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FINAL TECHNICAL MEMORANDUM FOR CONSIDERATIONS FOR RISK MANAGEMENT
SITE 16 SITE SCREENING AREA 16 NWS YORKTOWN VA
2/25/2013
CH2MHILL

Considerations for Risk Management at Site 16 / Site Screening Area 16

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Purpose

The purpose of this technical memorandum is to demonstrate that the groundwater and soil institutional controls identified in the September 1995 Record of Decision (ROD) for Site 16/Site Screening Area (SSA) 16 (Baker, 1995a) are not necessary for protection of human health or the environment based on a re-evaluation of the existing soil and groundwater data and resampling of those monitoring wells that have shown potential irregularities in their chemical analysis during the Round I Confirmation Study, Round One Remedial Investigation (RI), and Round Two RI. The selected remedy in the 1995 ROD was No Further Action (NFA) with Institutional Controls, following a soil and debris removal action conducted in 1994. The institutional controls comprise land-use controls (LUCs) preventing residential development and a groundwater use restriction preventing its use as potable water. Supported by multiple lines of evidence, the Department of the Navy (Navy) is proposing that an Explanation of Significant Difference (ESD) be developed to remove the institutional control requirements from the 1995 ROD, clarify that all media at Site 16/SSA 16 are suitable for unlimited use and unrestricted exposure, and document this site is closed with NFA for the protection of human health or the environment.

Site Setting and History

Site 16, the West Road Landfill, is located adjacent to West Road near Lee Road on Naval Weapon Station (WPNSTA) Yorktown. The landfill operated from the 1950s to the early 1960s. Wastes reportedly disposed at the site included dry carbon batteries, banding materials, pressure-transmitting fluid, other chemicals, and 55-gallon drums with unknown contents.

The boundary of SSA 16, the Building 402 Metal Disposal Area and Environs, overlaps the boundary of Site 16. SSA 16 was used for scrap metal storage. Because of overlapping geographic locations, previous investigations of Site 16 and SSA 16 were conducted concurrently. **Figure 1** shows approximate site boundaries.

Site 16 was first identified as a potential source of contamination during the 1984 Initial Assessment Study (IAS) (NEESA, 1984). Due to the waste materials reportedly disposed at the site and the location of the site upgradient of a wetland adjacent to Felgates Creek, Site 16 was recommended for further investigation in a confirmation study.

The confirmation study at Site 16 was conducted as a two-round investigation in 1984 (Dames and Moore, 1986) and 1988 (Dames and Moore, 1988). Site 16 groundwater and surface water and sediment from the tributary to Felgates Creek downgradient of Site 16 were collected during these two rounds of sampling.

Five groundwater samples, two surface water samples, and two sediment samples were collected during the Round I Confirmation Study (Dames and Moore, 1986). The analytical results indicated minimal site impacts to groundwater, surface water, and sediment. Methylene chloride, acetone, and phthalates were detected in several groundwater, surface water, and sediment samples; however, these constituents were considered to be laboratory contaminants. The only other detected volatile organic compound (VOC) was 1,1,1-trichloroethane (TCA), which was detected in groundwater from one well (16GW01) at a concentration of 110 micrograms per liter (µg/L). Several polycyclic aromatic hydrocarbons (PAHs) were detected in one sediment sample located slightly upgradient of the site. Total metals concentrations of antimony, lead, and zinc were detected in groundwater. Antimony was detected in three of five groundwater samples at concentrations of up to 12.7 µg/L. Lead was detected in four of the five groundwater samples at concentrations up to 1.8 µg/L. Zinc was detected in all five groundwater samples at concentrations up to 72 µg/L. Arsenic was detected in sediment and chromium was detected in sediment and surface water at concentrations not exceeding any applicable screening criteria. In order to confirm reproducibility of these results, the Round I Confirmation Study Report (Dames and Moore, 1986) recommended additional sampling for the same constituents.

During the Round II Confirmation Study (Dames and Moore, 1988), four groundwater samples, two surface water samples, and two sediment samples were collected from the same locations sampled during the Round I investigation with the exception of 16GW01, which was not sampled because it was dry. Levels of copper and phenols slightly exceeded the Virginia Criteria for the protection of aquatic life in surface water in one of the two samples collected. Of the constituents detected in sediment, none exceeded screening criteria and the metals concentrations were within background. Methylene chloride and phthalates were detected in several groundwater samples but were considered to be laboratory contaminants. Three chlorinated VOCs (1,1,1-TCA; 1,1-dichloroethane [DCA]; and 1,1-dichloroethene [DCE]) were detected in one groundwater sample. The only organic constituent that exceeded an applicable screening value was 1,1-DCE. This compound was detected at a concentration of 10 µg/L, 3 µg/L in excess of the maximum contaminant level (MCL) of 7 µg/L. Copper and zinc were detected in one or more groundwater samples at low concentrations not exceeding any applicable screening criteria. Antimony and lead were not detected in any groundwater samples during this investigation. The Round II Confirmation Study Report (Dames and Moore, 1988) did not include recommendations for further study.

A Round One RI for Site 16/SSA 16 was conducted in 1992 and included sampling of site soil, sediment, surface water, and groundwater (Baker and Weston, 1993). Analytical results of 14 soil samples collected at Site 16/SSA 16 indicated minimal site impact to soils. The only constituent detected in soils at a concentration exceeding an applicable screening value was arsenic, which was detected at a concentration of 1.7 milligrams per kilogram (mg/kg), 0.4 mg/kg in excess of the industrial risk-based concentration (RBC) for arsenic of 1.3 mg/kg. Groundwater samples were collected from the five existing wells at Site 16. Results were similar to those detected during the confirmation studies. Chlorinated VOCs were detected at concentrations not exceeding applicable screening values. Inorganic concentrations of aluminum, antimony, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel and zinc exceeded either the federal MCLs or the Virginia Primary Drinking Water Standards in samples from one or more monitoring wells. Chlorinated VOCs and metals were also detected in surface water. PAHs, inorganics, and polychlorinated biphenyls (PCBs) were detected in sediment. Based on these data, it was recommended that additional groundwater, surface water, sediment, benthic macro-invertebrate, and fish tissue sampling be conducted at Site 16/SSA 16 under a Round Two RI in order to further evaluate potential risks to human health and the environment at the site.

In 1994, a removal action was conducted at Site 16 (IT, 1995). The entire contents of the landfill and the metal debris area including approximately 420 tons of batteries, 60 tons of debris, 125 tons of silica gel, and other miscellaneous debris and buried waste, were removed from the site. Confirmation soil sampling was conducted following the removal of the waste material. Confirmation samples indicated concentrations of PCBs and one PAH (benzo[a]pyrene) above applicable screening criteria.

In late 1994, a Round Two RI (Baker, 1995b) was conducted to evaluate the risk and nature and extent of contamination at Site 16/SSA 16 following the removal action. Sampling included site soils, groundwater, surface water, sediments, and biota. The only unacceptable risks identified during the human health risk assessment (HHRA) conducted using the Round Two RI data were based on the residential use scenarios, and were associated with arsenic, antimony, and manganese in groundwater and antimony, arsenic, cadmium, chromium, and Arochlor-1254 in surface soil. **Attachment 1** includes the HHRA from the RI. A total of 13 surface soil, 17 subsurface soil, and 9 groundwater samples were collected as part of this RI, and all samples were analyzed for target compound list organics and target compound list inorganics. **Attachment 2** includes a sampling location map as well as maps identifying positive detections of organic and inorganic constituents in soils and groundwater.

In September 1995, a ROD (Baker, 1995a) was completed for Site 16/SSA 16. Although all waste had been removed at Site 16/SSA 16, the remedy included in the ROD was NFA with institutional controls to restrict residential land use and potable use of site groundwater. The reason for the selected remedy was related to potential risks from inorganics in surface soil and groundwater as detailed below. [1]

A review of the historical data suggested potential analytical interference associated with the antimony groundwater data. Consequently, in August 2012 additional groundwater sampling was conducted at Site 16 monitoring wells (6GW05 and 6GW07) for antimony, as agreed upon by the Navy, United States Environmental Protection Agency (USEPA), and Virginia Department of Environmental Quality (VDEQ), in order to further evaluate current groundwater concentrations of antimony. Neither total nor dissolved concentrations of antimony were detected in either monitoring well sample.

Groundwater Considerations

Groundwater risk drivers identified during the Round Two RI (Baker, 1995b) included antimony, arsenic, and manganese. Restrictions on use of groundwater as a potable water source were included in the ROD to address risks from ingestion of these inorganics. Considerations for the termination of these restrictions are provided in the sections that follow based on the detected concentrations of these inorganics compared to the federal MCLs.

Background

All total and dissolved concentrations of antimony, total concentrations of arsenic, and total concentrations of manganese from the Round Two RI (Baker, 1995b) were below maximum background values for these constituents. Dissolved concentrations of arsenic exceeded the maximum detected background concentration for this constituent in the sample from 16GW09 only. Dissolved concentrations of manganese exceeded the maximum detected background concentration for this constituent in samples from two locations (16GW04 and 16GW09). **Figure 1** shows Round Two RI concentrations of antimony, arsenic, and manganese from the September 1994 field investigation. **Table 1** summarizes Site 16/SSA 16 concentrations compared to background values for WPNSTA Yorktown.

TABLE 1
Antimony, Arsenic, and Manganese Concentrations in Groundwater (Round Two RI data, September 1994)

		Site 16 / SSA 16 Concentrations (µg/L)					Background Concentrations (µg/L)		
		Minimum	Maximum	Detects	Mean	95% Upper Confidence Limit (UCL)	Minimum	Maximum	Detects
Antimony	Total	< 12.4	< 12.4	0 / 10	--	--	16.4	16.4	1 / 18
	Dissolved	13.1	19.3	2 / 10	8.2	10.8	16.7	21.1	5 / 18
Arsenic	Total	3	21.4	5 / 10	4.9	8.5	3.5	36.4	6 / 18
	Dissolved	5.9	5.9	1 / 10	1.8	2.6	3	5.5	2 / 18
Manganese	Total	9.9	146	10 / 10	47.3	75.4	4.5	413	18 / 18
	Dissolved	1.1	114	10 / 10	27.9	50	1.1	54.4	15 / 18

[1] The selected remedy did not consider individual target organ effects or take into account current metal background levels used for risk management purposes.

1995 Round Two RI Human Health Risks

Hazard quotients (HQs) are calculated for individual analytes and are used to evaluate noncarcinogenic health effects during the HHRA process. An HQ above unity represents an unacceptable potential hazard related to an individual analyte. HQs for individual chemicals of potential concern (COPCs) are typically summed to produce a hazard index (HI) that represents a conservative, quantitative estimate of potential hazards associated with exposure to site contaminants. HIs above unity represent an unacceptable potential hazard related to cumulative exposure to multiple analytes. HQs that have the potential to impact the same target organs can be summed to produce HIs specific to individual organs. These HIs are more representative of potential hazards because they are target organ-specific. Risk calculations from the Round Two RI are included as **Attachment 3**.

For this site, the HI calculated by summing all HQs for ingestion of groundwater was 3 for the future child resident and 1.3 for the future adult resident (**Attachment 3**, Tables L-10 and L-17). However, these are not the HIs calculated by summing HQs of chemicals that affect the same target organ. Individual target organ HIs for each risk driver are described as follows.

Antimony in Groundwater

The 1995 HHRA determined an HQ of 1.7 for the future child resident and 0.74 for the future adult resident for ingestion of antimony in site groundwater. Ingestion of antimony can have critical hematological effects. None of the other COPCs at this site affect the body in this way, so antimony's HQ of 1.7 represents the cumulative target organ HI for hematological effects. Similarly, for the adult, the HQ of 0.74 represents the HI for hematological effects. Therefore, the unacceptable hazard resulting from exposure to antimony is for the future child resident only, but, as noted in the previous section, the concentrations of antimony at the site are below background concentrations.

Arsenic in Groundwater

The 1995 HHRA determined an HQ of 0.55 for the future child resident and 0.24 for the future adult resident for ingestion of arsenic in site groundwater. The noncarcinogenic target organ effect from arsenic is on the skin and the vascular system. No other COPCs at the site have this same target organ. Therefore, the potential hazards from arsenic on the skin and vascular systems of both future adult and child residents are acceptable (that is, below unity). Note that the carcinogenic risks to the future child and adult due to ingestion of arsenic in groundwater were also within acceptable ranges (between 1×10^{-4} and 1×10^{-6}).

Manganese in Groundwater

The 1995 HHRA determined an HQ of 0.64 for the future child resident and 0.27 for the future adult resident for ingestion of manganese in site groundwater. Knowing that the target organ effect from manganese is on the central nervous system (CNS) and no other COPCs at the site have this same target organ, the potential hazards from manganese on the CNS of both future adult and child residents are acceptable (that is, below unity).

Further, the maximum level of daily nutrient intake of manganese that is likely to pose no risk of adverse effects for children ages 7 months to 8 years is 0.13 milligrams per kilogram per day (mg/kg-day) (NAS, 2001). Using the conservative assumptions for the child (15 kilogram child drinking 1 liter of groundwater per day) and the exposure concentration of 50 µg/L of manganese, one could estimate the potential manganese ingestion for a child at this site as follows:

$$\frac{50\ \mu\text{g}/L \times \frac{1\text{ mg}}{10^3\,\mu\text{g}}}{15\text{ kg}} \times 1\text{ L/day} = 0.003\text{ mg/kg-day of manganese}$$

Therefore, in addition to the HQ determined for manganese, ingestion of manganese at this level at this site by a resident child would be almost two orders of magnitude below the maximum acceptable daily nutrient intake. A similar result is obtained even if the exposure concentration of 75.4 µg/L for total manganese is assumed.

Source Removal

The contents of the landfill and metal disposal area associated with Site 16/SSA 16 that may potentially have impacted groundwater have been removed and disposed offsite. Therefore, contaminant sources have been removed, the potential for future releases has been mitigated, and the risks previously calculated are expected to be appropriate for current and future site conditions.

Comparison to Maximum Contaminant Levels

Of the three groundwater risk drivers, antimony was the only inorganic that exceeded its applicable federal primary MCL (6 µg/L) in dissolved groundwater. Manganese exceeded its secondary MCL of 50 µg/L. Arsenic concentrations did not exceed the federal MCL of 50 µg/L at the time of the Round Two RI. The MCL has been modified since this document was produced; however, the highest dissolved arsenic concentration of 5.9 µg/L remains below the current MCL of 10 µg/L.

Partnering Team Discussion

Additional concerns were expressed by the USEPA with regards to the antimony concentrations exceeding MCLs in groundwater. It was determined that an additional round of groundwater samples for total and dissolved antimony would be collected. Project Action Limits (PALs) were developed as follows:

- Tap water Regional Screening Level (RSL) – 6 µg/L
- Federal MCL – 6 µg/L

It was agreed by the Team that if the most recent antimony groundwater samples were non-detect or below the PALs, then antimony does not pose an unacceptable risk to human health and that NFA would be necessary for groundwater.

August 2012 Groundwater Sampling Event

Two additional samples were collected and analyzed for antimony in August 2012 from the monitoring wells (16GW05 and 16GW07) that had shown detectable levels of dissolved antimony during the Round I Confirmation Study, Round One RI, and Round Two RI. Each monitoring well was sampled using low-flow sampling protocol and water quality parameters were stabilized over three consecutive readings prior to sample collection. There were no concentrations of antimony detected during the August 2012 sampling above the PALs. The results are presented in **Table 2** and on **Figure 1**.

TABLE 2
Antimony Concentrations in Groundwater (August, 2012)

	Site 16 / SSA 16 Concentrations (µg/L)	
	16GW05	**16GW07**
Total Antimony	0.23 B	0.19 B
Dissolved Antimony	0.19 B	0.22 B

Notes:
B - Analyte not detected above the level reported in blanks

Soil Considerations

Surface Soil

Institutional controls restricting residential land use were put in place at Site 16/SSA 16 in order to address an overall cumulative site HI of 1.6 for surface soil ingestion by a future child resident identified in the Round Two RI HHRA (Baker, 1995b). This unacceptable risk was mainly due to antimony (HQ=0.28), arsenic (HQ=0.26), cadmium (HQ=0.24), chromium (HQ=0.31), and Aroclor-1254 (HQ=0.23) detected in surface soil (**Attachment 3**, Table L-8). Individual HQs for these constituents do not meet or exceed 1.0. Target organs affected by these chemicals include skin (arsenic), blood (antimony), renal cortex (cadmium), and the immune system (Aroclor-1254). Chromium in its hexavalent state can also affect the skin. Therefore, only HQs for chromium and arsenic should be summed to calculate a target organ HI for skin of 0.57. Therefore, none of the individual HQs or those summed for cumulative effects is greater than 1 and thus soils do not warrant the need for land use restrictions.

Subsurface Soil

Potential risks to potential future residents via exposure to subsurface soil at Site 16 and SSA 16 were not evaluated in the Round Two RI (Baker, 1995b). However, a risk evaluation has been prepared for the purpose of this technical memorandum. The methodology used to evaluate the risks and the results of this evaluation are presented as follows.

Human Health Risks

For the purpose of evaluating subsurface soil, screening Table 6-3 of the Round Two RI (Baker, 1995b) (**Attachment 1**) was used to compare the subsurface soil screening values to current USEPA RSLs for residential soil. Based on this review, the following COPCs for the subsurface soil were identified: aluminum, arsenic, chromium, iron, manganese, and vanadium. Although beryllium concentrations exceeded the corresponding 1995 RBC, site concentrations of beryllium do not exceed the corresponding current residential and industrial RSLs.

Subsurface soil exposure point concentrations (EPCs) were calculated for each of the identified COPCs. The Round Two RI included subsurface soil samples collected from all depths, including depths greater than 15 feet below ground surface (bgs), to evaluate construction worker exposure to subsurface soil. It is unlikely soil at depths greater than 15 feet bgs would be contacted during construction activities or future residential use when subsurface soil could become surface soil. Therefore, EPCs were calculated without these deep subsurface soil samples.

ProUCL was used to determine the distribution and calculate the appropriate 95 percent UCL. The EPCs and data distributions are shown in **Table 3**.

Noncarcinogenic hazards to the child and adult residents were calculated based on EPCs. Carcinogenic risks were not calculated separately for the child and adult residents, but were calculated for a lifetime resident taking into account the differences in exposure from childhood to adulthood (body weights, daily soil ingestion rates, and exposure duration) that is anticipated for lifetime residents (USEPA, 1991). These calculations are shown in **Tables 4** through **6**. All of the exposure parameters used in the Round Two RI (Baker, 1995b) were incorporated into these calculations by using an adjustment of the chronic daily intake (and accounting for the omission of the soil collected at greater than 15 feet bgs), as shown in **Tables 4** through **6**. The toxicity data (toxicity information was updated from the Round Two RI, and current values were used) are shown in **Tables 7** and **8**.

Although the total noncarcinogenic hazard for child residents (3) exceeds USEPA's target HI of 1, none of the target organs have HIs above 1, as shown in **Table 4**. As shown in **Table 5**, the total noncarcinogenic hazard (0.9) for adult residents does not exceed USEPA's target HI of 1.

The total carcinogenic risk (3×10^{-4}) for the lifetime (child and adult) resident slightly exceeds USEPA's target risk range of 10^{-4} to 10^{-6}. The carcinogenic risk is primarily associated with chromium. The analytical data for chromium are for total chromium. However, the cancer slope factor used to calculate the carcinogenic risk is for hexavalent chromium, the more toxic (and carcinogenic) valence state of this metal. In the past, prior to including the New Jersey Environmental Protection Agency (New Jersey EPA) oral cancer slope factor for hexavalent chromium, USEPA's RSL table presented a Residential Soil RSL for total chromium assuming a one to six (1:6) ratio of hexavalent chromium to trivalent chromium. Assuming this ratio is applicable to soil at Site 16/SSA 16, the maximum concentration of hexavalent chromium (the total measured chromium concentration multiplied by 1/6, or 4.5 mg/kg) would not result in an unacceptable risk associated with exposure to chromium and the total carcinogenic risk for the lifetime resident would be within USEPA's target risk range.

Conclusions

In summary, the risk drivers identified for groundwater and soil are considered acceptable for unlimited use and unrestricted exposure for the following primary reasons:

Antimony in Groundwater

- All detected total and dissolved concentrations are below the maximum background concentrations.
- Additional groundwater samples collect in August 2012 indicate that there were no detectable total or dissolved concentrations.

Manganese in Groundwater

- The future adult resident and future child resident target organ HIs for ingestion of manganese in groundwater are below unity.

Arsenic in Groundwater

- The future adult resident and future child resident target organ HIs for ingestion of arsenic in groundwater are below unity. Carcinogenic effects from arsenic are also within the acceptable risk range.

Soils

As previously discussed, assuming a 1:6 ratio of trivalent chromium to hexavalent chromium, chromium would not result in an unacceptable risk and the total carcinogenic risk for the adult resident would be within USEPA's target risk range. No other metals drove risk to human health or the environment; thus, NFA is required for unlimited use and unrestricted exposure with regards to soil.

Recommendations

Based on these conclusions, the Navy recommends that the LUCs and aquifer restrictions at Site 16/SSA 16 be rescinded because they are not necessary in order for the site constituent concentrations to be adequately protective of human health or the environment. Consequently, it is recommended that an ESD be prepared to remove the institutional control requirements from the 1995 ROD, clarify that all media at Site 16/SSA 16 meet unlimited use and unrestricted exposure, and document this site is closed with NFA for the protection of human health or the environment.

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TABLE 3

Medium-Specific Exposure Point Concentration Summary

Site 16 and SSA 16, Yorktown Weapons Station

Scenario Timeframe: Current
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil

Exposure Point	**Chemical of Potential Concern**	**Units**	**Arithmetic Mean**	**95% UCL of Mean (N/T)**		**Maximum Concentration (Qualifier)**		**Exposure Point Concentration**			
								Value	**Units**	**Statistic**	**Rationale**
Subsurface Soil											
	Aluminum	MG/KG	1.0E+04	1.5E+04	(G)	2.8E+04		1.5E+04	MG/KG	App. G	1, 3, 4
	Arsenic	MG/KG	7.1E+00	2.0E+01	(NP)	3.8E+01	L	2.0E+01	MG/KG	95% Cheb	1
	Chromium	MG/KG	1.8E+01	2.7E+01	(G)	5.7E+01		2.7E+01	MG/KG	App. G	1, 3, 4
	Iron	MG/KG	1.1E+04	1.5E+04	(G)	3.9E+04		1.5E+04	MG/KG	App. G	1, 3, 4
	Manganese	MG/KG	4.7E+01	7.8E+01	(G)	1.2E+02	J	7.8E+01	MG/KG	App. G	4
	Vanadium	MG/KG	2.4E+01	3.5E+01	(G)	5.8E+01		3.5E+01	MG/KG	App. G	1, 3, 4

For duplicate sample results, the maximum value was used in the calculation.

ProUCL, Version 4.1 used to determine distribution of data using the Shapiro-Wilk W Test. ProUCL used to calculate RME EPC, following recommendations based on distribution and standard deviation in users guide (USEPA. May 2010. ProUCL, Version 4.1. Prepared by Lockheed Martin Environmental Services).

Options: Maximum Detected Value (Max); 95% Student's-T test UCL (95% Stud-t); 95% Chebyshev (Mean, Sd) UCL (95% Cheb); 95% Approximate Gamma (App. Gamma)

(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.

(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.

(3) Anderson-Darling Test indicates data are gamma distributed.

(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.

(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).

(6) The maximum detected concentration was used as the UCL because the value recommended by ProUCL 3.0 was higher than the Max.

MG/KG = milligrams per kilogram

G = Gamma distribution.

NP = Non-Parametric distribution.

TABLE 4

Child Resident

Ingestion

Constituent	EPC (MG/KG)	CDI, noncarc (1/Day)	RfD oral $(MG/KG\text{-}day)^{-1}$	HI	Noncancer Target Organ
Aluminum	1.5E+04	1.3E-05	1.0E+00	2E-01	Neurological
Arsenic	2.0E+01	1.3E-05	3.0E-04	9E-01	Skin/Vascular
Chromium	2.7E+01	1.3E-05	3.0E-03	1E-01	Not identified
Iron	1.5E+04	1.3E-05	7.0E-01	3E-01	Gastrointestinal
Manganese	7.8E+01	1.3E-05	2.4E-02	4E-02	CNS
Vanadium	3.5E+01	1.3E-05	5.0E-03	9E-02	Hair
Ingestion Total				2E+00	

EPC - calculated on Table 3

RfD from Table 7

CDI, noncarc - from Baker RI, Table L-8, the CDI NONCARC presented on Table L-8 divided by the EPC on Table L-8.

Dermal

Constituent	EPC (MG/KG)	CDI, noncarc (1/Day)	RfD dermal $(MG/KG\text{-}day)^{-1}$	HI	Noncancer Target Organ
Aluminum	1.5E+04	1.4E-06	1.0E+00	1E-01	Neurological
Arsenic	2.0E+01	4.1E-06	3.0E-04	3E-01	Skin/Vascular
Chromium	2.7E+01	1.4E-06	7.5E-05	5E-01	Not identified
Iron	1.5E+04	1.4E-06	7.0E-01	3E-02	Gastrointestinal
Manganese	7.8E+01	1.4E-06	8.0E-04	1E-01	CNS
Vanadium	3.5E+01	1.4E-06	1.3E-04	4E-01	Hair
Dermal Total				1E+00	

EPC - calculated on Table 3

RfD from Table 7

CDI, noncarc - from Baker RI, Table L-9, the CDI NONCARC presented on Table L-9 divided by the EPC on Table L-9, however incorrect ABS for arsenic used on table, so corrected value to 0.03.

Soil Total	3E+00

Note - no target organs with hazard index (HI)>1, so hazard within acceptable range.

TABLE 5

Adult Resident

Ingestion

Constituent	EPC (MG/KG)	CDI, noncarc (1/Day)	RfD oral $(MG/KG\text{-}day)^{-1}$	HI	Noncancer Target Organ
Aluminum	1.5E+04	1.4E-06	1.0E+00	2E-02	Neurological
Arsenic	2.0E+01	1.4E-06	3.0E-04	9E-02	Skin/Vascular
Chromium	2.7E+01	1.4E-06	3.0E-03	1E-02	Not identified
Iron	1.5E+04	1.4E-06	7.0E-01	3E-02	Gastrointestinal
Manganese	7.8E+01	1.4E-06	2.4E-02	4E-03	CNS
Vanadium	3.5E+01	1.4E-06	5.0E-03	1E-02	Hair
Ingestion Total				2E-01	

EPC - calculated on Table 3

RfD from Table 7

CDI, noncarc - from Baker RI, Table L-15, the CDI NONCARC presented on Table L-15 divided by the EPC on Table L-15.

Dermal

Constituent	EPC (MG/KG)	CDI, noncarc (1/Day)	RfD dermal $(MG/KG\text{-}day)^{-1}$	HI	Noncancer Target Organ
Aluminum	1.5E+04	7.3E-07	1.0E+00	1E-02	Neurological
Arsenic	2.0E+01	2.2E-06	3.0E-04	1E-01	Skin/Vascular
Chromium	2.7E+01	7.3E-07	7.5E-05	3E-01	Not identified
Iron	1.5E+04	7.3E-07	7.0E-01	2E-02	Gastrointestinal
Manganese	7.8E+01	7.3E-07	8.0E-04	7E-02	CNS
Vanadium	3.5E+01	7.3E-07	1.3E-04	2E-01	Hair
Dermal Total				7E-01	

EPC - calculated on Table 3

RfD from Table 7

CDI, noncarc - from Baker RI, Table L-16, the CDI NONCARC presented on Table L-16 divided by the EPC on Table L-16.

Soil Total	9E-01

Note - no target organs with hazard index (HI)>1, so hazard within acceptable range.

TABLE 6

Lifetime (Adult and Child) Resident

Ingestion

Constituent	EPC (MG/KG)	CDI, Carc (MG/KG-Day)	CSF oral (MG/KG-Day)	Cancer Risk
Aluminum	1.5E+04	1.6E-06	NA	
Arsenic	2.0E+01	1.6E-06	1.5E+00	5E-05
Chromium	2.7E+01	1.6E-06	5.0E-01	2E-05
Iron	1.5E+04	1.6E-06	NA	
Manganese	7.8E+01	1.6E-06	NA	
Vanadium	3.5E+01	1.6E-06	NA	
Ingestion Total				7E-05

EPC - calculated on Table 3

CSF from Table 8

Ingestion: CDI, Carc = (EDc*IRc/BWc) + (EDa*IRa/BWa)*CF*EF*1/ATc

using exposure assumption values from Baker RI, Table L-8 for child resident (EDc, IRc, BWc)

and Table L-15 for adult resident (EDa, IRa, BWa).

Dermal

Constituent	EPC (MG/KG)	CDI, Carc (MG/KG-Day)	CSF dermal $(MG/KG\text{-}day)^{-1}$	Cancer Risk
Aluminum	1.5E+04	3.6E-07	NA	
Arsenic	2.0E+01	1.1E-06	1.5E+00	3E-05
Chromium	2.7E+01	3.6E-07	2.0E+01	2E-04
Iron	1.5E+04	3.6E-07	NA	
Manganese	7.8E+01	3.6E-07	NA	
Vanadium	3.5E+01	3.6E-07	NA	
Dermal Total				2E-04

EPC - calculated on Table 3

CSF from Table 8

Dermal: CDI, Carc = (EDc*SAc*AF/ BWc) + (EDa*SAa*AF/BWa)*CF*EF*1/ATc

using exposure assumption values from Baker RI, Table L-9 for child resident (EDc, SAc, BWc)

and Table L-16 for adult resident (EDa, SAa, BWa).

Soil Total	3E-04

TABLE 7

Non-Cancer Toxicity Data -- Oral/Dermal

Site 16 and SSA 16, Yorktown Weapons Station

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Aluminum	Chronic	1.0E+00	mg/kg-day	NA	1.0E+00	mg/kg-day	Neurological	100	PPRTV	10/23/2006
	Subchronic	1.0E+00	mg/kg-day	NA	1.0E+00	mg/kg-day	Neurological	30	ATSDR	9/1/2008
Arsenic	Chronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin/Vascular	3/1	IRIS	12/13/2012
	Subchronic	3.0E-04	mg/kg-day	95%	3.0E-04	mg/kg-day	Skin/Vascular	3	HEAST	7/1/1997
Chromium (hexavalent)	Chronic	3.0E-03	mg/kg-day	2.5%	7.5E-05	mg/kg-day	Not identified	300/3	IRIS	12/13/2012
	Subchronic	5.0E-03	mg/kg-day	2.5%	1.3E-04	mg/kg-day	Blood	100	ATSDR	9/1/2008
Iron	Chronic	7.0E-01	mg/kg/day	NA	7.0E-01	mg/kg/day	Gastrointestinal	1.5	PPRTV	9/11/2006
	Subchronic	7.0E-01	mg/kg-day	NA	7.0E-01	mg/kg-day	Gastrointestinal	1.5	PPRTV	9/11/2006
Manganese (non-diet)	Chronic	2.4E-02	mg/kg-day	4%	8.0E-04	mg/kg-day	CNS	1	IRIS	12/13/2012
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese (diet)	Chronic	1.4E-01	mg/kg-day	100%	1.4E-01	mg/kg-day	CNS	1/1	IRIS	12/13/2012
	Subchronic	1.4E-01	mg/kg-day	100%	1.4E-01	mg/kg-day	CNS	1/1	HEAST	7/1/1997
Vanadium	Chronic	5.0E-03	mg/kg-day	2.6%	1.3E-04	mg/kg-day	Hair	100	IRIS/RSL	12/13/2012
	Subchronic	NA	NA	NA	NA	NA	NA	NA	NA	NA

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (Final).
Section 4.2 and Exhibit 4-1. USEPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%.
Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted Dermal RfD = RfD (oral) x Absorption Efficiency or ABS_{GI}

(3) For IRIS values, provided the date IRIS was searched.
For NCEA values, provided the date of the NCEA article provided.
For HEAST values, provided the date of HEAST document.
For PPRTV values, provided the date of PPRTV document.
For ATSDR values, provided the date of ATSDR toxicity profile.

ATSDR = Agency for Toxic Substance and Disease Registry

CNS = Central Nervous System

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

NA = Not Applicable

NCEA = National Center for Environmental Assessment

PPRTV = Provisional Peer-Reviewed Toxicity Assessment

RSL = Regional Screening Level Table

TABLE 8

Cancer Toxicity Data -- Oral/Dermal

Site 16 and SSA 16, Yorktown Weapons Station

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	EPA Carcinogen Group	Source	Date (2) (MM/DD/YY)
Aluminum	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.5E+00	95%	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	12/13/2012
Chromium (hexavalent)	5.0E-01	2.5%	2.0E+01	$(mg/kg\text{-}day)^{-1}$	D	NJEPA	4/8/2009
Iron	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final).
Section 4.2 and Exhibit 4-1. USEPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%.

(2) For IRIS values, provided the date IRIS was searched.
For NJEPA values, provided the date of NJEPA document.

IRIS = Integrated Risk Information System

NA = Not available

NJEPA = New Jersey Environmental Protection Agency

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

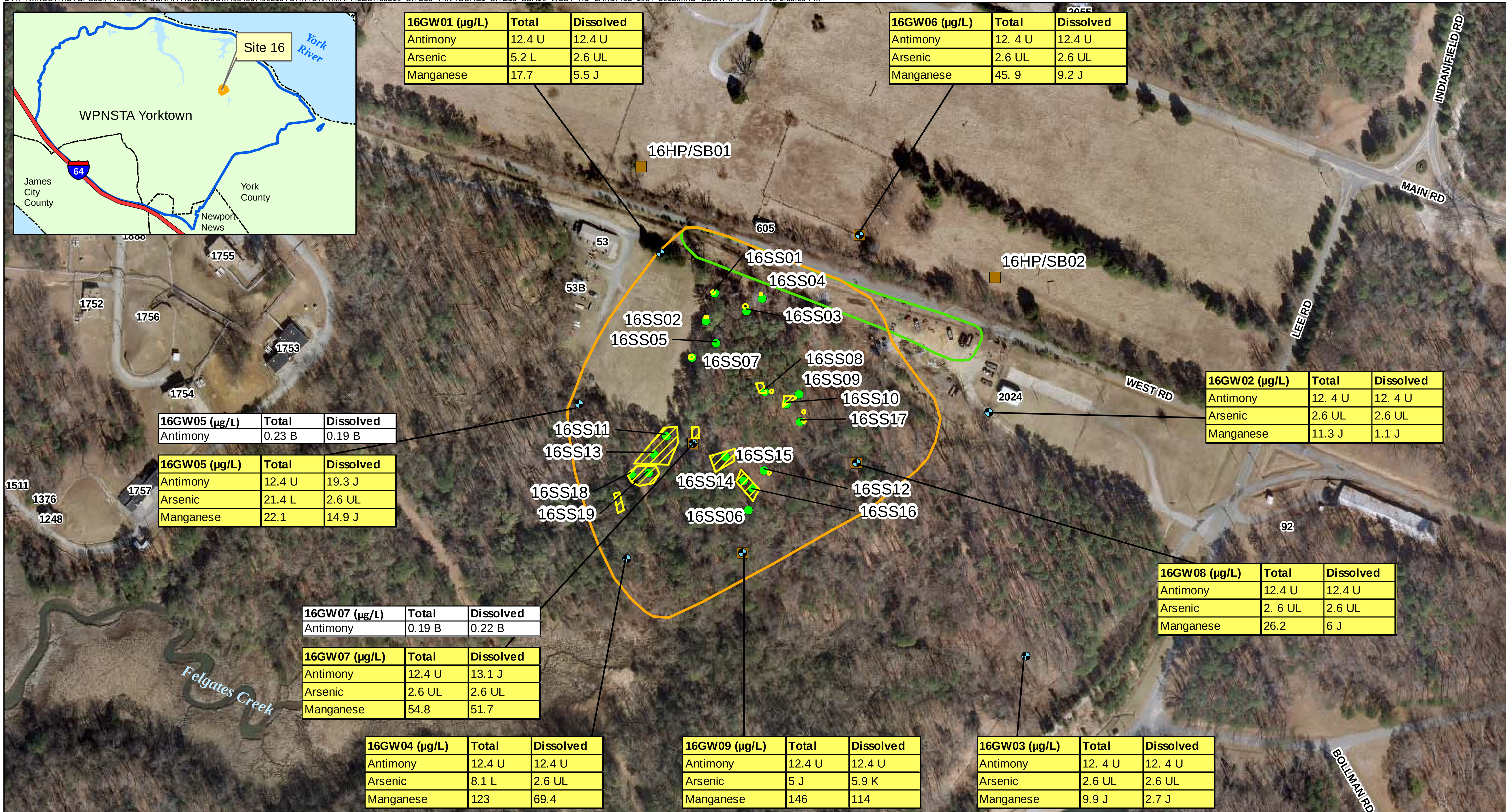
C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

Figure

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\400210YORKTOWN\MAPFILES\400210_SITE16_TM\FIGURE1_SITE16_SSA16_WEST_RD_LANDFILL_1994_2012.MXD CBOWMAN 1/7/2013 2:35:00 PM



16GW01 (µg/L)	Total	Dissolved
Antimony	12.4 U	12.4 U
Arsenic	5.2 L	2.6 UL
Manganese	17.7	5.5 J

16GW06 (µg/L)	Total	Dissolved
Antimony	12. 4 U	12.4 U
Arsenic	2.6 UL	2.6 UL
Manganese	45. 9	9.2 J

16GW02 (µg/L)	Total	Dissolved
Antimony	12. 4 U	12. 4 U
Arsenic	2.6 UL	2.6 UL
Manganese	11.3 J	1.1 J

16GW05 (µg/L)	Total	Dissolved
Antimony	0.23 B	0.19 B

16GW05 (µg/L)	Total	Dissolved
Antimony	12.4 U	19.3 J
Arsenic	21.4 L	2.6 UL
Manganese	22.1	14.9 J

16GW08 (µg/L)	Total	Dissolved
Antimony	12.4 U	12.4 U
Arsenic	2. 6 UL	2.6 UL
Manganese	26.2	6 J

16GW07 (µg/L)	Total	Dissolved
Antimony	0.19 B	0.22 B

16GW07 (µg/L)	Total	Dissolved
Antimony	12.4 U	13.1 J
Arsenic	2.6 UL	2.6 UL
Manganese	54.8	51.7

16GW04 (µg/L)	Total	Dissolved
Antimony	12.4 U	12.4 U
Arsenic	8.1 L	2.6 UL
Manganese	123	69.4

16GW09 (µg/L)	Total	Dissolved
Antimony	12.4 U	12.4 U
Arsenic	5 J	5.9 K
Manganese	146	114

16GW03 (µg/L)	Total	Dissolved
Antimony	12. 4 U	12. 4 U
Arsenic	2.6 UL	2.6 UL
Manganese	9.9 J	2.7 J

Legend

- Post Removal Soil Confirmation Sample
- Monitoring Well
- Subsurface Soil Sample Location
- Approximate SSA 16 Site Boundary
- Approximate Site 16 Boundary
- Approximate Waste Removal Area (Removed During 1994 Removal Action)

Note:
Waste removed from the site during the 1994 removal action included drums, batteries, steel cables, mine casings, inert scrap ordnance, and general debris.
Text boxes in white are from the August 2012 groundwater sampling event; text boxes in yellow are from the 1994 RI groundwater sampling event.
B - Analyte not detected above the level reported in blanks
µg/L - micrograms per Liter
UL - Not detected above associated value; detection limit may be biased low
J - Value flagged as estimated by data validator
U - Not detected above associated value
L - Value flagged as biased low by data validator
K - Value flagged as biased high by data validator

N W E S

0 100 200 Feet

Figure 1
Site 16 - West Road Landfill
SSA 16 - Building 402 Metal Disposal Area and Environs
Naval Weapons Station Yorktown
Yorktown, Virginia

CH2MHILL

Attachment 1
Round Two RI, HHRA (Baker, 1995)

6.0 HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment was performed as part of the RI/FS for Site 16/SSA 16 at WPNSTA Yorktown, to evaluate the potential risks associated with exposure to environmental media resulting from existing conditions at the site if no additional remedial action is undertaken. The baseline RA considers the most likely routes of potential human exposure for both current and future risk scenarios. The baseline RA was conducted in accordance with the Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989b), and the most recent updates. The baseline RA is comprised of nine sections; Section 6.1 presents an overview of the historical information for Site 16/SSA 16 pertinent to the development of the risk assessment technical approach. Section 6.2 presents the selection of chemicals of potential concern. Sections 6.3 and 6.4 present the Exposure Assessment and Toxicity Assessment, respectively. The risk characterization is presented in Section 6.5 and potential human health effects are provided in Section 6.6. Section 6.7 presents sources of uncertainty inherent in the estimation of inferential potential human health effects. A summary of the baseline RA is provided in Section 6.8 and total site risk to each potential human receptor is presented therein. Section 6.9 presents the references. Because the majority of SSA 16 overlies the northern portion of Site 16, the baseline RA addresses both areas as one site under consideration. A complete discussion of the spatial relationship between Site 16 and SSA 16 is included in Section 1.0; therefore, only a brief description is presented in the section below.

6.1 Site 16/SSA 16 Overview

Site 16 is a former landfill that reportedly received wastes such as dry carbon-zinc batteries and unknown types of chemicals. A removal action was conducted in 1994 to remove visible surface debris, including batteries, chemical drying agents, and mine casings (IT, 1995). SSA 16 is a former scrap metal storage area located along the northern border of, and overlying, Site 16. Access to the Site 16/SSA 16 is regulated by a fence which delineates the boundaries of the Station's Restricted Area, allowing only authorized personnel into the area. The site is vegetated primarily with trees and underbrush, but also includes open, grass-covered areas.

There are no drinking water wells at WPNSTA Yorktown; the coastal plain aquifer and other shallower aquifers are not used as a drinking water source. Drinking water is supplied by the City of Newport News. There are, however, five supply wells at WPNSTA Yorktown, located at Buildings 120, 352, 304, 28 (all for fire-fighting purposes), and Gate 13. Due to the poor water quality, the wells located at Buildings 120, 352, and 304, have been decommissioned and capped; a forth well at Building 28 was abandoned and filled with cement. The remaining well at Gate 13, which is located in the deeper Yorktown aquifer, is a newer well that supplies water to the toilet facilities associated with the weigh station. Though approved by the Virginia Department of Health for potable use, drinking water is supplied in the form of bottled water. Gate 13 is located in the western portion of WPNSTA Yorktown, several miles from Site 16/SSA 16.

6.2 Identification of Chemicals of Potential Concern

The selection of COPCs was based on the information provided in the USEPA Region III Technical Guidance on Selecting Exposure Routes and Contaminants of Concern, by Risk-Based Screening (SCCRBS), dated January 1993 (USEPA, 1993) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989b). COPC selection was completed for each environmental medium and area of concern using analytical data obtained during this RI as well as analytical data obtained after the removal action in 1994 (IT, 1995).

A discussion of laboratory analytical results and nature and extent of constituent contamination is presented in Section 4.0 of this report. In the RI report, chemicals detected in environmental media are discussed with respect to applicable Federal and Commonwealth standards and/or criteria. In these sections, a preliminary account of analytical results was presented. Chemicals detected in environmental media sampled during the RI were re-evaluated in this section to select COPCs for quantitative evaluation in the baseline RA. Chemicals selected as COPCs that could not be quantitatively evaluated, are discussed in the uncertainties section (Section 6.7) of the baseline RA.

6.2.1 COPC Selection Criteria

The primary criteria used in selecting a chemical as a COPC at Site 16/SSA 16 included comparing the maximum detected concentration to the USEPA Region III Chemicals of Concern (COC) Screening Table (USEPA, 1994e), in accordance with USEPA Region III SCCRBS guidance (USEPA, 1993).

In conjunction with concentration comparisons to the USEPA Region III COC screening table (COC values), a comparison to concentrations detected in Site 16/SSA 16 field and laboratory blanks was also conducted, to ensure that only site-related contaminants are evaluated in the quantitative estimation of human health effects (refer to Table 6-1). Furthermore, those constituents considered to be essential nutrients (which have relatively low toxicity) were not evaluated in this baseline RA.

The prevalence of a chemical detected in a given environmental medium, as well as the history of site-related activities are other important criteria applied in selecting COPCs at Site 16/SSA 16. Therefore, in conjunction with concentration comparisons to USEPA Region III COC Screening Concentrations (COC values) and evaluations of chemical prevalence, site history, and the assessment of essential nutrients, comparisons of groundwater, surface water, and sediment to available Commonwealth and Federal standards and criteria was conducted to determine whether chemicals eliminated by a direct comparison to COC values should be re-included as COPCs. Each of the aforementioned criteria are discussed in the paragraphs that follow.

USEPA Region III COC Screening Concentrations - Risk-Based COC Screening Concentrations (COC screening concentrations) were derived by USEPA, Region III in January 1993 and provided in tabular format to support selection of COPCs and address two major limitations in the COPC selection process presented in RAGS. First, using COC screening concentrations prioritizes chemical toxicity and focuses the risk assessment on those COPCs and potential exposure routes. Second, using the COC screening concentrations provides an absolute comparison of potential risks associated with the presence of a COPC in a given medium.

COC screening concentrations were derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. COC screening concentrations for potentially carcinogenic and noncarcinogenic chemicals were individually derived based on a target incremental lifetime cancer risk (ICR) of 1×10^{-06} and a target hazard quotient (HQ) of 0.1, respectively. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening concentrations are chronic oral and inhalation cancer slope factors; for noncarcinogens, they are oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of COC screening concentrations requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

In March 1994, USEPA Region III published a second COC screening table (COC values) which were also based on an ICR of 1 x 10^{-06} and a target HQ of 0.1. Subsequent publications of the table (i.e., Risk-Based Concentration [RBC] table) have included an ICR of 1 x 10^{-06} but an HQ of 1.0. However, since the RBCs are derived using similar equations and USEPA promulgated default exposure assumptions that were used to derive the COC values (USEPA, 1994e), the COC values can be updated from these RBC tables issued semi-annually by the USEPA Region III, by using the carcinogenic RBCs and dividing the accompanying noncarcinogenic RBCs by a factor of 10. An updated set of COC values can, therefore, be obtained each time the RBC Tables are updated. The COC values used in this baseline RA were derived from the RBC values issued by the USEPA Region III in the Fourth Quarter, 1994 (USEPA, 1994d).

In this baseline RA, the COC screening values derived for tap water will be applied to the screening of COPCs in groundwater and surface water, while those derived for residential soil exposures will be applied to the screening of COPCs in surface soils, subsurface soils, and sediments at Site 16/SSA 16.

Blank Concentrations - If a chemical is detected in both the environmental sample and a blank sample, it may not be retained as a COPC in accordance with RAGS depending on the concentration of the chemical in the media. Therefore, blank data were compared with results from environmental samples. If the blanks contained detectable results for common laboratory contaminants (i.e., acetone, 2-butanone, methylene, chloride, toluene, and phthalate esters), environmental sample results were considered as positive results only if they exceed 10 times the maximum amount detected in the associated blank. If the chemical detected in the blank(s) is not a common laboratory contaminant, environmental sample results were considered as positive results only if they exceeded five times the maximum amount detected in the associated blank(s). Furthermore, the elimination of an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

When assessing soil and sediment concentrations, the Contract Required Quantitation Limits (CRQLs) and percent moisture are accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile, pesticide and PCB contaminants the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of the aqueous samples; this correction is not necessary for the evaluation of volatile COPCs. Therefore, in order to assess contaminant levels in solid samples using an aqueous blank concentration, the concentration was multiplied by 5 or 10 (uncommon or common laboratory contaminants, respectively) and then multiplied by 33 to correct for the variance in the CRQL. Accounting for multipliers greater than 33 or the percent moisture was not necessary for this data set. Associated blanks for Site 16/SSA 16 included: field blanks, trip blanks, and equipment rinsate blanks.

The aforementioned methodologies for evaluating blanks are usually implemented during third party analytical data validation prior to the selection of COPCs in the risk assessment.

Essential Nutrients - Despite their inherent toxicity, certain inorganic constituents are essential nutrients. Essential nutrients need not be considered for further consideration in the baseline RA if they are present in relatively low concentration (i.e., slightly elevated above naturally occurring levels), or if the constituent is toxic at doses much higher than those which could be assimilated through exposures at the site. Elements evaluated as essential nutrients include calcium, iron, magnesium, potassium, and sodium.

Prevalence - The prevalence of a chemical in an environmental medium can be described by the frequency and concentration with which it is detected. A detection frequency greater than 5 percent (1 positive detection in 20 samples) was the detection frequency considered in the selection of COPCs in data sets comprised of 20 or more samples. Data sets with fewer than 20 samples were evaluated for any positive detections to determine whether the chemical should be included as a COPC.

6.2.2 Re-inclusion of Chemicals as COPCs

Chemicals can be re-included as COPCs for quantitative evaluation in the baseline RA despite having been eliminated as such, by a comparison to COC values (or other aforementioned criteria). For example, a chemical that was detected with a frequency of greater than 5 percent, at concentrations below the corresponding COC value, may be re-included if it is reasonable to assume that the chemical could be site related.

Chemicals also may be selected or re-included as COPCs if detected concentrations exceed the following Federal/Commonwealth standards or criteria.

Maximum Contaminant Levels - MCLs are potentially enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs have been adopted as enforceable standards for public drinking water systems, and apply to drinking water supplies consumed by a minimum of 25 persons. They have been developed for the prevention of human health effects associated with lifetime exposure (70 year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical and economic feasibility of removing the constituent from a public water supply (USEPA, 1994a).

Virginia Drinking Water Standards - Virginia Drinking Water Standards are the maximum contaminant level concentrations of a contaminant in water which is delivered to the users of a public water system. With the exception of nitrate, all inorganic chemical contaminant levels are based on potential adverse health effects resulting from long term exposure to the contaminant in drinking water. The maximum contaminant levels for organics apply to community water supplies, the volatile organics also apply to nontransient, noncommunity water systems.

Virginia Water Quality Standards (WQS) for the Protection of Human Health - The WQSs are Commonwealth-enforceable standards used for identifying the potential for human health risks. WQSs are protective of human health and consider potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). Commonwealth WQSs available for the protection of human health from potential carcinogenic substances are derived based on an incremental lifetime cancer risk of one additional case of cancer in an exposed population of 100,000 persons (i.e., 1×10^{-05}).

Ambient Water Quality Criteria (AWQC) - AWQC are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms for surface water bodies. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of organisms alone

(6.5 grams/day). The AWQCs for protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 1.0×10^{-07} to 1.0×10^{-05} range). The AWQCs used for comparison in this baseline RA included the human health recalculated values for water and organisms, and organisms only. Published criteria were used in the absence of recalculated values.

Sediment Screening Values - At present, promulgated sediment quality criteria do not exist to protect human health. However, sediment screening values (SSVs) have been published (Long, et al., 1995) for evaluating the potential for chemical constituents in sediment to cause adverse biological effects. This screening method was developed through evaluation of biological effects data for aquatic (marine and freshwater) organisms that were obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called an Effects Range-Median, or ER-M) were determined. If contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable.

According to USEPA Region III, exceedences of the ER-M would constitute a chemical's retention as a COPC. Therefore, constituents detected in the sediment at Site 16/SSA 16 were compared to the SSV ER-Ms to determine if any criteria were exceeded.

6.2.3 Selection of COPCs

Four environmental media (soil, groundwater, sediment, and surface water) were investigated at Site 16/SSA 16 during this investigation. The selection of soil COPCs was stratified to include the surface soil (0- to 6-inches bgs) and the subsurface soil (greater than 6-inches bgs); each of these intervals was evaluated individually. Tables 6-2 through 6-6 present the selection of COPCs for each environmental medium based on comparisons of USEPA Region III COPC screening concentrations and other applicable criteria, with the maximum detected concentration. Information is presented in these tables only for those constituents detected at least once, in the medium of interest. Other statistical information (i.e., normal 95th percent upper confidence limit for the arithmetic mean concentration [95% UCL], etc.) is presented in Appendix K.

The following paragraphs present the rationale for selection of COPCs. Sample locations, analytical results, and corresponding figures are presented in other sections of this RI report.

6.2.3.1 Surface Soil

Surface soil samples were collected from the 0- to 6-inch interval and analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and inorganics (metals). The sample set included seven samples (6 environmental and 1 duplicate sample), from the RI conducted by Baker Environmental, Inc. (Baker) in the summer/fall of 1994, and 20 confirmation samples (19 environmental and 1 duplicate sample) taken after the removal action conducted by IT Corporation in the spring of 1994. In total, twenty-seven samples were included in the surface soil data set. The COPC selection summaries for surface soil are presented in Table 6-2.

Two VOCs (acetone and methylene chloride) were detected in the surface soil samples in 1 of 27 samples and 19 of 27 samples, respectively. However, acetone and methylene chloride did not exceed their residential COC values, and were not retained as COPCs.

SVOCs, primarily PAHs and phthalate esters were detected in the surface soil. Twelve PAHs were detected in the surface soil, of which none exceeded the industrial COC value. However, benzo(a)pyrene, detected in four of twenty-seven samples, exceeded the residential COC value once and was retained as a surface soil COPC. None of the four phthalate esters exceeded their residential COC values.

Nine pesticides were detected in the surface soil, several at frequencies of less than 5 percent, none of which exceeded the residential COC value. Therefore, pesticides not were retained as surface soil COPCs.

Two PCBs (Aroclor-1254 and Aroclor-1260) were detected in 12 of 25 samples and 11 of 25 samples respectively. Each of these constituents exceeded their residential COC value and were retained as a surface soil COPC.

Nitroamine compounds were not detected in the surface soil at Site 16/SSA 16, therefore, none were retained as surface soil COPCs.

Inorganics were detected in all surface soil samples collected. The maximum detected concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, and vanadium exceed the corresponding Region III residential COC values. Calcium, iron, magnesium, potassium, and sodium also were detected in almost every sample, however, these constituents are considered to be essential nutrients and were not retained as COPCs. Therefore, aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, and vanadium were retained as surface soil COPCs for quantitative evaluation in the baseline RA.

6.2.3.2 Subsurface Soil

A total of three subsurface soil samples were collected from each soil boring location. These samples were collected from the 1- to 3-feet (bgs) interval, the midpoint, and just above the water table. However, if elevated PID readings or visible contamination was noted, the affected interval and the 2-foot interval below the affected layer, were selected in lieu of the 1- to 3-foot and midpoint samples, respectively. Each sample was analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and inorganics. The COPC selection summaries for subsurface soil are presented in Table 6-3.

Two VOCs (acetone and methylene chloride) were detected in the subsurface soil samples. However, acetone and methylene chloride did not exceed ten times the maximum blank concentration. As a result, they were qualified as blank contaminants according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not included as subsurface soil COPCs.

Phenol and phthalate esters (bis(2-ethylhexyl)phthalate and di-n-butylphthalate) also were detected in the subsurface soil. Each of these constituents also was detected in laboratory blanks, at concentrations below five times and ten times, respectively, the maximum blank concentration, and not included as subsurface soil COPCs.

Pesticides, PCBs, and nitramine compounds were not detected in the subsurface soil at Site 16/SSA 16, therefore, none were retained as subsurface soil COPCs.

Inorganics were detected in all subsurface soil samples collected. The maximum detected concentrations of aluminum, antimony, arsenic, beryllium, chromium, manganese, and vanadium exceed the corresponding Region III COC values. Calcium, iron, magnesium, potassium, and sodium also were detected in almost every sample, however, these constituents are considered to be essential nutrients and were not retained as COPCs. Therefore, aluminum, antimony, arsenic, beryllium, chromium, manganese, and vanadium were retained as subsurface soil COPCs for quantitative evaluation in the baseline RA.

6.2.3.3 Groundwater

Table 6-4 summarizes the COPC selections performed for constituents detected in groundwater. All samples were analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, unfiltered (total) and filtered (dissolved) inorganics; however, only the dissolved inorganics were considered for this baseline RA.

Six VOCs were detected in groundwater samples collected from Site 16/SSA 16: acetone, 1,1-dichloroethene, 1,1-dichloroethane, 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene. Four of these constituents (acetone, 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene) did not exceed ten times the maximum blank concentration; as a result, they were qualified as blank contaminants according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not retained as groundwater COPCs. 1,1-Dichloroethane did not exceed the applicable criteria and also was not retained as a groundwater COPC. However, since chlorinated solvents have been detected in groundwaters throughout WPNSTA Yorktown, these chemicals (1,1-dichloroethane, 1,1,1-trichloroethene, tetrachloroethene, and trichloroethene) were re-included as COPCs for quantitative evaluation in the baseline RA. 1,1-Dichloroethene (which also is a chlorinated solvent) did exceed the USEPA Region III Tapwater COC value and was retained as a groundwater COPC.

SVOCs, including one phthalate ester (di-n-butylphthalate) and 1,4-dichlorobenzene were detected in the groundwater. Di-n-butylphthalate did not exceed ten times the maximum blank concentration; as a result, it was qualified as blank contaminant and not retained as a groundwater COPC. 1,4-dichlorobenzene, however, exceeded the Region III Tapwater COC value and was retained as a groundwater COPC.

Trace levels of pesticides also were detected in the groundwater including: aldrin, endrin, and 4,4'-DDT. Aldrin exceeded the Region III tapwater COC value and the Virginia Drinking Water Standard while 4,4'-DDT exceeded the tapwater COC value. Because aldrin and 4,4'-DDT exceeded one or more of their comparison criteria, they were retained for further evaluation in the baseline RA.

Nitramine compounds were not detected in the groundwater at Site 16/SSA 16, therefore, none were retained as groundwater COPCs.

Of the filtered (dissolved) inorganics detected in the groundwater dissolved antimony, arsenic, beryllium, and manganese exceeded one or more criteria and were retained as dissolved groundwater COPCs for quantitative evaluation. In addition, calcium, iron, magnesium, potassium, and sodium also were detected in dissolved samples, however, these constituents are considered to be essential nutrients and were not retained as COPCs.

6.2.3.4 Surface Water

Table 6-5 summarizes the COPC selections performed for constituents detected in surface water. All samples were analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, unfiltered (total) and filtered (dissolved) inorganics.

Two VOCs (acetone and toluene) were detected in the surface water samples. However, acetone and toluene did not exceed ten times the maximum blank concentration. As a result, they were qualified as blank contaminants according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not included as surface water COPCs.

SVOCs, pesticides, PCBs, and nitramine compounds were not detected in the surface water at Site 16/SSA 16, therefore, none were retained as surface water COPCs.

Inorganics were detected in a majority of the surface water samples collected. The maximum detected concentrations of arsenic and manganese in the total (unfiltered) inorganic samples exceeded one or more of the corresponding criteria. In addition, calcium, iron, magnesium, potassium, and sodium also were detected in these samples, however, these constituents are considered to be essential nutrients and were not retained as COPCs. Therefore, arsenic and manganese were retained as surface water COPCs for quantitative evaluation in the baseline RA.

6.2.3.5 Sediment

Table 6-6 summarizes the COPC selections performed for constituents detected in sediment. All samples were analyzed for VOCs, SVOCs, pesticides, PCBs, nitramine compounds, and inorganics.

Sediment samples were collected from the 0- to 4-inch interval and the 4- to 8-inch interval at each sampling location. The COPC selection summaries for sediment are presented in Table 6-6.

Five VOCs (acetone, 2-butanone, carbon disulfide, chloromethane, and toluene) were detected in the sediment samples; however, acetone, 2-butanone, and toluene did not exceed ten times the maximum blank concentration and chloromethane did not exceed five times the maximum blank concentration. As a result, they were qualified as blank contaminants according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not included as sediment COPCs. Carbon disulfide did not exceed the criteria used for comparison and was not retained as a sediment COPC.

SVOCs and nitramine compounds were not detected in sediment samples at Site 16/SSA 16, therefore, none were retained as COPCs.

Two pesticides (endrin aldehyde and heptachlor epoxide) and one PCB (Aroclor-1260) also were detected in the sediment at concentrations which did not exceed the criteria for comparison and were not retained as sediment COPCs. Because Aroclor-1260 was retained as a COPC in soil samples, its occurrence is sediment is likely to be site related. Aroclor-1260 was, therefore, re-included as a COPC for sediment.

Inorganics were detected in a majority of sediment samples collected. The maximum detected concentrations of aluminum, arsenic, beryllium, manganese, and vanadium exceed the corresponding Region III residential soil COC values used for comparison. Calcium, iron, magnesium, potassium, and sodium also were detected in a majority of the sample, however, these constituents are considered to be essential nutrients and were not retained as COPCs. Therefore, aluminum, arsenic, manganese, and vanadium were retained as sediment COPCs for quantitative evaluation in the baseline RA.

6.2.4 Summary of COPCs

The following presents a comprehensive list of all selected COPCs, by media, identified at Site 16/SSA 16.

- **Surface Soil:** benzo(a)pyrene, Aroclor-1254, Aroclor-1260, aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, and vanadium.

- **Subsurface Soil:** aluminum, antimony, arsenic, beryllium, chromium, manganese, and vanadium.

- **Groundwater Samples (dissolved):** 1,1-dichloroethane, 1,1-dichloroethene, 1,1,1-trichloroethane, tetrachloroethene, trichloroethene, 1,4-dichlorobenzene, aldrin, 4,4'-DDT, antimony, arsenic, beryllium, and manganese.

- **Surface Water Samples (total):** arsenic and manganese.

- **Sediment Samples:** Aroclor-1260, aluminum, arsenic, beryllium, manganese, and vanadium.

6.3 Exposure Assessment

The exposure assessment addresses each current and future potential exposure pathway in soil, groundwater, surface water, sediment, and air. To determine whether human exposure could occur at Site 16/SSA 16 in the absence of remedial action, an exposure assessment which identifies potential exposure pathways and receptors was conducted. The following four elements were considered to ascertain whether a complete exposure pathway was present (USEPA, 1989b):

- A source and potential mechanism of chemical release

- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium
- An exposure route (e.g., ingestion) at the contact point

The exposure scenarios discussed herein represent USEPA's Reasonable Maximum Exposure (RME). Relevant equations for assessing intakes and exposure factors were obtained from RAGS (USEPA, 1989b), Exposure Factors Handbook (USEPA, 1989a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992a), and Standard Default Exposure Factors, Interim Final (USEPA, 1991a).

WPNSTA Yorktown will continue to function as one of the key Naval ordnance installations on the East Coast for the foreseeable future. Station housing for enlisted personnel is limited to areas around the golf course; Mason Row (senior officers Quarters), which overlooks the York River; and cottage types of homes scattered throughout the Station. Housing for most enlisted personnel is situated in the Skiffes Creek area south of the Station and Highway 143. There is currently no Station housing of enlisted personnel at Site 16/SSA 16.

The Station has been divided by the Navy into three basic land use areas: (1) explosive/ordnance storage, (2) ordnance production/maintenance, and (3) non-explosive and support functions (DoN, 1991). Categorized from an "explosives" standpoint, two general land use types emerge: real estate encumbered by the Explosive Safety Quantity Distance (ESQD) arc and that which is not encumbered. Site 16/SSA 16 is situated in an area encumbered by the ESQD arc and therefore, cannot be developed for Station housing of enlisted personnel. The area also is restricted, and only individuals having the proper clearance or Station passes are allowed in the area.

Current potential human receptors to COPCs detected in environmental media at Site 16/SSA 16 are limited to on-site adult civilian workers. Although future residential development of Site 16/SSA 16 is highly unlikely, future residential exposure for potential adult and child receptors was considered. As a conservative approach (since the shallow aquifer system within York County is not used as a potable water source because of low yields) child and adult residents were considered to be potentially exposed to organic and dissolved inorganic COPCs in the shallow groundwater. Total inorganic results were not evaluated since dissolved inorganic results are considered to be more representative of drinking water conditions at the tap. In addition to evaluating the potential exposure to future on-site residents, future construction workers, that may perform excavation and housing construction activities, also were evaluated as potential receptors.

6.3.1 Chemical Fate and Transport

This section discusses the potential release and migration of COPCs between or within media. The potential for a chemical to migrate spatially and persist in environmental media is important in the estimation of exposure. Section 5.0 presents a general discussion of the chemical fate and transport for the detected analytes; this subsection focuses only on the chemical classes of the selected COPCs.

The distribution relationships for a chemical between the environmental compartments of air, water, and soil can be evaluated using a series of equilibrium constants. By utilizing the physiochemical properties of a constituent, it is possible to estimate a chemical's expected environmental distribution and its ultimate environmental fate.

The environmental mobility and persistence of a chemical will be influenced primarily by its physical and chemical properties and the chemistry of the medium in which it occurs. Table 6-7 presents the physical and chemical properties associated with the organic COPCs identified at Site 16/SSA 16. The properties considered include: vapor pressure, water solubility, octanol-water partition coefficient, soil adsorption coefficient, specific gravity, Henry's Law constant, and mobility index. Calculated values, obtained using approximation methods, are presented when literature values are unavailable. A discussion of the environmental significance of each of these properties follows.

- Vapor pressure is an indication of the rate at which a chemical will volatilize. It is of primary significance as a removal mechanism at environmental interfaces such as surface soil-air and surface water-air. Vapor pressures for volatile organics, would be higher than vapor pressures for pesticides. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is not a significant removal mechanism when evaluating groundwater, subsurface soil, and sediment, but it is for surface water and soil. Therefore, volatilization is a significant loss process for VOCs in surface soil and surface water.

- Water solubility is used to determine the rate at which a chemical can be solubilized and potentially leached from soil by infiltrating precipitation. In general, more soluble chemicals are more readily leached than less soluble chemicals. The water solubilities presented in Table 6-7 indicate that VOCs, such as 1,1-dichloroethene, are much more soluble than the pesticides or PCBs.

- The octanol-water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the octanol water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the biological concentration factor, BCF) has been determined (Lyman et al., 1982). The coefficient also is useful in characterizing the sorption of compounds by organic soil where experimental values are not available. The octanol water partition coefficient also is used to estimate BCFs in aquatic organisms.

- The organic carbon adsorption coefficient (K_{oc}) is an indication of the tendency of a chemical to adhere to soil particles containing organic carbon. Chemicals with high soil/sediment adsorption coefficients generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which the more mobile chemicals (e.g., monocyclic aromatics) are transported in the aqueous media. Chemicals such as pesticides are relatively immobile in the environment and are preferentially bound to the soil. These compounds are not subject to aqueous transport to the extent as compounds with higher water solubilities, such as VOCs.

- Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a constituent will have a tendency to float or sink (as an immiscible liquid) in water if it is present as a pure compound or at concentrations which exceed its water solubility.

- Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. The ratio of these two parameters (Henry's Law constant) is used to calculate the equilibrium constituent concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings.

A quantitative assessment of mobility has been developed (Laskowski, et al., 1983) that uses water solubility (S), vapor pressure (VP), and the organic carbon partition coefficient (K_{oc}). This value is referred to as the Mobility Index (MI). It is calculated as follows:

$$MI = \log[(S \times VP)/K_{oc}]$$

A scale to evaluate MI is presented by Ford and Gurba (1984) as the following:

MI	Description
>5	Extremely mobile
<5 to 0	Very mobile
0 to -5	Slightly mobile
-5 to -10	Immobile
<-10	Very immobile

The MIs for the potential COPCs are also presented in Table 6-7.

The following paragraphs summarize the fate and transport data, by chemical class, for the potential COPCs at Site 16/SSA 16.

6.3.1.1 Volatile Organic Compounds

Volatile organic COPCs can be divided into two distinct classes, volatile aromatics, and chlorinated aromatics. Since none of the volatile aromatics (benzene, toluene, xylenes, and ethylbenzene) were detected at Site 16/SSA 16, only the chlorinated aromatics will be discussed.

Chlorinated aromatics include trichloroethene, tetrachloroethene, tetrachloroethane, vinyl chloride, 1,2-dichloroethane, total 1,2-dichloroethene, 1,1-dichloroethene, and 1,1,1-trichloroethane. These chemicals are comprised of chlorine substituted ethane or ethene moiety. Vinyl chloride, 1,2-dichloroethane, 1,1-dichloroethene, and 1,2-dichloroethene are most likely present as a result of the degradation of higher chlorinated ethenes and ethanes.

Volatile organics tend to be very mobile in environmental media as indicated by their presence in groundwater at Site 16/SSA 16. Their inherent mobility and relatively high MIs result from high water solubilities, high vapor pressures, and low K_{oc} and K_{ow} values. Volatile organics do not tend to persist in environmental media because photolysis, oxidation, and biodegradation figure significantly in their removal. They are seldom detected in surface soil where volatilization and other removal processes predominate, as is the case at Site 16/SSA 16.

6.3.1.2 Semivolatile Organic Compounds

In general, SVOCs are less mobile than the VOCs by virtue of their lower vapor pressures and lower water solubilities. K_{oc} and K_{ow} values for SVOCs are generally greater in magnitude than those for the VOCs, indicating the tendency for this class of compounds to adsorb strongly to soil and sediment. A class of this chemical group, PAHs, are ubiquitous in the environment. PAHs are produced naturally by plants, and are products of the incomplete combustion of fossil fuels. PAHs tend not to migrate appreciable distances through groundwater or surface water as solutes. The MIs in Table 6-7 indicate that PAHs, from a physio-chemical standpoint, are very immobile in the environment.

Transport of soil particulates containing PAHs, is most likely the primary migration mechanism. The overland flow of surface water carrying entrained particles and with subsequent sedimentation, resuspension, and settling throughout is possible. PAHs generally lack adequate vapor pressures to be transmitted via vaporization and subsequent airborne transport. However, their adsorption to particulates can be a means of transport by wind, as fugitive dust.

PAHs are somewhat persistent in the environment, although several processes do contribute to their in-situ degradation. Half-lives range from 10 years (pyrene) to 1 day (naphthalene) in groundwater.

Photolysis and oxidation may be important removal mechanisms in surface soil, while biodegradation is an important fate process in groundwater and subsurface soil.

6.3.1.3 Pesticides/PCBs

Pesticides/PCBs are extremely persistent and immobile chemicals in environmental media. These chemicals also are bioaccumulated and biomagnified in the food chain. They generally exhibit low vapor pressures, low water solubilities, and high K_{oc} and K_{ow} values (Clement, 1985). Adsorption to organic material in soil or sediment is probably the major fate of these contaminants in the environment.

PCBs are degraded by soil microorganisms and photolysis. Heavily chlorinated PCBs like Aroclor-1260 can be photolyzed by ultraviolet light, which is an extremely slow process. Photolysis of the heavier chlorinated PCBs might be the most important degradation process for these persistent contaminants.

The pesticide aldrin will form residues in soil and plants that will volatilize from soil surfaces, or be slowly transformed to dieldrin in soil. Biodegradation is expected to be slow and aldrin is not expected to leach into most groundwater. Aldrin is moderately persistent with a half-life in soil ranging from 20 to 100 days. It volatilizes from the water surface, is affected somewhat by photolysis, and can strongly absorb to sediment.

Technical grade DDT is a mixture of DDT and two primary isomers DDD and DDE. Volatilization is probably the most important transport process from soil and water, as evidenced by the ubiquitous nature of DDT, DDD, and DDE in the environment (Clement, 1985). In addition, sorption, bioaccumulation, photolysis, and biodegradation are other fate processes contributing to the environmental transport of DDT.

6.3.1.4 Inorganics

Different inorganic species behave differently in various environmental media. In general, inorganics can be transported through air, adhering to blowing dust, or move through surface water and groundwater as dissolved salts. Inorganics also can be carried with flowing water on suspended solids or attached to colloidal materials.

The most complicated pathway for inorganic chemicals is migration in subsurface soil and groundwater, where Eh and pH play critical roles. Table 6-8 presents an assessment of relative inorganic environmental mobilities as a function of Eh and pH. Subsurface soil at Site 16/SSA 16 is slightly acidic, therefore, inorganics in the subsurface should be slightly mobile.

6.3.2 Potential Migration Pathways

This section identifies the potential migration routes of COPCs at Site 16/SSA 16. These mechanisms were identified through an evaluation of the analytical results and known site characteristics.

6.3.2.1 Soil

Inorganic and organic compounds were detected in surface and subsurface soil at Site 16/SSA 16. COPCs present in Site 16/SSA 16 soil can migrate by leaching caused by infiltrating precipitation, advective transport in the direction of surface drainage (runoff) or by suspension of soil particulates in ambient air (dust).

The factors which control contaminant migration through soil, and then to groundwater, are dependent on the chemical and physical nature of the contaminants and of the soil and site hydrology. Some of the factors which influence the migration of chemicals in soil include: pH, Eh, particle size distribution, pore size or voids volume, lime content, content of organic matter, concentration of ions or salts, aerobic and anaerobic conditions, presence or absence of hydrous oxides, vegetative cover, topography, and climate.

6.3.2.2 Groundwater

Contaminants which come into contact with groundwater can migrate under the influence of groundwater flow. Migration through groundwater is dependent on the chemical nature of the contaminant and the chemical and physical nature of the aquifer. Groundwater flow velocity (a function of hydraulic gradient and conductivity), groundwater chemistry, porosity of the aquifer, permeability of the overlying soil, and the chemical make up of the aquifer are all factors which affect contaminant migration. Mobility of a contaminant in groundwater is particularly influenced by its water solubility and the organic carbon content of the substrate, as well as the nature and composition of the aquifer materials through which the groundwater flows. In general, compounds that have high solubility and low K_{oc} values tend to be more mobile in groundwater than those with low solubility and high K_{oc} values.

6.3.2.3 Surface Water/Sediment

Migratory pathways associated with surface water and sediment include the transport of contaminants via surface water movement, an adsorption/desorption process from surface water to sediment, and discharge to or from groundwater. The adsorption/desorption process, from surface water to sediment, can create contaminant "sinks". Adsorption/desorption mechanisms involve complex chemical and biochemical reactions. As chemicals are desorbed from sediment, they may then be available for uptake by receptors from the water column.

6.3.2.4 Air

COPCs adsorbed to soil particulates or as vapors can become entrained in ambient air. Because of the concentrations of COPCs detected in soil at Site 16/SSA 16, volatilization is likely to be a very minor potential migration pathway. COPCs migrating via air from Site 16/SSA 16 would most likely be as particulates entrained in air. This pathway also is likely limited by the vegetative cover and wooded areas in the vicinity of the site/SSA.

Air exposure may occur when subsurface soils become airborne, therefore, it is assumed that potential future construction workers could inhale soil particulates carried by the wind, while engaging in construction/excavation activities.

6.3.3 Conceptual Site Model

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of potential sources of contamination, affected media and all potential routes of migration of the contaminants present. A conceptual site model for Site 16/SSA 16 is presented as Figure 6-1.

The primary source of contamination is the former disposal areas at Site 16/SSA 16. The primary release mechanism are volatile emissions, surface runoff, and contaminant migration through groundwater. Fugitive dust generation from surface soil is not considered to be a significant potential release mechanism at Site 16/SSA 16 since the site is covered to a great extent by vegetation. Furthermore, volatilization was not considered significant since VOCs were not retained as surface soil or surface water COPCs at Site 16/SSA 16.

6.3.4 Potential Exposure Pathways and Potential Receptors

The potential receptors and exposure routes evaluated at Site 16/SSA 16 were selected considering current and future potential land use in accordance with the Master Plan for WPNSTA Yorktown (DoN, 1991). The following paragraphs present the rationale for the selection of potential exposure pathways for human receptors at Site 16/SSA 16.

Based on information available regarding the physical features, site setting, site historical activities, removal action data, the location of the site in the restricted area of the Station, current and expected land uses, and the restricted areas surrounding the site, four potential human receptors are proposed for evaluation. These include:

- future adult construction workers,
- future resident children (1-6 years)
- future resident adults
- current on-site adult civilian workers

Potential exposure to COPCs at Site 16/SSA 16 could occur in the future if utilities or buildings in the area are constructed or existing building and utilities require maintenance. The future adult construction worker will therefore be evaluated for accidental ingestion, dermal contact, and inhalation of fugitive dust from subsurface soil during excavation activities.

Currently, there are no facilities for personnel housing located at Site 16/SSA 16. The area will not be developed for personnel housing in the future because of the Stations mission and the areas incumbrance by the EQSD arc. Despite the unlikely nature of residential development by the military or general public, future residential exposure by children and adults will be evaluated. The future adult and child residential receptors could potentially be exposed to COPCs in surface soil, groundwater, surface water, and sediment by ingestion and dermal contact. The future adult resident could also be potentially exposed to COPCs in groundwater via inhalation of volatiles present in the shower water. Because Site 16/SSA 16 is located within the restricted area of the Station, the potential for current human exposure is limited. The most likely current receptor to COPCs in environmental media at Site 16/SSA 16 is the adult civilian on-site worker. Potential exposure to COPCs and media of concern for the current adult civilian on-site worker include accidental ingestion and dermal contact with the surface soil, surface water, and sediment, as well as, inhalation of fugitive dusts from the surface soil.

In summary, the following potential human exposure receptors and exposure pathways are being retained for quantitative evaluation in this baseline RA.

- Current civilian on-site adult workers:
  - Accidental ingestion of surface soil
  - Dermal contact with surface soil
  - Inhalation of fugitive dust
  - Accidental ingestion of surface water
  - Dermal contact with surface water
  - Accidental ingestion of sediment
  - Dermal contact with sediment

- Future on-site adult residents:
  - Accidental ingestion of surface soil
  - Dermal contact with surface soil
  - Ingestion of groundwater used as drinking water
  - Dermal contact with groundwater while bathing
  - Inhalation of volatiles in groundwater while showering
  - Accidental ingestion of surface water

- Dermal contact with surface water
- Accidental ingestion of sediment
- Dermal contact with sediment

- Future on-site child residents (1-6 years):
  - Accidental ingestion of surface soil
  - Dermal contact with surface soil
  - Ingestion of groundwater used as drinking water
  - Dermal contact with groundwater while bathing
  - Accidental ingestion of surface water
  - Dermal contact with surface water
  - Accidental ingestion of sediment
  - Dermal contact with sediment

- Future on-site adult construction workers:
  - Accidental ingestion of subsurface soil
  - Dermal contact with subsurface soil
  - Inhalation of fugitive dust

6.3.5 Quantification of Exposure

The chemical concentrations used in the estimation of chronic daily intakes (CDIs) for each medium are considered to be representative of the types of potential exposure encountered by each receptor. Exposure can occur discretely or at a number of sampling locations depending on the type of scenario considered for a given receptor. Furthermore, certain environmental media such as groundwater and surface water are migratory and chemical concentrations detected in this medium change frequently over time. Soil and sediment are, by nature, less transitory. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium.

Potential exposure to soil, groundwater, surface water and sediment at Site 16/SSA 16, regardless of location, is considered as having an equal probability of occurrence as an individual moves randomly across the site. Therefore, for these media, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992c) states that the average concentration is an appropriate estimator or the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on lifetime average exposures; and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

To quantify exposure, analytical data must be evaluated to determine its distributional nature. In general, two types of distributions are applied to environmental data. These are the normal and log-normal distributions.

For example, most large data sets from soil sampling are log-normally distributed rather than normally distributed. The geometric mean is the best estimator of central tendency for a log-normal data set (USEPA, 1992c). However, most Agency health criteria are based on the long-term average exposure which is expressed as the sum of all daily intakes divided by the total number of days in the averaging period. The geometric mean of a set of sampling results may not adequately represent random exposure and the cumulative intake that would result from long-term contact with site or SSA contaminants.

When estimating exposure concentrations, the objective of this risk assessment is to provide a conservative estimate of the average concentration to which a receptor could potentially be exposed in a manner consistent with Agency health criteria and standards. RAGS suggests that the 95 percent upper confidence limit (UCL) of the arithmetic mean (95% UCL) should be used for data sets of 10 samples or more. Therefore, the 95% UCL will be used to represent the exposure concentration for COPCs in soil, surface water, and sediment to which human receptors can be randomly exposed. Furthermore, since a "plume" of contamination was not evident in the Site 16/SSA 16 groundwater samples, the 95% UCL was also selected as the exposure point concentration for groundwater, to spatially represent the selected groundwater COPCs. However, in instances where the 95% UCL exceeded the maximum detected concentration in a given data set, the maximum detected concentration was used to represent the concentration term for that COPC.

The 95% UCL was calculated using the following equation (USEPA, 1992c):

$$95\%\ UCL = \bar{x} + t(s/\sqrt{n})$$

Where:

95% UCL = 95th percent upper confidence limit for the arithmetic mean concentration

$\bar{x}$ = mean
s = standard deviation
t = Student t statistic
n = number of samples

For results reported as "nondetect" (e.g., U, UJ, UL, and UK), a value of one half of the sample-specific detection limit was used to calculate the 95% UCL. A value of half the detection limit was assigned to nondetects when estimating the 95% UCL because the actual value could be between zero and a value just below the detection limit. Ninety-five percent UCLs were calculated only for the constituents detected in at least one sample collected from the environmental medium of interest. Other qualified concentrations also were used to calculate the 95% UCL, such as "J"-qualified (estimated), "L"-qualified (estimated, biased low) and "K"-qualified (estimated, biased high) data. Reported concentrations qualified with an "R" (rejected) were not used in the statistical evaluation.

According to the Region III Modifications to the National Functional Guidelines (NFGs), reported organic and inorganic concentrations that were qualified with a "B" were evaluated against the available field and laboratory blanks. For constituents considered by RAGS to be common laboratory blanks, chemicals were deemed positive detects only if their concentration exceeded 10 times the maximum blank concentration. For constituents not considered to be laboratory blanks, chemicals were considered as positive detects only if their concentration exceeded 5 times the maximum blank concentration.

The 95% UCL values and maximum detected values derived for Site 16/SSA16 COPCs are presented in Appendix K.

6.3.5.1 <u>Surface/Subsurface Soil and Sediment</u>

The following paragraphs present the algorithms used to derive chronic daily intakes or absorbed doses for each potential exposure pathway and affected environmental medium.

Accidental Ingestion of Soil/Sediment

The daily intake associated with the potential accidental ingestion of COPCs detected in soil or sediment was calculated using the following equation (USEPA, 1989b):

$$CDI = \frac{Cs \ x \ IR \ x \ CF \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, milligram per kilogram day (mg/kg-day)
Cs	=	Chemical concentration in soil or sediment, mg/kg
IR	=	Ingestion rate, mg/day
CF	=	Conversion factor, 10^{-6} kg/mg
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Relevant equations and factors required for estimating the daily intake were calculated and are presented in Appendix L.

Dermal Contact with Soil/Sediment

The absorbed dose associated with the potential dermal contact of COPCs in soil and sediment was calculated using the following equation (USEPA, 1989b):

$$DAD = \frac{CS \ x \ AF \ x \ ABS \ x \ CF \ x \ SA \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

DAD	=	Dermally absorbed dose, mg/kg-day
CS	=	Chemical concentration in the soil or sediment, mg/kg
AF	=	Adherence factor, milligram per square centimeter day ($mg/cm^2 \cdot d$)
ABS	=	Absorbed fraction, unitless
CF	=	Conversion factor, 10^6mg/kg

SA	=	Surface area of exposed skin, cm^2
EF	=	Exposure frequency, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Relevant equations and factors required for estimating the absorbed dose were calculated and are presented in Appendix L.

Inhalation of Fugitive Dust from Soil

The daily intake resulting from the inhalation of COPCs adsorbed onto fugitive dust particulates was estimated using the following equation (USEPA, 1989b):

$$CDI = \frac{Ca \ x \ RR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Ca	=	Chemical concentration in air as fugitive dust, milligrams per cubic meter ($mg/m^{3)}$
RR	=	Respiration rate, m^3/day
ET	=	Exposure time, hours/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

The air concentration (Ca) of a chemical in fugitive dust emissions was estimated from the following equation, as determined by Cowherd (1985), and provided by USEPA (1991b).

$$Ca = Cs \ x \ 1/PEF$$

Where:

Cs	=	Concentration of chemical in the soil, mg/kg
PEF	=	Particulate emission factor, m^3/kg

6.3.5.2 Groundwater/Surface Water

Ingestion of Potable Groundwater

The daily intake associated with the direct potential ingestion of the COPCs in groundwater under a potable use scenario was calculated using the following equation (USEPA, 1989b):

$$CDI = \frac{Cw \ x \ IR \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Cw	=	Chemical concentration in water, mg/L
IR	=	Ingestion rate, L/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Accidental Ingestion of Surface Water

The daily intake associated with the accidental ingestion of the COPCs in surface water was calculated using the following equation (USEPA, 1989b):

$$CDI = \frac{Cw \ x \ IR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Cw	=	Chemical concentration in water, mg/L
IR	=	Ingestion rate, L/day
ET	=	Exposure time, hours/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years
BW	=	Average body weight, kg
AT	=	Averaging time, days

Dermal Contact with Groundwater/Surface Water

The absorbed dose associated with potential dermal contact with COPCs in groundwater (while bathing) or surface water was calculated using the following equation (USEPA, 1989b):

$$DAD = \frac{Cw \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

Where:

DAD	=	Dermally absorbed dose, mg/kg-day
Cw	=	Concentration in water, mg/L
SA	=	Surface area of exposed skin, cm^2
PC	=	Permeability constant, cm/hr
ET	=	Exposure time, hours/day
EF	=	Exposure frequency, days/year
ED	=	Exposure duration, years
CF	=	Conversion factor, 1 L/1000 cm^3
BW	=	Average body weight, kg
AT	=	Averaging time, days

Inhalation of Volatile COPCs in Groundwater while Showering

The daily intake associated with the potential inhalation of the volatile COPCs in groundwater while showering was calculated using the following equation (USEPA, 1989b):

$$CDI = \frac{Ca \ x \ RR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg-day
Ca	=	Chemical concentration in air, mg/m^3, as determined from the Foster and Chrostowski Shower Model (Foster and Chrostowski, 1987)
RR	=	Respiration rate, m^3/day
ET	=	Exposure time, hours/day
EF	=	Frequency of exposure, days/year
ED	=	Exposure duration, years

BW	=	Average body weight, kg
AT	=	Averaging time, days

6.3.6 Exposure Factors Used To Derive Chronic Daily Intakes and Absorbed Doses

Tables 6-9 through 6-11 present the exposure factors used in the estimation of potential CDIs and DADs for COPCs retained for each receptor identified below. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors. When USEPA exposure factors are not available, best professional judgment and site-specific information are used to derive a conservative and defensible value. The following paragraphs present the rationale for the selection of exposure factors for each receptor group evaluated in the baseline RA.

6.3.6.1 Current Civilian On-Site Adult Workers

Surface Soil

This scenario assumes that a civilian adult working in the areas of Site 16/SSA 16 could potentially be exposed to COPCs in the surface soil via accidental ingestion, dermal contact, and inhalation of fugitive dust, during cutting/clearing of tall grasses and trees. It also was assumed that the on-site adult could contact surface water and sediment, via accidental ingestion and dermal contact, as part of a daily work routine. A respiration rate of 20 m^3/day or 0.83 m^3/hour (USEPA, 1991a) for a 70 kg adult was assumed for 250 days/year over a 25 year period, for eight hours per day. The averaging time of 9,125 days for noncarcinogens and 25,550 days for carcinogens, respectively, also were used.

Surface Water

The adult skin surface area (SA) available for dermal contact with surface water was estimated to be 5,300 cm^2, representing the skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes. Equations and chemical-specific permeability constants (Kp) presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to surface water. The ingestion rate was 0.05 L/day (USEPA, 1989b) while the exposure time was estimated to be 2 hours/day. The exposure frequency, exposure duration, and the averaging times were the same as those used for the surface soil scenario.

Sediment

The ingestion rate was assumed to be 100 mg/day (USEPA, 1991a), with a soil to skin adherence factor of 1 mg/cm^2 for clay mineral kaolin (USEPA, 1992b). Experimentally derived dermal absorption values of 6 percent (0.06) for PCBs (USEPA, 1992a), 3 percent (0.03) for arsenic (Webster, et al., 1993), as well as default values of 10 percent (0.10) for organics, and 1.0 percent (0.01) for inorganics (Ryan, et al., 1987), also were used to estimate sediment exposures. The surface area, exposure duration, exposure frequency, averaging time, and body weight were the same as those presented for the surface water scenario.

6.3.6.2 Future Child and Adult Residents

In the current Master Plan for WPNSTA Yorktown, future residential development of Site 16/SSA 16 is not projected (DoN, 1991). However, for the sake of conservatism, the potential exposure pathways associated with future potential residential development were estimated. Future adult and young child (ages 1-6 years) residents were evaluated for potential exposures via ingestion and dermal contact with COPCs in groundwater, when used as a potential potable water source. Future adult residents were further evaluated for the inhalation of volatiles in groundwater while showering. Future adult and child residents also were evaluated for potential exposures from accidental ingestion and dermal contact with surface soil, surface water, and sediment.

Surface Soil

The ingestion rate was assumed to be 200 mg/day (USEPA, 1991a) for the child and 100 mg/day for the adult with a fraction ingested rate of 100% or 1.0 (USEPA, 1989b). An exposure time of eight hours per day was considered with an exposure frequency of 350 days per year. The soil to skin adherence factor of 1 mg/cm^2 for clay mineral kaolin (USEPA, 1992b) and experimentally derived dermal absorption values of 6 percent (0.06) for PCBs, 3 percent (0.03) for arsenic and default values of 10 percent (0.10) for organics and 1.0 percent (0.01) for inorganics (Ryan, et al., 1987) also were used to estimate soil exposures. The exposure duration assumed for the adult was 24 years, the child exposure duration was assumed to be 6 years. The noncarcinogenic averaging times were 8,760 days for a 70 kg adult and 2,190 days for a 15 kg child; the carcinogenic averaging time was 25,550 days (USEPA, 1989b).

Groundwater

The skin surface area available for dermal contact with groundwater during bathing was estimated to be 20,000 cm^2 for the adult and 8,023 cm^2 for the child, representing whole body exposure (USEPA, 1992a). The exposure time was assumed to be 0.25 hours (15 minutes) a day with an ingestion rate of 2L/day for the adult and 1L/day for the child (USEPA, 1989b). Equations and chemical-specific Kp presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to groundwater. The respiration rate for the inhalation of volatile organic compounds while showering was assumed to be 0.83 m^3/hour. The averaging times, exposure frequency, exposure duration and body weights were the same as those presented for the surface soil exposure scenario.

Surface Water

The adult skin surface area available for dermal contact with surface water was estimated to be 5,300 cm^2, representing the skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes. The exposure frequency was assumed to be 45 days/year at 2 hours/day, for 24 years. Equations and chemical-specific Kp presented by USEPA (USEPA, 1992a) were used to estimate the absorption of COPCs by skin exposed to surface water. An ingestion rate of 0.05 L/day also was used. The averaging times were 8,760 days for the noncarcinogens and 25,550 days for the carcinogens.

A skin surface area of 2,115 cm^2 was used to represent the 95th percentile average skin surface area for a male/female young child (1-6 years), wearing a short-sleeved shirt, short pants, and shoes. The exposure frequency, ingestion rate, and exposure time are the same as the adult's, however the exposure duration was assumed to be 6 years. As with the adult, equations and chemical-specific Kp were used to estimate the absorption of COPCs by skin exposed to surface water. The averaging times were 2,190 days for the noncarcinogens and 25,550 days for the carcinogens.

Sediment

The ingestion rate was assumed to be 200 mg/day for the child and 100 mg/day for the adult, for two hours per day over 45 days per year. The soil to skin adherence factor of 1 mg/cm^2 for clay mineral kaolin (USEPA, 1992b) and experimentally derived dermal absorption values of 6 percent (0.06) for PCBs, 3 percent (0.03) for arsenic and default values of 10 percent (0.10) for organics and 1.0 percent (0.01) for inorganics also were used to estimate sediment exposures. The exposure duration, averaging time, and body weight were the same as those presented for the surface water medium.

6.3.6.3 Future Adult Construction Workers

Potential exposure to subsurface soil COPCs may occur to construction workers while performing soil excavation and construction activities. Exposure pathways evaluated include accidental ingestion, dermal contact, and inhalation of fugitive dust. Exposure was assumed to occur for 8 hours per day, 250 days per year, for a construction period of 1 year. A USEPA default value soil ingestion rate of 480 mg/day with a fraction ingested rate of 100% or 1.0 (USEPA, 1989b) and a respiration rate of 20 m^3/day or 0.83 m^3 /hour (USEPA, 1991a), also were assumed for a 70 kg construction worker. A skin surface area of 4,300 cm^2 (USEPA, 1992a) was evaluated for dermal contact with subsurface soil. The soil to skin adherence factor of 1 mg/cm^2 for clay mineral kaolin (USEPA, 1992b) and experimentally derived dermal absorption values of 0.06 for PCBs, 0.03 for arsenic, 0.10 for organics and 0.01 for inorganics also were used to estimate soil exposures

6.4 Toxicity Assessment

Section 6.3 presented potential exposure pathways and receptors for this baseline RA. This section will review the available toxicological information for COPCs retained for quantitative evaluation.

6.4.1 Toxicological Evaluation

The purpose of this section is to identify the potential health and environmental effects associated with potential exposure to the COPCs. A toxicological evaluation characterizes the inherent toxicity of a compound. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with potential exposure to the various chemicals. The end product is a collection of toxicological profiles for the COPCs. These toxicological profiles provide the qualitative weight-of-evidence that demonstrate whether the COPCs pose any actual or potential health and/or environmental effects.

Toxicological profiles addressing the COPCs at Site 16/SSA 16 are presented in Appendix M. In these toxicological profiles, the available human and animal data are presented. Human data from occupational exposures are often insufficient for determining quantitative indices of toxicity because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results are extrapolated to humans. There are several stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors and modifying factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate effects at high doses to effects at lower doses. Epidemiological data can then be used for inferential purposes to establish the credibility of the experimentally derived indices.

Toxic effects considered in these profiles include noncarcinogenic (toxic) and potentially carcinogenic health effects as well as environmental effects. Toxicological endpoints, routes of exposure, and doses in humans and/or animal studies are discussed. Potential carcinogenic health effects are associated with exposure to a potential carcinogen. Routes of exposure and doses in humans and/or animal studies are provided. Also considered is the USEPA's weight-of-evidence of a compound's carcinogenicity (i.e., Group A, known human carcinogens; Group-B, probable human carcinogens; Group C, possible human carcinogens; Group D, not classifiable as to its carcinogenicity). Environmental effects include acute and chronic toxic effects observed in aquatic biota and terrestrial wildlife.

The available toxicological information indicates that many of the COPCs have both noncarcinogenic and potential carcinogenic health effects in humans and/or in experimental animals. Although the COPCs may potentially cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risk to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component of the RA process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses (RfDs) and/or carcinogenic slope factors (CSFs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.4.2.1 Reference Doses

The RfDs and Reference Concentrations (RfCs for inhalation) are developed for chronic and/or subchronic human exposure to chemicals and are based solely on the noncarcinogenic effects of chemical substances. These values are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). The RfC is expressed as dose (mg) per cubic meter of air (m^3). They are generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect by an appropriate "uncertainty factor (UF)." Effect levels are determined from laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the RAGS (USEPA, 1989b).

- A UF of 10 is used to account for variation in the general population and is intended to protect sensitive subpopulations (e.g., elderly, children).

- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.

- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.

- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UFs, a modifying factor (MF) is applied to each reference dose and is defined as:

- A MF ranging from >1 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default value for the MF is 1.

Thus, the RfD incorporates the certainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety such that chronic human health effects are not underestimated.

6.4.2.2 Carcinogenic Slope Factor

CSFs are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989b). This factor is generally reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the 95% UCL.

CSFs also can be derived from USEPA promulgated unit risk values for air and/or water. CSFs derived from unit risks cannot, however, be applied to environmental media other than the medium considered in the unit risk estimate.

These slope factors also are accompanied by weight-of-evidence classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

Quantitative indices of toxicity and USEPA weight-of-evidence classifications are presented in Table 6-12 for the identified COPCs. The hierarchy (USEPA, 1989b) for choosing these values was:

- Integrated Risk Information System (IRIS) (USEPA, 1995)
- Health Effects Assessment Summary Table (HEAST) (USEPA, 1994b)
- Region III Specific Directives (USEPA, 1994d)

The IRIS data base is updated monthly and contains both verified RfDs, RfCs, and CSFs. The USEPA has formed an RfD work group to review existing data used to derive RfDs and RfCs. Once this task has been completed the verified RfD appears in IRIS. Like the RfD Work Group, the USEPA also has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work group to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS data base.

HEAST, on the other hand, provides both interim (unverified) and verified RfDs, RfCs, and CSFs. This document is published quarterly and incorporates any applicable changes to its data base.

6.4.2.3 Dermal Absorption Efficiency

Many of the RfDs and CSFs are based on an administered dose and do not account for the amount of a substance that can penetrate the exchange boundaries after contact. Therefore, to account for a difference in toxicity between an administered dose and an absorbed dose, the RfDs and CSFs (that were based on an administered dose) were adjusted (USEPA, 1989b). The adjustment for the RfD that would correspond to the absorbed dose is represented by multiplying the RfD by an oral absorption efficiency. The adjustment for the CSF that would correspond to the absorbed dose is represented by dividing the CSF by an oral absorption efficiency. The oral absorption efficiencies were obtained from sources such as the ECAO, IRIS, and ATSDR toxicological profiles. In some instances, published information was not available to determine the absorption efficiency or published information indicated that absorption efficiency was low for both dermal and oral routes of exposure (i.e., antimony). On these occasions, adjustments to the toxicity value were not conducted (e.g., an absorption efficiency of 100% was assumed). The absorption efficiencies used in this baseline RA for Site 16/SSA 16 are presented in Table 6-12.

6.5 Risk Characterization

The risk characterization combines the selected COPCs, the exposure assessment, and the toxicity assessment to produce a quantitative estimate of current potential human health risks associated with Site 16/SSA 16. Estimated ICRs and HIs for the identified potential adult receptor groups which could be exposed to COPCs via dermal contact, accidental ingestion, and inhalation of fugitive dust in the surface and subsurface soil, as well as dermal contact and ingestion of surface water, sediment, and groundwater by adults and children, and the inhalation of volatile groundwater COPCs by adults while showering, are discussed in this section. The ICRs and HIs were calculated for each of the soil, groundwater, surface water, and sediment COPCs using the 95% UCL of the arithmetic mean, or the maximum concentration if the 95% UCL exceeded the maximum, as the exposure point concentration. The human health risks expected due to chronic exposure through these exposure pathways, are estimated.

6.5.1 Carcinogenic Compounds

Quantitative risk calculations for potentially carcinogenic compounds estimate inferentially (versus probabilistically) the potential ICR for an individual in a specified population. This unit of risk refers to a potential cancer risk that is above the background cancer risk in unexposed individuals. For example, an ICR of 1×10^{-06} indicates that an exposed individual has an increased probability of one in one million of developing cancer subsequent to exposure, over the course of their lifetime.

The potential lifetime ICR for an individual was estimated from the following relationship:

$$ICR = \sum_{i=1}^{n} (CDI_i \text{ or } DAD_i) x\ CSF_i$$

where the CSF_i is expressed as $(mg/kg/day)^{-1}$ for compound i, and the CDI_i and dermally absorbed dose (DAD_i) is expressed as mg/kg/day for compound i. Since the units of CSF are (mg chemical/kg body weight-day)$^{-1}$ and the units of intake or dose are [mg chemical/kg body weight-day], the ICR value is dimensionless. The aforementioned equation was derived assuming that cancer is a nonthreshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

Estimated ICR values will be compared to the target risk range of 1×10^{-06} to 1×10^{-04} which represents the range of ICR values considered by USEPA to be generally acceptable (USEPA, 1990).

For quantitative estimation of risk, it is assumed that cancer risks from various exposure routes are additive. This method of adding risks may overestimate the overall risks since each individual risk uses the maximum detected concentration in the calculation. Since there are no mathematical models that adequately describe chemical antagonism or synergism (i.e., potential reverse or enhancement of effects), these issues will be discussed in narrative fashion in the uncertainty analysis.

6.5.2 Noncarcinogenic Compounds

Noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects are calculated by comparing (i.e., dividing) the CDI_i or DAD_i levels with threshold levels (RfDs) for each COPC.

Noncarcinogenic effects are estimated by calculating the Hazard Index (HI) which is derived as:

$$HI = \sum_{i=1}^{n} HQ_i$$

where: $HQ_i = (CDI_i \text{ or } DAD_i)/RfD_i$

An HQ is the ratio of the daily intake or absorbed dose to the reference dose (or reference concentration for inhalation exposure). HQ_i is the hazard quotient for contaminant i, CDI_i is the chronic daily intake (mg/kg/day) of contaminant i, DAD_i is the dermally absorbed dose (mg/kg/day) of contaminant i, and RfD_i is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure. RfC is the reference concentration used when determining exposure due to inhalation. Since the units of RfD are mg/kg-day and the units of CDI and DAD are mg/kg-day, the hazard quotient is dimensionless.

To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals, the HI, which is the sum of all the HQs, will be calculated. A ratio of 1.0 is used for examination of the HI. Ratios less than 1.0 indicate that adverse noncarcinogenic health effects are unlikely. Ratios greater than 1.0 indicate the potential for adverse noncarcinogenic health effects to occur at that exposure level and caution should be exercised. This does not mean, however, that adverse effects will definitely be observed since the RfD incorporates safety and modifying factors to ensure that it is well below that dose for which adverse effects have been observed. In the risk characterization, an HI value exceeding 1.0 (over multiple COPCs for a given medium and pathway), triggers a target organ analysis. In this analysis, HQs, resulting from COPCs affecting similar organ systems, are quantitatively summed to determine if the risk of adverse systemic effects may be present subsequent to exposure. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect. It should be noted that this summation approach ignores potential interactions among the various chemicals at the site which may either enhance or reduce the potential health effects.

6.6 Potential Human Health Effects

The human health estimates are based upon the exposure assumptions presented in Section 6.3. Potential human health effects considered in the baseline RA include carcinogenic effects and systemic or noncarcinogenic effects. Carcinogenic effects are expressed as ICRs while noncarcinogenic effects are expressed as HIs. Cancer effects are expressed as risk (ICRs) because the expression of cancer does not occur immediately after exposure but typically occurs years after the exposure. Estimated ICR values are compared to the target risk range of 1×10^{-06} to 1×10^{-04} which USEPA considers to be generally acceptable and protective of human health (USEPA, 1990). Noncarcinogenic health effects usually occur subsequent to exposure if a threshold intake level is exceeded. Therefore, noncarcinogenic health effects are expressed as HIs. Estimated HI values less than unity (i.e., 1.0) are considered by USEPA to be generally acceptable and protective of public health (USEPA, 1990). Risk estimates and HIs are not intended as a true indication of actual exposure; they are intended to provide decision makers with useful information regarding the significance of the observed contamination. Risk calculation spreadsheets, showing risk estimates and HIs, are presented in Appendix L.

6.6.1 Current Civilian On-Site Adult Workers

The following subsection describes the risk calculations for potential current civilian on-site adult workers from three environmental media, surface soil, surface water, and sediment. Table 6-13 summarizes the ICR and HI values for each pathway and medium, respectively.

Surface Soil

The ICR and HI values associated with direct contact of surface soil by current civilian adult on-site workers via accidental ingestion, dermal contact, or inhalation (e.g., fugitive dust) at Site 16/SSA 16 resulted in an HI value of 0.29. This HI value was well below 1.0. The total ICR value for ingestion, dermal contact, and inhalation was 2.0×10^{-05}. This value falls within USEPA's target risk range of 1×10^{-06} to 1×10^{-04}.

Surface Water

The ICR and HI values associated with direct contact of surface water by current civilian on-site adult workers at Site 16/SSA 16, via accidental ingestion or dermal contact, resulted in an HI value of 0.2 (using organic and total inorganic results). The HI value was well below 1.0. The total ICR value was 1.1 x 10^{-06} (using organic and total inorganic results). This value falls within USEPA's target risk range of 1 x 10^{-06} to 1 x 10^{-04}.

Sediment

The ICR and HI values associated with direct contact of sediment by current civilian on-site adult workers at Site 16/SSA 16, via accidental ingestion or dermal contact, resulted in an HI value of 0.11. This HI value was below 1.0. The total ICR value for ingestion and dermal contact was 1.5 x 10^{-05}. This value falls within USEPA's target risk range of 1 x 10^{-06} to 1 x 10^{-04}.

6.6.2 Future Adult and Child On-Site Residents

The following subsection will describe the risk calculations for potential future adult and child on-site residents from four environmental media, surface soil, groundwater, surface water, and sediment. Table 6-14 summarizes the ICR and HI values for each pathway and medium, respectively.

Surface Soil

An evaluation of potential risk to future adult residents, subsequent to exposure to surface soil via accidental ingestion and dermal contact, resulted in an HI value of 0.41 and an ICR value of 2.7 x 10^{-05}. The HI value was well below 1.0, while the ICR value fell within USEPA's generally acceptable target risk range of 1 x 10^{-06} to 1 x 10^{-04}.

The ICR and HI values associated with direct contact of surface soil by future child residents via accidental ingestion and dermal contact, resulted in an HI value of 2.0 and an ICR of 2.5 x 10^{-05}. The HI value exceeded unity due primarily to the concentrations of Aroclor-1254 (targeting the immune system), antimony (targeting the whole body and blood), arsenic (targeting the skin), cadmium (targeting the renal cortex), and chromium (no target organ specified) in the surface soil via the ingestion route of exposure. No one constituent exceeded and HQ of 1.0. The ICR fell within USEPA's generally acceptable target risk range of 1 x 10^{-06} to 1 x 10^{-04}.

Groundwater

An evaluation of potential risk subsequent to the ingestion and dermal contact of groundwater by future on-site adult residents included an HI value of 1.3 and an ICR value of 6.4 x 10^{-05} (using organic and dissolved inorganic results). The HI value exceeded the acceptable value of 1.0, due to concentrations of antimony (targeting the whole body and blood), arsenic (targeting the skin) and manganese (targeting the CNS and lungs) in the shallow groundwater. Dissolved antimony accounted for 57% of the HI value, manganese accounted for 21% of the HI value, while the arsenic accounted for 18% of the HI value, via the ingestion route of exposure. The ICR value derived using the organic and dissolved inorganic analytical results was within the target risk range.

The ICR and HI values associated with direct exposure to COPCs detected in groundwater by future on-site child residents via ingestion and dermal contact included an HI of 3.0 and an ICR of 3.7 x 10^{-05} (using organic and dissolved inorganic results). The HI value exceeded 1.0 due to the presence of antimony (targeting the whole body and blood), arsenic (targeting the skin) and manganese (targeting the CNS and lungs). Dissolved antimony accounted for 57% of the HI value, manganese accounted for 21% of the HI value, while the arsenic accounted for 18% of the HI value, via the ingestion route of exposure. The ICR value derived using the organic and dissolved inorganic analytical results was within the target risk range.

Surface Water

Potential exposure to COPCs in surface water by future adult residents resulted in an HI value of 0.03 and an ICR value of 1.8 x 10^{-07} (using organic and total inorganic results). The HI value was well below 1.0 and the ICR value fell below the USEPA's generally acceptable risk range of 1 x 10^{-06} to 1 x 10^{-04}.

The ICR and HI values associated with direct contact of surface water by future on-site child residents via ingestion and dermal contact included an HI of 0.09 and an ICR of 2.0 x 10^{-07} (using organic and total inorganic results). The HI value was well below 1.0 and the ICR value was below the USEPA's generally acceptable target risk range.

Sediment

An evaluation of potential risk subsequent to exposure to the accidental ingestion and dermal contact with sediment for the future adult resident, resulted in an HI value of 0.02 and an ICR value of 2.7×10^{-06}. The HI value was well below 1.0 while the ICR value fell within USEPA's target risk range of 1×10^{-06} to 1×10^{-04}.

The ICR and HI values associated with direct contact (accidental ingestion and dermal contact) of COPCs detected in Site 16/SSA 16 sediment samples by future child residents resulted in an HI value of 0.1 and an ICR value of 3.2×10^{-06}. The HI value was below 1.0 while the ICR value fell within USEPA's generally acceptable risk range of 1×10^{-06} to 1×10^{-04}.

6.6.3 Future Adult Construction Workers

The following subsection will describe the risk calculations for potential future on-site adult construction workers from one environmental medium, subsurface soil. Table 6-15 summarizes the ICR and HI values for each pathway and medium, respectively.

Subsurface Soil

ICR and HI values associated with direct contact (accidental ingestion, dermal contact, and inhalation of fugitive dust) of COPCs detected in subsurface soil samples by future construction workers were evaluated. An HI value of 0.5 and an ICR value of 1.9×10^{-06} were derived. The HI value was below 1.0, while the ICR value fell within USEPA's target risk range of 1×10^{-04} to 1×10^{-06}.

6.7 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty inherent in the following elements of the public health evaluation performed for Site 16/SSA 16:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Chemicals not quantitatively evaluated

Uncertainties associated with this risk assessment are discussed in the following paragraphs. Table 6-16 qualitatively summarizes the potential effects of certain uncertainties on the estimation of human health risks.

6.7.1 Sampling and Analysis

The development of a risk assessment depends on the reliability of, and uncertainties associated with, the analytical data available to the risk assessor. These, in turn, are dependent on the operating procedures and techniques applied to the collection of environmental samples in the field and their subsequent analyses in the laboratory. To minimize the uncertainties associated with sampling and analysis at Site 16/SSA 16, USEPA approved sampling and analytical methods were employed. Data was generated following USEPA's Statement of Work for CLP. Samples were analyzed for TCL organics (plus nitramine compounds), TAL inorganics, and cyanide. Samples were taken from locations specified in the approved Work Plan (Baker, 1994) along with the necessary QA/QC samples.

Analytical data are limited by the precision and accuracy of the methods of analysis which are reflected by the Relative Percent Difference (% RPD) of duplicate analyses and percent recoveries of spikes, respectively. In addition, the statistical methods used to compile and analyze the data (such as mean concentrations and detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

6.7.2 Selection of COPCs

The selection of COPCs is performed in a risk assessment following the evaluation of data. Analytical data also must be comprehensive in order to address the COPCs associated with the site. Types of COPCs encountered at Site 16/SSA 16 include VOCs in the groundwater, SVOCs in the surface soil, pesticides in the groundwater, PCBs in the surface soil and sediment, and inorganic constituents in each medium sampled.

Soil COPCs were selected based on comparisons of exposure point concentrations with Region III residential soil COC values. Groundwater COPCs were selected based on comparisons of exposure point concentrations with Region III tapwater COC values, Federal MCLs, and Commonwealth groundwater standards. Surface water COPCs were selected based on comparisons of exposure point concentrations to Federal and Commonwealth Water Quality Criteria, and Region III COC values for tapwater. Sediment COPCs were selected based on comparisons of exposure point concentrations to SSVs and residential soil COC values.

Region III COC values are based on exposure assumptions and equations that are intended to introduce conservatism in the risk assessment process by changing the COPC screening method from a relative toxicity screen as presented in RAGS, to an absolute comparison of risk. However, the use of the Region III COC values results in the application of a set of non-site-specific assumptions in the determination of COPCs at Site 16/SSA 16. In addition, the use of SSVs (which are intended for aquatic organisms) and residential soil COC values for the selection of human health COPCs in sediment, provides a very conservative screening tool.

Currently, Station closures are not planned for WPNSTA Yorktown, and future residential development is not considered an expected land use for the area. The application of the residential COPC screening concentrations to soil and groundwater COPC selections would, therefore, tend to result in a list of COPCs that could be considered overly conservative for a military base. However, the use of conservative COPC selections in the baseline RA ensures the protection of public health in that the results of the baseline RA are incorporated into the determination of remedial alternatives and remedial action objectives in the FS.

6.7.3 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium. For example, SVOCs such as PAHs (which are common constituents of fuels) or PCBs, if released to surface soils, are not expected to undergo appreciable downward migration to subsurface soils due to their relatively low water solubilities and moderate to high tendencies to adsorb to soil and clay particulates, which thereby reduce their overall environmental mobilities.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. The USEPA has published an Exposure Factors Handbook (USEPA, 1989a) which contains the best and latest values. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited numbers of individuals. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The use of a RME approach, designed as not to underestimate daily intakes, was employed throughout this risk assessment. The use of 95% UCL estimates of the arithmetic mean versus maximum values as the concentration term in estimating the CDI or DAD reduces the potential for underestimating exposure at the Site 16/SSA 16.

6.7.4 Toxicological Assessment

In making quantitative estimates of the toxicity of varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are at all available. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from high doses in animals to low doses in humans, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human pharmacokinetics.
- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.
- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans and from high doses to low doses. In deriving carcinogenic potency factors, the 95% UCL value is promulgated by the USEPA to prevent underestimation of potential risk.

Estimating the dermal absorption efficiency to account for a difference in toxicity between an administered dose and an absorbed dose, could account for a potential for an overestimation of risk. This is due to the uncertainty associated with obtaining the oral absorption efficiencies from several sources (such as the ECAO, IRIS, and ATSDR) that publish studies which can vary in their methodologies, test subjects, and subsequent findings. Few reports specifically address the percent absorbed via the dermal route of entry. However, in the end, the use of conservative assumptions, results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.7.5 Human Risk Characterization

The risk characterization bridges the gap between potential exposure and the possibility of systemic or carcinogenic human health effects, ultimately providing impetus for the remediation of the site or providing a basis for no remedial action. Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. USEPA promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

When assessing the potential for noncarcinogenic effects the HI is used. In instances where the HI exceeds 1.0, a quantitative target organ analysis is often conducted to determine if the potential for adverse health effects has been overestimated. In this manner, COPCs that are expected to induce the same type of effect or that act by the same mechanism, would be summed. The resultant summation would then more closely reflect the potential for adverse health effects to a particular target organ. However, since HQ's greater than unity did not occur in this baseline RA, the quantitative target organ analysis was not conducted.

6.7.6 Compounds Not Quantitatively Evaluated

The inorganic COPC lead, was not quantitatively evaluated in the baseline RA. Lead is currently considered a B2 - probable human carcinogen, as well as a developmental toxin in young children. The lack of promulgated toxicological indices for lead does not have significant effects on the underestimation of risk due to the presence of other COPCs such as arsenic, in environmental media at relatively high levels. Although this constituent was not quantitatively evaluated, this risk assessment has been performed using conservative exposure point concentrations, exposure scenarios (use of the groundwater aquifer as a drinking water source), and available toxicological information.

6.8 Summary of Risk Assessment Results

This section summarizes the results of the baseline RA and identifies environmental media and COPCs which could potentially pose human health risks and/or effects.

Risk results from each logical exposure pathway were summed for each receptor to determine the total site risk posed by Site 16/SSA16. The following subsections present the potential current and future exposure pathways and the subsequent potential total site risk to human health.

6.8.1 Current Potential Receptors

Potential current receptors to COPCs detected in environmental media at Site 16/SSA 16 include:

- Civilian On-Site Adult Workers

Potential current total site risks for this receptor are presented in Table 6-17. The total ICR value falls within USEPA's target risk range of 1×10^{-06} to 1×10^{-04}. The target risk range represents the range of potential risks that USEPA generally believes to be acceptable. The HI value presented in Table 6-17 for current potential human receptors also falls below 1.0 indicating that noncarcinogenic adverse human health risks would probably not occur subsequent to exposure.

6.8.2 Future Potential Receptors

Property use at Site 16/SSA 16 will remain the same in the foreseeable future. Future residential development of Site 16/SSA 16 is highly unlikely given its location within the restricted area of the Station and the newly-constructed security fence that encloses the site. However, for the sake of conservatism, future residential development and associated potential risks were evaluated. The potential human receptors evaluated for the future scenarios were:

- Future residents (adults and children)
- Future adult construction workers

The results of each of these scenarios are presented below.

Future Residents

Table 6-18 presents the total ICR and HI values for the future potential residential development of Site 16/SSA 16. It was assumed that future residents could potentially be exposed to COPCs in surface soil, groundwater, surface water, and sediment. Future development of groundwater for potable purposes is unlikely even in the event of future residential development because of the low yield and poor water quality of the shallow aquifers (i.e., the Cornwallis Cave Aquifer) and the availability of municipal water; however, potential potable exposure to COPCs in groundwater was evaluated for the sake of conservatism. Total ICR and HI values for future residents are the sum total of the resident adult and resident child HI and ICR values, respectively.

The total ICR value for future residents exceeded the USEPA's target risk range of 1×10^{-06} to 1×10^{-04}. This was due primarily to the presence of arsenic in the groundwater. HI values for future residents were greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur subsequent to exposure. Antimony, arsenic and manganese in groundwater as well as constituents in the surface soil, were the main contributors to the total HI value using organic and dissolved inorganic groundwater concentrations.

Future Adult Construction Worker

Future potential adult construction workers could be exposed to COPCs in subsurface soil during future building/excavation activities at Site 16/SSA 16. The total ICR value for the future adult construction worker was within the USEPA's target risk range; the HI value did not exceed 1.0. Therefore, carcinogenic or noncarcinogenic health effects would not be expected for adult construction workers, subsequent to exposure to subsurface soil. Table 6-18 presents the total ICR and HI values for this receptor.

6.9 References

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TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Type of Blank with Maximum Detected Value	Concentration for Comparison[(1)] (Aqueous-µg/L)	Concentration for Comparison[(2)] (Solid-µg/kg)
Volatiles:				
Acetone	17J	Trip Blank	170	170
2-Butanone	50	Field Blank	500	500
Bromodichloromethane	16	Field Blank	80	80
Chloroform	6.7	Rinsate Blank	33.5	33.5
Chloromethane	1.2	Rinsate Blank	6	6
Dibromochloromethane	2	Field Blank	10	10
4-Methyl-2-Pentanone	50	Field Blank	250	250
Methylene Chloride	18B	Trip Blank	180	180
Tetrachlorothene	210J	Field Blank	1,050	1,050
Toluene	3J	Field Blank	30	30
1,1,1-Trichloroethane	4J	Field Blank	20	20
Trichloroethene	24	Field Blank	120	120
Xylenes	5J	Field Blank	25	25
Semivolatiles:				
Acenaphthene	4J	Field Blank	20	660
bis(2-ethylhexyl)phthalate	2J	Rinsate Blank	20	660
Di-n-butylphthalate	5J	Rinsate Blank	50	1,650
2-Methylnaphthalene	6J	Field Blank	30	990
Naphthalene	30	Field Blank	150	4,950
Phenol	3J	Rinsate Blank	15	495
1,2,4-Trichlorobenzene	35	Field Blank	175	5,775

TABLE 6-1 (Continued)

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Type of Blank with Maximum Detected Value	Concentration for Comparison[1] (Aqueous-µg/L)	Concentration for Comparison[2] (Solid-µg/kg)
Pesticides:				
Heptachlor Epoxide	0.012J	Rinsate Blank	0.06	1.98
Nitramines:				
RDX	19	Rinsate Blank	95	3,135

(1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum detected concentration in a blank.

(2) Concentration is five or ten times the maximum detected concentration in a blank; converted to µg/kg.

TABLE 6-2

SURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Soil Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Acetone	10,000	780	1	0.008J	0	0	No
Methylene Chloride	380	85	19/27	0.003J-0.12J	0	0	No
Semivolatiles:							
Acenaphthylene	4,100*	310*	1/27	0.093J	0	0	No
Benzo(a)anthracene	3.9	0.88	4/27	0.057J-0.15J	0	0	No
Benzo(a)pyrene	0.39	0.088	4/27	0.05J-0.1J	0	1	Yes
Benzo(b)fluoranthene	3.9	0.88	5/27	0.1J-0.22J	0	0	No
Benzo(k)fluoranthene	39	8.8	5/27	0.034J-0.096J	0	0	No
Bis(2-ethylhexyl)phthalate	200	46	5/27	0.061J-0.66	0	0	No
Butylbenzylphthalate	20,000	1,600	1/27	0.565	0	0	No
Carbazole	140	32	1/27	0.19J	0	0	No
Chrysene	390	88	4/27	0.071J-0.16J	0	0	No

TABLE 6-2 (Continued)

SURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH
USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Soil Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
Contaminant[1]	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Diethylphthalate	82,000	6,300	1/27	0.094J	0	0	No
Di-n-Butylphthalate	10,000	780	6/27	0.040J-0.56	0	0	No
Fluoranthene	4,100	310	4/27	0.099J-0.42	0	0	No
Fluorene	4,100	310	1/27	0.051J	0	0	No
Indeno (1,2,3-cd) pyrene	3.9	0.88	3/27	0.061J-0.08J	0	0	No
Phenanthrene	4,100*	310*	4/27	0.045J-0.38J	0	0	No
Pyrene	3,100	230	4/27	0.1J-0.28J	0	0	No
Pesticides/PCBs:							
Alpha-chlordane	2.2	0.47	1/23	0.0031J	0	0	No
Beta-BHC	1.6	0.35	1/24	0.0033J	0	0	No
4,4 - DDD	12	2.7	1/23	0.0074J	0	0	No
4,4'-DDE	8.4	1.9	12/24	0.0014J-0.021J	0	0	No
4,4'-DDT	8.4	1.9	6/24	0.002J-0.048	0	0	No

TABLE 6-2 (Continued)

SURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Soil Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Dieldrin	0.18	0.04	11/27	0.00055J-0.017J	0	0	No
Endrin Ketone	--	--	6/25	0.00067J-0.017J	--	--	No
Heptachlor	0.64	0.14	1/24	0.0052J	0	0	No
Methoxychlor	510	39	1/23	0.0024J	0	0	No
Aroclor-1254	0.37	0.083	12/25	0.034J-2.1J	2	7	Yes
Aroclor-1260	0.37	0.083	11/25	0.036-1.4J	3	6	Yes
Inorganics:							
Aluminum	100,000	7,800	27/27	2,310J-14,900J	0	2	Yes
Antimony	41	3.1	2/26	9L-63.8J	1	2	Yes
Arsenic (c./n)	1.6/31	0.37/2.3	25/27	2.1J-20	24/0	24/21	Yes
Barium	7,200	550	27/27	12.5J-64.4	0	0	No
Beryllium	0.67	0.15	27/27	0.15J-0.79J	1	25	Yes

TABLE 6-2 (Continued)

SURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[(1)]	Soil Criteria[(2)]		Contaminant Frequency/Range[(3)]		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Cadmium	51	3.9	18/27	0.62J-66.5	1	6	Yes
Calcium+	--	--	27/27	191J-3,840J	--	--	No
Chromium (VI)	510	39	27/27	5.3-1,060	1	3	Yes
Cobalt	6,100	470	26/27	1.6J-47.7	0	0	No
Copper	3,800	290	27/27	2.7J-1,440	0	3	Yes
Cyanide (total)	2,000	160	3/26	2.8-128	0	0	No
Iron+	--	--	27/27	5,240-217,000	--	--	No
Lead	--	400[(4)]	27/27	3.9-2,610	--	1	Yes
Magnesium+	--	--	27/27	148J-2,040	--	--	No
Manganese	510	39	27/27	15.5J-875J	1	23	Yes
Mercury	31	2.3	12/27	0.11J-3.3J	0	2	Yes
Nickel	2,000	160	25/27	1.8J-57.5	0	0	No
Potassium+	--	--	22/27	108J-932J	--	--	No

TABLE 6-2 (Continued)

SURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH
USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Soil Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
Contaminant[1]	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Selenium	510	39	7/27	0.34J-0.64J	0	0	No
Silver	510	39	3/26	0.7J-12.4	0	0	No
Sodium+	--	--	27/27	25.2J-177J	--	--	No
Vanadium	720	55	26/27	6.8J-60.8	0	1	Yes
Zinc	31,000	2,300	27/27	8.4J-1,320	0	0	No

(1) Organic concentrations reported in µg/kg, Inorganic concentrations reported in mg/kg.
(2) COC Value = USEPA Region III COC screening value (USEPA, 1993a)
(3) J = Analyte was positively identified, value is estimated.
(4) Action level for residential soils (USEPA, 1994c)
-- = No criteria published
+ = Essential Nutrients
* = Naphthalene was used as a surrogate for the COC value.

TABLE 6-3

SUBSURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Region III Criteria		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
Contaminant[1]	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Methylene Chloride	380	85	1/19	0.005B	0	0	No
Acetone	10,000	780	10/19	0.007J-0.026B	0	0	No
Semivolatiles:							
bis(2-ethylhexyl)phthalate	200	46	4/19	0.13J-0.32J	0	0	No
Di-n-butylphthalate	10,000	780	1/19	0.96B	0	0	No
Phenol	61,000	4,700	1/19	0.38B	0	0	No
Inorganics:							
Aluminum	100,000	7,800	19/19	3,520J-28,400	0	10	Yes
Antimony	41	3.1	1/4	10.1L	0	1	Yes
Arsenic (c/n)	1.6/31	0.37/2.3	19/19	0.61J-38.2L	14/0	19/11	Yes
Barium	7,200	550	19/19	10.1J-65.9	0	0	No
Beryllium	0.67	0.15	14/19	0.22-2	4	14	Yes

TABLE 6-3 (Continued)

SUBSURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH
USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Calcium+	--	--	19/19	83.2J-8,140L	--	--	No
Chromium (VI)	510	39	19/19	3.8-56.5	0	3	Yes
Cobalt	6,100	470	19/19	1.2J-26	0	0	No
Copper	3,800	290	18/19	1.6L-19.7	0	0	No
Iron+	--	--	19/19	3,010-57,000	--	--	No
Lead	--	400[4]	19/19	3.3	--	0	No
Magnesium+	--	--	19/19	284J-3,690	--	--	No
Manganese	510	39	19/19	7.8K-466J	0	8	Yes
Nickel	2,000	160	11/15	4.4J-41.5	0	0	No
Potassium+	--	--	12/19	372J-4,720	--	--	No
Selenium	510	39	6/19	0.27JL-0.56L	0	0	No
Silver	510	39	2/13	1.3J-1.8L	0	0	No
Sodium+	--	--	19/19	13.4J-383J	--	--	No

TABLE 6-3 (Continued)

SUBSURFACE SOIL DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Region III Criteria		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Vanadium	720	55	19/19	5.5L-62.8	0	2	Yes
Zinc	31,000	2,300	19/19	4.5	0	0	No

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) COC Value = USEPA Region III COC screening value (USEPA, 1993a)
(3) L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
B = Detected in associated blank(s)
K = Value estimated; biased high
(4) Action level for residential soils (USEPA, 1994c)
-- = No criteria published
+ = Essential Nutrients

TABLE 6-4

GROUNDWATER DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS
COMPARED TO FEDERAL, REGION, AND COMMONWEALTH CRITERIA
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Groundwater Criteria[2]			Frequency/Range[3]		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:									
Acetone	--	370	--	2/2	0.6J-0.6J	--	0	--	No
1,1-Dichloroethene	7	0.044	7	2/10	2-2	0	2	0	Yes
1,1-Dichloroethane	--	81	--	2/10	0.81J-1	--	0	--	Yes[4]
1,1,1-Trichloroethane	200	130	200	2/10	2-7	0	0	0	Yes[4]
Tetrachloroethene	5	1.1	--	1/10	0.6J	0	0	0	Yes[4]
Trichloroethene	5	1.6	5	1/10	0.7J	0	0	0	Yes[4]
Semivolatiles:									
1,4-Dichlorobenzene	5	0.44	400	1/10	2J	0	1	0	Yes
Di-n-butylphthalate	--	370	--	1/10	1J	--	0	--	No
Pesticides:									
Aldrin	--	0.004	0.0013	1/10	0.043J	--	1	1	Yes
Endrin	2	1.1	0.2	1/10	0.02J	0	0	0	No
4,4'-DDT	--	0.2	0.0059	1/10	0.058J	--	0	1	Yes
Inorganics (Dissolved)									
Aluminum	--	3,700	--	1/10	17J	--	0	--	No

TABLE 6-4 (Continued)

GROUNDWATER DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS
COMPARED TO FEDERAL, REGION, AND COMMONWEALTH CRITERIA
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Groundwater Criteria[2]			Frequency/Range[3]		Comparison to Criteria			COPC Selection
Contaminant[1]	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Antimony	6	1.5	--	2/10	13.1J-19.3J	2	2	--	Yes
Arsenic (carcinogen)	50	0.038	50	1/10	5.9K	0	1	0	Yes
Barium	2,000	260	1,000	10/10	17.8J-54.4J	0	0	0	No
Beryllium	4	0.016	--	2/10	0.31J-0.34J	0	2	--	Yes
Calcium+	--	--	--	10/10	3,980J-127,000	--	--	--	No
Chromium	100	18	50	1/10	1.6J	0	0	0	No
Cobalt	--	220	--	1/10	2.3J	--	0	--	No
Copper	1,300	140	1,000	10/10	1.8J-10.1J	0	0	0	No
Iron+	--	--	--	9/10	4.2J-253	--	--	--	No
Lead	15	--	50	1/10	1.7K	0	--	0	No
Magnesium+	--	--	--	10/10	853J-4,040J	--	--	--	No
Manganese	--	18	--	10/10	1.1J-114	--	3	--	Yes
Nickel	100	73	--	2/10	6.3J-6.6J	0	0	--	No
Potassium+	--	--	--	10/10	717J-1,770J	--	--	--	No
Selenium	50	18	10	1/10	2.9J	0	0	0	No
Sodium+	--	--	--	10/10	2,770-10,220	--	--	--	No

TABLE 6-4 (Continued)

GROUNDWATER DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS
COMPARED TO FEDERAL, REGION, AND COMMONWEALTH CRITERIA
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Groundwater Criteria(2)			Frequency/Range(3)		Comparison to Criteria			COPC Selection
Contaminant(1)	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Vanadium	--	26	--	6/10	1.9J-2.7J	--	0	--	No
Zinc	--	1,100	--	10/10	5J-19.2J	--	0	--	No

(1) All concentrations reported in µg/L
(2) Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1994a; Drinking Water Regulations and Health Advisories)
Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
COC values - USEPA Region III COC screening value (USEPA, 1993a)
(3) J = Analyte was positively identified, value is estimated
L = Value estimated; biased low
K = Value estimated; biased high
(4) Contaminant re-included as a COPC (refer to text)
-- = No criteria published
+ = Essential Nutrient

TABLE 6-5

SURFACE WATER DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS
COMPARED TO FEDERAL, REGION, AND COMMONWEALTH CRITERIA
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Federal/Regional Criteria[2]			Virginia Water Quality Standards[3]		Frequency/Range[4]		COPC Selection
Contaminant[1]	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Volatiles:								
Acetone	--	--	370	--	--	1/1	10B	No
Toluene	10,000	300,000	75	6,800	200,000	2/4	1.4	No
Inorganics (Total):								
Aluminum	--	--	3,700	--	--	4/4	29.2J-99J	No
Arsenic (as carcinogen)	0.018	0.14	0.038	50	--	3/4	2.6L-2.9L	Yes
Barium	1,000*	--	260	2,000	--	4/4	35.3J-39.1J	No
Calcium+	--	--	--	--	--	4/4	53,700-57,500J	No
Iron+	300*	--	--	300	--	4/4	1,350J-2,000J	No
Lead	50*	--	--	15	--	1/4	5.9	No
Magnesium+	--	--	--	--	--	4/4	1,750J-2,600J	No
Manganese	50*	100*	18	50	--	4/4	189J-374J	Yes
Potassium+	--	--	--	--	--	3/4	3,120J-3,630J	No
Selenium	104	6,800	18	172	11,200	2/4	1.2J-1.9L	No

TABLE 6-5 (Continued)

SURFACE WATER DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS
COMPARED TO FEDERAL, REGION, AND COMMONWEALTH CRITERIA
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Federal/Regional Criteria[2]			Virginia Water Quality Standards[3]		Frequency/Range[4]		COPC Selection
Contaminant[1]	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Sodium+	--	--	--	--	--	4/4	6,040-12,500	No
Zinc	--	--	1100	5,000	--	3/4	3.2J-5.6J	No

Notes:

(1) All concentrations reported in µg/L
(2) Water Quality Criteria (WQC) human health values (recalculated) using IRIS as of 1990.
COC value - USEPA Region III COC screening value (USEPA, 1993a)
(3) Virginia Water Standards (Bureau of National Affairs - December 1994)
(4) J = Analyte was positively identified, value is estimated
B = Detected in associated blank(s)
L = Value is estimated; biased low
-- = No criteria published
+ = Essential Nutrient
* = Hardness dependent criteria (100 mg/L $CaCO_3$ used)

TABLE 6-6

SEDIMENT DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH SEDIMENT SCREENING VALUES AND USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Sediment Criteria(2)		Contaminant Frequency/Range(3)		Comparison to Criteria		COPC Selection
Contaminant(1)	SSV ER-M (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Volatiles:							
2-Butanone	--	4,700	2/9	0.027-0.039	--	0	No
Acetone	--	780	6/9	0.028-0.17	--	0	No
Carbon Disulfide	--	780	2/9	0.011J-0.038	--	0	No
Chloromethane	--	49	1/9	0.04J	--	0	No
Toluene	--	1,600	2/9	0.004J-0.044J	--	0	No
Pesticides/PCBs:							
Edrin Aldehyde	--	--	1/9	0.0064	--	--	No
Heptachlor epoxide	--	0.07	1/9	0.0026J	--	0	No
Aroclor-1260	0.18	0.37	2/9	0.027J-0.045J	0	0	Yes(4)
Inorganics:							
Aluminum	--	7800	9/9	1,130-22,500	0	1,125	Yes
Arsenic (c/n)	70	0.37/2.3	9/9	1.4J-12.2	0	0	Yes
Barium	--	550	9/9	6J-82.6	--	0	No
Beryllium	--	0.15	4/9	0.57J-0.93J	--	4	Yes

TABLE 6-6 (Continued)

SEDIMENT DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH SEDIMENT SCREENING VALUES AND USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant[1]	Sediment Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Cadmium+	9.6	3.9	1/9	2.6	0	0	No
Calcium+	--	--	9/9	1,900-27,600J	--	--	No
Chromium (VI)	370	39	9/9	4.3-37.4	0	0	No
Cobalt	--	470	7/9	2.1J-8.8J	--	0	No
Copper	270	290	8/9	3.5J-94.8	0	0	No
Iron+	--	--	9/9	5,140-39,100	--	--	No
Lead	218	400[5]	9/9	4.3J-34.4J	0	0	No
Magnesium+	--	--	9/9	192J-4,110	--	--	No
Manganese	--	39	9/9	41.1J-145L	--	9	Yes
Nickel	51.6	160	6/9	5.6J-20.6	0	0	No
Potassium+	--	--	6/9	581J-3,260	--	--	No
Selenium	--	39	6/9	0.26L-0.77J	--	0	No
Silver	3.7	39	4/9	2.1J-3.4J	0	0	No
Sodium+	--	--	9/9	77.8J-1,520J	--	--	No

TABLE 6-6 (Continued)

SEDIMENT DATA SUMMARY
FREQUENCY AND RANGE OF POSITIVE DETECTIONS AND COMPARISONS WITH SEDIMENT SCREENING VALUES AND USEPA REGION III COC SCREENING VALUES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Sediment Criteria[2]		Contaminant Frequency/Range[3]		Comparison to Criteria		COPC Selection
Contaminant[1]	SSV ER-M (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Vanadium	--	55	9/9	5.2J-57.6	--	1	Yes
Zinc	410	2,300	9/9	12.8-112	0	0	No

(1) Organic concentrations converted to mg/kg, Inorganic concentrations reported in mg/kg.
(2) SSV = Sediment Screening Value (Long, et al, 1995)
COC value = USEPA Region III COC screening value (USEPA, 1993a)
(3) L = Estimated value, biased low
J = Analyte was positively identified. Value is estimated.
(4) Contaminant re-included as a COPC (refer to text)
(5) Action level for residential soils (USEPA, 1994c)
-- = No criteria published
+ = Essential Nutrients

TABLE 6-7

**PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant ($atm\text{-}m^3/mole$)	Mobility Index
Volatiles:							
1,1-Dichloroethane	$1.82 \times 10^{+2}$	$5.5 \times 10^{+3}$	1.48	1.79	1.174	4.31×10^{-3}	5
1,1-Dichloroethene	$6.00 \times 10^{+2}$	$2.3 \times 10^{+3}$	1.81	1.84	1.22	3.4×10^{-02}	5
1,1,1-Trichloroethane	$1.23 \times 10^{+2}$	$1.5 \times 10^{+3}$	2.18	2.5	1.350	1.44×10^{-2}	3
Tetrachloroethene	$1.78 \times 10^{+1}$	$1.5 \times 10^{+2}$	2.56	2.6	1.626	2.59×10^{-2}	1
Trichloroethene	$5.79 \times 10^{+1}$	$1.1 \times 10^{+3}$	2.10	2.38	1.46	9.10×10^{-3}	3
Semivolatiles:							
Benzo(a)pyrene	5.6×10^{-09}	1.2×10^{-03}	6.74	6.06	--	1.55×10^{-06}	-18
1,4-Dichlorobenzene	1.18	79	3.23	3.60	1.25	2.9×10^{-03}	-1
Pesticides:							
Aldrin	6×10^{-06}	1.8×10^{-01}	4.98	5.30	1.6	1.60×10^{-05}	-11
4,4'-DDT	5.5×10^{-06}	5.00×10^{-03}	5.39	6.19	1.56	5.13×10^{-04}	-13
PCBs:							
Aroclor 1254	7.7×10^{-05}	0.03	4.59	6.03	1.50	2.8×10^{-03}	-10
Aroclor 1260	4.1×10^{-05}	0.003	4.87	6.11	1.58	7.1×10^{-03}	-12

Notes: -- = Value not available.

TABLE 6-8

**RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Relative Mobility	Environmental Conditions			
	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very High			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Cr, Se, Zn, Cu, Ni, Hg, Pb, Ba, Be, Ag

Notes:

As = Arsenic
Ag = Silver
Ba = Barium
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
Ni = Nickel
Pb = Lead
Se = Selenium
Zn = Zinc

Source: Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December 1992.

TABLE 6-9

EXPOSURE INPUT PARAMETERS FOR CURRENT CIVILIAN ADULT ON-SITE WORKERS POTENTIALLY EXPOSED TO COPCs IN SURFACE SOIL, SURFACE WATER, AND SEDIMENT VIA INGESTION, DERMAL CONTACT, AND INHALATION OF FUGITIVE DUST
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Input Parameter	Media	Units	Current Receptor Adult Civilian	Comments/References
ED, Exposure Duration	All Media	years	25	USEPA, 1991a
IR, Ingestion Rate	Soil/Sediment	mg/day	100	USEPA, 1991a
	Surface Water	L/day	0.05	USEPA, 1989b
EF, Exposure Frequency	All Media	days/yr	250	USEPA 1991a
AF, Adherence Factor	Soil/Sediment	mg/cm^2	1.0	USEPA, 1991a and 1992a
ABS, Dermal Absorption Factor for Organics/Inorganics	Soil/Sediment	unitless	Chemical-specific(1)	USEPA, 1992a and 1992b Ryan, et al., 1987 Webster, et al., 1993
ET, Exposure Time	Soil	hrs/day	8	USEPA, 1991a
	Surface Water	hrs/day	2	Professional Judgment
SA, Surface Area	All Media	cm^2/day	5,300(2)	USEPA, 1992a
PC, Permeability Constant	Surface Water	cm/hr	Chemical-Specific	USEPA, 1992a
FI, Fraction Ingested	Soil/Sediment	unitless	1	USEPA, 1989b
AT, Averaging Time AT_{nc}, noncarcinogens	All Media	days	9125	USEPA, 1989b
AT_c, carcinogens	All Media	days	25550	USEPA, 1989b
BW, Body Weight	All Media	kg	70	USEPA, 1989b
RR, Respiration Rate	Air	m^3/hr	0.83	USEPA, 1991a

Notes:

(1) The following absorbance factors will be applied to estimate dermal intake of COPCs:

Experimentally Derived (USEPA, 1992a): PCBs - 0.06; Cadmium - 0.01

Other Values (Ryan, et al., 1987 and Webster, et al., 1993): Oganics - 0.10; Inorganics - 0.01; Arsenic - 0.03

(2) Skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes.

TABLE 6-9 (Continued)

EXPOSURE INPUT PARAMETERS FOR CURRENT CIVILIAN ADULT ON-SITE WORKERS POTENTIALLY EXPOSED TO COPCs IN SURFACE SOIL, SURFACE WATER, AND SEDIMENT VIA INGESTION, DERMAL CONTACT, AND INHALATION OF FUGITIVE DUST SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

References:

Ryan, et al., 1987. Assessing Risk from Dermal Exposure at Hazardous Waste Sites.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

Webster, et al., 1993. *InVivo and InVitro* Percutaneous Absorption and Skin Decontamination of Arsenic from Water and Soil.

TABLE 6-10

EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS POTENTIALLY EXPOSED TO COPCs IN SURFACE SOIL, GROUNDWATER, SURFACE WATER, AND SEDIMENT VIA INGESTION, DERMAL CONTACT, AND INHALATION SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Input Parameter	Media	Units	Future Receptor		Comments/References
			Child (1 to 6 years)	Adult	
ED, Exposure Duration	All media	years	6	24	USEPA, 1991a
EF, Exposure Frequency	Groundwater	days/year	350	350	USEPA, 1991a
	Soil	days/year	350	350	USEPA, 1991a
	Sediment/ Surface Water	days/year	45	45	Professional Judgment
ET, Exposure Time	Sediment/ Surface Water	hrs/day	2	2	Professional Judgment
	Soil	hrs/day	8	8	USEPA, 1991a
	Groundwater	hrs/day	0.2	0.2	USEPA, 1989a
IR, Ingestion Rate	Groundwater	L/day	1	2	USEPA, 1991a
	Soil/Sediment	mg/day	200	100	USEPA, 1989b
	Surface Water	L/day	0.05	0.05	USEPA, 1989b
SA, Surface Area	Groundwater	cm^2	8,023	20,000	USEPA, 1992a
	Soil/Sediment/ Surface Water	cm^2	2,115[(1)]	5,300[(2)]	USEPA, 1989a and 1992a
FI, Fraction Ingested	Soil/Sediment	unitless	1	1	USEPA, 1989b
ABS, Absorbance Factor Organics/Inorganics	Soil/Sediment	unitless	Chemical Specific[(3)]	Chemical Specific[(3)]	USEPA, 1992a and 1992b Ryan, et al., 1987 Webster, et al., 1993
AF, Adherence Factor	Soil/Sediment	mg/cm^2	1	1	USEPA, 1992a
AT, Averaging Time AT_{nc}, noncarcinogens	All Media	day	2,190	8,760	USEPA, 1989b and 1991a
AT_c, carcinogens	All Media	day	25,550	25,550	USEPA, 1989b
BW, Body Weight	All Media	kg	15	70	USEPA, 1989b
PC, Permeability Constant	Groundwater/ Surface Water	cm/hr	Chemical-Specific	Chemical-Specific	USEPA, 1992a
RR, Respiration Rate	Air	m^3/hr	0.83	0.83	USEPA, 1991a

TABLE 6-10 (Continued)

EXPOSURE INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS POTENTIALLY EXPOSED TO COPCs IN SURFACE SOIL, GROUNDWATER, SURFACE WATER, AND SEDIMENT VIA INGESTION, DERMAL CONTACT, AND INHALATION SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Notes: (1) Average skin surface area for a male/female child (95th percentile), 1-6 years, wearing a short-sleeved shirt, short pants, and shoes.

(2) Skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes

(3) The following absorbance factors will be applied to estimate dermal intake of COPCs:

Experimentally Derived (USEPA, 1992a):	PCBs - 0.06 Cadmium - 0.01
Other Values (Ryan, et al., 1987 and Webster, et al., 1993:	Organics - 0.10 Inorganics - 0.01 Arsenic - 0.03

References:

Ryan, et al., 1987. Assessing Risk from Dermal Exposure at Hazardous Waste Sites.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications – Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual (Part A) Interim Final.

Webster, et al., 1993. *InVivo and InVitro* Percutaneous Absorption and Skin Decontamination of Arsenic from Water and Soil.

TABLE 6-11

EXPOSURE INPUT PARAMETERS FOR FUTURE ADULT CONSTRUCTION WORKERS POTENTIALLY EXPOSED TO COPCs IN SUBSURFACE SOIL VIA INGESTION, DERMAL CONTACT, AND INHALATION SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Input Parameter	Units	Future Receptor	Comments/Reference
		Adult Construction Worker	
IR, Ingestion Rate	mg/day	480	USEPA, 1991a
EF, Exposure Frequency	days/year	250	USEPA, 1991a
AF, Adherence Factor	mg/cm^2	1	USEPA, 1991a and 1992a
ABS, Dermal Absorption Factor Organics/Inorganics	unitless	Chemical-specific[1]	USEPA, 1992a and 1992b Ryan, et al., 1987 Webster, et al., 1993
ET, Exposure Time	hrs/day	8	USEPA, 1991a
RR, Respiration Rate	m^3/hr	0.83	USEPA, 1991a
SA, Exposed Surface Area	cm^2/day	4,300[2]	USEPA, 1992a
ED, Exposure Duration	years	1	USEPA, 1991a
FI, Fraction Ingested	unitless	1	USEPA, 1989b
BW, Body Weight	kg	70	USEPA, 1989b
AT, Averaging Times AT_{nc}, noncarcinogens	days	365	USEPA, 1989b
AT_c, carcinogens	days	25,550	USEPA, 1989b

Notes: [1] The following absorbance factors will be applied to estimate dermal intake of COPCs:

Experimentally Derived (USEPA, 1992a): PCBs - 0.06
Cadmium - 0.01

Other Values (Ryan, et al., 1987: and Webster, et al., 1993): Organics - 0.10
Inorganics - 0.01
Arsenic - 0.03

[2] Skin surface area available for contact for an individual wearing a sleeveless shirt, long pants, and shoes.

NA - Not Applicable

TABLE 6-11 (Continued)

EXPOSURE INPUT PARAMETERS FOR FUTURE ADULT CONSTRUCTION WORKERS POTENTIALLY EXPOSED TO COPCs IN SUBSURFACE SOIL VIA INGESTION, DERMAL CONTACT, AND INHALATION SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

References:

Ryan, et al., 1987. Assessing Risk from Dermal Exposure at Hazardous Waste Sites.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A). Interim Final.

Webster, et al., 1993. *In Vivo and In Vitro* Percutaneous Absorption and Skin Decontamination of Arsenic from Water and Soil.

TABLE 6-12

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSFi $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Dermal Absorption Value	WOE	Target Organ	Critical Effect
Volatiles:								
1,1-Dichloroethane	--	--	1.00E-01 (h)	1.43E-01 (a)	--	C	--	None Observed
1,1-Dichloroethene	6.0E-01 (i)	1.75E-01 (i)	9.0E-03 (i)	--	100%	C	Liver	Lesions
Tetrachloroethene	5.20E-02 (e)	2.02E-03 (e)	1.00E-02 (i)	--	100%	--	Liver	Hepatotoxicity
1,1,1-Trichloroethane	--	--	9.00E-02 (w)	2.86E-01 (w)	--	D	CNS	Effects
Trichloroethylene	6.00E-03 (e)	--	1.10E-02 (w)	6.00E-03 (e)	100%	B2	Liver	--
Semivolatiles:								
Benzo(a)pyrene	7.3 (i)	6.1 (h)	--	--	--	B2	--	--
1,4-Dichlorobenzene	2.4E-02 (h)	--	--	2.29E-01 (i)	100%	C	Liver	Increased weight
Pesticides:								
Aldrin	1.70E+01 (i)	1.71E+01 (i)	3.00E-05 (i)	--	7.8%	B2	Liver	Lesions
4,4'-DDT	3.4E-01 (i)	3.4E-01 (i)	5.00E-04 (i)	--	90%	B2	Liver	Lesions

TABLE 6-12 (Continued)

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSFi $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Dermal Absorption Value	WOE	Target Organ	Critical Effect
PCBs:								
Aroclor-1254[2]	7.70 (i)	--	2.00E-05 (s)	--	89%	B2	Immune System	Toxicity
Aroclor-1260[2]	7.70 (i)	--	--	--	89%	B2	--	--
Inorganics:								
Aluminum	--	--	1.00 (e)	--	--	NA	NA	NA
Antimony	--	--	4.00E-04 (i)	--	--	D	Whole Body/Blood	Increased mortality/ altered chemistry
Arsenic	1.75 (i)	15.1 (i)	3.00E-04 (i)	--	95%	A	Skin	Keratosis/ hyperpigmentation
Beryllium	4.30 (i)	8.40 (i)	5.00E-03 (i)	--	--	B2	--	None observed
Cadmium	--	6.30 (i)	5.00E-04 (i)	--	66%[3]	B1	Renal cortex	Significant proteinuria
Chromium (VI)	--	42.0 (i)	5.00E-03 (i)	--	--	A	--	None observed
Copper	--	--	3.71E-02 (h)	--	60%	D	Gastrointestinal system	Irritation
Lead	--	--	--	--	--	B2	--	--
Manganese (water)	--	--	5.00E-03 (i)	1.43E-05 (i)	5%	D	CNS/lung	Effects
Manganese (food)	--	--	1.40E-01 (i)	1.43E-05 (i)	5%	D	CNS/lung	Effects

TABLE 6-12 (Continued)

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSFi (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfDi (mg/kg/day)	Dermal Absorption Value	WOE	Target Organ	Critical Effect
Mercury	--	--	3.00E-04 (h)	8.57E-05 (h)	15%	D	Kidney/nervous system	Effects/Neurotoxicity
Vanadium	--	--	7.00E-03 (h)	--	--	D	--	--

Notes: (1) Under review
(2) Toxicity factor for polychlorinated biphenyls.
(3) Derived considering the percent difference between oral absorption (12%) and dermal absorption (4%) (Cassarett and Doull's, 1980).
i = Integrated Risk Information System (IRIS), 1995
e = Environmental Criteria and Assessment Office (ECAO) (as cited from 4th quarter USEPA, Region III RBC Tables)
h = Health Effects Assessment Summary Tables (HEAST), 1994
a = HEAST Alternative Method, 1994
s = HEAST Summary Tables FY 1994 Supplement No. 1
w = Withdrawn from IRIS or HEAST
NA = Not Available
-- = Information not published.

TABLE 6-13

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR CURRENT ADULT CIVILIAN WORKERS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Receptors	
	Civilian Adults	
Pathway	ICR	HI
Surface Soil		
Ingestion	6.2×10^{-06}	0.12
Dermal Contact	1.4×10^{-05}	0.17
Inhalation[1]	2.6×10^{-08}	<0.01
Subtotal	2.0×10^{-05}	0.29
Surface Water		
Ingestion	8.9×10^{-07}	0.04
Dermal Contact	2.0×10^{-07}	0.16
Subtotal	1.1×10^{-06}	0.20
Sediment		
Ingestion	6.1×10^{-06}	0.05
Dermal Contact	9.2×10^{-06}	0.06
Subtotal	1.5×10^{-05}	0.11
TOTAL	3.6×10^{-05}	0.6

Notes: [1] Fugitive dusts

TABLE 6-14

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Surface Soil				
Ingestion	8.3×10^{-06}	0.17	1.9×10^{-05}	1.6
Dermal Contact	1.9×10^{-05}	0.24	6.1×10^{-06}	0.39
Subtotal	2.7×10^{-05}	0.41	2.5×10^{-05}	2.0
Groundwater[1]				
Ingestion	6.3×10^{-05}	1.3	3.7×10^{-05}	3.0
Dermal Contact	9.3×10^{-07}	0.02	4.5×10^{-07}	0.04
Inhalation[2]	2.1×10^{-07}	<0.01	--	--
Subtotal	6.4×10^{-05}	1.3	3.7×10^{-05}	3.0
Surface Water				
Ingestion	1.5×10^{-07}	<0.01	1.8×10^{-07}	0.04
Dermal Contact	3.4×10^{-08}	0.03	1.6×10^{-08}	0.05
Subtotal	1.8×10^{-07}	0.03	2.0×10^{-07}	0.09

TABLE 6-14 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Receptors			
	Adults		Children (1-6 yrs.)	
Pathway	ICR	HI	ICR	HI
Sediment				
Ingestion	1.1×10^{-06}	0.01	2.5×10^{-06}	0.08
Dermal Contact	1.6×10^{-06}	0.01	7.4×10^{-07}	0.02
Subtotal	2.7×10^{-06}	0.02	3.2×10^{-06}	0.1
TOTAL	9.4×10^{-05}	1.8	6.5×10^{-05}	5.2

Notes:

(1) Risk value derived using dissolved (filtered) inorganic concentrations

(2) VOCs in shower water

TABLE 6-15

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR FUTURE ADULT CONSTRUCTION WORKERS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Receptor	
	Construction Workers	
Pathway	ICR	HI
Deep Subsurface Soil		
Ingestion	1.5×10^{-06}	0.39
Dermal Contact	3.7×10^{-07}	0.07
Inhalation[1]	2.7×10^{-10}	<0.01
TOTAL	1.9×10^{-06}	0.5

Notes: [1] Fugitive dusts

TABLE 6-16

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Environmental Sampling and Analysis Sufficient samples may not have been taken to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
Selection of COPCs The use of USEPA Region III COPC screening concentrations in selecting COPCs in soil, sediment, groundwater and surface water.			Low
The use of SSVs and USEPA Region III residential COPC screening concentrations in selecting COPCs in sediment for human health evaluation.	Moderate		
Exposure Assessment The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95% UCL data in the estimation of the soil, groundwater, surface water and sediment exposure point concentrations.	Low		
Using one-half of the detection limit or the CRQL as a surrogate concentration in the derivation of the 95% UCL.			Moderate
Assessing future residential property use when the likelihood of residential development is low.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Adjustment of the CSF and RfD to account for dermal absorption.	Moderate		

TABLE 6-16 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE HUMAN HEALTH RISK ASSESSMENT SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Toxicological Assessment Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
Lack of promulgated toxicological indices for the inhalation pathway.		Low	
Risk Characterization Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal, ingestion and inhalation)			Low
Compounds not quantitatively evaluated.		Low	

Notes:

Low - Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate - Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High - Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989b.

TABLE 6-17

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Receptors	Total ICR	Total HI
Current On-site Civilian Adult Workers[(1)]	3.6×10^{-05}	0.6

Notes: [(1)] On-site civilian adult workers could potentially be exposed to COPCs by accidental ingestion and dermal contact of surface soils, surface water and sediments, as well as inhalation of fugitive dusts from surface soil during clearing/cutting activities.

TABLE 6-18

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Future Receptors	Total ICR	Total HI
Residents[(1)]	1.6×10^{-04}	7.0
Construction Worker[(2)]	1.9×10^{-06}	0.5

Notes: (1) Resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils, groundwater, surface water and sediments, as well as inhalation of volatile organics in groundwater while showering.

Resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils, groundwater, surface water and sediments.

Total HI and ICR values for residents are the sum total of the resident adult and resident child HI and ICR values.

(2) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, as well as the inhalation of fugitive dusts during excavation activities.

TABLE 6-19

MULTIPLE RISK DESCRIPTOR INPUTS FOR SURFACE SOIL AND GROUNDWATER EXPOSURE BY POTENTIAL FUTURE RESIDENT ADULTS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Variable	Input	Reference
Body Weight (kg)	@ Normal (64.2, 13.19)	Paustenbach, 1992
Total Body Surface Area (cm^2)	@ Normal (17000, 1000)	Paustenbach, 1992
Soil Ingestion Rate (mg/d)	@ Uniform (50, 200)	USEPA - Range of Ingestion Rates
Groundwater Exposure Time (hrs/d)	@ Triang (0.12, 0.17, 0.20)	Triangular distribution of rates from Andelman 1994 and USEPA 1989.
Groundwater Ingestion Rate (L/d)	@ Lognormal (0.957, 0.0017)	USEPA Region III, 1992

TABLE 6-20

COMPARISON OF ICR VALUES DERIVED FOR FUTURE ADULT RESIDENTS USING THE RME AND MULTIPLE RISK DESCRIPTORS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Pathway	ICR Value Derived from RME	ICR Value Derived Using Multiple Risk Descriptors[(1)(2)]
Surface Soil		
Dermal Contact and Ingestion	2.7×10^{-5}	1.1×10^{-5} (9.3×10^{-6})[(3)]
Groundwater		
Dermal Contact and Ingestion	1.2×10^{-5}	6.3×10^{-6}
Total	3.9×10^{-5}	1.7×10^{-5}

RME - Reasonable Maximum Exposure

Notes: (1) Results derived using the arithmetic mean of those COPCs responsible for greater than 95 percent of the risk derived using the RME.

(2) Expected Value of the risk distribution presented. Three simulations of 500 iterations were calculated using the Latin Hypercube Method of Sampling.

(3) Derived using the geometric mean and geometric standard deviation from a lognormal data set.

TABLE 6-21

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS SITE 16 AND SSA 16 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Receptors	Total ICR	Total HI
On-site Civilian Adult Workers[(1)]	3.6×10^{-05} (3.5×10^{-05})	5.4×10^{-01} (5.3×10^{-01})

Notes: [(1)] On-site civilian adult workers could potentially be exposed to COPCs by accidental ingestion and dermal contact of surface soils, surface water and sediments, as well as inhalation of fugitive dusts from surface soil during clearing/cutting activities. Values presented in parenthesis included Total ICR and HI values using dissolved surface water concentrations.

TABLE 6-22

TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND HAZARD INDEX (HI) VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Well Number	Future Receptors	Total ICR	Total HI
16GW04	Resident Adults(1)(2)	7.2×10^{-04} (1.1×10^{-04})	$1.8 \times 10^{+01}$ ($2.8 \times 10^{+00}$)
	Resident Children(3)	1.5×10^{-04} (4.8×10^{-05})	$5.7 \times 10^{+00-}$ ($1.9 \times 10^{+00}$)
16GW05	Resident Adults(1)(2)	6.0×10^{-04} (4.9×10^{-5})	$1.5 \times 10^{+01}$ ($6.2 \times 10^{+00}$)
	Resident Children(3)	2.2×10^{-04} (1.4×10^{-05})	$5.9 \times 10^{+00}$ ($4.3 \times 10^{+00}$)
16GW06	Resident Adults(1)(2)	7.0×10^{-05} (5.4×10^{-05})	$4.4 \times 10^{+00}$ ($4.8 \times 10^{+00}$)
	Resident Children(3)	2.3×10^{-05} (1.7×10^{-05})	$2.1 \times 10^{+00}$ ($3.3 \times 10^{+00}$)
NA	Construction Worker(4)	1.9×10^{-06}	5.7×10^{-01}

Notes: (1) Resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils, groundwater, surface water and sediments, as well as inhalation of volatile organics in groundwater while showering. Values presented in parenthesis included Total ICR and HI values using dissolved groundwater and surface water concentrations.

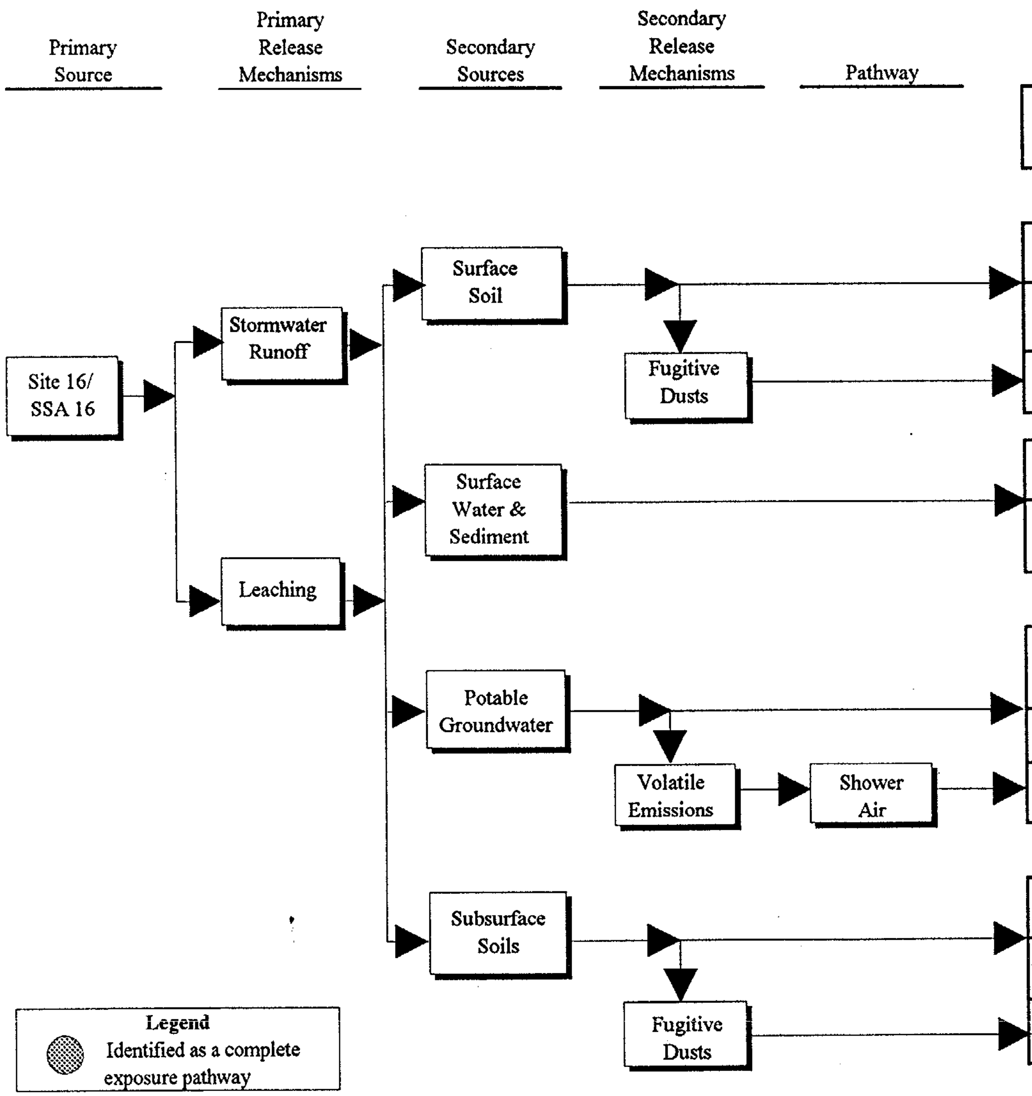
(2) Total HI and ICR values for resident adults are the sum total of the resident adult and resident child HI and ICR values.

(3) Resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils, groundwater, surface water and sediments, as well as inhalation of volatile organics in groundwater while showering. Values presented in parenthesis included Total ICR and HI values using dissolved groundwater and surface water concentrations.

(4) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, as well as the inhalation of fugitive dusts during excavation activities.

NA = Not Applicable

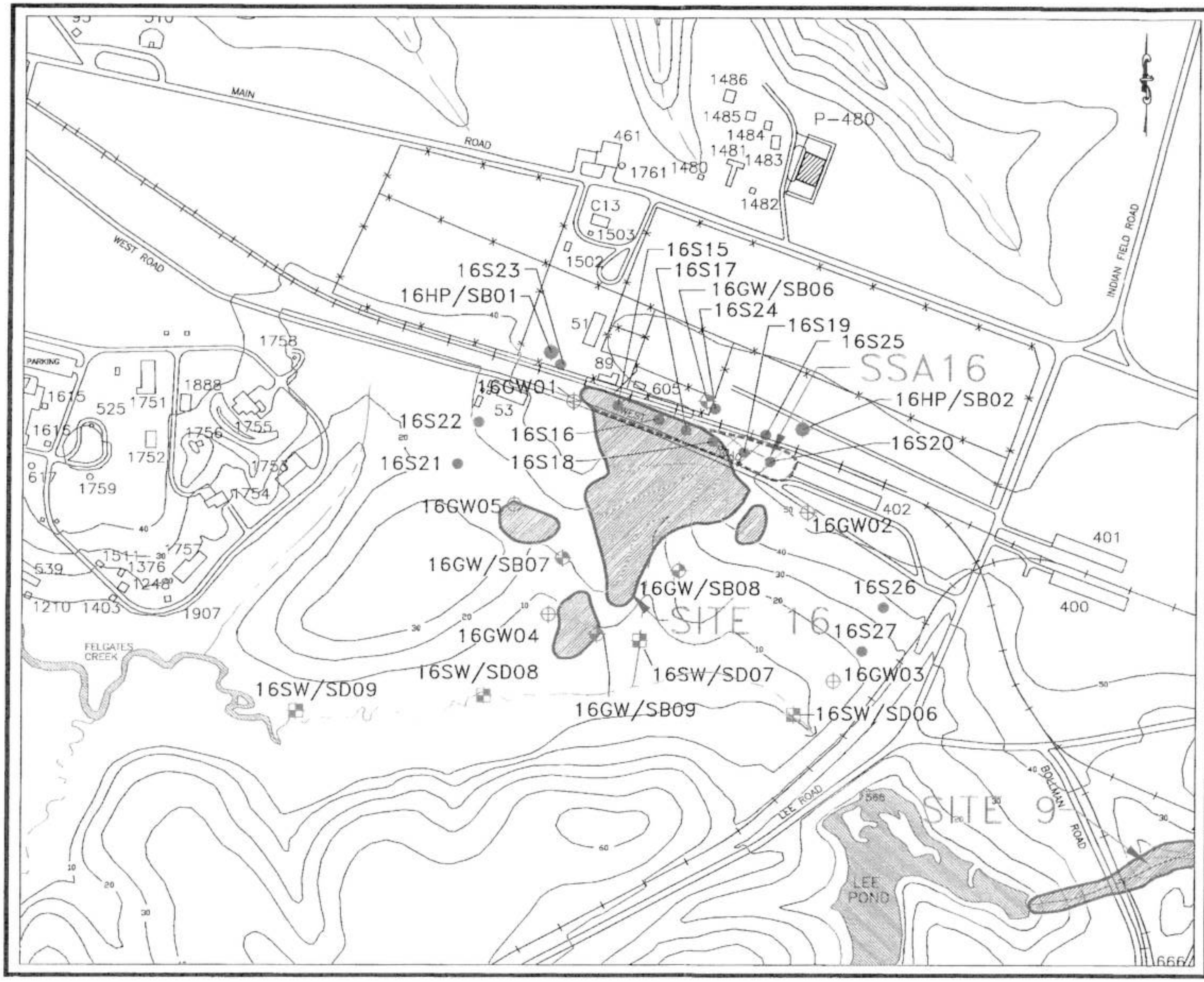
FIGURE 6-1
CONCEPTUAL SITE MODEL
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

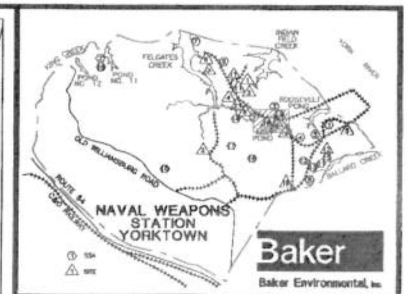


Exposure Route	Potential Receptors: Current Adult Worker	Future Resident Adults	Future Resident Children	Future Construction Workers
Ingestion	●	●	●	
Dermal Contact	●	●	●	
Inhalation	●			
Ingestion	●	●	●	
Dermal Contact	●	●	●	
Ingestion		●	●	
Dermal Contact		●	●	
Inhalation		●		
Ingestion				●
Dermal Contact				●
Inhalation				●

● Identified as a complete exposure pathway

Attachment 2
Round Two RI, Select Figures (Baker, 1995)





300 0 150 300

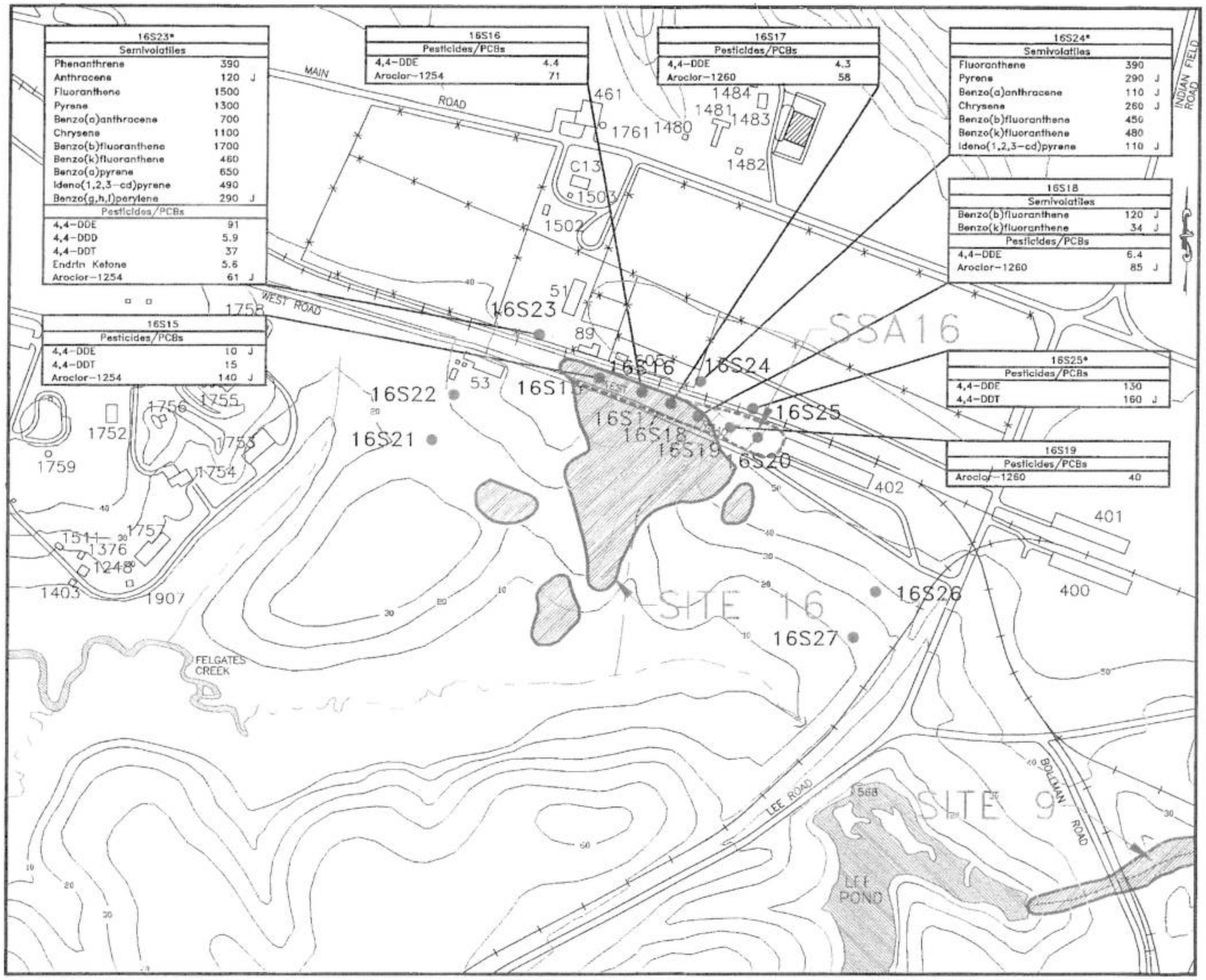
1 inch = 300 ft.

- DRAINAGE
- STRUCTURE WITH BUILDING NUMBER
- RAILROAD
- FENCE
- EDGE OF PAVEMENT
- INTERPRETTED AREA OF DISPOSAL
- APPROXIMATE EXTENT OF SSA 16
- GROUND SURFACE ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL)

- 16SW/SD06 SURFACE WATER/SEDIMENT/BIOTA SAMPLE LOCATION
- 16HP/SB06 HYDROPUNCH/SOIL BORING LOCATION
- 16S24 INDIVIDUAL SURFACE SOIL SAMPLE LOCATION
- 16GW/SB06 GROUNDWATER MONITORING WELL/ SOIL BORING LOCATION (BAKER, 1994)
- 16GW02 GROUNDWATER MONITORING WELL PREVIOUSLY INSTALLED (DAMES & MOORE, 1986)

FIGURE 2-1
SAMPLING LOCATION MAP
SITE 16 AND SSA 16

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA



1 inch = 300 ft.

DRAINAGE
STRUCTURE WITH BUILDING NUMBER
RAILROAD
FENCE
EDGE OF PAVEMENT
INTERPRETTED AREA OF DISPOSAL
APPROXIMATE EXTENT OF SSA 16
GROUND SURFACE ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL)

16S26 SURFACE SOIL SAMPLE LOCATION

J ESTIMATED

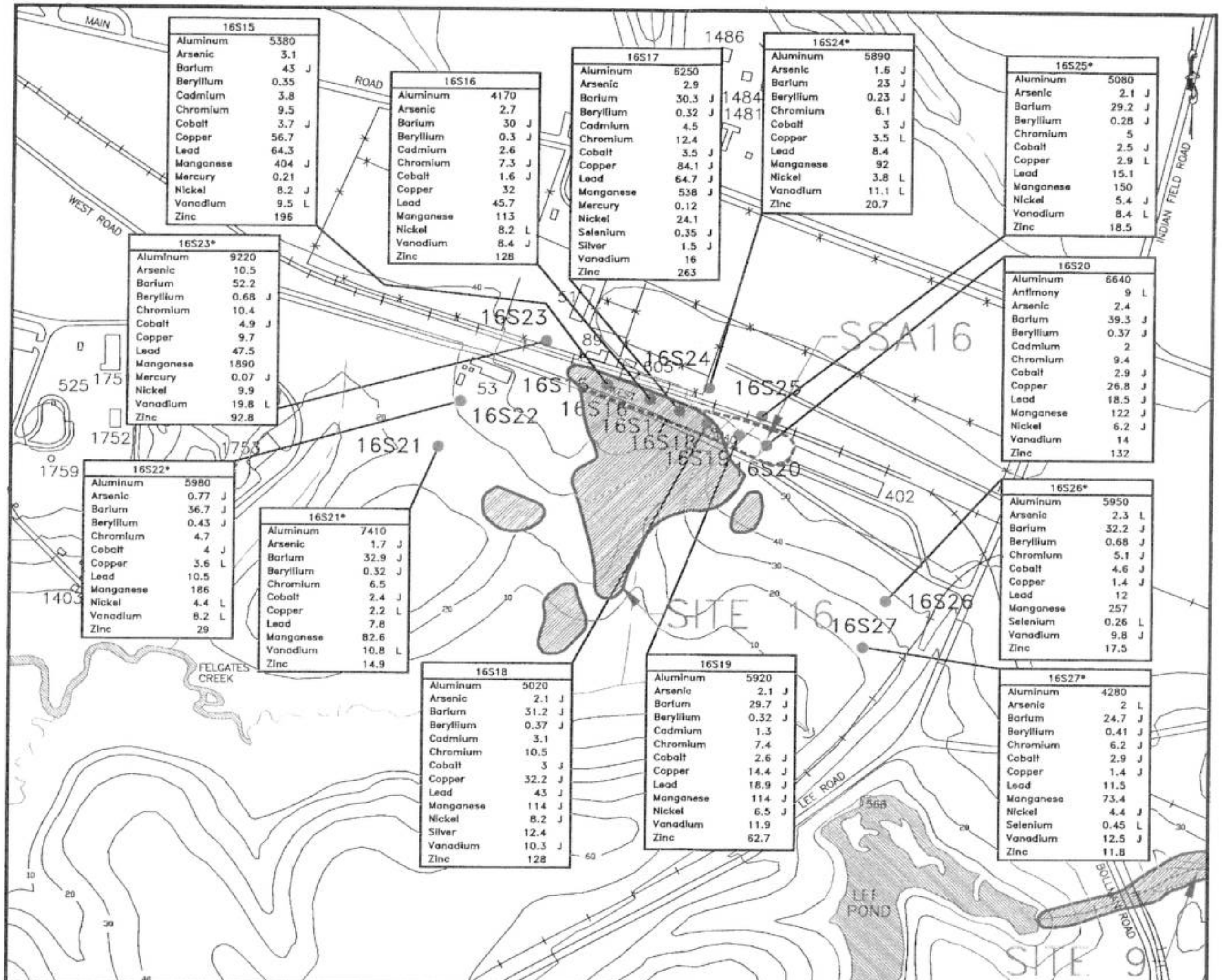
COMPOUND CONCENTRATIONS EXPRESSED IN ug/kg.

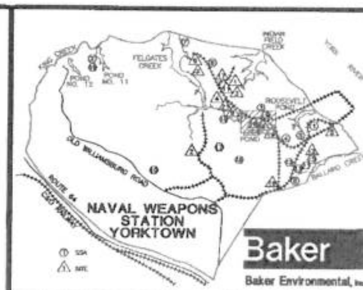
NOTE:
- SURFACE SOIL SAMPLING LOCATIONS SHOWN WITHOUT CONCENTRATIONS INDICATES NON-DETECTABLE LEVELS. SEE TABLES IN TEXT.
* SITE-SPECIFIC BACKGROUND SAMPLE

29151DWP

FIGURE 4-1
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SURFACE SOIL
SITE 16 AND SSA 16

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA





Baker
Baker Environmental, Inc.

300 0 150 300
1 inch = 300 ft.

DRAINAGE
STRUCTURE WITH BUILDING NUMBER
RAILROAD
FENCE
EDGE OF PAVEMENT
INTERPRETTED AREA OF DISPOSAL
APPROXIMATE EXTENT OF SSA 16
GROUND SURFACE ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL)

16S26 SURFACE SOIL SAMPLE LOCATION
J ESTIMATED
L BIASED LOW

ANALYTE CONCENTRATIONS EXPRESSED IN mg/kg.

* SITE-SPECIFIC BACKGROUND SAMPLE.

29151BWP

FIGURE 4-2
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SURFACE SOIL
SITE 16 AND SSA 16

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

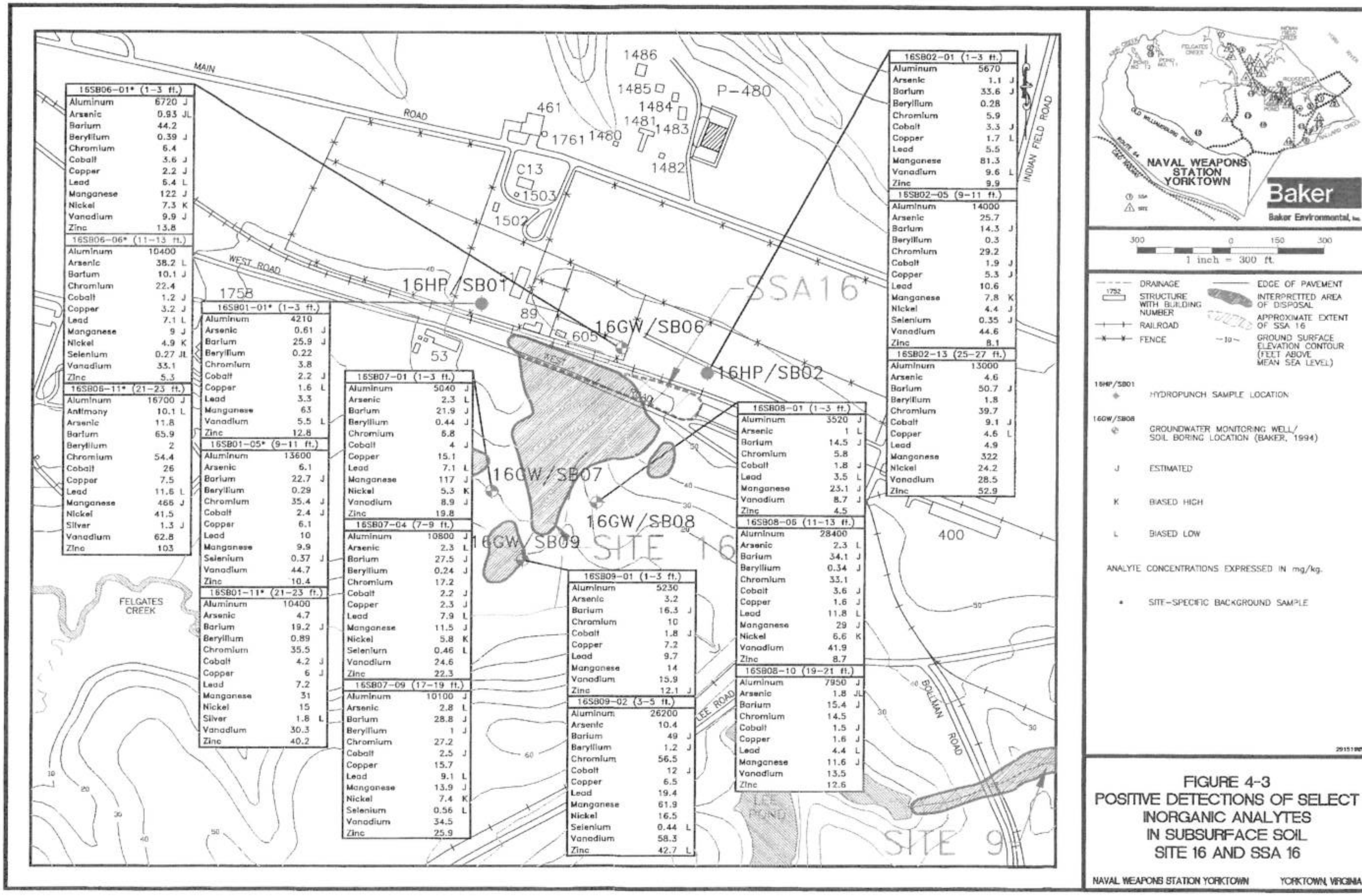


FIGURE 4-3
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN SUBSURFACE SOIL
SITE 16 AND SSA 16

NAVAL WEAPONS STATION YORKTOWN — YORKTOWN, VIRGINIA

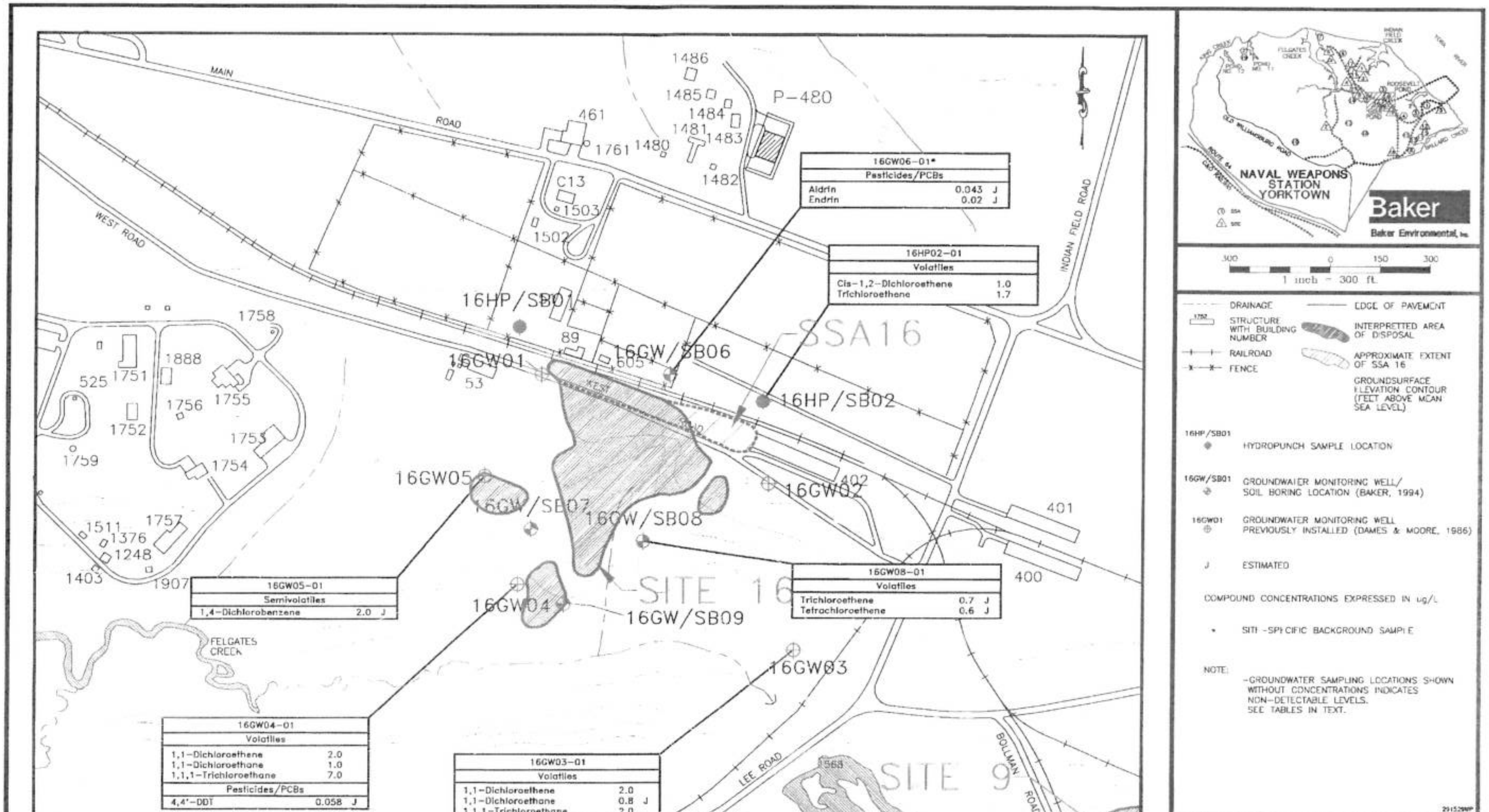
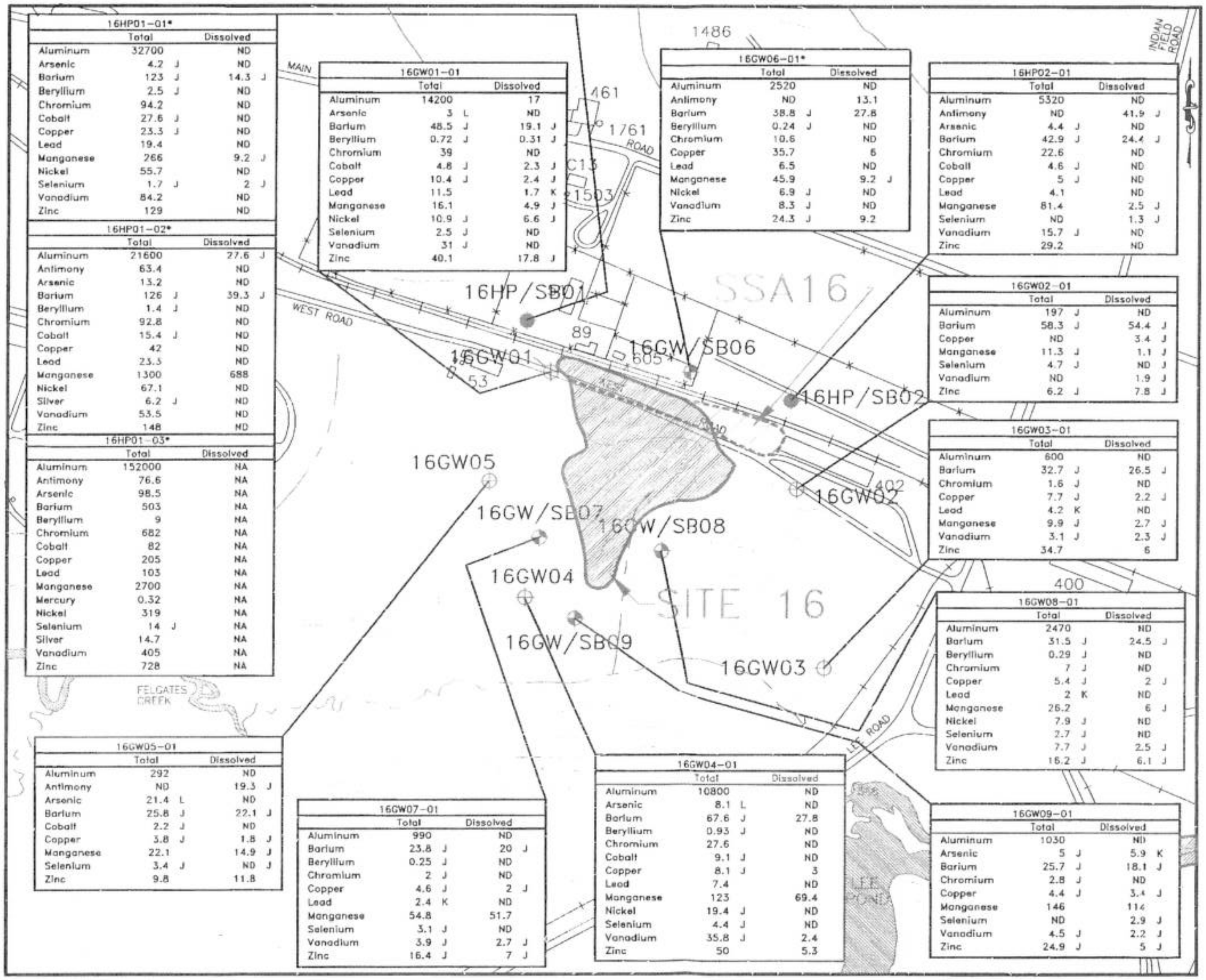


FIGURE 4-4
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN GROUNDWATER
SITE 16 AND SSA 16

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



16HP01-01*	Total		Dissolved	
Aluminum	32700		ND	
Arsenic	4.2	J	ND	
Barium	123	J	14.3	J
Beryllium	2.5	J	ND	
Chromium	94.2		ND	
Cobalt	27.6	J	ND	
Copper	23.3	J	ND	
Lead	19.4		ND	
Manganese	266		9.2	J
Nickel	55.7		ND	
Selenium	1.7	J	2	J
Vanadium	84.2		ND	
Zinc	129		ND	

16HP01-02*	Total		Dissolved	
Aluminum	21600		27.6	J
Antimony	63.4		ND	
Arsenic	13.2		ND	
Barium	126	J	39.3	J
Beryllium	1.4	J	ND	
Chromium	92.8		ND	
Cobalt	15.4	J	ND	
Copper	42		ND	
Lead	23.3		ND	
Manganese	1300		688	
Nickel	67.1		ND	
Silver	6.2	J	ND	
Vanadium	53.5		ND	
Zinc	148		ND	

16HP01-03*	Total		Dissolved
Aluminum	152000		NA
Antimony	76.6		NA
Arsenic	98.5		NA
Barium	503		NA
Beryllium	9		NA
Chromium	682		NA
Cobalt	82		NA
Copper	205		NA
Lead	103		NA
Manganese	2700		NA
Mercury	0.32		NA
Nickel	319		NA
Selenium	14	J	NA
Silver	14.7		NA
Vanadium	405		NA
Zinc	728		NA

16GW01-01	Total		Dissolved	
Aluminum	14200		17	
Arsenic	3	L	ND	
Barium	48.5	J	19.1	J
Beryllium	0.72	J	0.31	J
Chromium	39		ND	
Cobalt	4.8	J	2.3	J
Copper	10.4	J	2.4	J
Lead	11.5		1.7	K
Manganese	16.1		4.9	J
Nickel	10.9	J	6.6	J
Selenium	2.5	J	ND	
Vanadium	31	J	ND	
Zinc	40.1		17.8	J

16GW06-01*	Total		Dissolved	
Aluminum	2520		ND	
Antimony	ND		13.1	
Barium	38.8	J	27.8	
Beryllium	0.24	J	ND	
Chromium	10.6		ND	
Copper	35.7		6	
Lead	6.5		ND	
Manganese	45.9		9.2	J
Nickel	6.9	J	ND	
Vanadium	8.3	J	ND	
Zinc	24.3	J	9.2	

16HP02-01	Total		Dissolved	
Aluminum	5320		ND	
Antimony	ND		41.9	J
Arsenic	4.4	J	ND	
Barium	42.9	J	24.4	J
Chromium	22.6		ND	
Cobalt	4.6	J	ND	
Copper	5	J	ND	
Lead	4.1		ND	
Manganese	81.4		2.5	J
Selenium	ND		1.3	J
Vanadium	15.7	J	ND	
Zinc	29.2		ND	

16GW02-01	Total		Dissolved	
Aluminum	197	J	ND	
Barium	58.3	J	54.4	J
Copper	ND		3.4	J
Manganese	11.3	J	1.1	J
Selenium	4.7	J	ND	J
Vanadium	ND		1.9	J
Zinc	6.2	J	7.8	J

16GW03-01	Total		Dissolved	
Aluminum	600		ND	
Barium	32.7	J	26.5	J
Chromium	1.6	J	ND	
Copper	7.7	J	2.2	J
Lead	4.2	K	ND	
Manganese	9.9	J	2.7	J
Vanadium	3.1	J	2.3	J
Zinc	34.7		6	

16GW08-01	Total		Dissolved	
Aluminum	2470		ND	
Barium	31.5	J	24.5	J
Beryllium	0.29	J	ND	
Chromium	7	J	ND	
Copper	5.4	J	2	J
Lead	2	K	ND	
Manganese	26.2		6	J
Nickel	7.9	J	ND	
Selenium	2.7	J	ND	
Vanadium	7.7	J	2.5	J
Zinc	16.2	J	6.1	J

16GW05-01	Total		Dissolved	
Aluminum	292		ND	
Antimony	ND		19.3	J
Arsenic	21.4	L	ND	
Barium	25.8	J	22.1	J
Cobalt	2.2	J	ND	
Copper	3.8	J	1.8	J
Manganese	22.1		14.9	J
Selenium	3.4	J	ND	J
Zinc	9.8		11.8	

16GW07-01	Total		Dissolved	
Aluminum	990		ND	
Barium	23.8	J	20	J
Beryllium	0.25	J	ND	
Chromium	2	J	ND	
Copper	4.6	J	2	J
Lead	2.4	K	ND	
Manganese	54.8		51.7	
Selenium	3.1	J	ND	
Vanadium	3.9	J	2.7	J
Zinc	16.4	J	7	J

16GW04-01	Total		Dissolved
Aluminum	10800		ND
Arsenic	8.1	L	ND
Barium	67.6	J	27.8
Beryllium	0.93	J	ND
Chromium	27.6		ND
Cobalt	9.1	J	ND
Copper	8.1	J	3
Lead	7.4		ND
Manganese	123		69.4
Nickel	19.4	J	ND
Selenium	4.4	J	ND
Vanadium	35.8	J	2.4
Zinc	50		5.3

16GW09-01	Total		Dissolved	
Aluminum	1030		ND	
Arsenic	5	J	5.9	K
Barium	25.7	J	18.1	J
Chromium	2.8	J	ND	
Copper	4.4	J	3.4	J
Manganese	146		114	
Selenium	ND		2.9	J
Vanadium	4.5	J	2.2	J
Zinc	24.9	J	5	J

Baker
Baker Environmental, Inc.

300 0 150 300
1 inch = 300 ft.

DRAINAGE
1752 STRUCTURE WITH BUILDING NUMBER
RAILROAD
FENCE
EDGE OF PAVEMENT
INTERPRETED AREA OF DISPOSAL
APPROXIMATE EXTENT OF SSA 16
GROUND SURFACE ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL)

16HP/SB02 HYDROPUNCH SAMPLE LOCATION
16GW/SB07 GROUNDWATER MONITORING WELL/ SOIL BORING LOCATION (BAKER, 1994)
16GW02 GROUNDWATER MONITORING WELL PREVIOUSLY INSTALLED (DAMES & MOORE, 1986)

NA NOT ANALIZED
ND NOT DETECTED
J ESTIMATED
K BIASED HIGH
L BIASED LOW

ANALYTE CONCENTRATIONS EXPRESSED IN ug/L

* SITE-SPECIFIC BACKGROUND SAMPLE

291520WP

FIGURE 4-5
POSITIVE DETECTIONS OF SELECT INORGANIC ANALYTES IN GROUNDWATER
SITE 16 AND SSA 16

Attachment 3
Round Two RI, Risk Calculations (Baker, 1995)

TABLE L-1
CURRENT ON-SITE CIVILIAN ADULT WORKER
ACCIDENTAL INGESTION OF SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(FI)(CF)(EF)(ED)/(BW)(AT)

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
IR = THE INGESTION RATE (mg/d)
FI = FRACTION INGESTED (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (25yrs x 365d/yr)

ICR = (CDI * CSF)
HI = (CDI / RfD)

Constituents	CS (mg/Kg)	CF (10-6 Kg/mg)	IR (mg/d)	FI	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC	CDI NONCARC	CSF (Kg-d/mg)	RfD (mg/Kg-d)	INGESTION ICR	INGESTION HI	PERCENT RISK	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	1.00E-06	100	1	250	25	70	25550	9125	3.49E-08	9.78E-08	7.30E+00	--	2.6E-07	--	4.12	0.00
Aroclor 1254	3.53E-01	1.00E-06	100	1	250	25	70	25550	9125	1.23E-07	3.45E-07	7.70E+00	2.00E-05	9.5E-07	1.7E-02	15.35	14.35
Aroclor 1260	2.80E-01	1.00E-06	100	1	250	25	70	25550	9125	9.78E-08	2.74E-07	7.70E+00	--	7.5E-07	--	12.18	0.00
Aluminum	6.62E+03	1.00E-06	100	1	250	25	70	25550	9125	2.31E-03	6.48E-03	--	1.00E+00	0.0E+00	6.5E-03	0.00	5.38
Antimony	8.90E+00	1.00E-06	100	1	250	25	70	25550	9125	3.11E-06	8.71E-06	--	4.00E-04	0.0E+00	2.2E-02	0.00	18.10
Arsenic	6.08E+00	1.00E-06	100	1	250	25	70	25550	9125	2.12E-06	5.95E-06	1.75E+00	3.00E-04	3.7E-06	2.0E-02	60.09	16.48
Beryllium	3.40E-01	1.00E-06	100	1	250	25	70	25550	9125	1.19E-07	3.33E-07	4.30E+00	5.00E-03	5.1E-07	6.7E-05	8.26	0.06
Cadmium	9.56E+00	1.00E-06	100	1	250	25	70	25550	9125	3.34E-06	9.35E-06	--	5.00E-04	0.0E+00	1.9E-02	0.00	15.55
Chromium	1.21E+02	1.00E-06	100	1	250	25	70	25550	9125	4.22E-05	1.18E-04	--	5.00E-03	0.0E+00	2.4E-02	0.00	19.63
Copper	2.08E+02	1.00E-06	100	1	250	25	70	25550	9125	7.28E-05	2.04E-04	--	3.71E-02	0.0E+00	5.5E-03	0.00	4.57
Lead	3.11E+02	1.00E-06	100	1	250	25	70	25550	9125	1.09E-04	3.05E-04	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	1.00E-06	100	1	250	25	70	25550	9125	8.33E-05	2.33E-04	--	1.40E-01	0.0E+00	1.7E-03	0.00	1.38
Mercury	7.30E-01	1.00E-06	100	1	250	25	70	25550	9125	2.55E-07	7.14E-07	--	3.00E-04	0.0E+00	2.4E-03	0.00	1.98
Vanadium	2.17E+01	1.00E-06	100	1	250	25	70	25550	9125	7.58E-06	2.12E-05	--	7.00E-03	0.0E+00	3.0E-03	0.00	2.52
INGESTION TOTAL														6.2E-06	1.2E-01	100.00	100.00

FILENAME: CASS-D&I.WQ1

TABLE L-2
CURRENT ON-SITE CIVILIAN ADULT WORKER
DERMAL CONTACT WITH SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (25yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ)   CSF ADJ. = CSF/AD
HI = (DAD / RfD ADJ)   RfD ADJ. = RfD*AD

CONSTITUENTS	CS (mg/Kg)	AF (mg/c^2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC	DAD NONCARC	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT RISK	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	1	1.00E-06	5300	250	25	0.10	70	25550	9125	1.85E-07	5.19E-07	--	7.30E+00	--	1.4E-06	--	9.70	0.00
Aroclor 1254	3.53E-01	1	1.00E-06	5300	250	25	0.06	70	25550	9125	3.92E-07	1.10E-06	8.90E-01	8.65E+00	1.78E-05	3.4E-06	6.2E-02	24.36	36.30
Aroclor 1260	2.80E-01	1	1.00E-06	5300	250	25	0.06	70	25550	9125	3.11E-07	8.71E-07	8.90E-01	8.65E+00	--	2.7E-06	--	19.32	0.00
Aluminum	6.62E+03	1	1.00E-06	5300	250	25	0.01	70	25550	9125	1.23E-03	3.43E-03	--	--	1.00E+00	0.0E+00	3.4E-03	0.00	2.02
Antimony	8.90E+00	1	1.00E-06	5300	250	25	0.01	70	25550	9125	1.65E-06	4.62E-06	--	--	4.00E-04	0.0E+00	1.2E-02	0.00	6.79
Arsenic	6.08E+00	1	1.00E-06	5300	250	25	0.03	70	25550	9125	3.38E-06	9.46E-06	9.50E-01	1.84E+00	2.85E-04	6.2E-06	3.3E-02	44.67	19.53
Beryllium	3.40E-01	1	1.00E-06	5300	250	25	0.01	70	25550	9125	6.30E-08	1.76E-07	--	4.30E+00	5.00E-03	2.7E-07	3.5E-05	1.94	0.02
Cadmium	9.56E+00	1	1.00E-06	5300	250	25	0.01	70	25550	9125	1.77E-06	4.96E-06	6.60E-01	--	3.30E-04	0.0E+00	1.5E-02	0.00	8.84
Chromium	1.21E+02	1	1.00E-06	5300	250	25	0.01	70	25550	9125	2.23E-05	6.26E-05	--	--	5.00E-03	0.0E+00	1.3E-02	0.00	7.36
Copper	2.08E+02	1	1.00E-06	5300	250	25	0.01	70	25550	9125	3.86E-05	1.08E-04	6.00E-01	--	2.23E-02	0.0E+00	4.9E-03	0.00	2.86
Lead	3.11E+02	1	1.00E-06	5300	250	25	0.01	70	25550	9125	5.77E-05	1.61E-04	--	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	1	1.00E-06	5300	250	25	0.01	70	25550	9125	4.42E-05	1.24E-04	5.00E-02	--	7.00E-03	0.0E+00	1.8E-02	0.00	10.39
Mercury	7.30E-01	1	1.00E-06	5300	250	25	0.01	70	25550	9125	1.35E-07	3.79E-07	1.50E-01	--	4.50E-05	0.0E+00	8.4E-03	0.00	4.95
Vanadium	2.17E+01	1	1.00E-06	5300	250	25	0.01	70	25550	9125	4.02E-06	1.13E-05	--	--	7.00E-03	0.0E+00	1.6E-03	0.00	0.95
DERMAL CONTACT TOTAL																1.4E-05	1.7E-01	100.00	100.00

FILENAME: CASS-D&I.WQ1

TABLE L-3
CURRENT ON-SITE CIVILIAN ADULT WORKER PERFORMING CUTTING/CLEARING ACTIVITIES
INHALATION OF FUGITIVE DUSTS FROM SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CDI (mg/kg/d)= (Ca*RR*ET*EF*ED)/(BW*AT)

Where: Ca = Cs * (1/PEF)

ICR = CDI * CSFi
HQ = CDI / RfDi

Parameter	Description	Current Adult Worker	
CDI	Chronic daily intake (mg/kg/d)	CS	(Chemical Specific)
ICR	Incremental lifetime cancer risk	CS	
CSFi	Inhalation cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDi	Inhalation reference dose (mg/kg/d)	CS	
Ca	Concentration of chemical in air as fugitive dusts (mg/m3)	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	
PEF	Particulate emission factor (m3/kg)	4.63E+09	
RR	Respiration rate (m3/hr)	0.83	
ET	Exposure time (hrs/d)	8	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	25	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	

					Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	Ca (mg/m3)	CSFi 1/(mg/kg/d)	RfDi (mg/kg/d)	CDI (mg/kg/d)	ICR	% Contrib. Total ICR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)pyrene	1.00E-01	2.16E-11	6.10E+00	--	5.0E-13	3.1E-12	0.0%	1.4E-12	--	--
Aroclor 1254	3.53E+00	7.62E-10	--	--	1.8E-11	0.0E+00	0.0%	5.0E-11	--	--
Aroclor 1260	2.80E-01	6.05E-11	--	--	1.4E-12	0.0E+00	0.0%	3.9E-12	--	--
Aluminum	6.62E+03	1.43E-06	--	--	3.3E-08	0.0E+00	0.0%	9.3E-08	--	--
Antimony	8.90E+00	1.92E-09	--	--	4.5E-11	0.0E+00	0.0%	1.2E-10	--	--
Arsenic	6.08E+00	1.31E-09	1.51E+01	--	3.0E-11	4.6E-10	1.8%	8.5E-11	--	--
Beryllium	3.40E-01	7.34E-11	8.40E+00	--	1.7E-12	1.4E-11	0.1%	4.8E-12	--	--
Cadmium	9.56E+00	2.06E-09	6.30E+00	--	4.8E-11	3.0E-10	1.2%	1.3E-10	--	--
Chromium	1.21E+02	2.61E-08	4.20E+01	--	6.0E-10	2.5E-08	97.0%	1.7E-09	--	--
Copper	2.08E+02	4.50E-08	--	--	1.0E-09	0.0E+00	0.0%	2.9E-09	--	--
Lead	3.11E+02	6.73E-08	--	--	1.6E-09	0.0E+00	0.0%	4.4E-09	--	--
Manganese	2.38E+02	5.15E-08	--	1.43E-05	1.2E-09	0.0E+00	0.0%	3.3E-09	2.3E-04	99.9%
Mercury	7.30E-01	1.58E-10	--	8.57E-05	3.7E-12	0.0E+00	0.0%	1.0E-11	1.2E-07	0.1%
Vanadium	2.17E+01	4.69E-09	--	--	1.1E-10	0.0E+00	0.0%	3.0E-10	--	--
				Total ICR:		2.6E-08	100.0%	HI:	2.3E-04	100.0%

NOTES:
-- Not available

FILENAME: CAFDUST.WQ1

TABLE L-4
CURRENT ON-SITE CIVILIAN ADULT WORKER
SURFACE WATER INGESTION EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Accidental ingestion of surface water is calculated as follows:

CDI (mg/kg-day) = (C * IR * EF * ED)/(BW * ATc or ATn)

ICR = CDI * CSF

HI = CDI / RfD

Where:	INPUTS
C = contaminant concentration in water (mg/L)	Specific
IR = adult daily water ingestion rate (L/day)	0.05
EF = adult exposure frequency (days/yr)	250
ED = adult exposure duration (yrs)	25
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	9125
CSF = cancer slope factor (mg/kg-day)-1	Specific
RfD = reference dose (mg/kg-day)	Specific

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Ave Time Carc (yrs)	Carc Dose (mg/kg-day)	Slope Factor (mg/kg-day)-1	Carc Risk	Percent Carc Risk	Ave Time Noncarc (yrs)	Noncarc Dose (mg/kg-day)	Reference Dose (mg/kg-day)	Noncarc Hazard	Percent Noncarc Hazard
Arsenic	2.90E-03	0.05	250	25	70	25550	5.07E-07	1.75E+00	8.9E-07	100%	9125	1.42E-06	3.00E-04	4.7E-03	11%
Manganese	3.74E-01	0.05	250	25	70	25550	6.53E-05	--	0.0E+00	0%	9125	1.83E-04	5.00E-03	3.7E-02	89%
TOTAL						Total ICR:			8.9E-07	100%	Total HI:			4.1E-02	100%

File Name: CASW-INT.WQ1

TABLE L-5
CURRENT ON-SITE CIVILIAN ADULT WORKER
SURFACE WATER DERMAL EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

DAD (mg/kg-day) = (CW * SA * PC * ET * EF * ED * CF)/(BW * ATc or ATn)

ICR = DAD * CSF Adj. CSF Adj. = ICR/AD

HI = DAD / RfD Adj. RfD Adj. = RfD*AD

Where:	INPUTS
CW = contaminant concentration in surfacewater (mg/L)	Specific
SA = adult skin surface available for contact (cm2)	5300
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = adult exposure time (hours/day)	2
EF = adult exposure frequency (days/yr)	250
ED = adult exposure duration (years)	25
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	9125
AD = Adjustment for absorbed dose (unitless)	Specific

Note: Inputs are site and scenario specific

Contaminant	Concentration (mg/L)	Surface Area (cm2)	Dermal Perm. Const. (cm/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Volumetric Conversion (L/m3)	Body Weight (kg)	Ave Time Carc (years)	Absorbed Dose (unitless)	Carc Dose (mg/kg-day)	CSF Adj. (mg/kg-day)	Carc Risk	Percent Carc Risk	Ave Time Noncarc (years)	Noncarc Dose (mg/kg-day)	RfD Adj (mg/kg-day)	Noncarc Hazard	Percent Noncarc Hazard
Arsenic	2.90E-03	5300	1.00E-03	2	250	25	0.001	70	25550	0.95	1.07E-07	1.84E+00	2.0E-07	100%	9125	3.01E-07	2.85E-04	1.1E-03	1%
Manganese	3.74E-01	5300	1.00E-03	2	250	25	0.001	70	25550	0.05	1.39E-05	--	0.0E+00	0%	9125	3.88E-05	2.50E-04	1.6E-01	99%
TOTAL									Total ICR:				2.0E-07	100%	Total HI:			1.6E-01	100%

File Name: CASW-DRT.WQ1

TABLE L-6
CURRENT ON-SITE CIVILIAN ADULT WORKERS
ACCIDENTAL INGESTION OF SEDIMENTS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(FI)(CF)(EF)(ED)/(BW)(AT)

WHERE: CS = THE CONCENTRATION IN SEDIMENT (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
IR = THE INGESTION RATE (mg/d)
FI = Fraction Ingested (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (25yrs x 365d/yr)

ICR = (CDI * CSF)
HI = (CDI / RfD)

Constituents	CS (mg/Kg)	IR (mg/d)	FI	CF (10-6 Kg/mg)	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC.	CDI NONCARC.	CSF	RfD	INGESTIO ICR	INGESTION HI	PERCENT RISK	PERCENT NCARC
Aroclor-1260	3.29E-02	100	1	1.00E-06	250	25	70	25550	9125	1.15E-08	3.22E-08	7.70E+00	--	8.8E-08	--	1.45	0.00
Aluminum	1.49E+04	100	1	1.00E-06	250	25	70	25550	9125	5.21E-03	1.46E-02	--	1.00E+00	0.0E+00	1.5E-02	0.00	30.72
Arsenic	8.10E+00	100	1	1.00E-06	250	25	70	25550	9125	2.83E-06	7.93E-06	1.75E+00	3.00E-04	5.0E-06	2.6E-02	81.29	55.60
Beryllium	7.00E-01	100	1	1.00E-06	250	25	70	25550	9125	2.45E-07	6.85E-07	4.30E+00	5.00E-03	1.1E-06	1.4E-04	17.26	0.29
Manganese	1.10E+02	100	1	1.00E-06	250	25	70	25550	9125	3.85E-05	1.08E-04	--	1.40E-01	0.0E+00	7.7E-04	0.00	1.62
Vanadium	4.00E+01	100	1	1.00E-06	250	25	70	25550	9125	1.40E-05	3.91E-05	--	7.00E-03	0.0E+00	5.6E-03	0.00	11.77
INGESTION TOTAL														6.1E-06	4.8E-02	100.00	100.00

CASD-I&D.WQ1

TABLE L-7
CURRENT ON-SITE CIVILIAN ADULT WORKERS
DERMAL CONTACT WITH SEDIMENTS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (25yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ.)   CSF ADJ. = CSF/AD
HI = (DAD / RfD ADJ.)   RfD ADJ. = RfD*AD

CONSTITUENTS	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC	DAD NONCAR	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT RISK	PERCENT HAZARD
Aroclor-1260	3.29E-02	1	1.00E-06	5300	250	25	0.06	70	25550	9125	3.65E-08	1.02E-07	8.90E-01	8.65E+00	--	3.2E-07	--	3.45	0.00
Aluminum	1.49E+04	1	1.00E-06	5300	250	25	0.01	70	25550	9125	2.76E-03	7.74E-03	--	--	1.00E+00	0.0E+00	7.7E-03	0.00	12.25
Arsenic	8.10E+00	1	1.00E-06	5300	250	25	0.03	70	25550	9125	4.50E-06	1.26E-05	9.50E-01	1.84E+00	2.85E-04	8.3E-06	4.4E-02	90.47	70.01
Beryllium	7.00E-01	1	1.00E-06	5300	250	25	0.01	70	25550	9125	1.30E-07	3.63E-07	--	4.30E+00	5.00E-03	5.6E-07	7.3E-05	6.08	0.11
Manganese	1.10E+02	1	1.00E-06	5300	250	25	0.01	70	25550	9125	2.04E-05	5.72E-05	5.00E-02	--	7.00E-03	0.0E+00	8.2E-03	0.00	12.94
Vanadium	4.00E+01	1	1.00E-06	5300	250	25	0.01	70	25550	9125	7.41E-06	2.07E-05	--	--	7.00E-03	0.0E+00	3.0E-03	0.00	4.69
DERMAL CONTACT TOTAL																9.2E-06	6.3E-02	100.00	100.00

CASD-I&D.WQ1

TABLE L-8
FUTURE ON-SITE CHILD RESIDENTS
INGESTION OF SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVANT EQUATIONS:

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(CF)(EF)(ED)/(BW)(AT)

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
IR = THE INGESTION RATE (mg/d)
FI = FRACTION INGESTED (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (6yrs x 365d/yr)

ICR = (CDI * CSF)
HI = (CDI / RfD)

Constituents	CS (mg/Kg)	IR (mg/d)	FI	CF (10-6 Kg/mg)	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC	CDI NONCARC	CSF	RfD	INGESTION ICR	INGESTION HI	PERCENT RISK	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	200	1	1.00E-06	350	6	15	25550	2190	1.10E-07	1.28E-06	7.30E+00	--	8.0E-07	--	4.12	0.00
Aroclor-1254	3.53E-01	200	1	1.00E-06	350	6	15	25550	2190	3.87E-07	4.51E-06	7.70E+00	2.00E-05	3.0E-06	2.3E-01	15.35	14.35
Aroclor-1260	2.80E-01	200	1	1.00E-06	350	6	15	25550	2190	3.07E-07	3.58E-06	7.70E+00	--	2.4E-06	--	12.18	0.00
Aluminum	6.62E+03	200	1	1.00E-06	350	6	15	25550	2190	7.25E-03	8.46E-02	--	1.00E+00	0.0E+00	8.5E-02	0.00	5.38
Antimony	8.90E+00	200	1	1.00E-06	350	6	15	25550	2190	9.75E-06	1.14E-04	--	4.00E-04	0.0E+00	2.8E-01	0.00	18.10
Arsenic	6.08E+00	200	1	1.00E-06	350	6	15	25550	2190	6.66E-06	7.77E-05	1.75E+00	3.00E-04	1.2E-05	2.6E-01	60.09	16.48
Beryllium	3.40E-01	200	1	1.00E-06	350	6	15	25550	2190	3.73E-07	4.35E-06	4.30E+00	5.00E-03	1.6E-06	8.7E-04	8.26	0.06
Cadmium	9.56E+00	200	1	1.00E-06	350	6	15	25550	2190	1.05E-05	1.22E-04	--	5.00E-04	0.0E+00	2.4E-01	0.00	15.55
Chromium	1.21E+02	200	1	1.00E-06	350	6	15	25550	2190	1.32E-04	1.54E-03	--	5.00E-03	0.0E+00	3.1E-01	0.00	19.63
Copper	2.08E+02	200	1	1.00E-06	350	6	15	25550	2190	2.28E-04	2.67E-03	--	3.71E-02	0.0E+00	7.2E-02	0.00	4.57
Lead	3.11E+02	200	1	1.00E-06	350	6	15	25550	2190	3.41E-04	3.98E-03	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	200	1	1.00E-06	350	6	15	25550	2190	2.61E-04	3.05E-03	--	1.40E-01	0.0E+00	2.2E-02	0.00	1.38
Mercury	7.30E-01	200	1	1.00E-06	350	6	15	25550	2190	8.00E-07	9.33E-06	--	3.00E-04	0.0E+00	3.1E-02	0.00	1.98
Vanadium	2.17E+01	200	1	1.00E-06	350	6	15	25550	2190	2.38E-05	2.77E-04	--	7.00E-03	0.0E+00	4.0E-02	0.00	2.52
INGESTION TOTAL														1.9E-05	1.6E+00	100.00	100.00

RCSS-I&D.WQ1

TABLE L-9
FUTURE ON-SITE CHILD RESIDENTS
DERMAL CONTACT WITH SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (6yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ) CSF ADJ = CSF/AD
HI = (DAD / RfD ADJ) RfD ADJ = RfD*AD

CONSTITUENTS	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC.	DAD NONCARC.	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT CARC.	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	1	1.00E-06	2115	350	6	0.1	15	25550	2190	1.16E-07	1.35E-06	--	7.30E+00	--	8.5E-07	--	13.82	0.00
Aroclor-1254	3.53E-01	1	1.00E-06	2115	350	6	0.06	15	25550	2190	2.45E-07	2.86E-06	8.90E-01	8.65E+00	1.78E-05	2.1E-06	1.6E-01	34.69	41.74
Aroclor-1260	2.80E-01	1	1.00E-06	2115	350	6	0.06	15	25550	2190	1.95E-07	2.27E-06	8.90E-01	8.65E+00	--	1.7E-06	--	27.52	0.00
Aluminum	6.62E+03	1	1.00E-06	2115	350	6	0.01	15	25550	2190	7.67E-04	8.95E-03	--	--	1.00E+00	0.0E+00	8.9E-03	0.00	2.32
Antimony	8.90E+00	1	1.00E-06	2115	350	6	0.01	15	25550	2190	1.03E-06	1.20E-05	--	--	4.00E-04	0.0E+00	3.0E-02	0.00	7.80
Arsenic	6.08E+00	1	1.00E-06	2115	350	6	0.01	15	25550	2190	7.05E-07	8.22E-06	9.50E-01	1.84E+00	2.85E-04	1.3E-06	2.9E-02	21.20	7.48
Beryllium	3.40E-01	1	1.00E-06	2115	350	6	0.01	15	25550	2190	3.94E-08	4.60E-07	--	4.30E+00	5.00E-03	1.7E-07	9.2E-05	2.77	0.02
Cadmium	9.56E+00	1	1.00E-06	2115	350	6	0.01	15	25550	2190	1.11E-06	1.29E-05	6.60E-01	--	3.30E-04	0.0E+00	3.9E-02	0.00	10.16
Chromium	1.21E+02	1	1.00E-06	2115	350	6	0.01	15	25550	2190	1.40E-05	1.63E-04	--	--	5.00E-03	0.0E+00	3.3E-02	0.00	8.47
Copper	2.08E+02	1	1.00E-06	2115	350	6	0.01	15	25550	2190	2.42E-05	2.82E-04	6.00E-01	--	2.23E-02	0.0E+00	1.3E-02	0.00	3.28
Lead	3.11E+02	1	1.00E-06	2115	350	6	0.01	15	25550	2190	3.61E-05	4.21E-04	--	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	1	1.00E-06	2115	350	6	0.01	15	25550	2190	2.76E-05	3.22E-04	5.00E-02	--	7.00E-03	0.0E+00	4.6E-02	0.00	11.94
Mercury	7.30E-01	1	1.00E-06	2115	350	6	0.01	15	25550	2190	8.46E-08	9.87E-07	1.50E-01	--	4.50E-05	0.0E+00	2.2E-02	0.00	5.69
Vanadium	2.17E+01	1	1.00E-06	2115	350	6	0.01	15	25550	2190	2.51E-06	2.93E-05	--	--	7.00E-03	0.0E+00	4.2E-03	0.00	1.09
DERMAL CONTACT TOTAL																6.1E-06	3.9E-01	100.00	100.00

RCSS-I&D.WQ1

TABLE L-10
FUTURE ON-SITE RESIDENT CHILDREN
GROUNDWATER INGESTION EXPOSURE ASSESSMENT
ORGANICS AND DISSOLVED INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ingestion from drinking water is calculated as follows:

CDI (mg/kg-day) = C * IR * EF * ED/BW * AT or ATnc

ICR = CDI * CSF

HI = CDI / RfD

Where:	INPUTS
C = contaminant concentration in water (mg/L)	Specific
IR = child daily water ingestion rate (L/day)	1
EF = child exposure frequency (days/yr)	350
ED = child exposure duration (yrs)	6
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	2190
CSF = cancer slope factor (mg/kg-day)-1	Specific
RfD = reference dose (mg/kg-day)	Specific

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Ave Time Carc (years)	Carc Dose (mg/kg-day)	Slope Factor (mg/kg-day)-1	Carc Risk Child	Percent Carc Risk	Ave Time Noncarc (years)	Noncarc Dose (mg/kg-day)	Reference Dose (mg/kg-day)	Noncarc Hazard Child	Percent Noncarc Hazard
1,1-Dichloroethene	1.17E-03	1	350	6	15	25550	6.41E-06	6.00E-01	3.8E-06	10%	2190	7.48E-05	9.00E-03	8.3E-03	0%
1,4-Dichlorobenzene	2.00E-03	1	350	6	15	25550	1.10E-05	2.40E-02	2.6E-07	1%	2190	1.28E-04	--	--	0%
1,1-Dichloroethane	6.80E-04	1	350	6	15	25550	3.73E-06	--	0.0E+00	0%	2190	4.35E-05	1.00E-01	4.3E-04	0%
Tetrachloroethene	5.30E-04	1	350	6	15	25550	2.90E-06	5.20E-02	1.5E-07	0%	2190	3.39E-05	1.00E-02	3.4E-03	0%
1,1,1-Trichloroethane	2.49E-03	1	350	6	15	25550	1.36E-05	--	0.0E+00	0%	2190	1.59E-04	9.00E-02	1.8E-03	0%
Trichloroethene	5.60E-04	1	350	6	15	25550	3.07E-06	6.00E-03	1.8E-08	0%	2190	3.58E-05	1.10E-02	3.3E-03	0%
Aldrin	3.00E-05	1	350	6	15	25550	1.64E-07	1.70E+01	2.8E-06	8%	2190	1.92E-06	3.00E-05	6.4E-02	2%
4,4'-DDT	5.00E-05	1	350	6	15	25550	2.74E-07	3.40E-01	9.3E-08	0%	2190	3.20E-06	5.00E-04	6.4E-03	0%
Antimony	1.08E-02	1	350	6	15	25550	5.91E-05	--	0.0E+00	0%	2190	6.90E-04	4.00E-04	1.7E+00	57%
Arsenic	2.60E-03	1	350	6	15	25550	1.42E-05	1.75E+00	2.5E-05	68%	2190	1.66E-04	3.00E-04	5.5E-01	18%
Beryllium	2.00E-04	1	350	6	15	25550	1.10E-06	4.30E+00	4.7E-06	13%	2190	1.28E-05	5.00E-03	2.6E-03	0%
Manganese	5.00E-02	1	350	6	15	25550	2.74E-04	--	0.0E+00	0%	2190	3.20E-03	5.00E-03	6.4E-01	21%
TOTAL						Total ICR:			3.7E-05	100%	Total HI:			3.0E+00	100%

File Name: RCGW-ID.WQ1

TABLE L-11
FUTURE ON-SITE RESIDENT CHILDREN
GROUNDWATER DERMAL EXPOSURE ASSESSMENT
ORGANICS AND DISSOLVED INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Dermal Contact from groundwater is calcuated as follows:

DAD (mg/kg-day) = CW * SA * PC * ET * EF * ED * CF/BW * ATc or ATnc

ICR = DAD * CSF Adj CSF Adj = CSF/AD

HI = DAD / RfD Adj RfD Adj = RfD*AD

Where:	INPUTS
CW = contaminant concentration in water (mg/L)	Specific
SA = child skin surface available for contact (cm2)	8023
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = child exposure time (hours/day)	0.2
EF = child exposure frequency (days/yr)	350
ED = child exposure duration (years)	6
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	2190
AD = adjustment for absorbed dose (unitless)	Specific

Note: Inputs are site and scenario specific

Contaminant	Concentration (mg/L)	Surface Area (cm2)	Dermal Perm. Const. (cm/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Volumetric Conversion (L/m3)	Body Weight (kg)	Ave Time Carc (years)	Absorbed Dose (unitless)	Carc Dose (mg/kg-day)	Slope Factor (Adj) (mg/kg-day)-1	Carc Risk Child	Percent Carc Risk	Ave Time Noncarc (years)	Noncarc Dose (mg/kg-day)	Reference Dose (Adj) (mg/kg-day)	Noncarc Hazard Child	Percent Noncarc Hazard
1,1-Dichloroethene	1.17E-03	8023	1.60E-02	0.2	350	6	0.001	15	25550	--	1.65E-07	6.00E-01	9.9E-08	22%	2190	1.92E-06	9.00E-03	2.1E-04	1%
1,4-Dichlorobenzene	2.00E-03	8023	6.20E-02	0.2	350	6	0.001	15	25550	1	1.09E-06	2.40E-02	2.6E-08	6%	2190	1.27E-05	--	--	0%
1,1-Dichloroethane	6.60E-04	8023	8.90E-03	0.2	350	6	0.001	15	25550	--	5.32E-08	--	0.0E+00	0%	2190	6.21E-07	1.00E-01	6.2E-06	0%
Tetrachloroethene	5.30E-04	8023	3.70E-01	0.2	350	6	0.001	15	25550	1	1.72E-06	5.20E-02	9.0E-08	20%	2190	2.01E-05	1.00E-02	2.0E-03	5%
1,1,1-Trichloroethane	2.49E-03	8023	1.70E-02	0.2	350	6	0.001	15	25550	--	3.72E-07	--	0.0E+00	0%	2190	4.34E-06	9.00E-02	4.8E-05	0%
Trichloroethene	5.60E-04	8023	2.30E-01	0.2	350	6	0.001	15	25550	1	1.13E-06	6.00E-03	6.8E-09	2%	2190	1.32E-05	1.10E-02	1.2E-03	3%
Aldrin	3.00E-05	8023	1.60E-03	0.2	350	6	0.001	15	25550	0.078	4.22E-10	2.18E+02	9.2E-08	21%	2190	4.92E-09	2.34E-06	2.1E-03	5%
4,4'-DDT	5.00E-05	8023	4.30E-01	0.2	350	6	0.001	15	25550	0.9	1.89E-07	3.78E-01	7.1E-08	16%	2190	2.21E-06	4.50E-04	4.9E-03	12%
Antimony	1.04E-02	8023	1.00E-03	0.2	350	6	0.001	15	25550	--	9.49E-08	--	0.0E+00	0%	2190	1.11E-06	4.00E-04	2.8E-03	7%
Arsenic	2.60E-03	8023	1.00E-03	0.25	350	6	0.001	15	25550	0.95	2.86E-08	1.84E+00	5.3E-08	12%	2190	3.33E-07	2.85E-04	1.2E-03	3%
Beryllium	2.00E-04	8023	1.00E-03	0.25	350	6	0.001	15	25550	--	2.20E-09	4.30E+00	9.5E-09	2%	2190	2.56E-08	5.00E-03	5.1E-06	0%
Manganese	5.00E-02	8023	1.00E-03	0.25	350	6	0.001	15	25550	0.05	5.50E-07	--	0.0E+00	0%	2190	6.42E-06	2.50E-04	2.6E-02	64%
TOTAL									Total ICR:				4.5E-07	100%	Total HI:			4.0E-02	100%

File Name: RCGW-DD.WQ1

TABLE L-12
FUTURE ON-SITE RESIDENT CHILDREN
SURFACE WATER INGESTION EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ingestion from drinking water is calculated as follows:

CDI (mg/kg-day) = (C * IR * EF * ED)/(BW * ATc or ATn)

ICR = CDI * CSF

HI = CDI / RfD .

Where:	INPUTS
C = contaminant concentration in water (mg/L)	Specific
IR = child daily water ingestion rate (L/day)	0.05
EF = child exposure frequency (days/yr)	45
ED = child exposure duration (yrs)	6
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	2190
CSF = cancer slope factor (mg/kg-day)-1	Specific
RfD = reference dose (mg/kg-day)	Specific

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Ave Time Carc (years)	CDI Carc (mg/kg-day)	Slope Factor (mg/kg-day)-1	Carc Risk Child	Percent Carc Risk	Ave Time Noncarc (years)	CDI Noncarc (mg/kg-day)	Reference Dose (mg/kg-day)	Noncarc Hazard Child	Percent Noncarc Hazard
Arsenic	2.90E-03	0.05	45	6	15	25550	1.02E-07	1.75E+00	1.8E-07	100%	2190	1.19E-06	3.00E-04	4.0E-03	11%
Manganese	3.74E-01	0.05	45	6	15	25550	1.32E-05	--	0.0E+00	0%	2190	1.54E-04	5.00E-03	3.1E-02	89%
TOTAL							Total ICR:		1.8E-07	100%	Total HI:			3.5E-02	100%

File Name: RCSW-INT.WQ1

TABLE L-13
FUTURE ON-SITE RESIDENT CHILDREN
SURFACE WATER DERMAL EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Dermal Contact from groundwater is calcuated as follows:

DAD (mg/kg-day) = (CW * SA * PC * ET * EF * ED * CF)/(BW * ATc or ATn)

ICR = DAD * CSF Adj   CSF Adj = CSF/AD

HI = DAD / RfD Adj   RfD Adj = RfD*AD

Where:	INPUTS
CW = contaminant concentration in water (mg/L)	Specific
SA = child skin surface available for contact (cm2)	2115
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = child exposure time (hours/day)	2
EF = child exposure frequency (days/yr)	45
ED = child exposure duration (years)	6
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = child body weight (kg)	15
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	2190
AD = adjustment for absorbed dose (unitless)	Specific

Note: Inputs are site and scenario specific

Contaminant	Concentration (mg/L)	Surface Area (cm2)	Dermal Perm. Const. (cm/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Volumetric Conversion (L/m3)	Body Weight (kg)	Ave Time Carc (years)	Absorbed Dose (unitless)	DAD Carc (mg/kg-day)	CSF Adj (mg/kg-day)-1	Carc Risk Child	Percent Carc Risk	Ave Time Noncarc (years)	DAD Noncarc (mg/kg-day)	RfD Adj (mg/kg-day)	Noncarc Hazard Child	Percent Noncarc Hazard
Arsenic	2.90E-03	2115	1.00E-03	2	45	6	0.001	15	25550	9.50E-01	8.64E-09	1.84E+00	1.6E-08	100%	2190	1.01E-07	3.61E-04	2.8E-04	1%
Manganese	3.74E-01	2115	1.00E-03	2	45	6	0.001	15	25550	5.00E-02	1.11E-06	--	0.0E+00	0%	2190	1.30E-05	2.50E-04	5.2E-02	99%
TOTAL									Total ICR:				1.6E-08	100%	Total HI:			5.2E-02	100%

FILNAME: RCSW-DRT.WQ1

TABLE L-14
FUTURE ON-SITE CHILD RESIDENTS
DERMAL CONTACT AND INGESTION OF SEDIMENT
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc))

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (6yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ)   CSF ADJ = CSF/AD
HI = (DAD / RfD ADJ)   RfD ADJ = RfD*AD

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(CF)(EF)(ED)/(BW)(AT)

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
IR = THE INGESTION RATE (mg/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (6yrs x 365d/yr)

ICR = (CDI * CSF)

HI = (CDI / RfD)

Constituents	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC.	DAD NONCARC.	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT CARC.	PERCENT HAZARD
Aroclor-1260	3.29E-02	1	1.00E-06	2115	45	6	0.06	15	25550	2190	2.94E-09	3.43E-08	8.90E-01	8.65E+00	--	2.5E-08	--	3.45	0.00
Aluminum	1.49E+04	1	1.00E-06	2115	45	6	0.01	15	25550	2190	2.22E-04	2.59E-03	--	--	1.00E+00	0.0E+00	2.6E-03	0.00	12.25
Arsenic	8.10E+00	1	1.00E-06	2115	45	6	0.03	15	25550	2190	3.62E-07	4.22E-06	9.50E-01	1.84E+00	2.85E-04	6.7E-07	1.5E-02	90.47	70.01
Beryllium	7.00E-01	1	1.00E-06	2115	45	6	0.01	15	25550	2190	1.04E-08	1.22E-07	--	4.30E+00	5.00E-03	4.5E-08	2.4E-05	6.08	0.11
Manganese	1.10E+02	1	1.00E-06	2115	45	6	0.01	15	25550	2190	1.64E-06	1.92E-05	5.00E-02	--	7.00E-03	0.0E+00	2.7E-03	0.00	12.94
Vanadium	4.00E+01	1	1.00E-06	2115	45	6	0.01	15	25550	2190	5.96E-07	6.95E-06	--	--	7.00E-03	0.0E+00	9.9E-04	0.00	4.69
DERMAL CONTACT TOTAL																7.4E-07	2.1E-02	100.00	100.00

Constituents	CS (mg/Kg)	IR (mg/d)	CF (10-6 Kg/mg)	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC	CDI NONCARC	CSF	RfD	INGESTION ICR	INGESTION HI	PERCENT RISK	PERCENT HAZARD
Aroclor-1260	3.29E-02	200	1.00E-06	45	6	15	25550	2190	4.63E-09	5.40E-08	7.70E+00	--	3.6E-08	--	1.45	0.00
Aluminum	1.49E+04	200	1.00E-06	45	6	15	25550	2190	2.10E-03	2.45E-02	--	1.00E+00	0.0E+00	2.5E-02	0.00	30.72
Arsenic	8.10E+00	200	1.00E-06	45	6	15	25550	2190	1.14E-06	1.33E-05	1.75E+00	3.00E-04	2.0E-06	4.4E-02	81.29	55.60
Beryllium	7.00E-01	200	1.00E-06	45	6	15	25550	2190	9.86E-08	1.15E-06	4.30E+00	5.00E-03	4.2E-07	2.3E-04	17.26	0.29
Manganese	1.10E+02	200	1.00E-06	45	6	15	25550	2190	1.55E-05	1.81E-04	--	1.40E-01	0.0E+00	1.3E-03	0.00	1.62
Vanadium	4.00E+01	200	1.00E-06	45	6	15	25550	2190	5.64E-06	6.58E-05	--	7.00E-03	0.0E+00	9.4E-03	0.00	11.77
INGESTION TOTAL													2.5E-06	8.0E-02	100.00	100.00

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TABLE L-15
FUTURE ON-SITE ADULT RESIDENTS
INGESTION OF SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(FI)(CF)(EF)(ED)/(BW)(AT)

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
FI = FRACTION INGESTED (unitless)
IR = THE INGESTION RATE (mg/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (24yrs x 365d/yr)

ICR = (CDI * CSF)
HI = (CDI / RfD)

Constituents	CS (mg/Kg)	IR (mg/d)	FI	CF (10-6 Kg/mg)	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC	CDI NONCARC	CSF	RfD	INGESTION ICR	INGESTION HI	PERCENT RISK	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	100	1	1.00E-06	350	24	70	25550	8760	4.70E-08	1.37E-07	7.30E+00	--	3.4E-07	--	4.12	0.00
Aroclor-1254	3.53E-01	100	1	1.00E-06	350	24	70	25550	8760	1.66E-07	4.84E-07	7.70E+00	2.00E-05	1.3E-06	2.4E-02	15.35	14.35
Aroclor-1260	2.80E-01	100	1	1.00E-06	350	24	70	25550	8760	1.32E-07	3.84E-07	7.70E+00	--	1.0E-06	--	12.18	0.00
Aluminum	6.62E+03	100	1	1.00E-06	350	24	70	25550	8760	3.11E-03	9.07E-03	--	1.00E+00	0.0E+00	9.1E-03	0.00	5.38
Antimony	8.90E+00	100	1	1.00E-06	350	24	70	25550	8760	4.18E-06	1.22E-05	--	4.00E-04	0.0E+00	3.0E-02	0.00	18.10
Arsenic	6.08E+00	100	1	1.00E-06	350	24	70	25550	8760	2.86E-06	8.33E-06	1.75E+00	3.00E-04	5.0E-06	2.8E-02	60.09	16.48
Beryllium	3.40E-01	100	1	1.00E-06	350	24	70	25550	8760	1.60E-07	4.66E-07	4.30E+00	5.00E-03	6.9E-07	9.3E-05	8.26	0.06
Cadmium	9.56E+00	100	1	1.00E-06	350	24	70	25550	8760	4.49E-06	1.31E-05	--	5.00E-04	0.0E+00	2.6E-02	0.00	15.55
Chromium	1.21E+02	100	1	1.00E-06	350	24	70	25550	8760	5.67E-05	1.65E-04	--	5.00E-03	0.0E+00	3.3E-02	0.00	19.63
Copper	2.08E+02	100	1	1.00E-06	350	24	70	25550	8760	9.79E-05	2.86E-04	--	3.71E-02	0.0E+00	7.7E-03	0.00	4.57
Lead	3.11E+02	100	1	1.00E-06	350	24	70	25550	8760	1.46E-04	4.27E-04	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	100	1	1.00E-06	350	24	70	25550	8760	1.12E-04	3.27E-04	--	1.40E-01	0.0E+00	2.3E-03	0.00	1.38
Mercury	7.30E-01	100	1	1.00E-06	350	24	70	25550	8760	3.43E-07	1.00E-06	--	3.00E-04	0.0E+00	3.3E-03	0.00	1.98
Vanadium	2.17E+01	100	1	1.00E-06	350	24	70	25550	8760	1.02E-05	2.97E-05	--	7.00E-03	0.0E+00	4.2E-03	0.00	2.52
INGESTION TOTAL														8.3E-06	1.7E-01	100.00	100.00

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TABLE L-16
FUTURE ON-SITE ADULT RESIDENTS
DERMAL CONTACT WITH SURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (24yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ) CSF ADJ = CSF/AD
HI = (DAD / RfD ADJ) RfD ADJ = RfD*AD

CONSTITUENTS	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC	DAD NONCARC	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT RISK	PERCENT HAZARD
Benzo(a)pyrene	1.00E-01	1	1.00E-06	5300	350	24	0.1	70	25550	8760	2.49E-07	7.26E-07	--	7.30E+00	--	1.8E-06	--	9.70	0.00
Aroclor-1254	3.53E-01	1	1.00E-06	5300	350	24	0.06	70	25550	8760	5.27E-07	1.54E-06	8.90E-01	8.65E+00	1.78E-05	4.6E-06	8.6E-02	24.36	36.30
Aroclor-1260	2.80E-01	1	1.00E-06	5300	350	24	0.06	70	25550	8760	4.18E-07	1.22E-06	8.90E-01	8.65E+00	--	3.6E-06	--	19.32	0.00
Aluminum	6.62E+03	1	1.00E-06	5300	350	24	0.01	70	25550	8760	1.65E-03	4.81E-03	--	--	1.00E+00	0.0E+00	4.8E-03	0.00	2.02
Antimony	8.90E+00	1	1.00E-06	5300	350	24	0.01	70	25550	8760	2.22E-06	6.46E-06	--	--	4.00E-04	0.0E+00	1.6E-02	0.00	6.79
Arsenic	6.08E+00	1	1.00E-06	5300	350	24	0.03	70	25550	8760	4.54E-06	1.32E-05	9.50E-01	1.84E+00	2.85E-04	8.4E-06	4.6E-02	44.67	19.53
Beryllium	3.40E-01	1	1.00E-06	5300	350	24	0.01	70	25550	8760	8.46E-08	2.47E-07	--	4.30E+00	5.00E-03	3.6E-07	4.9E-05	1.94	0.02
Cadmium	9.56E+00	1	1.00E-06	5300	350	24	0.01	70	25550	8760	2.38E-06	6.94E-06	6.60E-01	--	3.30E-04	0.0E+00	2.1E-02	0.00	8.84
Chromium	1.21E+02	1	1.00E-06	5300	350	24	0.01	70	25550	8760	3.00E-05	8.76E-05	--	--	5.00E-03	0.0E+00	1.8E-02	0.00	7.36
Copper	2.08E+02	1	1.00E-06	5300	350	24	0.01	70	25550	8760	5.19E-05	1.51E-04	6.00E-01	--	2.23E-02	0.0E+00	6.8E-03	0.00	2.86
Lead	3.11E+02	1	1.00E-06	5300	350	24	0.01	70	25550	8760	7.75E-05	2.26E-04	--	--	--	0.0E+00	--	0.00	0.00
Manganese	2.38E+02	1	1.00E-06	5300	350	24	0.01	70	25550	8760	5.93E-05	1.73E-04	5.00E-02	--	7.00E-03	0.0E+00	2.5E-02	0.00	10.39
Mercury	7.30E-01	1	1.00E-06	5300	350	24	0.01	70	25550	8760	1.82E-07	5.30E-07	1.50E-01	--	4.50E-05	0.0E+00	1.2E-02	0.00	4.95
Vanadium	2.17E+01	1	1.00E-06	5300	350	24	0.01	70	25550	8760	5.40E-06	1.58E-05	--	--	7.00E-03	0.0E+00	2.3E-03	0.00	0.95
DERMAL CONTACT TOTAL																1.9E-05	2.4E-01	100.00	100.00

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TABLE L-17
FUTURE ON-SITE RESIDENT ADULTS
GROUNDWATER INGESTION EXPOSURE ASSESSMENT
ORGANICS AND DISSOLVED INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ingestion from drinking water is calculated as follows:

CDI (mg/kg-day) = C * IR * EF * ED/BW * AT or ATnc

ICR = CDI * CSF

HI = CDI / RfD

Where:	INPUTS
C = contaminant concentration in water (mg/L)	Specific
IR = adult daily water ingestion rate (L/day)	2
EF = adult exposure frequency (days/yr)	350
ED = adult exposure duration (yrs)	24
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	8760
CSF = cancer slope factor (mg/kg-day)-1	Specific
RfD = reference dose (mg/kg-day)	Specific

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Ave Time Carc (years)	Carc Dose (mg/kg-day)	Slope Factor (mg/kg-day)-1	Carc Risk Adult	Percent Carc Risk	Ave Time Noncarc (years)	Noncarc Dose (mg/kg-day)	Reference Dose (mg/kg-day)	Noncarc Hazard Adult	Percent Noncarc Hazard
1,1-Dichloroethene	1.17E-03	2	350	24	70	25550	1.10E-05	6.00E-01	6.6E-06	10%	8760	3.21E-05	9.00E-03	3.6E-03	0%
1,4-Dichlorobenzene	2.00E-03	2	350	24	70	25550	1.88E-05	2.40E-02	4.5E-07	1%	8760	5.48E-05	--	--	0%
1,1-Dichloroethane	6.80E-04	2	350	24	70	25550	6.39E-06	--	0.0E+00	0%	8760	1.86E-05	1.00E-01	1.9E-04	0%
Tetrachloroethene	5.30E-04	2	350	24	70	25550	4.98E-06	5.20E-02	2.6E-07	0%	8760	1.45E-05	1.00E-02	1.5E-03	0%
1,1,1-Trichloroethane	2.49E-03	2	350	24	70	25550	2.34E-05	--	0.0E+00	0%	8760	6.82E-05	9.00E-02	7.6E-04	0%
Trichloroethene	5.60E-04	2	350	24	70	25550	5.26E-06	6.00E-03	3.2E-08	0%	8760	1.53E-05	1.10E-02	1.4E-03	0%
Aldrin	3.00E-05	2	350	24	70	25550	2.82E-07	1.70E+01	4.8E-06	8%	8760	8.22E-07	3.00E-05	2.7E-02	2%
4,4'-DDT	5.00E-05	2	350	24	70	25550	4.70E-07	3.40E-01	1.6E-07	0%	8760	1.37E-06	5.00E-04	2.7E-03	0%
Antimony	1.08E-02	2	350	24	70	25550	1.01E-04	--	0.0E+00	0%	8760	2.96E-04	4.00E-04	7.4E-01	57%
Arsenic	2.60E-03	2	350	24	70	25550	2.44E-05	1.75E+00	4.3E-05	68%	8760	7.12E-05	3.00E-04	2.4E-01	18%
Beryllium	2.00E-04	2	350	24	70	25550	1.88E-06	4.30E+00	8.1E-06	13%	8760	5.48E-06	5.00E-03	1.1E-03	0%
Manganese	5.00E-02	2	350	24	70	25550	4.70E-04	--	0.0E+00	0%	8760	1.37E-03	5.00E-03	2.7E-01	21%
TOTAL						Total ICR:			6.3E-05	100%	Total HI:			1.3E+00	100%

File Name: RAGW-ID.WQ1

TABLE L-18
FUTURE ON-SITE RESIDENT ADULTS
GROUNDWATER DERMAL EXPOSURE ASSESSMENT
ORGANICS AND DISSOLVED INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Dermal Contact from groundwater is calcuated as follows:

DAD (mg/kg-day) = CW * SA * PC * ET * EF * ED * CF/BW * ATc or ATnc

ICR = DAD * CSF Adj   CSF Adj = CSF/AD

HI = DAD / RfD Adj   RfD Adj = RfD*AD

Where:	INPUTS
CW = contaminant concentration in water (mg/L)	Specific
SA = adult skin surface available for contact (cm2)	20000
PC = contaminant specific dermal permeability (cm/hr)	Specific
ET = adult exposure time (hours/day)	0.2
EF = adult exposure frequency (days/yr)	350
ED = adult exposure duration (years)	24
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	8760
AD = adjustment for absorbed dose	Specific

Note: Inputs are site and scenario specific

Contaminant	Concentration (mg/L)	Surface Area (cm2)	Dermal Perm. Const. (cm/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Volumetric Conversion (L/m3)	Body Weight (kg)	Ave Time Carc (years)	Absorbed Dose (unitless)	Carc Dose (mg/kg-day)	CSF Adj (mg/kg-day)-1	Carc Risk Adult	Percent Carc Risk	Ave Time Noncarc (years)	Noncarc Dose (mg/kg-day)	RfD Adj (mg/kg-day)	Noncarc Hazard Adult	Percent Noncarc Hazard
1,1-Dichloroethene	1.17E-03	20000	1.60E-02	0.2	350	24	0.001	70	25550	--	3.52E-07	6.00E-01	2.1E-07	23%	8760	1.03E-06	9.00E-03	1.1E-04	1%
1,4-Dichlorobenzene	2.00E-03	20000	6.20E-02	0.2	350	24	0.001	70	25550	1.00E+00	2.33E-06	2.40E-02	5.6E-08	6%	8760	6.79E-06	--	0.0E+00	0%
1,1-Dichloroethane	6.80E-04	20000	8.90E-03	0.2	350	24	0.001	70	25550	--	1.14E-07	--	0.0E+00	0%	8760	3.32E-07	1.00E-01	3.3E-06	0%
Tetrachloroethene	5.30E-04	20000	3.70E-01	0.2	350	24	0.001	70	25550	1.00E+00	3.68E-06	5.20E-02	1.9E-07	21%	8760	1.07E-05	1.00E-02	1.1E-03	6%
1,1,1-Trichloroethane	2.49E-03	20000	1.70E-02	0.2	350	24	0.001	70	25550	--	7.95E-07	--	0.0E+00	0%	8760	2.32E-06	9.00E-02	2.6E-05	0%
Trichloroethene	5.60E-04	20000	2.30E-01	0.2	350	24	0.001	70	25550	1.00E+00	2.42E-06	6.00E-03	1.5E-08	2%	8760	7.06E-06	1.10E-02	6.4E-04	3%
Aldrin	3.00E-05	20000	1.60E-03	0.2	350	24	0.001	70	25550	7.80E-02	9.02E-10	2.18E+02	2.0E-07	21%	8760	2.63E-09	2.34E-06	1.1E-03	6%
4,4'-DDT	5.00E-05	20000	4.30E-01	0.2	350	24	0.001	70	25550	9.00E-01	4.04E-07	3.78E-01	1.5E-07	16%	8760	1.18E-06	4.50E-04	2.6E-03	14%
Antimony	1.08E-02	20000	1.00E-03	0.2	350	24	0.001	70	25550	--	2.03E-07	--	0.0E+00	0%	8760	5.91E-07	4.00E-04	1.5E-03	8%
Arsenic	2.60E-03	20000	1.00E-03	0.2	350	24	0.001	70	25550	9.50E-01	4.88E-08	1.84E+00	9.0E-08	10%	8760	1.42E-07	2.85E-04	5.0E-04	3%
Beryllium	2.00E-04	20000	1.00E-03	0.2	350	24	0.001	70	25550	--	3.76E-09	4.30E+00	1.6E-08	2%	8760	1.10E-08	5.00E-03	2.2E-06	0%
Manganese	5.00E-02	20000	1.00E-03	0.2	350	24	0.001	70	25550	5.00E-02	9.40E-07	--	0.0E+00	0%	8760	2.74E-06	2.50E-04	1.1E-02	59%
TOTAL									Total ICR:				9.3E-07	100%	Total HI:			1.9E-02	100%

File Name: RAGW-DD.WQ1

TABLE L-19
FUTURE ON SITE RESIDENT ADULT
EXPOSURE ASSESSMENT FOR THE INHALATION OF VOLATILE ORGANICS IN GROUNDWATER
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Intake from the inhalation of volatile organics is calculated as follows:

Intake (mg/kg-day) = (C * EF * ED * ET * IR)/(BW * ATc or ATnc)

Risk = Intake * CSF or /RfD

Where:	INPUTS
C = contaminant concentration in air (mg/m3)	Calculated
CSF = carcinogenic slope factor	Specific
RfD = reference dose for noncarcinogen	Specific
IR = inhalation rate (m3/hr)	0.83
EF = adult exposure frequency (days)	350
ED = adult exposure duration (years)	24
ET = adult exposure time (hr/day)	0.2
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATnc = averaging time for noncarcinogen (days)	8760

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/m3)	Exposure Frequency (events/yr)	Inhalation Rate (m3/day)	Exposure Duration (yrs)	Exposure Time (hr/day)	Body Weight (kg)	Average Carc Time (days)	Carc Dose (mg/kg/day)	Slope Factor (mg/kg-day)-1	Carc Risk Adult	Percent Carc Risk	Ave Time Noncarc (days)	Noncarc Dose (mg/kg/day)	Reference Dose (mg/kg/day)	Noncarc Hazard Adult	Percent Noncarc Hazard
1,1-Dichloroethene	1.54E-03	350	0.83	24	0.2	70	25550	1.20E-06	1.75E-01	2.10E-07	100%	8760	3.50E-06	--	0.00E+00	0%
1,1-Dichloroethane	8.50E-04	350	0.83	24	0.2	70	25550	6.63E-07	--	0.00E+00	0%	8760	1.93E-06	1.43E-01	1.35E-05	5%
Tetrachloroethene	5.40E-04	350	0.83	24	0.2	70	25550	4.21E-07	2.02E-03	8.50E-10	0%	8760	1.23E-06	--	0.00E+00	0%
1,1,1-Trichloroethane	2.79E-03	350	0.83	24	0.2	70	25550	2.18E-06	--	0.00E+00	0%	8760	6.34E-06	2.86E-01	2.22E-05	8%
Trichloroethene	6.20E-04	350	0.83	24	0.2	70	25550	4.83E-07	--	0.00E+00	0%	8760	1.41E-06	6.00E-03	2.35E-04	81%
1,4-Dichlorobenzene	2.00E-03	350	0.83	24	0.2	70	25550	1.56E-06	--	0.00E+00	0%	8760	4.55E-06	2.29E-01	1.99E-05	7%
TOTAL							Total ICR:			2.1E-07	100%	Total HI:			2.9E-04	100%

FILENAME: RAGW-IH.WQ1

TABLE L-20
FUTURE ON-SITE RESIDENT ADULT
SURFACE WATER INGESTION EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ingestion from drinking water is calculated as follows:

CDI (mg/kg-day) = (C * IR * EF * ED)/(BW * ATc or ATn)

ICR = CDI * CSF

HI = CDI / RfD

Where:	INPUTS
C = contaminant concentration in water (mg/L)	Specific
IR = adult daily water ingestion rate (L/day)	0.05
EF = adult exposure frequency (days/yr)	45
ED = adult exposure duration (yrs)	24
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	8760
CSF = cancer slope factor (mg/kg-day)-1	Specific
RfD = reference dose (mg/kg-day)	Specific

Note: Inputs are scenario and site specific

Contaminant	Concentration (mg/L)	Ingestion Rate (L/day)	Exposure Frequency (days/year)	Exposure Duration (years)	Body Weight (kg)	Ave Time Carc (years)	CDI Carc (mg/kg-day)	Slope Factor (mg/kg-day)-1	Carc Risk Adult	Percent Carc Risk	Ave Time Noncarc (years)	CDI Noncarc (mg/kg-day)	Reference Dose (mg/kg-day)	Noncarc Hazard Adult	Percent Noncarc Hazard
Arsenic	2.90E-03	0.05	45	24	70	25550	8.76E-08	1.75E+00	1.5E-07	100%	8760	2.55E-07	3.00E-04	8.5E-04	11%
Manganese	3.74E-01	0.05	45	24	70	25550	1.13E-05	--	0.0E+00	0%	8760	3.29E-05	5.00E-03	6.6E-03	89%
TOTAL							Total ICR:		1.5E-07	100%	Total HI:			7.4E-03	100%

File Name: RASW-INT.WQ1

TABLE L-21
FUTURE ON-SITE RESIDENT ADULTS
SURFACE WATER DERMAL EXPOSURE ASSESSMENT
ORGANICS AND TOTAL INORGANICS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Dermal Contact from groundwater is calcuated as follows:

DAD (mg/kg-day) = (CW * SA * PC * ET * EF * ED * CF)/(BW * ATc or ATn)

ICR = DAD * CSF Adj   CSF Adj = CSF/AD

HI = DAD / RfD Adj   RfD Adj = RfD*AD

Where:	INPUTS
CW = contaminant concentration in water (mg/L)	Specific
SA = adult skin surface available for contact (cm2)	5300
PC = contaminant specific dermal permability (cm/hr)	Specific
ET = adult exposure time (hours/day)	2
EF = adult exposure frequency (days/yr)	45
ED = adult exposure duration (years)	24
CF = volumetric conversion factor for water (1liter/1000 cm3)	0.001
BW = adult body weight (kg)	70
ATc = averaging time for carcinogen (days)	25550
ATn = averaging time for noncarcinogen (days)	8760
AD = adjustment for absorbed dose (unitless)	Specific

Note: Inputs are site and scenario specific

Contaminant	Concentration (mg/L)	Surface Area (cm2)	Dermal Perm. Const. (cm/hr)	Exposure Time (hours/day)	Exposure Frequency (days/yr)	Exposure Duration (years)	Volumetric Conversion (L/m3)	Body Weight (kg)	Ave Time Carc (years)	Absorbed Dose (unitless)	DAD Carc (mg/kg-day)	CSF Adj (mg/kg-day)-1	Carc Risk Adult	Percent Carc Risk	Ave Time Noncarc (years)	DAD Noncarc (mg/kg-day)	RfD Adj (mg/kg-day)	Noncarc Hazard Adult	Percent Noncarc Hazard
Arsenic	2.90E-03	5300	1.00E-03	2	45	24	0.001	70	25550	9.50E-01	1.86E-08	1.84E+00	3.4E-08	100%	8760	5.41E-08	2.85E-04	1.9E-04	1%
Manganese	3.74E-01	5300	1.00E-03	2	45	24	0.001	70	25550	5.00E-02	2.39E-06	--	0.0E+00	0%	8760	6.98E-06	2.50E-04	2.8E-02	99%
TOTAL									Total ICR:				3.4E-08	100%	Total HI:			2.8E-02	100%

FILENAME: RASW-DRT.WQ1

TABLE L-22
FUTURE ON-SITE ADULT RESIDENTS
DERMAL CONTACT AND INGESTION OF SEDIMENTS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

RELEVENT EQUATIONS:

DAD = Dermally Absorbed Dose

DAD = (CS)(ABS)(AF)(SA)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (24yrs x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ) CSF ADJ = CSF/AD
HI = (DAD / RfD ADJ) RfD ADJ = RfD*AD

CDI = Chronic Daily Intake

CDI = (CS)(IR)(CF)(EF)(ED)/(BW)(ATn or ATc)

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
IR = THE INGESTION RATE (mg/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70yrs x 365d/yr)
ATn = THE AVERAGING TIME (24yrs x 365d/yr)
ICR = (CDI * CSF)
HI = (CDI / RfD)

CONSTITUENTS	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DAD CARC.	DAD NONCARC.	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT RISK	PERCENT HAZARD
Aroclor-1260	3.29E-02	1	1.00E-06	5300	45	24	0.06	70	25550	8760	6.31E-09	1.84E-08	8.90E-01	8.65E+00	--	5.46E-08	--	3.45	0.00
Aluminum	1.49E+04	1	1.00E-06	5300	45	24	0.01	70	25550	8760	4.78E-04	1.39E-03	--	--	1.00E+00	0.00E+00	1.39E-03	0.00	12.25
Arsenic	8.10E+00	1	1.00E-06	5300	45	24	0.03	70	25550	8760	7.78E-07	2.27E-06	9.50E-01	1.84E+00	2.85E-04	1.43E-06	7.96E-03	90.47	70.01
Beryllium	7.00E-01	1	1.00E-06	5300	45	24	0.01	70	25550	8760	2.24E-08	6.53E-08	--	4.30E+00	5.00E-03	9.63E-08	1.31E-05	6.08	0.11
Manganese	1.10E+02	1	1.00E-06	5300	45	24	0.01	70	25550	8760	3.53E-06	1.03E-05	5.00E-02	--	7.00E-03	0.00E+00	1.47E-03	0.00	12.94
Vanadium	4.00E+01	1	1.00E-06	5300	45	24	0.01	70	25550	8760	1.28E-06	3.73E-06	--	--	7.00E-03	0.00E+00	5.33E-04	0.00	4.69
DERMAL CONTACT TOTAL																1.6E-06	1.14E-02	100.00	100.00

Constituents	CS (mg/Kg)	IR (mg/d)	CF (10-6 Kg/mg)	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	CDI CARC	CDI NONCARC	CSF	RfD	INGESTION ICR	INGESTION HI	PERCENT RISK	PERCENT HAZARD
Aroclor-1260	3.29E-02	100	1.00E-06	45	24	70	25550	8760	1.99E-09	5.79E-09	7.70E+00	--	1.5E-08	--	1.45	0.00
Aluminum	1.49E+04	100	1.00E-06	45	24	70	25550	8760	9.01E-04	2.63E-03	--	1.00E+00	0.0E+00	2.6E-03	0.00	30.72
Arsenic	8.10E+00	100	1.00E-06	45	24	70	25550	8760	4.89E-07	1.43E-06	1.75E+00	3.00E-04	8.6E-07	4.8E-03	81.29	55.60
Beryllium	7.00E-01	100	1.00E-06	45	24	70	25550	8760	4.23E-08	1.23E-07	4.30E+00	5.00E-03	1.8E-07	2.5E-05	17.26	0.29
Manganese	1.10E+02	100	1.00E-06	45	24	70	25550	8760	6.66E-06	1.94E-05	--	1.40E-01	0.0E+00	1.4E-04	0.00	1.62
Vanadium	4.00E+01	100	1.00E-06	45	24	70	25550	8760	2.42E-06	7.05E-06	--	7.00E-03	0.0E+00	1.0E-03	0.00	11.77
INGESTION TOTAL													1.1E-06	8.6E-03	100.00	100.00

RASD-D&I.WQ1

TABLE L-23
FUTURE ON-SITE ADULT CONSTRUCTION WORKER
ACCIDENTAL INGESTION OF SUBSURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN VIRGINIA

RELEVENT EQUATIONS:

CDI = CHRONIC DAILY INTAKE

CDI = (CS)(IR)(FI)(CF)(EF)(ED)/(BW)(ATn or ATc) CDI

WHERE: CS = THE CONCENTRATION IN SOIL (mg/Kg)
CF = THE CONVERSION FACTOR (10-6 Kg/mg)
FI = FRACTION INGESTED (unitless)
IR = THE INGESTION RATE (mg/d)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (yr)
BW = BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70 x 365d/yr)
ATn - THE AVERAGING TIME (1 x 365d/yr)

ICR = (CDI * CSF)
HI = (CDI / RfD)

Constituents	CS (mg/Kg)	IR (mg/d)	FI	EF (d/yr)	ED (yr)	BW (Kg)	ATc (days)	ATn (days)	INGESTION CARC.	INGESTION NONCARC.	CSF	RfD	INGESTION ICR	INGESTION HI	Percent Risk	Percent Hazard
Aluminum	1.34E+04	480	1	250	1	70	25550	365	9.02E-04	6.31E-02	--	1.00E+00	0.0E+00	6.3E-02	0.00	16.25
Antimony	9.20E+00	480	1	250	1	70	25550	365	6.17E-07	4.32E-05	--	4.00E-04	0.0E+00	1.1E-01	0.00	27.80
Arsenic	1.04E+01	480	1	250	1	70	25550	365	6.98E-07	4.88E-05	1.75E+00	3.00E-04	1.2E-06	1.6E-01	84.10	41.90
Beryllium	8.00E-01	480	1	250	1	70	25550	365	5.37E-08	3.76E-06	4.30E+00	5.00E-03	2.3E-07	7.5E-04	15.90	0.19
Chromium	2.88E+01	480	1	250	1	70	25550	365	1.93E-06	1.35E-04	--	5.00E-03	0.0E+00	2.7E-02	0.00	6.96
Manganese	1.27E+02	480	1	250	1	70	25550	365	8.51E-06	5.96E-04	--	1.40E-01	0.0E+00	4.3E-03	0.00	1.09
Vanadium	3.36E+01	480	1	250	1	70	25550	365	2.25E-06	1.58E-04	--	7.00E-03	0.0E+00	2.3E-02	0.00	5.80
INGESTION TOTAL													1.5E-06	3.9E-01	100.00	100.00

CWSB-D&I.WQ1

TABLE L-24
FUTURE ON-SITE ADULT CONSTRUCTION WORKER
DERMAL CONTACT WITH SUBSURFACE SOILS
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN VIRGINIA

RELEVENT EQUATIONS:

DAD = DERMALLY ABSORBED DOSE

DAD = (CS)(SA)(AF)(ABS)(EF)(ED)(CF)/(BW)(ATn or ATc)

WHERE: CS = THE CHEMICAL CONCENTRATION (mg/Kg)
SA = THE EXPOSED SURFACE AREA OF THE SKIN (cm2)
AF = THE DERMAL ADHERENCE FACTOR (mg/cm2-d)
ABS = THE ABSORBED FRACTION (unitless)
EF = THE EXPOSURE FREQUENCY (d/yr)
ED = THE EXPOSURE DURATION (years)
CF = CONVERSION FACTOR (10-6 Kg/mg)
BW = THE AVERAGE RECEPTOR BODY WEIGHT (Kg)
ATc = THE AVERAGING TIME (70 x 365d/yr)
ATn = THE AVERAGING TIME (1 x 365d/yr)
AD = ADJUSTMENT FOR ABSORBED DOSE (unitless)

ICR = (DAD * CSF ADJ)   CSF ADJ = CSF/AD
HI = (DAD / RfD ADJ)   RfD ADJ = RfD*AD

CONSTITUENTS	CS (mg/Kg)	AF (mg/cm2-d)	CF (10-6 Kg/mg)	SA (cm2)	EF (d/yr)	ED (yrs)	ABS	BW (Kg)	ATc (days)	ATn (days)	DERMAL CARC.	DERMAL NONCARC.	AD (unitless)	CSF ADJ (Kg-d/mg)	RfD ADJ (mg/Kg-d)	DERMAL ICR	DERMAL HI	PERCENT CARC.	PERCENT HAZARD
Aluminum	1.34E+04	1	1.00E-06	4300	250	1	0.01	70	25550	365	8.08E-05	5.66E-03	--	--	1.00E+00	0.0E+00	5.7E-03	0.00	7.69
Antimony	9.20E+00	1	1.00E-06	4300	250	1	0.01	70	25550	365	5.53E-08	3.87E-06	--	--	4.00E-04	0.0E+00	9.7E-03	0.00	13.16
Arsenic	1.04E+01	1	1.00E-06	4300	250	1	0.03	70	25550	365	1.88E-07	1.31E-05	9.50E-01	1.84E+00	2.85E-04	3.5E-07	4.6E-02	94.35	62.65
Beryllium	8.00E-01	1	1.00E-06	4300	250	1	0.01	70	25550	365	4.81E-09	3.37E-07	--	4.30E+00	5.00E-03	2.1E-08	6.7E-05	5.65	0.09
Chromium	2.88E+01	1	1.00E-06	4300	250	1	0.01	70	25550	365	1.73E-07	1.21E-05	--	--	5.00E-03	0.0E+00	2.4E-03	0.00	3.30
Manganese	1.27E+02	1	1.00E-06	4300	250	1	0.01	70	25550	365	7.62E-07	5.34E-05	5.00E-02	--	7.00E-03	0.0E+00	7.6E-03	0.00	10.37
Vanadium	3.36E+01	1	1.00E-06	4300	250	1	0.01	70	25550	365	2.02E-07	1.41E-05	--	--	7.00E-03	0.0E+00	2.0E-03	0.00	2.75
DERMAL CONTACT TOTAL																3.7E-07	7.4E-02	100.00	100.00

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TABLE L-25
FUTURE ON-SITE ADULT CONSTRUCTION WORKER
INHALATION OF FUGITIVE DUSTS IN SUBSURFACE SOILS DURING EXCAVATION ACTIVITIES
SITE 16 AND SSA 16
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CDI (mg/kg/d) = (Ca*RR*ET*EF*ED)/(BW*AT)

Where: Ca = Cs * (1/PEF)

ICR = CDI * CSFi
HQ = CDI / RfDi

Parameter	Description	Current Adult Construction Worker	
CDI	Chronic daily intake (mg/kg/d)	CS	(Chemical Specific)
ICR	Incremental lifetime cancer risk	CS	
CSFi	Inhalation cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDi	Inhalation reference dose (mg/kg/d)	CS	
Ca	Concentration of chemical in air as fugitive dusts (mg/m3)	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	
PEF	Particulate emission factor (m3/kg)	4.63E+09	
RR	Respiration rate (m3/hr)	0.83	
ET	Exposure time (hrs/d)	8	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	1	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	365	

					Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	Ca (mg/m3)	CSFi 1/(mg/kg/d)	RfDi (mg/kg/d)	CDI (mg/kg/d)	ICR	% Contrib. Total ICR	CDI (mg/kg/d)	HQ	% Contrib. HI
Aluminum	1.34E+04	2.90E-06	--	--	2.7E-09	0.0E+00	0.0%	1.9E-07	--	--
Antimony	9.20E+00	1.99E-09	--	--	1.8E-12	0.0E+00	0.0%	1.3E-10	--	--
Arsenic	1.04E+01	2.25E-09	1.51E+01	--	2.1E-12	3.1E-11	11.6%	1.5E-10	--	--
Beryllium	8.00E-01	1.73E-10	8.40E+00	--	1.6E-13	1.3E-12	0.5%	1.1E-11	--	--
Chromium	2.82E+01	6.09E-09	4.20E+01	--	5.7E-12	2.4E-10	87.9%	4.0E-10	--	--
Manganese	1.27E+02	2.74E-08	--	1.43E-05	2.5E-11	0.0E+00	0.0%	1.8E-09	1.2E-04	100.0%
Vanadium	3.36E+01	7.26E-09	--	--	6.7E-12	0.0E+00	0.0%	4.7E-10	--	--
TOTAL					ICR:	2.7E-10	100.0%	HI:	1.2E-04	100.0%

NOTES:
-- Not available

FILENAME: CWFDUST.WQ1