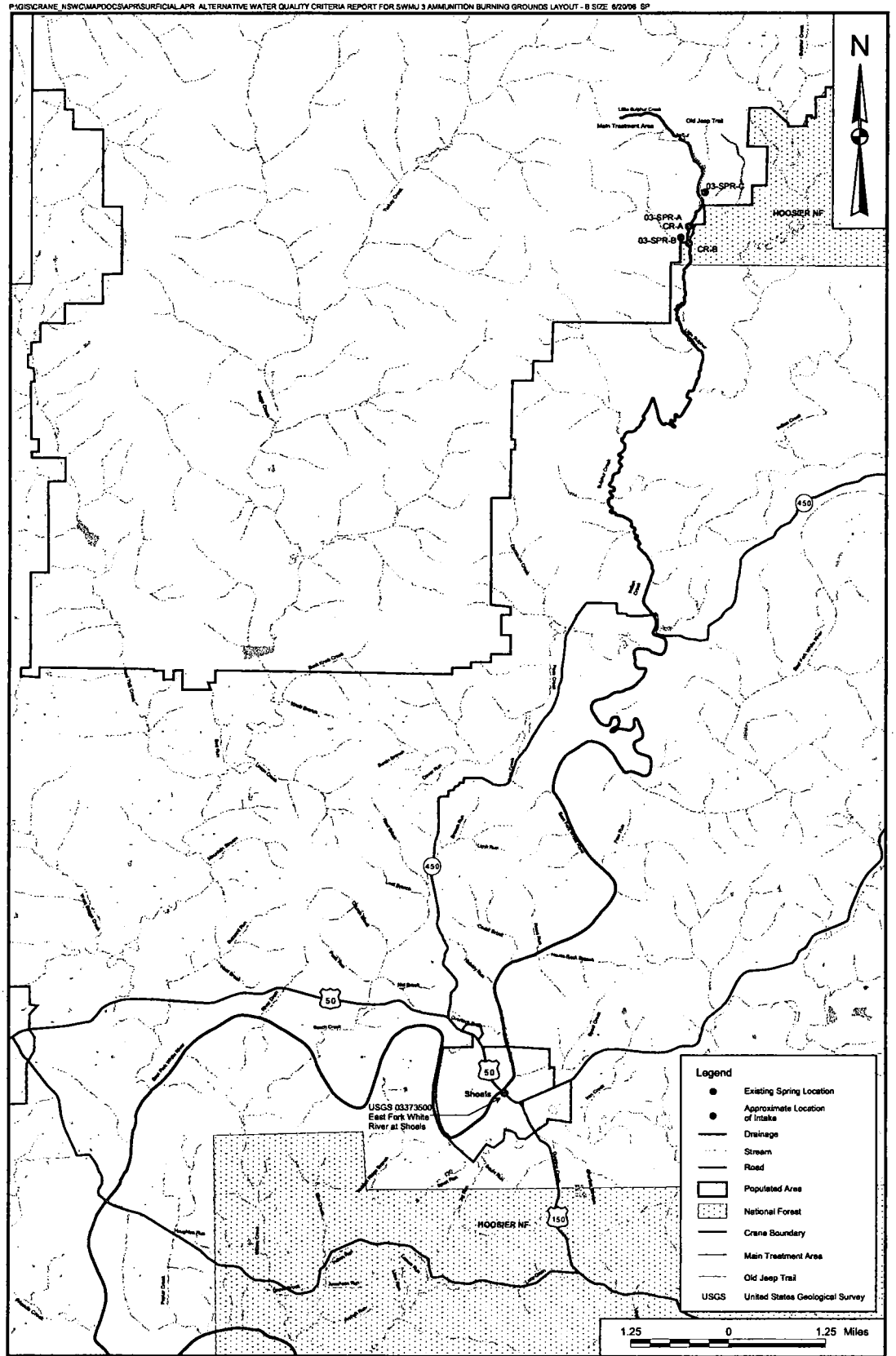
The amino-dinitrotoluenes concentration in surface waters is not presenting significant risks to off-site human receptors and is not affecting state-designated uses of the LSC, Sulphur Creek, and East Fork White River.

REFERENCES

USGS (United States Geological Survey), 2005. Website (http://nwis.waterdata.usgs.gov/in/nwis/monthly/?site_no=03373500&agency_cd=USGS)

Parametrix and ENSR (Parametrix, Inc. and ENSR International), 2005. Derivation of Toxicity Reference Values for the Acute and Chronic Toxicity of Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX) to Marine Aquatic Organism. Final Report. January.

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SURFICIAL.APR ALTERNATIVE WATER QUALITY CRITERIA REPORT FOR SWMU 3 AMMUNITION BURNING GROUNDS LAYOUT - B SIZE 6/20/06 SP



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C. FOSTER	6/09/05
CHECKED BY	DATE
V. PLACHY	6/20/06
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

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SURFACE WATER FEATURES ASSOCIATED
WITH LITTLE SULPHUR CREEK
ALTERNATIVE WATER QUALITY CRITERIA REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER CTO 0311	
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APPENDIX A

STREAM FLOW DATA

USGS 03373500 East Fork White River at Shoals, Indiana												
Monthly mean streamflow (gpm)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1993	4,681,309	2,733,382	5,762,543	6,157,515	2,798,462	2,017,047	1,937,604	1,123,424	1,652,596	2,576,291	8,245,029	4,798,005
1994	3,309,681	5,179,512	2,118,483	5,359,044	5,385,974	894,521	1,028,721	440,303	342,907	225,313	601,434	2,093,797
1995	2,016,598	2,957,797	3,358,155	4,389,120	8,357,236	3,530,057	1,214,088	2,159,327	383,302	363,104	514,809	1,344,698
1996	4,991,003	2,359,057	4,618,473	6,750,421	15,762,951	6,799,792	2,302,953	826,747	750,895	731,146	1,731,142	5,745,039
1997	4,622,961	5,134,629	7,167,834	4,171,437	3,766,591	8,657,953	1,438,055	1,066,423	492,817	223,518	214,092	531,416
1998	1,847,389	2,252,684	3,596,933	8,339,283	6,220,800	8,007,148	3,221,261	1,905,737	391,830	293,536	324,056	776,029
1999	5,008,956	6,117,569	4,739,657	2,325,843	1,796,222	954,664	657,538	246,408	162,477	157,091	142,279	284,110
2000	1,251,341	3,118,479	2,425,035	4,157,074	1,889,579	3,196,576	1,646,313	1,995,055	1,099,188	2,707,350	2,281,409	3,976,195
2001	1,618,934	4,375,655	1,819,562	1,149,457	1,116,243	2,397,656	1,916,060	756,281	1,080,785	3,940,289	2,776,918	9,694,753
2002	2,537,243	3,852,767	5,789,922	7,872,499	13,339,262	3,529,608	1,138,685	432,673	352,781	549,818	1,250,444	2,292,630
2003	3,349,627	3,106,361	5,493,694	3,091,998	5,964,517	3,505,820	3,496,844	1,021,989	1,877,012	ND	ND	ND

Source: USGS Website (http://nwis.waterdata.usgs.gov/in/nwis/monthly/?site_no=03373500&agency_cd=USGS)

June 9, 2005

Water System Number	Water System Name	Intake Type	Source Type	Principal City Served
ACTIVE				
IN5251002	CRANE WATER WORKS	C	GW	CRANE
IN5251003	CRANE DIV, NAVAL SURFACE WARFARE CENTER	C	SW	CRANE
IN5251004	EAST FORK WATER	C	GW	SHOALS
IN5251005	LOOGOOTEE WATER WORKS	C	GW	LOOGOOTEE
IN5251006	PERRY WATER SYSTEM, INC.	C	GW	LOOGOOTEE
IN5251007	SHOALS WATER COMPANY	C	GW	SHOALS
INACTIVE				
IN2140006	HICKORY RIDGE AMISH SCHOOL	NTNC	GW	
IN2140015	WASHINGTON BOAT CLUB AND CAMGROUND 0	NC	GW	
IN2140828	FAIRVIEW AMISH SCHOOL	NC	GW	
IN2510002	U.S. GYPSUM CO.	NTNC	GW	
IN2510800	MARTIN STATE FOREST	NC	SW	SHOALS
IN2510801	ZION AMISH CHRISTIAN SCHOOL	NTNC	GW	SHOALS
IN2510812	IMMANUEL MISSIONARY CHURCH	NTNC	GW	SHOALS
IN5251001	BURNS CITY WATER DEPT	C	SW	LOOGOOTEE
IN5251008	EAST FORK WATER COMPANY-	C	GW	

Intake Type
C — (Community) Serves at least 15 service connections used by year-round residents or regularly serves 25 year-round residents.
NC — (Transient Non-Community) Regularly serves at least 25 non-residential individuals (transient) during 60 or more days per year.
NTNC — (Non-Transient Non-Community) Serves at least the same 25 non-residential individuals during 6 months of the year.

Source Type
GW — Groundwater
SW — Surface water

APPENDIX B

CALCULATIONS AND DATA

B.1 HEXAHYDRO-1,3-5-TRINITRO-1,3,5-TRIAZINE (RDX)

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report RDX Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of RDX at Shoals Water Intake based upon highest concentration of RDX, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of RDX in Spring C for 30 days ($RDX\text{-}Conc_{SpC}$) = 6.4 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of RDX occurs from Spring C to Shoals intake.
7. The RDX concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 2 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
MNX = hexahydro-1,3,5-mononitroso-1,3,5-triazine
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
SpC = Spring C
SW = Surface Water
t = time
TNX = hexahydro-1,3,5-trinitroso-1,3,5-triazine

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report RDX Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of RDX in East Fork White River at the Shoals water intake (RDX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{RDX- } Conc_{Shoals} = \{[\text{RDX- } Conc_{SpC}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (\text{days})]\}$$

$$= \left| \frac{6.4\ \mu g/L}{30\ \text{days}} \right| \ 6\ gpm \left| \frac{30\ \text{days}}{142{,}279\ gpm} \right|$$

$$= \boxed{0.00027\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana RDX criterion for protection of public water supplies?

Is the RDX- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00027 µg/L < 2.00 µg/L.

The RDX concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report RDX Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-1 for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of RDX at mixing zone that would result in the RDX at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of RDX in Spring A for 30 days (RDX- $Conc_{SpA}$) = 71,128 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of RDX occurs from Spring A to Shoals intake.
7. The RDX concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 2 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report RDX Mixing Zone Concentration based on Spring A data.	
BASED ON Media Cleanup Standards Table 2-1 for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of RDX in East Fork White River at Shoals water intake (RDX-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{RDX-Conc}_{Shoals} = \{[\text{RDX- Conc}_{SpA}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (\text{days})]\}$$

$$= \left| \frac{71{,}128\ \mu g/L}{30\ \text{days}} \right| \ 4\ gpm \left| \frac{30\ \text{days}}{142{,}279\ gpm} \right|$$

$$= \boxed{1.9997\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana RDX criterion for protection of public water supplies?

Is the RDX- Conc_{Shoals} < $SW_{Calc\text{-}Conc}$

Is 1.99970 µg/L < 2.00 µg/L.

The RDX concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report MNX Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-mononitroso-1,3,5-triazine (MNX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of MNX at Shoals Water Intake based upon highest concentration of MNX, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of MNX in Spring C for 30 days ($MNX\text{-}Conc_{SpC}$) = 6.4 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of MNX occurs from Spring C to Shoals intake.
7. The MNX concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 0.61 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
MNX = hexahydro-1,3,5-mononitroso-1,3,5-triazine
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
# = Spring C
SW = Surface Water
t = time
TNX = Hexahydro-1,3,5-trinitroso-1,3,5-triazine

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report MNX Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-mononitroso-1,3,5-triazine (MNX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of MNX in East Fork White River at the Shoals water intake (MNX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{MNX- } Conc_{Shoals} = \{[\text{MNX- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \frac{6.4\ \mu g/L}{30\ days} \cdot 6\ gpm \cdot \frac{30\ days}{142{,}279\ gpm}$$

$$= \boxed{0.00027\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana MNX criterion for protection of public water supplies?

Is the MNX- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00027 µg/L < 0.61 µg/L.

The MNX concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report MNX Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-1 for hexahydro-1,3,5-mononitroso-1,3,5-triazine (MNX) a degradation product of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of MNX at mixing zone that would result in the MNX at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of MNX in Spring A for 30 days (MNX- $Conc_{SpA}$) = 2,809,941 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of MNX occurs from Spring A to Shoals intake.
7. The MNX concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 79.0 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - MNX = hexahydro-1,3,5-mononitroso-1,3,5-triazine
   - RDX = hexahydro-1,3,5-mononitroso-1,3,5-triazine
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report MNX Mixing Zone Concentration based on Spring A data.	
BASED ON Media Cleanup Standards Table 2-1 for hexahydro-1,3,5-mononitroso-1,3,5-triazine (MNX) a degradation product of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of MNX in East Fork White River at Shoals water intake (MNX-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{MNX-}\ \text{Conc}_{\text{Shoals}} = \{[\text{MNX-}\ \text{Conc}_{\text{SpA}}\ (\mu g/L)\ /\ t\ (\text{days})] * [\text{FR}_{\text{SpA}}\ (\text{gpm})]\} \div [\text{FR}_{\text{Shoals}}\ (\text{gpm})/\ t\ (\text{days})]\}$$

$$= \left|\frac{2{,}809{,}941\ \mu g/L}{30\ \text{days}}\right| \quad 4\ \text{gpm} \left|\frac{30\ \text{days}}{142{,}279\ \text{gpm}}\right|$$

$$= \boxed{78.9981\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Table 2-4 MNX criterion for protection of surface water/public water supplies?

Is the MNX- $\text{Conc}_{\text{Shoals}}$ < $\text{SW}_{\text{Calc-Conc}}$

Is 78.99810 µg/L < 79.0 µg/L.

The MNX concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report TNX Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of TNX at Shoals Water Intake based upon highest concentration of TNX, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of TNX in Spring C for 30 days ($TNX\text{-}Conc_{SpC}$) = 6.4 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNX occurs from Spring C to Shoals intake.
7. The TNX concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 79 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
SpC = Spring C
SW = Surface Water
t = time
TNX = hexahydro-1,3,5-trinitroso-1,3,5-triazine

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report TNX Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Calculations:

1. Calculate the concentration of TNX in East Fork White River at the Shoals water intake (TNX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$TNX\text{-}\ Conc_{Shoals} = \{[TNX\text{-}\ Conc_{SpC}\ (\mu g/L)\ /\ t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{6.4\ \mu g/L}{30\ days}\right| \quad 6\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00027\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana TNX criterion for protection of public water supplies?

Is the TNX- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00027 µg/L < 79 µg/L.

The TNX concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report TNX Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX) a degradation product of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of TNX at mixing zone that would result in the TNX at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of TNX in Spring A for 30 days (TNX- $Conc_{SpA}$) = 2,809,941 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNX occurs from Spring A to Shoals intake.
7. The TNX concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 79 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
   - SpA = Spring A
   - SW = Surface Water
   - t = time
   - TNX = hexahysro-1,3,5-trinitroso-1,3,5-triazine

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report TNX Mixing Zone Concentration based on Spring A data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX) a degradation product of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Calculations:

1. Calculate the concentration of TNX in East Fork White River at Shoals water intake (TNX-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{TNX-}\ \text{Conc}_{\text{Shoals}} = \{[\text{TNX-}\ \text{Conc}_{\text{SpA}}\ (\mu g/L) / t\ (\text{days})] * [\text{FR}_{\text{SpA}}\ (\text{gpm})]\} \div [\text{FR}_{\text{Shoals}}\ (\text{gpm}) / t\ (\text{days})]\}$$

$$= \left| \frac{2{,}809{,}941\ \mu g/L}{30\ \text{days}} \right| \quad 4\ \text{gpm} \left| \frac{30\ \text{days}}{142{,}279\ \text{gpm}} \right|$$

$$= \boxed{78.9981\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Table 2-4 TNX criterion for protection of surface water/public water supplies?

Is the TNX- $\text{Conc}_{\text{Shoals}}$ < $\text{SW}_{\text{Calc-Conc}}$

Is 78.99810 µg/L < 79.0 µg/L.

The TNX concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report DNX Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-dinitroso-1,3,5-triazine (DNX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of DNX at Shoals Water Intake based upon highest concentration of DNX, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of DNX in Spring C for 30 days
   ($DNX\text{-}Conc_{SpC}$) = 6.4 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of DNX occurs from Spring C to Shoals intake.
7. The DNX concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 79 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
MNX = hexahydro-1,3,5-mononitroso-1,3,5-triazine
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
# = Spring C
SW = Surface Water
t = time
TNX = hexahydro-1,3,5-trinitroso-1,3,5-triazine

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report DNX Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-dinitroso-1,3,5-triazine (DNX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Calculations:

1. Calculate the concentration of DNX in East Fork White River at the Shoals water intake (DNX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

DNX- $Conc_{Shoals}$ = {[DNX- $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{6.4 \text{ µg/L}}{30 \text{ days}} \right| \quad 6 \text{ gpm} \left| \frac{30 \text{ days}}{142{,}279 \text{ gpm}} \right|$$

$$= \boxed{0.00027 \text{ µg/L}}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana DNX criterion for protection of public water supplies?

Is the DNX- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00027 µg/L < 79 µg/L.

The DNX concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report DNX Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-dinitroso-1,3,5-triazine (DNX) a degradation product of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of DNX at mixing zone that would result in the DNX at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of DNX in Spring A for 30 days (DNX- $Conc_{SpA}$) = 2,809,941 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of DNX occurs from Spring A to Shoals intake.
7. The DNX concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 79.0 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - RDX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report DNX Mixing Zone Concentration based on Spring A data.	
BASED ON Media Cleanup Standards Table 2-4 for hexahydro-1,3,5-dinitroso-1,3,5-triazine (DNX) a degradation product of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Calculations:

1. Calculate the concentration of DNX in East Fork White River at Shoals water intake (DNX-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{DNX-}\ \text{Conc}_{\text{Shoals}} = \{[\text{DNX-}\ \text{Conc}_{\text{SpA}}\ (\mu g/L)\ /\ t\ (\text{days})] * [\text{FR}_{\text{SpA}}\ (\text{gpm})]\} \div [\text{FR}_{\text{Shoals}}\ (\text{gpm})/\ t\ (\text{days})]\}$$

$$= \left|\frac{2{,}809{,}941\ \mu g/L}{30\ \text{days}}\right| \quad 4\ \text{gpm} \left|\frac{30\ \text{days}}{142{,}279\ \text{gpm}}\right|$$

$$= \boxed{78.9981\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Table 2-4 DNX criterion for protection of surface water/public water supplies?

Is the DNX- $\text{Conc}_{\text{Shoals}}$ < $\text{SW}_{\text{Calc-Conc}}$

Is 78.99810 µg/L < 79.0 µg/L.

The DNX concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

B.2 DINITROTOLUENE

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,4,6-trinitrotoluene at the Fence Line.			
BASED ON Media Cleanup Standards Table 2-4 for 2,4,6-trinitrotoluene (TNT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of TNT at the Shoals Water Intake based upon highest TNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of TNT in Spring C for 30 days ($TNT\text{-}Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNT occurs from Spring C to Shoals intake.
7. The TNT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 2.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
TNT	= 2,4,6-trinitrotoluene	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of TNT in East Fork White River at Shoals water intake ($TNT\text{-}Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$TNT\text{-}Conc_{Shoals} = \{[TNT\text{-}Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana TNT criterion for protection of public water supplies?

Is the $TNT\text{-}Conc_{Shoals} < SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 2.0 µg/L.

The TNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CALCULATION WORKSHEET tab] PAGE 1 of 1 .

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,4,6-trinitrotoluene at the Mixing Zone	
BASED ON Media Cleanup Standards Table 2-4 for 2,4,6-trinitrotoluene (TNT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of TNT at fence line that would result in the TNT at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of TNT in Spring A for 30 days (TNT- $Conc_{SpA}$) = 71,115 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNT occurs from Spring A to Shoals intake.
7. The TNT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 2.0 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	TNT	= 2,4,6-trinitrotoluene
Conc	= concentration	SpA	= Spring A
FR	= flowrate	SW	= Surface Water
gpm	= gallons per minute	t	= time

Calculations:

1. Calculate the concentration of TNT in East Fork White River at Shoals water intake (TNT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(TNT- $Conc_{Shoals}$ = {[TNT- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{71{,}115 \text{ µg/L}}{30 \text{ days}}\right| \; 4 \text{ gpm} \left|\frac{30 \text{ days}}{142{,}279 \text{ gpm}}\right|$$

$$= \boxed{1.9993 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana TNT criterion for protection of public water supplies?

Is the TNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 1.99930 µg/L < 2.0 µg/L.

The TNT concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,4-dinitrotoluene at the Fence Line.			
BASED ON Media Cleanup Standards Table 2-4 for 2,4-dinitrotoluene (2,4-DNT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2,4-DNT at the Shoals Water Intake based upon highest 2,4-DNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,4-DNT in Spring C for 30 days (2,4-DNT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,4-DNT occurs from Spring C to Shoals intake.
7. The 2,4-DNT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 1.1 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
2,4-DNT	= 2,4-dinitrotoluene	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,4-DNT in East Fork White River at Shoals water intake (2,4-D $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{2,4-DNT-}\ Conc_{Shoals} = \{[\text{2,4-DNT-}\ Conc_{SpC}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (\text{days})]\}$$

$$= \frac{1.6\ \mu g/L}{30\ \text{days}} \quad 6\ gpm \quad \frac{30\ \text{days}}{142{,}279\ gpm}$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,4-DNT criterion for protection of public water supplies?

Is the DNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 1.1 µg/L.

The 2,4-DNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,4-dinitrotoluene at the Mixing Zone	
BASED ON Media Cleanup Standards Table 2-4 for 2,4-dinitrotoluene (2,4-DNT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2,4-DNT at fence line that would result in the 2,4-DNT at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,4-DNT in Spring A for 30 days
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
   (2,4-DNT- $Conc_{SpA}$) = 39,113
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,4-DNT occurs from Spring A to Shoals intake.
7. The 2,4-DNT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 1.1 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
2,4-DNT	= 2,4-dinitrotoluene	SW	= Surface Water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,4-DNT in East Fork White River at Shoals water intake (2,4-DNT $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$(2,4\text{-DNT-}\ Conc_{Shoals} = \{[2,4\text{-DNT-}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)]\ *\ [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{39{,}113\ \ \mu g/L}{30\ \ days}\right|\ 4\ \ gpm\ \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{1.0996\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,4-DNT criterion for protection of public water supplies?

Is the DNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 1.09960 µg/L < 1.1 µg/L.

The 2,4-DNT concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,6-dinitrotoluene at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-4 for 2,6-dinitrotoluene (2,6-DNT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2,6-DNT at Shoals Water Intake based upon highest 2,6-DNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,6-DNT in Spring C for 30 days (2,6-DNT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,6-DNT occurs from Spring C to Shoals intake.
7. The 2,6-DNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 5.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpC	= Spring C
2,6-DNT	= 2,6-dinitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,6-DNT in East Fork White River at Shoals water intake (2,6-DN $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{2,6-DNT-}\ Conc_{Shoals} = \{[\text{2,6-DNT-}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,6-DNT criterion for protection of public water supplies?

Is the DNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 5.0 µg/L.

The 2,6-DNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,6-dinitrotoluene at the Mixing Zone.	
BASED ON Media Cleanup Standards Table 2-4 for 2,6-dinitrotoluene (2,6-DNT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2,6-DNT at the mixing zone that would result in the 2,6-DNT at Shoals exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,6-DNT in Spring A for 30 days (2,6-DNT- $Conc_{SpA}$) = 177,414 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,6-DNT occurs from Spring A to Shoals intake.
7. The 2,6-DNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 5.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
2,6-DNT	= 2,6-dinitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,6-DNT in East Fork White River at Shoals water intake (2,6-[$Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(2,6-DNT- $Conc_{Shoals}$ = {[2,6-DNT- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{177{,}414 \ \mu g/L}{30 \ days} \right| \ 4 \ gpm \left| \frac{30 \ days}{142{,}279 \ gpm} \right|$$

$$= \boxed{4.9878 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,6-DNT criterion for protection of public water supplies?

Is the DNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 4.98780 µg/L < 5.0 µg/L.

The 2,6-DNT concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,6-dinitrotoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2,6-dinitrotoluene (2,6-DNT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 1,3,5-trinitrobenzene at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 1,3,5-trinitrobenzene (1,3,5-TNB).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 1,3,5-TNB at Shoals Water Intake based upon highest 1,3,5-TNB concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 1,3,5-TNB in Spring C for 30 days (1,3,5-TNB- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,3,5-TNB occurs from Spring C to Shoals intake.
7. The 1,3,5-TNB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 11.0 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	1,3,5-TNB	= 1,3,5-trinitrobenzene

Calculations:

1. Calculate the concentration of 1,3,5-TNB in East Fork White River at Shoals water intake (1,3,5-TNB- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{1,3,5-TNB-}\ Conc_{Shoals} = \{[\text{1,3,5-TNB-}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 1,3,5-TNB criterion for protection of public water supplies?

Is the 1,3,5-TNB- $Conc_{Shoal}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 11.0 µg/L.

The 1,3,5-TNB concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,3,5-trinitrobenzene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 1,3,5-trinitrobenzene (1,3,5-TNB a degradation product of 2,4,6-Trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 1,3,5-TNB at the mixing zone that would result in the 1,3,5-TNB at Shoals exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 1,3,5-TNB in Spring A for 30 days (1,3,5-TNB- $Conc_{SpA}$) = 390,310 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,3,5-TNB occurs from Spring A to Shoals intake.
7. The 1,3,5-TNB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 11.0 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpA	= Spring A
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	1,3,5-TNB	= 1,3,5-trinitrobenzene

Calculations:

1. Calculate the concentration of 1,3,5-TNB in East Fork White River at Shoals water intake (1,3,5-TNB $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$(1,3,5\text{-TNB-}\ Conc_{Shoals} = \{[1,3,5\text{-TNB-}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \frac{390{,}310\ \mu g/L}{30\ days} \quad \frac{4\ gpm}{} \quad \frac{30\ days}{142{,}279\ gpm}$$

$$= \boxed{10.9731\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 1,3,5-TNB criterion for protection of public water supplies?

Is the 1,3,5-TNB- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 10.97310 µg/L < 11.0 µg/L.

The 1,3,5-TNB concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 1,3-dinitrobenzene 1,3-DNB at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 1,3-dinitrobenzene 1,3-DNB (1,3-DNB).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 1,3-DNB at Shoals Water Intake based upon highest 1,3-DNB concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 1,3-DNB in Spring C for 30 days (1,3-DNB- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,3-DNB occurs from Spring C to Shoals intake.
7. The 1,3-DNB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 1.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpC	= Spring C
1,3-DNB	= 1,3-dinitrobenzene 1,3-DNB	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 1,3-DNB in East Fork White River at Shoals water intake (1,3-D $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{1,3-DNB- } Conc_{Shoals} = \{[\text{1,3-DNB- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \quad 6\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 1,3-DNB criterion for protection of public water supplies?

Is the 1,3-DNB- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 1.0 µg/L.

The 1,3-DNB concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,3-dinitrobenzene 1,3-DNB at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 1,3-dinitrobenzene 1,3-DNB (1,3-DNB a degradation product of 2,4,6-trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY EILove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 1,3-DNB at the mixing zone that would result in the 1,3-DNB at Shoals exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 1,3-DNB in Spring A for 30 days(1,3-DNB- $Conc_{SpA}$) = 35,483 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,3-DNB occurs from Spring A to Shoals intake.
7. The 1,3-DNB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 1.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
1,3-DNB	= 1,3-dinitrobenzene 1,3-DNB	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 1,3-DNB in East Fork White River at Shoals water intake (1,3-DNB $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$(1,3\text{-DNB-}\ Conc_{Shoals} = \{[1,3\text{-DNB-}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)]\ *\ [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{35{,}483\ \ \mu g/L}{30\ \ days}\right| \quad 4\ \ gpm \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{0.9976\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 1,3-DNB criterion for protection of public water supplies?

Is the 1,3-DNB- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.99760 µg/L < 1.0 µg/L.

The 1,3-DNB concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,4,6-trinitrophenyl-N-methylnitramine at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 2,4,6-trinitrophenyl-N-methylnitramine (Tetryl).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of Tetryl at Shoals Water Intake based upon highest Tetryl concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of Tetryl in Spring C for 30 days (Tetryl- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of Tetryl occurs from Spring C to Shoals intake.
7. The Tetryl concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 360 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	Tetryl	= 2,4,6-trinitrophenyl-N-methylnitramine

Calculations:

1. Calculate the concentration of Tetryl in East Fork White River at Shoals water intake (Tetryl $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{Tetryl- } Conc_{Shoals} = \{[\text{Tetryl- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana Tetryl criterion for protection of public water supplies?

Is the Tetryl- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 360 µg/L.

The Tetryl concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,4,6-trinitrophenyl-N-methylnitramine at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2,4,6-trinitrophenyl-N-methylnitramine (Tetryl a degradation product of 2,4,6-trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of Tetryl at the mixing zone that would result in the Tetryl at Shoals water exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of Tetryl in Spring A for 30 days
   (Tetryl- $Conc_{SpA}$) = 12,773,793 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of Tetryl occurs from Spring A to Shoals intake.
7. The Tetryl concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 360 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpA	= Spring A
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	Tetryl	= 2,4,6-trinitrophenyl-N-methylnitramine

Calculations:

1. Calculate the concentration of Tetryl in East Fork White River at Shoals water intake (Tetryl $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

   (Tetryl- $Conc_{Shoals}$ = {[Tetryl- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

   $$= \left|\frac{12{,}773{,}793 \text{ µg/L}}{30 \text{ days}}\right| \; 4 \text{ gpm} \left|\frac{30 \text{ days}}{142{,}279 \text{ gpm}}\right|$$

   $$= \boxed{359.1196 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana Tetryl criterion for protection of public water supplies?

   Is the Tetryl- $Conc_{Shoal}$ < $SW_{Calc\text{-}Conc}$

   Is 359.1196 µg/L < 360.0 µg/L.

The Tetryl concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

fc NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report nitrobenzene at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-4 for nitrobenzene (NB).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of NB at Shoals Water Intake based upon highest NB concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of NB in Spring C for 30 days (NB- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of NB occurs from Spring C to Shoals intake.
7. The NB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 17 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	NB	= nitrobenzene
Conc	= concentration	SpC	= Spring C
FR	= flowrate	SW	= Surface water
gpm	= gallons per minute	t	= time

Calculations:

1. Calculate the concentration of NB in East Fork White River at Shoals water intake (NB- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$NB\text{-}\ Conc_{Shoals} = \{[NB\text{-}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \ \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana NB criterion for protection of public water supplies?

Is the NB- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 17.0 µg/L.

The NB concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report nitrobenzene at the Mixing Zone.	
BASED ON Media Cleanup Standards Table 2-4 for nitrobenzene (NB a degradation product of 2,4,6-trinitrotoluene (TNT) .	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of NB at the mixing zone that would result in the NB at Shoals water intake exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of NB in Spring A for 30 days (NB- $Conc_{SpA}$) = 603,207 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of NB occurs from Spring A to Shoals intake.
7. The NB concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 17.0 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	NB	= nitrobenzene
Conc	= concentration	SpA	= Spring A
FR	= flowrate	SW	= Surface water
gpm	= gallons per minute	t	= time

Calculations:

1. Calculate the concentration of NB in East Fork White River at Shoals water intake (NB- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(NB- $Conc_{Shoals}$ = {[NB- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{603{,}207 \ \mu g/L}{30 \ days} \right| \ 4 \ gpm \left| \frac{30 \ days}{142{,}279 \ gpm} \right|$$

$$= \boxed{16.9584 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana NB criterion for protection of public water supplies?

Is the NB- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 16.95840 µg/L < 17.0 µg/L.

The NB concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2-amino-4,6-dinitrotoluene at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 2-amino-4,6-dinitrotoluene (2AmDNT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2AmDNT at Shoals Water Intake based upon highest 2AmDNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2AmDNT in Spring C for 30 days (2AmDNT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2AmDNT occurs from Spring C to Shoals intake.
7. The 2AmDNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 18 µg/L.
8. Terminology

2AmDNT	= 2-amino-4,6-dinitrotoluene	gpm	= gallons per minute
µg	= microgram	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2AmDNT in East Fork White River at Shoals water intake (2Am $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{2AmDNT- } Conc_{Shoals} = \{[\text{2AmDNT} \cdot Conc_{SpC}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpC}\ (\text{gpm})]\} \div [FR_{Shoals}\ (\text{gpm}) / t\ (\text{days})]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ \text{days}}\right| \ 6\ \text{gpm} \left|\frac{30\ \text{days}}{142{,}279\ \text{gpm}}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2AmDNT criterion for protection of public water supplies?

Is the 2AmDNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 18 µg/L.

The 2AmDNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2-amino-4,6-dinitrotoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2-amino-4,6-dinitrotoluene (2AmDNT a degradation product of 2,4,6-Trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2AmDNT at the mixing zone that would result in the 2AmDNT at Shoals exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2AmDNT in Spring A for 30 days
   (2AmDNT- $Conc_{SpA}$) = 638,690 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2AmDNT occurs from Spring A to Shoals intake.
7. The 2AmDNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 18 µg/L.
8. Terminology

2AmDNT	= 2-amino-4,6-dinitrotoluene	gpm	= gallons per minute
µg	= microgram	L	= liter
Calc	= calculated	SpA	= Spring A
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2AmDNT in East Fork White River at Shoals water intake (2AmDN' $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

$$(2AmDNT\text{-}\ Conc_{Shoals} = \{[2AmDNT\text{-}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{638{,}690\ \ \mu g/L}{30\ \ days}\right| \ 4\ \ gpm \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{17.9560\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2AmDNT criterion for protection of public water supplies?

   Is the 2AmDNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

   Is 17.95600 µg/L < 18.0 µg/L.

The 2AmDNT concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 4-amino-2,6-dinitrotoluene at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 4-amino-2,6-dinitrotoluene (4AmDNT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Objective: Estimate the concentration of 4AmDNT at Shoals Water Intake based upon highest 4AmDNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4AmDNT in Spring C for 30 days (4AmDNT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 day (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4AmDNT occurs from Spring C to Shoals intake.
7. The 4AmDNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 11.0 µg/L.
8. Terminology

4AmDNT	= 4-amino-2,6-dinitrotoluene	gpm	= gallons per minute
µg	= microgram	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 4AmDNT in East Fork White River at Shoals water intake (4Am $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$4AmDNT\text{-}\ Conc_{Shoals} = \{[4AmDNT\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4AmDNT criterion for protection of public water supplies?

Is the 4AmDNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 11 µg/L.

The 4AmDNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 4-amino-2,6-dinitrotoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 4-amino-2,6-dinitrotoluene (4AmDNT a degradation product of 2,4,6-trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of 4AmDNT at the mixing zone that would result in the 4AmDNT at Shoals exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4AmDNT in Spring A for 30 days
   (4AmDNT- $Conc_{SpA}$) = 390,310 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4AmDNT occurs from Spring A to Shoals intake.
7. The 4AmDNT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 11.0 µg/L.
8. Terminology

4AmDNT	= 4-amino-2,6-dinitrotoluene	gpm	= gallons per minute
µg	= microgram	L	= liter
Calc	= calculated	SpA	= Spring A
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 4AmDNT in East Fork White River at Shoals water intake (4AmDNT- $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

$$(4AmDNT\text{-}\ Conc_{Shoals} = \{[4AmDNT\cdot Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)]\ *\ [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{390{,}310\ \ \mu g/L}{30\ \ days}\right|\ 4\ \ gpm\ \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{10.9731\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4AmDNT criterion for protection of public water supplies?

   Is the 4AmDNT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

   Is 10.97310 µg/L < 11.0 µg/L.

The 4AmDNT concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,2'-6,6'-tetranitro-4,4'-azoxytoluene at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-4 for 2,2'-6,6'-tetranitro-4,4'-azoxytoluene (4,4-TN-AZOXY).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 4,4-TN-AZOXY at Shoals Water Intake based upon highest 4,4-TN-AZOXY concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4,4-TN-AZOXY in Spring C for 30 days (4,4-TN-AZOXY- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4,4-TN-AZOXY occurs from Spring C to Shoals intake.
7. The 4,4-TN-AZOXY concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 18 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	4,4-TN-AZOXY	= 2,2'-6,6'-tetranitro-4,4'-azoxytoluene

Calculations:

1. Calculate the concentration of 4,4-TN-AZOXY in East Fork White River at Shoals water intake (4,4-TN-AZOXY- ConcShoals) in (µg/L).

BASIS: 30 days

$$\text{4,4-TN-AZOXY- } Conc_{Shoals} = \{[\text{4,4-TN-AZOXY } Conc_{SpC} (\mu g/L) / t \text{ (days)}] * [FR_{SpC} \text{ (gpm)}]\} \div [FR_{Shoals} \text{ (gpm)}/ t \text{ (days)}]\}$$

$$= \left|\frac{1.6 \ \mu g/L}{30 \ \text{days}}\right| \ 6 \ \text{gpm} \left|\frac{30 \ \text{days}}{142{,}279 \ \text{gpm}}\right|$$

$$= \boxed{0.00007 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4,4-TN-AZOXY criterion for protection of public water supplies?

Is the 4,4-TN-AZOXY- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 18 µg/L.

The 4,4-TN-AZOXY concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,2'-6,6'-tetranitro-4,4'-azoxytoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2,2'-6,6'-tetranitro-4,4'-azoxytoluene (4,4-TN-AZOXY a degradation product of 2,4,6-trinitrotoluene (TNT) .		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 4,4-TN-AZOXY at the mixing zone that would result in the 4,4-TN-AZOXY exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4,4-TN-AZOXY in Spring A for 30 days (4,4-TN-AZOXY- $Conc_{SpA}$) = 638,690 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4,4-TN-AZOXY occurs from Spring A to Shoals intake.
7. The 4,4-TN-AZOXY concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 18 µg/L.
8. Terminology

µg	= microgram	L	= liter
Calc	= calculated	SpA	= Spring A
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time
gpm	= gallons per minute	4,4-TN-AZOXY	= 2,2'-6,6'-tetranitro-4,4'-azoxytoluene

Calculations:

1. Calculate the concentration of 4,4-TN-AZOXY in East Fork White River at Shoals water intake (4,4-TN-AZOXY-ConcShoals) in (µg/L).

   BASIS: 30 days

$$(4,4\text{-TN-AZOXY-}\ Conc_{Shoals} = \{[4,4\text{-TN-AZOXY}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \frac{638{,}690\ \ \mu g/L}{30\ \ days} \quad 4\ \ gpm \quad \frac{30\ \ days}{142{,}279\ \ gpm}$$

$$= \boxed{17.9560\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4,4-TN-AZOXY criterion for protection of public water supplies?

   Is the 4,4-TN-AZOXY- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

   Is 17.9560 µg/L < 18.0 µg/L.

The 4,4-TN-AZOXY concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCA Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1,1,2-tetrachloroethane (PCA).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of PCA at Shoals Water Intake based upon highest concentration of PCA, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of PCA in Spring C for 30 days
   (PCA- $Conc_{SpC}$) = 0.5 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of PCA occurs from Spring C to Shoals intake.
7. The PCA concentration calculated based upon Table 2-3 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 0.52 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg	= microgram	PCA	= 1,1,1,2-tetrachloroethane
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface Water
DNX	= hexahydro-1,3,5-dinitroso-1,3,5-triazine	t	= time
FR	= flowrate		
gpm	= gallons per minute		
L	= liter		

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCA Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1,1,2-tetrachloroethane (PCA).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of PCA in East Fork White River at the Shoals water intake (PCA- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$PCA\text{-}\ Conc_{Shoals} = \{[PCA\text{-}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{0.5\ \mu g/L}{30\ days}\right| \quad 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00002\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana PCA criterion for protection of public water supplies?

Is the PCA- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00002 µg/L < 0.52 µg/L.

The PCA concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCA Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1,1,2-tetrachloroethane (PCA).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of PCA at mixing zone that would result in the PCA at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of PCA in Spring A for 30 days (PCA- $Conc_{SpA}$) = 18,486 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of PCA occurs from Spring A to Shoals intake.
7. The PCA concentration calculated based upon Table 2-3 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 0.52 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - PCA = 1,1,1,2-tetrachloroethane
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCA Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1,1,2-tetrachloroethane (PCA).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Calculations:

1. Calculate the concentration of PCA in East Fork White River at Shoals water intake (PCA-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{PCA-Conc}_{Shoals} = \{[\text{PCA- Conc}_{SpA}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (\text{days})]\}$$

$$= \left| \frac{18{,}486\ \mu g/L}{30\ \text{days}} \right| \ 4\ gpm \left| \frac{30\ \text{days}}{142{,}279\ gpm} \right|$$

$$= \boxed{0.5197\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana PCA criterion for protection of public water supplies?

Is the PCA- Conc_{Shoals} < $SW_{Calc\text{-}Conc}$

Is 0.51970 µg/L < 0.52 µg/L.

The PCA concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report PCE Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-3 for perchloroethylene (PCE).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/24/2010

Objective: Estimate the concentration of PCE at Shoals Water Intake based upon highest concentration of PCE, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of PCE in Spring C for 30 days (PCE- $Conc_{SpC}$) = 0.5 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of PCE occurs from Spring C to Shoals intake.
7. The PCE concentration calculated based upon Table 2-3 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 100 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
PCE = perchloroethylene
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for perchloroethylene (PCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of PCE in East Fork White River at the Shoals water intake (PCE- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

PCE- $Conc_{Shoals}$ = {[PCE- $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm) / *t* (days)]}

$$= \left| \frac{0.5 \ \mu g/L}{30 \ days} \right| \ 6 \ gpm \left| \frac{30 \ days}{142{,}279 \ gpm} \right|$$

= **0.00002 µg/L**

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana PCE criterion for protection of public water supplies?

Is the PCE- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00002 µg/L < 100 µg/L.

The PCE concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for perchloroethylene (PCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of PCE at mixing zone that would result in the PCE at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of PCE in Spring A for 30 days (PCE- $Conc_{SpA}$) = 3,556,890 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of PCE occurs from Spring A to Shoals intake.
7. The PCE concentration calculated based upon Table 2-3 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 100 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - PCE = perchloroethylene
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report PCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for perchloroethylene (PCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of PCE in East Fork White River at Shoals water intake (PCE-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{PCE-Conc}_{Shoals} = \{[\text{PCE- Conc}_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/ t\ (days)]\}$$

$$= \left|\frac{3{,}556{,}890\ \mu g/L}{30\ \ days}\right| \quad 4\ \ gpm \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{99.9976\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana PCE criterion for protection of public water supplies?

Is the PCE- Conc_{Shoals} < $SW_{Calc\text{-}Conc}$

Is 99.99760 µg/L < 100 µg/L.

The PCE concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,1-DCE Shoals Water Intake Concentration based on Spring C dat			
BASED ON Media Cleanup Standards Table 2-3 for 1,1-dichloroethene (1,1-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of 1,1-DCE at Shoals Water Intake based upon highest concentration of 1,1-DCE, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of 1,1-DCE in Spring C for 30 days (1,1-DCE- $Conc_{SpC}$) = 0.5 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,1-DCE occurs from Spring C to Shoals intake.
7. The 1,1-DCE concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 7 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
1,1-DCE = 1,1-dichloroethene
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,1-DCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1-dichloroethene (1,1-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of 1,1-DCE in East Fork White River at the Shoals water intake (1,1-DC $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$1,1\text{-DCE-}\ Conc_{Shoals} = \{[1,1\text{-DC}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left| \frac{0.5\ \mu g/L}{30\ days} \right| \ 6\ gpm \left| \frac{30\ days}{142{,}279\ gpm} \right|$$

$$= \boxed{0.00002\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana 1,1-DCE criterion for protection of public water supplies?

Is the DCE- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00002 µg/L < 7.00 µg/L.

The 1,1-DCE concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,1-DCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1-dichloroethene (1,1-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of 1,1-DCE at mixing zone that would result in the 1,1-DCE at Shoals water exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of 1,1-DCE in Spring A for 30 days (1,1-DCE- $Conc_{SpA}$) = 248,973 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 1,1-DCE occurs from Spring A to Shoals intake.
7. The 1,1-DCE concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 7 µg/L.
8. Terminology

µg = microgram
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
L = liter
1,1-DCE = 1,1-dichloroethene
SpA = Spring A
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 1,1-DCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for 1,1-dichloroethene (1,1-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of 1,1-DCE in East Fork White River at Shoals water intake (1,1-DCE-ConcShoals) in

BASIS: 30 days

$$(1,1\text{-DCE-Conc}_{Shoals} = \{[1,1\text{-DC Conc}_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left| \frac{248{,}973\ \mu g/L}{30\ days} \right| \quad 4\ gpm \left| \frac{30\ days}{142{,}279\ gpm} \right|$$

$$= \boxed{6.9996\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 1,1-DCE criterion for protection of public water supplies?

Is the 1-DCl $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 6.99960 µg/L < 7.00 µg/L.

The 1,1-DCE concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report cis-1,2-DCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for cis-1,2-dichloroethene (cis-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of cis-1,2-DCE at Shoals Water Intake based upon highest concentration of cis-1,2-DCE, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of cis-1,2-DCE in Spring C for 30 days (cis-1,2-DCE- $Conc_{SpC}$) = 0.5 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of cis-1,2-DCE occurs from Spring C to Shoals intake.
7. The cis-1,2-DCE concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 70 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
cis-1,2-DCE = cis-1,2-dichloroethene
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report cis-1,2-DCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for cis-1,2-dichloroethene (cis-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of cis-1,2-DCE in East Fork White River at the Shoals water intake (cis-1,2- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{s-1,2-DCE-}\ Conc_{Shoals} = \{[\text{cis-1,2}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \frac{0.5\ \mu g/L}{30\ days} \quad 6\ gpm \quad \frac{30\ days}{142{,}279\ gpm}$$

$$= \boxed{0.00002\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana cis-1,2-DCE criterion for protection of public water supplies?

Is the DCE- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00002 µg/L < 70 µg/L.

The cis-1,2-DCE concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report cis-1,2-DCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for cis-1,2-dichloroethene (cis-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of cis-1,2-DCE at mixing zone that would result in the cis-1,2-DCE at Shoals exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of cis-1,2-DCE in Spring A for 30 days (cis-1,2-DCE- $Conc_{SpA}$) = 2,489,820 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of cis-1,2-DCE occurs from Spring A to Shoals intake.
7. The cis-1,2-DCE concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 70 µg/L.
8. Terminology

µg = microgram
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
L = liter
s-1,2-DCE = cis-1,2-dichloroethene
SpA = Spring A
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report cis-1,2-DCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for cis-1,2-dichloroethene (cis-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of cis-1,2-DCE in East Fork White River at Shoals water intake (cis-1,2-DCE-

BASIS: 30 days

$$\text{s-1,2-DCE-Conc}_{Shoals} = \{[\text{cis-1,2 Conc}_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/ t\ (days)]\}$$

$$= \frac{2{,}489{,}820\ \mu g/L}{30\ days} \quad 4\ gpm \quad \frac{30\ days}{142{,}279\ gpm}$$

$$= \boxed{69.9982\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana cis-1,2-DCE criterion for protection of public water supplies?

Is the 1,2-D $\text{Conc}_{Shoals} < \text{SW}_{Calc\text{-}Conc}$

Is 69.99820 µg/L < 70 µg/L.

The cis-1,2-DCE concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report trans-1,2-DCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for trans-1,2-dichloroethene (trans-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of trans-1,2-DCE at Shoals Water Intake based upon highest concentration of trans-1,2-DCE, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of trans-1,2-DCE in Spring C for 30 days (trans-1,2-DCE- $Conc_{SpC}$) = 0.5 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of trans-1,2-DCE occurs from Spring C to Shoals intake.
7. The trans-1,2-DCE concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 100 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
trans-1,2-DCE = trans-1,2-dichloroethene
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report trans-1,2-DCE Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for trans-1,2-dichloroethene (trans-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of trans-1,2-DCE in East Fork White River at the Shoals water intake (trans-1 $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{s-1,2-DCE-}\ Conc_{Shoals} = \{[\text{trans-1}\ Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \frac{0.5\ \mu g/L}{30\ days} \quad 6\ gpm \quad \frac{30\ days}{142{,}279\ gpm}$$

$$= \boxed{0.00002\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana trans-1,2-DCE criterion for protection of public water supplies?

Is the DCE- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00002 µg/L < 100 µg/L.

The trans-1,2-DCE concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report trans-1,2-DCE Mixing Zone Concentration based on Spring A data			
BASED ON Media Cleanup Standards Table 2-3 for trans-1,2-dichloroethene (trans-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of trans-1,2-DCE at mixing zone that would result in the trans-1,2-DCE at exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of trans-1,2-DCE in Spring A for 30 days (trans-1,2-DCE- $Conc_{SpA}$) = 3,556,890 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of trans-1,2-DCE occurs from Spring A to Shoals intake.
7. The trans-1,2-DCE concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 100 µg/L.
8. Terminology

µg = microgram
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
L = liter
s-1,2-DCE = trans-1,2-dichloroethene
SpA = Spring A
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report trans-1,2-DCE Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for trans-1,2-dichloroethene (trans-1,2-DCE).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of trans-1,2-DCE in East Fork White River at Shoals water intake (trans-1,2-DCE-

BASIS: 30 days

s-1,2-DCE- $Conc_{Shoals}$ = {[trans-1 $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \frac{3{,}556{,}890 \text{ µg/L}}{30 \text{ days}} \quad 4 \text{ gpm} \quad \frac{30 \text{ days}}{142{,}279 \text{ gpm}}$$

$$= \boxed{99.9976 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana trans-1,2-DCE criterion for protection of public water supplies?

Is the s-1,2-[$Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 99.99760 µg/L < 100 µg/L.

The trans-1,2-DCE concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report VC Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for vinyl chloride (VC).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of VC at Shoals Water Intake based upon highest concentration of VC, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of VC in Spring C for 30 days ($VC\text{-}Conc_{SpC}$) = 1 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of VC occurs from Spring C to Shoals intake.
7. The VC concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 2 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
DNX = hexahydro-1,3,5-dinitroso-1,3,5-triazine
FR = flowrate
gpm = gallons per minute
L = liter
VC = vinyl chloride
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report VC Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-3 for vinyl chloride (VC).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of VC in East Fork White River at the Shoals water intake (VC- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$VC\text{-}\ Conc_{Shoals} = \{[VC\text{-}\ Conc_{SpC}\ (\mu g/L)\ /\ t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)\ /\ t\ (days)]\}$$

$$= \left|\frac{1\ \mu g/L}{30\ days}\right| \quad 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00004\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana VC criterion for protection of public water supplies?

Is the VC- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00004 µg/L < 2 µg/L.

The VC concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report VC Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for vinyl chloride (VC).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Objective: Estimate the concentration of VC at mixing zone that would result in the VC at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of VC in Spring A for 30 days (VC- $Conc_{SpA}$) = 71,128 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of VC occurs from Spring A to Shoals intake.
7. The VC concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 2 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - VC = vinyl chloride
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report VC Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-3 for vinyl chloride (VC).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/24/2010

Calculations:

1. Calculate the concentration of VC in East Fork White River at Shoals water intake (VC-ConcShoals) in (µg/L).

   BASIS: 30 days

   $(VC\text{-}Conc_{Shoals} = \{[VC\text{-}\ Conc_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$

   $$= \left| \frac{71{,}128\ \mu g/L}{30\ days} \right| \ 4\ gpm \left| \frac{30\ days}{142{,}279\ gpm} \right|$$

   $$= \boxed{1.9997\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana VC criterion for protection of public water supplies?

   Is the $VC\text{-}\ Conc_{Shoals} < SW_{Calc\text{-}Conc}$

   Is 1.99970 µg/L < 2 µg/L.

   The VC concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,4-Diamino-6-nitrotoluene at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 2,4-Diamino-6-nitrotoluene (2,4-DA-6-NT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2,4-DA-6-NT at Shoals Water Intake based upon highest 2,4-DA-6-NT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,4-DA-6-NT in Spring C for 30 days
   (2,4-DA-6-NT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,4-DA-6-NT occurs from Spring C to Shoals intake.
7. The 2,4-DA-6-NT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc-Conc}$) = 73.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpC	= Spring C
4-DA-6-NT	= 2,4-Diamino-6-nitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,4-DA-6-NT in East Fork White River at Shoals water intake (2 $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

-DA-6-NT- $Conc_{Shoals}$ = {[2,4-DA $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \frac{1.6 \text{ µg/L}}{30 \text{ days}} \quad 6 \text{ gpm} \quad \frac{30 \text{ days}}{142{,}279 \text{ gpm}}$$

$$= \boxed{0.00007 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,4-DA-6-NT criterion for protection of public water supplies?

   Is the 3-NT- $Conc_{Shoals}$ < $SW_{Calc-Conc}$

   Is 0.00007 µg/L < 73.0 µg/L.

The 2,4-DA-6-NT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,4-Diamino-6-nitrotoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2,4-Diamino-6-nitrotoluene (2,4-DA-6-NT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2,4-DA-6-NT at the mixing zone that would result in the 2,4-DA-6-NT at exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,4-DA-6-NT in Spring A for 30 days (2,4-DA-6-NT- $Conc_{SpA}$) = 2,590,241 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,4-DA-6-NT occurs from Spring A to Shoals intake.
7. The 2,4-DA-6-NT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 73 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
4-DA-6-NT	= 2,4-Diamino-6-nitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,4-DA-6-NT in East Fork White River at Shoals water intake ($Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

-DA-6-NT- $Conc_{Shoals}$ = {[2,4-DA-6 $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{2{,}590{,}241 \text{ µg/L}}{30 \text{ days}}\right| \; 4 \text{ gpm} \left|\frac{30 \text{ days}}{142{,}279 \text{ gpm}}\right|$$

$$= \boxed{72.8215 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,4-DA-6-NT criterion for protection of public water supplies?

Is the 3-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 72.82150 µg/L < 73.0 µg/L.

The 2,4-DA-6-NT concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2,6-Diamino-4-Nitrotoluene at the Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-4 for 2,6-Diamino-4-Nitrotoluene (2,6-DA-4-NT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2,6-DA-4-NT at Shoals Water Intake based upon highest 2,6-DA-4-NT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,6-DA-4-NT in Spring C for 30 days
   (2,6-DA-4-NT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,6-DA-4-NT occurs from Spring C to Shoals intake.
7. The 2,6-DA-4-NT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 73.0 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpC	= Spring C
6-DA-4-NT	= 2,6-Diamino-4-Nitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,6-DA-4-NT in East Fork White River at Shoals water intake (2 $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

-DA-4-NT- $Conc_{Shoals}$ = {[2,6-DA $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{1.6 \ \mu g/L}{30 \ days} \right| \ 6 \ gpm \left| \frac{30 \ days}{142{,}279 \ gpm} \right|$$

$$= \boxed{0.00007 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,6-DA-4-NT criterion for protection of public water supplies?

   Is the 1-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

   Is 0.00007 µg/L < 73.0 µg/L.

The 2,6-DA-4-NT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2,6-Diamino-4-Nitrotoluene at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-4 for 2,6-Diamino-4-Nitrotoluene (2,6-DA-4-NT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2,6-DA-4-NT at the mixing zone that would result in the 2,6-DA-4-NT at exceeding the water quality criterion i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2,6-DA-4-NT in Spring A for 30 days (2,6-DA-4-NT- $Conc_{SpA}$) = 2,590,241 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2,6-DA-4-NT occurs from Spring A to Shoals intake.
7. The 2,6-DA-4-NT concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of surface water ($SW_{Calc\text{-}Conc}$) = 73 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
6-DA-4-NT	= 2,6-Diamino-4-Nitrotoluene	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2,6-DA-4-NT in East Fork White River at Shoals water intake ($Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{-DA-4-NT- } Conc_{Shoals} = \{[2,6\text{-DA-4 } Conc_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{2{,}590{,}241\ \mu g/L}{30\ days}\right| \ 4\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{72.8215\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2,6-DA-4-NT criterion for protection of public water supplies?

Is the -NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 72.82150 µg/L < 73.0 µg/L.

The 2,6-DA-4-NT concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 2-Nitrotoluene at the Fence Line.	
BASED ON Media Cleanup Standards Table 2-4 for 2-Nitrotoluene (2-NT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 2-NT at the Shoals Water Intake based upon highest 2-NT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2-NT in Spring C for 30 days (2-NT- $Conc_{SpC}$) = 1.9 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2-NT occurs from Spring C to Shoals intake.
7. The 2-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 71 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
2-NT	= 2-Nitrotoluene	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2-NT in East Fork White River at Shoals water intake (2-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{2-NT- } Conc_{Shoals} = \{[\text{2-NT- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.9\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00008\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2-NT criterion for protection of public water supplies?

Is the 2-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00008 µg/L < 71.0 µg/L.

The 2-NT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 2-Nitrotoluene at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-4 for 2-Nitrotoluene (2-NT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 2-NT at fence line that would result in the 2-NT at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 2-NT in Spring A for 30 days
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
   (2-NT- $Conc_{SpA}$) = 2,524,596 micrograms per liter (µg/L).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 2-NT occurs from Spring A to Shoals intake.
7. The 2-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 71 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
2-NT	= 2-Nitrotoluene	SW	= Surface Water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 2-NT in East Fork White River at Shoals water intake (2-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$(\text{2-NT- } Conc_{Shoals} = \{[\text{2-NT- } Conc_{SpA}\ (\mu g/L) / t\ (\text{days})] * [FR_{SpA}\ (\text{gpm})]\} \div [FR_{Shoals}\ (\text{gpm}) / t\ (\text{days})]\}$$

$$= \left|\frac{2{,}524{,}596\ \mu g/L}{30\ \text{days}}\right| \quad 4\ \text{gpm} \left|\frac{30\ \text{days}}{142{,}279\ \text{gpm}}\right|$$

$$= \boxed{70.9759\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 2-NT criterion for protection of public water supplies?

Is the 2-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 70.97590 µg/L < 71.0 µg/L.

The 2-NT concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 3-Nitrotoluene at the Fence Line.	
BASED ON Media Cleanup Standards Table 2-4 for 3-Nitrotoluene (3-NT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 3-NT at the Shoals Water Intake based upon highest 3-NT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 3-NT in Spring C for 30 days (3-NT- $Conc_{SpC}$) = 1.9 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 3-NT occurs from Spring C to Shoals intake.
7. The 3-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 42 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
3-NT	= 3-Nitrotoluene	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 3-NT in East Fork White River at Shoals water intake (3-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{3-NT- } Conc_{Shoals} = \{[\text{3-NT- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1.9\ \mu g/L}{30\ days}\right| \ 6\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00008\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 3-NT criterion for protection of public water supplies?

Is the 3-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00008 µg/L < 42.0 µg/L.

The 3-NT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 3-Nitrotoluene at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-4 for 3-Nitrotoluene (3-NT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 3-NT at fence line that would result in the 3-NT at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 3-NT in Spring A for 30 days
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
   (3-NT- $Conc_{SpA}$) = 1,493,423 micrograms per liter (µg/L).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 3-NT occurs from Spring A to Shoals intake.
7. The 3-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 42 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
3-NT	= 3-Nitrotoluene	SW	= Surface Water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 3-NT in East Fork White River at Shoals water intake (3-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$(\text{3-NT- } Conc_{Shoals} = \{[\text{3-NT- } Conc_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{1{,}493{,}423\ \mu g/L}{30\ \ days}\right| \quad 4\ \ gpm \left|\frac{30\ \ days}{142{,}279\ \ gpm}\right|$$

$$= \boxed{41.9858\ \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 3-NT criterion for protection of public water supplies?

Is the 3-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 41.98580 µg/L < 42.0 µg/L.

The 3-NT concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report 4-Nitrotoluene at the Fence Line.	
BASED ON Media Cleanup Standards Table 2-4 for 4-Nitrotoluene (4-NT).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of 4-NT at the Shoals Water Intake based upon highest 4-NT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4-NT in Spring C for 30 days (4-NT- $Conc_{SpC}$) = 1.9 U micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4-NT occurs from Spring C to Shoals intake.
7. The 4-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 46 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
4-NT	= 4-Nitrotoluene	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 4-NT in East Fork White River at Shoals water intake (4-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{4-NT- } Conc_{Shoals} = \{[\text{4-NT- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left| \frac{1.9\ \mu g/L}{30\ days} \right| \ 6\ gpm \left| \frac{30\ days}{142{,}279\ gpm} \right|$$

$$= \boxed{0.00008\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4-NT criterion for protection of public water supplies?

Is the 4-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00008 µg/L < 46.0 µg/L.

The 4-NT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report 4-Nitrotoluene at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-4 for 4-Nitrotoluene (4-NT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of 4-NT at fence line that would result in the 4-NT at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of 4-NT in Spring A for 30 days
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
   (4-NT- $Conc_{SpA}$) = 1,635,654 micrograms per liter (µg/L).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of 4-NT occurs from Spring A to Shoals intake.
7. The 4-NT concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 46 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
4-NT	= 4-Nitrotoluene	SW	= Surface Water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of 4-NT in East Fork White River at Shoals water intake (4-NT- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(4-NT- $Conc_{Shoals}$ = {[4-NT- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{1{,}635{,}654 \text{ µg/L}}{30 \text{ days}} \right| \; 4 \text{ gpm} \left| \frac{30 \text{ days}}{142{,}279 \text{ gpm}} \right|$$

$$= \boxed{45.9844 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana 4-NT criterion for protection of public water supplies?

Is the I-NT- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 45.98440 µg/L < 46.0 µg/L.

The 4-NT concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report n-Nitrosodimethylamine at the Fence Line.	
BASED ON Media Cleanup Standards Table 2-4 for n-Nitrosodimethylamine (DMNA).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Objective: Estimate the concentration of DMNA at the Shoals Water Intake based upon highest DMNA concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of DMNA in Spring C for 30 days (DMNA- $Conc_{SpC}$) = 0.94 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of DMNA occurs from Spring C to Shoals intake.
7. The DMNA concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 70 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
DMNA	= n-Nitrosodimethylamine	L	= liter
Calc	= calculated	SpC	= Spring C
Conc	= concentration	SW	= Surface water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of DMNA in East Fork White River at Shoals water intake (DMN $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

DMNA- $Conc_{Shoals}$ = {[DMNA $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{0.9\ \mu g/L}{30\ days}\right| \quad 6\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00004\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana DMNA criterion for protection of public water supplies?

Is the MNA- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00004 µg/L < 70.0000 µg/L.

The DMNA concentration at Shoals Intake for Spring C IS LESS THAN the calculated Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report n-Nitrosodimethylamine at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-4 for n-Nitrosodimethylamine (DMNA).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of DMNA at fence line that would result in the DMNA at the mixing zone exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of DMNA in Spring A for 30 days
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
   (DMNA- $Conc_{SpA}$) = 2,489,038 micrograms per liter (µg/L).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of DMNA occurs from Spring A to Shoals intake.
7. The DMNA concentration calculated based upon Table 2-4 of the SWMU 3 CMP for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 70 µg/L.
8. Terminology

µg	= microgram	gpm	= gallons per minute
Calc	= calculated	L	= liter
Conc	= concentration	SpA	= Spring A
DMNA	= n-Nitrosodimethylamine	SW	= Surface Water
FR	= flowrate	t	= time

Calculations:

1. Calculate the concentration of DMNA in East Fork White River at Shoals water intake (DMN $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(DMNA- $Conc_{Shoals}$ = {[DMNA $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{2{,}489{,}038 \text{ µg/L}}{30 \text{ days}}\right| \; 4 \text{ gpm} \left|\frac{30 \text{ days}}{142{,}279 \text{ gpm}}\right|$$

$$= \boxed{69.9763 \text{ µg/L}}$$

2. Is the concentration at Shoals water intake less than the Indiana DMNA criterion for protection of public water supplies?

Is the DMNA- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 69.97630 µg/L < 70.0 µg/L.

The DMNA concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

B.3 2,4,6-TRINITROTOLUENE (2,4,6-TNT)

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report HMX Shoals Water Intake Concentration based on Spring C data.			
BASED ON Media Cleanup Standards Table 2-4 for Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of HMX at Shoals Water Intake based upon highest concentration of HMX, gallons per minute, and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of HMX in Spring C for 30 days ($HMX\text{-}Conc_{SpC}$) = 4.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of HMX occurs from Spring C to Shoals intake.
7. The HMX concentration calculated based upon Table 2-4 of the SWMU 3 Corrective Measures Proposal for protection of public water supplies ($SW_{Calc\text{-}Conc}$) = 220 µg/L.
8. MNX, DNX, and TNX use RDX as their surrogate because insufficient toxicological data is available for them and they are structurally similar to RDX.
9. Terminology

µg = microgram
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
L = liter
HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
SpC = Spring C
SW = Surface Water
t = time

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report HMX Shoals Water Intake Concentration based on Spring C data.	
BASED ON Media Cleanup Standards Table 2-4 for Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of HMX in East Fork White River at the Shoals water intake (HMX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$\text{HMX- } Conc_{Shoals} = \{[\text{HMX- } Conc_{SpC}\ (\mu g/L) / t\ (days)] * [FR_{SpC}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left| \frac{4.6\ \mu g/L}{30\ days} \right| \quad 6\ gpm \left| \frac{30\ days}{142{,}279\ gpm} \right|$$

$$= \boxed{0.00019\ \mu g/L}$$

Calculations (continued):

2. Is the concentration at Shoals water intake less than the Indiana HMX criterion for protection of public water supplies?

Is the HMX- $Conc_{Shoals}$ < $SW_{Calc\text{-}Conc}$

Is 0.00019 µg/L < ### µg/L.

The HMX concentration at Shoals Intake for Spring C IS LESS THAN the Table 2-4 criterion for surface water/protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110155	
SUBJECT Alternative Water Quality Criterion Report HMX Mixing Zone Concentration based on Spring A data.			
BASED ON Media Cleanup Standards Table 2-1 for Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY ElLove	APPROVED BY	DATE 2/3/2010

Objective: Estimate the concentration of HMX at mixing zone that would result in the HMX at Shoals water intake exceeding the water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The maximum concentration of HMX in Spring A for 30 days (HMX- $Conc_{SpA}$) = 7,825,170 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of HMX occurs from Spring A to Shoals intake.
7. The HMX concentration calculated based upon Table 2-4 of SWMU 3 the Corrective Measures Proposal for protection of surface water supplies ($SW_{Calc\text{-}Conc}$) = 220 µg/L.
8. Terminology
   - µg = microgram
   - Calc = calculated
   - Conc = concentration
   - FR = flowrate
   - gpm = gallons per minute
   - L = liter
   - HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
   - SpA = Spring A
   - SW = Surface Water
   - t = time

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110155
SUBJECT Alternative Water Quality Criterion Report HMX Mixing Zone Concentration based on Spring A data.	
BASED ON Media Cleanup Standards Table 2-1 for Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	ElLove		2/3/2010

Calculations:

1. Calculate the concentration of HMX in East Fork White River at Shoals water intake (HMX-ConcShoals) in (µg/L).

BASIS: 30 days

$$(\text{HMX-Conc}_{Shoals} = \{[\text{HMX-Conc}_{SpA}\ (\mu g/L) / t\ (days)] * [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm) / t\ (days)]\}$$

$$= \left|\frac{7{,}825{,}170\ \mu g/L}{30\ days}\right| \quad 4\ gpm \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{219.9951\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana HMX criterion for protection of public water supplies?

Is the HMX-Conc_{Shoals} < $SW_{Calc\text{-}Conc}$

Is 219.995 µg/L < 220 µg/L.

The HMX concentration at Shoals Intake for Spring A IS LESS THAN the Table 2-4 criterion for the protection of surface water/public water supply.

B.4 AMINODINITROTOLUENES

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report 4-amino-2,6-dinitrotoluene/2-amino-4,6-dinitrotoluene at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-1 for 4-amino-2,6-dinitrotoluene/2-amino-4,6-dinitrotoluene (A-DNT).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Objective: Estimate the concentration of A-DNT at Shoals water intake based upon highest A-DNT concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max conc of A-DNT in Spring C for 30 days (A-DNT- $Conc_{SpC}$) = 1.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of A-DNT occurs from Spring C to Shoals intake.
7. The A-DNT concentration calculated based upon Indiana Administrative Code (IAC) 327 IAC 2-1-6(a)(2)(B) and (C) for protection of public water supplies ($IAC_{Calc\text{-}Conc}$) = 67.0 µg/L.
8. Terminology

µg	= microgram	IAC	= Indiana Administrative Code
Calc	= calculated	L	= liter
Conc	= concentration	LSC	= Little Sulfur Creek
FR	= flowrate	A-DNT	= 4-amino-2,6-dinitrotoluene/2-amino-4,6-dinitrotoluene
gpm	= gallons per minute	SpC	= Spring C

Calculations:

1. Calculate the concentration of A-DNT in East Fork White River at Shoals water intake (A-DI $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

A-DNT- $Conc_{Shoals}$ = {[A-DNT $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{1.6\ \mu g/L}{30\ days}\right| \quad 6\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00007\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana A-DNT criterion for protection of public water supplies?

Is the DNT- $Conc_{Shoals}$ < $IAC_{Calc\text{-}Conc}$

Is 0.00007 µg/L < 67.0 µg/L.

The A-DNT concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

B.5 4,4'-TN-AZOXY

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report 4,4'-TN-AZOXY at Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-1 for 2,4,6-trinitrotoluene [TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY)].		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Objective: Estimate the concentration of TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) at Shoals water intake based upon highest TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) concentration and lowest flow in Spring C using 4-4'-TN-AZOXY.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max conc of TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) in Spring C for 30 days
   (TNT- $Conc_{SpC}$) = 5.6 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) occurs from Spring C to Shoals intake.
7. The 4,4'-TN-AZOXY concentration calculated based upon Indiana Administrative Code (IAC) 327 IAC 2-1-6(a)(2)(B) for protection of public water supplies ($IAC_{Calc\text{-}Conc}$) = 10,000 µg/L.
8. TNT degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY)use TNT as their surrogate because insufficient toxicological data is available for them and they are structurally similar to TNT.
9. Terminology

µg = microgram
4,4'-TN-AZOXY = 2,2'-6,6'-tetranitro-4,4'-azoyltoluene
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
IAC = Indiana Administrative Code
L = liter
LSC = Little Sulfur Creek
TNT = 2,4,6-trinitrotoluene
SpA = Spring A

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110120
SUBJECT Alternative Water Quality Criterion Report 4,4'-TN-AZOXY at Shoals Water Intake.	
BASED ON Media Cleanup Standards Table 2-1 for 2,4,6-trinitrotoluene [TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY)].	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	KTurnbull		5/8/2007

Calculations:

1. Calculate the concentration of TNT in East Fork White River at Shoals water intake (TNT- $Conc_{Shoals}$) in (µg/L).

   BASIS: 30 days

'-TN-AZOXY- $Conc_{Shoals}$ = {[4,4'-TN-AZC $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left| \frac{5.6 \ \mu g/L}{30 \ days} \right| \ 6 \ gpm \left| \frac{30 \ days}{142{,}279 \ gpm} \right|$$

$$= \boxed{0.00024 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) criterion for protection of public water supplies?

   Is the TNT- $Conc_{Shoals}$ < $IAC_{Calc\text{-}Conc}$

   Is 0.00024 µg/L < 10,000 µg/L.

The 4,4'-TN-AZOXY concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report 4,4'-TN-AZOXY at the Mixing Zone.			
BASED ON Media Cleanup Standards Table 2-1 for 2,4,6-trinitrotoluene [TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY)].		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Objective: Estimate the concentration of TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) at the mixing zone that would result in the TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) at Shoals water intake exceeding the alternative water quality criterion (i.e., protective of public water supplies) for Spring A using 4,4'-TN-AZOXY.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max conc of 4,4'-TN-AZOXY.
(4,4'-TN-AZOXY- $Conc_{SpA}$) = 35,500,000 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY) occurs from Spring A to Shoals intake.
7. The 4,4'-TN-AZOXY concentration calculated based upon Indiana Administrative Code (IAC) 327 IAC 2-1-6(a)(2)(B) for protection of public water supplies ($IAC_{Calc\text{-}Conc}$) = 1,000 µg/L.
8. Terminology

µg = microgram
4,4'-TN-AZOXY = 2,2'-6,6'-tetranitro-4,4'-azoyltoluene
Calc = calculated
Conc = concentration
FR = flowrate
gpm = gallons per minute
IAC = Indiana Administrative Code
L = liter
LSC = Little Sulfur Creek
TNT = 2,4,6-trinitrotoluene
SpA = Spring A

CLIENT NSWC Crane	JOB NUMBER 112GN8383; 0000.QR0110120
SUBJECT Alternative Water Quality Criterion Report 4,4'-TN-AZOXY at the Mixing Zone.	
BASED ON Media Cleanup Standards Table 2-1 for 2,4,6-trinitrotoluene [TNT and degradation products (2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, and 4,4'-TN-AZOXY)].	DRAWING NUMBER Not Applicable

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	KTurnbull		5/8/2007

Calculations:

1. Calculate the concentration of 4,4'-TN-AZOXY in East Fork White River at Shoals water intake (4,4'-TN-AZOXY-$Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

$$4,4'\text{-TN-AZOXY-}\ Conc_{Shoals} = \{[4,4'\text{-TN-AZOXY}\ Conc_{SpA}\ (\mu g/L)\ /\ t\ (days)]\ *\ [FR_{SpA}\ (gpm)]\} \div [FR_{Shoals}\ (gpm)/\ t\ (days)]\}$$

$$= \left|\frac{35{,}500{,}000\ \mu g/L}{30\ days}\right| \quad 4\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{998.0391\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana 4,4'-TN-AZOXY criterion for protection of public water supplies?

Is the 4,4'-TN-AZOXY- $Conc_{Shoals}$ < $IAC_{Calc\text{-}Conc}$

Is 998 µg/L < 1,000 µg/L.

The 4,4'-TN-AZOXY concentration at Shoals Intake for 4,4'-TN-AZOXY IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

B.6 CYCLOTETRAMETHYLENETETRANITRAMINE (HMX)

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-1 for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine [HMX].		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Objective: Estimate the concentration of HMX at Shoals water intake based upon highest HMX concentration and lowest flow in Spring C.

Inputs and Assumptions:

1. Spring C comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max concentration of HMX or HMX degradation products (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) in Spring C for 30 days
   (HMX- $Conc_{SpC}$) = 0.79 micrograms per liter (µg/L).
3. Spring C flowrate for 30 days (FR_{SpC}) = 6 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of HMX or HMX degradation products (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) occurs from Spring C to Shoals intake.
7. The HMX concentration calculated based upon Indiana Administrative Code (IAC) 327 IAC 2-1-6(a)(2)(B) and (C) for protection of public water supplies ($IAC_{Calc\text{-}Conc}$) = 1,700 µg/L.
8. Terminology

µg	= microgram	IAC	= Indiana Administrative Code
Calc	= calculated	L	= liter
Conc	= concentration	LSC	= Little Sulfur Creek
FR	= flowrate	SpC	= Spring C
gpm	= gallons per minute		
HMX	= octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine		

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine at the Shoals Water Intake.			
BASED ON Media Cleanup Standards Table 2-1 for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Calculations:

1. Calculate the concentration of HMX in East Fork White River at Shoals water intake (HMX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

HMX- $Conc_{Shoals}$ = {[HMX- $Conc_{SpC}$ (µg/L) / *t* (days)] * [FR_{SpC} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \left|\frac{0.79\ \mu g/L}{30\ days}\right| \quad 6\ gpm \quad \left|\frac{30\ days}{142{,}279\ gpm}\right|$$

$$= \boxed{0.00003\ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana HMX criterion for protection of public water supplies?

Is the HMX- $Conc_{Shoals}$ < $IAC_{Calc\text{-}Conc}$

Is 0.00003 µg/L < 1,700 µg/L.

The HMX concentration at Shoals Intake for Spring C IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-1 for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine [HMX].		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Objective: Estimate the concentration of HMX at the mixing zone that would result in the HMX at Shoals water intake exceeding the alternative water quality criterion (i.e., protective of public water supplies) for Spring A.

Inputs and Assumptions:

1. Spring A comprises the entire flow of Little Sulfur Creek (t) for 30 days .
2. The max conc of HMX in Spring A for 30 days
   (HMX- $Conc_{SpA}$) = 60,400,000 micrograms per liter (µg/L).
3. Spring A flowrate for 30 days (FR_{SpA}) = 4 gallons per minute (gpm).
4. The closest downstream public water supply intake is on the East Fork White River at Shoals.
5. East Fork White River at Shoals flowrate for 30 days (FR_{Shoals}) = 142,279 gpm.
6. No photolytic or biological degradation of HMX occurs from Spring A to Shoals intake.
7. The HMX concentration calculated based upon Indiana Administrative Code (IAC) 327 IAC 2-1-6(a)(2)(B) and (C) for protection of public water supplies ($IAC_{Calc\text{-}Conc}$) = 1700.0 µg/L.
8. Terminology

µg	= microgram	IAC	= Indiana Administrative Code
Calc	= calculated	L	= liter
Conc	= concentration	LSC	= Little Sulfur Creek
HMX	= octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	SpA	= Spring A
FR	= flowrate		
gpm	= gallons per minute		

CLIENT NSWC Crane		JOB NUMBER 112GN8383; 0000.QR0110120	
SUBJECT Alternative Water Quality Criterion Report octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine at the Mixing Zone			
BASED ON Media Cleanup Standards Table 2-1 for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine [HMX].		DRAWING NUMBER Not Applicable	
BY VJPlachy	CHECKED BY KTurnbull	APPROVED BY	DATE 5/8/2007

Calculations:

1. Calculate the concentration of HMX in East Fork White River at Shoals water intake (HMX- $Conc_{Shoals}$) in (µg/L).

BASIS: 30 days

(HMX- $Conc_{Shoals}$ = {[HMX- $Conc_{SpA}$ (µg/L) / *t* (days)] * [FR_{SpA} (gpm)]} ÷ [FR_{Shoals} (gpm)/ *t* (days)]}

$$= \frac{60{,}400{,}000 \ \mu g/L}{30 \ days} \quad 4 \ gpm \quad \frac{30 \ days}{142{,}279 \ gpm}$$

$$= \boxed{1{,}698 \ \mu g/L}$$

2. Is the concentration at Shoals water intake less than the Indiana HMX criterion for protection of public water supplies?

Is the HMX- $Conc_{Shoals}$ < $IAC_{Calc\text{-}Conc}$

Is 1,698 µg/L < 1,700 µg/L.

The HMX concentration at Shoals Intake for Spring A IS LESS THAN the calculated Indiana criterion for the protection of the public water supply.

APPENDIX C

ALTERNATIVE WATER QUALITY CRITERION (WCQ) CALCULATIONS FOR SURFACE WATER [LITTLE SULPHUR CREEK (LCS)]

C.1 ALTERNATIVE RDX WATER QUALITY CRITERIA CALCULATIONS FOR SURFACE WATER

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR RDX

Surface alternative water quality criterion (WQC) for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8-6. Since RDX is classified as a carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.6 (Determination of concentrations providing an acceptable degree of protection to public health for cancer). The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8.6:

$$C = \frac{D \times W_h}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

C = derived surface water quality standard for RDX
D = dose
W_h = average human adult body weight = 70 kg
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

The dose (D) can be derived using one of several options provided in 327 IAC 2-1-8.6 (b) (1) (A), (B), and (C). Subsection (B) states that the goal for cancer "shall be a concentration estimated to cause one (1) additional cancer over the background rate in one hundred thousand (100,000) individuals exposed to that concentration". This corresponds to a $1x10^{-5}$ cancer risk.

Subsection (B)(ii) indicates that the dose (D) can be determined by dividing the cancer slope factor, known as q_1^* (or CSF) by $1x10^{-5}$. Therefore, the U.S. EPA CSF for RDX currently published in IRIS (0.11 $(mg/kg/day)^{-1}$) was used to calculate D. This CSF was has been used to assess risks and to derive cleanup concentrations in other media at Crane and it is appropriate that the CSF be used to derive the WQC for surface water. This CSF has also been used by U.S. EPA Regions 3 and 9 to develop their soil and water remediation goals. Using the method recommended in Subsection (B)(ii), the value of D is:

$$D = \frac{1x10^{-5}}{0.11(mg/kg/d)^{-1}} \quad \text{(Equation 2)}$$

$$D = 9.1 \times 10^{-5} \text{ mg/kg/day}$$

The BCF for RDX was calculated according to Code 327 IAC 2-1-8.7. There are a number of BCFs for RDX published in the literature. For example TOXNET (online at http://toxnet.nlm.nih.gov/) provides a range of measured BCFs of 4 to 5.9 L/kg for RDX. However, according to this rule, the measured BCFs must be normalized by the percent lipid content of the fish used in the measurements. Since the percent lipid content was not known, it was necessary to estimate the BCF using equations provided in Code 327 IAC 2-1-8.7.

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF
Log Kow for RDX = 0.87 (TOXNET, online, May 2005)

Using Equation 3, BCF_c = 1.28 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula:

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 1.28 x 2 = 2.56 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for RDX:

- WQC for surface water protected for drinking water supply = 3 µg/L
- WQC for surface water not protected for drinking water supply = 86 µg/L

Example Calculation for Protected Water Supply

$$C = \frac{9.1\text{x}10^{-5}\ \text{x}\ 70\,\text{kg}}{2\text{L/d} + (0.025\ \text{kg/day x } 2.56\ \text{L/kg})}$$

$$= \frac{0.00636\ \text{mg}}{2.06\ \text{L}}$$

= 0.0031 mg/L

= 3 µg/L

Note that a WQC could also be calculated according to 327 IAC 2-1-8.5 for the non-carcinogenic health effects of RDX (on the prostate). However, calculations show that the non-carcinogenic WQC would be approximately 35 times greater than the WQC based on cancer. Only the more conservative carcinogenic WQC (3 µg/L) is presented.

Example Calculation for Unprotected Water Supply

$$C = \frac{9.1\text{x}10^{-5}\ \text{x}\ 70\,\text{kg}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 2.56\ \text{L/kg})}$$

$$= \frac{0.00636\ \text{mg}}{0.074\ \text{L}}$$

= 0.086 mg/L

= 86 µg/L

C.2 DINITROTOLUENE

C.2.1 2,4-DINITROTOLUENE

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR 2,4-DINITROTOLUENE

Surface water quality criterion (WQC) for 2,4-dinitrotoluene were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8.6. Since 2,4-dinitrotoluene is classified as a non-carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.5 [Determination of the human life cycle safe concentration (HLSC)]. The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8.5:

$$HLSC = \frac{MgT\,(mg/day)}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

HLSC = the human life cycle safe concentration (µg/L)
MgT = maximum milligrams of toxicant per day causing no adverse effects to humans daily for a lifetime (mg/day)
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

MgT can be derived using one of several options provided in 327 IAC 2-1-8.5 (1) or (2) using a U.S. EPA MCL (if available) or a No Observable Adverse Effect Level (NOAEL) from a human or animal study. No MCL is currently available for 2,4-dinitrotoluene. Therefore, the MgT was derived from the reference dose (RfD) currently used by the U.S. EPA for 2,4-dinitrotoluene which is based on a NOAEL. The most recently published RfD for 2,4-dinitrotoluene is 0.002 mg/kg/day (IRIS, online, January 2006). The MgT was derived as follows:

$$MgT = RfD \times W_h \quad \text{(Equation 2)}$$

Where:

RfD = non-carcinogenic reference dose for 2,4-dinitrotoluene
W_h = average human adult body weight = 70 kg (327 IAC 2-1-8.5 (2)(C)

Therefore:

$$MgT = 0.002 \text{ mg/kg/day} \times 70 \text{ kg}$$

$$= 0.14 \text{ mg/day}$$

The BCF for 2,4-dinitrotoluene was calculated according to Code 327 IAC 2-1-8.7, as follows:

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF
Log Kow for the 2,4-dinitrotoluene = 2.1 (Kow = 125)

Using Equation 3, BCF_c = 14.15 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula from Code 327 IAC 2-1-8.7 (4):

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 14.15 x 2 = 28.3 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for 2,4-dinitrotoluene:

- WQC for surface water protected for drinking water supply = 52 µg/L
- WQC for surface water not protected for drinking water supply = 200 µg/L

Example Calculation for Protected Water Supply

$$HLSC = \frac{0.14\ \text{mg/day}}{2\text{L/d} + (0.025\ \text{kg/day x } 28.3\ \text{L/kg})}$$

$$= \frac{0.14\ \text{mg}}{2.707\ \text{L}}$$

= 0.0517 mg/L

= 52 µg/L

Example Calculation for Unprotected Water Supply

$$HLSC = \frac{0.14\ \text{mg/day}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 28.3\ \text{L/kg})}$$

$$= \frac{0.14\ \text{mg}}{0.717\ \text{L}}$$

= 0.195 mg/L

= 195 µg/L

Using TtNUS' significant figures policy for organic chemicals, this value rounds off to 200 µg/L.

C.2.2 2,6-DINITROTOLUENE

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR 2,6-DINTROTOLUENE

Surface water quality criterion (WQC) for 2,6-dinitrotoluene were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8.6. Since 2,6-dinitrotoluene is classified as a non-carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.5 [Determination of the human life cycle safe concentration (HLSC)]. The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8.5:

$$HLSC = \frac{MgT\ (mg/day)}{WC + (F \times BCF)} \text{ (Equation 1)}$$

Where:

HLSC = the human life cycle safe concentration (µg/L)
MgT = maximum milligrams of toxicant per day causing no adverse effects to humans daily for a lifetime (mg/day)
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

MgT can be derived using one of several options provided in 327 IAC 2-1-8.5 (1) or (2) using a U.S. EPA MCL (if available) or a No Observable Adverse Effect Level (NOAEL) from a human or animal study. No MCL is currently available for 2,6-dinitrotoluene. Therefore, the MgT was derived from the reference dose (RfD) currently used by the U.S. EPA for 2,6-dinitrotoluene which is based on a NOAEL. The most recently published RfD for 2,6-dinitrotoluene is 0.001 mg/kg/day. This value was developed by the U.S.EPA's National Center for Environmental Assessment (NCEA) and listed in the U.S. EPA Region 3 Risk-based concentrations (RBC) tables (U.S. EPA Region 3, April 2007). The MgT was derived as follows:

$$MgT = RfD \times W_h \text{ (Equation 2)}$$

Where:

RfD = non-carcinogenic reference dose for 2,6-dinitrotoluene
W_h = average human adult body weight = 70 kg (327 IAC 2-1-8.5 (2)(C)

Therefore:

$$MgT = 0.001 \text{ mg/kg/day} \times 70 \text{ kg}$$

$$= 0.07 \text{ mg/day}$$

The BCF for 2,6-dinitrotoluene was calculated according to Code 327 IAC 2-1-8.7, as follows:

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \text{ (Equation 3)}$$

Where:
BCFc = the calculated BCF
Log Kow for the 2,6-dinitrotoluene = 1.87 (Kow = 74.1)

Using Equation 3, BCF_c = 9.03 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula from Code 327 IAC 2-1-8.7 (4):

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 9.03 x 2 = 18.07 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for 2,6-dinitrotoluene:

- WQC for surface water protected for drinking water supply = 29 µg/L
- WQC for surface water not protected for drinking water supply = 150 µg/L

Example Calculation for Protected Water Supply

$$HLSC = \frac{0.07\ \text{mg/day}}{2\text{L/d} + (0.025\ \text{kg/day x } 18.07\ \text{L/kg})}$$

$$= \frac{0.07\ \text{mg}}{2.45\ \text{L}}$$

= 0.0285 mg/L

= 29 µg/L

Example Calculation for Unprotected Water Supply

$$HLSC = \frac{0.07\ \text{mg/day}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 18.07\ \text{L/kg})}$$

$$= \frac{0.07\ \text{mg}}{0.46\ \text{L}}$$

= 0.15 mg/L

= 150 µg/L

C.3 2,4,6-TRINITROTOLUENE (2,4,6-TNT)

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR 2,4,6-TRINITROTOLUENE

Surface water quality criterion (WQC) for 2,4,6-trinitrotoluene (TNT) were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8.6. Since TNT is classified as a carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.6 (Determination of concentrations providing an acceptable degree of protection to public health for cancer). The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8.6:

$$C = \frac{D \times W_h}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

C = derived surface water quality standard for TNT
D = dose
W_h = average human adult body weight = 70 kg
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

The dose (D) can be derived using one of several options provided in 327 IAC 2-1-8.6 (b) (1) (A), (B), and (C). Subsection (B) states that the goal for cancer "shall be a concentration estimated to cause one (1) additional cancer over the background rate in one hundred thousand (100,000) individuals exposed to that concentration". This corresponds to a $1x10^{-5}$ cancer risk.

Subsection (B)(ii) indicates that the dose (D) can be determined by dividing the cancer slope factor, known as q_1^* (or CSF) by $1x10^{-5}$. Therefore, the U.S. EPA CSF for TNT currently published in IRIS (0.03 $(mg/kg/day)^{-1}$) was used to calculate D. This CSF was has been used to assess risks and to derive cleanup concentrations in other media at Crane and it is appropriate that the CSF be used to derive the WQC for surface water. This CSF has also been used by U.S. EPA Regions 3 and 9 to develop their soil and water remediation goals. Using the method recommended in Subsection (B)(ii), the value of D is:

$$D = \frac{1x10^{-5}}{0.03(mg/kg/d)^{-1}} \quad \text{(Equation 2)}$$

$$D = 3.33 \times 10^{-4} \text{ mg/kg/day}$$

The BCF for TNT was calculated according to Code 327 IAC 2-1-8.7. There are a number of BCFs for TNT published in the literature. However, according to this rule, the measured BCFs must be normalized by the percent lipid content of the fish used in the measurements. Since the percent lipid content was not known, it was necessary to estimate the BCF using equations provided in Code 327 IAC 2-1-8.7.

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF
Log Kow for TNT = 1.6 (U.S. EPA Soil Screening Guidance)

Using Equation 3, BCF_c = 5.34 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula:

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 5.34 x 2 = 10.67 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for TNT:

- WQC for surface water protected for drinking water supply = 10 µg/L
- WQC for surface water not protected for drinking water supply = 84 µg/L

Example Calculation for Protected Water Supply

$$C = \frac{3.33\text{x}10^{-4}\ \text{x}\ 70\text{kg}}{2\text{L/d} + (0.025\ \text{kg/day x } 10.67\ \text{L/kg})}$$

$$= \frac{0.0233\ \text{mg}}{2.267\ \text{L}}$$

= 0.01 mg/L

= 10 µg/L

Note that a WQC could also be calculated according to 327 IAC 2-1-8.5 for the non-carcinogenic health effects of TNT. However, calculations show that the non-carcinogenic WQC would be greater than the WQC based on cancer. Only the more conservative carcinogenic WQC (10 µg/L) is presented.

Example Calculation for Unprotected Water Supply

$$C = \frac{3.33\text{x}10^{-4}\ \text{x}\ 70\text{kg}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 10.67\ \text{L/kg})}$$

$$= \frac{0.0233\ \text{mg}}{0.277\ \text{L}}$$

= 0.084 mg/L

= 84 µg/L

Using TtNUS' significant figures policy for organic chemicals, this value rounds off to 84 µg/L.

C.4 AMINODINITROTOLUENES

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR AMINODINITROTOLUENES

Surface alternative water quality criterion (WQC) for the aminodinitrotoluenes (2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene) were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8.6. Since the aminodinitrotoluenes are classified as non-carcinogens by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.5 [Determination of the human life cycle safe concentration (HLSC)]. The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8.5:

$$HLSC = \frac{MgT\ (mg/day)}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

HLSC = the human life cycle safe concentration (µg/L)
MgT = maximum milligrams of toxicant per day causing no adverse effects to humans daily for a lifetime (mg/day)
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

MgT can be derived using one of several options provided in 327 IAC 2-1-8.5 (1) or (2) using a U.S. EPA MCL (if available) or a No Obseravable Adverse Effect Level (NOAEL) from a human or animal study. No MCL is currently available for the aminodinitrotoluenes. Therefore, the MgT was derived from the reference dose (RfD) currently used by the U.S. EPA for the aminodinitrotoluenes which is based on a NOAEL. The most recently published RfD for the aminodinitrotoluenes is 0.002 mg/kg/day. This value was developed by the U.S. EPA's National Center for Environmental Assessment (NCEA) and listed in the U.S. EPA Region 3 Risk-based concentrations (RBC) tables (U.S. EPA Region 3, April 2007). The MgT was derived as follows:

$$MgT = RfD \times W_h \quad \text{(Equation 2)}$$

Where:

RfD = non-carcinogenic reference dose for the aminodinitrotoluenes
W_h = average human adult body weight = 70 kg (327 IAC 2-1-8.5 (2)(C)

Therefore:

$$MgT = 0.002\ mg/kg/day \times 70\ kg$$

$$= 0.14\ mg/day$$

The BCF for the aminodinitrotoluenes was calculated according to Code 327 IAC 2-1-8.7, as follows:

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF

Log Kow for the aminodinitrotoluenes = 1.06 (Kow = 11.5)

Using Equation 3, BCF_c = 1.86 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula from Code 327 IAC 2-1-8.7 (4):

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 1.86 x 2 = 3.72 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for the aminodinitrotoluenes:

- WQC for surface water protected for drinking water supply = 67µg/L
- WQC for surface water not protected for drinking water supply = 1,350 µg/L

Example Calculation for Protected Water Supply

$$HLSC = \frac{0.14\ \text{mg/day}}{2\text{L/d} + (0.025\ \text{kg/day x } 3.72\ \text{L/kg})}$$

$$= \frac{0.14\ \text{mg}}{2.093\ \text{L}}$$

= 0.067 mg/L

= 67 µg/L

Example Calculation for Unprotected Water Supply

$$HLSC = \frac{0.14\ \text{mg/day}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 3.72\ \text{L/kg})}$$

$$= \frac{0.14\ \text{mg}}{0.103\ \text{L}}$$

= 1.359 mg/L

= 1,359 µg/L

Using TtNUS' significant figures policy for organic chemicals, this value rounds off to 1,350 µg/L.

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR 2,6-DIAMINO-4-NITROTOLUENE and 2,4-DIAMINO-6-NITROTOLUENE

Surface water quality criterion (WQC) for 2,6-diamino-4-nitrotoluene (2,6-D-4-NT) and 2,4-diamino-6-nitrotoluene (2,4-D-6-NT) uses aminodinitrotoluene as its surrogate because insufficient toxicological data is available and they are structurally similar to diaminonitroluenes. The WQC were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8.5 and 2-1-8.6. Because aminodinitrotoluenes are classified as a non-carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8.5 [Determination of the human life cycle safe concentration (HLSC)]. Appendix C.4 contains the detailed calculation for aminodinitrotoluenes.

- Alternative WQC for surface water protected for drinking water supply = 67 micrograms per liter (µg/L)

- Alternative WQC for surface water not protected for drinking water supply = 1,350 µg/L

C.5 2,2'-6,6'-TETRANITRO-4,4'AZOXYTOLUENE

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION FOR 2,2-6,6'-TETRANITRO-4,4'-AZOXYTOLUENE (4,4'-TN-AZOXY) as 1,3,5-TRINITORBENZENE

Surface alternative water quality criterion (WQC) for 2,2-6,6'-tetranitro-4,4'-azoxytoluene (4,4'-TN-AZOXY) were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8-5 and 2-1-8-6. Because 1,3,5-trinitrobenzene is classified as a non-carcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8-5 [Determination of the human life cycle safe concentration (HLSC)]. The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8-5:

$$HLSC = \frac{MgT\,(mg/day)}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

HLSC = the human life cycle safe concentration (µg/L)
MgT = maximum milligrams of toxicant per day causing no adverse effects to humans daily for a lifetime (mg/day)
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

MgT can be derived using one of several options provided in 327 IAC 2-1-8-5 (1) or (2) using a U.S. EPA MCL (if available) or a No Observable Adverse Effect Level (NOAEL) from a human or animal study. No MCL is currently available for 1,3,5-TNB. Therefore, the MgT was derived from the reference dose (RfD) currently used by the U.S. EPA for 1,3,5-TNB which is based on a NOAEL. The most recently published RfD for 1,3,5-TNB is 0.03 mg/kg/day (IRIS, online, April 2007). The MgT was derived as follows:

$$MgT = RfD \times W_h \quad \text{(Equation 2)}$$

Where:

RfD = noncarcinogenic reference dose for 1,3,5-TNB
W_h = average human adult body weight = 70 kg (327 IAC 2-1-8-5 (2)(C)

Therefore:

$$MgT = 0.03\ mg/kg/day \times 70\ kg$$

$$= 2.1\ mg/day$$

The BCF for 1,3,5-TNB was calculated according to Code 327 IAC 2-1-8-7, as follows:

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF
Log Kow for the 1,3,5-TNB = 1.1 (Kow = 12.6)

Using Equation 3, BCF_c = 2.01 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula from Code 327 IAC 2-1-8-7 (4):

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 2.01 x 2 = 4.02 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for 1,3,5-TNB:

- WQC for surface water protected for drinking water supply = 1,000 µg/L
- WQC for surface water not protected for drinking water supply = 19,000 µg/L

Example Calculation for Protected Water Supply

$$HLSC = \frac{2.1\,\text{mg/day}}{2\text{L/d} + (0.025\ \text{kg/day x } 4.02\ \text{L/kg})}$$

$$= \frac{2.1\,\text{mg}}{2.1\,\text{L}}$$

= 1.0 mg/L

= 1,000 µg/L

Example Calculation for Unprotected Water Supply

$$HLSC = \frac{2.1\,\text{mg/day}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 4.02\ \text{L/kg})}$$

$$= \frac{2.1\,\text{mg}}{0.11\,\text{L}}$$

= 19 mg/L

= 19,000 µg/L

Using TtNUS' significant figures policy for organic chemicals, this value rounds off to 19,000 µg/L.

C.6 HMX (OCTAHYDRO-1,3,5,7-TRITRANITRO-1,3,5,7-TETRAZOCINE)

DERIVATION OF A SURFACE WATER ALTERNATIVE QUALITY CRITERION HMX

Surface water quality criterion (WQC) for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) were calculated according to the guidance provided in Indiana Administrative Codes 327 IAC 2-1-8-5 and 2-1-8-6. Since HMX is classified as a noncarcinogen by the United States Environmental Protection Agency (U.S. EPA), the derivation of the WQC was performed primarily according to Code 327 IAC 2-1-8-5 [Determination of the human life cycle safe concentration (HLSC)]. The following general formula for deriving a WQC for carcinogens is provided in 327 IAC 2-1-8-5:

$$HLSC = \frac{MgT\,(mg/day)}{WC + (F \times BCF)} \quad \text{(Equation 1)}$$

Where:

HLSC = the human life cycle safe concentration (µg/L)
MgT = maximum milligrams of toxicant per day causing no adverse effects to humans daily for a lifetime (mg/day)
WC = daily water consumption
= 0.01 L per day for surface water not protected for drinking water supply
= 2 L per day surface water protected for drinking water supply
F = daily fish consumption rate = 0.025 kg per day
BCF = water to fish tissue bioconcentration factor

MgT can be derived using one of several options provided in 327 IAC 2-1-8-5 (1) or (2) using a U.S. EPA MCL (if available) or a No Observable Adverse Effect Level (NOAEL) from a human or animal study. No MCL is currently available for HMX. Therefore, the MgT was derived from the reference dose (RfD) currently used by the U.S. EPA for HMX which is based on a NOAEL. The most recently published RfD for HMX is 0.05 mg/kg/day (IRIS, online, January 2006). The MgT was derived as follows:

$$MgT = RfD \times W_h \quad \text{(Equation 2)}$$

Where:

RfD = noncarcinogenic reference dose for HMX
W_h = average human adult body weight = 70 kg (327 IAC 2-1-8-5 (2)(C)

Therefore:

$$MgT = 0.05\ mg/kg/day \times 70\ kg$$

$$= 3.5\ mg/day$$

The BCF for HMX was calculated according to Code 327 IAC 2-1-8-7, as follows:

The 1st step in deriving a BCF is to derive a calculated BCF from the octanol/water partition coefficient (K_{ow}) using the following equation:

$$\text{Log } BCF_c = 0.847 \log K_{ow} - 0.628 \quad \text{(Equation 3)}$$

Where:
BCFc = the calculated BCF

Log Kow for the HMX = 0.82 (Kow = 6.6)

Using Equation 3, BCF_c = 1.166 L/kg

The 2nd step in deriving a BCF is to normalize BCF_c for lipid content using the formula from Code 327 IAC 2-1-8-7 (4):

$$BCF_f = BCF_c\ (9.6/4.8)\ \text{(Equation 4)}$$

Where BCF_f = the final bioconcentration factor = 1.166 x 2 = 2.33 L/kg

Based on the above equation and exposure factors, the following surface water WQC were calculated for HMX:

- WQC for surface water protected for drinking water supply = 1,700 µg/L
- WQC for surface water not protected for drinking water supply = 51,000 µg/L

Example Calculation for Protected Water Supply

$$HLSC = \frac{3.5\ \text{mg/day}}{2\text{L/d} + (0.025\ \text{kg/day x } 2.33\ \text{L/kg})}$$

$$= \frac{3.5\ \text{mg}}{2.058\ \text{L}}$$

= 1.7 mg/L

= 1,700 µg/L

Example Calculation for Unprotected Water Supply

$$HLSC = \frac{3.5\ \text{mg/day}}{0.01\text{L/d} + (0.025\ \text{kg/day x } 2.33\ \text{L/kg})}$$

$$= \frac{3.5\ \text{mg}}{0.068\ \text{L}}$$

= 51.28 mg/L

= 51,280 µg/L

Using TtNUS' significant figures policy for organic chemicals, this value rounds off to 51,000 µg/L.

APPENDIX D

SPRINGS A AND C DATA

TABLE D-1.1
RDX CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	RDX
		UNITS	µg/L
		CRITERIA	3
03-SPR-A	2/28/1999	ASPA1A99	1.5
03-SPR-A	5/20/1999	ASPA2A99	6.
03-SPR-A	5/20/1999	ASPA2A99-D	6.6
03-SPR-A	9/13/1999	ASPA3A99	120.
03-SPR-A	3/29/2000	ASPA1A00	7.4
03-SPR-A	3/29/2000	ASPA1A00-D	8.5
03-SPR-A	6/26/2000	ASPA2A00	11.
03-SPR-A	9/29/2000	ASPA3A00	9.2
03-SPR-A	12/18/2000	ASPA4A00	1.9
03-SPR-A	4/10/2001	ASPA1A01	10.
03-SPR-A	7/10/2001	ASPA2A01	5.1
03-SPR-A	7/10/2001	ASPA2A01-D	4.9
03-SPR-A	9/17/2001	ASPA3A01	52.
03-SPR-A	12/20/2001	ASPA4A01	3.5
03-SPR-A	12/20/2001	ASPA4A01-D	2.9
03-SPR-A	3/12/2002	ASPA1A02	3.4
03-SPR-A	6/20/2002	ASPA2A02	37.
03-SPR-A	6/20/2002	ASPA2A02-D	35.
03-SPR-A	9/10/2002	ASPA3A02	140.
03-SPR-A	12/9/2002	ASPA4A02	73.
03-SPR-A	3/7/2003	ASPA1A03	1.6
03-SPR-A	6/30/2003	ASPA2A03	50.
03-SPR-A	9/9/2003	ASPA3A03	66.
03-SPR-A	12/17/2003	ASPA4A03	2.5
03-SPR-A	3/16/2004	ASPA1A04	11.
03-SPR-Ap	4/24/2004	03SPAP01	7.4
03-SPR-A	6/29/2004	ASPA2A04	52.
03-SPR-A	9/16/2004	ASPA3A04	100.
		Maximum	140.

Value Exceeds Criteria
Location/Date of Maximum Value

RDX — hexahydro-1,3,5-trinitro-1,3,5-triazine

TABLE D-1.2
RDX CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	RDX
		UNITS	µg/L
		CRITERIA	3
03-SPR-C	02/28/99	ASPC1A99	1.7
03-SPR-C	05/20/99	ASPC2A99	1.9
03-SPR-C	09/13/99	ASPC3A99	0.72
03-SPR-C	09/13/99	ASPC3A99-D	0.77
03-SPR-C	03/14/00	ASPC1A00	1.8
03-SPR-C	03/14/00	ASPC1A00-D	1.7
03-SPR-C	06/28/00	ASPC2A00	4.1
03-SPR-C	06/28/00	ASPC2A00-D	5
03-SPR-C	09/29/00	ASPC3A00	3.2
03-SPR-C	12/19/00	ASPC4A00	1.7
03-SPR-C	04/10/01	ASPC1A01	1.4
03-SPR-C	07/10/01	ASPC2A01	4.9
03-SPR-C	09/17/01	ASPC3A01	3.6
03-SPR-C	12/18/01	ASPC4A01	1.6
03-SPR-C	03/11/02	ASPC1A02	2.5
03-SPR-C	06/24/02	ASPC2A02	3.9
03-SPR-C	09/09/02	ASPC3A02	0.62999 U
03-SPR-C	12/12/02	ASPC4A02	3.1
03-SPR-C	03/10/03	ASPC1A03	1.7
03-SPR-C	06/26/03	ASPC2A03	3.6
03-SPR-C	09/09/03	ASPC3A03	6.4
03-SPR-C	12/18/03	ASPC4A03	2.9
03-SPR-C	12/18/03	ASPC4A03-D	2.5
03-SPR-C	03/03/04	ASPC1A04	1.1
03-SPR-C	03/03/04	ASPC1A04-D	1.2
03-SPR-C	06/29/04	ASPC2A04	4.9
03-SPR-C	06/29/04	ASPC2A04-D	4.3
03-SPR-C	09/16/04	ASPC3A04	1.9
		Maximum	6.4

Value Exceeds Criteria
Location/Date of Maximum Value

RDX — hexahydro-1,3,5-trinitro-1,3,5-triazine

TABLE D-2.1
2,4-DINITROTOLUENE CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,4-DNT
		UNITS	µg/L
		CRITERIA	52
03-SPR-A	11/5/1998	ABGSPRASW01	0.86 U
03-SPR-A	2/28/1999	ASPA1A99	0.29 U
03-SPR-A	5/20/1999	ASPA2A99	0.33 U
03-SPR-A	9/13/1999	ASPA3A99	0.87 U
03-SPR-A	3/29/2000	ASPA1A00	0.66 U
03-SPR-A	6/26/2000	ASPA2A00	0.95999 U
03-SPR-A	12/18/2000	ASPA4A00	0.73 U
03-SPR-A	4/10/2001	ASPA1A01	0.51999 U
03-SPR-A	7/10/2001	ASPA2A01	0.70999 U
03-SPR-A	9/17/2001	ASPA3A01	0.62 U
03-SPR-A	12/20/2001	ASPA4A01	0.97 U
03-SPR-A	3/12/2002	ASPA1A02	0.57999 U
03-SPR-A	6/20/2002	ASPA2A02	1.1 U
03-SPR-A	9/10/2002	ASPA3A02	0.43999 U
03-SPR-A	12/9/2002	ASPA4A02	1.1 U
03-SPR-A	3/7/2003	ASPA1A03	0.43999 U
03-SPR-A	6/30/2003	ASPA2A03	1.2 U
03-SPR-A	9/9/2003	ASPA3A03	0.68 U
03-SPR-A	12/17/2003	ASPA4A03	0.52999 U
03-SPR-A	3/16/2004	ASPA1A04	0.54 U
03-SPR-A	6/29/2004	ASPA2A04	0.54 U
03-SPR-A	9/16/2004	ASPA3A04	0.51999 U
		Maximum	1.2

Value Exceeds Criteria
Location/Date of Maximum Value

2,4-DNT - 2,4-Dinitrotoluene.

TABLE D-2.2
2,4-DINITROTOLUENE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,4-DNT
		UNITS	µg/L
		CRITERIA	52
03-SPR-C	11/5/1998	ABGSPRCSW01	0.79 U
03-SPR-C	2/28/1999	ASPC1A99	1.6 U
03-SPR-C	5/20/1999	ASPC2A99	0.66 U
03-SPR-C	9/13/1999	ASPC3A99	0.31 U
03-SPR-C	3/14/2000	ASPC1A00	0.95999 U
03-SPR-C	6/28/2000	ASPC2A00	0.79 U
03-SPR-C	12/19/2000	ASPC4A00	1.2 U
03-SPR-C	4/10/2001	ASPC1A01	0.83999 U
03-SPR-C	7/10/2001	ASPC2A01	0.38999 U
03-SPR-C	9/17/2001	ASPC3A01	0.62 U
03-SPR-C	12/18/2001	ASPC4A01	0.50999 U
03-SPR-C	3/11/2002	ASPC1A02	0.36 U
03-SPR-C	6/24/2002	ASPC2A02	1.2 U
03-SPR-C	9/9/2002	ASPC3A02	0.62999 U
03-SPR-C	12/12/2002	ASPC4A02	1.2 U
03-SPR-C	3/10/2003	ASPC1A03	1.2 U
03-SPR-C	6/26/2003	ASPC2A03	1.4 U
03-SPR-C	9/9/2003	ASPC3A03	0.91 U
03-SPR-C	12/18/2003	ASPC4A03	0.5 U
03-SPR-C	3/3/2004	ASPC1A04	0.52999 U
03-SPR-C	6/29/2004	ASPC2A04	0.52999 U
03-SPR-C	9/16/2004	ASPC3A04	0.50999 U
		Maximum	1.6

Value Exceeds Criteria
Location/Date of Maximum Value

2,4-DNT - 2,4-Dinitrotoluene.

TABLE D-2.3
2,6-DINITROTOLUENE CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,6-DNT
		UNITS	µg/L
		CRITERIA	29
03-SPR-A	11/5/1998	ABGSPRASW01	0.86 U
03-SPR-A	3/29/2000	ASPA1A00	0.66 U
03-SPR-A	4/10/2001	ASPA1A01	0.51999 U
03-SPR-A	3/12/2002	ASPA1A02	0.57999 U
03-SPR-A	3/7/2003	ASPA1A03	0.43999 U
03-SPR-A	3/16/2004	ASPA1A04	0.54 U
03-SPR-A	2/28/1999	ASPA1A99	0.29 U
03-SPR-A	6/26/2000	ASPA2A00	0.95999 U
03-SPR-A	7/10/2001	ASPA2A01	0.70999 U
03-SPR-A	6/20/2002	ASPA2A02	1.1 U
03-SPR-A	6/30/2003	ASPA2A03	1.2 U
03-SPR-A	6/29/2004	ASPA2A04	0.54 U
03-SPR-A	5/20/1999	ASPA2A99	0.33 U
03-SPR-A	9/17/2001	ASPA3A01	0.62 U
03-SPR-A	9/10/2002	ASPA3A02	0.43999 U
03-SPR-A	9/9/2003	ASPA3A03	0.68 U
03-SPR-A	9/16/2004	ASPA3A04	0.51999 U
03-SPR-A	9/13/1999	ASPA3A99	0.87 U
03-SPR-A	12/18/2000	ASPA4A00	0.73 U
03-SPR-A	12/20/2001	ASPA4A01	0.97 U
03-SPR-A	12/9/2002	ASPA4A02	1.1 U
03-SPR-A	12/17/2003	ASPA4A03	0.52999 U
		Maximum	1.2

Value Exceeds Criteria
Location/Date of Maximum Value

2,6-DNT - 2,6-Dinitrotoluene.

TABLE D-2.4
2,6-DINITROTOLUENE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,6-DNT
		UNITS	µg/L
		CRITERIA	29
03-SPR-C	11/5/1998	ABGSPRCSW01	0.79 U
03-SPR-C	2/28/1999	ASPC1A99	1.6 U
03-SPR-C	5/20/1999	ASPC2A99	0.66 U
03-SPR-C	9/13/1999	ASPC3A99	0.31 U
03-SPR-C	3/14/2000	ASPC1A00	0.95999 U
03-SPR-C	6/28/2000	ASPC2A00	0.79 U
03-SPR-C	12/19/2000	ASPC4A00	1.2 U
03-SPR-C	4/10/2001	ASPC1A01	0.83999 U
03-SPR-C	7/10/2001	ASPC2A01	0.38999 U
03-SPR-C	9/17/2001	ASPC3A01	0.62 U
03-SPR-C	12/18/2001	ASPC4A01	0.50999 U
03-SPR-C	3/11/2002	ASPC1A02	0.36 U
03-SPR-C	6/24/2002	ASPC2A02	1.2 U
03-SPR-C	9/9/2002	ASPC3A02	0.62999 U
03-SPR-C	12/12/2002	ASPC4A02	1.2 U
03-SPR-C	3/10/2003	ASPC1A03	1.2 U
03-SPR-C	6/26/2003	ASPC2A03	1.4 U
03-SPR-C	9/9/2003	ASPC3A03	0.91 U
03-SPR-C	12/18/2003	ASPC4A03	0.5 U
03-SPR-C	3/3/2004	ASPC1A04	0.52999 U
03-SPR-C	6/29/2004	ASPC2A04	0.52999 U
03-SPR-C	9/16/2004	ASPC3A04	0.50999 U
		Maximum	1.6

Value Exceeds Criteria
Location/Date of Maximum Value

2,6-DNT - 2,6-Dinitrotoluene.

TABLE D-3.1
2,4,6-TRINITROTOLUENE CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,4,6-TNT
		UNITS	µg/L
		CRITERIA	10
03-SPR-A	11/5/1998	ABGSPRASW01	0.86 U
03-SPR-A	2/28/1999	ASPA1A99	0.49 J
03-SPR-A	5/20/1999	ASPA2A99	0.84
03-SPR-A	9/13/1999	ASPA3A99	1.8
03-SPR-A	3/29/2000	ASPA1A00	0.69999
03-SPR-A	6/26/2000	ASPA2A00	0.95999 U
03-SPR-A	12/18/2000	ASPA4A00	0.73 U
03-SPR-A	4/10/2001	ASPA1A01	0.81
03-SPR-A	7/10/2001	ASPA2A01	0.70999 U
03-SPR-A	9/17/2001	ASPA3A01	0.62 U
03-SPR-A	12/20/2001	ASPA4A01	0.97 U
03-SPR-A	3/12/2002	ASPA1A02	0.57999 U
03-SPR-A	6/20/2002	ASPA2A02	4.1
03-SPR-A	9/10/2002	ASPA3A02	1.6
03-SPR-A	12/9/2002	ASPA4A02	5.5
03-SPR-A	3/7/2003	ASPA1A03	0.43999 U
03-SPR-A	6/30/2003	ASPA2A03	3.
03-SPR-A	9/9/2003	ASPA3A03	3.
03-SPR-A	12/17/2003	ASPA4A03	0.52999 U
03-SPR-A	3/16/2004	ASPA1A04	1.4
03-SPR-A	6/29/2004	ASPA2A04	4.5
03-SPR-A	9/16/2004	ASPA3A04	5.6
		Maximum	5.6

Value Exceeds Criteria
Location/Date of Maximum Value

2,4,6-TNT - 2,4,6-Trinitrotoluene.

TABLE D-3.2
2,4,6-TRINITROTOLUENE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2,4,6-TNT
		UNITS	µg/L
		CRITERIA	10
03-SPR-C	11/5/1998	ABGSPRASW01	0.79 U
03-SPR-C	2/28/1999	ASPC1A99	1.6 U
03-SPR-C	5/20/1999	ASPC2A99	0.66 U
03-SPR-C	9/13/1999	ASPC3A99	0.31 U
03-SPR-C	3/14/2000	ASPC1A00	0.95999 U
03-SPR-C	6/28/2000	ASPC2A00	0.79 U
03-SPR-C	12/19/2000	ASPC4A00	0.12 U
03-SPR-C	4/10/2001	ASPC1A01	0.83999 U
03-SPR-C	7/10/2001	ASPC2A01	0.4
03-SPR-C	9/17/2001	ASPC3A01	0.62 U
03-SPR-C	12/18/2002	ASPC4A01	0.50999 U
03-SPR-C	3/11/2002	ASPC1A02	0.36 U
03-SPR-C	6/24/2002	ASPC2A02	1.2 U
03-SPR-C	9/9/2002	ASPC3A02	0.62999 U
03-SPR-C	12/12/2002	ASPC4A02	1.2 U
03-SPR-C	3/10/2003	ASPC1A03	1.2 U
03-SPR-C	6/26/2003	ASPC2A03	1.4 U
03-SPR-C	9/9/2003	ASPC3A03	0.91 U
03-SPR-C	12/18/2003	ASPC4A03	0.5 U
03-SPR-C	12/18/2003	ASPC4A03-D	0.5 U
03-SPR-C	3/3/2004	ASPC1A04	0.52999 U
03-SPR-C	6/29/2004	ASPC2A04	0.52999 U
03-SPR-C	9/16/2004	ASPC3A04	0.50999 U
		Maximum	1.6

Value Exceeds Criteria
Location/Date of Maximum Value

TABLE D-4.1
2-AMINO-4,6-DINITROTOLUENE/4-AMINO-2,6-DINITROTOLUENE CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CMS REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2-A-DNT		4-A-DNT	
		UNITS	µg/L		µg/L	
		CRITERIA	67		67	
03-SPR-A	2/28/1999	ASPA1A99	0.29	U	0.29	U
03-SPR-A	5/20/1999	ASPA2A99	0.33	U	0.77	
03-SPR-A	9/13/1999	ASPA3A99	2.1		4.9	
03-SPR-A	3/29/2000	ASPA1A00	0.66	U	0.66	U
03-SPR-A	6/26/2000	ASPA2A00	0.95999	U	1.	
03-SPR-A	9/29/2000	ASPA3A00	70			
03-SPR-A	12/18/2000	ASPA4A00	0.73	U	0.73	U
03-SPR-A	4/10/2001	ASPA1A01	0.51999	U	0.82999	
03-SPR-A	7/10/2001	ASPA2A01	0.70999	U	0.75	
03-SPR-A	9/17/2001	ASPA3A01	1.8		3.9	
03-SPR-A	12/20/2001	ASPA4A01	0.97	U	0.97	U
03-SPR-A	3/12/2002	ASPA1A02	0.57999	U	0.57999	U
03-SPR-A	6/20/2002	ASPA2A02	1.1		2.5	
03-SPR-A	9/10/2002	ASPA3A02	1.5		2.7	
03-SPR-A	12/9/2002	ASPA4A02	1.6		3.7	J
03-SPR-A	3/7/2003	ASPA1A03	0.43999	U	0.43999	U
03-SPR-A	6/30/2003	ASPA2A03	1.2		2.8	
03-SPR-A	9/9/2003	ASPA3A03	1.7		3.7	
03-SPR-A	12/17/2003	ASPA4A03	0.52999	U	0.52999	U
03-SPR-A	3/16/2004	ASPA1A04	0.54	U	0.54	U
03-SPR-Ap	4/24/2004	03SPAP01	0.252	U	0.54	
03-SPR-A	6/29/2004	ASPA2A04	1.2		3.	
03-SPR-A	9/16/2004	ASPA3A04	2.4		6.2	
		Maximum	70.			

2-A-DNT — 2-amino-4,6-dinitrotoluene
4-A-DNT — 4-amino-2,6-dinitrotoluene

Maximum Value
Location/Date of Maximum Value

TABLE D-4.2
2-AMINO-4,6-DINITROTOLUENE/4-AMINO-2,6-DINITROTOLUENE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CMS REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	PARAMETER	2-A-DNT		4-A-DNT	
		UNITS	µg/L		µg/L	
		CRITERIA	67		67	
03-SPR-C	2/28/1999	ASPC1A99	1.6	U	1.6	U
03-SPR-C	5/20/1999	ASPC2A99	0.66	U	0.66	U
03-SPR-C	9/13/1999	ASPC3A99	0.31	U	0.31	U
03-SPR-C	3/14/2000	ASPC1A00	0.95999	U	0.95999	U
03-SPR-C	6/28/2000	ASPC2A00	0.79	U	0.79	U
03-SPR-C	12/19/2000	ASPC4A00	1.2	U	1.2	U
03-SPR-C	4/10/2001	ASPC1A01	0.83999	U	0.83999	U
03-SPR-C	7/10/2001	ASPC2A01	0.38999	U	0.38999	U
03-SPR-C	9/17/2001	ASPC3A01	0.62	U	0.62	U
03-SPR-C	12/18/2001	ASPC4A01	0.50999	U	0.50999	U
03-SPR-C	3/11/2002	ASPC1A02	0.36	U	0.36	U
03-SPR-C	6/24/2002	ASPC2A02	1.2	U	1.2	U
03-SPR-C	9/9/2002	ASPC3A02	0.62999	U	0.62999	UJ
03-SPR-C	12/12/2002	ASPC4A02	1.2	U	1.2	U
03-SPR-C	3/10/2003	ASPC1A03	1.2	U	1.2	U
03-SPR-C	6/26/2003	ASPC2A03	1.4	U	1.4	U
03-SPR-C	9/9/2003	ASPC3A03	0.91	U	0.91	U
03-SPR-C	12/18/2003	ASPC4A03	0.5	U	0.5	U
03-SPR-C	3/3/2004	ASPC1A04	0.52999	U	0.52999	U
03-SPR-C	6/29/2004	ASPC2A04	0.52999	U	0.52999	U
03-SPR-C	9/16/2004	ASPC3A04	0.50999	U	0.50999	U
		Maximum	1.6	U		

2-A-DNT — 2-amino-4,6-dinitrotoluene
4-A-DNT — 4-amino-2,6-dinitrotoluene

Maximum Value
Location/Date of Maximum Value

TABLE D-5.1
EXPLOSIVE DEGRADATION PRODUCTS CONCENTRATIONS IN SPRING A
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	FRACTION	EXP
		UNITS	µg/L
		CRITERIA	86
2,4-Diamino-6-Nitrotoluene			
03-SPR-A	11/5/1998	ABGSPRA	0.86 U
2,6-Diamino-4-Nitrotoluene			
03-SPR-A	11/5/1998	ABGSPRA	0.86 U
4,4'-TN-AZOXY			
03-SPR-A	11/5/1998	ABGSPRA	0.86 U
MNX			
03-SPR-A	11/5/1998	ABGSPRA	0.86 U
		Maximum	0.86

4,4'-TN-AZOXY - 2,2-6,6'-tetranitro-4,4'-azoxytoluene.
MNX -hexahydro-1,3,5-mononitroso-1,3,5-triazine.

Maximum Value
Location/Date of Maximum Value

TABLE D-5.2
EXPLOSIVE DEGRADATION PRODUCTS CONCENTRATIONS IN SPRING C
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	FRACTION	EXP
		UNITS	µg/L
		CRITERIA	86
2,4-Diamino-6-Nitrotoluene			
03-SPR-C	11/5/1998	ABGSPRC	0.79 U
2,6-Diamino-4-Nitrotoluene			
03-SPR-C	11/5/1998	ABGSPRC	0.79 U
4,4'-TN-AZOXY			
03-SPR-C	11/5/1998	ABGSPRC	0.79 U
MNX			
03-SPR-C	11/5/1998	ABGSPRC	0.79 U
		Maximum	0.79

4,4'-TN-AZOXY - 2,2-6,6'-tetranitro-4,4'-azoxytoluene.
MNX -hexahydro-1,3,5-mononitroso-1,3,5-triazine.

Maximum Value
Location/Date of Maximum Value

TABLE D-6.1
HMX CONCENTRATIONS IN SPRING A
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	FRACTION	EXP
		UNITS	µg/L
		CRITERIA	84
03-SPR-A	11/5/1998	ABGSPRA	26.
		Maximum	26.

HMX -octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

Maximum Value
Location/Date of Maximum Value

TABLE D-6.2
HMX CONCENTRATIONS IN SPRING C
ALTERNATIVE WATER QUALITY CRITERION REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	FRACTION	EXP
		UNITS	µg/L
		CRITERIA	84
03-SPR-C	11/5/1998	ABGSPRC	0.79 U
		Maximum	0.79

HMX -octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.

Maximum Value
Location/Date of Maximum Value

APPENDIX E

SURFACE WATER QUALITY CRITERION FOR HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX) AQUATIC RECEPTORS

SURFACE WATER QUALITY CRITERION
FOR
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX)

AQUATIC RECEPTORS

A water quality screening level for RDX using water quality standard methodology which is equivalent to Indiana Department of Environmental Management (IDEM) procedures described in 327 IAC 2-1-8.3 [Determination of chronic aquatic criteria (CAC)] has recently been developed for the U.S. Army (Parametrix and ENSR, 2005). The U.S. Army document is attached (Attachment A). Note that although the title of this document indicates that it is for marine organisms, water quality criterion (WQC) developed for both marine and freshwater are presented in the document.

In the U.S. Army document, (Parametrix and ENSR, 2005) compiled a dataset of toxicity data that was adequate to develop acute and chronic WQC for RDX using U.S. EPA guidance for deriving ambient water quality criterion for protection of aquatic life (U.S. EPA, 1985). The same U.S. EPA guidance is cited in the IDEM water quality standards regulation, 327 IAC 2-1-6, Minimum surface water quality standards, as one approach used to develop acute and chronic water quality criteria for Indiana. Acute and chronic WQC were developed for RDX as 3,100 and 3,070 µg/L, respectively (Parametrix and ENSR, 2005). However, U.S. EPA Region 5 indicated that there was an error in the way the chronic value was calculated. U.S. EPA Region 5 noted that the authors incorrectly applied the toxicity test RDX solubility concentration of 17 mg/L from one of the studies (Peters et al. 1991) to represent an acute value and inappropriately generated an acute-to-chronic ratio (ACR) of 3.6325. The correct freshwater ACR in Table 7-2 of ENSR (2005) should be the geometric mean of the two freshwater fish (*Pimephales promelas*) ACR values in Table 6-2 of ENSR (2005) which is 3.3047. This would cause the chronic RDX water screening value to become 1.87 mg/L. Therefore, a chronic value of 1,870 µg/L will be used as the screening level for RDX in surface water at NSWC Crane.

A terrestrial life cycle safe concentration (TLSC) was also calculated according to the IDEM water quality standards. The attached table presents the calculation of the TLSC, including the equation and parameters. The TLSC was only calculated for mammals because no avian toxicity data were available. The calculated TLSC value is 2,800 µg/L (Table 1-1).

References

Parametrix and ENSR (Parametrix, Inc. and ENSR International), 2005. Derivation of Toxicity Reference Values for the Acute and Chronic Toxicity of Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX) to Marine Aquatic Organisms Final Report. Prepared for the U.S. Army Public Works, Fort Lewis, Washington. January.

U.S. EPA (United States Environmental Protection Agency), 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses. U.S. Environmental Protection Agency, Washington, DC. PB85-227049.

TABLE E-1
CALCULATION OF TERRESTRIAL LIFE CYCLE SAFE CONCENTRATION FOR RDX
IDEM WATER QUALITY STANDARDS BASIS
WATER QUALITY STANDARDS REPORT FOR SWMU 3 - AMMUNTION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NOAEL (mg/kg-day)	Body Weight (BW) (kg)	Drinking Water rate (DW) (L/day)	Uncertainty Factor (U)	Fraction of Days Dosed Per Week (Fw)	Terrestrial Life Cycle Safe Concentration (TLSC) (mg/L)
7	0.03	0.0075	10	1	2.8

TLSC = [NOAEL * (BW/DW) * Fw]/U

IDEM - Indiana Department of Environmental Management
kg - kilogram
L - liter
mg - milligram
NOEL - No-Observable-Adverse-Effects-Level
RDX – hexahydro-1,3,5-trinitro-1,3,5-triazine
SWMU – solid waste management unit

- The NOAEL is based on a chronic study (2 year) with mice. The endpoint was reproduction (testicular degeneration). The source of the study was Lish et al., 1984 as cited in Talmage et al., 1999.
- The source of the mouse body weight and drinking water rate is Sample et al., 1996
- It is assumed that the fraction of days doses per week is 1 because the RDX was administered in the diet.
- An uncertainty factor of 10 was assumed because it was a long-term chronic study with a reproductive endpoint.

Lish et al. (Lish P.M., B.S. Levine, E.M. Furedi, E.M Sagartz, and V.S. Rac), 1984. Determination of the chronic mammalian toxicological effects of RDX: twenty-four month chronic toxicity/carcinogenicity study of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in the B6C3F1 hybrid mouse. Phase VI. Vol. 1. AD A160774. IIT Research Institute, Chicago, IL. U.S. Army Medical Research and Development Command, Frederick, MD.

Sample et al. (Sample, B.E., D.M. Opresko, and G.W. Suter II), 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory. June. ES/ER/TM-86/R3.

Talmage et al, (Talmage, Sylvia S., Dennis M. Opresko, Christopher J. Maxwell, Christopher J.E. Welsh, F. Michael Cretella, Patricia H. Reno, and F. Bernard Daniel), 1999. "Nitroaromatic Munition Compounds: Environmental Effects and Screening Values." Rev. Environ. Contam. Toxicol. 161:1-156.

TABLE E-2
SUMMARY OF AQUATIC LIFE SCREENING LEVELS FOR EXPLOSIVES
WATER QUALITY STANDARDS REPORT FOR SWMU 3 - AMMUNTION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA
INDIANA

Chemical	Aquatic Values				Source
	Acute (ug/L)	Basis	Chronic (µg/L)	Basis	
RDX	3096	CMC	3073	CCC	1
HMX	3800	SAV	330	SCV	2
2-amino,4,6-dinitrotoluene	350	SAV	20	SCV	2
3,5-Dinitroaniline	460	SAV	60	SCV	2
1,3,5-Trinitrobenzene	60	SAV	11	SCV	2
2,4,6-Trinitrotoluene	570	WQC	90	WQC	2

CMC - Criterion maximum concentration
CCC - Criterion chronic concentration
SAV - Secondary acute value
SCV - Secondary chronic value
WQC - Water quality criterion

1 - Parametrix and ENSR (2005)
2 - Talmage, et al., (1999)

µg/L = microgram/liter

TABLE E-3
CALCULATION OF TERRESTRIAL LIFE CYCLE SAFE CONCENTRATION FOR EXPLOSIVES
WATER QUALITY STANDARDS REPORT FOR SWMU 3 - AMMUNTION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA
INDIANA

Chemical	NOAEL or LED_{10} (mg/kg-day)	Source[1]	Species	Body Weight (BW) (kg)[2]	Drinking Water rate (DW) (L/day)[2]	Uncertainty Factor (U)	Fraction of Days Dosed Per Week (Fw)	Terrestrial Life Cycle Safe Concentration (TLSC) (mg/L)[3]
RDX	1.19	a	rat	0.35	0.046	10	1	0.91
	3.65	a	quail	0.177	0.0184	10	1	3.5
HMX	1	b	rabbit	3.8	0.268	10	1	1.4
2-amino,4,6-dinitrotoluene	0.67	c*	dog	12.7	0.652	10	1	1.3
	0.7	c**	rat	0.35	0.046	10	1	0.53
	0.01	c*	quail	0.177	0.0184	10	1	0.0096
3,5-Dinitroaniline	No Data							
1,3,5-Trinitrobenzene	2.68	d	rat	0.35	0.046	10	1	2.0
2,4,6-Trinitrotoluene	0.2	e	dog	12.7	0.652	10	1	0.39
	0.07	e	quail	0.177	0.0184	10	1	0.067

TLSC = (NOAEL * (BW/DW) * Fw)/U
NOAEL - No Observable Adverse Effects Level
LED_{10} - Lower estimated dose associated with 10 percent increased incidence (of measured effect).
mg/kg-day = milligrams per kilogram per day.
BW = body weight.
kg = kilogram.
L/day = liters per day.
U = uncertainty factor.
Fw = Fraction of days dosed per week.
TLSC = Terrestrial Life Cycle Safe Concentration.
mg/L = milligram per liter.

1 - Sources of NOAELs
a - Salice, C. and Holdsworth, G., July 2002
b - USCHPPM, October 2001a
c - USCHPPM, January 2006 (*2,4-Dinitrotoluene, **2,6-Dinitrotoluene)
d - Salice, C. and Holdsworth, G., 2001
e - Johnson, M. and McAtee, M., 2000

2 - Sample et al., (1996), except for quail. Quail body weights and ingestion rates were mean values from Crane Ecological Risk Assessments.
3 - From Indiana Administrative Code. Article 2. Water Quality Standards. Section 8.4

APPENDIX E

SAMPLE DATA
FOR
SWMU 3 (AMMUNITION BURNING GROUNDS)

TABLE E-1.1

RDX CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	RDX (µg/L)
02/28/99	1.5
05/20/99	6.
05/20/99	6.6
09/13/99	120.
03/29/00	7.4
03/29/00	8.5
06/26/00	11.
09/29/00	9.2
12/18/00	1.9
04/10/01	10.
07/10/01	5.1
07/10/01	4.9
09/17/01	52.
12/20/01	3.5
12/20/01	2.9
03/12/02	3.4
06/20/02	37.
06/20/02	35.
09/10/02	140.
12/09/02	73.
03/07/03	1.6
06/30/03	50.
09/09/03	66.
12/17/03	2.5
03/16/04	11.
04/24/04	7.4
06/29/04	52.
09/16/04	100.
	140.

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

CRITERIA (µg/L)
3

TABLE E-1.2

RDX CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	RDX (µg/L)
02/28/99	1.7
05/20/99	1.9
09/13/99	0.72
09/13/99	0.77
03/14/00	1.8
03/14/00	1.7
06/28/00	4.1
06/28/00	5
09/29/00	3.2
12/19/00	1.7
04/10/01	1.4
07/10/01	4.9
09/17/01	3.6
12/18/01	1.6
03/11/02	2.5
06/24/02	3.9
09/09/02	0.62999 U
12/12/02	3.1
03/10/03	1.7
06/26/03	3.6
09/09/03	6.4
12/18/03	2.9
12/18/03	2.5
03/03/04	1.1
03/03/04	1.2
06/29/04	4.9
06/29/04	4.3
09/16/04	1.9
	6.4

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

CRITERIA (µg/L)
3

TABLE E-2.1

2,4-DNT CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,4-DNT (µg/L)
11/5/1998	0.86 U
2/28/1999	0.29 U
5/20/1999	0.33 U
9/13/1999	0.87 U
3/29/2000	0.66 U
6/26/2000	0.95999 U
12/18/2000	0.73 U
4/10/2001	0.51999 U
7/10/2001	0.70999 U
9/17/2001	0.62 U
12/20/2001	0.97 U
3/12/2002	0.57999 U
6/20/2002	1.1 U
9/10/2002	0.43999 U
12/9/2002	1.1 U
3/7/2003	0.43999 U
6/30/2003	1.2 U
9/9/2003	0.68 U
12/17/2003	0.52999 U
3/16/2004	0.54 U
6/29/2004	0.54 U
9/16/2004	0.51999 U
Maximum	1.2 U

Value Exceeds Criteria
Location/Date of Maximum Value

µg/L - Microgram per liter.
2,4-DNT - 2,4-Dinitrotoluene.

CRITERIA (µg/L)
52

TABLE E-2.2

2,4-DINITROTOLUENE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,4-DNT (µg/L)
11/5/1998	0.79 U
2/28/1999	1.6 U
5/20/1999	0.66 U
9/13/1999	0.31 U
3/14/2000	0.95999 U
6/28/2000	0.79 U
12/19/2000	1.2 U
4/10/2001	0.83999 U
7/10/2001	0.38999 U
9/17/2001	0.62 U
12/18/2001	0.50999 U
3/11/2002	0.36 U
6/24/2002	1.2 U
9/9/2002	0.62999 U
12/12/2002	1.2 U
3/10/2003	1.2 U
6/26/2003	1.4 U
9/9/2003	0.91 U
12/18/2003	0.5 U
3/3/2004	0.52999 U
6/29/2004	0.52999 U
9/16/2004	0.50999 U
Maximum	1.6 U

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
2,4-DNT - 2,4-Dinitrotoluene.

CRITERIA (µg/L)
52

TABLE E-2.3

2,6-DNT CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,6-DNT (µg/L)
11/5/1998	0.86 U
3/29/2000	0.66 U
4/10/2001	0.51999 U
3/12/2002	0.57999 U
3/7/2003	0.43999 U
3/16/2004	0.54 U
2/28/1999	0.29 U
6/26/2000	0.95999 U
7/10/2001	0.70999 U
6/20/2002	1.1 U
6/30/2003	1.2 U
6/29/2004	0.54 U
5/20/1999	0.33 U
9/17/2001	0.62 U
9/10/2002	0.43999 U
9/9/2003	0.68 U
9/16/2004	0.51999 U
9/13/1999	0.87 U
12/18/2000	0.73 U
12/20/2001	0.97 U
12/9/2002	1.1 U
12/17/2003	0.52999 U
Maximum	1.2 U

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
2,6-DNT - 2,6-Dinitrotoluene.

CRITERIA (µg/L)
29

TABLE E-2.4

2,6-DNT CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,6-DNT (µg/L)
11/5/1998	0.79 U
2/28/1999	1.6 U
5/20/1999	0.66 U
9/13/1999	0.31 U
3/14/2000	0.95999 U
6/28/2000	0.79 U
12/19/2000	1.2 U
4/10/2001	0.83999 U
7/10/2001	0.38999 U
9/17/2001	0.62 U
12/18/2001	0.50999 U
3/11/2002	0.36 U
6/24/2002	1.2 U
9/9/2002	0.62999 U
12/12/2002	1.2 U
3/10/2003	1.2 U
6/26/2003	1.4 U
9/9/2003	0.91 U
12/18/2003	0.5 U
3/3/2004	0.52999 U
6/29/2004	0.52999 U
9/16/2004	0.50999 U
Maximum	1.6 U

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
2,6-DNT - 2,6-Dinitrotoluene.

CRITERIA (µg/L)
29

TABLE E-3.1

TNT CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,4,6-TNT µg/L
11/5/1998	0.86 U
2/28/1999	0.49 J
5/20/1999	0.84
9/13/1999	1.8
3/29/2000	0.69999
6/26/2000	0.95999 U
12/18/2000	0.73 U
4/10/2001	0.81
7/10/2001	0.70999 U
9/17/2001	0.62 U
12/20/2001	0.97 U
3/12/2002	0.57999 U
6/20/2002	4.1
9/10/2002	1.6
12/9/2002	5.5
3/7/2003	0.43999 U
6/30/2003	3.
9/9/2003	3.
12/17/2003	0.52999 U
3/16/2004	1.4
6/29/2004	4.5
9/16/2004	5.6
Maximum	5.6

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
TNT - 2,4,6-Trinitrotoluene.

CRITERIA (µg/L)
29

TABLE E-3.2

TNT CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2,4,6-TNT µg/L
11/5/1998	0.79 U
2/28/1999	1.6 U
5/20/1999	0.66 U
9/13/1999	0.31 U
3/14/2000	0.95999 U
6/28/2000	0.79 U
12/19/2000	1.2 U
4/10/2001	0.83999 U
7/10/2001	0.4
9/17/2001	0.62 U
12/18/2001	0.50999 U
3/11/2002	0.36 U
6/24/2002	1.2 U
9/9/2002	0.62999 U
12/12/2002	1.2 U
3/10/2003	1.2 U
6/26/2003	1.4 U
9/9/2003	0.91 U
12/18/2003	0.5 U
12/18/2003	0.5 U
3/3/2004	0.52999 U
6/29/2004	0.52999 U
9/16/2004	0.50999 U
Maximum	0.4

Value Exceeds Criteria
Date of Maximum Value

µg/L - Microgram per liter.
TNT - 2,4,6-Trinitrotoluene.

CRITERIA (µg/L)
29

TABLE E-4.1

AMINO-DINITROTOLUENES CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
02/28/99	0.29	U	0.29	U
05/20/99	0.33	U	0.77	
05/20/99	0.73	U	0.8	
09/13/99	2.1		4.9	
03/29/00	0.66	U	0.66	U
03/29/00	1.9	U	1.9	U
06/26/00	0.95999	U	1.	
09/29/00	70.			
12/18/00	0.73	U	0.73	U
04/10/01	0.51999	U	0.82999	
07/10/01	0.70999	U	0.75	
07/10/01	0.56	U	0.81	
09/17/01	1.8		3.9	
12/20/01	0.97	U	0.97	U
12/20/01	0.41999	U	0.41999	U
03/12/02	0.57999	U	0.57999	U
06/20/02	1.1		2.5	
06/20/02	1.3		2.4	
09/10/02	1.5		2.7	
12/09/02	1.6		3.7	J
03/07/03	0.43999	U	0.43999	U
06/30/03	1.2		2.8	
09/09/03	1.7		3.7	
12/17/03	0.52999	U	0.52999	U
03/16/04	0.54	U	0.54	U
04/24/04	0.252	U	0.54	
06/29/04	1.2		3.	
09/16/04	2.4		6.2	

70.

µg/L - Microgram per liter.
Amino-dinitrotoluenes - 2-A-DNT/4-A-DNT.
2-A-DNT — 2-amino-4,6-dinitrotoluene.
4-A-DNT — 4-amino-2,6-dinitrotoluene.

Maximum Value
Date of Maximum Value

CRITERIA (µg/L)	
2-A-DNT	2-A-DNT
67	67

TABLE E-4.2

AMINO-DINITROTOLUENES CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
02/28/99	1.6	U	1.6	U
05/20/99	0.66	U	0.66	U
09/13/99	0.31	U	0.31	U
09/13/99	0.4	U	0.4	U
03/14/00	0.95999	U	0.95999	U
03/14/00	0.76999	U	0.76999	U
06/28/00	0.79	U	0.79	U
06/28/00	1.	U	1.	U
09/29/00	.			
12/19/00	1.2	U	1.2	U
04/10/01	0.83999	U	0.83999	U
07/10/01	0.38999	U	0.38999	U
09/17/01	0.62	U	0.62	U
12/18/01	0.50999	U	0.50999	U
03/11/02	0.36	U	0.36	U
06/24/02	1.2	U	1.2	U
09/09/02	0.62999	U	0.62999	UJ
12/12/02	1.2	U	1.2	U
03/10/03	1.2	U	1.2	U
06/26/03	1.4	U	1.4	U
09/09/03	0.91	U	0.91	U
12/18/03	0.5	U	0.5	U
12/18/03	0.5	U	0.5	U
03/03/04	0.52999	U	0.52999	U
03/03/04	0.52999	U	0.52999	U
06/29/04	0.52999	U	0.52999	U
06/29/04	0.52999	U	0.52999	U
09/16/04	0.50999	U	0.50999	U
Maximum	1.6	U		

µg/L - Microgram per liter.
Amino-dinitrotoluenes - 2-A-DNT/2-A-DNT.
2-A-DNT — 2-amino-4,6-dinitrotoluene.
4-A-DNT — 4-amino-2,6-dinitrotoluene.

Maximum Value
Date of Maximum Value

CRITERIA (µg/L)	
2-A-DNT	4-A-DNT
67	67

TABLE E-5

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN SURFACE WATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
CRA	11/5/1998	158	146
CRB	11/5/1998	131	130
CRA	2/28/1999	37.1	48.3
CRB	2/28/1999	35	39.7
CRA	5/20/1999	65.8	59.6
CRB	5/20/1999	64.9	60.4
CRB	9/13/1999	158	158
CRA	3/8/2000	70.7	72.1
CRB	3/8/2000	70.3	67.2
CRA	6/9/2000		127
CRB	6/9/2000		128
CRB	12/12/2000	49	42.9
CRA	12/18/2000	46.2	45.4
03SWSD15	6/10/2001	61.6	63.1
03SWSD16	6/10/2001	83.1	81.7
03SWSD17	6/10/2001	96.1	105
03SWSD18	6/10/2001	98.3	97.7
03SWSD19	6/10/2001	97.5	98.3
03SWSD01	6/11/2001	63 J	58.2 J
03SWSD06	6/11/2001	120 J	114 J
03SWSD02	6/12/2001	76 J	72.8 J
03SWSD03	6/12/2001	73.9 J	60.9 J
03SWSD01	9/9/2001	56.7 J	47.1 J
03SWSD02	9/9/2001	55.7 J	47 J
03SWSD03	9/9/2001	78.7 J	76.5 J
03SWSD06	9/9/2001	124 J	106 J
03SWSD08	9/9/2001	58.7 J	40.4 J
03SWSD09	9/9/2001	126 J	85.8 J
03SWSD11	9/9/2001	103 J	75.7 J
03SWSD13	9/9/2001	76.1 J	51.8 J
03SWSD14	9/9/2001	45.6 J	37.7 J
03SWSD15	9/9/2001	74.3 J	80 J
03SWSD16	9/9/2001	132 J	136 J
03SWSD17	9/9/2001	131 J	141 J
03SWSD18	9/9/2001	156 J	147 J
03SWSD19	9/9/2001	145 J	138 J
CRB	9/21/2004		
	Maximum	158	

1 - total barium.
2 - filtered barium.

µg/L - Microgram per liter.

Location/Date of Maximum Value

TABLE E-6

TCE CONCENTRATIONS IN SURFACE WATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)
CRA	11/5/1998	0.5 U
CRB	11/5/1998	0.5 U
CRA	2/28/1999	0.5 U
CRB	2/28/1999	0.5 U
CRA	5/20/1999	0.5 U
CRB	5/20/1999	0.5 U
CRB	9/13/1999	0.5 U
CRA	3/8/2000	0.5 U
CRB	3/8/2000	0.5 U
CRB	12/12/2000	0.5 U
CRA	12/18/2000	0.5 U
03SWSD15	6/10/2001	0.5 U
03SWSD16	6/10/2001	0.5 U
03SWSD17	6/10/2001	0.4 J
03SWSD18	6/10/2001	0.5 U
03SWSD19	6/10/2001	0.5 U
03SWSD01	6/11/2001	0.5 U
03SWSD06	6/11/2001	0.5 U
03SWSD02	6/12/2001	0.5 U
03SWSD03	6/12/2001	0.5 U
03SWSD01	9/9/2001	0.5 U
03SWSD02	9/9/2001	0.5 U
03SWSD03	9/9/2001	0.5 U
03SWSD06	9/9/2001	0.5 U
03SWSD08	9/9/2001	0.5 U
03SWSD09	9/9/2001	0.5 U
03SWSD11	9/9/2001	0.5 U
03SWSD13	9/9/2001	0.5 U
03SWSD14	9/9/2001	0.5 U
03SWSD15	9/9/2001	0.5 U
03SWSD16	9/9/2001	0.5 U
03SWSD17	9/9/2001	0.5 U
03SWSD18	9/9/2001	0.5 U
03SWSD19	9/9/2001	0.5 U
CRB	9/21/2004	
	Maximum	0.4

µg/L - Microgram per liter.
TCE - trichloroethene.

Location/Date of Maximum Value

TABLE E-7

2-A-DNT AND 4-A-DNT CONCENTRATIONS IN SURFACE WATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)	4-A-DNT (µg/L)
CRA	11/5/1998	0.71 U	0.71 U
CRB	11/5/1998	0.9 U	1.2 J
CRA	2/28/1999	0.7 U	0.7 U
CRB	2/28/1999	0.65 U	0.65 U
CRA	5/20/1999	0.55 U	0.55 U
CRB	5/20/1999	0.6 U	0.6 U
CRB	9/13/1999	0.52 U	0.52 U
CRA	3/8/2000	1.3 U	1.3 U
CRB	3/8/2000	0.53 U	0.53 U
CRB	12/12/2000	0.97 U	0.97 U
CRA	12/18/2000	0.94 U	0.94 U
03SWSD15	6/10/2001	0.35 U	0.35 U
03SWSD16	6/10/2001	0.35 U	0.35 U
03SWSD17	6/10/2001	0.37 J	0.83
03SWSD18	6/10/2001	0.35 U	0.68 J
03SWSD19	6/10/2001	0.35 U	0.54 J
03SWSD01	6/11/2001	0.35 U	0.35 U
03SWSD06	6/11/2001	0.75 J	1.7
03SWSD02	6/12/2001	0.35 U	0.35 U
03SWSD03	6/12/2001	0.35 U	0.35 U
03SWSD01	9/9/2001	0.35 U	0.35 U
03SWSD02	9/9/2001	0.35 U	0.35 U
03SWSD03	9/9/2001	0.35 U	0.35 U
03SWSD06	9/9/2001	0.35 U	1.4 J
03SWSD08	9/9/2001	0.35 U	0.35 U
03SWSD09	9/9/2001	0.35 U	0.35 U
03SWSD11	9/9/2001	0.35 U	0.35 U
03SWSD13	9/9/2001	0.35 U	0.35 U
03SWSD14	9/9/2001	0.35 U	0.35 U
03SWSD15	9/9/2001	0.35 U	0.35 U
03SWSD16	9/9/2001	0.35 U	0.35 U
03SWSD17	9/9/2001	1.5 J	2.9
03SWSD18	9/9/2001	0.35 U	0.35 U
03SWSD19	9/9/2001	0.35 U	0.35 U
CRB	9/21/2004	0.52 U	0.52 U
	Maximum	2.9	

µg/L - Microgram per liter.
2-ADNT — 2-amion-4,6-dinitrotoluene.
4-ADNT — 4-amino-2,6-dinitrotoluene.

Location/Date of Maximum Value

CRITERIA (µg/L)	
2-A-DNT	4-A-DNT
67	67

TABLE E-8

RDX CONCENTRATIONS IN SURFACE WATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)
CRA	11/5/1998	28
CRB	11/5/1998	20
CRA	2/28/1999	1.6
CRB	2/28/1999	1
CRA	5/20/1999	3.6
CRB	5/20/1999	3.1
CRB	9/13/1999	3.8
CRA	3/8/2000	4.5 J
CRB	3/8/2000	7.2 J
CRB	12/12/2000	1.1
CRA	12/18/2000	1.9
03SWSD15	6/10/2001	2.4 J
03SWSD16	6/10/2001	2.3
03SWSD17	6/10/2001	11
03SWSD18	6/10/2001	9.5
03SWSD19	6/10/2001	7.7 J
03SWSD01	6/11/2001	0.35 U
03SWSD06	6/11/2001	4.4
03SWSD02	6/12/2001	0.35 U
03SWSD03	6/12/2001	0.35 U
03SWSD01	9/9/2001	0.35 U
03SWSD02	9/9/2001	0.35 U
03SWSD03	9/9/2001	0.35 U
03SWSD06	9/9/2001	8.3
03SWSD08	9/9/2001	0.35 U
03SWSD09	9/9/2001	1.5 J
03SWSD11	9/9/2001	4.8
03SWSD13	9/9/2001	0.94
03SWSD14	9/9/2001	0.35 U
03SWSD15	9/9/2001	0.84
03SWSD16	9/9/2001	0.62
03SWSD17	**9/9/2001**	63
03SWSD18	9/9/2001	39 J
03SWSD19	9/9/2001	10
CRB	9/21/2004	14
	Maximum	63

µg/L - Microgram per liter.
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine.

Value Exceeding Criteria
Location/Date of Maximum Value

CRITERIA (µg/L)
3

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
03B04	02/23/99	77.4	95.9
03C25	02/24/99	15.6	20.8
03C10	02/25/99	42.4	47.7
03C11	02/25/99	22.9	26.2
03C12	02/25/99	88.7	105.
03C02P2	02/26/99	61.2	71.6
03C07	02/26/99	29.6	41.
03C03	02/27/99	38.3	47.8
03C04	02/27/99	31.4	49.
03C09P2	03/01/99	15.4	13.4
03C15	03/01/99	23.1	22.9
03C26	03/02/99	37.4	36.9
03C27	03/02/99	34.3	32.7
03C17	03/08/99	11.	11.
03C30	03/08/99	61.1	57.7
03B02	03/10/99	76.1	75.2
03C20	03/11/99	29.7	29.9
03C08P2	03/12/99	70.2	63.1
03B04	05/17/99	83.9	74.
03B02	05/18/99	82.2	74.8
03C03	05/18/99	39.	35.4
03C17	05/18/99	11.7	10.
03C02P2	05/19/99	85.9	76.3
03C07	05/19/99	30.7	26.
03C09P2	05/19/99	14.8	11.8
03C04	05/21/99	28.7	29.2
03C11	05/21/99	54.3	38.3
03C10	05/22/99	44.3	44.3
03C12	05/22/99	90.9	89.3
03C20	05/22/99	33.9	30.6
03C15	05/23/99	23.	21.
03C26	05/23/99	37.9	35.2
03C08P2	05/24/99	16.4	62.9
03C27	05/24/99	31.9	31.1
03C30	05/24/99	69.1	66.4
03C25	05/25/99	1.1 U	15.8
03C02P2	09/07/99	105.	105.
03C10	09/08/99	46.6	44.
03C12	09/08/99	96.9	99.6
03C15	09/08/99	25.1	24.9
03C27	09/08/99	33.	33.2
03B02	09/09/99	88.	91.3

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
03B04	09/09/99	95.	107.
03C17	09/09/99	13.2	13.8
03C11	09/10/99	23.1	27.
03C25	09/10/99	16.8	18.1
03C30	09/10/99	17.2	73.
03C03	09/11/99	42.3	49.7
03C04	09/11/99	30.6	31.7
03C07	09/11/99	31.9	32.9
03C09P2	09/11/99	15.2	15.3
03C08P2	09/12/99	81.8	89.6
03C26	09/12/99	41.6	47.3
03C20	09/14/99	30.4	34.4
WATER WELL	09/23/99	40.6	37.6
03C02P2	03/06/00	101.	95.3
03C04	03/14/00	30.9	25.9
03C07	03/14/00	32.8	33.7
03C12	03/15/00	92.1	96.
03C30	03/21/00	61.1	46.
03C11	03/22/00	23.6	22.4
03C15	03/23/00	22.8	23.6
03C20	03/23/00	32.1	32.7
03C25	03/24/00	16.6	16.9
03C09P2	03/25/00	13.9	13.7
03B04	03/27/00	87.8	86.8
03B02	03/28/00	83.4	79.3
03C27	03/28/00	33.3	34.1
03C26	03/29/00	38.4	39.7
03C08P2	03/30/00	64.7	59.9
03C03	04/01/00	42.7	42.9
03C10	04/01/00	45.1	45.4
03C17	04/01/00	13.3	12.2
03C17	05/25/00	13.6	12.9
03C25	05/25/00		15.2
03C20	06/01/00	34.4	36.4
03C12	06/05/00		102.
03C09P2	06/06/00	14.9	15.4
03C11	06/06/00		24.9
03C15	06/07/00	23.9	25.6
03C02P2	06/08/00	99.8	108.
03C07	06/15/00	33.8	34.4
03C03	06/19/00	44.8	45.4
03C08P2	06/20/00	61.	60.2

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
03C26	06/21/00	43.2	44.2
03C27	06/21/00	35.4	36.9
03B02	06/23/00	92.9	93.1
03C10	06/23/00	51.2	50.3
03B04	06/26/00	96.3	98.7
03C04	06/27/00	23.7	23.7
03C30	06/28/00	58.6	54.2
03B02	09/07/00	94.6	88.2
03C25	09/07/00	18.9	16.4
03B04	09/08/00	107.	96.4
03C07	09/08/00	33.7	30.9
03C10	09/08/00	48.5	44.8
03C03	09/12/00	44.9	39.9
03C17	09/12/00	13.8	12.1
03C27	09/12/00	38.4	35.
03C04	09/13/00	43.4	20.7
03C08P2	09/13/00	27.2	56.1
03C12	09/13/00	40.1	114.
03C26	09/14/00	60.	38.
03C09P2	09/15/00	16.2	13.4
03C11	09/15/00	24.	22.6
03C02P2	09/18/00	132.	123.
03C15	09/18/00	24.	23.2
03C20	09/18/00	33.	32.2
03C30	09/19/00		
03C25	11/29/00	18.1	17.8
03C02P2	11/30/00	70.3	68.1
03C27	11/30/00	37.2	37.8
03C03	12/01/00	45.2	44.2
03C09P2	12/01/00	15.1	14.7
03C10	12/01/00	47.1	48.6
03B04	12/04/00	104.	97.
03B02	12/05/00	97.5	88.7
03C04	12/05/00	26.9	22.2
03C17	12/05/00	13.1	12.3
03C30	12/07/00	54.7	49.5
03C11	12/11/00	23.7	22.6
03C12	12/14/00	111.	104.
03C15	12/21/00	25.6	24.5
03C07	12/27/00	32.6	30.8
03C20	12/28/00	34.3	33.4
03C08P2	01/02/01	71.8	65.9

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)		BARIUM[2] (µg/L)	
03C26	01/04/01	42.6		40.	
03C02P2	03/05/01	66.7		66.1	
03C25	03/06/01	17.8		16.9	
03B02	03/07/01	75.4		75.8	
03B04	03/08/01	87.2		82.4	
03C04	03/12/01	24.6		21.4	
03C12	03/13/01	92.2		91.9	
03C03	03/14/01	37.8		37.6	
03C09P2	03/14/01	14.3		13.3	
03C10	03/19/01	44.9		43.6	
03C11	03/20/01	22.6		21.8	
03C07	03/21/01	34.2		30.9	
03C20	03/21/01	32.1		31.3	
03C27	03/22/01	30.5		30.5	
03C15	03/26/01	25.5		25.4	
03C26	03/27/01	39.4		38.6	
03C08P2	03/28/01	69.5		64.4	
03C17	04/02/01	13.8		11.1	
03C30	04/03/01	51.2		54.2	
03-07	06/07/01	153.	J		
03-20	06/09/01	44.8	J		
03-23	06/09/01	58.3	J		
03C09P2	06/12/01				
03C02P2	06/13/01				
03C25	06/18/01				
03C15	06/19/01				
03C10	06/20/01				
03B02	06/21/01				
03B04	06/21/01				
03-13	06/23/01	66.8	J		
03-17	06/24/01	26.2	J		
03-18	06/24/01	58.6	J		
03-11	06/25/01	88.6	J		
03-12	06/25/01	46.2	J		
03-14	06/25/01	96.5	J		
03-24	06/25/01	50.9	J		
03-25	06/25/01	19.4	J	18.1	J
03C27	06/25/01	31.		31.6	
03C07	06/26/01	29.7		33.	
03C26	06/26/01	37.8		39.	
03C04	06/27/01	23.7		17.	
03C11	06/27/01	19.9		19.7	

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)		BARIUM[2] (µg/L)
03C12	06/27/01	89.		91.6
03C08P2	06/28/01	63.		56.5
03C20	06/28/01	31.4		31.3
03C03	07/02/01	36.4		41.1
03C17	07/03/01	13.		17.5
03C30	07/03/01	48.2		50.6
03-15	07/10/01	88.5	J	
03-16	07/10/01	43.	J	
03-21	07/10/01	275.	J	
03-22	07/10/01	173.	J	
03-10	07/11/01	71.3	J	
03C03	08/29/01	37.7		39.9
03C25	08/30/01	16.4		16.2
03C27	09/04/01	31.3		31.9
03C09P2	09/05/01	13.4		12.9
03C20	09/05/01	30.4		30.8
03C15	09/06/01	25.6		25.6
03C02P2	09/10/01	113.		113.
03C04	09/10/01			
03C08P2	09/17/01	55.		57.6
03C17	09/17/01	11.8		10.4
03C07	09/18/01	29.6		29.7
03C04	09/19/01	22.2		20.
03C26	09/19/01	37.9		37.5
03C30	09/20/01	45.7		41.
03C25	11/13/01	17.8		16.7
03C02P2	11/26/01	85.6		90.1
03C15	11/27/01	27.4		29.3
03C03	11/30/01	35.8		38.5
03C04	12/03/01	22.6		21.3
03C20	12/03/01	31.1		32.1
03C26	12/04/01	37.9		39.1
03C08P2	12/05/01	56.5		54.6
03C30	12/10/01	51.2		50.4
03C07	12/11/01	33.5		32.2
03C17	12/13/01	14.7		11.6
03C09P2	12/17/01	17.6		13.9
03C27	12/19/01	42.8		39.
03C25	02/08/02	17.8		16.7
03C02P2	02/11/02	71.		68.
03C03	02/22/02	33.8		44.5
03C09P2	02/22/02	13.7		15.3

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
03C04	02/25/02	24.7	21.1
03C26	02/25/02	36.1	45.9
03C07	02/27/02	27.	36.3
03C08P2	02/28/02	64.8	79.4
03C20	02/28/02	28.7	37.3
03C27	03/04/02	30.7	38.8
03C17	03/05/02	11.1	12.5
03C15	03/06/02	25.9	28.2
03C30	03/07/02	54.2	50.5
03C03	05/14/02	34.3	35.5
03C09P2	05/15/02	13.	12.
03C02P2	05/16/02	62.8	63.
03C26	05/20/02	35.5	35.5
03C20	05/21/02	28.4	28.8
03C17	05/22/02	11.	9.5
03C27	05/28/02	27.3	29.
03C30	05/30/02	58.	36.7
03C15	06/05/02	27.8	27.1
03C08P2	06/06/02	62.5	56.7
03C04	06/10/02	21.9	17.
03C07	06/18/02	30.3	31.2
03C03	08/20/02	34.8	35.3
03C26	08/20/02	36.5	35.9
03C15	08/21/02	26.5	25.5
03C20	08/22/02	30.1	30.9
03C30	08/26/02	50.6	46.7
03C27	08/27/02	27.6	26.7
03C04	08/28/02	20.	18.3
03C07	08/28/02	25.9	26.1
03C09P2	08/29/02	14.1	11.7
03C08P2	09/03/02	57.1	51.6
03C02P2	09/04/02	80.2	79.8
03C09P2	09/04/02		
03C04	09/05/02		
03C17	09/05/02	12.5	10.8
03C25	09/10/02	16.4	15.6
03C25	10/31/02	15.8	15.1
03C03	11/04/02	39.5	39.2
03C09P2	11/06/02	19.6	13.5
03C02P2	11/07/02	106.	105.
03C26	11/12/02	37.8	42.1
03C17	11/13/02	12.1	11.1

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)	BARIUM[2] (µg/L)
03C27	11/14/02	28.8	29.1
03C20	11/18/02	31.5	30.7
03C04	11/19/02	24.1	17.5
03C08P2	11/20/02	59.9	55.
03C07	11/25/02	29.4	28.8
03C15	11/26/02	28.5	28.
03C30	12/04/02	57.3	33.6
03C03	02/24/03	36.2	36.5
03C08P2	02/25/03	64.7	57.3
03C09P2	02/26/03	16.5	12.4
03C30	02/27/03	53.2	49.4
03C26	03/03/03	37.9	38.7
03C02P2	03/04/03	61.6	60.9
03C15	03/05/03	28.4	27.9
03C07	03/06/03	28.8	29.4
03C04	03/11/03	34.7	18.2
03C17	03/11/03	11.4	10.9
03C20	03/12/03	30.4	31.
03C09P2	05/19/03	16.8	12.
03C03	05/21/03	35.6	36.4
03C25	05/27/03	15.4	15.4
03C26	05/29/03	37.2	37.7
03C27	06/02/03	25.8	26.
03C20	06/04/03	28.6	28.4
03C08P2	06/09/03	55.8	52.6
03C02P2	06/10/03	83.9	85.4
03C15	06/17/03	24.9	25.2
03C07	06/18/03	30.1	30.7
03C17	06/19/03	10.	9.
03C04	06/23/03	21.8	15.5
03C30	06/24/03	39.5	46.
03C26	08/22/03	37.4	38.3
03C03	08/25/03	34.1	37.2
03C20	08/25/03	30.5	31.7
03C02P2	08/26/03	86.2	93.3
03C07	08/26/03	26.9	28.8
03C30	08/27/03	44.9	34.9
03C09P2	08/28/03	16.6	12.4
03C04	09/02/03	21.2	16.7
03C08P2	09/03/03	53.3	53.
03C15	09/04/03	23.3	23.7
03C27	09/05/03	26.4	28.4

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)		BARIUM[2] (µg/L)	
03C17	09/08/03	10.6		9.8	
03C25	09/09/03	15.8		15.4	
03C03	11/06/03	36.8		35.7	
03C25	11/10/03	16.4		16.3	
03C09P2	11/12/03	19.3		12.6	
03C20	11/17/03	31.3		31.9	
03C26	11/20/03	39.5		40.4	
03C27	11/25/03	31.7		33.4	
03C02P2	12/01/03	72.2		72.8	
03C15	12/02/03	25.7		26.4	
03C08P2	12/08/03	57.6		52.4	
03C04	12/09/03	25.2		18.9	
03C30	12/11/03	56.8		36.5	
03C07	12/15/03	28.5		29.9	
03C17	12/22/03	10.9		10.5	
03C25	02/26/04	16.3		15.6	
03C02P2	02/27/04	45.4		43.8	
03C04	03/02/04	23.5		18.8	
03C26	03/02/04	37.7		38.1	
03C03	03/05/04	36.1		36.4	
03C09P2	03/08/04	18.7		12.5	
03C20	03/09/04	29.8		31.2	
03C08P2	03/10/04	59.3		56.	
03C17	03/11/04	11.2		11.	
03C07	03/12/04	26.7		28.3	
03C27	03/15/04	28.2		29.2	
03C30	03/15/04	48.4		34.	
03C15	03/17/04	27.6		27.4	
03-01	04/04/04	26.1	J		
03-38	04/04/04	19.2	J		
03-33	04/06/04	71.2	J	71.1	J
03C01P2	04/06/04	49.4	J		
03C06	04/06/04	49.8	J		
03C21	04/06/04	39.4	J		
03-09	04/07/04	54.8	J		
03-31	04/07/04	14.6	J		
03C03P2	04/07/04	93.3	J	83.8	J
03C14	04/07/04	60.4	J		
03-16	04/08/04	46.6	J		
03-21	04/08/04	252.	J		
03-24	04/08/04	42.9	J		
03C05	04/08/04	52.7	J		

TABLE E-9

FILTERED AND TOTAL BARIUM CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURS PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	BARIUM[1] (µg/L)		BARIUM[2] (µg/L)	
03C28	04/08/04	69.	J		
03SB060/TW01	04/17/04	230.	J		
03-12	04/18/04	49.8	J		
03-15	04/18/04	73.4	J		
03SB063/TW02	04/19/04	62.9	J	53.5	J
03SB090/TW03	04/19/04	1,140.	J	124.	J
03SB103/TW05	04/21/04	160.	J	168.	J
03TW04	04/21/04	259.	J	247.	J
03-39	04/22/04	14.6	J		
03-07	04/24/04	136.	J		
03SB050/TW06	04/24/04	3,780.	J	3,830.	J
03C25	06/01/04	16.3		15.4	
03C03	06/07/04	36.9		37.2	
03C02P2	06/08/04	96.1		94.1	
03C04	06/16/04	22.8		18.	
03C26	06/16/04	39.7		39.4	
03C09P2	06/17/04	20.9		12.2	
03C20	06/18/04	32.8		31.5	
03C15	06/21/04	28.		29.3	
03C27	06/22/04	28.3		28.4	
03C07	06/28/04	27.5		29.	
03C08P2	06/30/04	65.		61.	
03C17	06/30/04	10.4		9.8	
03C30	06/30/04	56.4		39.4	
03C25	09/02/04	19.		14.8	
03C03	09/07/04	38.		36.6	
03C04	09/08/04	24.3		18.3	
03C20	09/08/04	34.1		32.4	
03C02P2	09/09/04	97.4		97.2	
03C09P2	09/13/04	18.		12.6	
03C30	09/13/04	55.7		33.5	
03C07	09/14/04	27.1		27.7	
03C26	09/14/04	45.6		40.9	
03C08P2	09/15/04	55.4		54.7	
03C27	09/17/04	27.9		30.1	
03C15	09/20/04	28.6		28.4	
03C17	09/20/04	12.4		10.1	
		3,830.			

1 - total barium.
2 - filtered barium.

µg/L - Microgram per liter.

Location/Date of Maximum Value

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03B04	02/23/99	0.5	U
03C25	02/24/99	0.5	U
03C10	02/25/99	63	
03C11	02/25/99	2,100	
03C12	02/25/99	22	
03C02P2	02/26/99	77	
03C07	02/26/99	4.7	
03C03	02/27/99	0.5	U
03C04	02/27/99	0.5	U
03C09P2	03/01/99	160	
03C15	03/01/99	0.5	U
03C26	03/02/99	4.2	
03C27	03/02/99	4.	
03C17	03/08/99	0.5	U
03C30	03/08/99	0.5	U
03B02	03/10/99	0.5	U
03C20	03/11/99	3,700	
03C08P2	03/12/99	71	
03B04	05/17/99	0.5	U
03B02	05/18/99	0.5	U
03C03	05/18/99	0.5	U
03C17	05/18/99	0.5	U
03C02P2	05/19/99	3.2	
03C07	05/19/99	3.	
03C09P2	05/19/99	150	
03C04	05/21/99	0.6	
03C11	05/21/99	760	
03C10	05/22/99	63	
03C12	05/22/99	19	
03C20	05/22/99	3,300	
03C15	05/23/99	0.5	U
03C26	05/23/99	9.1	
03C08P2	05/24/99	61	
03C27	05/24/99	3.8	
03C30	05/24/99	0.5	U
03C25	05/25/99	0.5	U
03C02P2	09/07/99	10	
03C10	09/08/99	61	
03C12	09/08/99	21	
03C15	09/08/99	0.5	U
03C27	09/08/99	4.2	
03B02	09/09/99	0.5	U
03B04	09/09/99	0.5	U
03C17	09/09/99	0.5	U

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C11	09/10/99	2,300	
03C25	09/10/99	0.5	U
03C30	09/10/99	0.5	U
03C03	09/11/99	0.5	U
03C04	09/11/99	0.5	U
03C07	09/11/99	4.3	
03C09P2	09/11/99	170	
03C08P2	09/12/99	63	
03C26	09/12/99	8.9	
03C20	09/14/99	3,400	
WATER WELL	09/23/99	0.5	U
03C02P2	03/06/00	12	
03C04	03/14/00	0.5	U
03C07	03/14/00	4.5	
03C12	03/15/00	21	
03C30	03/21/00	0.5	U
03C11	03/22/00	2,200	
03C15	03/23/00	0.5	U
03C20	03/23/00	3,300	
03C25	03/24/00	0.5	U
03C09P2	03/25/00	120	
03B04	03/27/00	0.5	U
03B02	03/28/00	0.5	U
03C27	03/28/00	4.2	
03C26	03/29/00	10	
03C08P2	03/30/00	63	
03C03	04/01/00	0.5	U
03C10	04/01/00	54	
03C17	04/01/00	0.5	U
03C17	05/25/00	0.5	U
03C25	05/25/00	0.5	U
03C20	06/01/00	3,300	
03C12	06/05/00	20	
03C09P2	06/06/00	110	
03C11	06/06/00	2,500	
03C15	06/07/00	0.5	U
03C02P2	06/08/00	9.2	
03C07	06/15/00	2.9	
03C03	06/19/00	0.5	U
03C08P2	06/20/00	747	
03C26	06/21/00	10	
03C27	06/21/00	4.4	
03B02	06/23/00	0.5	U
03C10	06/23/00	72	

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03B04	06/26/00	0.5	U
03C04	06/27/00	0.5	U
03C30	06/28/00	0.5	U
03B02	09/07/00	0.5	U
03C25	09/07/00	0.5	U
03B04	09/08/00	0.5	U
03C07	09/08/00	4.6	
03C10	09/08/00	68	
03C03	09/12/00	0.5	U
03C17	09/12/00	0.5	U
03C27	09/12/00	3.8	
03C04	09/13/00	0.5	U
03C08P2	09/13/00	66	
03C12	09/13/00	20	
03C26	09/14/00	8.2	
03C09P2	09/15/00	120	
03C11	09/15/00	2,300	
03C02P2	09/18/00	11	
03C15	09/18/00	0.5	U
03C20	09/18/00	4,500	
03C30	09/19/00	0.5	U
03C25	11/29/00	0.5	U
03C02P2	11/30/00	2.9	
03C27	11/30/00	3.8	
03C03	12/01/00		
03C09P2	12/01/00	130	
03C10	12/01/00	68	
03B04	12/04/00	0.5	U
03B02	12/05/00	0.5	U
03C04	12/05/00	0.5	U
03C17	12/05/00	0.5	U
03C30	12/07/00	0.5	U
03C11	12/11/00	2,300	
03C12	12/14/00	25	
03C15	12/21/00	0.5	U
03C07	12/27/00	5.9	
03C20	12/28/00	3,500	
03C08P2	01/02/01	67	
03C26	01/04/01	9.6	
03C02P2	03/05/01	5.	
03C25	03/06/01	0.5	U
03B02	03/07/01	0.5	U
03B04	03/08/01	0.5	U
03C04	03/12/01	0.5	U

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C12	03/13/01	19.	
03C03	03/14/01	0.5	U
03C09P2	03/14/01	150.	
03C10	03/19/01	55.	
03C11	03/20/01	2,300.	
03C07	03/21/01	20.	
03C20	03/21/01	3,200.	
03C27	03/22/01	13.	
03C15	03/26/01	0.5	U
03C26	03/27/01	8.8	
03C08P2	03/28/01	66.	
03C17	04/02/01	0.5	U
03C30	04/03/01	0.5	U
03-07	06/07/01	640.	
03-20	06/09/01	0.3	J
03-23	06/09/01	0.5	U
03C09P2	06/12/01	120.	
03C02P2	06/13/01	9.4	
03C25	06/18/01	0.5	U
03C15	06/19/01	0.5	U
03C10	06/20/01	48.	
03B02	06/21/01	0.5	U
03B04	06/21/01	0.5	U
03-13	06/23/01	0.5	U
03-17	06/24/01	0.5	U
03-18	06/24/01	0.5	U
03-11	06/25/01	0.5	U
03-12	06/25/01	3.7	J
03-14	06/25/01	0.5	U
03-24	06/25/01	23.	J
03-25	06/25/01	0.5	U
03C27	06/25/01	3.	
03C07	06/26/01	5.	
03C26	06/26/01	8.8	
03C04	06/27/01	0.5	U
03C11	06/27/01	1,900.	
03C12	06/27/01	16.	
03C08P2	06/28/01	57.	
03C20	06/28/01	2,400.	
03C03	07/02/01	0.5	U
03C17	07/03/01	0.5	U
03C30	07/03/01	0.5	U
03-15	07/10/01	57.	J
03-16	07/10/01	0.5	U

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03-21	07/10/01	1.6	U
03-22	07/10/01	6	J
03-10	07/11/01	0.9	U
03C03	08/29/01	0.5	U
03C25	08/30/01	0.5	U
03C27	09/04/01	3.7	
03C09P2	09/05/01	180	
03C20	09/05/01	3,500	
03C15	09/06/01	0.6	
03C02P2	09/10/01	7.1	
03C04	09/10/01	0.6	
03C08P2	09/17/01	59	
03C17	09/17/01	0.5	U
03C07	09/18/01	5.5	
03C04	09/19/01		
03C26	09/19/01	11	
03C30	09/20/01	0.5	U
03C25	11/13/01	0.5	U
03C02P2	11/26/01	11	
03C15	11/27/01	0.5	U
03C03	11/30/01	0.5	U
03C04	12/03/01	0.6	
03C20	12/03/01	2,900	
03C26	12/04/01	11	
03C08P2	12/05/01	67	
03C30	12/10/01	0.5	U
03C07	12/11/01	4.2	
03C17	12/13/01	0.5	U
03C09P2	12/17/01	180	
03C27	12/19/01	4.9	
03C25	02/08/02	0.5	U
03C02P2	02/11/02	3.9	
03C03	02/22/02	0.5	U
03C09P2	02/22/02	170	
03C04	02/25/02	0.6	
03C26	02/25/02	10	
03C07	02/27/02	4.3	
03C08P2	02/28/02	58	
03C20	02/28/02	3,000	
03C27	03/04/02	3.2	
03C17	03/05/02	0.5	U
03C15	03/06/02	0.5	U
03C30	03/07/02	0.5	U
03C03	05/14/02	0.5	U

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C09P2	05/15/02	97.	J
03C02P2	05/16/02	2.9	
03C26	05/20/02	13.	
03C20	05/21/02	1,900.	
03C17	05/22/02	0.8	
03C27	05/28/02	4.	
03C30	05/30/02	0.5	U
03C15	06/05/02	0.5	U
03C08P2	06/06/02	47.	
03C04	06/10/02	0.5	
03C07	06/18/02	4.5	
03C03	08/20/02	0.5	U
03C26	08/20/02	13.	
03C15	08/21/02	0.5	U
03C20	08/22/02	1,500.	
03C30	08/26/02	0.5	U
03C27	08/27/02	3.9	
03C04	08/28/02	0.5	U
03C07	08/28/02	4.3	
03C09P2	08/29/02		
03C08P2	09/03/02	58.	
03C02P2	09/04/02	3.1	
03C09P2	09/04/02	190.	
03C04	09/05/02		
03C17	09/05/02	0.5	U
03C25	09/10/02	0.5	U
03C25	10/31/02	1.	U
03C03	11/04/02	1.	U
03C09P2	11/06/02	160.	
03C02P2	11/07/02	12.	
03C26	11/12/02	13.	
03C17	11/13/02	1.	U
03C27	11/14/02	3.8	
03C20	11/18/02	2,000.	
03C04	11/19/02	0.8	J
03C08P2	11/20/02	59.	
03C07	11/25/02	7.2	
03C15	11/26/02	1.	U
03C30	12/04/02	1.	U
03C03	02/24/03	1.	U
03C08P2	02/25/03	73.	
03C09P2	02/26/03	180.	
03C30	02/27/03	1.	U
03C26	03/03/03	17.	

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C02P2	03/04/03	2.3	
03C15	03/05/03	1.	U
03C07	03/06/03	5.8	
03C04	03/11/03	1.	U
03C17	03/11/03	1.	U
03C20	03/12/03	2,600	
03C09P2	05/19/03	110	
03C03	05/21/03	0.5	U
03C25	05/27/03	0.5	U
03C26	05/29/03	13	
03C27	06/02/03	3.5	
03C20	06/04/03	2,000	
03C08P2	06/09/03	55	
03C02P2	06/10/03	4.8	
03C15	06/17/03	0.5	U
03C07	06/18/03	0.5	U
03C17	06/19/03	0.5	U
03C04	06/23/03	0.3	J
03C30	06/24/03	0.5	U
03C26	08/22/03	9.3	
03C03	08/25/03	0.5	U
03C20	08/25/03	3,200	
03C02P2	08/26/03	10	
03C07	08/26/03	5.2	
03C30	08/27/03	0.5	U
03C09P2	08/28/03	160	
03C04	09/02/03	0.5	
03C08P2	09/03/03	62	
03C15	09/04/03	0.5	U
03C27	09/05/03	3.8	
03C17	09/08/03	0.5	U
03C25	09/09/03	0.5	U
03C03	11/06/03	0.5	U
03C25	11/10/03	0.5	U
03C09P2	11/12/03	0.5	U
03C20	11/17/03	2,700	
03C26	11/20/03	15	
03C27	11/25/03	3.8	
03C02P2	12/01/03	2.9	
03C15	12/02/03	0.5	U
03C08P2	12/08/03	58	
03C04	12/09/03	0.4	J
03C30	12/11/03	0.5	U
03C07	12/15/03	5.7	

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C17	12/22/03	0.5	U
03C25	02/26/04	0.5	U
03C02P2	02/27/04	15	
03C04	03/02/04	0.5	U
03C26	03/02/04	3.4	
03C03	03/05/04	0.5	U
03C09P2	03/08/04	110	
03C20	03/09/04	1,400	
03C08P2	03/10/04	54	
03C17	03/11/04	0.5	U
03C07	03/12/04	5.2	
03C27	03/15/04	3.5	
03C30	03/15/04	0.5	U
03C15	03/17/04	0.5	U
03-01	04/04/04	52	
03-38	04/04/04	130	
03-33	04/06/04	0.8	J
03C01P2	04/06/04	0.3	U
03C06	04/06/04	7.5	
03C21	04/06/04	0.3	U
03-09	04/07/04	0.3	U
03-31	04/07/04	0.6	J
03C03P2	04/07/04	120	
03C14	04/07/04	0.3	U
03-16	04/08/04	0.3	U
03-21	04/08/04	0.6	J
03-24	04/08/04	17	
03C05	04/08/04	0.3	U
03C28	04/08/04	0.3	U
03SB060/TW01	04/17/04	0.3	U
03-12	04/18/04	2.2	
03-15	04/18/04	30	
03SB063/TW02	04/19/04	310	
03SB090/TW03	04/19/04	0.3	U
03SB103/TW05	04/21/04	23	
03TW04	04/21/04	0.3	U
03-39	04/22/04	180	
03-07	04/24/04	920	
03SB050/TW06	04/24/04	0.3	U
03C25	06/01/04	0.5	U
03C03	06/07/04	0.5	U
03C02P2	06/08/04	4.2	
03C04	06/16/04	0.5	
03C26	06/16/04	15	

TABLE E-10

TRICHLORETHENE CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	TCE (µg/L)	
03C09P2	06/17/04	160.	
03C20	06/18/04	2,000.	
03C15	06/21/04	0.5	U
03C27	06/22/04	2.8	
03C07	06/28/04	4.4	
03C08P2	06/30/04	53.	
03C17	06/30/04	0.5	U
03C30	06/30/04	0.5	U
03C25	09/02/04	0.5	UJ
03C03	09/07/04	0.5	UJ
03C04	09/08/04	0.5	UJ
03C20	09/08/04	2,400.	
03C02P2	09/09/04	9.1	J
03C09P2	09/13/04	180.	J
03C30	09/13/04	0.5	UJ
03C07	09/14/04	6.1	J
03C26	09/14/04	13.	J
03C08P2	09/15/04	47.	J
03C27	09/17/04	2.8	J
03C15	09/20/04	0.5	UJ
03C17	09/20/04	0.5	UJ
	Maximum	4,500.	

µg/L - Microgram per liter.

Value Exceeding Criteria
Location/Date of Maximum Value

CRITERIA (µg/L)
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TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03B04	02/23/99	0.94	U	0.94	U
03C25	02/24/99	1.2	U	1.2	U
03C10	02/25/99	1.5	U	1.5	U
03C11	02/25/99	1.	U	1.	U
03C12	02/25/99	0.74	U	0.74	U
03C02P2	02/26/99	0.49	U	0.49	U
03C07	02/26/99	1.2	U	1.2	U
03C03	02/27/99	1.	U	1.	U
03C04	02/27/99	0.46	U	0.46	U
03C09P2	03/01/99	0.44	U	0.44	U
03C15	03/01/99	0.49	U	0.49	U
03C26	03/02/99	1.4	U	1.4	U
03C27	03/02/99	1.3	U	1.3	U
03C17	03/08/99	1.2	U	1.2	U
03C30	03/08/99	0.56	U	0.56	U
03B02	03/10/99	0.58	U	0.58	U
03C20	03/11/99	12.		18.	
03C08P2	03/12/99	2.6		4.5	
03B04	05/17/99	0.52	U	0.52	U
03B02	05/18/99	0.95	UJ	0.95	UJ
03C03	05/18/99	0.2	U	0.2	U
03C17	05/18/99	0.36	U	0.36	U
03C02P2	05/19/99	0.68	U	0.68	U
03C07	05/19/99	0.64	U	0.64	U
03C09P2	05/19/99	0.75	U	0.75	U
03C04	05/21/99	1.	U	1.	U
03C11	05/21/99	0.71	U	0.71	U
03C10	05/22/99	0.65	U	0.65	U
03C12	05/22/99	0.3	U	0.3	U
03C20	05/22/99	11.		17.	
03C15	05/23/99	1.1	U	1.1	U
03C26	05/23/99	0.81	U	0.81	U
03C08P2	05/24/99	2.6		0.44	U
03C27	05/24/99	0.55	U	0.55	U
03C30	05/24/99	0.79	U	0.79	U
03C25	05/25/99	1.	U	1.	U
03C02P2	09/07/99	0.95	U	0.95	U
03C10	09/08/99	0.49	U	1.3	J
03C12	09/08/99	0.75	U	0.75	U
03C15	09/08/99	1.4	U	1.4	U
03C27	09/08/99	0.86	U	0.86	U
03B02	09/09/99	0.3	U	0.3	U
03B04	09/09/99	0.64	U	0.64	U
03C17	09/09/99	1.4	U	1.4	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03C11	09/10/99	0.51	U	0.56	J
03C25	09/10/99	0.79	U	0.79	U
03C30	09/10/99	0.25	U	0.25	U
03C03	09/11/99	0.7	U	0.7	U
03C04	09/11/99	1.5	U	1.5	U
03C07	09/11/99	0.23	U	0.4	J
03C09P2	09/11/99	0.31	U	0.31	U
03C08P2	09/12/99	2.1	J	3.9	J
03C26	09/12/99	0.61	U	0.61	U
03C20	09/14/99	12		19	
WATER WELL	09/23/99	0.88	U	0.88	U
03C02P2	03/06/00	0.41999	U	0.41999	U
03C04	03/14/00	0.52999	U	0.52999	U
03C07	03/14/00	1.3	U	1.3	U
03C12	03/15/00	0.46	U	0.46	U
03C30	03/21/00	1.3	U	1.3	U
03C11	03/22/00	1.2	U	1.2	U
03C15	03/23/00	1.1	U	1.1	U
03C20	03/23/00	12		14	
03C25	03/24/00	0.73	U	0.73	U
03C09P2	03/25/00	0.75	U	0.75	U
03B04	03/27/00	0.68	U	0.68	U
03B02	03/28/00	0.6	U	0.6	U
03C27	03/28/00	0.87	U	0.87	U
03C26	03/29/00	1.	U	1.	U
03C08P2	03/30/00	2.9		3.9	
03C03	04/01/00	1.2	U	1.2	U
03C10	04/01/00	0.94999	U	0.94999	U
03C17	04/01/00	0.52999	U	0.52999	U
03C17	05/25/00	0.73	U	0.73	U
03C25	05/25/00				
03C20	06/01/00	14		18	
03C12	06/05/00				
03C09P2	06/06/00	1.	U	1.	U
03C11	06/06/00				
03C15	06/07/00	0.57999	U	0.57999	U
03C02P2	06/08/00	1.1	U	1.1	U
03C07	06/15/00	1.3	U	1.3	U
03C03	06/19/00	1.1	U	1.1	U
03C08P2	06/20/00	3.1		4.5	
03C26	06/21/00	1.2	U	1.2	U
03C27	06/21/00	1.3	U	1.3	U
03B02	06/23/00	0.79	U	0.79	U
03C10	06/23/00	0.55	U	0.70999	

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03B04	06/26/00	1.1	U	1.1	U
03C04	06/27/00	0.61	U	0.61	U
03C30	06/28/00	1.1	U	1.1	U
03B02	09/07/00	0.21999	U	0.21999	U
03C25	09/07/00	0.87999	U	0.87999	U
03B04	09/08/00	0.87999	U	0.87999	U
03C07	09/08/00	0.63999	U	0.63999	U
03C10	09/08/00	0.87	U	1.	
03C03	09/12/00	0.68	U	0.68	U
03C17	09/12/00	1.4	U	1.4	U
03C27	09/12/00	1.1	U	1.1	U
03C04	09/13/00	1.1	U	1.1	U
03C08P2	09/13/00	2.		3.4	
03C12	09/13/00	0.52999	U	0.52999	U
03C26	09/14/00	0.41999	U	0.41999	U
03C09P2	09/15/00	0.46	U	0.46	U
03C11	09/15/00	1.6	U	1.6	U
03C02P2	09/18/00	0.51999	U	0.51999	U
03C15	09/18/00	0.76999	U	0.76999	U
03C20	09/18/00	12.		17.	
03C30	09/19/00				
03C25	11/29/00	0.64999	U	0.64999	U
03C02P2	11/30/00	0.83999	U	0.83999	U
03C27	11/30/00	0.68	U	0.68	U
03C03	12/01/00	1.4	U	1.4	U
03C09P2	12/01/00	0.99	U	0.99	U
03C10	12/01/00	0.94999	U	1.4	
03B04	12/04/00	1.4	U	1.4	U
03B02	12/05/00	0.87999	U	0.87999	U
03C04	12/05/00	1.5	U	1.5	U
03C17	12/05/00	0.52999	U	0.52999	U
03C30	12/07/00	0.68	U	0.68	U
03C11	12/11/00	0.83999	U	0.83999	U
03C12	12/14/00	1.	U	1.	U
03C15	12/21/00	0.46999	U	0.46999	U
03C07	12/27/00	0.83999	U	0.83999	U
03C20	12/28/00	11.		16.	
03C08P2	01/02/01	2.7		4.2	
03C26	01/04/01	1.3	U	1.3	U
03C02P2	03/05/01	0.94999	U	0.94999	U
03C25	03/06/01	0.82999	U	0.82999	U
03B02	03/07/01	0.79	U	0.79	U
03B04	03/08/01	0.81	U	0.81	U
03C04	03/12/01	1.	U	1.	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03C12	03/13/01	0.89999	U	0.89999	U
03C03	03/14/01	0.36	U	0.36	U
03C09P2	03/14/01	0.87	U	0.87	U
03C10	03/19/01	0.74	U	0.93	
03C11	03/20/01	0.70999	U	0.70999	U
03C07	03/21/01	0.89999	U	0.89999	U
03C20	03/21/01	12		16	
03C27	03/22/01	1.	U	1.	U
03C15	03/26/01	1.	U	1.	U
03C26	03/27/01	1.2	U	1.2	U
03C08P2	03/28/01	2.3		3.2	
03C17	04/02/01	1.2	U	1.2	U
03C30	04/03/01	1.9	U	1.9	U
03-07	06/07/01	0.35	U	0.35	U
03-20	06/09/01	0.35	U	0.35	U
03-23	06/09/01	0.35	U	0.62	J
03C09P2	06/12/01	1.1	U	1.1	U
03C02P2	06/13/01	0.70999	U	0.70999	U
03C25	06/18/01	1.	U	1.	U
03C15	06/19/01	0.49	U	0.49	U
03C10	06/20/01	0.91	U	1.1	
03B02	06/21/01	0.31	U	0.31	U
03B04	06/21/01	0.34999	U	0.34999	U
03-13	06/23/01	0.47	R	0.77	J
03-17	06/24/01	0.35	U	0.35	U
03-18	06/24/01	0.35	U	0.35	U
03-11	06/25/01	0.35	U	0.35	U
03-12	06/25/01	1		1.5	
03-14	06/25/01	0.55	J	0.82	J
03-24	06/25/01	0.35	U	0.35	U
03-25	06/25/01	0.35	U	0.35	U
03C27	06/25/01	0.73	U	0.73	U
03C07	06/26/01	0.83999	U	0.83999	U
03C26	06/26/01	1.6	U	1.6	U
03C04	06/27/01	0.70999	U	0.70999	U
03C11	06/27/01	0.76999	U	0.76999	U
03C12	06/27/01	0.61	U	0.61	U
03C08P2	06/28/01	2.8		3.5	
03C20	06/28/01	12		14	
03C03	07/02/01	0.36	U	0.36	U
03C17	07/03/01	0.36	U	0.36	U
03C30	07/03/01	0.93999	U	0.93999	U
03-15	07/10/01	0.12	U	0.35	U
03-16	07/10/01	0.12	U	0.35	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03-21	07/10/01	2.6		10.	
03-22	07/10/01	0.12	U	0.35	U
03-10	07/11/01	0.12	U	0.35	U
03C03	08/29/01	0.89999	U	0.89999	U
03C25	08/30/01	1.1	U	1.1	U
03C27	09/04/01	0.4	U	0.4	U
03C09P2	09/05/01	0.79	U	0.79	U
03C20	09/05/01	12.		15.	
03C15	09/06/01	0.43999	U	0.43999	U
03C02P2	09/10/01	0.52999	U	0.52999	U
03C04	09/10/01	1.2	U	1.2	U
03C08P2	09/17/01	2.7		8.7	
03C17	09/17/01	1.8	U	1.8	U
03C07	09/18/01	0.76999	U	0.76999	U
03C04	09/19/01				
03C26	09/19/01	0.99	U	0.99	U
03C30	09/20/01	1.2	U	1.2	U
03C25	11/13/01	0.68	U	0.68	U
03C02P2	11/26/01	0.81999	U	0.81999	U
03C15	11/27/01	0.52999	U	0.52999	U
03C03	11/30/01	1.1	U	1.1	U
03C04	12/03/01	1.6	U	1.6	U
03C20	12/03/01	9.9		15.	
03C26	12/04/01	1.1	U	1.1	U
03C08P2	12/05/01	2.3		3.6	
03C30	12/10/01	0.95999	U	0.95999	U
03C07	12/11/01	1.7	U	1.7	U
03C17	12/13/01	1.	U	1.	U
03C09P2	12/17/01	0.73	U	0.73	U
03C27	12/19/01	0.74	U	0.74	U
03C25	02/08/02	0.97	U	0.97	U
03C02P2	02/11/02	0.68999	U	0.68999	U
03C03	02/22/02	0.50999	U	0.50999	U
03C09P2	02/22/02	0.31	U	0.31	U
03C04	02/25/02	0.91	U	0.91	U
03C26	02/25/02	0.57999	U	0.57999	U
03C07	02/27/02	0.40999	U	0.40999	U
03C08P2	02/28/02	2.7		3.7	
03C20	02/28/02	13.		18.	
03C27	03/04/02	0.38999	U	0.38999	U
03C17	03/05/02	0.52999	U	0.52999	U
03C15	03/06/02	0.34	U	0.34	U
03C30	03/07/02	0.37	U	0.37	U
03C03	05/14/02	1.1	U	1.1	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03C09P2	05/15/02	1.3	U	1.3	U
03C02P2	05/16/02	0.66	U	0.66	U
03C26	05/20/02	0.87999	U	0.87999	U
03C20	05/21/02	12		15	
03C17	05/22/02	0.83999	U	0.83999	U
03C27	05/28/02	0.77999	U	0.77999	U
03C30	05/30/02	1.3	U	1.3	U
03C15	06/05/02	0.92	U	0.92	U
03C08P2	06/06/02	2.5		3.1	
03C04	06/10/02	0.99	U	0.99	U
03C07	06/18/02	0.57999	U	0.57999	U
03C03	08/20/02	0.37999	U	0.37999	UJ
03C26	08/20/02	0.6	U	0.6	UJ
03C15	08/21/02	0.47999	U	0.47999	UJ
03C20	08/22/02	0.4	U	0.4	UJ
03C30	08/26/02	0.28	U	0.28	UJ
03C27	08/27/02	0.57999	U	0.57999	UJ
03C04	08/28/02	0.			
03C07	08/28/02	0.40999	U	0.40999	UJ
03C09P2	08/29/02	0.46	U	0.46	UJ
03C08P2	09/03/02	2.4		3.2	
03C02P2	09/04/02	0.34999	U	0.34999	UJ
03C09P2	09/04/02				
03C04	09/05/02	0.57999	U	0.57999	UJ
03C17	09/05/02	0.4	U	0.4	UJ
03C25	09/10/02	0.41999	U	0.41999	UJ
03C25	10/31/02	0.34999	U	0.34999	U
03C03	11/04/02	0.69999	U	0.69999	U
03C09P2	11/06/02	1.2	U	1.2	U
03C02P2	11/07/02	0.33	U	0.33	U
03C26	11/12/02	0.70999	U	0.70999	UJ
03C17	11/13/02	1.1	U	1.1	UJ
03C27	11/14/02	0.77999	U	0.77999	UJ
03C20	11/18/02	13		15	J
03C04	11/19/02	0.89999	U	0.89999	UJ
03C08P2	11/20/02	2.5		3.3	J
03C07	11/25/02	1.	U	1.	U
03C15	11/26/02	1.1	U	1.1	U
03C30	12/04/02	1.2	U	1.2	UJ
03C03	02/24/03	1.4	U	1.4	U
03C08P2	02/25/03	2		2.6	
03C09P2	02/26/03	0.68	U	0.68	U
03C30	02/27/03	1.1	U	1.1	U
03C26	03/03/03	0.91	U	0.91	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03C02P2	03/04/03	1.1	U	1.1	U
03C15	03/05/03	1.3	U	1.3	U
03C07	03/06/03	1.1	U	1.1	U
03C04	03/11/03	0.99	U	0.99	U
03C17	03/11/03	1.3	U	1.3	U
03C20	03/12/03	12		14	
03C09P2	05/19/03	0.56999	U	0.56999	U
03C03	05/21/03	1.2	U	1.2	U
03C25	05/27/03	1.1	U	1.1	U
03C26	05/29/03	0.21999	U	0.21999	U
03C27	06/02/03	0.81	U	0.81	U
03C20	06/04/03	11		13	
03C08P2	06/09/03	2.2		2.9	
03C02P2	06/10/03	1.3	U	1.3	U
03C15	06/17/03	1.	U	1.	U
03C07	06/18/03	1.9	U	1.9	U
03C17	06/19/03	1.7	U	1.7	U
03C04	06/23/03	0.79	U	0.79	U
03C30	06/24/03	0.76999	U	0.76999	U
03C26	08/22/03	0.70999	U	0.70999	U
03C03	08/25/03	0.83999	U	0.83999	U
03C20	08/25/03	10		12	
03C02P2	08/26/03	0.46	U	0.46	U
03C07	08/26/03	0.81	U	0.81	U
03C30	08/27/03	1.2	U	1.2	U
03C09P2	08/28/03	1.4	U	1.4	U
03C04	09/02/03	1.4	U	1.4	U
03C08P2	09/03/03	2		2.5	
03C15	09/04/03	1.	U	1.	U
03C27	09/05/03	0.3	U	0.3	U
03C17	09/08/03	1.5	U	1.5	U
03C25	09/09/03	0.31	U	0.31	U
03C03	11/06/03	0.50999	U	0.50999	U
03C25	11/10/03	0.52999	U	0.52999	U
03C09P2	11/12/03	0.49	U	0.49	U
03C20	11/17/03	10		13	
03C26	11/20/03	0.54	U	0.54	U
03C27	11/25/03	0.52999	U	0.52999	U
03C02P2	12/01/03	0.52999	U	0.52999	U
03C15	12/02/03	0.50999	U	0.50999	U
03C08P2	12/08/03	2.1		2.9	
03C04	12/09/03	0.51999	U	0.51999	U
03C30	12/11/03	0.56	U	0.56	U
03C07	12/15/03	0.6	U	0.6	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)		4-A-DNT (µg/L)	
03C17	12/22/03	0.56	U	0.56	U
03C25	02/26/04	0.49	U	0.49	U
03C02P2	02/27/04	0.51999	U	0.51999	U
03C04	03/02/04	0.56	U	0.56	U
03C26	03/02/04	0.52999	U	0.52999	U
03C03	03/05/04	0.56999	U	0.56999	U
03C09P2	03/08/04	0.52999	U	0.52999	U
03C20	03/09/04	13		16	
03C08P2	03/10/04	2.4		3.3	
03C17	03/11/04	0.52999	U	0.52999	U
03C07	03/12/04	0.47999	U	0.54	
03C27	03/15/04	0.50999	U	0.50999	U
03C30	03/15/04	0.54	U	0.54	U
03C15	03/17/04	0.51999	U	0.51999	U
03-01	04/04/04	0.35	J	0.78	
03-38	04/04/04	0.36	J	0.99	
03-33	04/06/04	0.24	U	0.24	U
03C01P2	04/06/04	0.272	U	0.272	U
03C06	04/06/04	0.25	U	0.25	U
03C21	04/06/04	0.258	U	0.258	U
03-09	04/07/04	0.264	U	0.264	U
03-31	04/07/04	0.26	U	0.26	U
03C03P2	04/07/04	4.3		4.5	
03C14	04/07/04	0.248	U	0.248	U
03-16	04/08/04	0.255	U	0.255	U
03-21	04/08/04	0.68	J	2.7	
03-24	04/08/04	0.24	U	0.24	U
03C05	04/08/04	0.258	U	0.258	U
03C28	04/08/04	0.253	U	0.253	U
03SB060/TW01	04/17/04	0.25	U	0.25	U
03-12	04/18/04	0.56	J	0.91	
03-15	04/18/04	0.26	U	0.26	U
03SB063/TW02	04/19/04	0.24	U	0.24	U
03SB090/TW03	04/19/04	0.242	U	0.242	U
03SB103/TW05	04/21/04	0.81	J	2.2	
03TW04	04/21/04	0.24	U	0.24	U
03-39	04/22/04	0.27	U	0.7	
03-07	04/24/04	0.25	U	0.43	J
03SB050/TW06	04/24/04	0.266	U	0.266	U
03C25	06/01/04	0.54	U	0.54	U
03C03	06/07/04	0.49	U	0.49	U
03C02P2	06/08/04	0.55	U	0.55	U
03C04	06/16/04	0.56	U	0.56	U
03C26	06/16/04	0.54	U	0.54	U

TABLE E-11

AMINO-DINITROTOLUENES CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	2-A-DNT (µg/L)	4-A-DNT (µg/L)
03C09P2	06/17/04	0.52999 U	0.58999
03C20	06/18/04	11	13
03C15	06/21/04	0.54 U	0.54 U
03C27	06/22/04	0.55 U	0.55 U
03C07	06/28/04	0.55 U	0.55 U
03C08P2	06/30/04	1.8	2.5
03C17	06/30/04	0.52999 U	0.52999 U
03C30	06/30/04	0.54 U	0.54 U
03C25	09/02/04	0.56 U	0.56 U
03C03	09/07/04	0.52999 U	0.52999 U
03C04	09/08/04	0.52999 U	0.52999 U
03C20	09/08/04	9.4	12
03C02P2	09/09/04	0.51999 U	0.51999 U
03C09P2	09/13/04	0.54 U	0.54 U
03C30	09/13/04	0.52999 U	0.52999 U
03C07	09/14/04	0.52999 U	0.52999 U
03C26	09/14/04	0.56999 U	0.56999 U
03C08P2	09/15/04	2.2	3
03C27	09/17/04	0.52999 U	0.52999 U
03C15	09/20/04	0.55 U	0.55 U
03C17	09/20/04	0.52999 U	0.52999 U
	Maximum	19.	

µg/L - Microgram per liter.
Amino-dinitrotoluens - 2-A-DNT/4-A-DNT.
2-A-DNT - 2-amino-4,6-dinitrotoluene.
4-A-DNT - 4-amino-2,6-dinitrotoluene.

Value Exceeding Criteria
Location/Date of Maximum Value

CRITERIA (µg/L)	
2-A-DNT	4-A-DNT
0.62	0.62

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03B04	02/23/99	0.94	U
03C25	02/24/99	1.2	U
03C10	02/25/99	140.	
03C11	02/25/99	34.	
03C12	02/25/99	14.	
03C02P2	02/26/99	2.9	
03C07	02/26/99	23.	
03C03	02/27/99	1.	U
03C04	02/27/99	0.46	U
03C09P2	03/01/99	130.	
03C15	03/01/99	0.49	U
03C26	03/02/99	1.4	U
03C27	03/02/99	1.3	U
03C17	03/08/99	1.2	U
03C30	03/08/99	0.56	U
03B02	03/10/99	0.58	U
03C20	03/11/99	180.	
03C08P2	03/12/99	110.	
03B04	05/17/99	0.52	U
03B02	05/18/99	0.95	UJ
03C03	05/18/99	0.2	U
03C17	05/18/99	0.36	U
03C02P2	05/19/99	1.9	
03C07	05/19/99	19.	
03C09P2	05/19/99	150.	
03C04	05/21/99	1.	U
03C11	05/21/99	12.	
03C10	05/22/99	100.	
03C12	05/22/99	11.	
03C20	05/22/99	150.	
03C15	05/23/99	1.1	U
03C26	05/23/99	0.81	U
03C08P2	05/24/99	81.	
03C27	05/24/99	0.55	U
03C30	05/24/99	0.79	U
03C25	05/25/99	1.	U
03C02P2	09/07/99	17.	
03C10	09/08/99	100.	
03C12	09/08/99	28.	
03C15	09/08/99	1.4	U
03C27	09/08/99	0.86	U
03B02	09/09/99	0.3	U
03B04	09/09/99	0.64	U

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03C17	09/09/99	1.4	U
03C11	09/10/99	25.	
03C25	09/10/99	0.79	U
03C30	09/10/99	0.25	U
03C03	09/11/99	0.7	U
03C04	09/11/99	1.5	U
03C07	09/11/99	21.	
03C09P2	09/11/99	130.	
03C08P2	09/12/99	86.	
03C26	09/12/99	0.8	
03C20	09/14/99	170.	
WATER WELL	09/23/99	0.88	U
03C02P2	03/06/00	12.	J
03C04	03/14/00	0.5	U
03C07	03/14/00	34.	
03C12	03/15/00	12.	
03C30	03/21/00	1.2	U
03C11	03/22/00	31.	
03C15	03/23/00	0.99	U
03C20	03/23/00	190.	
03C25	03/24/00	0.68	U
03C09P2	03/25/00	160.	
03B04	03/27/00	0.62999	U
03B02	03/28/00	0.56	U
03C27	03/28/00	0.81999	U
03C26	03/29/00	1.2	
03C08P2	03/30/00	90.	
03C03	04/01/00	1.1	U
03C10	04/01/00	130.	
03C17	04/01/00	0.5	U
03C17	05/25/00	0.68	U
03C25	05/25/00	0.84	U
03C20	06/01/00	210.	
03C12	06/05/00	26.	
03C09P2	06/06/00	180.	
03C11	06/06/00	29.	
03C15	06/07/00	0.55	U
03C02P2	06/08/00	17.	
03C07	06/15/00	27.	
03C03	06/19/00	1.	U
03C08P2	06/20/00	95.	
03C26	06/21/00	1.1	U
03C27	06/21/00	1.2	U

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03B02	06/23/00	0.74	U
03C10	06/23/00	110.	
03B04	06/26/00	1.1	U
03C04	06/27/00	0.56999	U
03C30	06/28/00	1.1	U
03B02	09/07/00	0.21999	U
03C25	09/07/00	0.87999	U
03B04	09/08/00	0.87999	U
03C07	09/08/00	30.	
03C10	09/08/00	120.	
03C03	09/12/00	0.68	U
03C17	09/12/00	1.4	U
03C27	09/12/00	1.1	U
03C04	09/13/00	1.1	U
03C08P2	09/13/00	87.	
03C12	09/13/00	15.	
03C26	09/14/00	0.51999	
03C09P2	09/15/00	150.	
03C11	09/15/00	35.	
03C02P2	09/18/00	12.	
03C15	09/18/00	0.76999	U
03C20	09/18/00	190.	
03C30	09/19/00	0.61	U
03C25	11/29/00	0.61	U
03C02P2	11/30/00	0.79	U
03C27	11/30/00	0.62999	U
03C03	12/01/00	1.3	U
03C09P2	12/01/00	170.	
03C10	12/01/00	130.	
03B04	12/04/00	1.3	U
03B02	12/05/00	0.82999	U
03C04	12/05/00	1.4	U
03C17	12/05/00	0.5	U
03C30	12/07/00	0.62999	U
03C11	12/11/00	32.	
03C12	12/14/00	18.	
03C15	12/21/00	0.43999	U
03C07	12/27/00	19.	
03C20	12/28/00	180.	
03C08P2	01/02/01	92.	
03C26	01/04/01	1.2	U
03C02P2	03/05/01	1.5	
03C25	03/06/01	0.82999	U

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03B02	03/07/01	0.79	U
03B04	03/08/01	0.81	U
03C04	03/12/01	1.	U
03C12	03/13/01	11.	
03C03	03/14/01	0.36	U
03C09P2	03/14/01	170.	
03C10	03/19/01	130.	
03C11	03/20/01	31.	
03C07	03/21/01	29.	
03C20	03/21/01	170.	
03C27	03/22/01	1.	U
03C15	03/26/01	1.	U
03C26	03/27/01	1.2	U
03C08P2	03/28/01	79.	
03C17	04/02/01	1.2	U
03C30	04/03/01	1.9	U
03-07	06/07/01	1.5	J
03-20	06/09/01	0.35	U
03-23	06/09/01	12.	
03C09P2	06/12/01	180.	
03C02P2	06/13/01	12.	
03C25	06/18/01	0.93999	U
03C15	06/19/01	0.46	U
03C10	06/20/01	120.	
03B02	06/21/01	0.28999	U
03B04	06/21/01	0.33	U
03-13	06/23/01	16.	
03-17	06/24/01	4.2	
03-18	06/24/01	3.8	
03-11	06/25/01	0.35	U
03-12	06/25/01	35.	
03-14	06/25/01	11.	
03-24	06/25/01	7.2	
03-25	06/25/01	0.35	U
03C27	06/25/01	0.68	U
03C07	06/26/01	39.	
03C26	06/26/01	1.5	U
03C04	06/27/01	0.67	U
03C11	06/27/01	34.	
03C12	06/27/01	9.3	
03C08P2	06/28/01	88.	
03C20	06/28/01	180.	
03C03	07/02/01	0.34	U

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03C17	07/03/01	0.34	U
03C30	07/03/01	0.87999	U
03-15	07/10/01	4.8	
03-16	07/10/01	24.	
03-21	07/10/01	280.	J
03-22	07/10/01	18.	
03-10	07/11/01	14.	
03C03	08/29/01	0.83999	U
03C25	08/30/01	1.1	U
03C27	09/04/01	0.37999	U
03C09P2	09/05/01	180.	
03C20	09/05/01	170.	
03C15	09/06/01	0.40999	U
03C02P2	09/10/01	7.7	
03C04	09/10/01	1.2	U
03C08P2	09/17/01	92.	
03C17	09/17/01	1.7	U
03C07	09/18/01	42.	
03C04	09/19/01	0.	
03C26	09/19/01	1.1	
03C30	09/20/01	1.1	U
03C25	11/13/01	0.62999	U
03C02P2	11/26/01	4.5	
03C15	11/27/01	0.5	U
03C03	11/30/01	1.1	U
03C04	12/03/01	1.5	U
03C20	12/03/01	190.	
03C26	12/04/01	1.4	
03C08P2	12/05/01	92.	
03C30	12/10/01	0.89999	U
03C07	12/11/01	36.	
03C17	12/13/01	0.93999	U
03C09P2	12/17/01	190.	
03C27	12/19/01	0.69999	U
03C25	02/08/02	0.92	U
03C02P2	02/11/02	1.4	
03C03	02/22/02	0.50999	U
03C09P2	02/22/02	190.	
03C04	02/25/02	0.91	U
03C26	02/25/02	0.57999	U
03C07	02/27/02	38.	
03C08P2	02/28/02	89.	
03C20	02/28/02	200.	

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)
03C27	03/04/02	0.38999 U
03C17	03/05/02	0.52999 U
03C15	03/06/02	0.34 U
03C30	03/07/02	0.37 U
03C03	05/14/02	1. U
03C09P2	05/15/02	190.
03C02P2	05/16/02	2.3
03C26	05/20/02	1.1
03C20	05/21/02	200.
03C17	05/22/02	0.79 U
03C27	05/28/02	0.73 U
03C30	05/30/02	1.2 U
03C15	06/05/02	0.87 U
03C08P2	06/06/02	96.
03C04	06/10/02	0.93 U
03C07	06/18/02	36.
03C03	08/20/02	0.37999 U
03C26	08/20/02	1.6
03C15	08/21/02	0.47999 U
03C20	08/22/02	210.
03C30	08/26/02	0.28 U
03C27	08/27/02	0.57999 U
03C04	08/28/02	0.
03C07	08/28/02	30.
03C09P2	08/29/02	230.
03C08P2	09/03/02	99.
03C02P2	09/04/02	14.
03C09P2	09/04/02	0.
03C04	09/05/02	0.57999 U
03C17	09/05/02	0.4 U
03C25	09/10/02	0.41999 U
03C25	10/31/02	0.34999 U
03C03	11/04/02	0.69999 U
03C09P2	11/06/02	180.
03C02P2	11/07/02	6.1
03C26	11/12/02	1.6
03C17	11/13/02	1.1 U
03C27	11/14/02	0.77999 U
03C20	11/18/02	250.
03C04	11/19/02	0.89999 U
03C08P2	11/20/02	89.
03C07	11/25/02	45.
03C15	11/26/02	1.1 U

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03C30	12/04/02	1.2	U
03C03	02/24/03	1.4	U
03C08P2	02/25/03	68.	
03C09P2	02/26/03	170.	
03C30	02/27/03	1.1	U
03C26	03/03/03	1.7	
03C02P2	03/04/03	1.1	U
03C15	03/05/03	1.3	U
03C07	03/06/03	35.	
03C04	03/11/03	0.99	U
03C17	03/11/03	1.3	U
03C20	03/12/03	200.	
03C09P2	05/19/03	160.	
03C03	05/21/03	1.2	U
03C25	05/27/03	1.1	U
03C26	05/29/03	0.88999	
03C27	06/02/03	0.81	U
03C20	06/04/03	190.	
03C08P2	06/09/03	73.	
03C02P2	06/10/03	10.	
03C15	06/17/03	1.	U
03C07	06/18/03	31.	
03C17	06/19/03	1.7	U
03C04	06/23/03	0.79	U
03C30	06/24/03	0.76999	U
03C26	08/22/03	1.6	
03C03	08/25/03	0.83999	U
03C20	08/25/03	180.	
03C02P2	08/26/03	9.8	
03C07	08/26/03	24.	
03C30	08/27/03	1.2	U
03C09P2	08/28/03	190.	
03C04	09/02/03	1.4	U
03C08P2	09/03/03	73.	
03C15	09/04/03	1.	U
03C27	09/05/03	0.3	U
03C17	09/08/03	1.5	U
03C25	09/09/03	0.31	U
03C03	11/06/03	0.50999	U
03C25	11/10/03	0.52999	U
03C09P2	11/12/03	200.	
03C20	11/17/03	220.	
03C26	11/20/03	1.8	

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)
03C27	11/25/03	0.52999 U
03C02P2	12/01/03	2.7
03C15	12/02/03	0.50999 U
03C08P2	12/08/03	82.
03C04	12/09/03	0.51999 U
03C30	12/11/03	0.56 U
03C07	12/15/03	39.
03C17	12/22/03	0.56 U
03C25	02/26/04	0.49 U
03C02P2	02/27/04	1.1
03C04	03/02/04	0.56 U
03C26	03/02/04	1.8
03C03	03/05/04	0.56999 U
03C09P2	03/08/04	240.
03C20	03/09/04	270.
03C08P2	03/10/04	92.
03C17	03/11/04	0.52999 U
03C07	03/12/04	43.
03C27	03/15/04	0.50999 U
03C30	03/15/04	0.54 U
03C15	03/17/04	0.51999 U
03-01	04/04/04	70.
03-38	04/04/04	130.
03-33	04/06/04	22.
03C01P2	04/06/04	0.272 U
03C06	04/06/04	0.25 U
03C21	04/06/04	0.258 U
03-09	04/07/04	0.264 U
03-31	04/07/04	1.8
03C03P2	04/07/04	620.
03C14	04/07/04	0.9
03-16	04/08/04	19.
03-21	04/08/04	120.
03-24	04/08/04	7.7
03C05	04/08/04	0.258 U
03C28	04/08/04	0.253 U
03SB060/TW01	04/17/04	0.99
03-12	04/18/04	39.
03-15	04/18/04	13.
03SB063/TW02	04/19/04	2.3
03SB090/TW03	04/19/04	0.242 U
03SB103/TW05	04/21/04	76.
03TW04	04/21/04	0.73

TABLE E-12

RDX CONCENTRATIONS IN GROUNDWATER
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

LOCATION	SAMPLE DATE	RDX (µg/L)	
03-39	04/22/04	78.	
03-07	04/24/04	1.1	
03SB050/TW06	04/24/04	0.266	U
03C25	06/01/04	0.54	U
03C03	06/07/04	0.49	U
03C02P2	06/08/04	10.	
03C04	06/16/04	0.56	U
03C26	06/16/04	3.1	
03C09P2	06/17/04	330.	
03C20	06/18/04	190.	
03C15	06/21/04	0.54	U
03C27	06/22/04	0.55	U
03C07	06/28/04	36.	
03C08P2	06/30/04	77.	
03C17	06/30/04	0.52999	U
03C30	06/30/04	0.54	U
03C25	09/02/04	0.56	U
03C03	09/07/04	0.52999	U
03C04	09/08/04	0.52999	U
03C20	09/08/04	180.	
03C02P2	09/09/04	9.4	
03C09P2	09/13/04	200.	
03C30	09/13/04	0.52999	U
03C07	09/14/04	37.	
03C26	09/14/04	2.1	
03C08P2	09/15/04	82.	
03C27	09/17/04	0.52999	U
03C15	09/20/04	0.55	U
03C17	09/20/04	0.52999	U
		330	

µg/L - Microgram per liter.
RDX — hexahydro-1,3,5-trinitro-1,3,5-triazine .

Location/Date of Maximum Value

TABLE E-13

TCE CONCENTRATIONS IN SPRING A
(1999 THROUGH 2004)
CORRECRIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	TCE (µg/L)	
02/28/99	0.6	
05/20/99	0.5	U
05/20/99	0.5	U
09/13/99	0.5	U
03/29/00	0.3	J
03/29/00	0.5	U
06/26/00	0.5	U
09/29/00	0.5	U
12/18/00	0.5	U
04/10/01	0.5	U
07/10/01	0.4	J
07/10/01	0.4	J
09/17/01	0.5	U
12/20/01	0.4	J
12/20/01	0.4	J
03/12/02	0.5	U
06/20/02	0.5	U
06/20/02	0.5	U
09/10/02	0.5	U
12/09/02	1.	U
03/07/03	1.	U
06/30/03	0.5	U
09/09/03	0.5	U
12/17/03	0.5	U
03/16/04	0.5	U
04/24/04	1.	J
06/29/04	0.5	U
09/16/04	0.5	UJ
Maximum	1.	

µg/L - Microgram per liter.
TCE — Trichloroethene.

Date of Maximum Value

TABLE E-14

TCE CONCENTRATIONS IN SPRING C
(1999 THROUGH 2004)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

SAMPLE DATE	TCE (µg/L)	
02/28/99	0.5	U
05/20/99	0.5	U
09/13/99	0.5	U
09/13/99	0.5	U
03/14/00	0.5	U
03/14/00	0.5	U
06/28/00	0.5	U
06/28/00	0.5	U
09/29/00	0.5	U
12/19/00	0.5	U
04/10/01	0.5	U
07/10/01	0.5	U
09/17/01	0.5	U
12/18/01	0.5	U
03/11/02	0.5	U
06/24/02	0.5	U
09/09/02	0.5	U
12/12/02	1.	U
03/10/03	1.	U
06/26/03	0.5	U
09/09/03	0.5	U
12/18/03	0.5	U
12/18/03	0.5	U
03/03/04	0.5	U
03/03/04	0.5	U
06/29/04	0.5	U
06/29/04	0.5	U
09/16/04	0.5	UJ
Maximum:	0.	

µg/L - Microgram per liter.
TCE — Trichloroethene.

APPENDIX F

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE (RDX) CONCENTRATION DATA AND PLOTS

TABLE F-1

SPRING A RDX CONCENTRATION PLOT DATA
(11-5-98 THROUGH 3/7/03)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

RDX Results for Spring A				
EVENT	OTR-YR	Sample Date	Estimated Quantity (gpm)	Sample Results (µg/L)
1	4-98	11/5/1998	6	63
2	1-99	2/28/1999	150	1.5
3	2-99	5/20/1999	250	6.3
4	3-99	9/13/1999	4	120
5	4-99	1/11/2000	25	33
6	1-00	3/29/2000	50	8
7	2-00	6/26/2000	50	11
9	4-00	12/18/2000	150	1.9
10	1-01	4/10/2001	50	10
11	2-01	7/10/2001	50	5
12	3-01	9/17/2001	25	110 PE
14	1-02	3/12/2002	75	3.4 PE
15	2-02	6/20/2002	50	36
17	4-02	12/9/2002	75	73
18	1-03	3/7/2003	150	1.6

RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

FIGURE F-1

RDX FLOWRATE VERSES CONCENTRATION FOR SPRING A
(11/5/98 through 3/7/03)

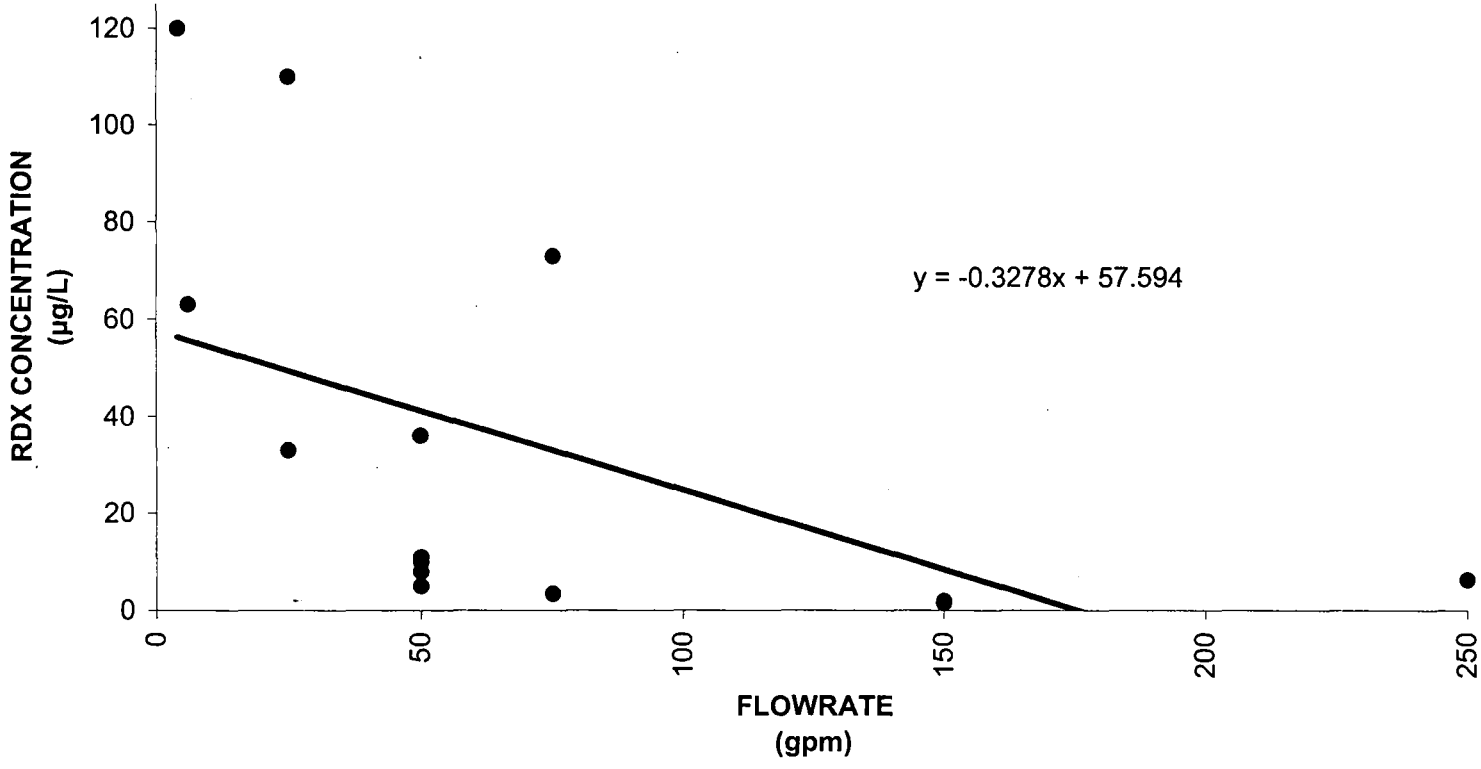


TABLE F-2

SPRING C CONCENTRATION PLOT DATA
(11/5/98 THROUGH 3/10/03)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

RDX Results for Spring C				
EVENT	OTR-YR	Sample Date	Estimated Quantity (gpm)	Sample Results (µg/L)
1	4-98	11/5/1998	6	1.4
2	1-99	2/28/1999	300	1.7
3	2-99	5/20/1999	175	1.9
4	3-99	9/13/1999	4	0.8
5	4-99	1/11/2000	10	6
6	1-00	3/14/2000	50	1.8
7	2-00	6/18/2000	50	4.6 P
8	3-00	9/29/2000	25	3.2
9	4-00	12/19/2000	100	1.7
10	1-01	4/10/2001	50	1.4
11	2-01	7/10/2001	50	4.9
12	3-01	9/17/2001	25	3.6 P
13	4-01	12/18/2001	113	1.6
14	1-02	3/11/2002	75	2.5 P
15	2-02	6/24/2002	50	3.9
16	3-02	9/9/2002	20	0 U
17	4-02	12/12/2002	50	3.1
18	1-03	3/10/2003	125	1.7

RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

FIGURE F-2

RDX FLOWRATE VERSES CONCENTRATION FOR SPRING C
(11/5/98 through 3/10/03)

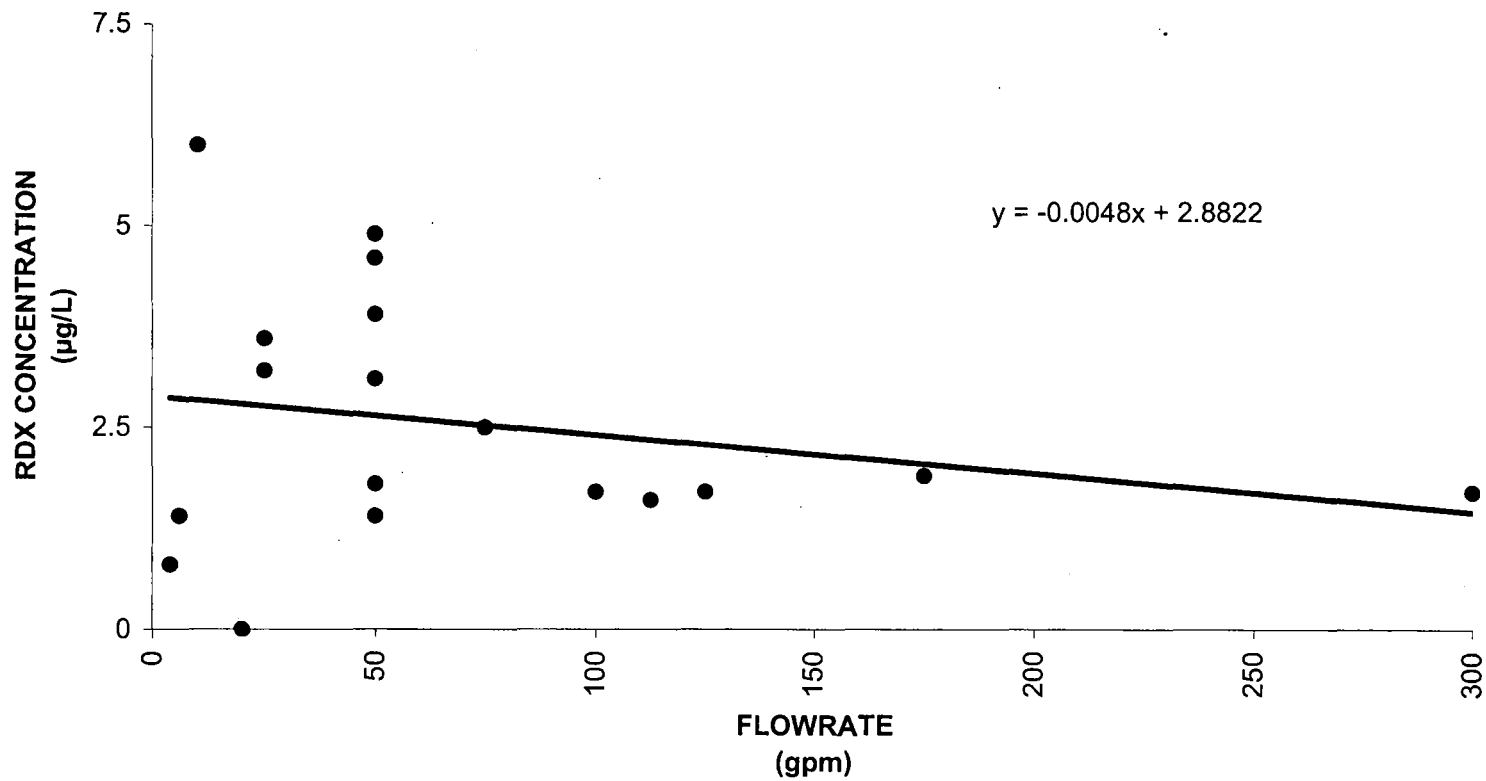


TABLE F-3

CREEK A CONCENTRATION PLOT DATA
(11/5/98 THROUGH 12/18/00)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

RDX Results for Creek A				
EVENT	OTR-YR	Sample Date	Estimated Quantity (gpm)	Sample Results (µg/L)
1	4-98	11/15/1998	20	28 J
2	1-99	2/28/1999	800	1.6
3	2-99	5/20/1999	300	3.6
5	4-99	1/10/2000	50	0.958333
6	1-00	3/8/2000	50	4.5
7	2-00	6/9/2000	20	23
8	3-00	9/20/2000	50	17
9	4-00	12/18/2000	300	1.1 P

RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

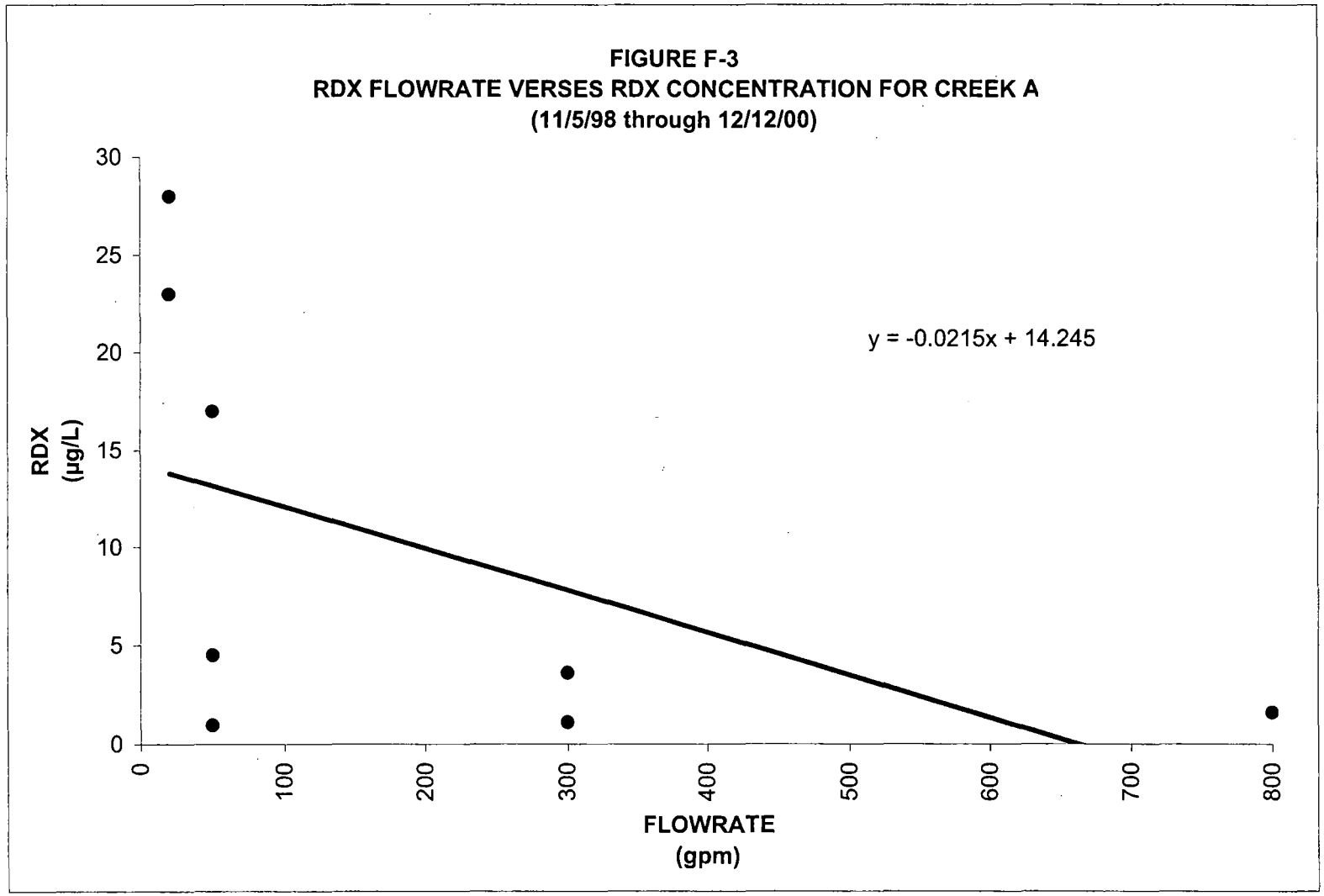


FIGURE F-3
RDX FLOWRATE VERSES RDX CONCENTRATION FOR CREEK A
(11/5/98 through 12/12/00)
y = -0.0215x + 14.245
RDX
(µg/L)
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
FLOWRATE
(gpm)

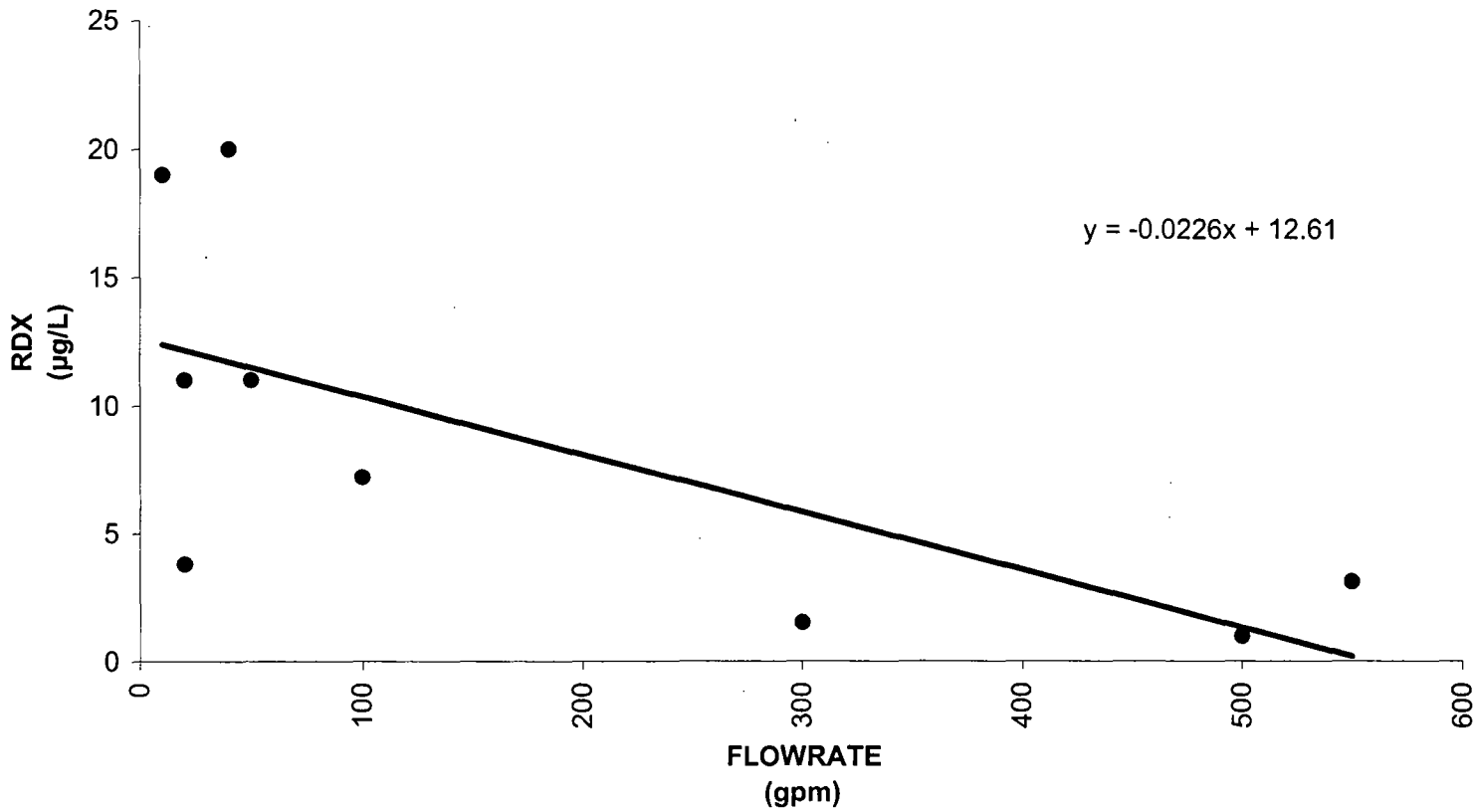
TABLE F-4

CREEK B CONCENTRATION PLOT DATA
(11/5/98 THROUGH 12/12/00)
CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

RDX Results for Creek B				
EVENT	OTR-YR	Sample Date	Estimated Quantity (gpm)	Sample Results (µg/L)
1	4-98	11/15/1998	40	20
2	1-99	2/28/1999	500	0.97
3	2-99	5/20/1999	550	3.1
4	3-99	9/13/1999	20	3.8
5	4-99	12/28/1999	10	19
6	1-00	3/8/2000	100	7.2 J
7	2-00	6/9/2000	20	11
8	3-00	9/20/2000	50	11
9	4-00	12/18/2000	300	1.5

RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.

FIGURE F-4
RDX FLOWRATE VERSES RDX CONCENTRATION FOR CREEK B
(11/5/98 through 12/12/00)



APPENDIX G

CONCEPTUAL SITE MODEL
FOR
SOLID WASTE MANAGEMENT UNIT 3

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-03-D-0057

Rev. 2
07/09

Conceptual Site Model
for
Solid Waste Management Unit 3 (Ammunition Burning Grounds)

Naval Surface Warfare Center
Crane, Indiana

Contract Task Order 0311

July 2009

NAVFAC
Naval Facilities Engineering Command
Southeast
2155 Eagle Drive
North Charleston, South Carolina 29406

TETRA TECH NUS, Inc.

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ACRONYMS

µg/L	micrograms per liter
2-A-DNT	2-amino-4,6-dinitrololuene
4-A-DNT	4-amino-2,6-dinitrotoluene
ABG	Ammunition Burning Grounds
Ammunition Burning Grounds	SWMU 3
BC/BC	Big Clifty Sandstone/Beech Creek Limestone
CCCRA	Current Contamination Conditions Risk Assessment
CMP	Corrective Measures Proposal
COC	chemical of concern
DBG	Dye Burial Ground
ft^3/s	cubic feet per second
G-H	Golconda-Haney
Golconda-Haney aquifer	Haney Limestone aquifer
gpm	gallons per minute
HHRSE	Human Health Risk Screening Evaluation
IDEM	Indiana Department of Environmental Management
LSC	Little Sulphur Creek
msl	mean sea level
MCL	Maximum Contaminant Level
MTA	Main Treatment Area
NSWC	Naval Surface Warfare Center
OB	open burning
OJT	Old Jeep Trail
PCDD	Polychlorinated dibenzodioxin
RBTL	risk-based target levels
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	RCRA Facility Investigation
SWMU	Solid Waste Management Unit
TCA	tetrachloroethane
TCDD	Tetrachlorodibenzodioxin
TCE	trichloroethylene
TNT	2,4,6-trinitrotoluene

USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
VOC	volatile organic compound
WES	Waterways Experiment Station
WQC	water quality criteria

1.0 INTRODUCTION

This document presents the conceptual site model for the Naval Surface Warfare Center (NSWC) Crane Solid Waste Management Unit (SWMU) 3 [Ammunition Burning Grounds (ABG)]. The conceptual site model provides a tool for identifying contamination sources, contaminant migration pathways, and potential receptors and includes an identification of uncertainties. The conceptual site model provides a framework for development of the Corrective Measures Study (CMS) so that the study can be focused on identification and evaluation of practical and cost-effective remedial actions. Figure 1 presents a schematic of the conceptual site model for the Main Treatment Area (MTA). Figure 2 presents a schematic of the conceptual site model for the Old Jeep Trail (OJT). These conceptual site models are discussed in detail in Sections 3 and 4, respectively. Section 5 summarizes the conceptual site models for the MTA and OJT.

Section 2 provides a description of physical characteristics of SWMU 3. The operational history, physical features, and environmental data collected to date are developed into a conceptual site model that explains how and where site operations and physical features resulted in the existence and movement of various contaminants at SWMU 3. The model also supports inferences about future site conditions and potential routes of exposure to site contaminants for humans and ecological receptors.

2.0 SUMMARY OF SITE INFORMATION

2.1 GENERAL LOCATION INFORMATION

NSWC Crane is located in a rural, sparsely populated region of south-central Indiana, approximately 75 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky and immediately east of Burns City and Crane Village, Indiana.

The ABG and OJT are located in a remote hilly area in the eastern portion of the installation along Little Sulphur Creek (LSC). The OJT area is located in the valley of LSC, approximately one-half mile south-southeast of the ABG on Jeep Trail 25. These areas lie within the Sulphur Creek drainage basin, which is one of five main drainage basins that carry surface water off the installation. LSC is a small stream whose headwaters originate in channels on the north, west, and south of the ABG. These ephemeral channels run through the ABG area and converge on the eastern side of the ABG. From the ABG, LSC runs southeastward through the OJT area and then southward to the NSWC Crane property boundary.

2.2 TOPOGRAPHY AND PHYSICAL FEATURES

The LSC watershed, which contains the ABG MTA and OJT, is characterized by rugged relief, with ground surface elevations ranging from about 600 to 800 feet above mean sea level (msl) in the headwaters of LSC. At the OJT, ground surface elevations range from approximately 550 to 800 feet above msl. The surface elevation is approximately 500 feet above msl where LSC exits the southern border of the installation.

The ABG MTA is relatively flat and is within the headwater area of LSC. The ABG treatment area was formerly kept devoid of vegetation to minimize the potential for fires during open burning treatments. However, since the early 1990s, areas along LSC within the ABG have been seeded with grass to minimize erosion of soil into LSC. The OJT site is located in a gravel-covered area on the western side of the gravel access road (Jeep Trail 25) where the road widens in excess of 50 feet. The OJT and the remainder of the LSC valley are surrounded by wooded areas along the hillsides to the east and west, with miscellaneous natural ground vegetation under the tree canopy and along the creek banks.

2.3 GEOLOGY

Bedrock underlying the Crane facility consists of sedimentary rocks from the Lower Pennsylvanian age Mansfield Formation (Raccoon Creek Group) and the Upper Mississippian age Stephensport and West

Baden Groups (see Figure 3). Due to erosion and the moderate relief in the area, the Lower Pennsylvanian and Upper Mississippian rock units crop out on the ridgetops and along the stream valleys. A map showing the uppermost bedrock units in the LSC watershed is provided as Figure 4.

The United States Army Corps of Engineers (USACE), the Indiana Geological Survey, and Indiana University have been investigating the geology and hydrogeology of the LSC watershed since the early 1980s. Based on boring logs drilled to various depths throughout the LSC watershed, the USACE has developed a detailed understanding of the geologic units in the watershed. Several existing USACE geologic cross sections are reproduced in this report. The lines of section for these figures are presented in Figure 5. Cross section A-A' (Figure 6) is the shortest cross section and traverses in a northeast-southwest direction directly through the OJT area. This cross section is most pertinent to discussions of the OJT area. Cross-section P-P' (Figure 7) also traverses in a northeast-southwest direction, but covers a greater distance. It extends from the Dye Burial Ground (DBG) area (SWMU 2) in the northeast, through the southeastern corner of the MTA, and southwestward to well 03C25, located on the western side of the watershed. Cross section C-C'/D-D' (Figure 8) extends in a semicircle around the northern and eastern edges of the MTA. Cross section AA-AA' (Figure 9) traverses from the northwestern to the southeastern portions of the watershed. The cross-section K'-K" (Figure 10), the longest cross-section, traverses from north of MTA to the southern end of the study area near the NSWC Crane property line.

2.4 GROUNDWATER HYDROLOGY

2.4.1 Description of Aquifers and Aquitards

Based on 20 years of drilling and hydrogeological investigations in the LSC watershed (most notably in the MTA area), the hydrostratigraphic units and hydrogeologic conditions in the watershed are well characterized and documented. However, because of the fractured rock units and karstic nature of the limestone formations present in the watershed, the groundwater flow system is very complex and therefore, there are some uncertainties concerning the details of the flow system in localized areas at a small scale.

Four primary aquifers in the LSC watershed have been identified in the Pennsylvanian and Upper Mississippian strata:

- Pennsylvanian sandstones
- the Haney Limestone [also referred to as the Golconda-Haney (G-H) aquifer]

- the Big Clifty Sandstone/Beech Creek Limestone (BC/BC) aquifer
- the Beaver Bend Limestone

The Pennsylvanian sandstone aquifer is the uppermost aquifer and is present only along the tops of ridges at elevations above 615 feet above msl. Typically, the base of the Pennsylvanian Mansfield Formation is even higher (about 650 to 660 feet above msl). The Pennsylvanian rocks are up to 120 feet thick (Figures 7 through 10). The Pennsylvanian sandstone aquifer actually consists of two or more irregular sandstone units that are commonly separated by shale, siltstone, and clay lenses and some coal beds. The stratigraphy, lithologic characteristics, and hydraulic characteristics of the Pennsylvanian strata of this area are discussed in detail by Barnhill and Hansley (1993), Kvale and Barnhill (1994), Fisher (1996), and Murphy and Wade (1998). The hydrogeologic characteristics of the Pennsylvanian aquifer were also presented in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report for SWMU 2 (DBG) (TtNUS, 2002). This SWMU is located in the far northeastern corner of the LSC watershed. The Pennsylvanian sandstone aquifer is not present in the ABG area, the OJT area, or the LSC valley floor.

The Glen Dean Limestone is present beneath the Pennsylvanian aquifer in isolated areas of the watershed. Because of its limited presence in the watershed and its complete absence from the ABG, OJT area, and LSC valley, it is not considered a separate aquifer unit and is not discussed further in this report.

The Hardinsburg Shale is up to 50 feet thick and contains mostly shale with some low-permeability sandstone in the middle. This formation forms a nearly continuous, relatively impermeable barrier to groundwater flow between the Pennsylvanian sandstones above and the G-H Limestone below.

The G-H Limestone aquifer crops out on the sides of LSC and Johnson Hollow (Figures 4 and 5). This limestone aquifer is up to 20 feet thick. A small spring (location 02SWSD07, Figure 5) located south-southwest of the DBG discharges groundwater from the G-H aquifer (Murphy and Wade, 1998; TtNUS, 2002).

The Indian Springs Shale aquitard (the 20-foot-thick upper member of the Big Clifty Formation) underlies the G-H Limestone and minimizes vertical movement of groundwater downward into the Big Clifty Sandstone through most of the watershed. In places where the Indian Springs Shale and higher strata have been removed by post-Pennsylvanian erosion, surface recharge into the Big Clifty Sandstone is relatively rapid.

The Big Clifty Sandstone and the underlying Beech Creek Limestone are both permeable rock units and are in direct hydraulic communication with one another. Together, they form the most important aquifer unit in the LSC watershed. The porosity and permeability of the Big Clifty Sandstone are due to intergranular pore spaces and to fractures (i.e., it has both primary and secondary permeability). The Beech Creek Limestone is very dense and well cemented; all of its permeability and porosity are due to vertical fractures, bedding-plane fractures, and solution openings along the fractures. The lithology, fracture patterns, and permeability characteristics of the Big Clifty Sandstone and the Beech Creek Limestone are detailed in reports by the USACE (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994) and the Indiana Geological Survey (Barnhill and Ambers, 1994). The BC/BC aquifer is exposed near the ground surface in the eastern half of the ABG, along the LSC valley, and in the lower elevations of Johnson Hollow (Figure 5). Beneath the ridges, the aquifer is approximately 60 feet thick, and fracture flow is dominant in the limestone. Solution openings and cavities become larger and hydraulically more significant close to the stream valleys where conduit systems in the limestone have developed. Starting in the eastern half of the ABG and continuing down the LSC valley to the facility property line, the dissolution of the Beech Creek Limestone was so extensive that the overlying limestone and the Big Clifty Sandstone has collapsed. The collapsed zones extend along the centers of the LSC valley and Johnson Hollow, are permeable, and are hydraulically connected to the BC/BC aquifer on both sides of the valleys (see Figures 6 through 10).

The Elwren, Sample, and Reelsville Formations lie beneath the BC/BC aquifer and have a combined thickness of about 75 feet. The permeability of the shales in these formations is so low that a significant hydraulic head difference (about 46 feet) exists between the BC/BC aquifer above and the Beaver Bend Limestone aquifer below (Baedke, 1998). The chemistry of the groundwater in the BC/BC and Beaver Bend aquifers is also significantly different (Baedke, 1998). Based on the geological, hydrogeological, and geochemical evidence mentioned above and on previous reports, the hydrological separation of the BC/BC aquifer from lower strata in the LSC watershed appears to be significant. Groundwater flows laterally through the BC/BC aquifer on top of the Elwren Shale and discharges as springs along the valley bottoms where this aquifer is exposed.

The Beaver Bend Limestone is about 12 feet thick and forms an important aquifer below the Elwren-Sample-Reelsville aquiclude. Five monitoring wells and one groundwater production well have been drilled and screened in the Beaver Bend aquifer at NSWC Crane, all within the ABG area. Groundwater samples collected from the monitoring wells in 1987 through 1992 have shown minor contamination by trichloroethylene (TCE) and the explosive compound hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (Murphy, 1994). However, a groundwater sample collected from the ABG "Break Room Water Well" (Figure 5) in 1999 showed the groundwater in the Beaver Bend aquifer did not contain detectable

concentrations of RDX or TCE or any other organic contaminants (TtNUS, 2000). Because of its depth, hydraulic isolation, and lack of significant contamination, this aquifer unit is not discussed further in this report.

Karst System Monitoring

Part of the ABG is underlain by a karst system. Several studies of the karst system have been conducted by the USACE Waterways Experiment Station (WES) and the Indiana University Department of Geological Sciences. Additional information regarding the behavior of the karst system was obtained from a thesis prepared by Stephen J. Baedke, a graduate student at Indiana University. The presumed locations of the karst system in the LSC watershed are shown in Figure 12. the Karst system is shown on Figures 11, 12, and 13.

As discussed earlier in this section, there are three aquifers present at the ABG, one of which is a karst system. Karst systems show both temporal and spatial variation between diffuse-type and conduit-type groundwater flow. From highest to lowest, the three aquifer systems present at the ABG are the G-H aquifer, the Beech Creek aquifer, and the Beaver Bend aquifer. Of the three aquifers, the Beech Creek aquifer is the karst system.

Karst parameters, including pH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, and Cl^{-}, are being measured within the Beech Creek aquifer to monitor the behavior of the karst system at the MTA to determine if there are any changes in the behavior of the aquifers present at the ABG. This occurs as part of the routine groundwater monitoring program conducted at the MTA in accordance with the RCRA operating permit. If the behavior of the aquifer system changes, evaluations will be conducted to evaluate the necessity for changes in the current monitoring system.

2.5 GROUNDWATER FLOW DIRECTIONS

In general, shallow groundwater flow patterns in the site area mimic topography; highest groundwater elevations are typically found along ridge crests, and groundwater flow is toward the major stream or tributary valleys. Recharge to the shallow groundwater system generally occurs over most of the uplands and sideslopes. Groundwater moves downward and then laterally, where it discharges to the deeper stream valleys as springs, seeps, and baseflow.

A total of four aquifers are present in the LSC watershed, consisting primarily of sandstone and limestone. These aquifers are separated by shale and siltstone aquitards. The upper aquifers, which

include the Pennsylvanian sandstones and the G-H Limestone, are exposed in outcrops on the upper hillsides surrounding the MTA, OJT area, and LSC valley bottom. The G-H limestone is underlain by the Indian Springs Shale. Groundwater in the G-H aquifer is prevented from seeping downward into the BC/BC aquifer by the intervening Indian Springs Shale. Instead, perched groundwater in the G-H aquifer flows on top of the shale toward nearby outcrops. In the northeastern portion of the watershed (by the DBG), groundwater in the G-H aquifer generally flows southwest toward an unnamed tributary of LSC (TtNUS, 2002). The aquifer also dips to the southwest. A small spring located southwest of the DBG (northeast of the MTA) is a discharge point for the G-H aquifer where it crops out on the hillside. In the MTA area, groundwater in the G-H aquifer generally flows inward toward the MTA from the northern, western, and southern sides (Hunt, 1988; Murphy, 1994; Duwelius et al., 1995). When groundwater reaches the cropline of the G-H aquifer in the MTA area, it is apparently seeping near the ground surface through residual soils and weathered shale until it reaches the cropline of the Big Clifty Sandstone. There, it infiltrates into the Big Clifty Sandstone. No visible surface seeps or springs have been reported emanating from the G-H aquifer in the vicinity of the MTA.

The next lower aquifer, the BC/BC aquifer, is the most studied of the four aquifers in the site area because:

- It lies directly under the MTA and OJT areas.
- It is the aquifer where the highest concentrations of contaminants have been detected during previous investigations.
- It contains conduits that feed the majority of springs and baseflow in LSC.

Potentiometric surface maps for the BC/BC aquifer in the LSC watershed have been presented in previous reports (Murphy and Ciocco, 1990; Murphy, 1994). In general, the highest groundwater elevations (560 to 565 feet above msl) in this aquifer were found at the northern end of the LSC watershed (north of the MTA and in the vicinity of the DBG). Groundwater flow was generally from north to south in the watershed, and flow direction was also inward toward LSC (i.e., from the perimeter of the watershed toward the creek and Johnson Hollow). The elevation where groundwater discharges from Spring C was about 530 feet above msl. The lowest groundwater elevations (about 510 to 515 feet above msl) were recorded at the southern end of the watershed at Spring A and well 03B10. A comprehensive set of elevations was measured on June 12 and 13, 2002 and on April 24 and 25, 2004. Water levels were measured in a total of 120 monitoring wells and at four stream gauge locations in June 2002 and 118 monitoring wells and two stream gauge locations in April 2004. A total of 64 monitoring wells are screened in the Big Clifty Sandstone, Beech Creek Limestone, or the collapse breccia material along LSC. The water levels measured in these 64 wells, along with the water levels of three stream

gauge locations, were used to map the potentiometric surface in the BC/BC aquifer. These water levels and potentiometric contours are presented on Figures 11 and 12. Figure 12 shows the highest groundwater elevation (577.59 feet above msl) was measured in the DBG (well 02C20) at the northeastern end of the watershed. The lowest groundwater elevations (511 to 51 feet above msl) were measured at the southern end of the watershed, close to LSC (wells 03B10 and 03C37 and Spring A). The wells in the MTA area had groundwater levels of 543 to 560 feet above msl. Wells in the OJT area had water levels ranging from 535 to 543 feet above msl. The groundwater potentiometric map, based on the April 2004 set of measurements, shows that groundwater flow is from north to south and from the perimeter of the watershed toward the stream (Figure 12). These groundwater flow directions are very similar to those observed in previous sets of water-level measurements (e.g., Murphy, 1994). However, in the smaller area surrounding the OJT study site, a localized flow system in the BC/BC/breccia zone aquifer is contrary to the overall flow system for the watershed described above. Measurements of groundwater elevations at OJT in the past (Murphy and Ciocco, 1990; Murphy, 1996) and measurements made during the latest CMS investigation show that a groundwater ridge runs from the northwest to the southeast beneath LSC. Figure 13 shows the potentiometric contours for the BC/BC aquifer in the OJT area. Potentiometric contours indicate that groundwater is flowing away from this ridge, under the streambed toward the northeast and the southwest.

As stated in previous investigations, LSC is a losing stream between ABG and OJT and probably southward toward Spring C. In this section of the watershed, the streambed is usually dry and groundwater is flowing either through the breccia zone materials parallel to the stream (i.e., underflow) or it is flowing back into the western bedrock valley wall, as is suggested by Figure 12. These localized flow directions (i.e., away from the Creek toward the northeast and southwest) are in contrast to the overall watershed flow directions, which are toward the stream valley (Figure 12). The apparent contradiction in flow directions can be explained however by the presence of karst conduits that run in a north-south direction on both sides of the stream valley. The approximate locations of these karst groundwater conduits are shown on Figure 12. The majority of groundwater in the OJT area is likely flowing toward the karst conduits (Figure 13). In June 2001, there were relatively large horizontal hydraulic gradients toward the northeast (0.0219 between wells 03-07 and 03-24) and southwest (0.0414 between wells 03-07 and 03-17). In September 2001, the gradients were much lower (0.0253 toward the northeast and 0.00684 toward the southwest).

Groundwater in the BC/BC aquifer and the conduits eventually discharge back into the stream at Springs A, A', B, C, smaller springs, and diffuse seepage through the streambed. All this discharge occurs at Spring C and south of Spring C, where the top of the Elwren Shale intersects the streambed and LSC becomes a gaining stream (i.e., flow of water is from the ground into the stream). LSC becomes a

perennial stream at Spring C, where the flow of groundwater to the stream is sufficient to maintain flow in the stream continuously. More details regarding the conduits and springs are presented below.

The Beaver Bend limestone is 10 to 12 feet thick and comprises the lowest aquifer that has been investigated in this watershed. Five monitoring wells in the MTA area are screened in the Beaver Bend Limestone. Based on data from these five wells, the Beaver Bend is fully saturated and flowing southward at a very gentle gradient (Murphy, 1994). The Beaver Bend is considered to be isolated hydraulically from the BC/BC aquifer above, based on the following:

- The thickness (approximately 70 feet) and low permeability of the intervening Elwren-Reelsville-Sample aquiclude.
- The large hydraulic head difference (approximately 46 feet) between the two aquifers.
- The large difference in basic chemical composition of groundwaters that have been found in the two aquifers. The groundwater in the BC/BC aquifer contains mostly calcium, magnesium, bicarbonate, and some sulfate as its primary ions. However, the Beaver Bend groundwater clearly has a sodium and bicarbonate composition (Baedke, 1998).

2.6 GROUNDWATER DISCHARGE AND SPRINGS

As stated previously, the BC/BC aquifer discharges to the ground surface from both sides of the valley via numerous springs and baseflow in LSC downstream of Spring C. These springs and baseflow are forced to the ground surface because, at this point in the watershed, the stream has incised down to the underlying Elwren Shale. Springs A, A', B, and C are the largest in this watershed area. The locations of these springs are shown on Figure 12. Springs A, A', and B are located on the western side of the valley, approximately 6,000 to 6,800 feet south of the ABG. Spring C is located on the eastern side of the creek, about 2,000 feet south of the OJT area. Presumably, Springs A, A', and B are draining the portion of the BC/BC aquifer west of the creek, and Spring C is draining the aquifer east of the creek. These springs flow year round; however, flow rates fluctuate rapidly due to rainstorm or large snowmelt events. Flow rates of Springs A and C were measured continuously in March and April 1996 (see Figure 14).

As shown in Figure 14, the flow rates of the two springs rose rapidly in response to rain events and declined fairly rapidly within a few days. The peak flows in these two springs during the 2-month time period were approximately 10,000 gallons per minute (gpm) or 22.3 cubic feet per second (ft^3/s). It has been noted in previous reports (e.g., Hunt, 1988; Murphy and Ciocco, 1990) that the springs become

turbid during high flow events and then clear up and return to normal flow within a day or two after a storm event. The flashiness of the spring flows and the fact that the discharge becomes turbid during a storm indicate that the springs are linked to conduit systems that take surface recharge and transfer it through the conduit systems quickly. The suspended solids contained in the discharge waters likely come from the areas of recharge and gradually move through the conduit system, primarily during storm events.

2.7 SURFACE HYDROLOGY

The surface drainage at NSWC Crane has formed a dense, dendritic pattern throughout the installation. Most of the major streams flow in a general southward or southwestward direction. Seven primary creeks in five drainage basins carry surface water off the installation, where they eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. Figure 15 shows the main drainage basins of NSWC Crane. The OJT study area lies within the Sulphur Creek drainage basin, which drains roughly 30 percent of NWSC Crane.

LSC is a tributary of Sulphur Creek and is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation. The creek consists of a north and a south fork from the headwaters to approximately the center of the MTA. From the MTA, a single channel meanders south-southeastward a distance of approximately 0.5 mile to the OJT area and then continues another 0.6 mile until it reaches the installation boundary. Several intermittent tributaries discharge into LSC from both sides of the stream, including the Johnson Hollow tributary, which intersects with LSC near the NSWC Crane boundary. The DBG (SWMU 2) is located north of the OJT, and surface drainage from this site enters several ephemeral gullies that drain into LSC between MTA and OJT.

The LSC channel is usually dry north (upstream) of Spring C. During dry periods of summer and fall, the flow rate in the creek between Springs C and A is typically less than about 50 gpm. Downstream of where the discharge from Spring A enters the creek, the dry weather flow in the creek is typically greater than 100 gpm. Flow rates in the creek were visually estimated on June 19, 2001. The flow estimate for a stream gauge was about 20 gpm. Downstream of Spring A, the flow rate in the creek can increase by two to three orders of magnitude, due in large part to the rapid increases in the flow rates of the springs along the creek.

From the installation boundary, LSC flows southward about 2 miles until it enters Sulphur Creek. Sulphur Creek then flows southward and empties into Indian Creek, which drains into the East Fork of the White

River and then southwestward into the Wabash River. Figure 16 shows the surface water hydrology of the LSC watershed.

3.0 MAIN TREATMENT AREA

3.1 TREATMENT OPERATIONS

The MTA is an active RCRA-permitted open burning (OB) facility for the treatment of reactive hazardous wastes. Figure 17 shows the layout of the MTA. Large-scale open burning of waste propellant, explosives, and explosive-contaminated materials has taken place at the MTA since the 1940s. The materials burned range from pure propellant and explosives to chlorinated and non-chlorinated solvents and packaging materials contaminated with propellants and explosives. Prior to the initiation of the use of containment facilities (steel pans and concrete pads), open burning typically took place directly on the ground surface. Often these operations took place directly on the ground surface in pits that were dug into the ground. Until the early 1990s, unlined surface impoundments were used to dewater sludges that contained explosives, propellants, and solvents. Until removed in the late 1980s, an unlined waste pile was used to store residuals from burning operations at the OJT and the MTA. Until the early 1990s, the MTA was kept devoid of vegetation, which resulted in significant erosion and transport of surface soils to LSC. During the period that these practices took place, a direct pathway existed for contamination of surface and subsurface soils. All treatment operations currently take place in containment facilities and tanks. The waste pile and surface impoundments have been decommissioned. Therefore, contamination is no longer being released to soils or into LSC from routine MTA treatment operations. Any accidental releases would be immediately cleaned up in compliance with provisions of the RCRA Permit.

3.2 SOIL CONTAMINATION

Historical treatment practices have resulted in the release of explosives and solvents to soils at SWMU 3. Investigations were conducted to determine the locations of soil sources of explosives (RDX), chlorinated organics (TCE), and metals (barium) contamination at the MTA. In general, the highest RDX contamination was observed in the upper 2 feet of the soil horizon and was observed to decrease with depth. Samples collected during the April 2004 field investigation did not provide evidence that a continuing source of RDX contamination is present in soils. Samples collected during the April 2004 field event showed evidence of a direct link between the soil overburden and the bedrock for TCE at some isolated locations. Figure 18 is a tag map that shows soil sample between locations and all detections of RDX and TCE for the April 2004 investigation. Barium was found in significant concentrations only in surface soils samples. No evidence was found of a direct link between soil barium sources and the bedrock. Figure 19 is a tag map showing soil sample locations and all detections for barium for the April 2004 investigation.

3.3 GROUNDWATER FLOW AND CONTAMINATION

The groundwater flow direction at SWMU 3 is generally toward LSC. Dissolved contaminants move in groundwater along the bedrock surface until they find an opening that allows them to migrate deeper into bedrock. As groundwater migrates along fractures, dissolved contamination will diffuse into the rock matrix. The back-diffusion of contaminated water from the matrix into the open fractures will provide a long-term source of contamination and will slow the rate of plume migration. RDX, TCE, and barium contamination, released as the result of historical practices, have migrated into the bedrock and serve as a continuing source of groundwater contamination. If the dip of the bedrock surface is in a direction other than the direction of groundwater flow, the contaminants will move in unexpected directions along the bedrock surface. If contaminants migrate further down and into the BC/BC aquifer, they will again move in the direction of groundwater flow.

3.4 SPRING DISCHARGES OF GROUNDWATER AND CONTAMINATION

The MTA is underlain by a karst system in the Beech Creek Formation that leads southward along the western side of the valley toward Springs A and A' (shown schematically in Figures 5 and 12). After making its way through saturated overburden and bedrock, MTA groundwater, and hence the MTA groundwater contaminants, are conveyed through the karst conduit to LSC via Springs A and A' (shown on Figures 5 and 11). RDX concentrations ranged from 0 to 140 micrograms per liter (µg/L) at Spring A between 1998 and 2004, with an approximate average concentration of 36 µg/L. These concentrations are less than the average RDX concentration in groundwater underlying the MTA (71 µg/L). As expected, uncontaminated and/or less contaminated groundwater enters the conduit all along its path from the MTA to the location of Spring A. This results in dilution of contaminants between the MTA and Springs A and A'. Spring A' is part of the same conduit system that drains the MTA and discharges to LSC. The RDX concentration in Spring A' was 7.4 µg/L in April 2004, which is significantly less than the average groundwater RDX concentration in the MTA.

The hydrographs for Spring A and C in Figure 14 illustrates the wide variation in water flow rates that occur in the springs, depending on whether base flow is observed or it is supplemented with varying degrees of precipitation. Precipitation increases the infiltration of water into the conduits. This not only affects transport and dilution in the conduits, but also causes corresponding increases in spring water flow rates.

3.5 TCE

When the karst conduit system is only partially full (i.e., some air space exists in the conduits), the conduits approximates open channel flow, and a significant amount of volatile organic compounds (VOCs) could potentially volatilize out of the groundwater during transit. This seems to be the situation in the conduit between the MTA and Springs A and A', because even though TCE concentrations are greater than RDX concentrations in MTA groundwater, TCE concentrations in groundwater discharging from the springS (commonly not detected) are much less than RDX concentrations. Any TCE that is not volatized in the karst system would be expected to volatize rapidly after discharge to LCS.

3.6 NATURAL ATTENUATION

It is evident that natural attenuation process are slowing plume migration and are reducing contaminant concentrations between the MTA and Springs A and A'. In summary:

- Matrix diffusion is reducing the rate of plume migration in fractured bedrock before groundwater enters the karst system.

- Dilution is reducing the concentrations of RDX, TCE, and barium in the karst system before the groundwater discharges through Springs A and A' into LSC.

- TCE is volatizing within the karst system before discharge through the springs.

In addition to dilution and volatilization, other natural attenuation processes such as biotic and abiotic degradation may also operate to reduce contaminant concentrations during storage and migration within bedrock beneath the MTA before entering the karst conduit system. Breakdown products of RDX (MNX, DNX, and TNX) were detected during monitoring conducted from 1999 through 2002. Based on the concentration-time graphs for MTA wells; there is little indication that natural attenuation is rapidly reducing groundwater contaminant concentrations within the MTA area. However, the relatively stable trends indicate that monitored natural attenuation processes are acting to stabilize the plume and slow migration.

3.7 GROUNDWATER CONTAMINATION SOURCES

As noted previously, historical practices that resulted in the release of contamination to soils and groundwater have not been utilized since the early 1990s, and all treatment operations now take place in containment devices. Therefore, contamination is no longer being released as the result of routine

operation practices. The lack of decreasing concentrations of the RDX and TCE in groundwater within the MTA implies that the sources resulting from historical operations have not been depleted. Based on the April 2004 soil and groundwater data, it is difficult to identify a single primary source contributing to groundwater contamination. The heterogeneous distribution of soil contamination indicates that multiple treatment areas were responsible for the observed groundwater contamination. Based on the April 2004 soil and groundwater data and groundwater data collected during the RCRA groundwater monitoring program, the sources appear to be present in a combination of overburden soils, bedrock, and the karst system. The April 2004 investigation did not provide evidence of RDX and barium contamination in soils immediately above the bedrock except in isolated locations. Therefore, it is probable that significant sources of RDX and barium are also located in the bedrock or karst system or some combination of the two. The April 2004 investigation did provide evidence of subsurface soils with TCE contamination directly above the bedrock in isolated locations. It is likely that TCE has also migrated into the bedrock and/or the karst system. It is not possible to determine the relative distribution of TCE among soils, bedrock, and the karst system.

3.8 MIGRATION OF CONTAMINATION

In summary, all contaminated MTA groundwater is discharged into LSC, primarily at Springs A and A'. Except during periods of significant precipitation, LSC is dry between the MTA and Spring C. LSC is a losing stream with surface waters infiltrating into the karst system. LSC becomes a perennial stream at the location where Spring C discharges into LSC. The LSC surface waters flow off-site. LSC surface waters do not generally contain any TCE because, as discussed previously, the TCE appears to volatize in the karst system and from LSC. The LSC surface waters generally contain RDX in concentrations above the risk-based target levels (RBTLs) established in the RCRA Permit.

3.9 CHEMICALS AND MEDIA OF CONCERN

Human health and ecological risk assessments [Current Contamination Conditions Risk Assessment (CCCRA)] for existing contamination conditions were conducted in 1999 (TtNUS, 1999) as part of the hazardous waste permitting process for the open burning treatment operations at the MTA. The operating RCRA Permit issued by United States Environmental Protection Agency (U.S. EPA) Region 5 established requirements for groundwater monitoring including RBTLs for hazardous constituents. The Permit requires the Navy to develop a Corrective Action Plan for groundwater when statistically significant concentrations of hazardous constituents exceed RBTLs at point-of-compliance wells at the MTA. Annual groundwater monitoring reports for the years 2000, 2001, 2002, and 2003, which were prepared for the Navy (SAIC 2002a, SAIC 2002b, SAIC 2003a, and SAIC 2003b), have identified hazardous constituents

that were detected in statistically significant concentrations and greater than RBTLs. A risk assessment was conducted for current receptors (site worker, construction worker, and trespasser). The following summarizes the chemicals of concern (COCs) and media in which they are found as described in these documents.

- Groundwater: The CCCRA identified RDX, TCE, various degradation products of 2,4,6-trinitrotoluene (TNT) and TCE, and metals (principally barium) as COCs for future residents or workers ingesting groundwater at the MTA. The annual groundwater monitoring reports identified RDX, TCE, and barium as the principal contaminants present in statistically significant concentrations and greater than RBTLs in point-of-compliance wells at the MTA. All barium concentrations in MTA groundwater samples were less than the Safe Drinking Water Act Maximum Contaminant Level (MCL) of 2,000 µg/L. Therefore, barium concentrations are considered to be acceptable. Any risks to receptors from groundwater contaminated with RDX and TCE at the MTA are currently controlled because contaminated groundwater (BC/BC aquifer) at the ABG is not used as a drinking water source. The MTA is currently used only for an industrial use (RCRA-permitted OB facility). OB treatment operations prevent use of the MTA for residences. When RCRA-permitted OB operations cease, the MTA will be either clean-closed or closed as a landfill.

- Springs A and A': The CCCRA did not identify any COCs for Springs A or A'. The annual groundwater monitoring reports have identified RDX and barium as the principal contaminants present in statistically significant concentrations and greater than RBTLs at Spring A. Any risks to receptors from these COCs are currently controlled because the Navy controls the property where Springs A and A' discharge.

- Surface Waters: The CCCRA identified RDX and arsenic as COCs for off-site residents using LSC surface waters as drinking water sources. The annual groundwater monitoring reports have not identified any COCs for LSC surface waters.

- Soils: The CCCRA identified arsenic, zinc, polychlorinated dibenzodioxins (PCDD), and tetrochlorodibenzodioxin (TCDD) as COCs for future residents ingesting home-grown fruits, vegetables, beef, and/or milk. Any risks to receptors from home-grown agricultural products at the MTA are currently controlled because the MTA is not used for any agricultural purposes. Open burning treatment operations prevent use of the MTA for residences or agriculture. Reasonable future land use for the MTA does not include residential or agricultural use. The follow-on MTA Human Health Risk Screening Evaluation (HHRSE) (see Section 2 of the CMP) identified potential risks to one current receptor, which was the construction worker from exposure to soils containing lead. This risk is

currently controlled because no construction is allowed to take place at the MTA. If construction does place, appropriate controls would be put in place to control construction worker exposure.

- Ecological - Soils: The CCCRA did not identify any significant ecological risks or COCs within the MTA. In addition, open burning treatment operations preclude the use of the MTA for ecological habitat.

- Ecological - LSC: The CCCRA did not identify any significant ecological risks or COCs in LSC.

4.0 OLD JEEP TRAIL

The OJT is an inactive area that is adjacent to and downstream in the LCS valley (southeast) of the MTA. The OJT was used to burn out bomb casings (burn area) and open burn explosives-contaminated materials in a pit (burn pit). Treatment operations took place from the mid-1970s through 1983. Figure 20 shows the approximate locations of these areas. At the burn area, bomb casings, from which the bulk explosives had been removed, were filled with initiating powder, tilted on end toward a hillside east of the OJT, and flashed to complete the demilitarization process. The burn pit was a trench or natural depression, approximately 100 feet long, 30 feet wide, and 10 to 12 feet deep, located just south-southeast of the burn area (Figure 20). Powder was flashed and explosives-contaminated materials were burned in this pit. The area has not been used for any operations since 1983 at which time it was filled with clean fill material and revegetated. The area is now overgrown with brush, trees, and grasses.

Historical treatment practices have resulted in the release of explosives, solvents, and metals to the soils and groundwater underlying the OJT. Investigations were conducted to determine the locations of soil sources of explosives (RDX), chlorinated organics (TCE), and metals (barium) contamination at the OJT. In general, RDX contamination decreased with depth. Samples collected during the June 2001 and April 2004 field investigations did not provide direct evidence that the source of RDX contamination in soils has been located. Samples collected during these field events showed evidence of a direct link between the soil overburden and the bedrock for TCE. Figure 21 is a tag map that shows soil sample locations and all detections or RDX and TCE during these investigations. Figure 22 is a tag map that shows soil sample locations and all detections at OJT of barium during these investigations.

In general, physical site conditions and hydrologic processes for the OJT area are similar to those discussed for the MTA and as follows:

- RDX and TCE have been released to soils and groundwater as the result of historical site operations.
- Contaminants are leaching downward through the soil and impacting groundwater.
- Contaminated groundwater is migrating eastward toward a karst conduit.
- From the OJT, groundwater enters a karst conduit and flows rapidly southward.

- Unlike the western conduit system, the eastern conduit system transmits the groundwater to Spring C (rather than Springs A or A').

- An extensive amount of dilution takes place within the conduit before the groundwater reaches Spring C.

The hydrographs for Springs A and C in Figure 14 illustrate the wide variation in water flow rates that occur in the springs, depending on whether base flow is observed or is supplemented with varying degrees of precipitation. Precipitation increases the infiltration of water into the conduits. This not only affects transport and dilution in the conduits but also causes corresponding increases in spring water flow rates.

CHEMICALS AND MEDIA OF CONCERN

An RFI was conducted was conducted for the OJT and LSC. The RFI report (TtNUS, 2005) included human health and ecological risk assessments for the OJT and LSC. The RCRA Permit requires groundwater monitoring for the MTA that includes monitoring of Spring C. The following summarizes the COCs and media in which they are found as described in the risk assessments, which are contained in the RFI Report and for Spring C in the Annual Groundwater Monitoring Reports.

- Groundwater: TCE, 1,1,2,2-tetrachloroethane (TCA), and 4-amino-2,6-dinitrotoluene (4-A-DNT) were identified as COCs for future residents and workers ingesting groundwater at the OJT. Any risks to receptors for groundwater at the OJT are currently controlled because the OJT is under control of the Navy and groundwater at the site is not used as a drinking water source.

- Spring C: The RFI did not include a separate evaluation of Spring C. The Annual Groundwater Monitoring Reports have identified barium as the principal contaminant present in statistically significant concentrations and greater than RBTLs at Spring C. Data for RDX contained in the RFI Report shows that RDX is generally present at concentrations greater than the RBTL established in the RCRA Permit.

- Soils: TNT, RDX, and lead were identified as COCs for future residents exposed to soils. Risks to residential receptors are currently controlled because the OJT is under control of the Navy and is not used for residences.

- Surface Waters: 2-amino-4,6-dinitrotoluene (2-A-DNT), 4-A-DNT, and RDX were identified as COCs for future residents ingesting surface water. Any risks to receptors from ingestion of surface water at the OJT are currently controlled because the portion of LSC that is within the boundary of NSWC Crane is under control of the Navy. Alternate water quality criteria (WQC) were determined in accordance with Indiana Department of Environmental Management (IDEM) requirements for protection of IDEM-designated uses of LSC and downstream surface waters. All concentrations of 2-A-DNT, 4-A-DNT, and RDX are significantly less than these alternate WQC.

- Ecological – Soils: No significant ecological risks or COCs were identified for the OJT.

- Ecological – LSC: No significant ecological risks or COCs were identified in LSC.

5.0 SUMMARY OF AMMUNITION BURNING GROUNDS CONCEPTUAL SITE MODEL

Figure 1 is a schematic drawing of the conceptual site model for the MTA. It shows, in principle, that contaminants were released into surface/subsurface soils and migrated toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. The following is a summary of the conceptual site model for the MTA:

- Groundwater underlying the MTA is contaminated with RDX, TCE, and degradation products of RDX and TCE in excess of risk-based concentrations. The presence of degradation products indicates that natural degradation is occurring.

- The relative distribution of RDX and TCE contamination sources between the overburden, bedrock, and karst system is not known.

- The distribution of RDX and TCE contamination sources in the overburden soil, bedrock, and karst system appears to be heterogeneous in nature.

- Current practices (open burning in containment structures) have eliminated any releases of contaminants to soils and groundwater. Therefore, the contaminant source is being depleted.

- MTA groundwater discharges through the karst system into LSC through Springs A and A'.

- TCE is volatized in the karst system and is not present in LSC surface waters.

- RDX concentrations in surface waters originating from Spring A discharges are less than applicable IDEM WQC for public water supply and incidental contact with surface waters.

- The existing use for the MTA is industrial. Receptors associated with the existing use (industrial) include the site worker, construction worker, and trespasser.

- Contaminated groundwater underlying the MTA is not used and therefore, does not present a risk under the industrial use scenario.

- Excess risk is present only for the construction worker resulting from exposure to metals.

- Excess risk is present for future residents ingesting groundwater. Reasonable future uses for the MTA do not include residential housing.

- The industrial nature of the MTA (OB operations, paved areas, etc.) eliminates ecological habit. Therefore, ecological uses are not viable at the MTA.

Figure 2 is a schematic drawing of the conceptual site model for the OJT. It shows, in principle, that contaminants were released into surface/subsurface soils and migrated toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. Exposure to the contaminants could result in unacceptable health risks to humans. The following is a summary of the conceptual site model for the OJT:

- Groundwater underlying the OJT is contaminated with RDX and TCE.

- RDX and TCE contamination sources appear to be distributed among the overburden soil, bedrock, and karst system.

- The relative distribution of RDX and TCE contamination sources between the overburden, bedrock, and karst system is not known due to the heterogeneous distribution of contamination at the OJT.

- Open burning operations, which, resulted in the release of contaminants have not taken place since the 1980s. Therefore, the contaminant source is being depleted.

- OJT groundwater discharges through the karst system into LSC at Spring C.

- LSC becomes a perennial stream below the Spring C discharge point.

- RDX concentrations in surface waters originating from Spring C discharges are below applicable IDEM water quality criteria for public water supply and incidental contact with surface waters.

- TCE is volatized in the karst system and is not present in LSC surface waters.

- The existing use for the OJT is industrial. Receptors associated with the existing use (industrial) include the site worker, construction worker, and trespasser.

- Contaminated groundwater underlying the OJT is not used and; therefore, does not present a risk under the industrial use scenario.

- Excess risk is presented to future residents ingesting groundwater. Reasonable future uses for the OJT do not include residential housing.

- No excess risk to ecological receptors at the OJT or LSC has been identified.

CONCLUSIONS FOR AMMUNITION BURNING GROUNDS CORRECTIVE MEASURES PROPOSAL

Following are conclusions regarding the development of the CMP for the ABG. These recommendations are based on the conceptual site model which has been presented in this section.

- The CMP should focus on existing and planned future uses for the MTA and the OJT (industrial).

- Screening and detailed evaluation of alternatives to address risk to the construction worker at the MTA is not necessary. The alternatives evaluated should include only the no-action and land use controls

- Screening and detailed evaluations of alternatives to address excess risk from ingestion of ground water and exposure to soils is not necessary because the withdrawal of contaminated Beech Creek/ Big Clifty groundwater does not occur under the current and future industrial use scenario. However, to assure that no changes occur in land use the no-action and LUC alternatives should be evaluated.

- LTM of groundwater underlying the MTA and OJT should be included in the preferred alternative. The LTM program should be designed to provide information as to whether contaminants are naturally degrading.

- The LTM program should include monitoring of LSC surface waters to ensure that concentrations of contaminants remain below IDEM WQC.

- The LTM program should include periodic checks to determine whether any modifications occur in state-designated uses of LSC surface waters or any changes occur in the locations where the uses occur (i.e. public water supply intake). If such changes occur an evaluation should be conducted to

determine whether contamination concentrations in LSC are adversely affecting the state-designated uses.

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prepared by TtNUS for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina, June.

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FIGURE 1
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
MAIN TREATMENT AREA
CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

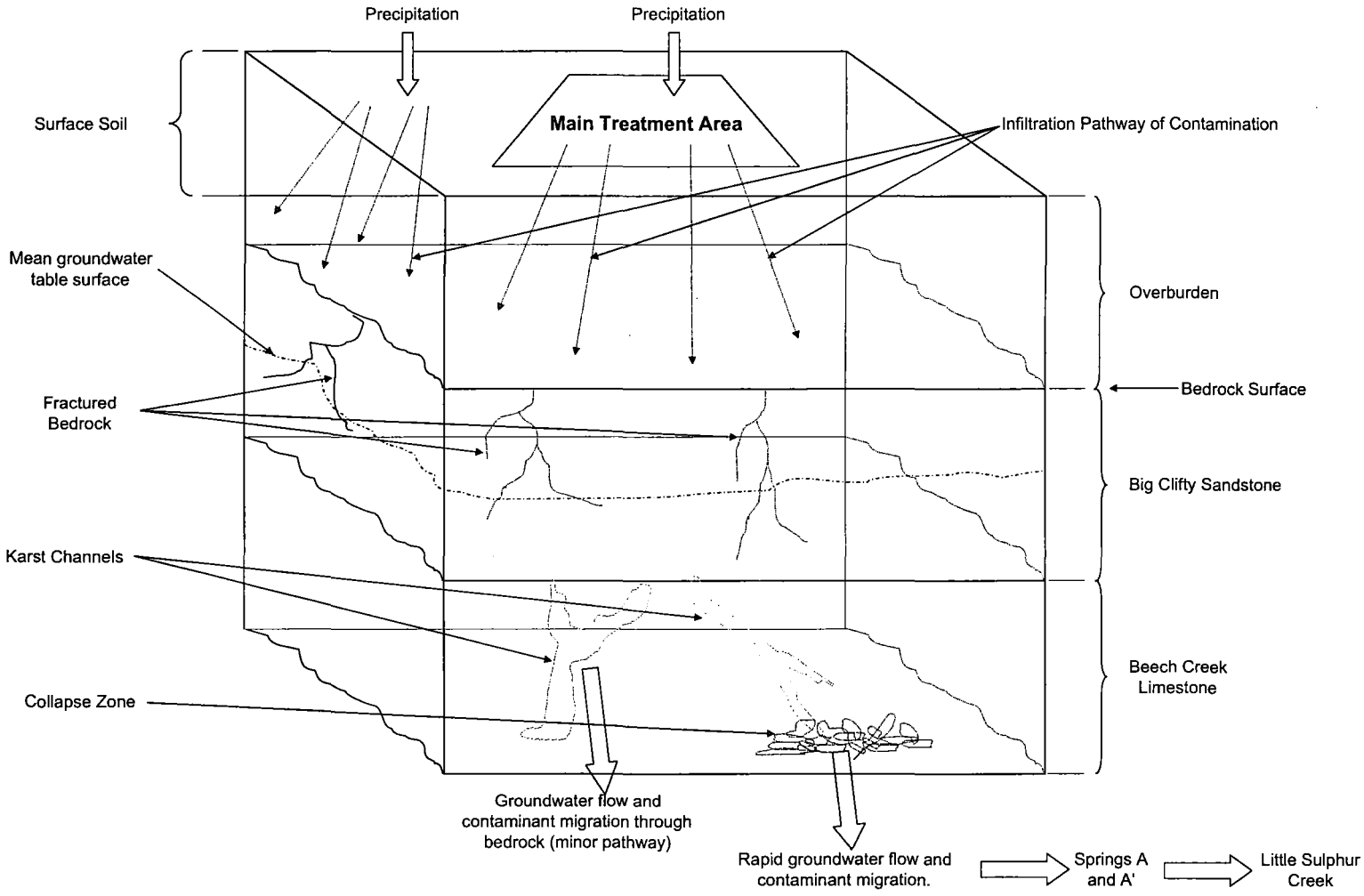
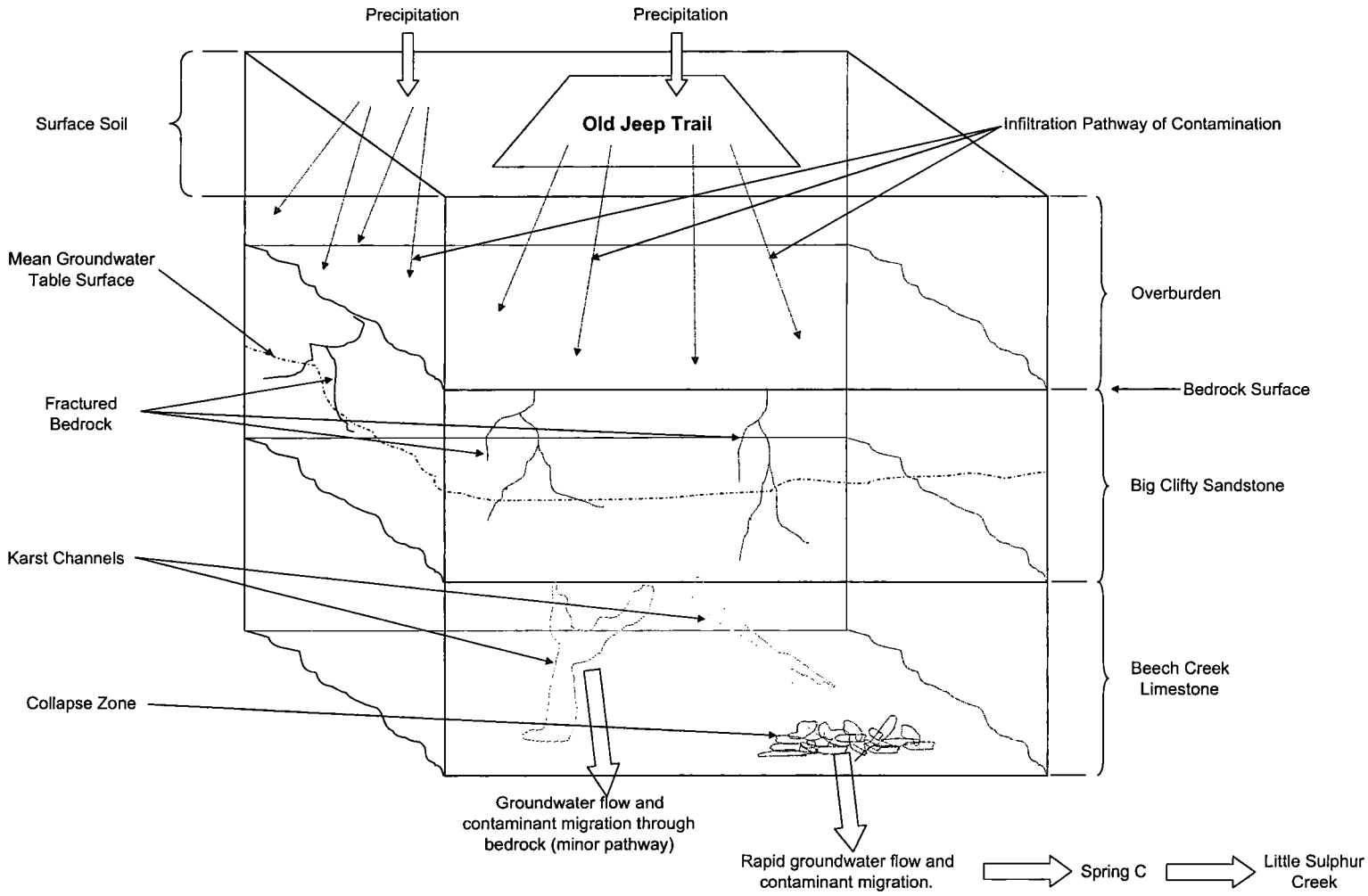
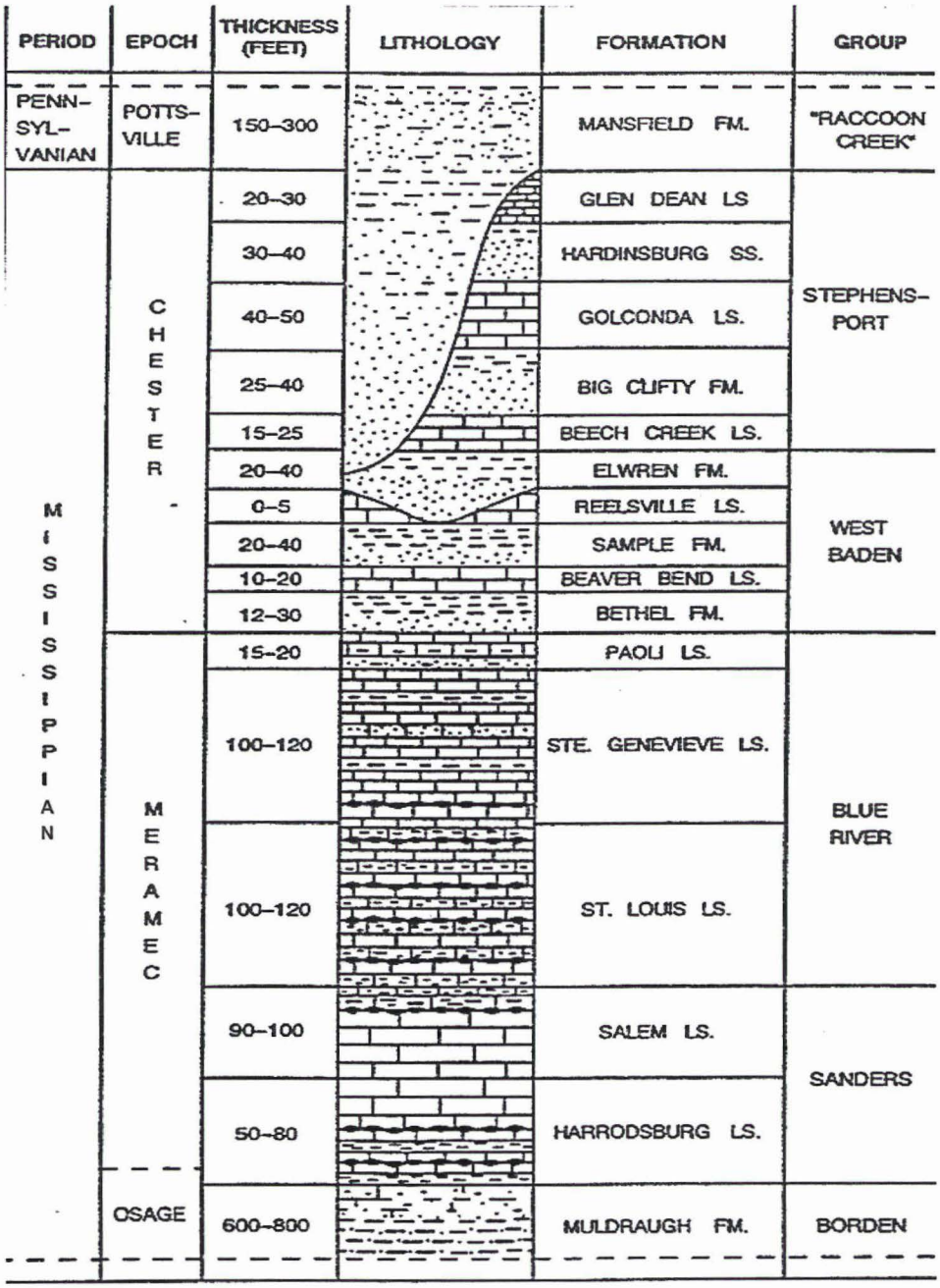


FIGURE 2
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
OLD JEEP TRAIL
CONCEPTURAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA





Source: Palmer, 1989

DRAWN BY A. JANOCHA — DATE 7/21/02	NAVFAC	GENERALIZED STRATIGRAPHIC COLUMN CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY J. SCHUBERT — DATE 8/21/02			APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 3 — REV 0

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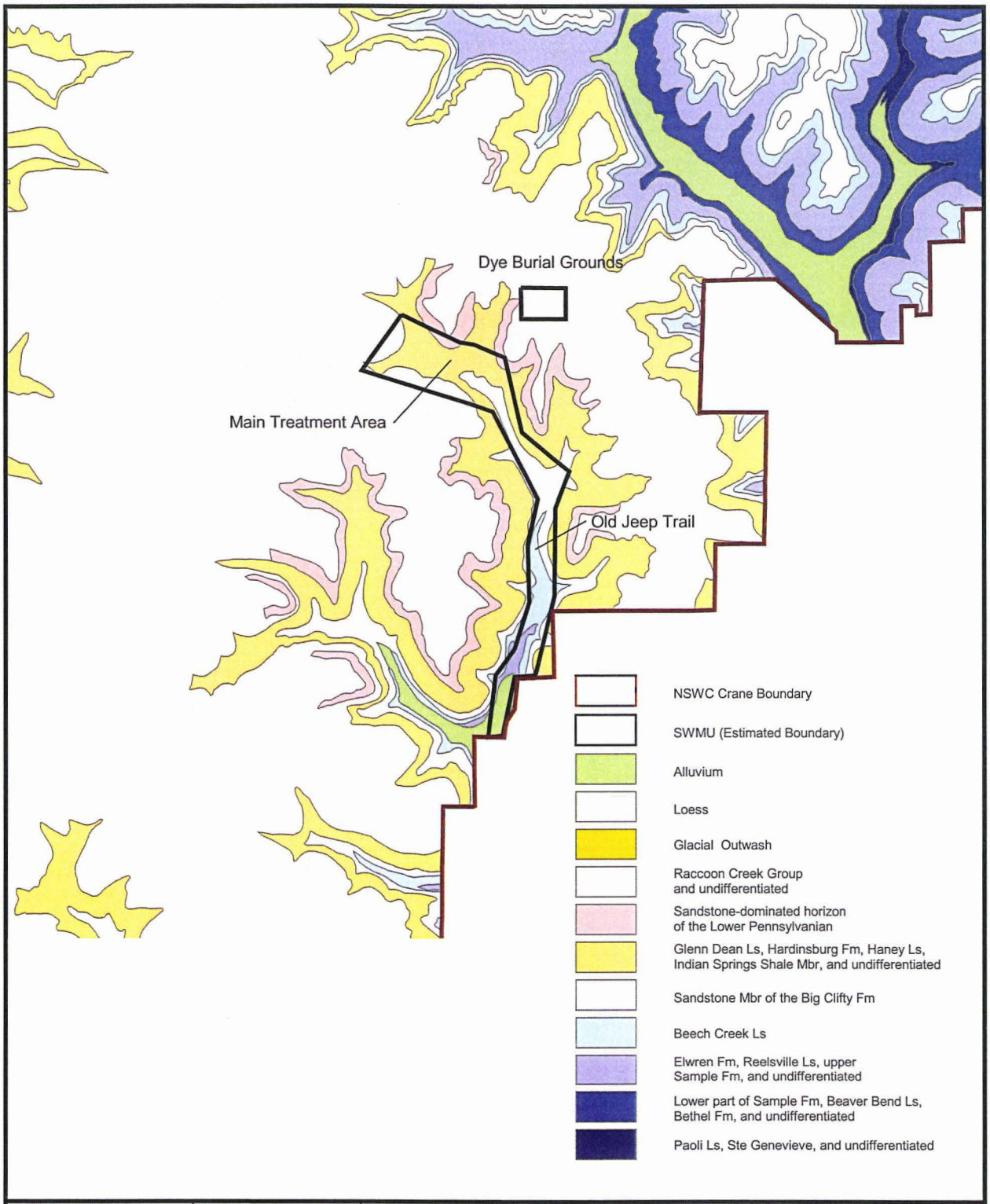

DRAWN BY A. JANOCHA	DATE 11/20/02	SURFICIAL BEDROCK MAP CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY J. GOERDT	DATE 11/20/02		APPROVED BY T. JOHNSTON — DATE 11/20/02
COST/SCHEDULE-AREA			APPROVED BY — — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 4 — REV 0

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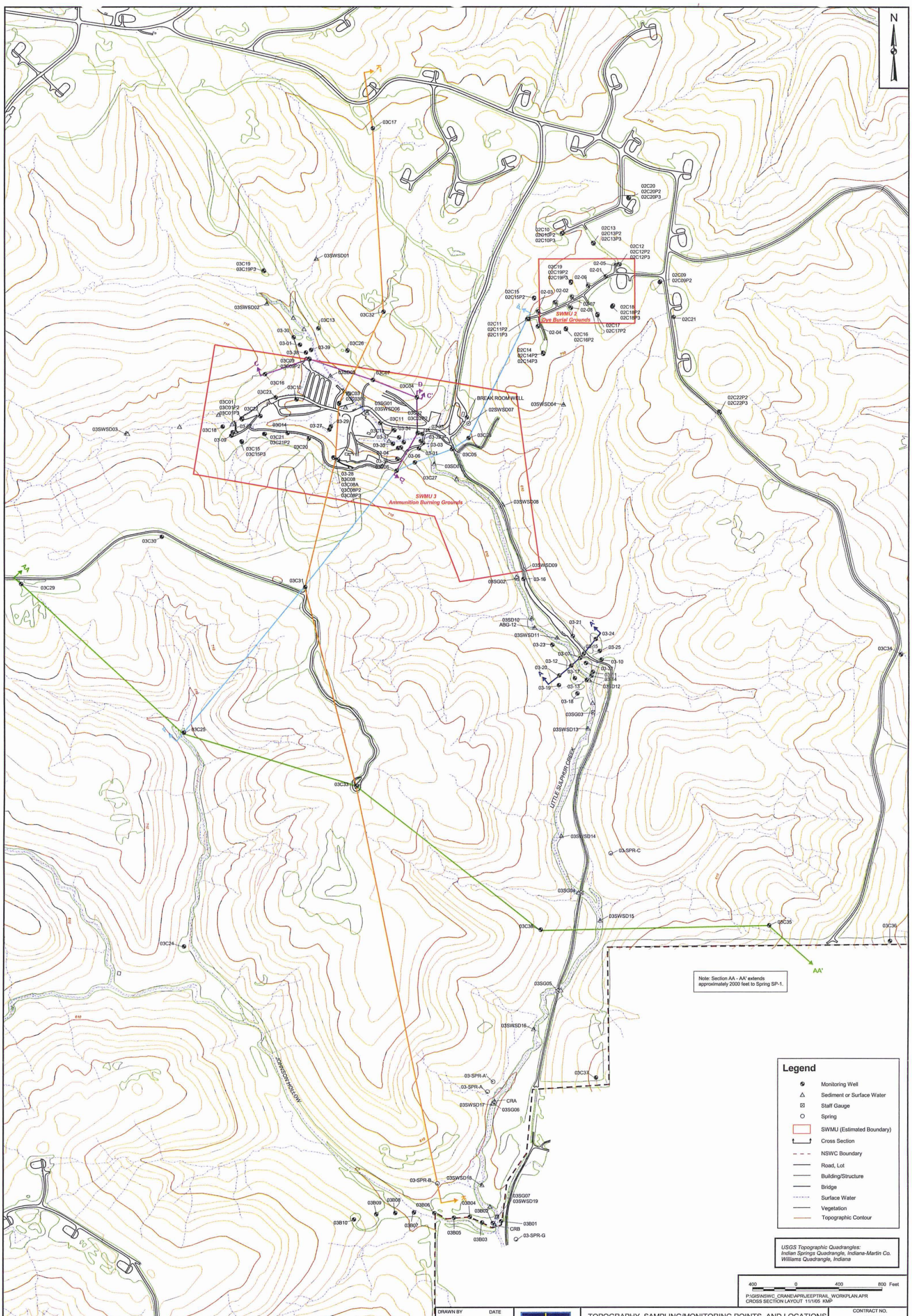

DRAWN BY	DATE
A. JANOCHA	6/19/02
CHECKED BY	DATE
F. RAMSER	8/22/02
CHECKED BY	DATE
J. SCHUBERT	8/22/02
SCALE	
AS NOTED	

NAVFAC

TOPOGRAPHY, SAMPLING/MONITORING POINTS, AND LOCATIONS OF GEOLOGIC CROSS SECTIONS IN THE WATERSHED CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA

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CTO 0311	
OWNER NO.	
8383	
APPROVED BY	DATE
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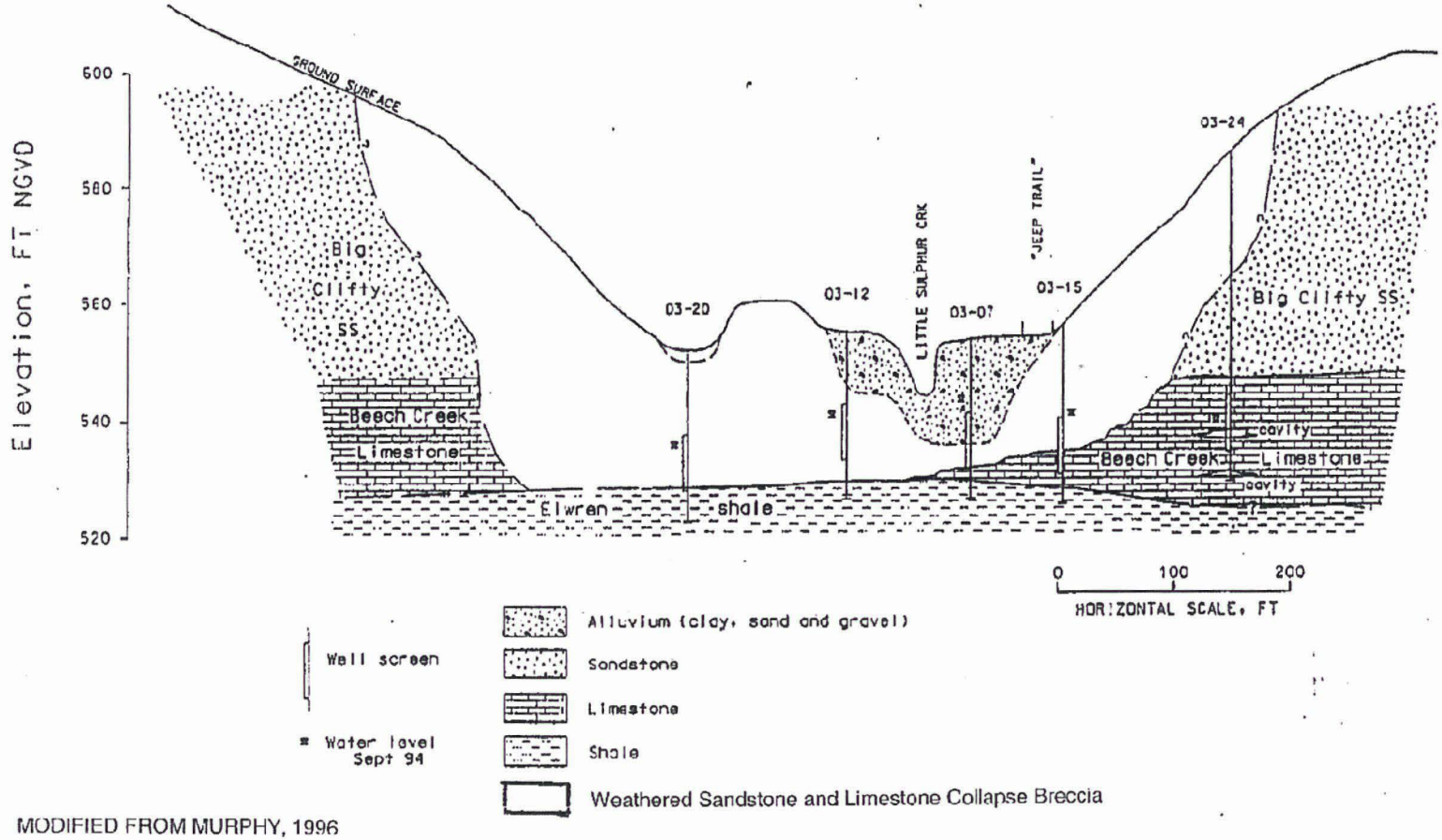
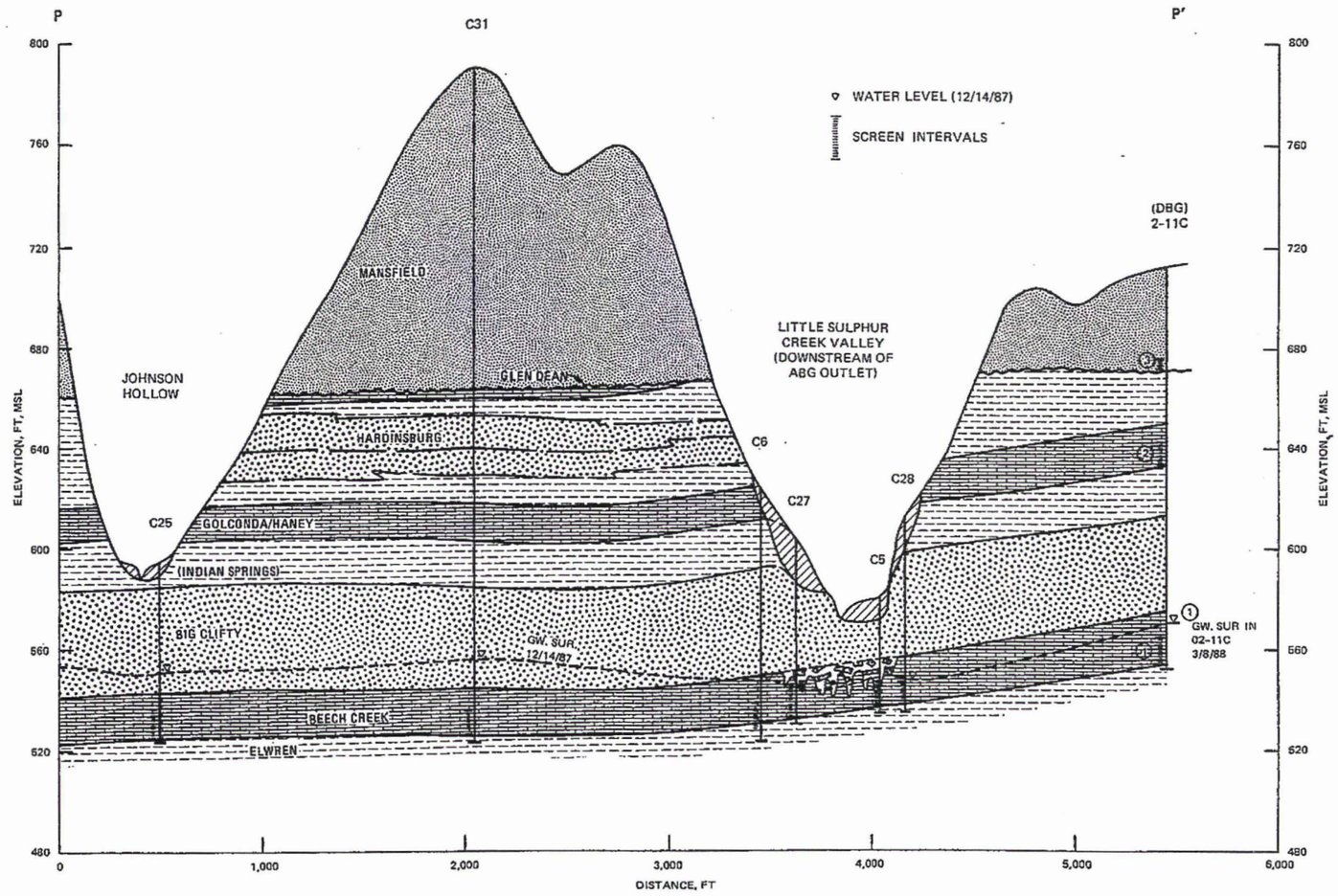
FIGURE 5	0



MODIFIED FROM MURPHY, 1996

DRAWN BY A. JANOCHA DATE 7/17/02	NAVFAC	GEOLOGIC CROSS SECTION A-A'	CONTRACT NUMBER CTO 0311
CHECKED BY J. SCHUBERT DATE 7/17/02		CONCEPTUAL SITE MODEL REPORT FOR	APPROVED BY — DATE —
COST/SCHEDULE-AREA		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
SCALE AS NOTED		NSWC CRANE CRANE, INDIANA	DRAWING NO. FIGURE 6 REV 0

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR GEOLOGIC CROSS SECTION A-A' LAYOUT 11/1/05 KMP



LEGEND

- UNDIFFERENTIATED
- CLAY SYMBOL
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE

Modified from Hunt, 1988.

CONTRACT NO. CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 7

REV 0

GEOLOGIC CROSS SECTION P-P'
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

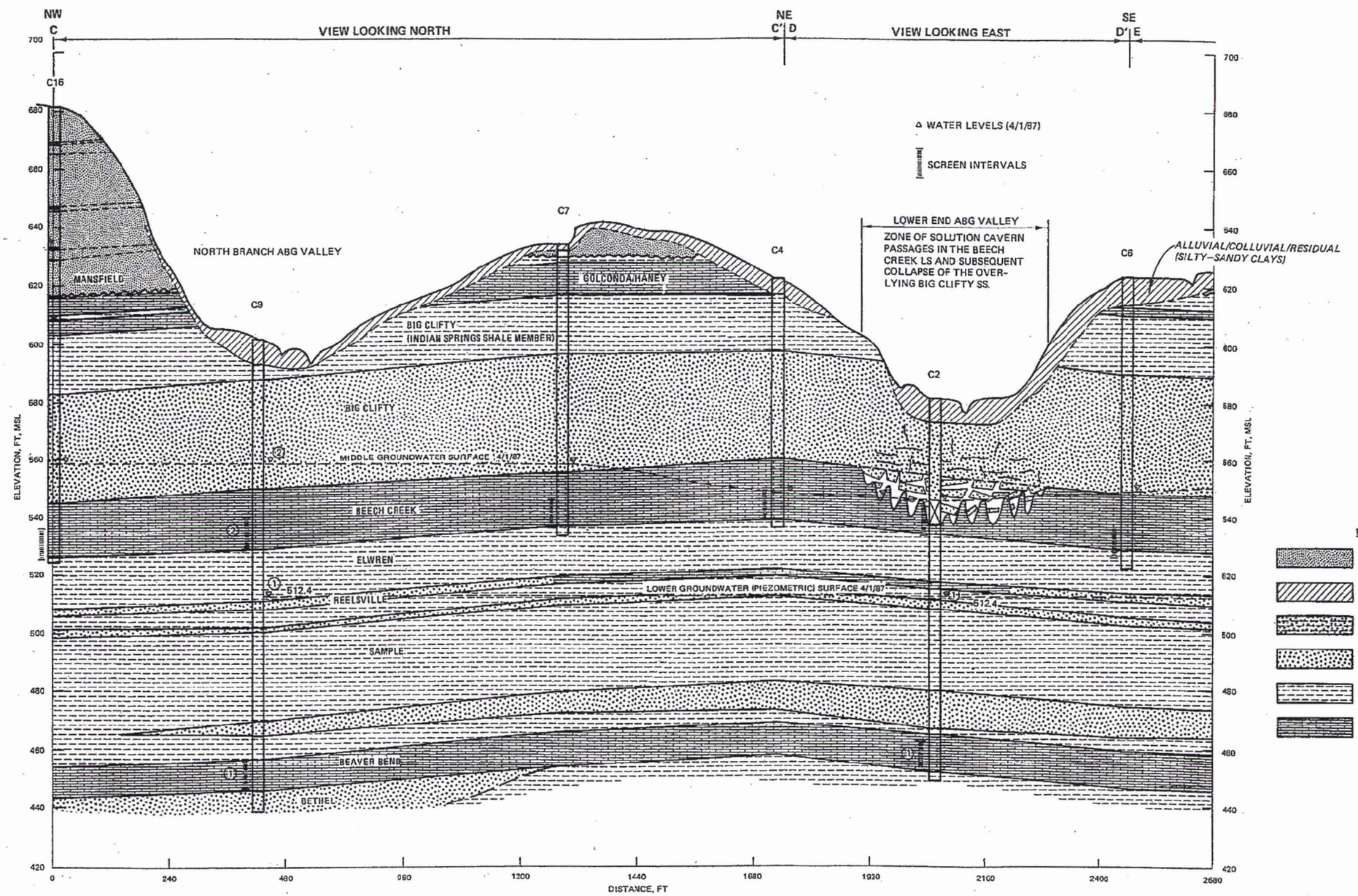
DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED

/GIS/NSWC_CRANE/APR/JEEPTRAIL_WORKPLAN.APR GEOLOGIC CROSS SECTION C-C' AND D-D' LAYOUT 11/1/05 KMP



Modified from Hunt, 1988.

CONTRACT NO. CTO 0311

APPROVED BY ___ DATE ___

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DRAWING NO. FIGURE 8

REV 0

GEOLOGIC CROSS SECTION C-C' AND D-D'
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

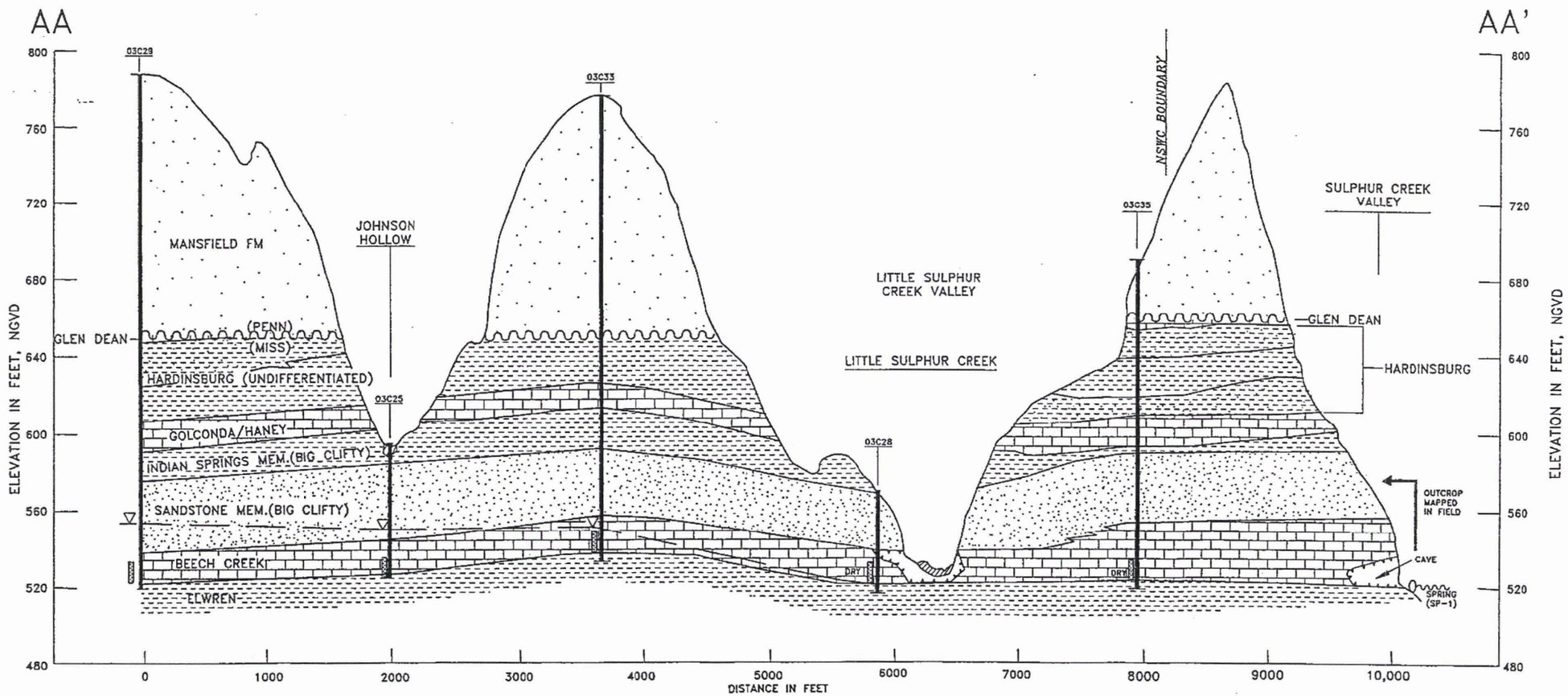
NAVFAC

DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED



LEGEND

- SOIL OVERBURDEN
- UNDIFFERENTIATED (PENNSYLVANIAN)
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE
- WATER SURFACE (3/29/91)
- SCREEN INTERVAL
- POSTULATED COLLAPSE OR SOLUTION ZONE

Modified from Murphy, 1994.

CONTRACT NO. CTO 0311

APPROVED BY ___ DATE ___

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REV 0

GEOLOGIC CROSS SECTION AA-AA'
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

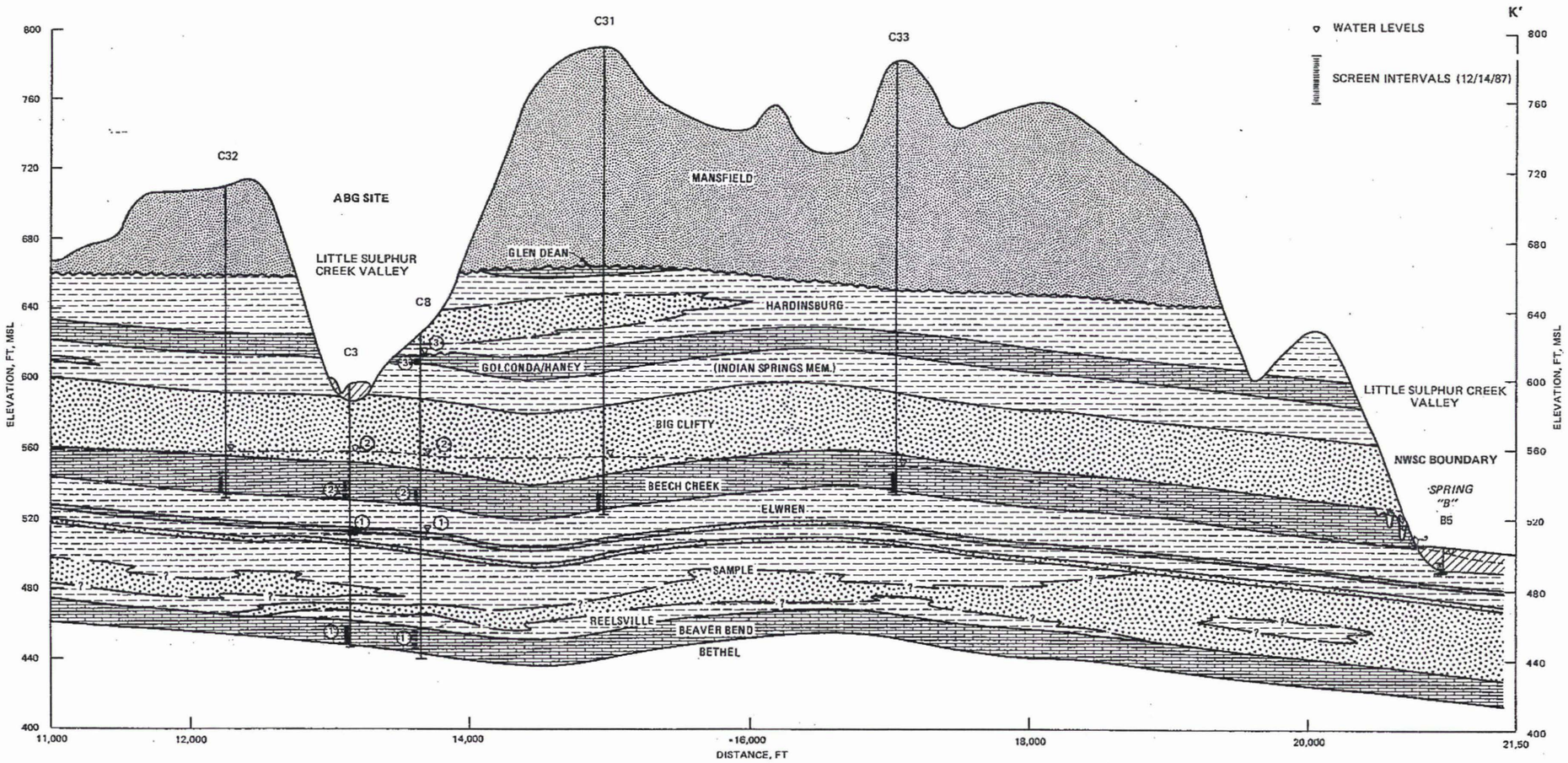
NAVFAC

DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED



LEGEND

- UNDIFFERENTIATED
- CLAY SYMBOL
- SHALE AND SANDSTONE
- SANDSTONE
- SHALE
- LIMESTONE

Modified from Hunt, 1988.

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APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 10

REV 0

GEOLOGIC CROSS SECTION K'-K"
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 7/17/02

CHECKED BY J. SCHUBERT DATE 7/17/02

COST/SCHED-AREA

SCALE AS NOTED

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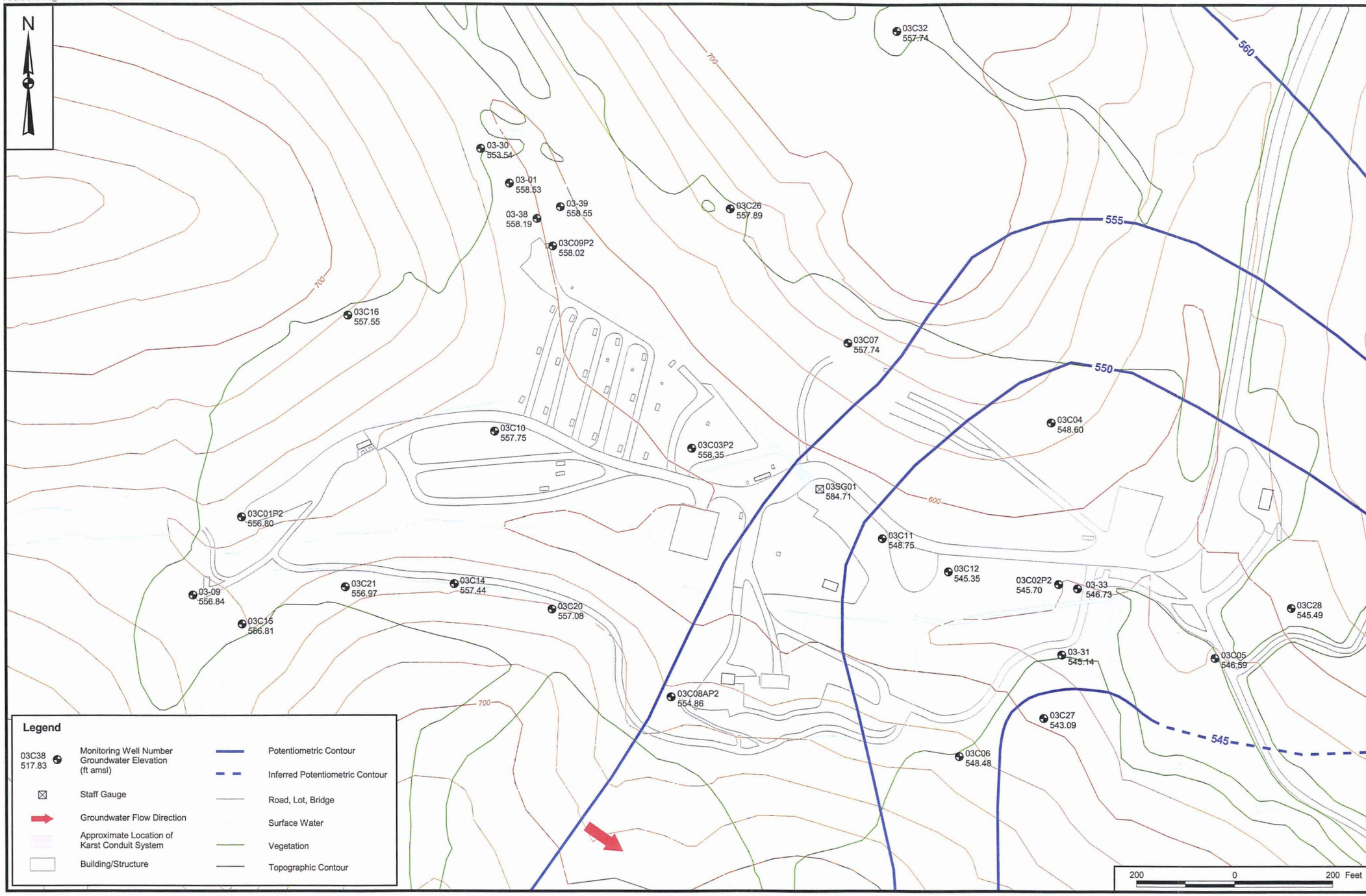

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DRAWING NO. FIGURE 11

REV 0

GROUNDWATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004
MAIN TREATMENT AREA INSET
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

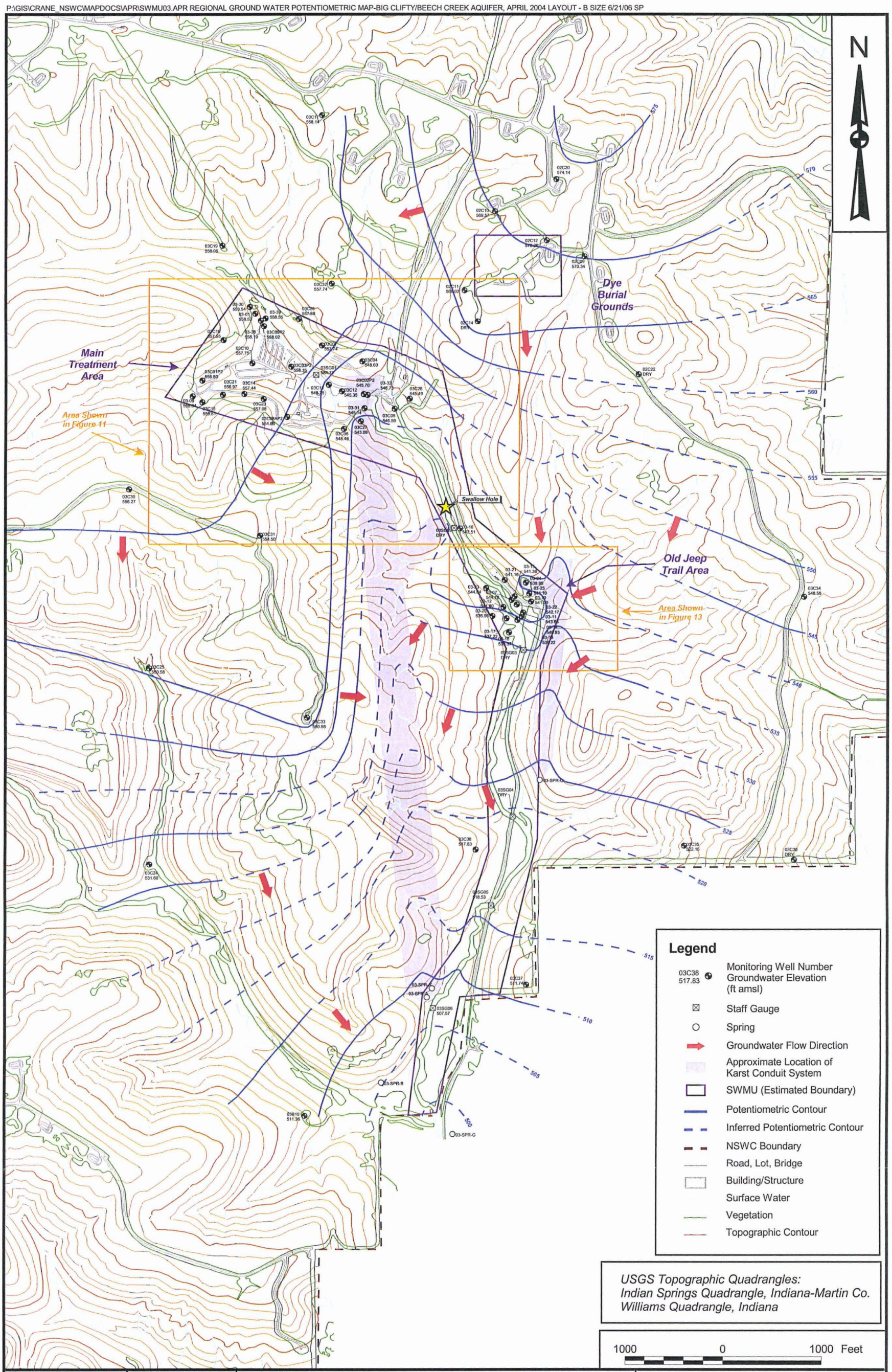
DRAWN BY A. JANOCHA DATE 8/11/04

CHECKED BY J. LUCAS DATE 9/16/04

COST/SCHED-AREA

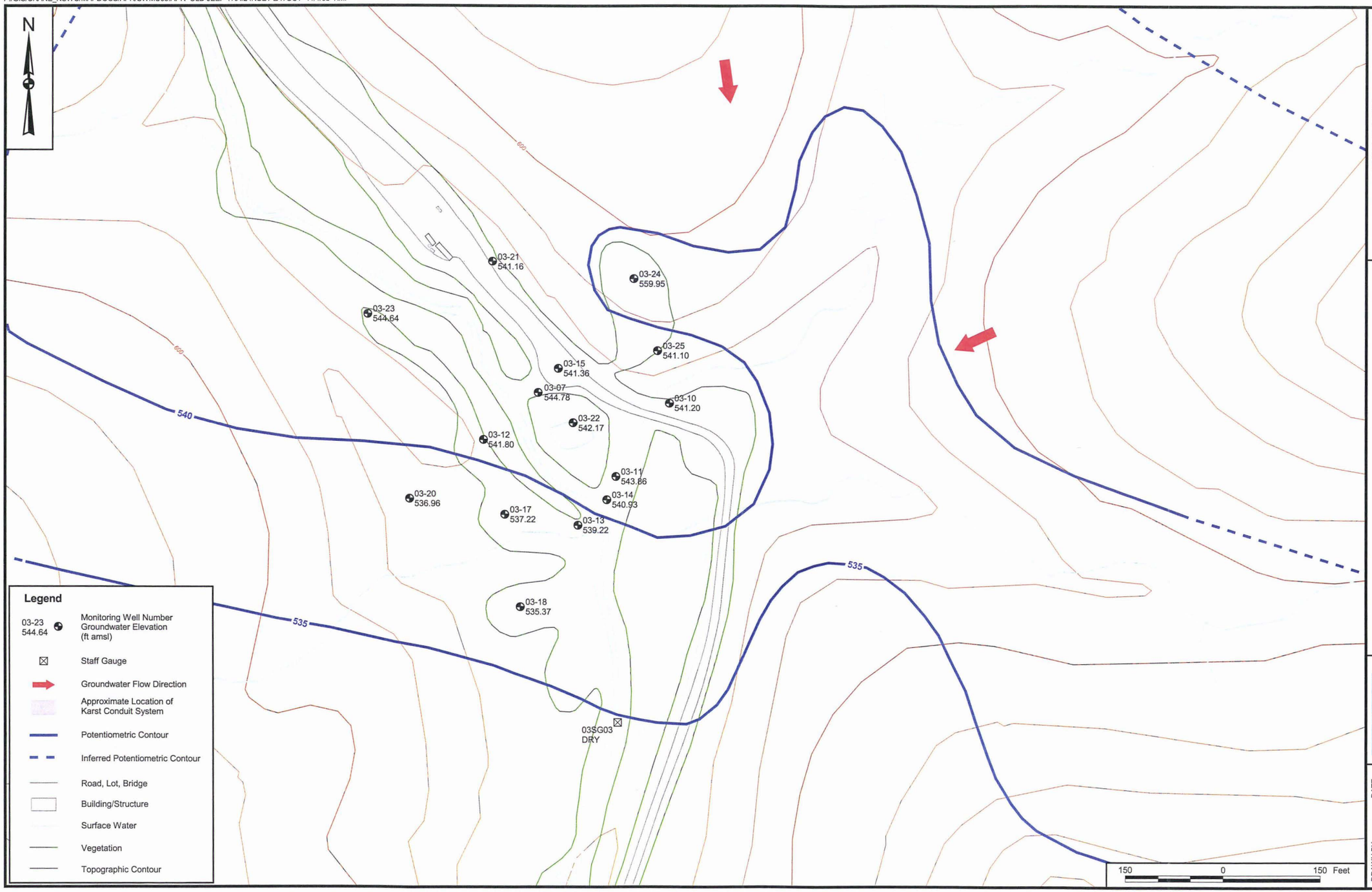
SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03.APR REGIONAL GROUND WATER POTENTIOMETRIC MAP-BIG CLIFTY/BEECH CREEK AQUIFER, APRIL 2004 LAYOUT - B SIZE 6/21/06 SP



DRAWN BY S. PAXTON	DATE 6/21/06	REGIONAL GROUNDWATER POTENTIOMETRIC MAP FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004 CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY V. PLACHY	DATE 6/21/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 12 REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR OLD JEEP TRAIL INSET LAYOUT 11/1/05 KMP



CONTRACT NO.
CTO 0311

APPROVED BY — DATE

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REV 0

GROUNDWATER POTENTIOMETRIC MAP
FOR THE BIG CLIFTY - BEECH CREEK AQUIFER, APRIL 2004
OLD JEEP TRAIL INSET
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

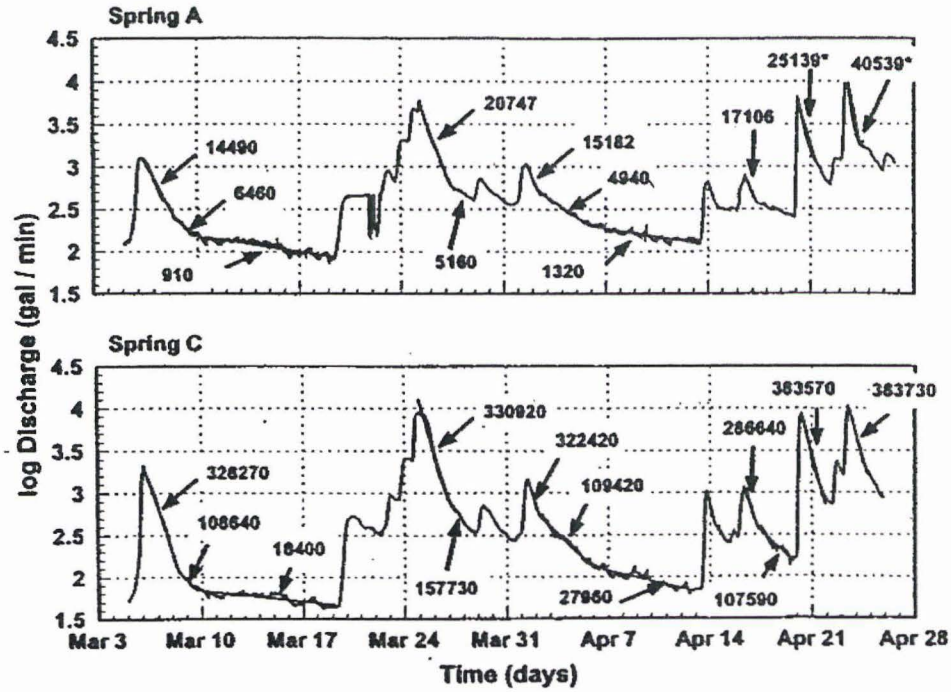
NAVFAC

DRAWN BY A. JANOCHA — DATE 8/11/04

CHECKED BY J. LUCAS — DATE 9/16/04

COST/SCHED-AREA

SCALE AS NOTED



Two-month hydrographs for Springs A and C (thin lines) during March – April 1996. Heavy lines show the conduit-, mixed-, and diffuse-flow systems. Numbers correspond to the ratio of T/Sy calculated from the corresponding segment of the hydrograph. An * next to the values of T/Sy indicates that discharges exceeded the calibrated range of the weir and pressure transducers for the rain event

SOURCE: JOCK AND KROTHE, 2002

DRAWN BY A. JANOCHA DATE 7/21/02		FLOW HYDROGRAPHS FOR SPRINGS A AND C, MARCH-APRIL 1996	CONTRACT NUMBER CTO 0311
CHECKED BY J. SCHUBERT DATE 7/21/02		CONCEPTUAL SITE MODEL REPORT FOR	APPROVED BY — DATE —
COST/SCHEDULE-AREA		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC	NSWC CRANE CRANE, INDIANA	DRAWING NO. FIGURE 14 REV 0

P:\GIS\NSWC_CRANE\APR\JEEPTRAIL_WORKPLAN.APR FLOW HYDROGRAPHS FOR SPRINGS A AND C, MARCH-APRIL 1996 LAYOUT 11/1/05 KMP

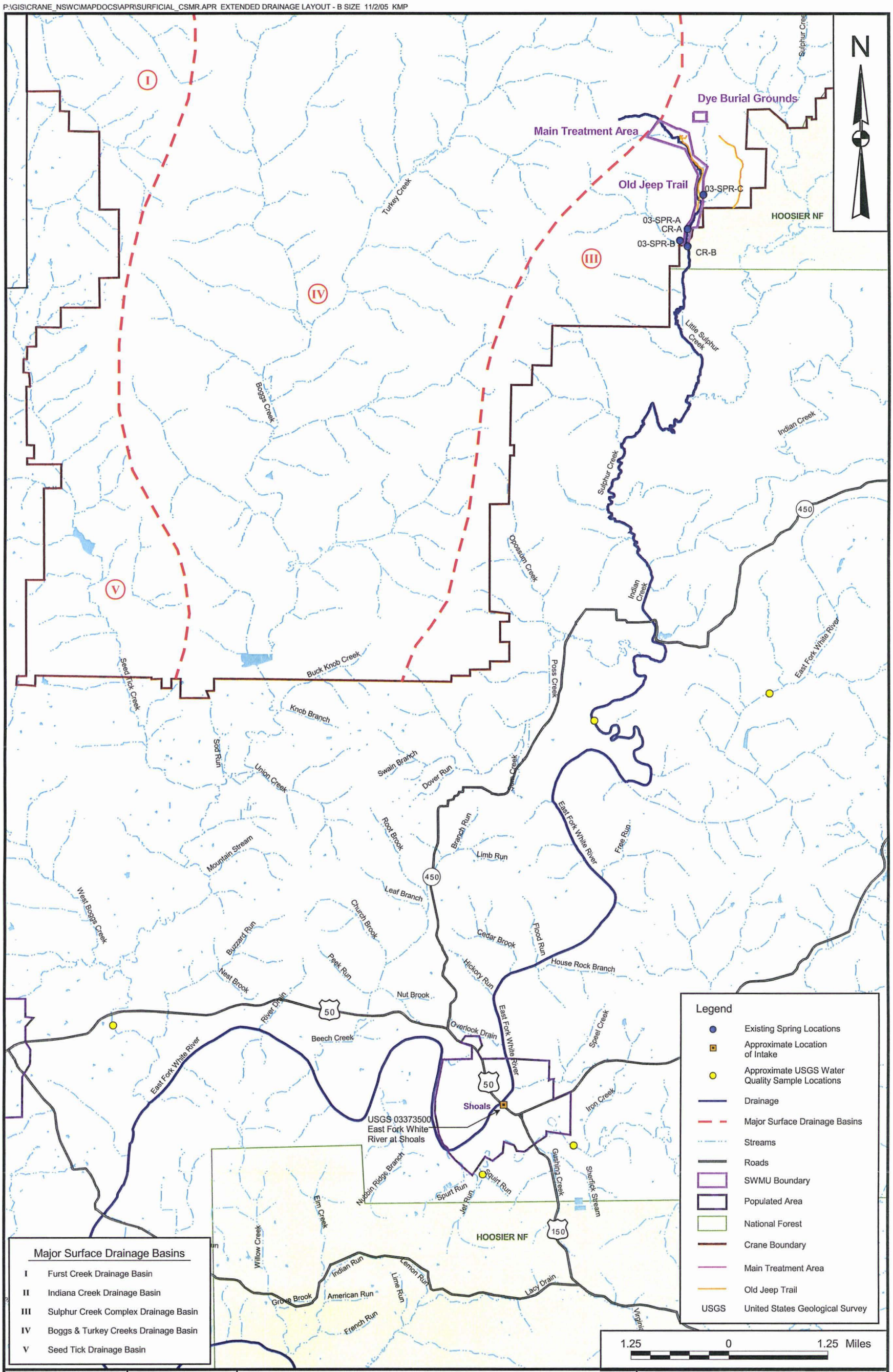
SOURCE: "Initial Assessment of Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY J. LAMEY	DATE 6/1/00	LOCATION OF AMMUNITION BURNING GROUNDS, OLD JEEP TRAIL, LITTLE SULPHUR CREEK, AND MAJOR DRAINAGE BASINS CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY J. SCHUBERT	DATE 8/22/02		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 15 / REV 0

NAVFAC

P:\GIS\NSWC_CRANE\7651.APR AOC LOCATIONS AND DRAINAGE BASINS 11/1/05 KMP

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SURFICIAL_CSMR.APR EXTENDED DRAINAGE LAYOUT - B SIZE 11/2/05 KMP



Major Surface Drainage Basins

I	Furst Creek Drainage Basin
II	Indiana Creek Drainage Basin
III	Sulphur Creek Complex Drainage Basin
IV	Boggs & Turkey Creeks Drainage Basin
V	Seed Tick Drainage Basin

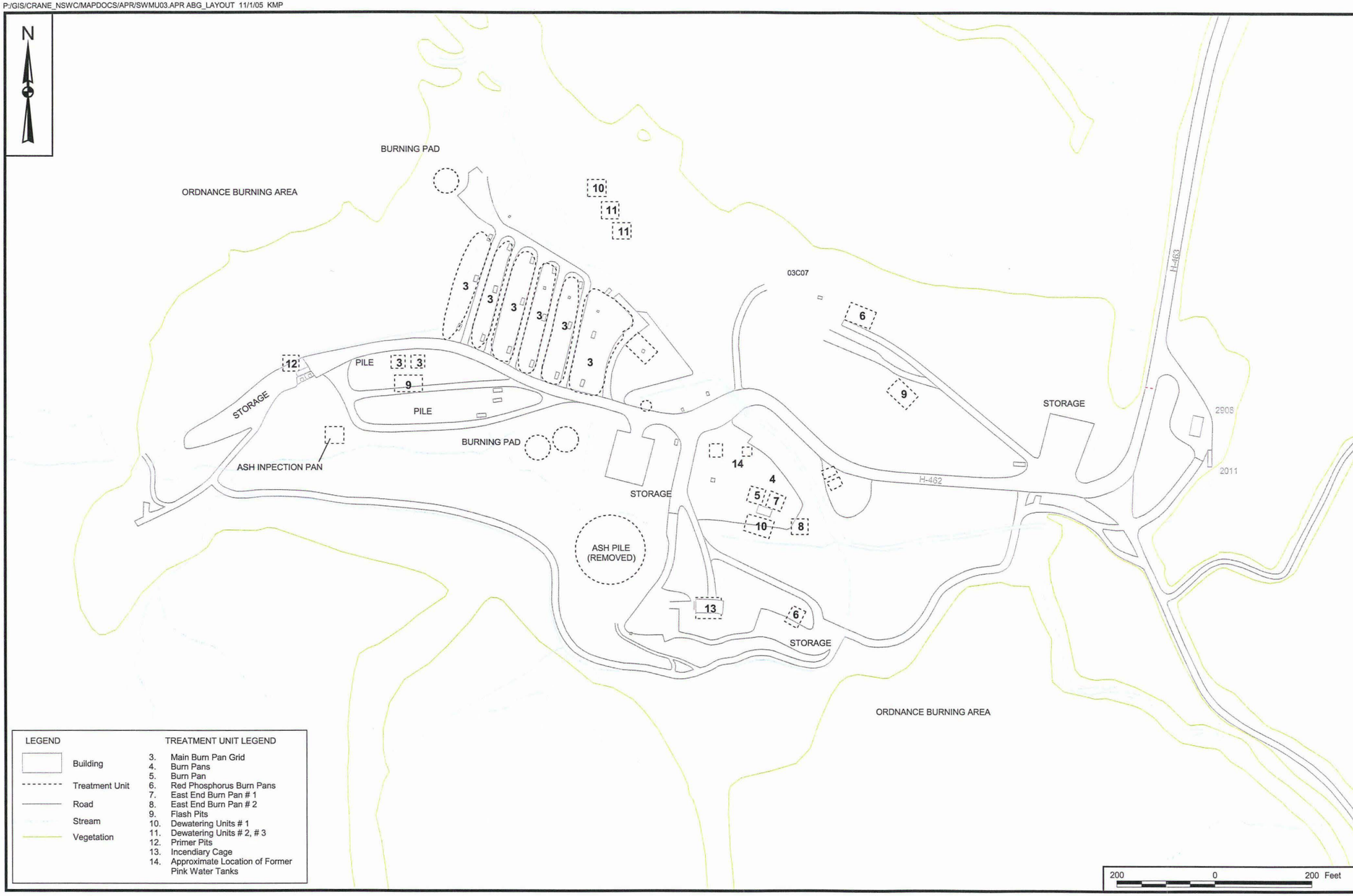
DRAWN BY	DATE
C. FOSTER	6/8/05
CHECKED BY	DATE
V. PLACHY	10/21/05
COST/SCHEDULE-AREA	
SCALE	AS NOTED

NAVFAC

SURFACE WATER FEATURES ASSOCIATED WITH LITTLE SULPHUR CREEK
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER CTO 0311	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 16	REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03.APR ABG_LAYOUT 11/1/05 KMP



LEGEND

- Building
- Treatment Unit
- Road
- Stream
- Vegetation

TREATMENT UNIT LEGEND

3. Main Burn Pan Grid
4. Burn Pans
5. Burn Pan
6. Red Phosphorus Burn Pans
7. East End Burn Pan # 1
8. East End Burn Pan # 2
9. Flash Pits
10. Dewatering Units # 1
11. Dewatering Units # 2, # 3
12. Primer Pits
13. Incendiary Cage
14. Approximate Location of Former Pink Water Tanks

CONTRACT NO.
CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 17

REV 0

AMMUNITION BURNING GROUNDS MAIN TREATMENT AREA
CONCEPTUAL SITE MODEL REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

NAVFAC

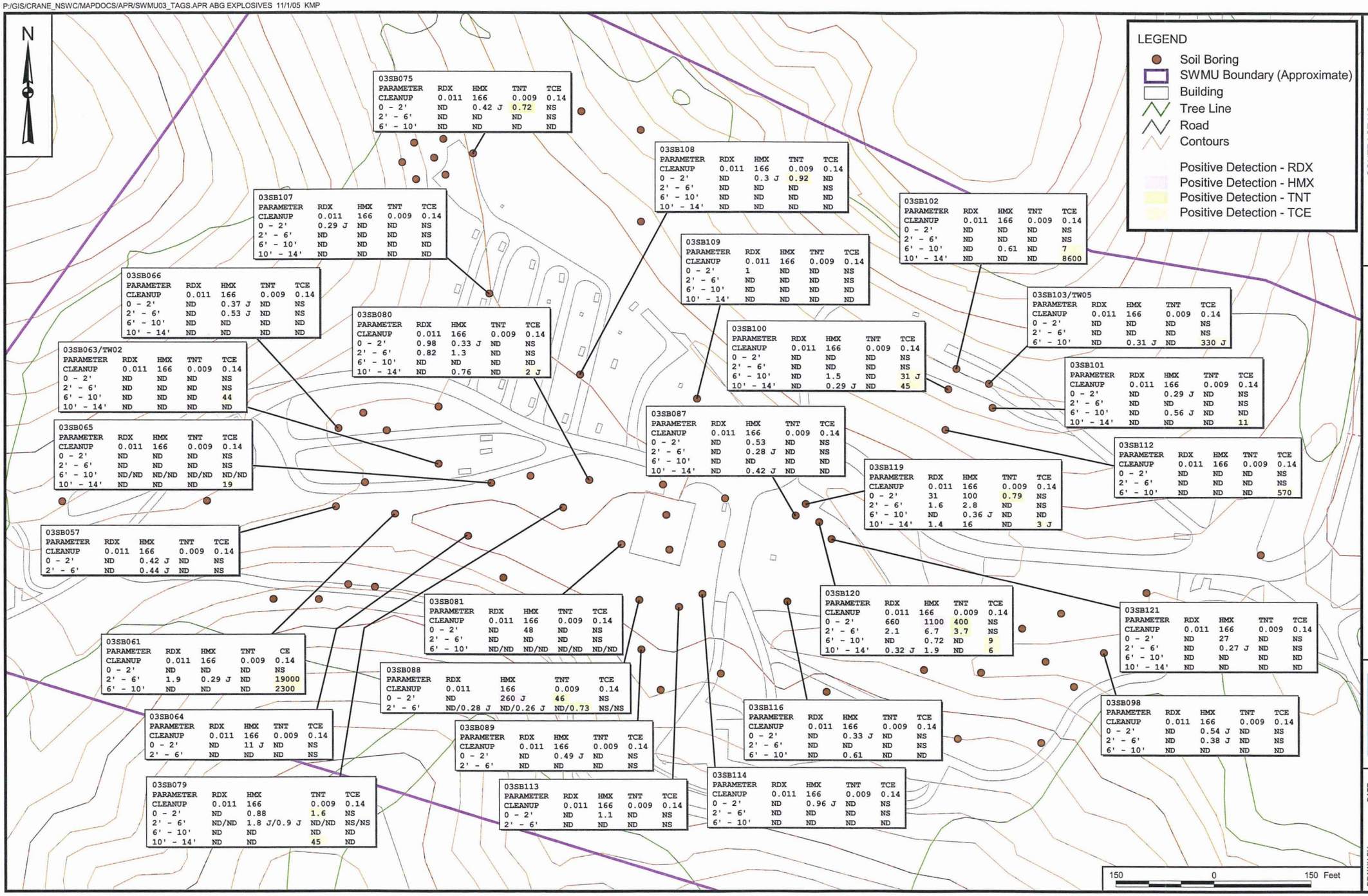
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY J. LUCAS DATE 9/15/04

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03_TAGS.APR ABG EXPLOSIVES 11/1/05 KMP



CONTRACT NO. CTO 0311

APPROVED BY DATE

APPROVED BY DATE

DRAWING NO. FIGURE 18

REV 0

PRIMARY ORGANIC CONTAMINANTS IN SURFACE AND SUBSURFACE SOILS (MG/KG)
CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS (MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

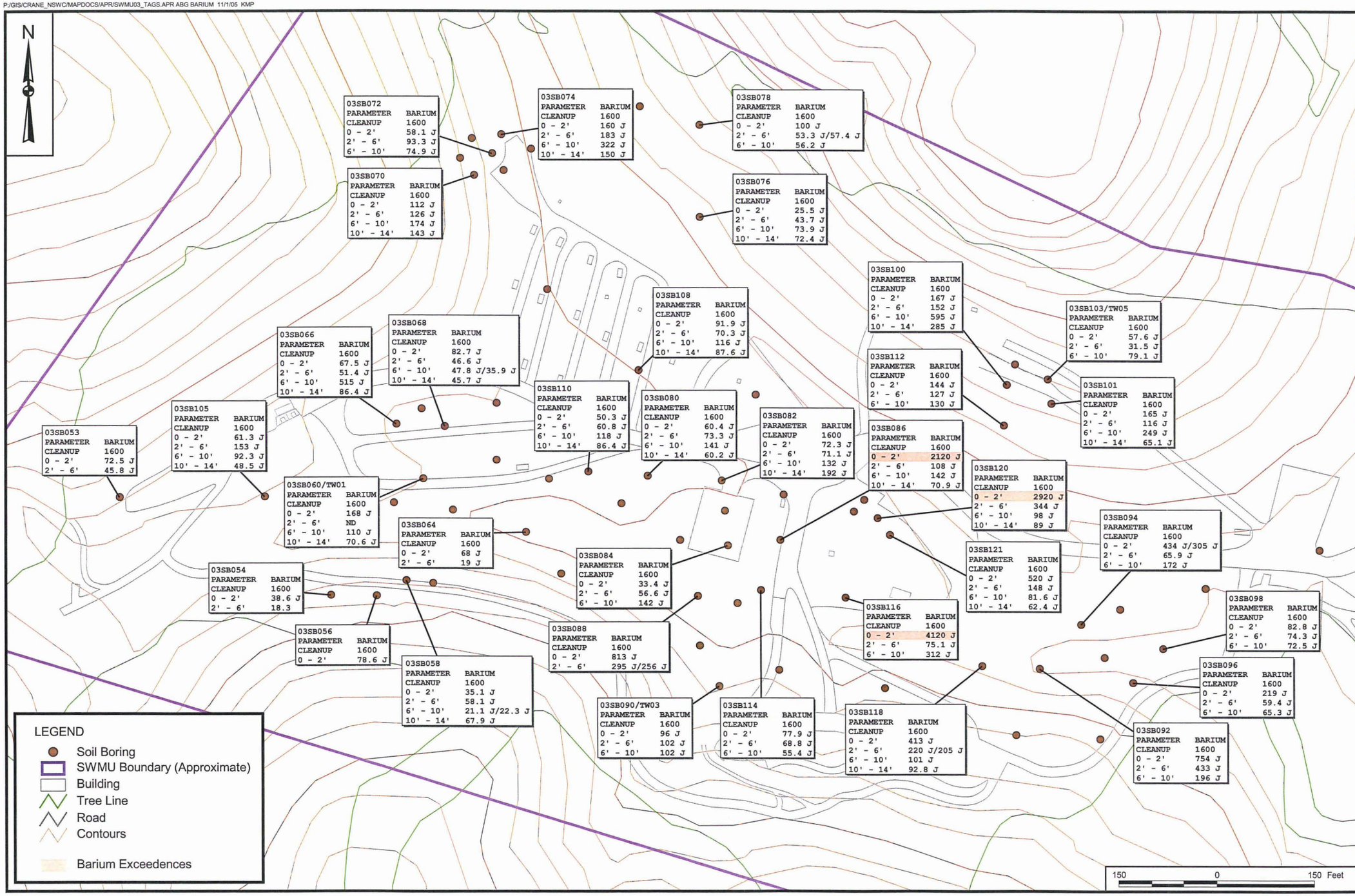
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY L. SINAGOGA DATE 9/15/05

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU03_TAGS.APR ABG BARIUM 11/1/05 KMP



CONTRACT NO.
CTO 0311

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 19

REV 0

BARIUM CONCENTRATIONS IN SURFACE AND SUBSURFACE SOILS (MG/KG)
CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS (MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

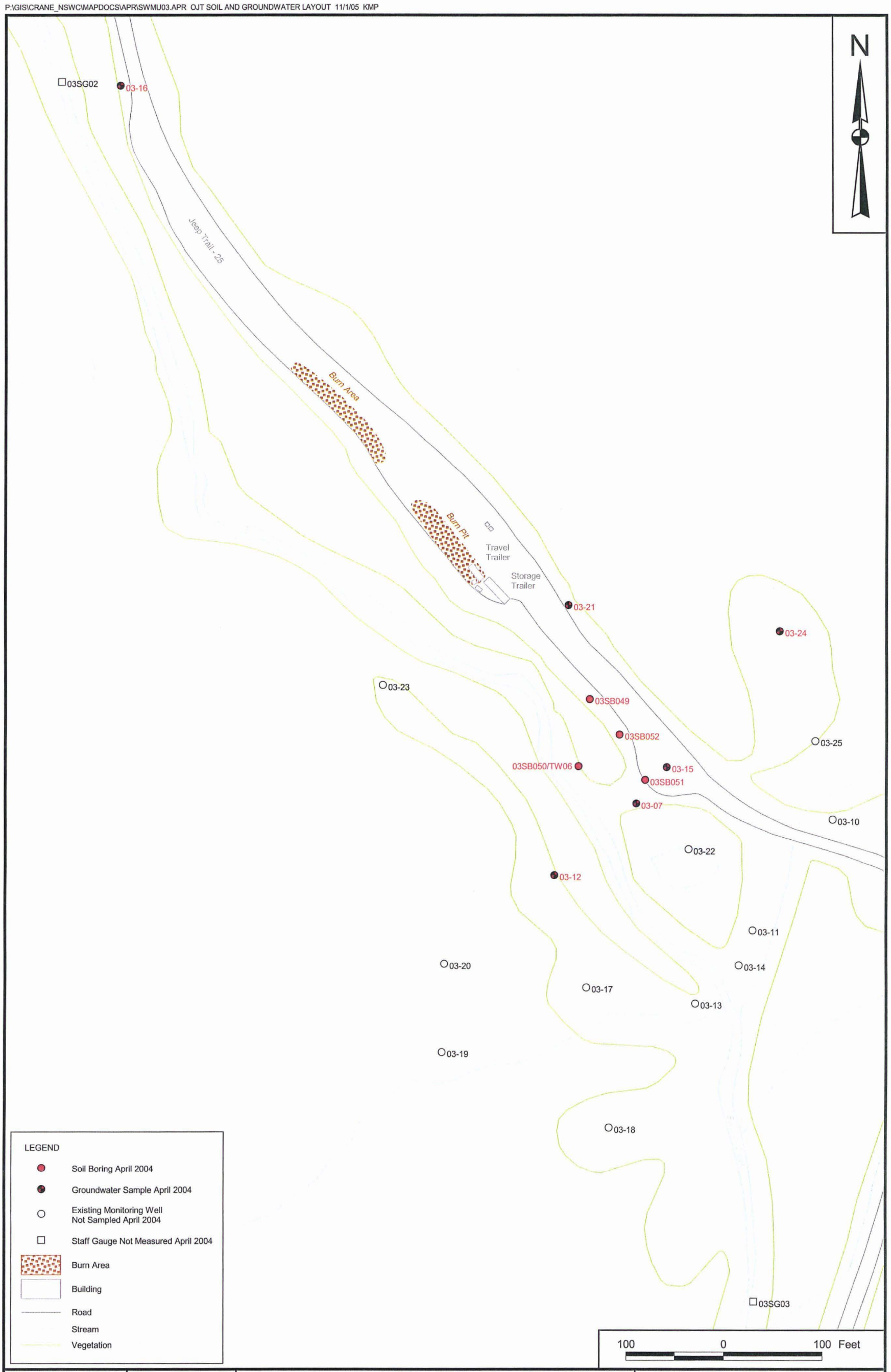
DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY L. SINAGOGA DATE 9/15/05

COST/SCHED-AREA

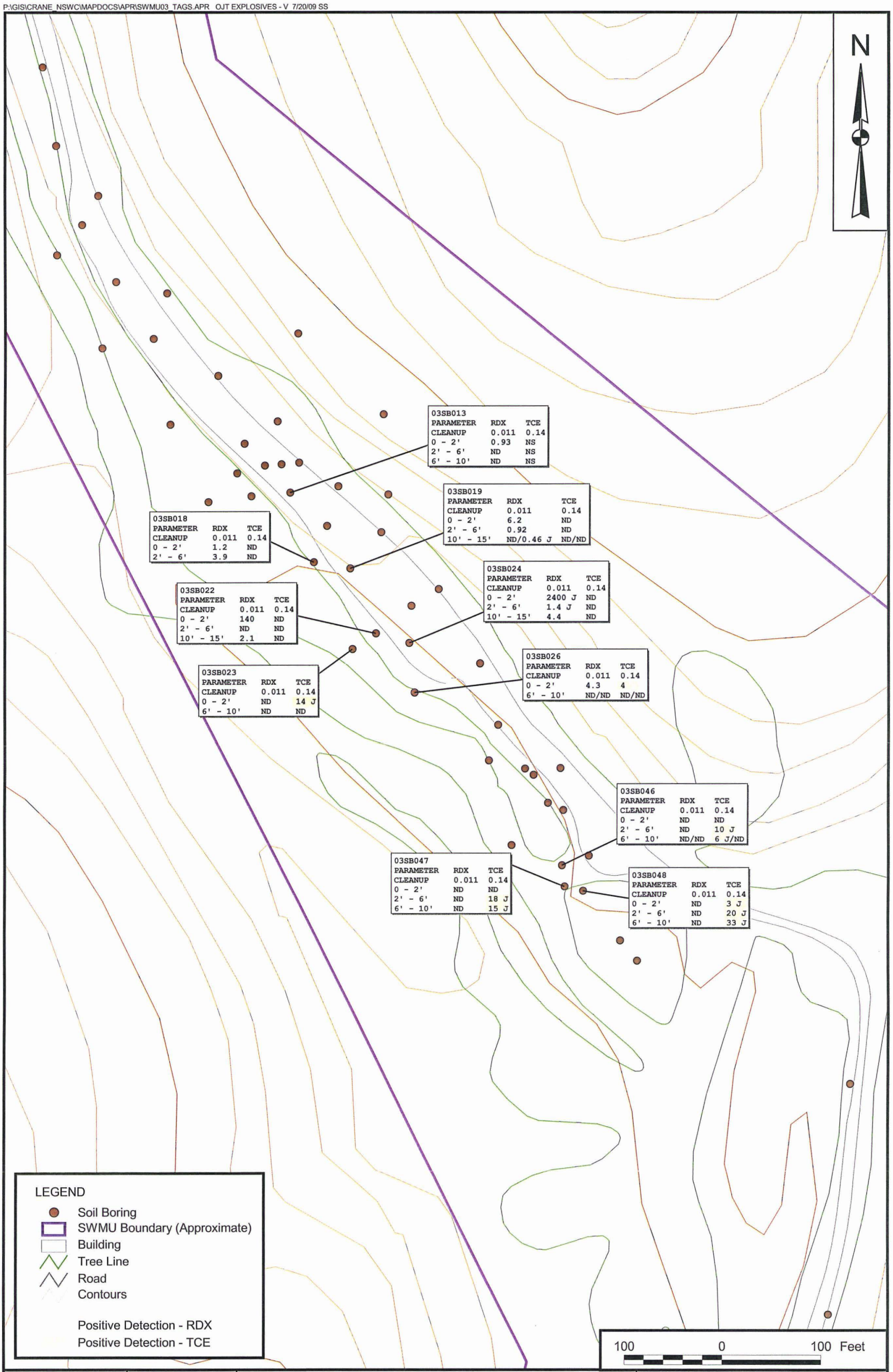
SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03.APR OJT SOIL AND GROUNDWATER LAYOUT 11/1/05 KMP



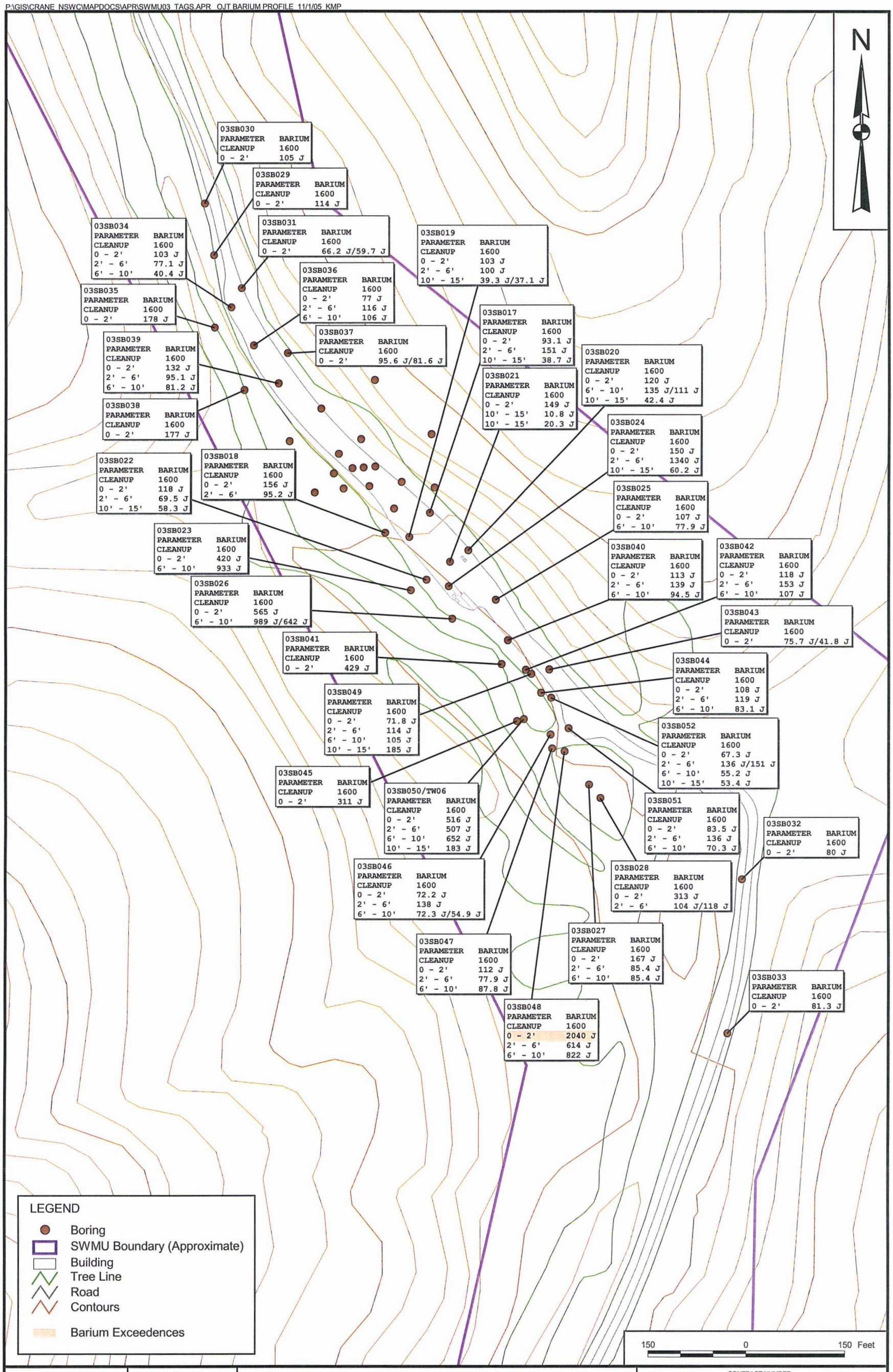
DRAWN BY A. JANOCHA	DATE 9/15/04	SOIL AND GROUNDWATER SAMPLING LOCATIONS APRIL 2004 OLD JEEP TRAIL AREA CONCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY J. LUCAS	DATE 9/15/04		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 20 REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03_TAGS.APR OJT EXPLOSIVES - V 7/20/09 SS



DRAWN BY C. FOSTER	DATE 11/22/04	OLD JEEP TRAIL EXPLOSIVES AND TCE	CONTRACT NUMBER CTO 0311
CHECKED BY C. RUMER	DATE 7/20/09	CONCEPTUAL SITE MODEL REPORT FOR	APPROVED BY — DATE —
COST/SCHEDULE-AREA		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC	NSWC CRANE CRANE, INDIANA	DRAWING NO. FIGURE 21 REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU03_TAGS.APR OJT BARIUM PROFILE 11/1/05 KMP



DRAWN BY C. FOSTER	DATE 11/08/04	OLD JEEP TRAIL BARIUM COINCEPTUAL SITE MODEL REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0311
CHECKED BY R. BASINSKI	DATE 01/28/05		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 22 REV 0

APPENDIX H

ALTERNATIVE COST ESTIMATES

APPENDIX H-1

COST ESTIMATE

ALTERNATIVE MTA-S2-METALS: LAND USE CONTROLS

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S2-Metals: Land Use Controls
Capital Cost

6/16/2011 9:00 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
Subtotal							$0	$0	$7,600	$0	$7,600
Overhead on Labor Cost @ 30%									$2,280		$2,280
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$0	$0	$760	$0	$760
Tax on Materials and Equipment Cost @ 7.0%								$0		$0	$0
Total Direct Cost							$0	$0	$10,640	$0	$10,640
Indirects on Total Direct Cost @ 0%											$0
Profit on Total Direct Cost @ 10%											$1,064
Subtotal											$11,704
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$11,704
Engineering on Total Field Cost @ 0%											$0
Contingency on Total Field Cost @ 25%											$2,926
TOTAL CAPITAL COST											**$14,630**

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S2-Metals: Land Use Controls
Annual Cost

6/16/2011 9:00 AM

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Ammunition Burning Grounds
Crane, Indiana
Alternative MTA-S2-Metals: Land Use Controls
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$14,630		$14,630	1.000	$14,630
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$77,301**

APPENDIX H-2

COST ESTIMATE
ALTERNATIVE OJT-S2: LAND USE CONTROLS

NSWC CRANE
Crane, Indiana
SWMU 3 Old Jeep Trail CMP
Alternative OJT-S2: Land Use Controls
Capital Cost

6/16/2011 9:00 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
Subtotal							$0	$0	$7,600	$0	$7,600
Overhead on Labor Cost @ 30%									$2,280		$2,280
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$0	$0	$760	$0	$760
Tax on Materials and Equipment Cost @ 7.0%								$0		$0	$0
Total Direct Cost							$0	$0	$10,640	$0	$10,640
Indirects on Total Direct Cost @ 0%											$0
Profit on Total Direct Cost @ 10%											$1,064
Subtotal											$11,704
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$11,704
Engineering on Total Field Cost @ 0%											$0
Contingency on Total Field Cost @ 25%											$2,926
TOTAL CAPITAL COST											**$14,630**

NSWC CRANE
Crane, Indiana
SWMU 3 Old Jeep Trail CMP
Alternative OJT-S2: Land Use Controls
Annual Cost

6/16/2011 9:00 AM

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Old Jeep Trail CMP
Crane, Indiana
Alternative OJT-S2: Land Use Controls
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$14,630		$14,630	1.000	$14,630
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$77,301**

APPENDIX H-2A

COST ESTIMATE

ALTERNATIVE OJT-S3: EXCAVATION AND OFF-SITE DISPOSAL

NSWC CRANE
Crane, Indiana
SWMU 3 Old Jeep Trail CMP
Alternative OJT-S3: Excavation, Off-Site Disposal, and LUCs
Capital Cost

6/16/2011 9:01 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare Documents & Plans including Permits	160	hr			$38.00		$0	$0	$6,080	$0	$6,080
2 MOBILIZATION AND DEMOBILIZATION											
2.1 Site Support Facilities (trailers, phone, electric, etc.)	1	ls		$1,000.00		$3,500.00	$0	$1,000	$0	$3,500	$4,500
2.2 Equipment Mobilization/Demobilization	4	ea			$183.00	$518.00	$0	$0	$732	$2,072	$2,804
3 FIELD SUPPORT											
3.1 Office Trailer	1	mo				$360.00	$0	$0	$0	$360	$360
3.2 Field Office Equipment, Utilities, & Support	1	mo		$519.00			$0	$519	$0	$0	$519
3.3 Storage Trailer	1	mo				$94.00	$0	$0	$0	$94	$94
3.4 Layout Survey	2	day	$1,800.00				$3,600	$0	$0	$0	$3,600
3.5 Site Superintendent	30	day		$123.00	$384.64		$0	$3,690	$11,539	$0	$15,229
3.6 Site Health & Safety and QA/QC	30	day		$123.00	$307.68		$0	$3,690	$9,230	$0	$12,920
3.7 UXO Technician	10	day		$123.00	$295.80		$0	$1,230	$2,958	$0	$4,188
4 DECONTAMINATION											
4.1 Decontamination Services	1	mo		$1,220.00	$2,245.00	$1,550.00	$0	$1,220	$2,245	$1,550	$5,015
4.2 Equipment Decon Pad	1	ls		$7,000.00	$6,500.00	$1,200.00	$0	$7,000	$6,500	$1,200	$14,700
4.3 Decon Water	1,000	gal		$0.20			$0	$200	$0	$0	$200
4.4 Decon Water Storage Tank, 6,000 gallon	1	mo				$782.00	$0	$0	$0	$782	$782
4.5 Clean Water Storage Tank, 4,000 gallon	1	mo				$703.00	$0	$0	$0	$703	$703
4.6 Disposal of Decon Waste (liquid & solid)	1	mo	$985.00				$985	$0	$0	$0	$985
5 SITE PREPARATION											
5.1 Brush Chipper	5	day				$288.60	$0	$0	$0	$1,443	$1,443
5.2 Stump Chipper	5	day				$169.35	$0	$0	$0	$847	$847
5.3 Site Labor, (3 laborers)	15	day			$274.80		$0	$0	$4,122	$0	$4,122
6 EXCAVATION AND DISPOSAL											
6.1 Excavator	3	day			$362.80	$947.40	$0	$0	$1,088	$2,842	$3,931
6.2 Site Labor, (3 laborers)	9	day			$274.80		$0	$0	$2,473	$0	$2,473
6.3 Waste Disposal Characterization / Analytical	4	ea	$1,100.00	$30.00	$50.00	$30.00	$4,400	$120	$200	$120	$4,840
6.4 On-Site Soil Treatment (Maectite)	1,134	cy	$50.00				$56,700	$0	$0	$0	$56,700
6.5 Transportation and Disposal, subtitle D	1,684	ton	$64.00				$107,776	$0	$0	$0	$107,776
6.6 Verification Sampling, TCE	15	ea	$110.00	$30.00	$50.00	$30.00	$1,650	$450	$750	$450	$3,300
7 RESTORATION											
7.1 Dozer	5	day			$362.80	$778.80	$0	$0	$1,814	$3,894	$5,708
7.2 Compactor	5	day			$362.80	$596.80	$0	$0	$1,814	$2,984	$4,798
7.3 Site Labor, (3 laborers)	15	day			$274.80		$0	$0	$4,122	$0	$4,122
7.4 Common Fill	949	cy		$13.14			$0	$12,470	$0	$0	$12,470
7.5 Topsoil	185	cy		$33.00			$0	$6,105	$0	$0	$6,105
7.6 Seed, Mulch, & Fertilize	10	msf	$117.00				$1,170	$0	$0	$0	$1,170
7.7 Road Fabric	535	sy		$0.14			$0	$75	$0	$0	$75
7.8 Road Gravel, 12"	535	sy		$15.30	$0.68	$1.06	$0	$8,186	$364	$567	$9,116
8 POST CONSTRUCTION DOCUMENTS											
8.1 Completion Report	50	hr			$38.00		$0	$0	$1,900	$0	$1,900
Subtotal							$176,281	$45,954	$57,932	$23,408	$303,575
Overhead on Labor Cost @ 30%									$17,380		$17,380
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$17,628	$4,595	$5,793	$2,341	$30,358
Tax on Materials and Equipment Cost @ 7.0%								$3,217		$1,639	$4,855
Total Direct Cost							$193,909	$53,766	$81,105	$27,387	$356,168

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Indirects on Total Direct Cost @ 15%	(excluding transportation and disposal cost)										$37,111
Profit on Total Direct Cost @ 10%											$35,617
Subtotal											$428,896
Health & Safety Monitoring @ 1%											$4,289
Total Field Cost											$433,185
Engineering on Total Field Cost @ 10%											$43,318
Contingency on Total Field Cost @ 20%											$86,637
TOTAL CAPITAL COST											**$563,140**

NSWC CRANE
Crane, Indiana
SWMU 3 Old Jeep Trail CMP
Alternative OJT-S3: Excavation, Off-Site Disposal, and LUCs
Annual Cost

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Old Jeep Trail CMP
Crane, Indiana
Alternative OJT-S3: Excavation, Off-Site Disposal, and LUCs
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$563,140		$563,140	1.000	$563,140
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$625,811**

APPENDIX H-3

COST ESTIMATE
ALTERNATIVE MTA-GW2: LAND USE CONTROLS AND LONG TERM MONITORING

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative MTA-GW2: Limited Action - Land Use Controls and Long Term Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NAVAL SURFACE WARFARE CENTER CRANI
Crane, Indiana
SWMU 3
Alternative MTA-GW2: Limited Action - Land Use Controls and Long Term Monitorir
Operation and Maintenance Cos

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of Installation Cost; replacement signs, etc
3	Sampling labor, travel & living, supplie	2	ea	$670	$1,340	1 person/2day per weel
4	Analysis of groundwate	8	ea	$292	$2,336	TNT and degradatior
2	Annual Repor	1	ea	$1,000	$1,000	
				O & M per year	**$4,807**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative MTA-GW2: Limited Action - Land Use Controls and Long Term Monitorin
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Sampling	$4,660	$2,330	$1,165		Assume 1 people for 2 days at $65/hr each, field supplies $125, Annual for all years.
Analysis/Water	$1,577	$3,154	$1,134		Analyze samples from two aquifier at four (8) existing wells plus one (1) QA sample for metals for each sampling event. Annual sampling
Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per repo
Site Inspectior	$1,000	$1,000	$1,000		To verify continued implementation of the LU
Site Review				$15,000	Site review every 5 years for 30 years
TOTALS	**$8,237**	**$8,484**	**$4,299**	**$15,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative MTA-GW2: Limited Action - Land Use Controls and Long Term Monitoring
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$2,618			$2,618	1.000	$2,618
1		$4,807	$8,237	$13,044	0.935	$12,196
2		$4,807	$8,484	$13,290	0.873	$11,603
3		$4,807	$8,484	$13,290	0.816	$10,845
4		$4,807	$4,299	$9,106	0.763	$6,948
5		$4,807	$19,299	$24,106	0.713	$17,187
6		$4,807	$4,299	$9,106	0.666	$6,065
7		$4,807	$4,299	$9,106	0.623	$5,673
8		$4,807	$4,299	$9,106	0.582	$5,300
9		$4,807	$4,299	$9,106	0.544	$4,954
10		$4,807	$19,299	$24,106	0.508	$12,246
11		$4,807	$4,299	$9,106	0.475	$4,325
12		$4,807	$4,299	$9,106	0.444	$4,043
13		$4,807	$4,299	$9,106	0.415	$3,779
14		$4,807	$4,299	$9,106	0.388	$3,533
15		$4,807	$19,299	$24,106	0.362	$8,726
16		$4,807	$4,299	$9,106	0.339	$3,087
17		$4,807	$4,299	$9,106	0.317	$2,887
18		$4,807	$4,299	$9,106	0.296	$2,695
19		$4,807	$4,299	$9,106	0.277	$2,522
20		$4,807	$19,299	$24,106	0.258	$6,219
21		$4,807	$4,299	$9,106	0.242	$2,204
22		$4,807	$4,299	$9,106	0.226	$2,058
23		$4,807	$4,299	$9,106	0.211	$1,921
24		$4,807	$4,299	$9,106	0.197	$1,794
25		$4,807	$19,299	$24,106	0.184	$4,435
26		$4,807	$4,299	$9,106	0.172	$1,566
27		$4,807	$4,299	$9,106	0.161	$1,466
28		$4,807	$4,299	$9,106	0.150	$1,366
29		$4,807	$4,299	$9,106	0.141	$1,284
30		$4,807	$19,299	$24,106	0.131	$3,158
					TOTAL PRESENT WORTH	**$158,702**

APPENDIX H-4

COST ESTIMATE
ALTERNATIVE OJT-GW2: LAND USE CONTROLS AND LONG TERM MONITORING

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative OJT-GW2: Limited Action - Land Use Controls and Long Term Monitoring
Capital Cost

Item	Quantity	Unit	Subcontract	Unit Cost Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NAVAL SURFACE WARFARE CENTER CRANI
Crane, Indiana
SWMU 3
Alternative OJT-GW2: Limited Action - Land Use Controls and Long Term Monitorir
Operation and Maintenance Cos

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of Installation Cost; replacement signs, etc
3	Sampling labor, travel & living, supplie	2	ea	$670	$1,340	1 person/2day per weel
4	Analysis of groundwate	6	ea	$481	$2,886	RDX, TNT, their degradation, and VOC:
2	Annual Repor	1	ea	$1,000	$1,000	
				O & M per year	**$5,357**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative OJT-GW2: Limited Action - Land Use Controls and Long Term Monitorin
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Sampling	$4,660	$2,330	$1,165		Assume 1 people for 2 days at $65/hr each, field supplies $125, Annual for all years.
Analysis/Water	$1,577	$3,154	$1,134		Analyze samples from two aquifier at four (8) existing wells plus one (1) QA sample for metals for each sampling event. Annual sampling
Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per repo
Site Inspectior	$1,000	$1,000	$1,000		To verify continued implementation of the LU
Site Review				$15,000	Site review every 5 years for 30 years
TOTALS	**$8,237**	**$8,484**	**$4,299**	**$15,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative OJT-GW2: Limited Action - Land Use Controls and Long Term Monitoring
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$2,618			$2,618	1.000	$2,618
1		$5,357	$8,237	$13,594	0.935	$12,710
2		$5,357	$8,484	$13,840	0.873	$12,083
3		$5,357	$8,484	$13,840	0.816	$11,294
4		$5,357	$4,299	$9,656	0.763	$7,367
5		$5,357	$19,299	$24,656	0.713	$17,580
6		$5,357	$4,299	$9,656	0.666	$6,431
7		$5,357	$4,299	$9,656	0.623	$6,016
8		$5,357	$4,299	$9,656	0.582	$5,620
9		$5,357	$4,299	$9,656	0.544	$5,253
10		$5,357	$19,299	$24,656	0.508	$12,525
11		$5,357	$4,299	$9,656	0.475	$4,587
12		$5,357	$4,299	$9,656	0.444	$4,287
13		$5,357	$4,299	$9,656	0.415	$4,007
14		$5,357	$4,299	$9,656	0.388	$3,746
15		$5,357	$19,299	$24,656	0.362	$8,925
16		$5,357	$4,299	$9,656	0.339	$3,273
17		$5,357	$4,299	$9,656	0.317	$3,061
18		$5,357	$4,299	$9,656	0.296	$2,858
19		$5,357	$4,299	$9,656	0.277	$2,675
20		$5,357	$19,299	$24,656	0.258	$6,361
21		$5,357	$4,299	$9,656	0.242	$2,337
22		$5,357	$4,299	$9,656	0.226	$2,182
23		$5,357	$4,299	$9,656	0.211	$2,037
24		$5,357	$4,299	$9,656	0.197	$1,902
25		$5,357	$19,299	$24,656	0.184	$4,537
26		$5,357	$4,299	$9,656	0.172	$1,661
27		$5,357	$4,299	$9,656	0.161	$1,555
28		$5,357	$4,299	$9,656	0.150	$1,448
29		$5,357	$4,299	$9,656	0.141	$1,361
30		$5,357	$19,299	$24,656	0.131	$3,230
					TOTAL PRESENT WORTH	**$165,527**

APPENDIX H-5

COST ESTIMATE

ALTERNATIVE LSC-SW2: LONG TERM MONITORING AND EVALUATION OF PUBLIC WATER SUPPLIES UPSTREAM OF SHOALS, INDIANA WATER INTAKE

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative LSC-SW2: Limited Action - Long Term Monitoring
Capital Cost

Item	Quantity	Unit	Subcontract	Unit Cost Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NAVAL SURFACE WARFARE CENTER CRANI
Crane, Indiana
SWMU 3
Alternative LSC-SW2: Limited Action - Long Term Monitorin
Operation and Maintenance Cos

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of Installation Cost; replacement signs, etc
3	Sampling labor, travel & living, supplie	16	ea	$80	$1,280	1 person
4	Analysis of groundwate	16	ea	$336	$5,376	RDX
2	Annual Repor	1	ea	$1,000	$1,000	review of LSC intakes upstream of Shoal intak
				O & M per year	**$7,787**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative LSC-SW2: Limited Action - Long Term Monitoring
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Sampling	$4,660	$2,330	$1,165		Assume 1 people for 2 days at $65/hr each, field supplies $125, Annual for all years.
Analysis/Water	$1,577	$3,154	$1,134		Analyze samples from two aquifier at four (8) existing wells plus one (1) QA sample for metals for each sampling event. Annual sampling
Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per repor
Site Inspectior	$1,000	$1,000	$1,000		To verify continued implementation of the LU(
Site Review				$15,000	Site review every 5 years for 30 years
TOTALS	**$8,237**	**$8,484**	**$4,299**	**$15,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 3
Alternative LSC-SW2: Limited Action - Long Term Monitoring
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$2,618			$2,618	1.000	$2,618
1		$7,787	$8,237	$16,024	0.935	$14,982
2		$7,787	$8,484	$16,270	0.873	$14,204
3		$7,787	$8,484	$16,270	0.816	$13,277
4		$7,787	$4,299	$12,086	0.763	$9,222
5		$7,787	$19,299	$27,086	0.713	$19,312
6		$7,787	$4,299	$12,086	0.666	$8,049
7		$7,787	$4,299	$12,086	0.623	$7,530
8		$7,787	$4,299	$12,086	0.582	$7,034
9		$7,787	$4,299	$12,086	0.544	$6,575
10		$7,787	$19,299	$27,086	0.508	$13,760
11		$7,787	$4,299	$12,086	0.475	$5,741
12		$7,787	$4,299	$12,086	0.444	$5,366
13		$7,787	$4,299	$12,086	0.415	$5,016
14		$7,787	$4,299	$12,086	0.388	$4,689
15		$7,787	$19,299	$27,086	0.362	$9,805
16		$7,787	$4,299	$12,086	0.339	$4,097
17		$7,787	$4,299	$12,086	0.317	$3,831
18		$7,787	$4,299	$12,086	0.296	$3,577
19		$7,787	$4,299	$12,086	0.277	$3,348
20		$7,787	$19,299	$27,086	0.258	$6,988
21		$7,787	$4,299	$12,086	0.242	$2,925
22		$7,787	$4,299	$12,086	0.226	$2,731
23		$7,787	$4,299	$12,086	0.211	$2,550
24		$7,787	$4,299	$12,086	0.197	$2,381
25		$7,787	$19,299	$27,086	0.184	$4,984
26		$7,787	$4,299	$12,086	0.172	$2,079
27		$7,787	$4,299	$12,086	0.161	$1,946
28		$7,787	$4,299	$12,086	0.150	$1,813
29		$7,787	$4,299	$12,086	0.141	$1,704
30		$7,787	$19,299	$27,086	0.131	$3,548
					TOTAL PRESENT WORTH	**$195,681**

APPENDIX H-6

COST ESTIMATE

ALTERNATIVE MTA-S3-METALS: EXCAVATION AND OFF-SITE DISPOSAL

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S3-Metals: Excavation, Off-Site Disposal and LUCs
Capital Cost

6/16/2011 9:01 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
1.2 Prepare Documents & Plans including Permits	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
2 MOBILIZATION AND DEMOBILIZATION											
2.1 Equipment Mobilization/Demobilization	2	ea			$183.00	$518.00	$0	$0	$366	$1,036	$1,402
3 FIELD SUPPORT											
3.1 Storage Trailer	1	mo				$94.00	$0	$0	$0	$94	$94
3.2 Construction Layout Survey	1	day	$1,800.00				$1,800	$0	$0	$0	$1,800
3.3 Site Superintendent, Site Health & Safety, and QA/QC	5	day		$123.00	$384.64		$0	$615	$1,923	$0	$2,538
3.4 Underground Utility Clearance	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
4 DECONTAMINATION											
4.1 Equipment Decon Pad & Services	1	ls		$1,220.00	$2,245.00	$1,550.00	$0	$1,220	$2,245	$1,550	$5,015
4.2 Disposal of Decon Waste (liquid & solid)	1	ls	$500.00				$500	$0	$0	$0	$500
5 EXCAVATION, DISPOSAL, AND RESTORATION											
5.1 Backhoe/Loader	5	day			$362.80	$349.40	$0	$0	$1,814	$1,747	$3,561
5.2 Site Labor, (2 laborers)	10	day			$274.80		$0	$0	$2,748	$0	$2,748
5.3 Waste Disposal Characterization / Analytical	2	ea	$850.00	$30.00	$50.00	$30.00	$1,700	$60	$100	$60	$1,920
5.4 On-Site Soil Treatment (Maectite)	59	cy		$50.00			$0	$2,950	$0	$0	$2,950
5.5 Transportation and Disposal, subtitle D	88	ton	$65.00				$5,720	$0	$0	$0	$5,720
5.6 Verification Sampling, Lead	10	ea	$50.00	$30.00	$50.00	$30.00	$500	$300	$500	$300	$1,600
5.7 Common Fill	49	cy		$13.14			$0	$644	$0	$0	$644
5.8 Topsoil	15	cy		$33.00			$0	$495	$0	$0	$495
5.9 Seed, Mulch, & Fertilize	2	msf	$117.00				$234	$0	$0	$0	$234
6 POST CONSTRUCTION DOCUMENTS											
6.1 Completion Report	100	hr			$38.00		$0	$0	$3,800	$0	$3,800
Subtotal							$17,954	$6,284	$28,696	$4,787	$57,721
Overhead on Labor Cost @ 30%									$8,609		$8,609
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$1,795	$628	$2,870	$479	$5,772
Tax on Materials and Equipment Cost @ 7.0%								$440		$335	$775
Total Direct Cost							$19,749	$7,352	$40,175	$5,601	$72,877
Indirects on Total Direct Cost @ 35%			(excluding transportation and disposal cost)								$23,330
Profit on Total Direct Cost @ 10%											$7,288
Subtotal											$103,495
Health & Safety Monitoring @ 2%											$2,070
Total Field Cost											$105,565
Engineering on Total Field Cost @ 20%											$21,113
Contingency on Total Field Cost @ 25%											$26,391
TOTAL CAPITAL COST											**$153,069**

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S3-Metals: Excavation, Off-Site Disposal and LUCs
Annual Cost

6/16/2011 9:01 AM

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Ammunition Burning Grounds
Crane, Indiana
Alternative MTA-S3-Metals: Excavation, Off-Site Disposal and LUCs
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$153,069		$153,069	1.000	$153,069
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$215,740**

APPENDIX H-7

COST ESTIMATE

ALTERNATIVE MTA-S2-VOCs: LAND USE CONTROLS

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S2-VOCs: Land Use Controls
Capital Cost

6/16/2011 9:01 AM

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
Subtotal							$0	$0	$7,600	$0	$7,600
Overhead on Labor Cost @ 30%									$2,280		$2,280
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$0	$0	$760	$0	$760
Tax on Materials and Equipment Cost @ 7.0%								$0		$0	$0
Total Direct Cost							$0	$0	$10,640	$0	$10,640
Indirects on Total Direct Cost @ 0%											$0
Profit on Total Direct Cost @ 10%											$1,064
Subtotal											$11,704
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$11,704
Engineering on Total Field Cost @ 0%											$0
Contingency on Total Field Cost @ 25%											$2,926
TOTAL CAPITAL COST											**$14,630**

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S2-VOCs: Land Use Controls
Annual Cost

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Ammunition Burning Grounds
Crane, Indiana
Alternative MTA-S2-VOCs: Land Use Controls
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$14,630		$14,630	1.000	$14,630
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$77,301**

APPENDIX H-7A

COST ESTIMATE

ALTERNATIVE MTA-S3-VOCs: EXCAVATION AND OFF-SITE DISPOSAL

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S3-VOCs: Excavation, Off-Site Disposal, and LUCs
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
1.2 Prepare Documents & Plans	300	hr			$38.00		$0	$0	$11,400	$0	$11,400
2 MOBILIZATION AND DEMOBILIZATION											
2.1 Site Support Facilities (trailers, phone, electric, etc.)	1	ls		$1,000.00		$3,500.00	$0	$1,000	$0	$3,500	$4,500
2.2 Equipment Mobilization/Demobilization	5	ea			$183.00	$518.00	$0	$0	$915	$2,590	$3,505
3 FIELD SUPPORT											
3.1 Office Trailer	3	mo				$360.00	$0	$0	$0	$1,080	$1,080
3.2 Field Office Equipment, Utilities, & Support	3	mo		$519.00			$0	$1,557	$0	$0	$1,557
3.3 Storage Trailer	3	mo				$94.00	$0	$0	$0	$282	$282
3.4 Utility Connection/Disconnection (phone/electric)	1	ls	$1,250.00				$1,250	$0	$0	$0	$1,250
3.5 Construction Layout Survey	3	day	$1,800.00				$5,400	$0	$0	$0	$5,400
3.6 Site Superintendent	55	day		$123.00	$384.64		$0	$6,765	$21,155	$0	$27,920
3.7 Site Health & Safety and QA/QC	55	day		$123.00	$307.68		$0	$6,765	$16,922	$0	$23,687
3.8 Underground Utility Clearance	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
4 DECONTAMINATION											
4.1 Decontamination Services	2	mo		$1,220.00	$2,245.00	$1,550.00	$0	$2,440	$4,490	$3,100	$10,030
4.2 Equipment Decon Pad	1	ls		$7,000.00	$6,500.00	$1,200.00	$0	$7,000	$6,500	$1,200	$14,700
4.3 Decon Water	2,000	gal		$0.20			$0	$400	$0	$0	$400
4.4 Decon Water Storage Tank, 6,000 gallon	2	mo				$780.00	$0	$0	$0	$1,560	$1,560
4.5 Clean Water Storage Tank, 4,000 gallon	2	mo				$702.00	$0	$0	$0	$1,404	$1,404
4.6 Disposal of Decon Waste (liquid & solid)	2	mo	$985.00				$1,970	$0	$0	$0	$1,970
5 EXCAVATION AND DISPOSAL											
5.1 Excavator	27	day			$362.80	$1,224.00	$0	$0	$9,796	$33,048	$42,844
5.2 Hydraulic Hammer	10	day				$352.20	$0	$0	$0	$3,522	$3,522
5.3 Dozer with ripper	15	day			$362.80	$2,105.00	$0	$0	$5,442	$31,575	$37,017
5.4 Site Labor, (3 laborers)	81	day			$274.80		$0	$0	$22,259	$0	$22,259
5.5 Waste Disposal Characterization / Analytical	5	ea	$850.00	$30.00	$50.00	$30.00	$4,250	$150	$250	$150	$4,800
5.6 Transportation and Disposal, subtitle D	7,216	ton	$65.00				$469,040	$0	$0	$0	$469,040
5.7 Verification Sampling, TCE	35	ea	$125.00	$30.00	$50.00	$30.00	$4,375	$1,050	$1,750	$1,050	$8,225
6 SITE RESTORATION											
6.1 Common Fill	4,859	cy		$13.14			$0	$63,847	$0	$0	$63,847
6.2 Topsoil	275	cy		$33.00			$0	$9,075	$0	$0	$9,075
6.3 Gravel Surface, 9" thick	0	sy		$11.15			$0	$0	$0	$0	$0
6.4 Seed, Mulch, & Fertilize	37	msf	$117.00				$4,329	$0	$0	$0	$4,329
6.5 Excavator	15	day			$362.80	$1,224.00	$0	$0	$5,442	$18,360	$23,802
6.6 Compactor	15	day			$362.80	$1,094.00	$0	$0	$5,442	$16,410	$21,852
6.7 Dozer, 200 hp	15	day			$362.80	$2,105.00	$0	$0	$5,442	$31,575	$37,017
6.8 Site Labor, (3 laborers)	45	day			$274.80		$0	$0	$12,366	$0	$12,366
7 POST CONSTRUCTION DOCUMENTS											
7.1 Completion Report	100	hr			$38.00		$0	$0	$3,800	$0	$3,800
Subtotal							$498,114	$100,049	$140,971	$150,406	$889,540
Overhead on Labor Cost @ 30%									$42,291		$42,291
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$49,811	$10,005	$14,097	$15,041	$88,954
Tax on Materials and Equipment Cost @ 7.0%								$7,003		$10,528	$17,532
Total Direct Cost							$547,925	$117,058	$197,359	$175,975	$1,038,317
Indirects on Total Direct Cost @ 35%			(excluding transportation and disposal cost)								$198,558

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Profit on Total Direct Cost @ 10%											$103,832
Subtotal											$1,340,707
Health & Safety Monitoring @ 2%											$26,814
Total Field Cost											$1,367,521
Engineering on Total Field Cost @ 20%											$273,504
Contingency on Total Field Cost @ 5%											$68,376
TOTAL CAPITAL COST											**$1,709,401**

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S3-VOCs: Excavation, Off-Site Disposal, and LUCs
Annual Cost

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Ammunition Burning Grounds
Crane, Indiana
Alternative MTA-S3-VOCs: Excavation, Off-Site Disposal, and LUCs
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$1,709,401		$1,709,401	1.000	$1,709,401
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$1,772,072**

APPENDIX H-7B

COST ESTIMATE

ALTERNATIVE MTA-S4-VOCs: SOIL VAPOR EXTRACTION ENHANCED BY PNEUMATIC FRACTURING

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S4-VOCs: Soil Vapor Extraction and LUCs
Capital Cost

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1	**PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS**											
1.1	Prepare Documents & Plans including Permits	300	hr			$38.00		$0	$0	$11,400	$0	$11,400
1.2	Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
2	**MOBILIZATION AND DEMOBILIZATION**											
2.1	Site Support Facilities (trailers, phone, electric, etc.)	1	ls		$1,000.00		$3,500.00	$0	$1,000	$0	$3,500	$4,500
2.3	Drill Rig Equipment Mobilization/Demobilization	1	ea	$2,500.00				$2,500	$0	$0	$0	$2,500
2.2	Equipment Mobilization/Demobilization	3	ea			$183.00	$518.00	$0	$0	$549	$1,554	$2,103
3	**FIELD SUPPORT**											
3.1	Office Trailer	3	mo				$360.00	$0	$0	$0	$1,080	$1,080
3.2	Field Office Equipment, Utilities, & Support	3	mo		$519.00			$0	$1,557	$0	$0	$1,557
3.3	Storage Trailer	3	mo				$94.00	$0	$0	$0	$282	$282
3.4	Utility Connection/Disconnection (phone/electric)	1	ls	$1,250.00				$1,250	$0	$0	$0	$1,250
3.5	Construction Layout Survey	3	day	$1,800.00				$5,400	$0	$0	$0	$5,400
3.6	Site Superintendent	55	day		$123.00	$384.64		$0	$6,765	$21,155	$0	$27,920
3.7	Site Health & Safety and QA/QC	55	day		$123.00	$307.68		$0	$6,765	$16,922	$0	$23,687
3.8	Underground Utility Clearance	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
4	**DECONTAMINATION**											
4.1	Decontamination Services	2	mo		$1,220.00	$2,245.00	$1,550.00	$0	$2,440	$4,490	$3,100	$10,030
4.2	Equipment Decon Pad	1	ls		$7,000.00	$6,500.00	$1,200.00	$0	$7,000	$6,500	$1,200	$14,700
4.3	Decon Water	2,000	gal		$0.20			$0	$400	$0	$0	$400
4.4	Decon Water Storage Tank, 6,000 gallon	2	mo				$780.00	$0	$0	$0	$1,560	$1,560
4.5	Clean Water Storage Tank, 4,000 gallon	2	mo				$702.00	$0	$0	$0	$1,404	$1,404
4.6	Disposal of Decon Waste (liquid & solid)	2	mo	$985.00				$1,970	$0	$0	$0	$1,970
5	**WELLS**											
5.1	Pneumatic Fracturing	1	ls	$100,000.00				$100,000	$0	$0	$0	$100,000
	TCE Area 1											
5.2	Extraction Wells, 2" dia., 25 wells	300	lf	$50.00				$15,000	$0	$0	$0	$15,000
5.3	Passive Vent Wells, 2" dia., 16 wells	192	lf	$50.00				$9,600	$0	$0	$0	$9,600
5.4	Well Vaults/Heads	41	ea		$375.00	$210.00		$0	$15,375	$8,610	$0	$23,985
5.5	Collect/Containerize IDW	41	ea	$68.00				$2,788	$0	$0	$0	$2,788
5.6	Transport/Dispose IDW Off Site	41	drum	$165.00				$6,765	$0	$0	$0	$6,765
	TCE Area 2											
5.7	Extraction Wells, 2" dia., 4 wells	28	lf	$50.00				$1,400	$0	$0	$0	$1,400
5.8	Passive Vent Wells, 2" dia., 1 well	7	lf	$50.00				$350	$0	$0	$0	$350
5.9	Well Vaults/Heads	5	ea		$375.00	$210.00		$0	$1,875	$1,050	$0	$2,925
5.10	Collect/Containerize IDW	5	ea	$68.00				$340	$0	$0	$0	$340
5.11	Transport/Dispose IDW Off Site	5	drum	$165.00				$825	$0	$0	$0	$825
6	**SVE SYSTEM**											
6.1	Pilot Test	1	ls	$30,000.00				$30,000	$0	$0	$0	$30,000
	TCE Area 1											
6.2	Blower (250 scfm), Moisture Tank, & Trailer	1	ea		$200,000.00	$1,600.00		$0	$200,000	$1,600	$0	$201,600
6.3	2" PVC Pipe, Sch 40	375	lf		$2.36	$3.41		$0	$885	$1,279	$0	$2,164
6.4	2" PVC Pipe Elbows	50	ea		$7.90	$23.50		$0	$395	$1,175	$0	$1,570
6.5	2" PVC Pipe Tees	25	ea		$28.00	$38.50		$0	$700	$963	$0	$1,663
6.6	2" by 4" PVC Bushings	25	ea		$9.98	$23.50		$0	$250	$588	$0	$837
6.7	4" PVC Pipe, Sch 40	600	lf		$7.95	$6.92		$0	$4,770	$4,152	$0	$8,922
6.8	4" PVC Pipe Elbows	25	ea		$31.50	$47.00		$0	$788	$1,175	$0	$1,963
6.9	4" PVC Pipe Tees	25	ea		$44.50	$70.00		$0	$1,113	$1,750	$0	$2,863
6.10	2" True Union Ball Valve	50	ea		$86.01	$38.50		$0	$4,301	$1,925	$0	$6,226
6.11	Vacuum Gage, 2 1/2" dia.	25	ea		$12.90	$23.50		$0	$323	$588	$0	$910
6.12	Rotameter	25	ea		$152.93	$47.00		$0	$3,823	$1,175	$0	$4,998
6.13	1" Sample Valve	25	ea		$7.39	$23.50		$0	$185	$588	$0	$772
6.14	Flexible Connectors, 2"	25	ea		$162.00	$28.50		$0	$4,050	$713	$0	$4,763

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
6.15 GAC Unit, 2 @ 500 lbs. each	1	ls		$3,870.00	$328.00		$0	$3,870	$328	$0	$4,198
TCE Area 2											
6.16 Blower (40 scfm), Moisture Tank, & Trailer	1	ea		$32,000.00	$345.00		$0	$32,000	$345	$0	$32,345
6.17 2" PVC Pipe, Sch 40	40	lf		$2.36	$3.41		$0	$94	$136	$0	$231
6.18 2" PVC Pipe Elbows	8	ea		$7.90	$23.50		$0	$63	$188	$0	$251
6.19 2" PVC Pipe Tees	4	ea		$28.00	$38.50		$0	$112	$154	$0	$266
6.20 2" by 4" PVC Bushings	4	ea		$9.98	$23.50		$0	$40	$94	$0	$134
6.21 4" PVC Pipe, Sch 40	30	lf		$7.95	$6.92		$0	$239	$208	$0	$446
6.22 4" PVC Pipe Elbows	4	ea		$31.50	$47.00		$0	$126	$188	$0	$314
6.23 4" PVC Pipe Tees	4	ea		$44.50	$70.00		$0	$178	$280	$0	$458
6.24 2" True Union Ball Valve	8	ea		$86.01	$38.50		$0	$688	$308	$0	$996
6.25 Vacuum Gage, 2 1/2" dia.	4	ea		$12.90	$23.50		$0	$52	$94	$0	$146
6.26 Rotameter	4	ea		$152.93	$47.00		$0	$612	$188	$0	$800
6.27 1" Sample Valve	4	ea		$7.39	$23.50		$0	$30	$94	$0	$124
6.28 Flexible Connectors, 2"	4	ea		$162.00	$28.50		$0	$648	$114	$0	$762
6.29 GAC Unit, 2 @ 100 lbs. each	1	ls		$1,050.00	$178.00		$0	$1,050	$178	$0	$1,228
TCE Areas 1 and 2											
6.30 Utility Connection	1	ls	$15,000.00				$15,000	$0	$0	$0	$15,000
6.31 Electrical Supplies & Controls	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
6.32 Backhoe/Loader	20	day			$362.80	$349.40	$0	$0	$7,256	$6,988	$14,244
6.32 Site Labor, 2 laborers	20	day			$274.80		$0	$0	$5,496	$0	$5,496
6.33 System Start-up Test	1	ls		$5,250.00	$2,750.00		$0	$5,250	$2,750	$0	$8,000
7 POST CONSTRUCTION DOCUMENTS											
7.1 Completion Report	150	hr			$38.00		$0	$0	$5,700	$0	$5,700
Subtotal							$213,188	$309,808	$120,044	$20,668	$663,708
Overhead on Labor Cost @ 30%									$36,013		$36,013
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$21,319	$30,981	$12,004	$2,067	$66,371
Tax on Materials and Equipment @ 7%								$21,687		$1,447	$23,133
Total Direct Cost							$234,507	$362,476	$168,061	$24,182	$789,226
Indirects on Total Direct Cost @ 25%											$197,306
Profit on Total Direct Cost @ 10%											$78,923
Subtotal											$1,065,455
Health & Safety Monitoring @ 2%											$21,309
Total Field Cost											$1,086,764
Contingency on Total Field Cost @ 25%											$271,691
Engineering on Total Field Cost @ 15%											$163,015
TOTAL COST											**$1,521,469**

Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S4-VOCs: Soil Vapor Extraction and LUCs
Operation and Maintenance Costs per Year (years 1 to 5)

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	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
1	Energy - Electric (TCE Area 1)	105,120	kWh	$0.11	$11,563	
2	Energy - Electric (TCE Area 2)	17,520	kWh	$0.11	$1,927	
3	Equipment Maintenance	1	ls	$15,414.84	$15,415	5% of Installation Cost
4	Labor	50	wk	$580.00	$29,000	10 hours per week
5	VOCs Analysis - off-gas	72	ea	$150.00	$10,800	6 samples each month
6	Quarterly Reports	4	ea	$2,000.00	$8,000	
	Cost for One Year Operation				$76,705	
	Replace Carbon after First Year:	TCE Area 1			$4,000	
		TCE Area 2			$800	

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S4-VOCs: Soil Vapor Extraction and LUCs
Annual Cost

Item	Cost Year 1	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S4-VOCs: Soil Vapor Extraction and LUCs
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$1,521,469			$1,521,469	1.000	$1,521,469
1		$81,505	$2,915	$84,420	0.978	$82,522
2		$76,705	$2,915	$79,620	0.956	$76,080
3		$76,705	$2,915	$79,620	0.934	$74,370
4		$76,705	$2,915	$79,620	0.913	$72,698
5		$76,705	$2,915	$79,620	0.893	$71,063
6			$2,915	$2,915	0.872	$2,543
7			$2,915	$2,915	0.853	$2,486
8			$2,915	$2,915	0.834	$2,430
9			$2,915	$2,915	0.815	$2,376
10			$2,915	$2,915	0.797	$2,322
11			$2,915	$2,915	0.779	$2,270
12			$2,915	$2,915	0.761	$2,219
13			$2,915	$2,915	0.744	$2,169
14			$2,915	$2,915	0.727	$2,120
15			$2,915	$2,915	0.711	$2,073
16			$2,915	$2,915	0.695	$2,026
17			$2,915	$2,915	0.679	$1,980
18			$2,915	$2,915	0.664	$1,936
19			$2,915	$2,915	0.649	$1,892
20			$2,915	$2,915	0.635	$1,850
21			$2,915	$2,915	0.620	$1,808
22			$2,915	$2,915	0.606	$1,768
23			$2,915	$2,915	0.593	$1,728
24			$2,915	$2,915	0.579	$1,689
25			$2,915	$2,915	0.566	$1,651
26			$2,915	$2,915	0.554	$1,614
27			$2,915	$2,915	0.541	$1,578
28			$2,915	$2,915	0.529	$1,542
29			$2,915	$2,915	0.517	$1,507
30			$2,915	$2,915	0.506	$1,474
					TOTAL PRESENT WORTH	**$1,947,253**

APPENDIX H-7C

COST ESTIMATE

ALTERNATIVE MTA-S5-VOCs: IN-SITU ELECTRICAL RESISTANCE HEATING

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S5-VOCs: Electrical Resistance Heating
Capital Cost

6/16/2011 9:02 AM

Item	Quantity	Unit	Subcontract	Unit Cost Material	Labor	Equipment	Extended Cost Subcontract	Material	Labor	Equipment	Subtotal
1 PROJECT PLANNING & DOCUMENTS											
1.1 Prepare Documents & Plans	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
1.2 Prepare Permits	300	hr			$38.00		$0	$0	$11,400	$0	$11,400
1.3 Prepare Work Plans	400	hr			$38.00		$0	$0	$15,200	$0	$15,200
1.4 Prepare LUCs	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
2 MOBILIZATION AND DEMOBILIZATION											
2.1 Site Support Facilities (trailers, phone, electric, etc.)	1	ls		$1,000.00		$3,500.00	$0	$1,000	$0	$3,500	$4,500
2.2 Equipment Mobilization/Demobilization	5	ea			$183.00	$518.00	$0	$0	$915	$2,590	$3,505
3 FIELD SUPPORT AND SITE ACCESS											
3.1 Office Trailer	12	mo				$360.00	$0	$0	$0	$4,320	$4,320
3.2 Field Office Equipment, Utilities, & Support	12	mo		$519.00			$0	$6,228	$0	$0	$6,228
3.3 Storage Trailer	12	mo				$94.00	$0	$0	$0	$1,128	$1,128
3.4 Survey Support	10	day	$1,800.00				$18,000	$0	$0	$0	$18,000
3.5 Site Superintendent (part-time during ERH)	90	day		$123.00	$384.64		$0	$11,070	$34,618	$0	$45,688
3.6 Site Health & Safety and QA/QC	40	day		$123.00	$307.68		$0	$4,920	$12,307	$0	$17,227
3.7 Underground Utility Clearance	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
4 DECONTAMINATION											
4.1 Decontamination Services	2	mo		$1,220.00	$2,245.00	$1,550.00	$0	$2,440	$4,490	$3,100	$10,030
4.2 Temporary Equipment Decon Pad	1	ls		$1,500.00	$2,000.00	$300.00	$0	$1,500	$2,000	$300	$3,800
4.3 Decon Water	2,000	gal		$0.20			$0	$400	$0	$0	$400
4.4 Decon Water Storage Tank, 6,000 gallon	2	mo				$780.00	$0	$0	$0	$1,560	$1,560
4.5 Clean Water Storage Tank, 4,000 gallon	2	mo				$702.00	$0	$0	$0	$1,404	$1,404
4.6 Disposal of Decon Waste (liquid & solid)	2	mo	$985.00				$1,970	$0	$0	$0	$1,970
5 ELECTRICAL RESISTANCE HEATING											
5.1 Project Design & Support	1	ls	$49,000.00				$49,000	$0	$0	$0	$49,000
5.2 Electrode Materials Mobilization	1	ls	$235,000.00				$235,000	$0	$0	$0	$235,000
5.3 Subsurface Installation	1	ls	$74,000.00				$74,000	$0	$0	$0	$74,000
5.4 Utility Connection	1	ls		$391,050.00	$103,950.00		$0	$391,050	$103,950	$0	$495,000
5.5 Surface Installation & Start-up	1	ls	$252,000.00				$252,000	$0	$0	$0	$252,000
5.6 Remediation System Operation	1	ls	$841,000.00				$841,000	$0	$0	$0	$841,000
5.7 Demobilization & Final Report	1	ls	$27,000.00				$27,000	$0	$0	$0	$27,000
5.8 Electrodes & VR Wells Drilling	1,348	lf	$35.00				$47,180	$0	$0	$0	$47,180
5.9 TMPs Drilling	136	lf	$25.00				$3,400	$0	$0	$0	$3,400
5.10 Pre ERH Soil Samples	20	ea	$200.00				$4,000	$0	$0	$0	$4,000
5.11 Drill Materials Disposal	53	ton	$216.00				$11,448	$0	$0	$0	$11,448
5.12 Site Labor (2 laborers)	80	day			$274.80		$0	$0	$21,984	$0	$21,984
5.13 Skid-Steer	40	day				$261.20	$0	$0	$0	$10,448	$10,448
5.14 Excavator, 2 cy	20	day			$362.80	$1,124.00	$0	$0	$7,256	$22,480	$29,736
5.15 Granular Carbon	8,000	lb		$2.50			$0	$20,000	$0	$0	$20,000
5.16 Vapor Sampling & Analysis	51	ea	$200.00				$10,200	$0	$0	$0	$10,200
5.17 Condensate/Discharge Sampling & Analysis	17	ea	$265.00				$4,505	$0	$0	$0	$4,505
5.18 Sampling Labor & Operational Checks	249	hr			$38.00		$0	$0	$9,462	$0	$9,462
5.19 Electricity Usage	3,480,000	kWh		$0.11			$0	$382,800	$0	$0	$382,800
5.20 Confirmatory Borings Drilling	223	lf	$35.00				$7,805	$0	$0	$0	$7,805
5.21 Soil Sampling & Analysis	32	ea	$200.00				$6,400	$0	$0	$0	$6,400
5.22 ERH Well Abandonment	1,348	lf	$6.00				$8,088	$0	$0	$0	$8,088
6 SITE RESTORATION											
6.1 Topsoil	275	cy		$33.00			$0	$9,075	$0	$0	$9,075
6.2 Seed, Mulch, & Fertilize	37	msf	$117.00				$4,329	$0	$0	$0	$4,329
6.3 Dozer, 200 hp	5	day			$362.80	$2,105.00	$0	$0	$1,814	$10,525	$12,339

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
7 POST CONSTRUCTION COST											
7.1 Contractor Completion Report	150	hr			$38.00		$0	$0	$5,700	$0	$5,700
7.2 Remedial Action Closeout Report	200	hr			$38.00		$0	$0	$7,600	$0	$7,600
Subtotal							$1,612,825	$830,483	$253,896	$61,355	$2,758,559
Overhead on Labor Cost @ 30%									$76,169		$76,169
G & A on Labor, Material, Equipment, & Subs Cost @ 10%							$161,283	$83,048	$25,390	$6,136	$275,856
Tax on Materials and Equipment Cost @ 7.0%								$58,134		$4,295	$62,429
Total Direct Cost							$1,774,108	$971,665	$355,454	$71,785	$3,173,012
Indirects on Total Direct Cost @ 15%			(excluding transportation and disposal cost)								$473,939
Profit on Total Direct Cost @ 10%											$317,301
Subtotal											$3,964,252
Health & Safety Monitoring @ 1%											$39,643
Total Field Cost											$4,003,895
Engineering on Total Field Cost @ 4%											$160,156
Contingency on Total Field Cost @ 15%											$600,584
TOTAL CAPITAL COST											**$4,764,635**

NSWC CRANE
Crane, Indiana
SWMU 3 Ammunition Burning Grounds
Alternative MTA-S5-VOCs: Electrical Resistance Heating
Annual Cost

Item	Item Cost yearly	Notes
Site Inspection & Report	$2,650	One-day visit to verify LUCs
Subtotal	$2,650	
Contingency @ 10%	$265	
TOTAL	**$2,915**	

NSWC CRANE
SWMU 3 Ammunition Burning Grounds
Crane, Indiana
Alternative MTA-S5-VOCs: Electrical Resistance Heating
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate 2.3%	Present Worth
0	$4,764,635		$4,764,635	1.000	$4,764,635
1		$2,915	$2,915	0.978	$2,849
2		$2,915	$2,915	0.956	$2,785
3		$2,915	$2,915	0.934	$2,723
4		$2,915	$2,915	0.913	$2,662
5		$2,915	$2,915	0.893	$2,602
6		$2,915	$2,915	0.872	$2,543
7		$2,915	$2,915	0.853	$2,486
8		$2,915	$2,915	0.834	$2,430
9		$2,915	$2,915	0.815	$2,376
10		$2,915	$2,915	0.797	$2,322
11		$2,915	$2,915	0.779	$2,270
12		$2,915	$2,915	0.761	$2,219
13		$2,915	$2,915	0.744	$2,169
14		$2,915	$2,915	0.727	$2,120
15		$2,915	$2,915	0.711	$2,073
16		$2,915	$2,915	0.695	$2,026
17		$2,915	$2,915	0.679	$1,980
18		$2,915	$2,915	0.664	$1,936
19		$2,915	$2,915	0.649	$1,892
20		$2,915	$2,915	0.635	$1,850
21		$2,915	$2,915	0.620	$1,808
22		$2,915	$2,915	0.606	$1,768
23		$2,915	$2,915	0.593	$1,728
24		$2,915	$2,915	0.579	$1,689
25		$2,915	$2,915	0.566	$1,651
26		$2,915	$2,915	0.554	$1,614
27		$2,915	$2,915	0.541	$1,578
28		$2,915	$2,915	0.529	$1,542
29		$2,915	$2,915	0.517	$1,507
30		$2,915	$2,915	0.506	$1,474
				TOTAL PRESENT WORTH	**$4,827,306**

APPENDIX I

APPLICABILITY EVALUATION OF IN-SITU BIOREMEDIATION AT SWMU 3 - AMMUNITION BURNING GROUNDS, NSA CRANE

December 9, 2009

APPLICABILITY EVALUATION OF IN-SITU BIOREMEDIATION AT SWMU 3 – AMMUNITION BURNING GROUNDS, NSWC CRANE, INDIANA

Introduction

The United States Environmental Protection Agency (EPA) Region 5 provided comments on the draft Corrective Measures Proposal (CMP) Report for Solid Waste Management Unit (SWMU) 3 – Ammunition Burning Grounds on May 22, 2008. Comment EPA-8 requested evaluation of the possibility of using in-situ bioremediation (referred to in the comment as bioaugmentation) for treating trichloroethene (TCE) groundwater hotspot areas at MTA/OJT. This request was made in reference to a pilot study of TCE bioaugmentation in a fracture rock environment at the Naval Air Warfare Center (NAWC) in Trenton, New Jersey.

In addition to the Geosyntec webpage referenced in the EPA's comments, we have also located poster presentations from technical conferences on this project. The posters are a USGS poster presented in the SERDP/ESTCP symposium (2007), a USGS poster presented at an EPA workshop (2008), and the Geosyntec poster presented in the USGS Toxics Meeting in 2009. These posters help illustrate more up-to-date details of this pilot study. Electronic copies of the three posters are attached.

This document presents our technical assessment of the effectiveness and implementability of in-situ bioaugmentation of TCE located in hotspot areas at MTA/OJT.

Description of Bioaugmentation Pilot Study at NAWC

Whether or not a technology will be effective and implementable at a site is site specific. This section reviews the available information for the pilot study conducted at the NAWC site, which can help to determine whether the conditions at this site are comparable to the ABG Crane site.

As shown in the Geosyntec's poster, Geosyntec did two injections for the pilot study. The first injection was conducted in July 2005, using 110 gallons of EOS® with 120 L highly concentrated KB-1 culture (10^{11} gene copies per liter). The second injection was conducted in July 2008 for the primary objective of re-establishing concentrations of electron donors due to the observation that the previously injected electron donors (EOS) were largely depleted after 12 to 15 months.

Between the two injection events, related wells were monitored in 15 monitoring events. It is not clear whether the monitoring events were limited to the injection/extraction wells shown in Figure 1, or have been extended to other unnoted monitoring wells.

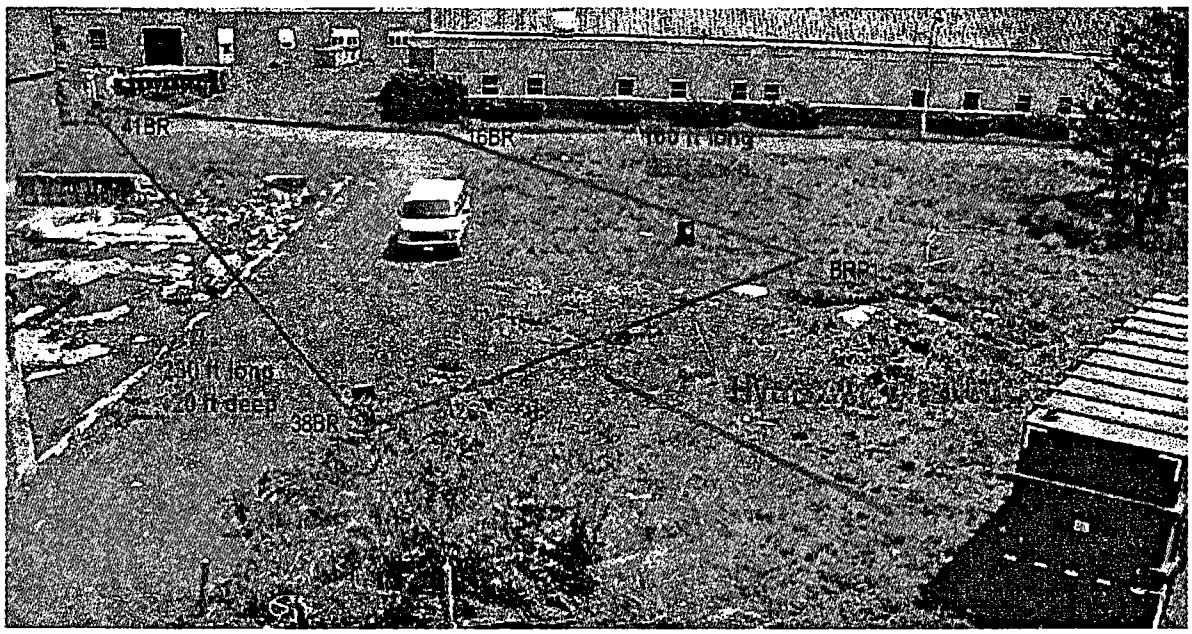


Figure 1 View of the Bioaugmentation Test Plot at NAWC (Geosyntec, 2009)

The plot study site is about 9000 square feet. TCE concentrations before the pilot ranged from 206 µg/L to 15,800 µg/L. It was noted on the Geosyntec webpage that TCE concentrations generally reached detection limit (less than 1 ppb) within six weeks of the first injection. Detection limit concentrations of the degradation products (e.g. 1,2-cis-DCE, vinyl chloride, and ethane) were also achieved within seven months. In addition, no rebound of TCE concentrations was observed as of the webpage update date. The figures on the Geosyntec's poster in 2009 (Figures 2 and 3 in this document) show that the TCE concentrations in the two injections wells (BRP1 and 38BR) are negligible as of March 2008 (before the second injection). However, because the TCE concentrations on the figures are expressed in micromoles/liter and the smallest resolution is 0.5 micromoles/liter (1 micromoles/liter = 131.39 µg/L), it is difficult to identify the actual TCE concentrations in this 3-year period in relation to regulatory criteria, such as the MCL (5 µg/L). The figures also show that rebound of degradation products (e.g. cis-DCE, vinyl chloride, and ethane) occurred after the seven months of first injection, at which the detection limit concentrations of these products were observed.

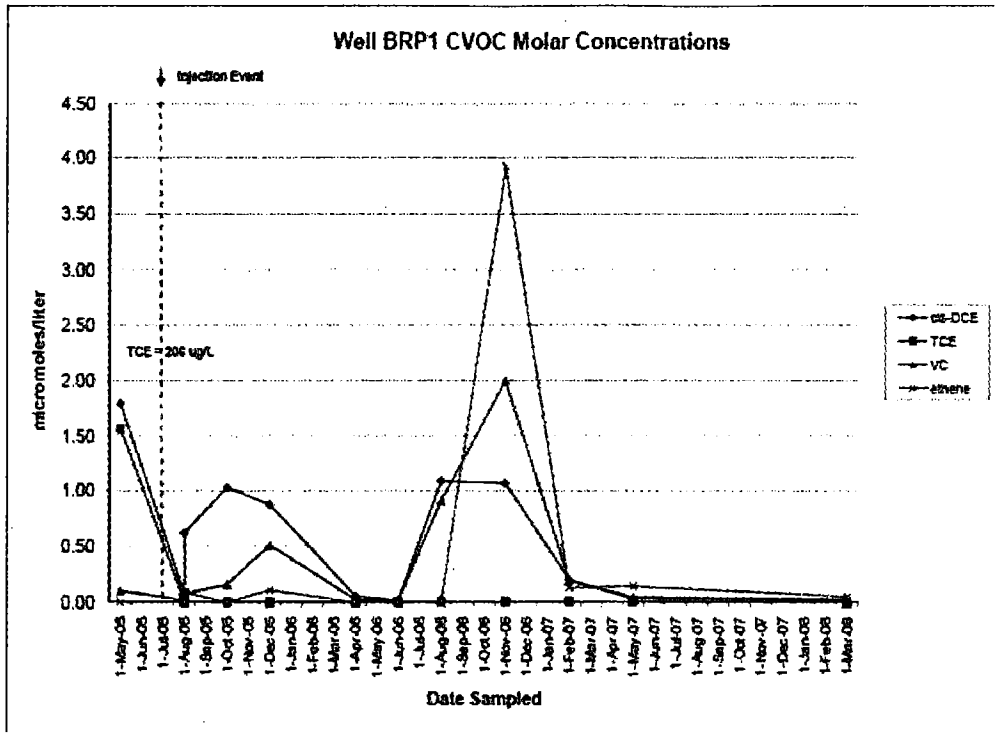


Figure 2 Well BRP1 CVOC Molar Concentrations (Geosyntec, 2009)

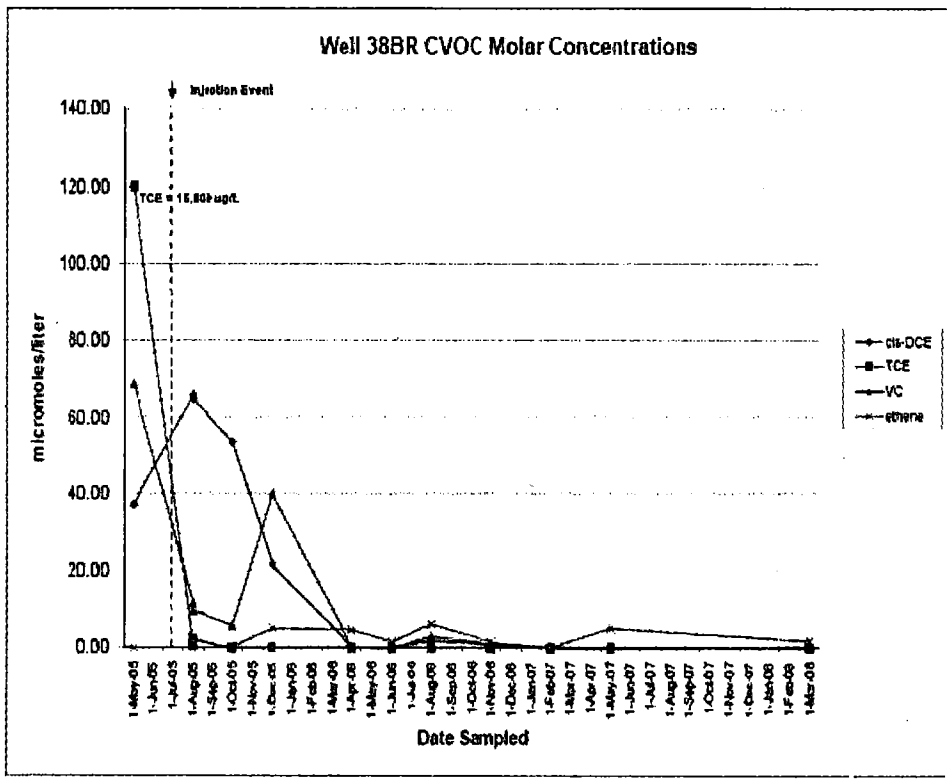


Figure 3 Well 38BR CVOC Molar Concentrations (Geosyntec, 2009)

For the second injection, the figure in the poster (Figures 4) shows that the TCE concentrations in the injection water (as recirculation was established between injection and extraction wells) keep increasing from the negligible concentration (in terms of micromoles/liter unit) during the injection event. Figure 5 shows that the concentrations of TCE and its degradation products in the injection well (BRP1) spiked in August 2008 after the second injection, and their concentrations became negligible again (in terms of micromoles/liter unit) in December 2008.

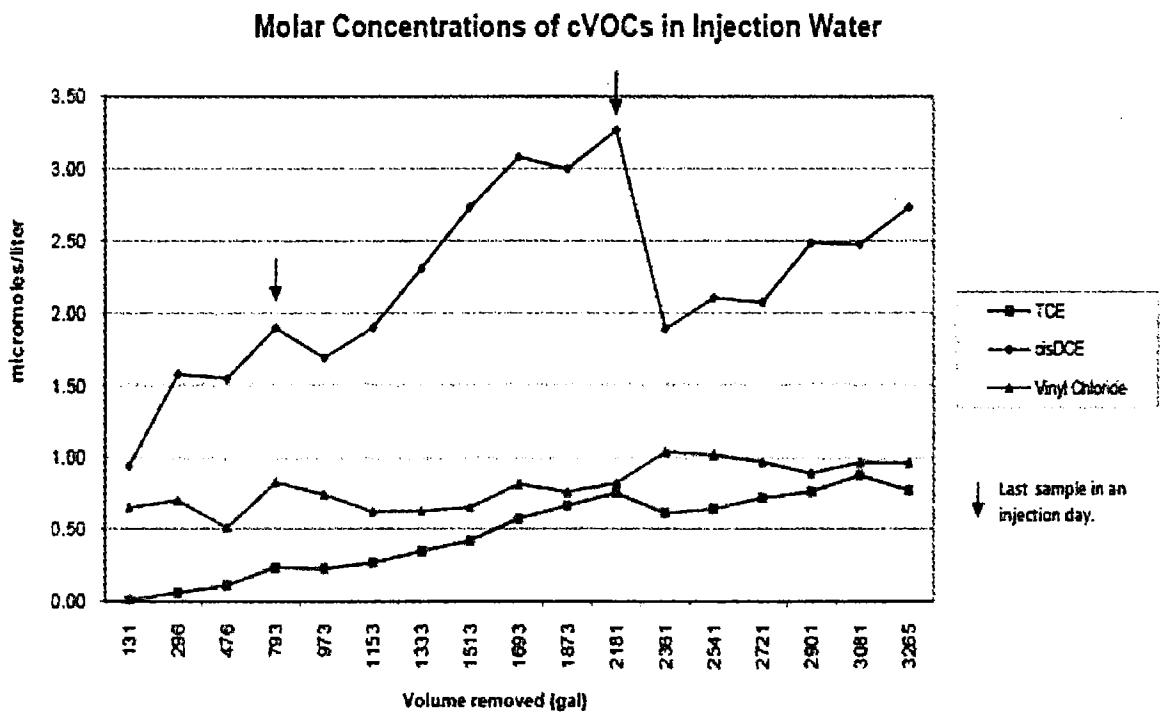


Figure 4 Molar Concentrations of cVOCs in Injection Water (Geosyntec, 2009)

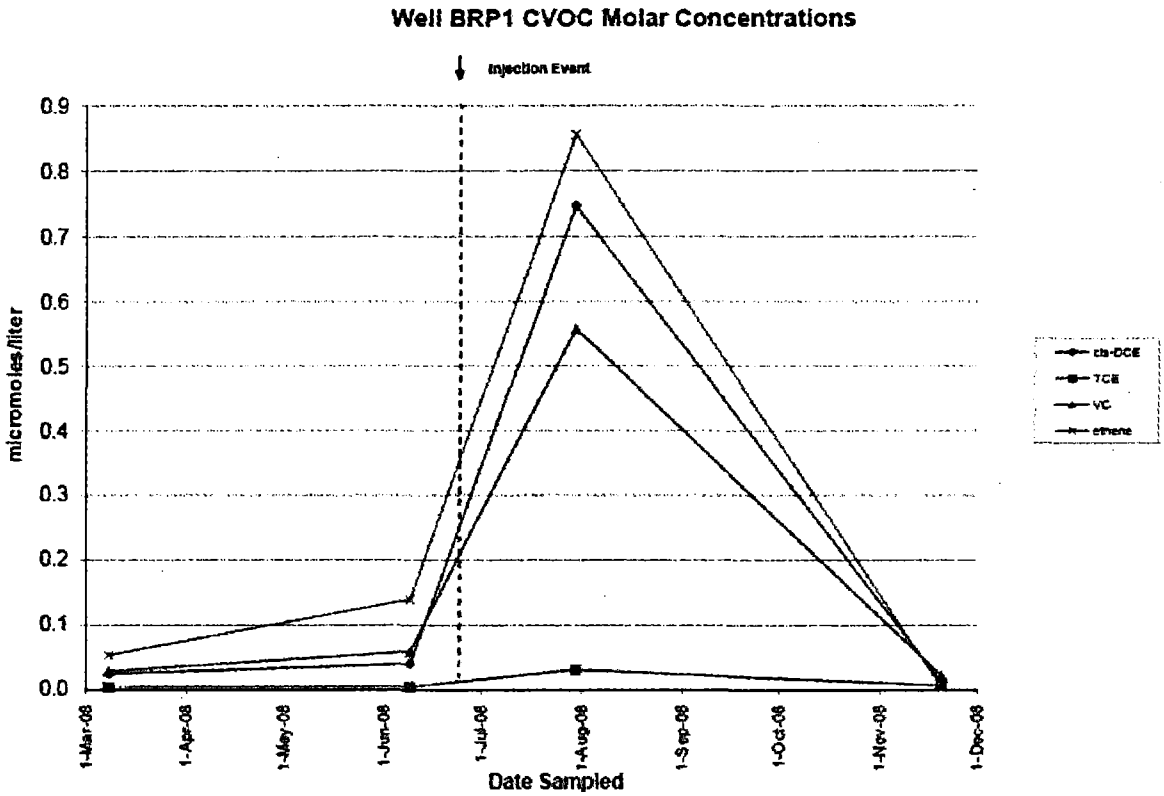


Figure 5 Well BRP1 CVOC Molar Concentrations (Geosyntec, 2009)

What's also worth mentioning is that the conceptualization, design, and implementation of this pilot study was built on the extensive data collected by the USGS for a number of years at this site. This site is one of the USGS's research sites. USGS conducted extensive characterization studies to understand the heterogeneity of the bedrock geology, the preferential flow paths, and groundwater residence time using a large amount of hydraulic tests, tracer tests, and modeling (as documented in the attached posters). Geosyntec states in the poster that "understanding the detailed geologic framework of the bedrock formation is critical to the success of the application". Currently this degree of information at the ABG is not available. It would require a significant effort to collect the data required to understand the site conceptual model sufficiently to achieve a similar degree of success at the ABG.

Effectiveness and Implementability of Bioaugmentation at ABG, Crane

Site conditions of the ABG site are reviewed and compared to the NAWC site. The effectiveness and implementability of using bioaugmentation at ABG is evaluated in the following aspects:

- Level of Characterization
- Treatment Endpoint and Long Term Effectiveness
- The Link between Hot Spot Cleanup and Downstream Receptors

Level of Characterization

As described previously, the NAWC Trenton site was extensively characterized by USGS in their research programs. It is apparent that thoroughly understanding the geology, preferential pathways, transport properties, and the contaminant mass distribution are necessary pre-requisites for cost-effective implementation of bioaugmentation at a fractured bedrock site, as indicated by the pilot study at the NAWC Trenton site. The characterization effort at the ABG site, though substantial, is certainly not comparable to what has been done in the USGS's research site. It is unclear whether the site conditions are comparable, and even if it is comparable; the ABG lacks sufficient characterization data for the remedial design of bioaugmentation. For example, the "hot spots" referenced in the EPA's comment have not been clearly delineated and characterized. Therefore, the performance uncertainty for bioaugmentation at the ABG site is high.

Treatment Endpoint and Long Term Effectiveness

The pilot study at NAWC Trenton is a successful demonstration for reducing the aqueous phase TCE mass at a fractured bedrock site. The mass reduction is indicated by the significant decrease in TCE concentrations and the appearance of degradation compounds. However, whether the treated groundwater concentrations can remain under MCL and/or state standards in the long term is still uncertain. (Meanwhile, this discussion is limited to TCE because the concentrations of other degradation products are still above standards according to Figures 2 and 3.

As indicated in the review for the pilot study previously, the available information is not sufficient to determine whether the TCE concentrations were below MCL or the state groundwater standard throughout all the time in that:

1) It is not clear whether the regulatory standard for TCE has been met in places other than the injection wells;
2) Due to the use of the micromoles/liter unit and figure resolution (1 micromoles/liter = 131.39 μg/L), it is not clear whether the "negligible" concentrations on the figure are always below the regulatory standard (e.g. 5 μg/L) since 2005.

More importantly, the long-term effect of the treatment on contaminant concentrations remains uncertain due to the problem of back diffusion from the rock matrix. It has been widely acknowledged recently by researchers and practitioners that a long-term plume itself is a "source" because the contaminant has diffused into the soil/rock matrix, which serves as a "contaminants reservoir". Back diffusion from this "reservoir" will continue to slowly release contaminants into the groundwater over the long term. The USGS poster (USGS, 2007) indicates that at the NAWC site "the concentrations of TCE and DCE in the

pore water of the rock core show significant variation with depth. The highest concentrations are generally adjacent to fractures. TCE concentrations in water samples pumped from hydraulically isolated borehole intervals can show little or no relation to concentrations in the pore water of the rock adjacent to the fractures." This description shows that the "contaminants reservoir" has been formed at the NAWC Trenton site. Therefore, back diffusion effect will affect the groundwater quality in the long term. However, long term data is not available to determine the long term effectiveness of this pilot study.

If a long term release through back diffusion is anticipated, it is intuitive that the attenuation capacity from microbial activity should be sufficient to accommodate the release for the concentrations to remain steady. Although TCE mass reduction was demonstrated in the pilot study, the sustainability of the current concentration reduction remains uncertain. As a matter of fact, a second injection at the NAWC site was conducted partially because the electron donors were largely depleted after 12 to 15 months, so a re-injection is needed to re-establish concentrations of the donor. Therefore, the long term effectiveness of bioaugmentation at the ABG site is unclear.

The Link between Hot Spot Cleanup and Downstream Receptors

The research community is still evaluating whether source reduction is a cost-effective method for protecting the downgradient receptors (Sale, 2008). The relationship among source (including the "contaminants reservoir"), plume, and receptors is not clearly understood to date. Under some conditions, source reduction may yield little response to the plume, thus offer little influence to the downstream receptors.

At the ABG site, the flow pathways are not clearly identified to date. The tracer studies conducted only demonstrated that groundwater eventually discharges to springs along Little Sulphur Creek; however, the relationship of the individual hot spots to the flow (thus receptors) has not been thoroughly studied. The effect of hot spot cleanup on receptors through the unidentified complex flow pathways is not clear. Therefore, conducting bioaugmentation at hot spot areas may not be a cost-effective method to reduce the risks and protect off-site receptors.

Summary

Based on the currently available information, the effectiveness and implementability of source and and/or plume treatment using bioaugmentation at the ABG site are highly uncertain due to the complex geology, hydrogeology, and contaminant distribution. Bioaugmentation at the ABG site is not a cost-effective technology to reduce the long-term risk of off-site receptors. Conversely, because it is anticipated that the ABG will continue to operate as a burning grounds, the site is expected to remain under the industrial land use scenario, land use and engineering controls are in place, the natural attenuation capacity is

sufficient to reducte the risk to human health and the environment to on-site and off-site receptors as demonstrated in previous studies, and an active monitoring program is in place to ensure this site does not pose any undue risks, source treatment using bioaugmentation should not be considered further. If one or more of these conditions were to change then this recommendation should be re-evaluated.

References

Geosyntec, 2009, Bioaugmentation in Fractured Rock: A Long-Term Pilot Study at the NAWC Site, USGS Toxics Meeting

USGS, 2007 Characterizing Spatial Heterogeneity in Fractured Rock to Evaluate Mass Removal of TCE, DCE, and Vinyl Chloride at the Naval Air Warfare Center, West Trenton, NJ, SERDP & ESTCP Partners in Environmental Technology Technical Symposium & Workshop

USGS, 2008, Station 4: Aquifer Testing & Flow Modeling to Identify Hydraulic Connections and Predict GW Flux

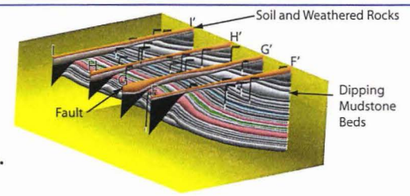
Sale, T. 2008, Personal Communication with Keith Henn, Colorado State University.

STATION 4: Aquifer Testing & Flow Modeling To Identify Hydraulic Connections and Predict GW Flux

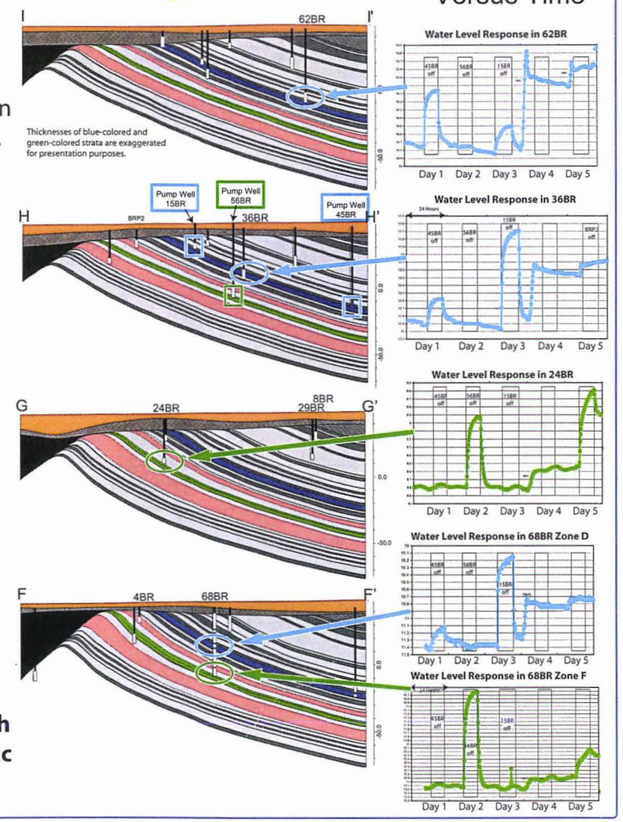
Claire R. Tiedeman (tiedeman@usgs.gov), Pierre J. Lacombe (placombe@usgs.gov), and Daniel J. Goode (djgoode@usgs.gov)

Aquifer Tests

- Short term aquifer tests conducted by taking advantage of pump & treat system at NAWC.
- Tests: **Temporarily turn off the pumps in individual wells of the pump & treat system.**
- Sequence of turning a pump off and on again was repeated, to conduct a short-term aquifer test in each of 7 pumping wells.
- Water levels recorded in ~40 monitor wells open to a wide range of depths and mudstone strata.
- Data provide excellent information about presence or absence of hydraulic connections between open intervals of wells.
- **Water levels in wells open to blue-colored strata rise rapidly when pump is off in 15BR or 45BR.**
- **Water levels in wells open to green-colored strata rise rapidly when pump is off in 56BR.**



Aquifer Test Results: Water Levels Versus Time



CONCLUSIONS:

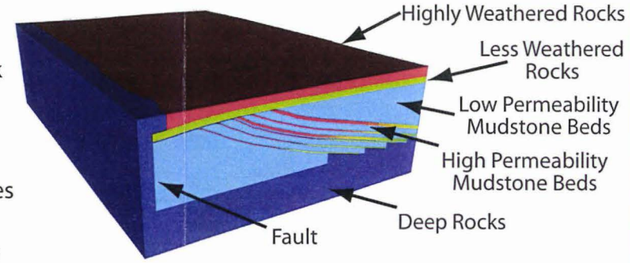
- **Pump & treat systems can be used very advantageously to conduct aquifer tests at contaminated sites:**
  - -- Majority of pumping wells can remain on, for hydraulic containment of contaminants.
  - -- Additional storage and treatment of contaminated water are not necessary.
- **Short (~9-hour) aquifer tests are long enough to yield information about site-scale hydraulic connections** in these fractured mudstones.

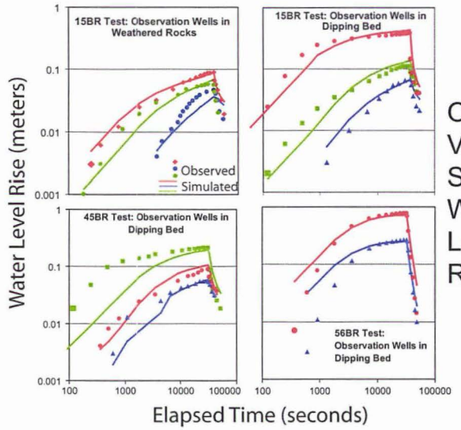
GW Modeling

Aquifer test data and geologic framework used together to develop and calibrate a site scale MODFLOW-2000 model

- Objectives: Identify heterogeneity structure of the rocks and estimate values of hydraulic properties.
- Use a fairly simple representation of the true system.
- Model simulates water level rises produced by the aquifer tests conducted by turning off pumps in wells 45BR, 56BR, and 15BR, and provides a good fit to the data.

Calibrated model is then modified to simulate hydraulic heads and flows under conditions of ALL wells pumping. **This enables prediction of important ground-water flow rates in area where bioaugmentation will take place.**



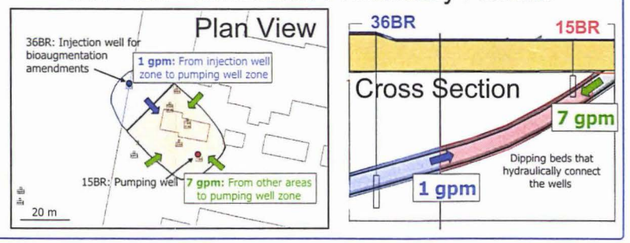


Observed Versus Simulated Water Level Rises

CONCLUSIONS:

- **Powerful combination of aquifer test data and geologic framework allowed development and calibration of a realistic site-scale flow model.**
- **Ground-water fluxes predicted with this model are essential information needed for designing remediation strategies.**

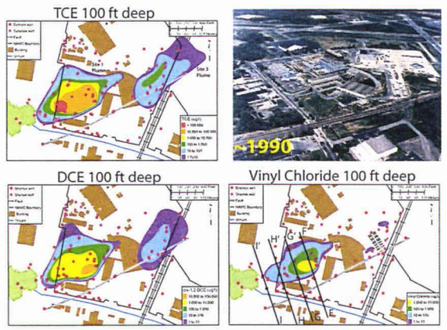
GW Flux Predictions: Preliminary Results

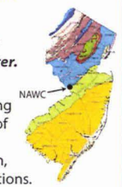


Characterizing Spatial Heterogeneity in Fractured Rock to Evaluate Mass Removal of TCE, DCE, and Vinyl Chloride at the Naval Air Warfare Center, West Trenton, NJ

Allen M. Shapiro, Claire R. Tiedeman, and Daniel J. Goode (U.S. Geological Survey)

Research on the Fate of Chlorinated Solvents in Fractured Rock

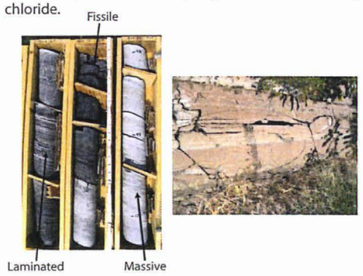


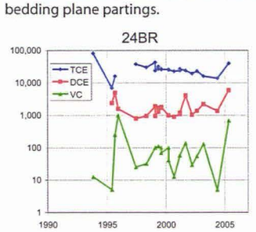


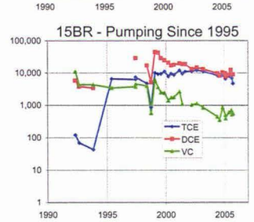
Fractured rocks are one of the most challenging geologic environments for remediating contaminated ground water.

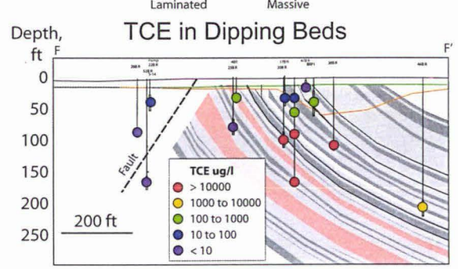
The U.S. Geological Survey, with the support of SERDP (ER-1555), is developing methods to evaluate the mass removal of aqueous-phase chlorinated solvents by pumping, monitored natural attenuation, and bioaugmentation under field conditions. This research is being conducted at the former Naval Air Warfare Center (NAWC), West Trenton, NJ. The NAWC was a Navy jet-engine testing facility that operated from the 1950's to the mid-1990's. TCE and jet fuel leaked into the subsurface, and TCE naturally degraded to DCE and vinyl chloride.

The rocks underlying the NAWC are dipping mudstones of the Lockatong formation in the Newark Basin. A comination of drilling, geophysical logging, and hydraulic testing has identified the ity of the bedding in the rocks. The most permeable frac- ccur as bedding plane partings in thin laminated and fissile mudstone units. Massive mudstones are much less permeable. Stratabound subvertical fractures are observed, and are likely to transmit fluid and solutes, but are much less permeable than the bedding plane partings.









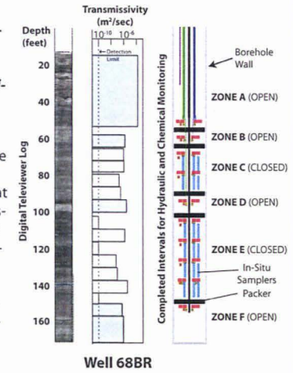
Despite more than a decade of continuous pumping, concentrations in most wells have not decreased significantly. The water abstracted from bedrock wells largely represents the water in fractures. Because of decades of residence time of TCE in the formation, TCE and its daughter products have likely diffused into the primary porosity of the rock (see the panel to the right), and is acting as a contaminant source that slowly diffuses back into permeable fractures.

Characterizing Pathways of Fluid Movement

Evaluating the fate of contaminants and remediaton strategies in fractured rock requires an understanding of pathways of fluid movement. The hydraulic significance of fractures can vary over many orders of magnitude and the complex connectivity of fractures can yield highly convoluted flow paths over dimensions from meters to kilometers.

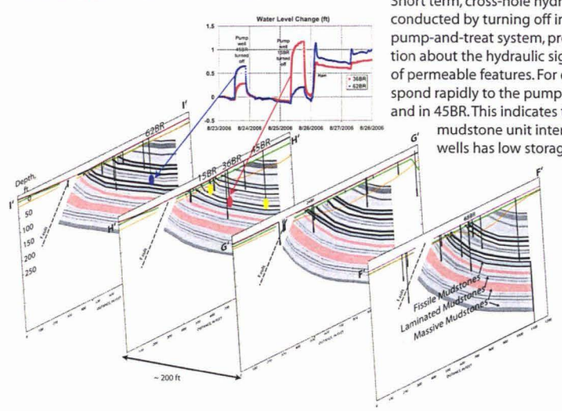
Single-Hole Hydraulic Tests

The hydraulic significance of fractures can be estimated from single-hole hydraulic tests conducted by isolating a short interval in a bedrock borehole using packers. Packers are inflatable or mechanical devices that seal against the borehole wall. Geophysical logging tools, such as acoustic and digital images of the borehole walls are used to identify fracture locations and design the single-hole hydraulic tests. Hydraulic tests conducted over the length of a borehole can identify vertical variability in the tranmsissivity of fractures, and locations for geochemical and hydraulic monitoring. Single-hole hydraulic tests conducted over short intervals in a boreholecan also be used to collect water samples for analyses of water chemistry, redox conditions, and microbial activity.



Cross-Hole Hydraulic Tests

Cross-hole hydraulic tests are also needed to identify the spatial continuity and areal extent of highly transmissive fractures. Cross-hole testing is usually conducted by injecting or withdrawing ground water from a single borehole, while monitoring the fluid pressure responses at one or more boreholes in the formation. At sites of ground-water contamination, where multiple pumping wells are used to contain the extent of contamination, it might not be feasible to turn all pumps off to perform cross-hole hydraulic tests. Cross-hole hydraulic tests at sites of ground-water contamination can also be conducted by manipulating the rates of pumping wells. Interpretations of the hydraulic responses require nonstandard methods.



Short term, cross-hole hydraulic tests at the NAWC, conducted by turning off individual wells of the 7-well pump-and-treat system, provide significant information about the hydraulic significance and connectivity of permeable features. For example, 36BR and 62BR respond rapidly to the pumps being turned off in 15BR and in 45BR. This indicates that the thin black fissile mudstone unit intersected by each of these wells has low storage and high permeability.

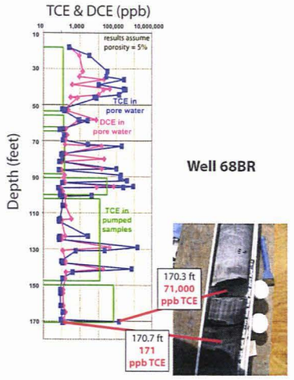
The responses to these short-term tests in ~40 monitoring wells are being used to develop conceptual and numerical models of flow and transport pathways in this highly heterogeneous bedded mudstones at the NAWC.

Characterizing the Distribution of TCE, DCE, and Vinyl Chloride

All rocks have an intrinsic porosity. The intrinsic porosity may not be capable of transmiting significant quantities of water, but it can act as a fluid-filled reservoir in contact with permeable fractures. Depending on the concentration gradient, chemical constituents can diffuse into or out of the intrinsic porosity of the rock. The release of chemical mass from the intrinsic porosity will depend on chemical diffusion, regardless of the volume of fluid that passes through adjacent fractures.

The intrinsic porosity of the mudstones at the NAWC varies from a few percent to greater than 15 % of the total void space of the rock. In sedimentary rocks, like the mudstones of the Lockatong Formation, the intrinsic porosity is likely to be significantly greater than the porosity (void volume) of fractures. Consequently, the mass of TCE , DCE and VC in the pore water of the intrinsic porosity is likely to be larger than the chemical mass residing in fractures. In evaluating the success of remediation strategies, it is necessary to identify the concentrations of TCE, DCE, and VC in both the void space of the fractures and the intrinsic porosity of the rock.

The concentrations of TCE and DCE in the pore water of the rock core show significant variation with depth. The highest concentrations are generally adjacent to fractures. TCE concentrations in water samples pumped from hydraulically isolated borehole intervals can show little or no relation to concentrations in the pore water of the rock adjacent to the fractures. The water samples collected from pumping isolated sections of boreholes draw water from permeable fractures.

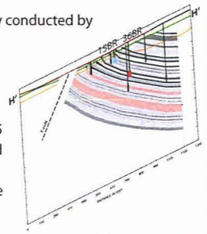


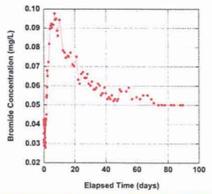
Characterizing Chemical Residence Times

Hydraulic tests provide valuable insight into preferential flow paths, but do not provide direct evidence of ground-water residence times and the magnitude of processes that control the retention of chemical constituents in fractured rock. In situ tracer tests provide a means of estimating formation properties that control the fate of ground-water contaminants and assist in the design and evaluation of remediation strategies.

In situ tracer tests are conducted by injecting a known mass of a dissolved constituent in the formation and monitoring its temporal arrival at one or more boreholes. Because of the heterogeneity of most fractured aquifers, and the sparse number of monitoring locations, tracer tests conducted under ambient ground-water flow conditions are unlikely to be successful. Tracer tests in fractured rock are usually conducted by pumping one or more locations to recover the injected tracer mass.

At the NAWC, the pumping wells operating in the pump-and-treat system were used to recover the tracer solutions injected in the formation. A converging tracer tests was conducted by injecting a bromide solution over approximately 1 hour into the open interval of 36BR, while 15BR was pumped continuously at approximately 8 gpm. 15BR and 36BR are separated by approximately 135 ft. The open interval of 36BR is down dip of the open interval of 15BR, and both wells intersect the same bedding-plane fracture. Hydraulic tests indicate that transmissivity of the bedding-plane fracture decreases in the down dip direction.





The decreasing transmissivity of the bedding-plane fracture with depth appears to retard the migration of the tracer solution to the pumped well. The stabilization of the bromide concentration approximately 70 days after the tracer injection indicates the significance of chemical diffusion into the intrinsic porosity of the rock.

JSGS Toxics Meeting January 2009

Geosyntec consultants

Bioaugmentation in Fractured Rock: A Long-Term Pilot Study at the NAWC Site

USGS science for a changing world

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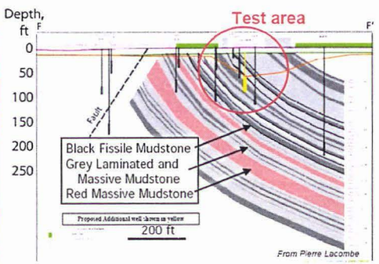
Abstract

The former Naval Air Warfare Center in West Trenton, NJ (Site) has been the subject of an active groundwater remediation program since 1994. Historical releases of chlorinated volatile organic compounds (CVOC), principally trichloroethene (TCE), led to the presence of elevated concentrations of these compounds in the subsurface bedrock aquifer. The current remedial system is based on extraction and treatment of contaminated groundwater and has been operating since 1997. The primary purpose of the system was to contain the CVOC plume and prevent off-Site migration. The concentrations of CVOC in groundwater at monitoring points have generally decreased in the period from 1997 to the present, but remained above groundwater quality standards.

A large-scale pilot study was designed to test bioaugmentation as a remedy at the Site, an approach that includes the addition of a culture containing TCE degrading bacteria and a substrate to sustain growth and activity. Extensive research was conducted by the U. S. Geological Survey (USGS) and the U.S. Navy to characterize the bedrock matrix and flow pathways. The test area is bounded by four monitoring wells that were used as well pairs for injection and extraction to distribute KB-1™, a culture containing *Dehalococcoides ethenogenes* (DHE) and EOS®, an emulsified edible oil electron donor substrate. Injections of bacteria and the electron donor occurred in July 2005. Three years of post-injection monitoring was performed. A second, smaller scale injection of electron donor was conducted in July 2008 to re-establish the concentration of donor in the test plot and to evaluate groundwater quality during extended pumping. Substantial reductions of CVOC concentrations at the wells have been measured.

Site Description/Characterization

Former Naval Air Warfare Center, West Trenton, NJ



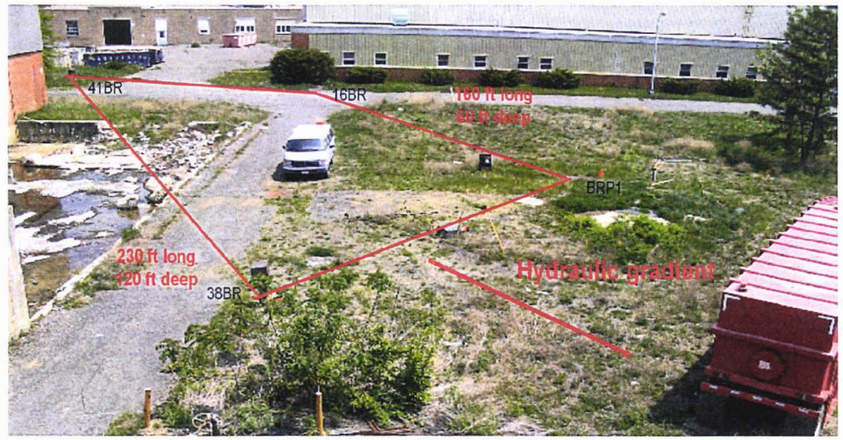
Subsurface: Dipping Lockatong Mudstones

- The Lockatong Formation: laminated to thick mudstones, highly variable primary porosity. Groundwater is conveyed through fractures and joints.
- Concentrations of TCE in the test plot ranged from 206 µg/L to 15,800 µg/L.
- Estimated hydraulic conductivity (non-pumping conditions) range from 0.08 ft/day to 130 ft/day, indicating the heterogeneity of the bedrock system (Brown et al, 2003).
- It is estimated that 10,000 gallons of TCE was released to bedrock over the 50 year history of the NAWC.

Pilot Study Implementation

Electron Donor and KB-1™ Injection

- Injections of EOS® (2% by volume in groundwater) and KB-1® were performed in July 2005.
- Two injection techniques were used:
  - (1) Groundwater recirculation using a well pair or clean groundwater and a flow-proportional pump, or
  - (2) Injection under pressure through an inflated packer into a low permeability well (38BR).
- Approximately 4,000 gallons of water and 110 gallons of EOS® were injected (pH neutralized to ~7).
- KB-1™ was added after an initial injection of EOS® amended water and followed by a longer injection period to aid distribution of the culture. A total of 120L of the concentrated (10^{11} gene copies per liter) culture was injected.
- To date, 15 monitoring events have been performed, through November 2008.
- Injection was followed by an addition of a volume of unamended water equal to the volume of the open interval to clear the well screen ("chase water").

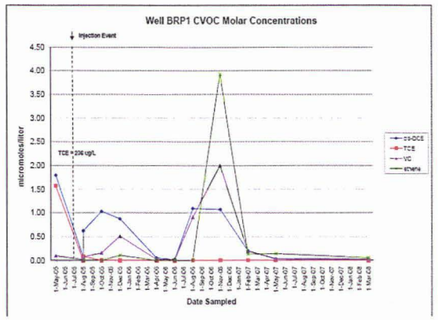


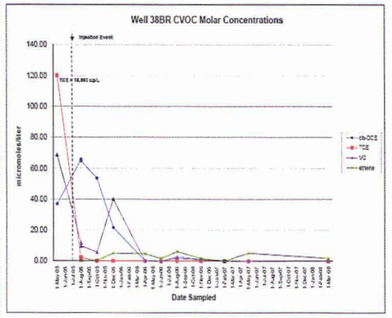
View of the Bioaugmentation Test Plot at NAWC

Results : First Injection

Monitoring

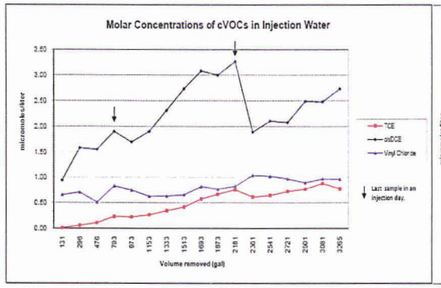
- EOS® was monitored using Total Organic Carbon (TOC), Chemical Oxygen Demand (COD) and Volatile Fatty Acids (VFA).
- DHE was tracked using quantitative polymerase chain reaction (PCR) at the SiREM Laboratory.
- Groundwater monitoring included field parameters (ORP, pH, dissolved oxygen, specific conductance, turbidity, and temperature), VOCs, dissolved gases (methane, ethane, ethene, and carbon dioxide), and inorganic parameters (sulfate, sulfide, nitrate, nitrite, chloride, ortho-phosphate, alkalinity).
- The injection event was followed by 15 monitoring events over three years.

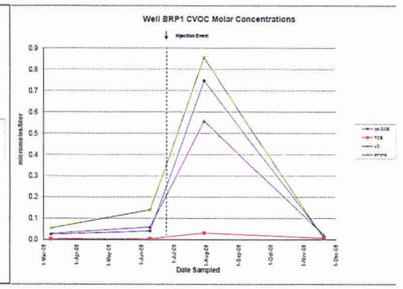




Second Injection

- A second injection of electron donor solution was performed in July of 2008 to achieve three objectives (1) re-establish concentrations of donor in the plot, (2) repeat a well-pair injection from the first event to determine the distribution of donor in the plot, and (3) to examine groundwater water quality during a long-term pumping event, allowing the collection of samples from distances beyond the monitoring wells.
- The injection well pair used was BRP-1 for injection and 41BR for extraction.
- Concentrations of CVOC in groundwater removed from 41BR and injected in BRP1 increased during pumping (below left) indicating the presence of partially treated target compounds in the plot.
- CVOCs at wells BRP-1 (below right) and 41BR were degraded four months after injection.





Conclusions

- Three years after the initial injection event, concentrations of COVC in groundwater at the monitoring wells are compliant with NJDEP groundwater quality standards with the exception of vinyl chloride at well BRP-1 (3.7 µg/L) and 16BR (3.0 µg/L).
- Concentrations of CVOC measured in groundwater extracted during extended pumping for the second injection event indicate incomplete degradation at some distance from the wells in the plot which may be the result of depleted electron donor in the plot or discrete zones where direct contact between the injected materials and the CVOC was not achieved.
- EOS®, measured as TOC, was largely depleted after 12 to 15 months.
- High concentrations of viable DHE have been measured at each well throughout the study.
- Two injection techniques have been tested, one for zones with moderate to high hydraulic conductivity (well pair pumping and injection) and one for low conductivity zones (low pressure injection).
- Understanding the detailed geologic framework of the bedrock formation is critical to the success of the application.
- Bioaugmentation is a promising technology for the treatment of high concentrations of CVOC in fractured bedrock.
- Current research being conducted under the SERDP program by USGS and Geosyntec at NAWC includes a detailed comparison of the rates of removal of CVOC under natural attenuation, pumping, and bioaugmentation conditions.