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TECHNICAL MEMORANDUM DEVELOPMENT OF PRELIMINARY CLEANUP LEVELS AT SOLID WASTE MANAGEMENT UNIT 9 SOUTHSIDE SEWAGE LAGOONS MILLINGTON
SUPPACT TN
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5724 Summer Trees Drive • Memphis, Tennessee 38134 • Telephone 901-372-7962 • Facsimile 901-372-2454 • www.ensafe.com

TECHNICAL MEMORANDUM

To: Jim Reed, SOUTHNAVFACENGCOM
Brian Donaldson, USEPA Region IV
Clayton Bullington, TDEC — DSW
Tonya Barker, NSA Mid-South PWD — Environmental Division
Jack Carmichael, USGS
EnSafe Project Team

From: Robert Smith, EnSafe Inc.

Date: May 1, 2000

RE: Development of Preliminary Cleanup Levels — SWMU 9/Southside Sewage Lagoons, NSA Mid-South, Revision: 1

Preliminary cleanup levels were calculated for surface water and fish tissue for NSA Mid-South SWMU 9 data. Calculation of the cleanup levels presented in Attachment A was performed in accordance with USEPA guidance (USEPA, 1991; USEPA, 1995) and project specific guidelines outlined in the *General Human Health Risk Assessment Approach for NSA Memphis* (Attachment B). Preliminary cleanup levels were developed because either there are no applicable risk-based concentrations (RBCs) available for the media of concern or the RBCs available were too conservative for the exposure scenarios relevant at SWMU 9.

After derivation of the site-specific cleanup levels was completed, analytical data were then compared to these levels to determine if maximum detected chemical concentrations exceed site-specific levels. Analytical data used for this comparison are presented in Attachment C. Surface water sample locations are shown on Figure 8.2.4 from the Assembly E RFI report (EnSafe, February 1998), and is included as Attachment D.

Organization of This Technical Memorandum

The main text of this memorandum explains land use and exposure, followed by brief discussions of the methodology and toxicity values, used for cleanup standard calculation, and the uncertainties associated with using these cleanup levels. Results of the comparison between the cleanup standard and detected chemicals is discussed at the close of the memorandum. For a quick reference to information, refer to the text box to the right. Tables and analytical data are organized in their own attachments. See the lookup tables for a detailed list of the tables.

Land Use Conditions and Exposure Scenarios

The site is currently an industrial property. However, preliminary cleanup levels were derived based on potential future recreational uses such as swimming, paddle boating, and fishing. Receptors expected to contact contaminated media include an adult and children (1-6 years). Although noncarcinogenic risk was evaluated separately for both the adult and child receptor, carcinogenic risk was evaluated using the lifetime-weighted average (LWA) approach, which assumes the an exposure duration of 6 years for a child and 24 years for an adult. Relevant exposure pathways used to determine whether compounds detected in surface water, and fish tissue negatively impact recreational receptors are:

- Incidental ingestion of compounds in surface water while swimming
- Dermal contact with compounds in surface water while swimming
- Ingestion of locally caught fish

Because the land use and exposure scenario assumes contact with contaminated media will occur during swimming, paddleboating, and fishing, sediment was not considered a media of concern. According to Region 4, sediment that is not associated with an intermittent stream does not require evaluation (USEPA, 1995). Cleanup levels for sediment were not calculated and will not be addressed further.

Surface Water Cleanup Levels

For this project, it is assumed that receptors may be exposed to chemicals detected in surface water while swimming. Parameters used for surface water exposure were modified from the groundwater parameters presented in the HHRA technical memorandum based on site-specific and pathway-specific information, Region 4 guidance (USEPA, 1995), and values described in the *Exposure Factors Handbook* (USEPA , 1997a).

Table A-1 summarizes preliminary cleanup levels calculated for barium, the only chemical detected in surface water samples. Cleanup levels were calculated using USEPA algorithms (1989 and 1995) and Attachment B. The proposed cleanup level for barium is based on noncarcinogenic effects. Cleanup levels were estimated using incidental ingestion of surface water and dermal contact with surface water as the primary exposure pathways of concern. The calculated cleanup levels for the recreational scenario are presented in Table A-2. Tables A-3 to A-8 present parameter values, the rationale for any modifications, and intake equations used to calculate surface water chemical intake (Table A-2).

Fish Cleanup Levels

Table A-9 summarizes fish cleanup levels calculated using USEPA algorithms (1989) based on ingestion of locally caught fish as the primary exposure pathway of concern. Fish cleanup levels were calculated in lieu of using Region 3 RBCs because Region 3 values were thought to be overly conservative as they are based on a residential scenario which is not applicable to SWMU 9. The lower calculated value was selected as the site-specific cleanup level based on toxic effect (that is, noncarcinogenic or carcinogenic). The calculated cleanup levels for the recreational scenario are presented in Tables A-10 (adult), A-11 (child), and A-12 (LWA).

Because no site-specific exposure parameters were developed for fish ingestion at NSA Mid-South, the values selected were based on guidance provided in the *Exposure Factors Handbook*

(USEPA, 1997a) and recommendations from Region 4 (USEPA, 1999). All equations, exposure parameter values, and justification for their selection are provided in Table A-13. Daily intake calculations are in Tables A-14 and A-15.

Toxicity Values

The toxicity values used to calculate of cleanup levels (Table A-16) were obtained from the following sources:

- Integrated Risk Information System (IRIS), April 1999.
- Health Effects Assessment Summary Tables (HEAST), (USEPA, 1997b).
- Region 3 Risk-Based Concentration Table. October 1999. (USEPA, 1999).

There were several chemicals detected that did not have toxicity values in the sources identified previously. For the chemicals listed below, surrogate values were selected based on structural similarities.

Chemical	Surrogate Chemical
mercury	mercuric chloride
endosulfan sulfate	Endosulfan
endrin aldehyde	Endrin
gamma-Chlordane	Chlordane

Uncertainties

The uncertainty discussion is describes assumptions made that may affect the overall level of confidence in the site-specific cleanup levels. For the development of site-specific cleanup levels, uncertainties are categorized based on the selection of substances used for comparison, toxicity

criteria, and exposure assumptions. The remainder of this section details the uncertainties associated with this technical memorandum.

Exposure Assessment Uncertainties

Uncertainties in the exposure assessment could arise from the following sources:

- Use of standard assumptions instead of site-specific data selected on the basis of "best professional judgment."
- Selection of a value from a wide range reported in published literature thought to best represent the site under study.
- The degree of "protectiveness" or "conservatism" inherent in the current risk assessment guidance.
- Lack of sufficient data and necessary assumptions made to complete the development of site-specific cleanup levels.

The types and sources of exposure uncertainties are outlined below.

Concentrations Used for Evaluation

Maximum concentrations at the point of exposure were used in all comparisons. The use of maximum concentrations does not consider natural degradation of chemicals in environmental media. Because it has been well recognized that many organic chemicals degrade in the environment, this conservative approach most likely results in a conservative site-specific cleanup level that effectively protects human health.

Selection of Exposure Pathways

Although not considered likely in the actual environmental situation, it was assumed that the populations of concern could simultaneously be exposed to multiple chemicals through all possible pathways. This assumption results in conservative site-specific cleanup levels that are protective of human health.

Exposure Parameter Values for Each Pathway

To conduct a quantitative exposure assessment, many assumptions must be made concerning the exposure scenarios (e.g., frequency and exposure duration, intake rate of contaminated media). Site-specific values are often unavailable and the use of default values (primarily upper-bound estimates) is likely to contribute to exposure assessment uncertainty. For the SWMU 9 recreational scenarios, default values were used in the exposure assessment when site-specific values could not be determined. The default values used represent worst-case values and overestimate exposure. Examples of uncertainties related to the selection of parameter values are summarized below:

- **Ingestion Pathway — Fraction Ingested from Contaminated Source — Fish**
  The derivation of the site-specific cleanup levels for fish ingestion assumes that all fish ingested by the recreational users will come from this contaminated source, i.e., the fraction ingested (FI) term is assumed to be 100%. This does not take into account fish obtained from other sources such as fish purchased from markets or fish caught in other surface water bodies. Using an FI value of 100% is highly conservative and most likely results in a an artificially inflated site-specific cleanup level.

Toxicity Assessment Uncertainties

Uncertainties in the quantitative toxicity assessment are well recognized, but the degree can vary depending on the major sources of uncertainty for a particular site. The types of toxicity uncertainties for this risk assessment are outlined below.

Uncertainties Inherent in the Risk Assessment Process

- Use of animal data to predict potential human health effects.

- Extrapolation of effects observed in animals exposed to high doses to probable outcomes in humans following exposure to low environmental contaminant levels.

- A conservative approach to calculate toxicological criteria such as the oral and dermal reference dose (RfD) with uncertainty spans of perhaps one order of magnitude. These estimates can change when additional information becomes available. The carcinogenic slope factors and unit risks are typically calculated by the USEPA using a linearized multistage model, which leads to a plausible upper-bound risk estimate, although the true value of the risk is unknown and may be as low as zero (USEPA, 1986).

- The site-specific cleanup level for chromium was calculated using toxicity values provided for hexavalent chromium. There is no available information that indicates hexavalent chromium is present at this site. By using hexavalent chromium toxicity values for data reported as total chromium, the site-specific cleanup level is most likely too conservative.

Uncertainties Common to Current EPA Guidance on Risk Assessment

- Lack of pertinent toxicological data for the chemicals selected for the quantitative risk assessment. For calculating site-specific cleanup levels, surrogate toxicity values were used for those chemicals with no published toxicity values. It was assumed that chemicals

with similar structures might have similar toxicological effects. The greatest uncertainty with this assumption is the actual toxicological effect could be greater than or less than the surrogate compound's, potentially resulting in screening out compounds that may pose a human health problem. The chemicals listed below had surrogate toxicity values used in the calculation of the site-specific cleanup level.

Chemical	Surrogate Chemical
mercury	mercuric chloride
endosulfan sulfate	Endosulfan
endrin aldehyde	Endrin
gamma-Chlordane	Chlordane

- Lack of specific toxicity criteria to evaluate the dermal exposure route. The current USEPA default position is to adjust the oral toxicity value with an oral absorption factor and adopt this adjusted value as the surrogate dermal toxicity value. The validity and scientific basis for this extrapolation warrant further deliberation, because the mechanism for absorption through a skin barrier (i.e., the dermal route) is expected to be different than through a gastrointestinal system (i.e., the oral route). However, the current method recommended by USEPA to extrapolate default dermal toxicity values does not reflect the specific conditions under which the reference toxicological study was conducted (e.g., method of administration such as gavage, water, or diet, and vehicle of administration such as solvent, oil, or solution).

Uncertainties Specific to this Site

Site-specific cleanup levels were calculated assuming recreational receptors can be exposed to contaminated surface water, and fish 365 days of the year. This assumption is most likely incorrect because recreational use of the facility is not likely to occur during cold or inclement

weather. Therefore, the 52 day per year exposure frequency assumed for surface water is an overestimate.

Conclusions

The preliminary cleanup levels developed for the recreational scenario are presented in Table A-1 for surface water, and Table A-9 for fish. Except for Aroclor-1254 and Aroclor-1260 in fish tissue, no other maximum detected surface water or fish tissue concentrations exceeded preliminary site-specific cleanup levels.

Recommendations

Based on the comparison of the maximum detected contaminant concentrations in surface water and fish tissue to the preliminary cleanup levels established for the exposure scenarios addressed in this technical memorandum, fish tissue is the only media that will need to be addressed to reduce risk to human health or the environment. No further action is warranted for the surface water or the sediment at this site; however, exposure to the fish tissue should be addressed using one (or combination) of the three options; prohibit fishing by posting signs (current method), remove and dispose of fish, and/or prohibit access to site by installing a fence around the site.

References

E/A & H. (1996, February). Technical Memorandum, *Revision 1: General Human Health Risk Assessment (HHRA) Approach for NSA Memphis*. E/A&H: Memphis, Tennessee.

EnSafe Inc. (1998, February). *RCRA Facility Investigation Report, Assembly E, SWMUs 2, 9, 14, 38, 59, and 65, Naval Support Activity Memphis (Rev: 1)*. EnSafe: Memphis, Tennessee.

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USEPA. (1995, November). *Supplemental Guidance to Risk Assessment Guidance for Superfund (RAGS) Region 4 Bulletins.*

USEPA. (1992). *Human Health Evaluation Manual, Supplemental Guidance: "Interim Dermal Risk Assessment Guidance."* September 23, 1992.

USEPA. (1991). *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual Part B, Development of Risk-Based Preliminary Remediation Goals.* EPA/540/R-92/003. Office of Research and Development: Washington, DC.

USEPA. (1989). *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A).* Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response: Washington, DC.

USEPA. (1986). *Guidelines for Carcinogenic Risk Assessment.* EPA/600/8-87/045. August 1987.

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Attachment A

Preliminary Site-Specific Cleanup Levels and Supporting Tables

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TABLE A-1
SUMMARY OF SITE-SPECIFIC CLEANUP LEVELS FOR SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Detected Compound	Maximum Concentration (mg/L)	Maximum Sample Identification[a]	Site-Specific Cleanup Level for Recreational Scenario (mg/L)		Basis		Exceeds Recreational Action Level	
			Adult	Child	Adult	Child	Adult	Child
Barium	0.214	009W000201	2.08E+02	1.28E+01	N	N	No	No

a. Sample identification indicates sample where maximum concentration was detected.
N - Noncarcinogen
C - Carcinogen

TABLE A-2
DEVELOPMENT OF SITE-SPECIFIC CLEANUP LEVELS FOR SURFACE WATER
POTENTIAL RECREATIONAL SCENARIO: ADULT, CHILD, LIFETIME WEIGHTED AVERAGE EXPOSURES
INCIDENTAL INGESTION AND DERMAL CONTACT
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

NONCARCINOGENIC - ADULT

EQUATION	TC	=	HQ	/	[	(	IF oral	/	RfD oral	)	+	(	IF derm	/	RfD derm)	)]
UNITS	mg/L		Unitless				L/kg-day		mg/kg-day				L/kg-day		mg/kg-day	
Barium	2.08E+02	=	1	/	[	(	3.05E-05	/	7.00E-02	)	+	(	6.11E-05	/	1.40E-02	)]

NONCARCINOGENIC – CHILD

Compound	TC	=	HQ	/	[	(	IF oral	/	RfD oral	)	+	(	IF derm	/	RfD derm)	)]
	mg/L		Unitless				L/kg-day		mg/kg-day				L/kg-day		mg/kg-day	
Barium	1.28E+01	=	1	/	[	(	2.85E-03	/	7.00E-02	)	+	(	5.24E-04	/	1.40E-02	)]

CARCINOGENIC - LIFETIME-WEIGHTED AVERAGE

Compound	TC	=	TR	/	[	(	IF oral	×	SF oral	)	+	(	IF derm	×	SF derm	)]
	mg/L		Unitless				L/kg-day		$(mg/kg\text{-}day)^{-1}$				L/kg-day		$(mg/kg\text{-}day)^{-1}$	
Barium	N/A	=	1.00E-05	/	[	(	2.55E-04	×	N/A	)	+	(	6.58E-05	×	N/A	)]

TC = Target concentration
HQ = Hazard quotient
TR = Target risk
IF oral = Oral intake factor. Detailed information regarding the definition of IF oral is presented in Tables 12 and 13.
IF dermal = Dermal intake factor. Detailed information regarding the definition of IF dermal is presented in Tables 14 and 15.
RfD oral = oral reference dose
RfD dermal = dermal reference dose
SF oral = oral slope factor
SF dermal = dermal slope factor

TABLE A-3
EXPOSURE INTAKE FORMULA AND PARAMETERS
RECREATIONAL LAND USE: ADULT AND CHILD
INCIDENTIAL INGESTION OF CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Intake equation:

$$IF\ ing_{noncarcinogenic} = \frac{IR \times ET \times EF \times ED \times FI}{BW \times AT}$$

$$IF\ ing_{carcinogenic} = \left\{\left(\frac{IRa \times ETa \times EDa}{BWa}\right) + \left(\frac{IRc \times ETc \times EDc}{BWc}\right)\right\} \times \left\{\frac{(FI \times EF)}{AT}\right\}$$

Parameters	Definition	Units	Value Adult	Value Child	Reference
IF oral	Intake factor – oral route	L/kg-day	Calculated		USEPA, 1989[a]
IR	Ingestion rate	L/hour	0.01	0.05	USEPA, 1995
FI	Fraction ingested from contaminated source	unitless	1	1	Conservative assumption
ET	Exposure time	hours/day	1.5	6	USEPA, 1997
EF	Exposure frequency	days/year	52	52	Conservative assumption[b, c]
ED	Exposure duration	years	24	6	USEPA, 1991
BW	Body weight	kg	70	15	USEPA, 1989
AT	Average time				
	– Carcinogenic effects	days	25,550	25,550	USEPA, 1989[d]
	– Noncarcinogenic effects	days	8,760	2,190	

a. Intake is expressed as an administered dose.
b. Based on the default ingestion rates recommended by USEPA Region 4 for swimming.
c. Assumes receptor would contact chemicals in surface water 1 day per week per year.
d. Averaging time of exposure for carcinogenic effects is based on 70-year lifetime (70 years x 365 days/yr) = 25,550 days). Averaging times of exposure for noncarcinogenic effects is based on 24 and 6 year exposure duration (24 years X 365 days/year = 8,760 days) and 6 years x 365 days/year = 2,190 days), for the adult and child respectively.

Sources:

USEPA 1989. Risk Assessment Guidance for Superfund. Volume I. Part A. (EPA 540/1-89/002).

USEPA 1995. Supplemental Guidance to RAGS: Region 4 Bulletins: Human Health Risk Assessment.

USEPA 1991. Risk Assessment Guidance for Superfund: Volume I. Part B. (EPA/540/R-92/003).

USEPA 1997. Exposure Factors Handbook. (EPA/600/P-95/002).

TABLE A-4
INGESTION-SPECIFIC INTAKE FACTOR
RECREATIONAL ADULT AND CHILD EXPOSURE: INGESTION OF CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Noncarcinogens

EQUATION	IF ing	= ((	IR	×	FI	×	ET	×	EF	×	ED	)	÷	(	BW	×	AT	))
UNITS	L/kg - day		L/hour		unitless		hours/day		days/yr		yr				kg		days	
All Chemicals																		
Adult	3.05E-05	= ((	0.01	×	1	×	1.5	×	52	×	24	)	÷	(	70	×	8,760	))
Child	2.85E-03	= ((	0.05	×	1	×	6	×	52	×	6	)	÷	(	15	×	2,190	))

See Table 13 for definitions and sources of equation variables identified as follows:
IF = intake factor
IR = ingestion rate of water
FI = fraction ingested from contaminated source
ET = exposure time
EF = exposure frequency
ED = exposure duration
BW = body weight
AT = averaging time

TABLE A-5
INGESTION-SPECIFIC INTAKE FACTOR
RECREATIONAL LIFETIME-WEIGHTED AVERAGE EXPOSURE: INGESTION OF CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Carcinogens

EQUATION	IF ing	= [(	IRa	×	ETa	×	EDa	÷	BWa	)+(	IRc	×	ETc	×	EDc	÷	BWc	)]	×	[(	FI	×	EF	) ÷	AT	]
UNITS	L/kg - day		L/hour		hours		years		kg		L/hour		hours		years		kg				unitless		days/year		days	
All Chemicals	2.55E-04	= [(	0.01	×	1.5	×	24	÷	70	)+(	0.05	×	6	×	6	÷	15	)]	×	[(	1	×	52	) ÷	25550	]

See Table 13 for definitions and sources of equation variables identified as follows:
IF = intake factor
IRa = ingestion rate - adult
ETa = exposure time - adult
EDa = exposure duration - adult
BWa = body weight - adult
IRc = ingestion rate - child
ETc = exposure time - child
EDc = exposure duration - child
BWc = body weight -child
FI = fraction ingested from contaminated source
EF = exposure frequency
AT = averaging time

TABLE A-6
EXPOSURE INTAKE FORMULA AND PARAMETERS
RECREATIONAL LAND USE: ADULT AND CHILD
DERMAL CONTACT WITH CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Intake equation:

$$IF\ derm_{noncarcinogenic} = \frac{SA \times EF \times ED \times ET \times CF \times PC}{BW \times AT}$$

$$IF\ derm_{carcinogenic} = \left\{\left(\frac{SAa \times EDa}{BWa}\right) + \left(\frac{SAc \times EDc}{BWc}\right)\right\} \times \left\{\frac{(EF \times ET \times CF \times PC)}{AT}\right\}$$

Parameters	Definition	Units	Value Adult	Value Child	Reference
IF derm	Intake factor – dermal	L/kg-day	Calculated		USEPA, 1989
SA	Skin surface area available for contact	cm^2/event	20000	9180	USEPA, 1997[a]
EF	Exposure frequency	days/year	52	52	Conservative assumption[b, c]
ED	Exposure duration	years	24	6	USEPA, 1989
ET	Exposure time	hours/day	1.5	6	USEPA, 1997
CF	Conversion factor	L/cm^3	1E-03	1E-03	SI system
PC	Permeability constant	cm/hr	chemical specific		USEPA, 1992
BW	Body weight	kg	70	15	USEPA, 1989
AT	Average time				
	– Carcinogenic effects	days	25,550	25,550	USEPA, 1989[d]
	– Noncarcinogenic effects	days	8,760	2,190	

a. The adult skin surface area is the upper percentile value presented for bathing/swimming in USEPA, 1997. The child surface area is based on the 95th percentile of the total body surface area for male children 5 to 6 years old.
b. Worst-case assumption
c. Assumes receptor contacts chemicals in surface water 1 day per week per year.
d. Averaging time of exposure for carcinogenic effects is based on 70-year lifetime (70 years x 365 days/yr) = 25,550 days). Averaging times of exposure for noncarcinogenic effects is based on 30 and 6 year ED (24 years X 365 days/year = 8,760 days) and 6 years x 365 days/year = 2,190 days), for the adult and child respectively.

SI System = International System of Units

Sources:

USEPA 1989 Risk Assessment Guidance for Superfund. Volume I. Part A. EPA 540/1-89/002.

USEPA 1997. Exposure Factors Handbook. (EPA/600/P-95/002).

USEPA 1992. Dermal Exposure Assessment: Principles and Applications (EPA/600/8-91/011B).

TABLE A-7
DERMAL-SPECIFIC INTAKE FACTOR
RECREATIONAL ADULT AND CHILD EXPOSURE: DERMAL CONTACT WITH CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Noncarcinogens

EQUATION	IF derm	= ((	SA	×	ET	×	PC[a]	×	EF	×	ED	×	CF	) ÷ (	BW	×	AT	))
UNITS	L/kg - day		cm^2		hours/day		cm/hour		days/yr		years		L/cm^3		kg		days	
Adult	6.11E-05	= ((	20000	×	1.5	×	1E-03	×	52	×	24	×	1E-03	) ÷ (	70	×	8,760	))
Child	5.24E-04	= ((	9200	×	6	×	1E-03	×	52	×	6	×	1E-03	) ÷ (	15	×	2,190	))

See Table 16 for definitions and sources of equation variables identified as follows:
a = Barium is the only COPC in surface water. The permeability constant is the default value recommended in USEPA, 1992.

IF = intake factor
SA = skin surface area available for contact
ET = exposure time
PC = permeability constant
EF = exposure frequency
ED = exposure duration
CF = conversion factor
BW = body weight
AT = averaging time

TABLE A-8
DERMAL-SPECIFIC INTAKE FACTOR
RECREATIONAL LIFETIME-WEIGHTED AVERAGE EXPOSURE: DERMAL CONTACT WITH CHEMICALS IN SURFACE WATER
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Carcinogens

EQUATION	IF derm	= [(	SAa	×	ETa	×	EDa	)+(	BWa	)+(	SAc	×	ETc	×	EDc	)+(	BWc	)] × [(	EF	×	CF	×	PC	)	÷	AT	]
UNITS	L/kg - day		cm^2		hours		years		kg		cm^2				years		kg		days/yr		L/cm^3					days	
Barium	6.58E-05	= [(	20000	×	1.5	×	24	)+(	70	)+(	9180	×	6	×	6	)+(	15	)] × [(	52	×	1E-03	×	1E-03	)	÷	25550	]

See Table 16 for definitions and sources of equation variables identified as follows:
IF = intake factor
SA = skin surface area available for contact
ET = exposure time
PC = permeability constant
EF = exposure frequency
ED = exposure duration
CF = conversion factor
BW = body weight
AT = averaging time

TABLE A-9
SUMMARY OF SITE-SPECIFIC CLEANUP LEVELS FOR FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Detected Compound	Maximum Concentration (mg/kg)	Maximum Sample Identification[a]	Site-Specific Cleanup Level for Recreational Scenario (mg/kg)		Basis		Exceeds Recreational Action Level	
			Adult	Child	Adult	Child	Adult	Child
Metals								
Aluminum	19.6	009J020002	2.80E+03	1.00E+03	N	N	No	No
Arsenic	0.03	009J020002	3.20E-02	3.20E-02	N	C	No	No
Barium	28	009J020002	1.96E+02	7.00E+01	N	N	No	No
Calcium	13400	009J020002	N/A	N/A	N/A	N/A	No	No
Chromium	2.2	009J010001	8.40E+00	3.00E+00	N	N	No	No
Cobalt	0.1	009J020002	1.68E+02	6.00E+01	N	N	No	No
Copper	2	009J010001	1.12E+02	4.00E+01	N	N	No	No
Iron	48	009J020002	N/A	N/A	N/A	N/A	No	No
Lead	0.31	009J020002	N/A	N/A	N/A	N/A	No	No
Magnesium	392	009J020002	N/A	N/A	N/A	N/A	No	No
Manganese	20	009J020002	3.92E+02	1.40E+02	N	N	No	No
Mercury	0.09	009J010001	8.40E-01	N/A	N/A	N/A	No	No
Nickel	1.1	009J010001	5.60E+01	2.00E+01	N	N	No	No
Potassium	2600	009J010001	N/A	N/A	N/A	N/A	No	No
Selenium	0.22	009J020002	1.40E+01	5.00E+00	N	N	No	No
Sodium	1100	009J020002	N/A	N/A	N/A	N/A	No	No
Vanadium	0.42	009J020002	1.96E+01	7.00E+00	N	N	No	No
Zinc	23	009J020002	8.40E+02	3.00E+02	N	N	No	No
Pesticide/PCBs								
4,4'-DDE	0.088	009J010001	1.41E-01	1.41E-01	C	C	No	No
Aroclor-1254	0.28	009J020001	2.40E-02	2.00E-02	N	N	Yes	Yes
Aroclor-1260	0.1	009J010001	2.40E-02	2.40E-02	N	N	Yes	Yes
Endrin	0.049	009J010001	8.40E-01	3.00E-01	N	N	No	No
SVOCs								
Di-n-butylphthalate	0.12	009J020002	2.80E+02	1.00E+02	N	N	No	No

a. Sample identification indicates sample where maximum concentration was detected.
N - Noncarcinogen
C - Carcinogen

TABLE A-10
DEVELOPMENT OF SITE-SPECIFIC CLEANUP LEVELS FOR FISH
POTENTIAL RECREATIONAL SCENARIO: ADULT EXPOSURE
INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

NONCARCINOGENIC

Compound	TC mg/kg	=	HQ unitless	/ [(	IF oral kg/kg-day	/	RfD oral mg/kg-day	)
Aluminum	2.80E+03	=	1	/ [(	3.57E-04	/	1E+00	)
Arsenic	8.40E-01	=	1	/ [(	3.57E-04	/	3E-04	)
Barium	1.96E+02	=	1	/ [(	3.57E-04	/	7E-02	)
Calcium	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Chromium	8.40E+00	=	1	/ [(	3.57E-04	/	3E-03	)
Cobalt	1.68E+02	=	1	/ [(	3.57E-04	/	6E-02	)
Copper	1.12E+02	=	1	/ [(	3.57E-04	/	4E-02	)
Iron	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Lead	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Magnesium	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Manganese	3.92E+02	=	1	/ [(	3.57E-04	/	1.4E-01	)
Mercury	8.40E-01	=	1	/ [(	3.57E-04	/	3E-04	)
Nickel	5.60E+01	=	1	/ [(	3.57E-04	/	2E-02	)
Potassium	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Selenium	1.40E+01	=	1	/ [(	3.57E-04	/	5E-03	)
Sodium	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Vanadium	1.96E+01	=	1	/ [(	3.57E-04	/	7E-03	)
Zinc	8.40E+02	=	1	/ [(	3.57E-04	/	3E-01	)
4,4'-DDE	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Aroclor-1254	5.60E-02	=	1	/ [(	3.57E-04	/	2E-05	)
Aroclor-1260	N/A	=	1	/ [(	3.57E-04	/	N/A	)
Endrin	8.40E-01	=	1	/ [(	3.57E-04	/	3E-04	)
Di-n-butylphthalate	2.80E+02	=	1	/ [(	3.57E-04	/	1E-01	)

TC = Target concentration
HQ = Hazard quotient
IF oral = Oral intake factor. Detailed information regarding the definition of IF oral is presented in Table 19.
RfD oral = oral reference dose
N/A = Not applicable

TABLE A-11
DEVELOPMENT OF SITE-SPECIFIC CLEANUP LEVELS FOR FISH
POTENTIAL RECREATIONAL SCENARIO: CHILD EXPOSURE
INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

NONCARCINOGENIC

Compound	TC mg/kg	=	HQ unitless	/ [(	IF oral kg/kg-day	/	RfD oral mg/kg-day	)
Aluminum	1.00E+03	=	1	/ [(	1.00E-03	/	1E+00	)
Arsenic	3.00E-01	=	1	/ [(	1.00E-03	/	3E-04	)
Barium	7.00E+01	=	1	/ [(	1.00E-03	/	7E-02	)
Calcium	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Chromium	3.00E+00	=	1	/ [(	1.00E-03	/	3E-03	)
Cobalt	6.00E+01	=	1	/ [(	1.00E-03	/	6E-02	)
Copper	4.00E+01	=	1	/ [(	1.00E-03	/	4E-02	)
Iron	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Lead	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Magnesium	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Manganese	1.40E+02	=	1	/ [(	1.00E-03	/	1E-01	)
Mercury	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Nickel	2.00E+01	=	1	/ [(	1.00E-03	/	2E-02	)
Potassium	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Selenium	5.00E+00	=	1	/ [(	1.00E-03	/	5E-03	)
Sodium	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Vanadium	7.00E+00	=	1	/ [(	1.00E-03	/	7E-03	)
Zinc	3.00E+02	=	1	/ [(	1.00E-03	/	3E-01	)
4,4'-DDE	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Aroclor-1254	2.00E-02	=	1	/ [(	1.00E-03	/	2E-05	)
Aroclor-1260	N/A	=	1	/ [(	1.00E-03	/	N/A	)
Endrin	3.00E-01	=	1	/ [(	1.00E-03	/	3E-04	)
Di-n-butylphthalate	1.00E+02	=	1	/ [(	1.00E-03	/	1E-01	)

TC = Target concentration
HQ = Hazard quotient
IF oral = Oral intake factor. Detailed information regarding the definition of IF oral is presented in Table 19.
RfD oral = oral reference dose
N/A = Not applicable

TABLE A-12
DEVELOPMENT OF SITE-SPECIFIC CLEANUP LEVELS FOR FISH
POTENTIAL RECREATIONAL SCENARIO: LIFETIME-WEIGHTED AVERAGE EXPOSURE
INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

CARCINOGENIC

Compound	TC mg/kg	=	TR unitless	/ [(	IF oral kg/kg-day	×	SF oral $(mg/kg\text{-}day)^{-1}$	)
Aluminum	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Arsenic	3.20E-02	=	1E-05	/ [(	2.08E-04	×	1.5E+00	)
Barium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Calcium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Chromium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Cobalt	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Copper	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Iron	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Lead	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Magnesium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Manganese	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Mercury	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Nickel	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Potassium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Selenium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Sodium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Vanadium	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Zinc	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
4,4'-DDE	1.41E-01	=	1E-05	/ [(	2.08E-04	×	3.4E-01	)
Aroclor-1254	2.40E-02	=	1E-05	/ [(	2.08E-04	×	2E+00	)
Aroclor-1260	2.40E-02	=	1E-05	/ [(	2.08E-04	×	2E+00	)
Endrin	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)
Di-n-butylphthalate	N/A	=	1E-05	/ [(	2.08E-04	×	N/A	)

TC = Target concentration
TR = Target risk
IF oral = Oral intake factor. Detailed information regarding the definition of IF oral is presented in Table 19.
SF oral = oral slope factor
N/A = Not applicable

TABLE A-13
EXPOSURE INTAKE FORMULA AND PARAMETERS
RECREATIONAL LAND USE: ADULT AND CHILD
INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Intake equation:

$$IF\ oral_{noncarcinogenic} = \frac{IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$IF\ oral_{carcinogenic} = \left\{\left(\frac{IRa \times EDa}{BWa}\right) + \left(\frac{IRc \times EDc}{BWc}\right)\right\} \times \left\{\frac{CF \times FI \times EF}{AT}\right\}$$

Parameters	Definition	Units	Value Adult	Value Child	Reference
IF oral	Intake factor – fish ingestion	kg fish/kg BW - day	Calculated		USEPA, 1989[a]
IR	Ingestion rate	g fish/day	25	15	Recommended value[b]
CF	Conversion factor	kg/g	1E-03	1E-03	SI system
FI	Fraction ingested from contaminated source	unitless	1	1	Conservative assumption[c]
EF	Exposure frequency	days/year	365	365	USEPA, 1989
ED	Exposure duration	years	24	6	USEPA, 1991
BW	Body weight	kg	70	15	USEPA, 1989
AT	Average time				
	– Carcinogenic effects	days	25,550	25,550	USEPA, 1989[d]
	– Noncarcinogenic effects	days	8,760	2,190	

a. Daily intake is expressed as an administered dose.
b. Value recommended by Brian Donaldson, Region 4 USEPA (September 1999).
c. Assumes all of the ingested fish is from the contaminated source.
d. Averaging time of exposure for carcinogenic effects is based on 70-year lifetime (70 years x 365 days/yr) = 25,550 days). Averaging times of exposure for noncarcinogenic effects is based on 24 and 6 year exposure duration (24 years × 365 days/year = 8,760 days) and 6 years x 365 days/year = 2,190 days), for the adult and child respectively.

SI System = International System of Units

Sources:

USEPA 1989 Risk Assessment Guidance for Superfund. Volume I. Part A. (EPA 540/1-89/002).

USEPA 1991. Risk Assessment Guidance for Superfund: Volume I. Part B. (EPA/540/R-92/003).

USEPA 1997. Exposure Factor Handbook. (EPA/600/P-95/002).

TABLE A-14
INGESTION-SPECIFIC INTAKE FACTOR
RECREATIONAL ADULT EXPOSURE: INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Noncarcinogens

EQUATION	IF oral	= ((	IR	×	EF	×	ED	×	FI	×	CF	) + (	BW	×	AT	))
UNITS	kg/kg - day		g/day		days/yr		yr		unitless		kg/g		kg		days	
All Chemicals																
Adult	3.57E-04	= ((	25	×	365	×	24	×	1	×	1E-03	) + (	70	×	8,760	))
Child	1.00E-03	= ((	15	×	365	×	6	×	1	×	1E-03	) + (	15	×	2,190	))

See Table 23 for definitions and sources of equation variables identified as follows:

IF = intake factor
AT = averaging time
BW = body weight
FI = fraction ingested
IR = ingestion rate
EF = exposure frequency
ED = exposure duration
CF = conversion factor

TABLE A-15
INGESTION-SPECIFIC INTAKE FACTOR
RECREATIONAL LIFETIME-WEIGHTED AVERAGE EXPOSURE: INGESTION OF CONTAMINATED FISH
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Carcinogens

EQUATION	IF oral	= [(	IRa	×	EDa	+	BWa	)+(	IRc	×	EDc	+	BWc	)] × [(	EF	×	FI	×	CF	) ÷	AT	]
UNITS	kg/kg - day		g/day		years		kg		g/day		years		kg		days/yr		unitless		kg/g		days	
All Chemicals	2.08E-04	= [(	25	×	24	+	70	)+(	15	×	6	+	15	)] × [(	365	×	1	×	1E-03	) ÷	25550	]

See Table 23 for definitions and sources of equation variables identified as follows:

IF = intake factor
IR = ingestion rate
EF = exposure frequency
ED = exposure duration
FI = fraction ingested
CF = conversion factor
BW = body weight
AT = averaging time

TABLE A-16
ORAL/DERMAL TOXICITY AND CHEMICAL-SPECIFIC VALUES
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Parameter	RfDo mg/kg-day		CSFo $(mg/kg\text{-}day)^{-1}$		RfDd mg/kg-day		CSFd $(mg/kg\text{-}day)^{-1}$	
Herbicides								
2,4,5-TP	8E-03	I	ND		4E-03	V	ND	
2,4-D	1E-02	I	ND		5E-03	V	ND	
2,4-DB	8E-03	I	ND		4E-03	V	ND	
Dalapon	3E-02	I	ND		1.5E-02	V	ND	
Dicamba	3E-02	I	ND		1.5E-02	V	ND	
Dichlorprop	ND		ND		ND		ND	
MCPA	5E-04	I	ND		2.5E-04	V	ND	
MCPP	1E-03	I	ND		5E-04	V	ND	
Metals								
Aluminum	1E+00	E	ND		2E-01		ND	
Arsenic	3E-04	I	1.5	I	2.4E-04	V	1.88	V
Barium	7E-02	I	ND		1.4E-02	V	ND	
Beryllium	2E-03	I	ND		4E-04	V	ND	
Cadmium-Water	5E-04	I	ND		1E-04	V	ND	
Calcium	EN		EN		EN		EN	
Chromium	3E-03	I	ND		6E-04	V	ND	
Cobalt	6E-02	E	ND		1.2E-02	V	ND	
Copper	4E-02	H	ND		8E-03	V	ND	
Iron	3E-01	E	ND		6E-02		ND	
Lead	ND		ND		ND		ND	
Magnesium	EN		EN		EN		EN	
Manganese	1E-01	I	ND		2.8E-02		ND	
Mercury (inorganic)	3E-04	I	ND		6E-05		ND	
Nickel	2E-02	I	ND		4E-03	V	ND	
Potassium	EN		EN		EN		EN	
Selenium	5E-03	I	ND		1E-03	V	ND	
Silver	5E-03	I	ND		1E-03	V	ND	
Sodium	EN		EN		EN		EN	
Tin	6E-01	H	ND		1.2E-01	V	ND	
Vanadium	7E-03	H	ND		1.4E-03	V	ND	
Zinc	3E-01	I	ND		6E-02	V	ND	
Pesticides/Polychlorinated Biphenyls								
Aroclor-1254	2E-05	I	2	I	1E-05	V	4	V
Aroclor-1260	ND		2	I	ND	V	4	V
Chlordane	5E-04	I	3.5E-01	I	2.5E-04	V	7E-01	V
DDD	ND		2.4E-01	I	ND		4.8E-01	V
DDE	ND		3.4E-01	I	ND		6.8E-01	V
DDT	5E-04	I	3.4E-01	I	2.5E-04	V	6.8E-01	V
Dieldrin	5E-05	I	16	I	2.5E-05	V	3.2E+01	V
Endosulfan	6E-03	I	ND		3E-03	V	ND	

TABLE A-16
ORAL/DERMAL TOXICITY AND CHEMICAL-SPECIFIC VALUES
NSA MID-SOUTH – SWMU 9
MILLINGTON, TENNESSEE

Parameter	RfDo mg/kg-day		CSFo $(mg/kg\text{-}day)^{-1}$		RfDd mg/kg-day		CSFd $(mg/kg\text{-}day)^{-1}$	
Endrin	3E-04	I	ND		1.5E-04	V	ND	
Methoxychlor	5E-03	I	ND		2.5E-03	V	ND	
Semivolatile Organic Compounds								
4-Chloroaniline	4E-03	I	ND		2E-03	V	ND	
Bis(2-ethylhexyl)phthalate	2E-02	I	1.4E-02	I	1E-02	V	2.8E-02	V
Diethylphthalate	8E-01	I	ND		4E-01	V	ND	
Di-n-butylphthalate	1E-01	I	ND		2E-02		ND	
Dinoseb	1E-03	I	ND		5E-04	V	ND	
Fluoranthene	4E-02	I	ND		2E-02	V	ND	
Pyrene	3E-02	I	ND		1.5E-02	V	ND	
Volatile Organic Compounds								
2-Butanone	6E-01	I	ND		4.8E-01	V	ND	
Acetone	1E-01	I	ND		8E-02	V	ND	
Chlorobenzene	2E-02	I	ND		1.6E-02	V	ND	
Total Petroleum Hydrocarbons								
TPH	6E-01	R4	ND		4.8E-01	R4	ND	
TPH-DRO	6E-01	R4	ND		4.8E-01	R4	ND	

Sources:

I = IRIS
H = HEAST
V = Adjusted RfDo or CSFo using guidance in Region 4 Bulletin: Toxicity Assessment (11/95) Oral absorption efficiencies are 0.2 for metals, 0.8 for VOCs, and 0.5 for all other compounds.
R4 = Oral reference dose provided by USEPA Region 4 in *Supplemental Guidance to RAGS Region 4* Bulletins (1995).
RfDo = oral reference dose
mg/kg-day = milligrams per kilogram
RfDd = adjusted dermal reference dose
CSFo = oral cancer slope factor
CSFd = dermal cancer slope factor-

Attachment B

General Human Health Risk Assessment Approach

EnSafe / Allen & Hoshall

a joint venture for professional services

Program Management Office
Shelby Oaks Plaza
5909 Shelby Oaks Dr.
Suite 201
Memphis, TN 38134
Phone (901) 383-9115
Fax (901) 383-1743

EnSafe/Allen & Hoshall Branch Offices:

Charleston
935 Houston Northcutt Blvd.
Suite 113
Mt. Pleasant, SC 29464
Phone (803) 884-0029
Fax (803) 856-0107

Cincinnati
400 TechneCenter Dr.
Suite 301
[illegible]d, OH 45150
[illegible] (513) 248-8449
Fax (513) 248-8447

Pensacola
2114 Airport Blvd.
Suite 1150
Pensacola, FL 32504
Phone (904) 479-4595
Fax (904) 479-9120

Norfolk
303 Butler Farm Road
Suite 113
Hampton, VA 23666
Phone (804) 766-9556
Fax (804) 766-9558

Raleigh
5540 Centerview Drive
Suite 205
Raleigh, NC 27606
Phone (919) 851-1886
Fax (919) 851-4043

Nashville
311 Plus Park Blvd.
Suite 130
Nashville, TN 37217
Phone (615) 399-8800
Fax (615) 399-7467

[illegible]
[illegible]aller Drive
Suite 326
Irving, TX 75038
Phone (214) 791-3222
Fax (214) 791-0405

TECHNICAL MEMORANDUM

TO: Mark Taylor/David Porter, SOUTHDIV
Tonya Barker/Rob Williamson, NSA Memphis
Brian Donaldson, USEPA
Jim Morrison, TDEC
Jack Carmichael, USGS
Brenda Duggar, MSCHD
E/A&H Project Team

FROM: Brian Mulhearn, E/A&H JBM

DATE: February 4, 1997

RE: Revision 1 General Human Health Risk Assessment (HHRA) Approach for NSA Memphis

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This memorandum discusses the general HHRA approach for NSA Memphis and incorporates USEPA's suggestions received during the January 28, 1997 Base Realignment and Closure (BRAC) Cleanup Team meeting. This text will not be reproduced in subsequent HHRAs with the exception of the final report, where the text will be included as an appendix. Initially, HHRAs will include only site-specific information and will reference this memorandum, reducing the bulk necessary to present site-specific risk information to risk managers. Deviations from these general methods will be justified and discussed in site-specific HHRAs.

1 BASELINE RISK ASSESSMENT

1.1 Introduction

A baseline risk assessment (BRA) establishes a baseline of risk to facilitate risk management decisions. Risk is the estimated potential for toxic effects on actual or hypothetical human or ecological receptors, while baseline risk refers to risk arising from exposures to chemicals assuming site conditions remain unchanged. BRAs are used by risk managers to decide if remedial actions are necessary and to determine the extent of remediation necessary to reduce the risk to acceptable levels. Generally, a BRA is divided into two sections, one assessing human health risk, and a second addressing ecological risk. This section addresses generally applied HHRA methods, while ecological risk assessment methods will be addressed in the site-specific assessments. Data management and analysis methods which will be used to reach the conclusions of site-specific HHRAs are discussed below. The following sections describe the methods, procedures, considerations, toxicological information, and related uncertainties possibly affecting HHRAs at NSA Memphis.

1.2 Background

The site background will be summarized in this section of the site-specific HHRAs.

2 General Guidance

HHRAs will generally be prepared in accordance with the guidelines set forth in the following documents, although some may not apply to every site:

- *Provisional Guidance for Quantitative Risk Assessment of PAHs*, U.S. Environmental Protection Agency, ECAO-CIN-842, EPA/600/BP92/001C, July 1993.

- *Risk Assessment Guidance for Superfund (RAGS), Volume I — Human Health Evaluation Manual, Part A*, U.S. Environmental Protection Agency/Office of Emergency and Remedial Response (OERR), EPA/540/1-89/002, December 1989 (Interim).

2.1 Objectives

The objectives of the BRA will be to:

- Characterize the source media and determine the chemicals of potential concern (COPCs) for affected environmental media.

- Identify potential receptors and quantify their potential exposures under current and future conditions for all affected environmental media.

- Qualitatively and quantitatively evaluate the adverse effects associated with the site-specific COPCs in each medium.

- Characterize the baseline carcinogenic and noncarcinogenic risks associated with exposure to environmental media at the site(s) under current and future land use conditions.

- Evaluate the uncertainties related to exposure predictions, toxicological data, and resulting carcinogenic risk and noncarcinogenic hazard estimations.

- Establish Remedial Goal Options (RGOs) for chemicals of concern (COC) in each environmental medium based on risk/hazard to facilitate risk management decision-making.

The value of the risk assessment as a basis for making remedial decisions and determining whether detected site concentrations have the potential for toxic effects or increased cancer incidences depends upon adequately characterizing chemical contamination. Variables considered in characterizing the study area and its associated risk will include the amount, type, and location of sources; the pathways of exposure (media type and migration routes); and the

- *Uncertainty*: discussion and evaluation of the areas of recognized uncertainty in human health risk assessments in addition to medium - and exposure pathway-specific influences.

- *Risk/hazard summary*: presentation and discussion of the results of the quantification of exposure (risk and hazard) for the potential receptors and their exposure pathways identified under the current and future conditions.

- *RGOs*: computation of exposure concentrations corresponding to risk projections within the USEPA target risk range of 1E-6 to 1E-4 for carcinogenic COCs and hazard quotient goals of 0.1, 1, and 3 for noncarcinogenic COCs.

3 Site Characterization

When performing a HHRA, environmental media data are compiled to determine potential site-related chemicals and exposures as outlined in RAGS Part A. The steps identifying COPCs are discussed below.

3.1 Data Sources

The number of samples collected from each medium will be detailed in this section of the site-specific HHRAs, and tables will show which sample designations will be included and how data are grouped (when applicable). In addition, the analytical methods, the name of the analyzing laboratory, and data quality objectives will be referenced at this point in the HHRA.

3.2 Data Validation

Data validation is an after-the-fact, independent, systematic process of evaluating data and comparing them to established criteria to confirm they are of the technical quality necessary to support the decisions made in the RFI process. Parameters specific to the data are reviewed to determine whether they meet the stipulated DQOs. The quality objectives address five principal parameters: precision, accuracy, completeness, comparability, and representativeness. To

each "U" value will be compared to one-half of the lowest hit (normally "J" qualified) at the same site. The lesser of these two values will be used as the best estimate of the concentration potentially present below the sample quantitation limit, and will be inserted into the adjusted dataset. For inorganic chemicals, the rule is simpler: One-half of each "U" value will be used to represent the concentration of the corresponding sample when compiling the adjusted dataset. If two nondetects are reported for any one location (a result of QA/QC samples), one-half the lesser of the "U" values will be compared to the lowest hit at the site (for organics, as above) or applied directly (for inorganics) to estimate a concentration value to be used in the NSA Memphis risk calculations. If a parameter is not detected at a site, neither data management method will be applied, and the parameter will not be considered in screening or formal assessment.

Once the dataset is complete, statistical methods will be used to evaluate the analytical results to (1) identify COPCs and (2) establish exposure point concentrations (EPCs) at potential receptor locations. The statistical methods used in data evaluation are discussed below. The rationale used to develop this methodology and the statistical techniques is based on the following sources:

- RAGS Part A
- *Supplemental Guidance to RAGS: Calculating the Concentration Term*, May 1992
- *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987)

Microsoft Fox Pro and Borland[1] Quattro Pro will typically be used for data management and statistical calculations. For each set of data used to describe the concentration of chemicals in a contaminated area, the following information will be tabulated in accordance with RAGS: frequency of detection, range of quantitation limits, range of detected values, and average of

1 *References to specific software products are not to be construed as an endorsement by the U.S. Navy or E/A&H.*

The maximum concentration reported for each carcinogenic polycyclic aromatic hydrocarbon (PAH) will be compared to its corresponding screening value. In addition, all carcinogenic PAH concentrations reported at that location will be converted to the benzo(a)pyrene equivalent concentration (BEQ), which will be compared to the screening value for benzo(a)pyrene. PAH conversions will be performed using current Toxic Equivalency Factors (TEFs) for PAHs in accordance with USEPA Region IV *Supplemental Guidance to RAGS Bulletin 2* (USEPA, November 1995).

3.4.2 Comparison of Site-Related Data to Background Concentrations

Background data for NSA Memphis will be referenced in this section, or background reference concentrations from E/A&H's August 27, 1996 *Reference Concentrations* technical memorandum will be used. Following comparison to risk- and hazard-based screening values, CPSSs whose maximum detected concentrations exceeded corresponding background reference concentrations will be formally assessed in the HHRA, unless otherwise noted.

The maximum reported concentration of a CPSS will be compared to its reference background concentration (when applicable). This comparison helps account for naturally occurring elements, such as beryllium, manganese, and arsenic. Thus, risk and/or hazard associated with naturally occurring elements are not addressed where their concentrations are similar to corresponding background.

In the HHRA, if the maximum concentration of a CPSS is determined to be less than either two-times mean background or the risk-based screening values, then the CPSS will not be considered further unless deemed appropriate based on chemical-specific characteristics (e.g., degradation product with greater toxicity).

An exposure scenario of concern will be identified as a scenario with incremental excess lifetime cancer risk (ILCR) estimated greater than 1E-4 or a hazard index (HI) estimated greater than 1. In the next step, COPCs exceeding 1E-6 ILCR or a HQ greater than 0.1 in a scenario of concern are retained as COCs. Section 5, Toxicity Assessment, discusses cancer risk thresholds and noncancer toxicity in detail.

4 Exposure Assessment

This section of the HHRAs will determine the magnitude of contact that a potential receptor may have with site-related COPCs. Exposure assessment involves four stages:

- Characterizing the physical setting and land use of the site.
- Identifying COPC release and migration pathway(s).
- Identifying the potential receptors, under various land use or site condition scenarios, and the pathways through which they might be exposed.
- Quantifying the intake rates, or contact rates, of COPCs.

4.1 Exposure Setting and Land Use

The site setting and land use will be detailed or referenced in this section of the site-specific HHRAs. This information is used to develop appropriate exposure estimates for different land use assumptions. If the future use of the area in question is known, this information will be used to define exposure assumptions used when calculating risk (e.g., sites known to be commercially zoned will not be assessed for residential land use). Future land use will be specified with as much accuracy as possible in site-specific HHRAs, particularly for property being transferred from the Navy to the City of Millington.

USEPA Region IV guidance calls for assuming lognormal distributions for environmental data and the calculation of 95% UCL on the mean for use in exposure quantification. Applying the UCL is generally inappropriate with less than 10 samples. Therefore, the maximum concentrations detected will be used for all datasets with less than 10 samples. In general, outliers have been included when calculating the UCL because high values seldom appear as outliers for a lognormal distribution. Including outliers increases the overall uncertainty of the calculated risks and conservatively biases exposure estimates.

For sample sets of 10 and greater, the UCL will be calculated for a lognormal distribution as follows:

$$UCL = e^{\left(\bar{a}+0.5s_a^2 + \frac{H_{0.95}\ x\ s_a}{\sqrt{n-1}}\right)}$$

where:

$\bar{a}$	=	$\Sigma a/n$ = sample arithmetic mean of the log-transformed data, $a = \ln(x)$
s_a	=	sample standard deviation of the log-transformed data
n	=	number of samples in the data set
$H_{0.95}$	=	value for computing the one-sided upper 95% confidence limit on the lognormal mean from standard statistical tables (Gilbert, 1987)

EPCs and UCLs will be summarized and tabulated when applicable in the site-specific HHRA.

4.5 Quantification of Exposure

This section describes the models, equations, and intake model variables used to quantify doses or intakes of the COPCs for the surface soil and groundwater exposure pathways. The models are designed to estimate route- and medium-specific factors, which are multiplied by the EPC

Table 1
Parameters Used to Estimate CDI

Pathway Parameters	Resident Adult	Resident Child	Adult Worker	Trespassing Child (age 7-16)	Units
Surface Soil Ingestion and Dermal Contact					
Ingestion Rate (soil)	100[a]	200[a]	50[a]	100[a]	mg/day
Ingestion Rate (water)	2	1	1	NA	L/day
Exposure Frequency	350[b]	350[b]	250[b]	52[f]	days/year
Exposure Duration	24[c]	6[c]	25[c]	10[g]	years
Dermal Contact Area	4,100[a]	2,900[a]	4,100[a]	4,100[a]	cm^2
Skin Adherence Factor	1	1	1	1	mg/cm^2
Absorption Factor	0.01 (organics) 0.001 (inorganics)	0.01 (organics) 0.001 (inorganics)	0.01 (organics) 0.001 (inorganics)	0.01 (organics) 0.001 (inorganics)	unitless
Oral Absorption Efficiency	0.8 (VOCs) 0.5 (other organic compounds) 0.2 (inorganics)	0.8 (VOCs) 0.5 (other organic compounds) 0.2 (inorganics)	0.8 (VOCs) 0.5 (other organic compounds) 0.2 (inorganics)	0.8 (VOCs) 0.5 (other organic compounds) 0.2 (inorganics)	unitless
Conversion Factor	1E-6	1E-6	1E-6	1E-6	kg/mg
Body Weight	70[a]	15[a]	70[a]	45[a]	kg
Averaging Time, Noncancer	8,760[d]	2,190[d]	9,125[d]	3,650[d]	days
Averaging Time, Cancer	25,550[e]	25,550[e]	25,550[e]	25,550[e]	days

Notes:

a — USEPA (1989a) *Risk Assessment Guidance for Superfund Vol. I, Human Health Evaluation Manual (Part A)*.
b — USEPA (1991b) *Risk Assessment Guidance for Superfund Vol. I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors, Interim Final*, OSWER Directive: 9285.6-03.EPA/600/8-89/043.
c — USEPA (1991a), *Risk Assessment Guidance for Superfund: Vol. I — Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, OSWER Directive 9285.7-01B.
d — Calculated as the product of ED (years) x 365 days/year.
e — Calculated as the product of 70 years (assumed lifetime) x 365 days per year.
f — Assuming one day per week exposure.
g — Assuming trespassing occurs during the 10-year adolescent/teenage period.
NA — Not applicable.

The FI/FC factors modify the concentrations to more closely approximate site-wide exposure conditions for a given exposure unit area. When the UCL is used as EPC, no FI/FC adjustments will be made. In addition, CPSSs not eliminated from the HHRAs based on the screening comparisons described in Section 3.4 may be eliminated as a COPC because the UCL concentration does not exceed the corresponding background concentration or RBC. This will be discussed on a site-specific basis.

Consequently, CDI for carcinogens would be calculated as follows for site residents:

$$CDI_s = (EPC_s)(EF)(LWA)(F)(FI)/(AT)$$

where:

CDI_s = ingested dose (mg/kg-day)

EPC_s = exposure point concentration of contaminant in soil (mg/kg)

EF = exposure frequency (days/year)

F = conversion factor (1E-6 kg/mg)

FI = fraction ingested from contaminated source (unitless)

AT = averaging time (days)

LWA = lifetime weighted average

Dermal Contact with COPCs in Surface Soil

The following equation is used to estimate intake due to dermal contact with COPCs in soil:

$$CDI_{sd} = (EPC_s)(CF)(EF)(ED)(F)(FC)(ABS)(AF)/(BW)(AT)$$

where:

CDI_{sd} = dermal dose (mg/kg-day)

EPC_s = exposure point concentration of contaminant in soil (mg/kg)

CF = contact factor (cm^2)

EF = exposure frequency (days/year)

ED = exposure duration (years)

F = conversion factor (1E-6 kg/mg)

FC = fraction contacted from contaminated source (unitless)

ABS = absorption factor (unitless value, specific to organic versus inorganic compounds)

AF = adherence factor (milligrams per square centimeter [mg/cm^2])

BW = body weight (kg)

AT = averaging time (days)

Table 2

Multipliers[a] Used to Estimate Chronic Daily Intake

		Soil		Groundwater
		Ingestion	*Dermal Contact*	*Ingestion*
Exposure Scenario	**Exposure Type**	**All Chemicals**	**Organics[b]**	**All Chemicals[c]**
Resident	Noncarcinogens (adult)	1.37E-6	5.62E-7	2.74E-2
	Noncarcinogens (child)	1.28E-5	1.85E-6	6.39E-2
	Carcinogens (LWA)	1.57E-6	3.51E-7	1.49E-2
Trespasser	Noncarcinogens	3.17E-7	1.30E-7	NA
(age 7-16)	Carcinogens	4.52E-8	1.85E-8	NA
Site Worker	Noncarcinogens	4.89E-7	4.01E-7	9.78E-3
	Carcinogens	1.75E-7	1.43E-7	3.49E-3

Notes:

NA — Not applicable

LWA — Lifetime weighted average

[a] — The product of the multiplier and the exposure point concentration equals the chronic daily intake for a given chemical assuming a reasonable maximal exposure scenario.

[b] — The multiplier for inorganics is multiplied by a factor of 0.1 to account for the dermal absorption factor of 0.001 for inorganics; the multiplier for organic compounds includes the 0.01 factor.

[c] — The ingestion intake is also used to address inhalation risk in accordance with USEPA's Supplemental Guidance To RAGS Bulletin 3; ingestion risk is approximately equal to risk posed by dermal and inhalation exposure while showering, and this is applied to volatile organic compounds only.

toxicological values are used in risk formulae to assess the upper-bound level of cancer risk and noncancer hazard associated with exposure to a given chemical concentration.

For carcinogens, the potential risk posed by a chemical is computed by multiplying the CDI (as mg/kg-day) by the SF (in reciprocal mg/kg-day). The HQ (for noncarcinogens) is computed by dividing the CDI by the RfD. USEPA has set standard limits (or points of departure) for carcinogens and noncarcinogens to evaluate whether significant risk is posed by a chemical (or combination of chemicals). For carcinogens, the point-of-departure range is 1E-6, with a generally accepted range of 1E-6 to 1E-4. These risk values correlate with one in 10,000 (1E-4) and one in 1 million (1E-6) excess cancer incidence resulting from exposure to toxic compounds from outside the body.

For noncarcinogens, other toxic effects are generally considered possible if the HQ (or sum of HQs for a pathway-hazard index) exceeds the threshold value of 1. Although both cancer risk and noncancer hazard are generally additive only if the target organ is common to multiple chemicals, a most conservative estimate of each may be obtained by summing the individual risks or hazards, regardless of target organ. Site-specific HHRAs for NSA Memphis will take the universal summation approach for each class of toxicant. Details regarding the risk formulae applied to site data are provided in Section 6, Risk Characterization.

Critical studies used in establishing toxicity classifications by USEPA are shown in the IRIS database, which is the primary source for information necessary to estimate risk. HEAST, Fiscal Year 1995 is the secondary source for this information. In addition, USEPA's National Center for Environmental Assessment (NCEA) will be used as a source when necessary. In accordance with RAGS, a table will summarize toxicological data in the site-specific HHRAs in the form of RfDs and SFs obtained for COPCs identified in site media, as well uncertainty/modifying factors, target organs, and cancer classes (where available).

are developed for individual chemicals, exposure pathways, transfer media, and source media, and for each receptor for all media to which one may be exposed. The qualitative component usually involves comparing COC concentrations in media with established criteria or standards for chemicals for which there are no corresponding toxicity values. The risk characterization helps guide risk-management decisions.

Generally, the risk characterization will follow the methodology prescribed by RAGS Part A, as modified by more recent information and supplemental guidance cited in the earlier sections of this memorandum. *The USEPA methods are designed to be health-protective and tend to overestimate risk rather than underestimate it. The risk results, therefore, are generally overly conservative, because risk characterization involves summing the overestimated risk estimates.*

6.1 Risk Characterization Methodology

Potential excess risks to humans following exposure to COPCs will be estimated using methods established by USEPA, when available. As discussed above, these methods are health-protective and are likely to overestimate risk. Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also pose a noncarcinogenic hazard. The potential human health effects associated with chemicals that produce carcinogenic and other toxic effects will be characterized separately, as discussed below.

6.1.1 Carcinogenic Effects of Chemicals

The risk attributed to exposure to carcinogens is estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

$$ILCR = (CDI)(SF)$$

Chemical noncarcinogenic effects are evaluated on a chronic basis, using chronic RFD values. An HQ of 1 indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be a concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to several chemicals, an HI will be calculated as the sum of the HQs by:

$$HI = HQ_1 + HQ_2 + \ldots HQ_i$$

where:

HI	=	Hazard Index (unitless)
HQ	=	Hazard Quotient (unitless)

Risk and hazard projections will be summarized in tabular format on a medium- and exposure pathway-specific basis in the HHRAs.

6.2 Surface Soil Pathways

Generally, the incidental ingestion and dermal contact pathways will be characterized for surface soil. Surface soil onsite will be evaluated under scenarios and exposure pathways outlined in the site-specific HHRAs.

6.3 Groundwater Pathways

Groundwater pathways will typically consist of ingestion and inhalation of volatilized chemicals in groundwater. The site-specific HHRAs will detail the pathways which will be addressed. Most groundwater pathways are not complete because municipal water supplies are used, and this will be discussed in the HHRAs.

9 Remedial Goal Options

RGOs are chemical concentrations computed to equate with specific risk and/or hazard goals that may be established for a particular site. As previously discussed, COCs are identified as any COPC that significantly contributes to a scenario of concern. RGOs will be calculated for each land use scenario with cumulative risk estimates greater than 1E-4 or cumulative hazard indices greater than 1.0. Based on this method, COCs may be identified, requiring RGO calculation. Inclusion in the RGO table does not necessarily indicate that remedial action will be required to address a specific chemical. Instead, RGOs are provided to facilitate risk-management decisions.

In accordance with USEPA Supplemental RGO Guidance, RGOs will be calculated at 1E-4, 1E-5, and 1E-6 risk levels for carcinogenic COCs and HI goals of 3, 1, and 0.1 for noncarcinogenic COCs. RGOs will be based on specific scenarios which will be identified in the site-specific HHRAs.

Attachment C

Analytical Data For
NSA Mid-South SWMU 9 Media

Table C-1 Chemicals Detected in Surface Water C-1

Table C-2 Chemicals Detected in Fish Tissue C-2

TABLE C-1
CHEMICALS DETECTED IN SURFACE WATER
NSA MID-SOUTH SWMU 9

Units are micrograms per liter (µg/L).

Chemical		Range of Detected Concentrations	Frequency of Detection	Average Detected Concentration (ug/L)	Location of Maximum Concentration
Metal	Barium	152 - 214	2 / 2	183	009W000101

TABLE C-2
CHEMICALS DETECTED IN FISH TISSUE
NSA MID-SOUTH SWMU 9

Metals units are milligram per kilogram (mg/kg). Organic compound units are micrograms per kilogram (µg/kg).

Chemical		Range of Detected Concentrations	Frequency of Detection	Average Detected Concentration	Location of Maximum Concentration
Metal	Aluminum	1.1 - 19.6	3 / 3	8.4	009J020002
	Arsenic	0.03 - 0.03	1 / 3	0.03	009J020002
	Barium	8.4 - 28.2	3 / 3	16.5	009J020002
	Calcium	7060 - 13400	3 / 3	10587	009J020002
	Chromium	1 - 2.2	3 / 3	1.4	009J010001
	Cobalt	0.05 - 0.1	2 / 3	0.075	009J020002
	Copper	1 - 2.2	3 / 3	1.53	009J010001
	Iron	15.4 - 47.8	3 / 3	27.5	009J020002
	Lead	0.05 - 0.31	3 / 3	0.17	009J020002
	Magnesium	265 - 392	3 / 3	327	009J020002
	Manganese	8.6 - 20.3	3 / 3	13	009J020002
	Mercury	0.01 - 0.09	2 / 3	0.05	009J010001
	Nickel	0.92 - 1.1	2 / 3	1.01	009J010001
	Potassium	2140 - 2600	3 / 3	2367	009J010001
	Selenium	0.13 - 0.22	3 / 3	0.16	009J020002
	Sodium	976 - 1100	3 / 3	1045	009J020002
	Vanadium	0.13 - 0.42	3 / 3	0.24	009J020002
	Zinc	14 - 23.2	3 / 3	18.1	009J020002
Pesticide/PCBs	4,4'-DDE	0.027 - 0.088	3 / 3	0.052	009J010001
	Aroclor-1254	0.1 - 0.28	3 / 3	0.19	009J020001
	Aroclor-1260	0.038 - 0.1	3 / 3	0.072	009J010001
	Endrin	0.025 - 0.049	3 / 3	0.038	009J010001
SVOCs	Di-n-butylphthalate	0.096 - 0.12	2 / 3	0.11	009J020002

Notes:
PCB = polychlorinated biphenyl

METHOD	PARAM	MAX	VQUAL	RESULT	CAS_NO	SAMPLE_ID
TAL-METAL	Aluminum	19.6000	J	19.6000	7429905	009J020002
TAL-METAL	Arsenic	0.0300	J	0.0300	7440382	009J020002
TAL-METAL	Barium	28.2000	J	28.2000	7440393	009J020002
TAL-METAL	Calcium	13400.0000	J	13400.0000	7440702	009J020002
TAL-METAL	Chromium	2.2000		2.2000	7440473	009J010001
TAL-METAL	Cobalt	0.1000	J	0.1000	7440484	009J020002
TAL-METAL	Copper	2.2000	J	2.2000	7440508	009J010001
TAL-METAL	Iron	47.8000		47.8000	7439896	009J020002
TAL-METAL	Lead	0.3100		0.3100	7439921	009J020002
TAL-METAL	Magnesium	392.0000		392.0000	7439954	009J020002
TAL-METAL	Manganese	20.3000	J	20.3000	7439965	009J020002
TAL-METAL	Mercury	0.0900	J	0.0900	7439976	009J010001
TAL-METAL	Nickel	1.1000		1.1000	7440020	009J010001
TAL-METAL	Potassium	2600.0000		2600.0000	7440097	009J010001
TAL-METAL	Selenium	0.2200		0.2200	7782492	009J020002
TAL-METAL	Sodium	1100.0000		1100.0000	7440235	009J020002
TAL-METAL	Vanadium	0.4200	J	0.4200	7440622	009J020002
TAL-METAL	Zinc	23.2000	J	23.2000	7440666	009J020002
TCL-PEST	4,4'-DDE	88.0000	J	88.0000	72559	009J010001
TCL-PEST	Aroclor-1254	280.0000	J	280.0000	11097691	009J020001
TCL-PEST	Aroclor-1260	100.0000	J	100.0000	11096825	009J010001
TCL-PEST	Endrin	49.0000	J	49.0000	72208	009J010001
TCL-SVOA	Di-n-butylphthalate	120.0000	J	120.0000	84742	009J020002

Attachment D

Figure 8.2.4
Surface Water Sample Locations
SWMU 9 — Sewage Lagoons

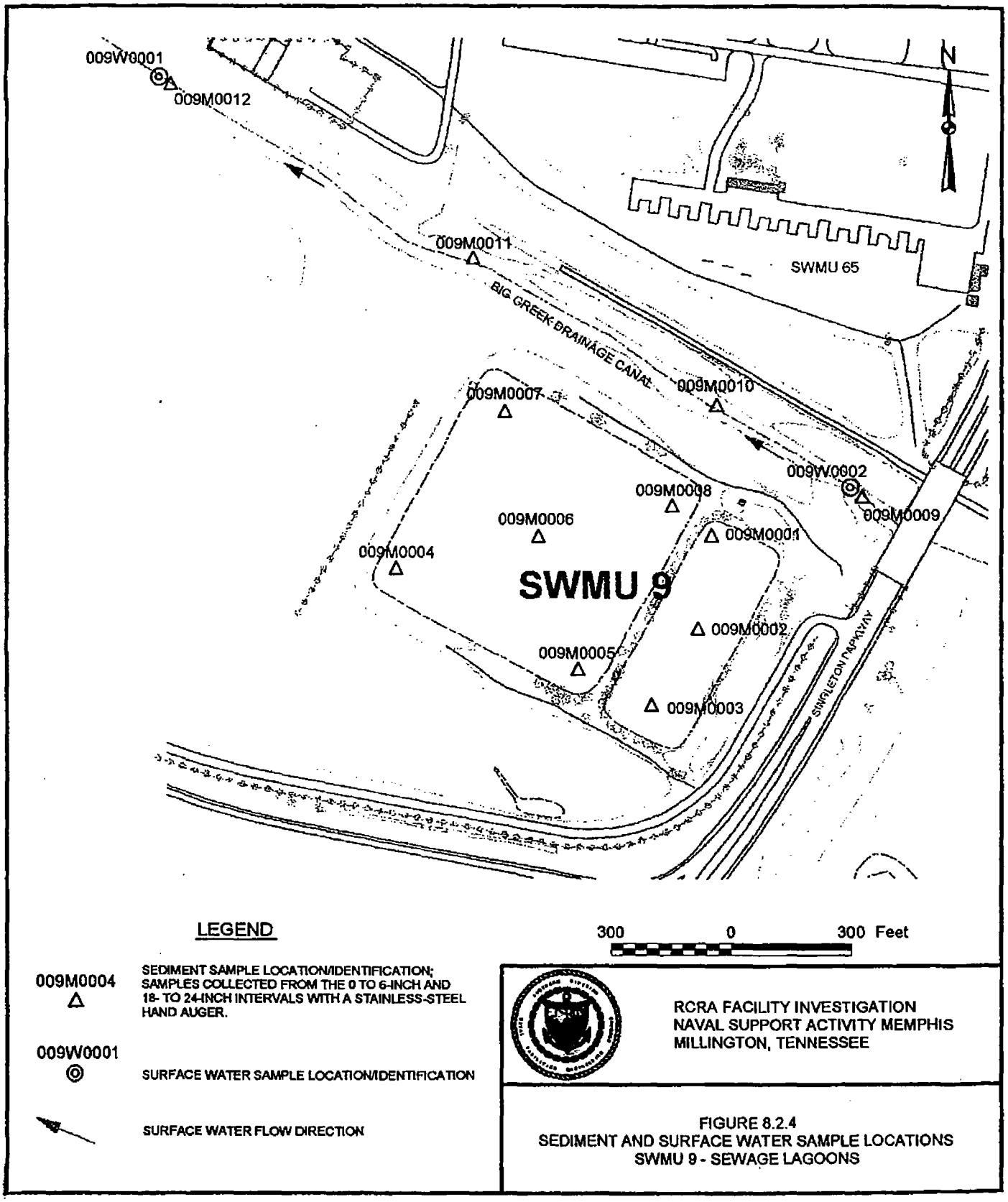

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FIGURE 8.2.4
SEDIMENT AND SURFACE WATER SAMPLE LOCATIONS
SWMU 9 - SEWAGE LAGOONS