Appendix C

Human Health Risk Assessment Tables

1.0 Introduction

The purpose of the baseline human health risk assessment is to provide a risk-based interpretation of the data collected during the RI and provide conservative estimates of potential human health risks posed by chemicals that are present at or migrating from the Site. The results of the risk assessment may also be used to identify areas that may be considered for no further action, prioritize early actions, and determine the need for additional field work. In summary, the objectives of the baseline HHRA are to:

- Quantify exposures and characterize baseline risks to potentially exposed individuals (both current and future) at or near the Site;
- Identify those chemicals that may pose risks to human health; and
- Provide the basis with which to assess the need, if any, for additional studies.

The data collected as part of this RI work plan will be used, along with appropriate data from previous studies and the baseline HHRA work previously completed by WDNR, as the foundation for a supplemental baseline HHRA. The methodology for updating the work will follow that present in the *Risk Assessment Guidance for Superfund: Vol. I Part A – Human Health Evaluation Manual* (USEPA, 1989) and several more recent regulatory guidance documents and resources as appropriate such as:

- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (OSWER 9355.4-24, March 2001)
- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312, July 2004)
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10 December 2002)
- A summary of up-to-date guidance and screening criteria presented in http://risk.lsd.ornl.gov/homepage/rap_docs.shtml, (Oak Ridge National Laboratory, On-line.)

The approach that will be followed for developing the site-specific baseline HHRA incorporates the following fundamental components:

- Data Evaluation
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

This Appendix provides the detailed information that will be used for developing the baseline HHRA for the Site that was not discussed in the text of the Work Plan.

2.0 Sources of RBSCs

For Constituents in Soil

- The PRGs calculated for soils under an industrial scenario will be adopted as RBSCs for selecting COPCs in soil samples collected from areas used for industrial purposes.
- The PRGs calculated for soils under a residential scenario will be adopted as RBSCs for selecting COPCs in soil samples collected from areas used for non-industrial purposes (e.g., recreational or residential use).

For Constituents in Groundwater

- The Maximum Contaminant Level (MCL) will be selected as RBSCs for the purpose of identifying COPCs in groundwater
- For chemicals lacking MCLs, the PRGs calculated for tap water under a residential scenario will be adopted as RBSCs for selecting COPCs in groundwater samples.

For Constituents in Soil Gas

- A chemical detected in soil gas samples will be identified as a COPC, if its maximum concentration exceeds the soil gas screening value provided in *Evaluating The Vapor Intrusion To Indoor Air Pathway From Groundwater and Soils (USEPA 2001).*

For Constituents in Indoor Air Samples

- A chemical detected in indoor air samples will be identified as a COPC, if its maximum concentration exceeds the screening value provided in *Evaluating The Vapor Intrusion To Indoor Air Pathway From Groundwater and Soils (USEPA 2001).*

For Constituents in Ambient Air Samples

- The PRGs calculated for ambient air will be adopted as RBSCs for selecting COPCs in the ambient air samples.

For Constituents in Surface Water

- Due to the lack of PRGs specifically derived for surface water, the Federal ambient water quality criteria (AWQC) established as protective of human receptors from risks associated with the use of surface water as the source of potable water will be adopted as conservative RBSCs for selecting COPCs in surface water samples.

For Constituents in Sediment

- Due to the lack of PRGs specifically derived for sediments, the PRGs calculated for soils under a residential scenario will be adopted as RBSCs for selecting COPCs in sediment samples.

For Constituents in Fish Tissue

- The RBCs calculated for fish tissue will be adopted as RBSCs for selecting COPCs in tissue samples.

3.0 Distribution Testing and Calculation of 95% UCLs

95% UCL for Datasets that Fit a Normal Distribution

The population mean (μ) is a measure of the central tendency of a distribution. As such, it is an appropriate measure of the concentration in a medium (e.g. soil) that a receptor may contact throughout the duration of the assumed exposure. The population mean typically is estimated using the mean of sample data (i.e., the average) and an upper confidence limit of the mean. For

datasets that fit a normal distribution, the 95% UCL will be calculated using the Student-t statistic with the following equation (from EPA 1992a):

$$UCL_{95} = \bar{x} + s \times t_{0.05,\, n-1} \Big/ \sqrt{n}$$

where :	x	=	sample mean
	s	=	sample standard deviation
	$t_{0.05, n-1}$	=	one-sided t-statistic for 5% type I error
	n	=	number of samples

95% UCL for Datasets that Fit a Lognormal Distribution

Datasets will be considered lognormal where the w-test is greater than 0.05 for log transformed data sets and an Anderson-Darling test probability greater than 0.90. The 95% UCLs will be calculated using the H-statistic[1] as shown below (from EPA 1992a):

$$UCL_{95} = \exp\left(\bar{y} \times 0.5 S_y^{\,2} + S_y \times H_{0.95,\, n,\, Sy} \Big/ \sqrt{n-1} \right)$$

where:	y	=	mean of ln transformed data
	Sy	=	standard deviation of ln transformed data
	$H_{0.95,n,Sy}$	=	H-statistic for 95% confidence limit
	n	=	number of samples

Besides the H-statistical method for datasets that fit a lognormal distribution, Schulz and Griffin (1999) recommend that an alternative method, specifically the Chebychev inequality method, be considered. The Chebychev method provides an alternative to and check on the H-statistic and is considered a conservative estimate of the 95% UCL of a distribution. EPA (1999) also provides additional information about the use of the Chebychev inequality to estimate the 95% UCL of log-normally distributed data. For log-normally distributed data, the mean and standard error of the mean may be estimated using Minimum Variance Unbiased Estimate (MVUE) equations presented in Gilbert (1987; pg. 165). The Chebychev inequality 95% UCL has been shown to be more conservative than UCLs calculated using the other methods described above (EPA 1999). Therefore, the Chebychev UCL provides a conservative estimate of the 95% UCL of lognormal

data and will be used to evaluate whether the H-statistic generates a 95% UCL that is unrealistically large. The Chebychev UCL equation is shown below:

$$UCL_{95} = \mu_1 + 4.47 \times \sigma(\mu_1)$$

where: μ_1 = ln MVUE mean estimate (Gilbert 1987)
$\sigma(\mu_1)$ = ln MVUE mean standard error (Gilbert 1987)

EPA (1997) has correlated the generation of unrealistic 95% UCLs based on the use of the H-statistic with data sets that exhibit high coefficients of variation (CV) and small sample sizes. A high CV is also problematic for the Chebychev inequality. The CV is defined as the ratio between the standard deviation of the data and the mean, expressed as a percentage. A high CV, according to EPA (1997), is greater than 100%. To correct for this EPA (1997) suggests the use of the Jackknife procedure in estimating the MVUE of the lognormal mean. To perform the Jackknife, the MVUE of the mean is calculated after deleting one observation at a time in sequence:

$$\phi_i = (n \bullet MVUE) - [(n-1) \bullet MVUE_{-i}]$$

Where $MVUE_i$ is the MVUE estimate after deleting the *i*th sample observation. The Jackknifed mean is then:

$$\Phi = \frac{\sum(\phi)}{n}$$

The Jackknifed standard error of the MVUE is the sum of squares for the Jackknifed estimates:

$$SE_{MVUE} = \sqrt{\frac{\sum(\phi_i - \Phi)^2}{n \bullet (n-1)}}$$

The UCL is then calculated based on the t-distribution and the Jackknifed standard error.

$$UCL_{95} = \Phi + t_{1\text{-}0.95,n\text{-}1} \bullet SE_{MVUE}$$

[1] The H-statistic is only functional for standard deviations between 0.10 and 10. If the dataset standard deviation is outside of the bounds, the Chebychev and bootstrap methods will be evaluated for use in lieu of the H-statistic methodology.

This method is recommended when unrealistic UCLs are suspected from the use of the H-statistic on log-normally distributed data, specifically when the CV is high (>100%) or when the sample size is low (<30 observations)(EPA 1997).

95% UCL for Datasets that are Neither Normal Nor Lognormal

Use of the equations shown above is inappropriate for datasets that, through distribution testing, fit neither a normal or lognormal distribution or are based on a "mixed" population of detects and non-detects. Therefore, alternative methods are used for estimating 95% UCLs for datasets that are considered non-normal. Non-normal datasets provide a poor fit to normal or lognormal distributions and particularly occur where data may be artificially skewed due to biased sampling or through the combination of samples from different populations that occur within a single exposure unit. The alternative statistical procedures that will be used for evaluating nonparametric distributions include:

1) Bootstrap;
2) Bootstrap-t;
3) Hall's Bootstrap-t Transformation; and
4) Jackknife

The major advantage of these methods is they can provide a robust approximation of the UCL without having to make assumptions regarding an underlying distribution to the data (EPA 1997). Any method can be used; however, the Jackknife method tends to be more robust and more conservative (and thus preferred) on datasets with fewer samples (e.g., sample sizes less than 15^2). All of the bootstrap methods assume that the random re-sampling of the dataset will result in a dataset (i.e., of bootstrap means, t-statistic or Q-statistic) that will be normally distributed or nearly so. For high levels of bias, the bootstrap-t is designed to normalize the re-samples; while if the raw dataset is highly skewed, Hall's transformation is designed to normalize the re-samples.

The underlying premise of normality for the bootstrap methods can be compromised in highly "mixed" datasets (i.e., those with very high levels of non-detects) or by the presence of outliers within the dataset (see Frey and Burnmaster 1999, Kilian 1998, Kelly 1999). Outliers are particularly troublesome for the bootstrap methods causing violations of the assumptions

required for the Edgeworth expansions used in the t-bootstrap and Hall's transformed t (see Hall 1992, Davidson and Hinkley 1997). The presence of outliers in the parent dataset can actually increase or exacerbate the skewness within the re-sampled datasets and even cause complete method failure (where the 95th percentile of the bootstrapped distribution is an empty set – see Hall 1992). Similarly, if the dataset contains a significant number of non-detects whose surrogate values are constant, the bootstrap re-sampled dataset can be of n samples with exactly the same value. If this occurs, there is no variance within the dataset and the bootstrap methods will fail. It has been observed that such failures occur most often in smaller datasets (e.g., < 15 samples) when the percent detection is less than 50%. A final salient issue regarding the bootstrap methods is a high level of variability between simulations based on small sample sizes, especially in wide ranging datasets. Under such circumstances, the jackknife method is far more stable (reproducible) and as such, the preferred method.

A basic discussion of these methods and the underlying assumptions of normality for the re-sampled data is provided in Efron and Gong (1983), Hall (1992), Davidson and Hinkley (1997) as well as by EPA (1997), with further discussion of the bootstrap methods described in Schulz and Griffin (1999). A copy of Efron and Gong (1983), EPA (1997) and Schulz and Griffin (1999) are provided as attachments.

Bootstrap Methods

The standard bootstrap, bootstrap-t, and Hall's bootstrap-t transformation reflect a technique that involves random re-sampling with replacement of a data set of size *n* to generate many additional simulated data sets of size *n* that may be examined for variability or uncertainty (Schulz and Griffin 1999). The standard bootstrap may provide confidence intervals that have less than nominal coverage probability due to bias and skewness reflected in the data (Schulz and Griffin 1999). Bias is defined as the relative difference between the raw data mean and the bootstrapped mean. Bias is not considered significant unless it exceeds 25% of the raw data variance (e.g., see Efron and Gong 1983). Sample skewness can be tested for significance using the methods presented in Gibbons (1994). If neither bias nor skewness is significant, the standard bootstrap is the preferred method because the bootstrap extensions such as the Studentized (bootstrap-t) and Hall's transformation (Edgeworth expansions) can result in variable results. The bootstrap-t method is preferred when bias is high and skewness is insignificant whereas when skewness is high, Hall's transformation is the preferred method.

[2] A sample size of 15 was selected as none of the validation exercises presented within the references have evaluated

The procedure for performing the bootstrap methods mentioned above for a data set containing *n* samples is described below:

Step 1: Calculate the raw data mean, standard deviation, and skewness:

$$\overline{X}_{raw} = \frac{\sum X_i}{n}$$

$$SD = \sqrt{\frac{\sum \left(X_i - \overline{X}_{raw}\right)^2}{n}}$$

$$v = \frac{\sum \left(X_i - \overline{X}_{raw}\right)^3}{n \times SD^3}$$

Where X_{raw} equals the mean of the raw data, SD_{raw} equals the standard deviation of the dataset, and v equals the skewness of the dataset.

Step 2: Randomly select *n* samples (with replacement) from the original *n* data and calculate the mean and standard deviation. Repeat 1000 times (minimum).

Step 3: Calculate the mean and standard deviation of each randomly drawn resample of the data set. Then calculated a W-value as follows:

$$W_i = \frac{\left(\overline{X}_{Bi} - \overline{X}_{raw}\right)}{SD_i}$$

Where X_{Bi} and SD_i are the mean and standard deviation of the ith resample of the data set and X_{raw} is the mean of the original data set. Repeat 1000 times.

Step 4: Calculate the Q statistic as a function of W for Hall's adjustment for skewness. Repeat 1000 times.

$$Q(W_i) = W_i + \frac{v \times W_i^2}{3} + \frac{v^2 \times W_i^3}{27} + \frac{v}{6 \times n}$$

Step 5: Rank the values W_i and $Q(W_i)$ from smallest to largest.

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sample sizes less than 15 (see also Frey and Burmaster 1999).

For the standard bootstrap calculate the bootstrap mean and standard error:

$$\overline{\overline{X}}_{GB} = \frac{\sum_{i=0}^{it} \overline{X}_{Bi}}{it}$$

Where *it* equals the number of iterations (re-samples; e.g., 1000), X_{Bi} equals the mean of the i^{th} resample and X_{GB} equals the bootstrap mean. The bootstrap standard error is:

$$\sigma_B = \sqrt{\frac{1}{it-1} \times \sum_{i=0}^{it} \left(\overline{X}_{Bi} - \overline{\overline{X}}_{GB} \right)^2}$$

The standard bootstrap 95% UCL is then calculated using the z-statistic:

$$95\%UCL = \overline{\overline{X}}_{GB} + Z_{0.05} \times \sigma_B$$

Considering the bootstrap-t method, the 50^{th} ranked value[3] of W is used to represent "$t_{0.05}$" in the following equation for the 95% UCL:

$$95\%UCL = \overline{X}_{raw} - t_{0.05} \times SD_{raw}$$

Hall's bootstrap-t transformation proceeds by calculating the inverse of the Q(W) function of the ordered $Q(W_i)$ values:

$$W(Q_i) = \frac{3 \times \left\{ \left[1 + v \times \left(\frac{Q - v}{6 \times n} \right) \right]^{1/3} - 1 \right\}}{v}$$

Here again, if 1000 re-samples were taken, the 50^{th} value represents the 5^{th} percentile such that the 95% UCL is calculated as follows:

$$95\%UCL = \overline{X}_{raw} - W(Q)_{0.05} \times SD_{raw}$$

These bootstrap approaches have the advantage in that they do not rely on the assumption of a special parametric form for the distribution of the population (EPA 1997). The underlying assumption is however, that the calculated X_{Bi}'s t-statistics (W_i's), and Q(W)'s are normally distributed. Subsequent to the bootstrap calculations, the distribution of the bootstrap statistics (X_{Bi}'s, W_i's, and Q(W)'s) will be evaluated for departure from normality using the correlation between the expected quantiles of the normal distribution for the bootstrap output and the observed quantiles for the re-sampled datasets ($Q_{expected}$-$Q_{observed}$ plots; see USEPA 1998). Such Q-Q plots are considered one of the most effective means of evaluating the bootstrap normality "fit" (see Davidson and Hinkley 1997). If the assumption of normality or near-normality cannot be met, the jackknife procedure will be used.

Jackknife Method

The Jackknife procedure is similar to the standard bootstrap as described above. When the data cannot be defined as normal or lognormal and the sample size is below 15, the Jackknife is preferred as a more conservative method (e.g., see Efron and Gong [1983]). The jackknifed mean and standard error are calculated as follows:

Step 1: n pseudovalues (ϕ) are first calculated by leaving out each of the observations in turn:

$$\phi = (n \times \overline{X}) - [(n-1) \times \overline{X}_{i-1}]$$

Step 2: The jackknifed estimate of the mean is then:

$$\Phi = \sum(\phi) \div n$$

Step 3: The standard error of the mean is calculated as:

$$SE_{mean} = \sqrt{\sum(\phi_i - \Phi)^2 / [n \bullet (n-1)]}$$

Step 4: The upper confidence limit of the jackknifed mean is calculated as:

$$UCL_{\alpha} = \Phi + t_{1-\alpha,n-1} \bullet SE_{mean}$$

[3] The 50th W value represents the 5th percentile given 1000 resamples.

Table C-1
Exposure Parameters--Industrial Workers

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	50	(a)	50	(a)
	EF	Exposure Frequency (d/yr)	219	(c,e)	250	(c,e)
	ED	Exposure Duration (years)	6.6	(d,e)	25	(d,e)
	FI	Fraction Ingested (unitless)	site-/area-specific	(e)	site-/area-specific	(e)
	BW	Body Weight (kg)	70	(b,g,h)	70	(b,g,h)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,409	(f)	9,125	(f)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	1,930	(j)	1,930	(j)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.02	(k)	0.1	(k)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	(c)	--	(c)	--
	ED	Exposure Duration (years)	6.6	(d,e)	25	(d,e)
	BW	Body Weight (kg)	70	(b,g,h)	70	(b,g,h)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,409	(f)	9,125	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(b,g,h)	25,550	(b,g,h)
Inhalation of Soil-Derived Chemicals	IR	Inhalation Rate (m^3/hour)	0.55	(l)	1.0	(m)
	ET	Exposure Time (hr/d)(site-/area-specific)	8	(n)	8	(n)
	EF	Exposure Frequency (d/yr)	219	(c,e)	250	(c,e)
	ED	Exposure Duration (years)	6.6	(d,e)	25	(d,e)
	BW	Body Weight (kg)	70	(b,g,h)	70	(b,g,h)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,409	(f)	9,125	(f)
	AT_c	Averaging Time for Carcinogens (days)	25,550	(b,g,h)	25,550	(b,g,h)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1997. Table 1-2 of *Exposure Factors Handbook*, Volume I based on mean or average value.
(b) US EPA, 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.
(c) The value of 250 days/yr is recommended as the upperbound EF value in the *Exposure Factors Handbook*. The value of 219 days/yr was used as the average EF value in USEPA's Adult Lead Model.
(d) Values represent the 95th (for RME) and 50th percentile (for CTE) of occupational tenure, as provided in the *Exposure Factors Handbook*.
(e) Site-/Area-specific values to be used, if available.
(f) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).
(g) US EPA, 1989. RAGS, Volume I, Human Health Evaluation Manual (Part A).
(h) 70 kg body weight and 70 year lifetime are used to be consistent with the development of cancer slope factors.
(i) Recommended surface area for industrial workers. Exhibit 3-5 in RAGS Part E. (USEPA, 2001a).
(j) Suggested value represents the total skin surface area for head and hands, assuming that a worker wears long sleeve shirts,long pants and shoes. This value may be adjusted based on the following body part-specific surface area (mean, in cm^2), as provided in Table 6-4 of the *Exposure Factors Handbook* (US EPA, 1997).

	Men	Women
Head	1,180	1,100
Hands	840	746
Forearms	1,140	1,360
Lower Legs	2,070	1,940
Feet	1,120	975

(k) Recommended default values for a groundskeeper. Exhibit 3-3 in RAGS Part E. (USEPA, 2001a).
(l) US EPA, 1997. Table 5-23 of *Exposure Factors Handbook*, Volume 1, based on calculated average of recommended mean values for male and female.
(m) US EPA, 1997. *Exposure Factors Handbook*, Volume 1, Table 5-23. Value for short-term exposures for adults at light activity level.
(n) US EPA, 1997. Table 15-68 of *Exposure Factors Handbook*, Volume 3, 50th percentile value for time spent at work (males and females, all ages).

Table C-2
Exposure Parameters--Construction Workers

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	100	(a)	330	(b)
	EF	Exposure Frequency (d/yr)	(c)		250	(c,d)
	ED	Exposure Duration (years)	1	(e)	1	(e)
	FI	Fraction Ingested (unitless)(Site-/Area-specific)	(f)		(f)	
	BW	Body Weight (kg)	70	(g,h,i)	70	(g,h,i)
	ATn_c	Averaging Time for Non-carcinogenic Effects (days)	365	(o)	365	(o)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(g,h,i)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	1,930	(j)	1,930	(j)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.10	(k)	0.30	(k)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)(Site-/Area-specific)	(c)		(c)	
	ED	Exposure Duration (years)	1	(e)	1	(e)
	BW	Body Weight (kg)	70	(g,h,i)	70	(g,h,i)
	ATn_c	Averaging Time for Non-carcinogenic Effects (days)	365	(o)	365	(o)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(g,h,i)
Inhalation of Soil Derived Chemicals or Groundwater VOCs	IR	Inhalation Rate (m^3/hour)	1.3	(m)	1.5	(l)
	ET	Exposure Time (hr/d)(Site-/Area specific-specific)	8	(n)	8	(n)
	EF	Exposure Frequency (d/yr)(Site-/Area-specific)	(c)		(c)	
	ED	Exposure Duration (years)	1	(e)	1	(e)
	BW	Body Weight (kg)	70	(g,h,i)	70	(g,h,i)
	ATn_c	Averaging Time for Non-carcinogenic Effects (days)	365	(o)	365	(o)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(g,h,i)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.
(b) US EPA, 2001b. Based on recommended ingesion rate for construction workers, provided in *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.
(c) Site-/Area-specific values will be used, if available.
(d) US EPA, 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.
(e) Construction activities are assumed to occur over a 1 year period.
(f) Site-/Area-specific values to be derived.
(g) US EPA, 1991. *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors.*
(h) US EPA, 1989. RAGS, Volume I, Human Health Evaluation Manual (Part A).
(i) 70 kg body weight and 70 year lifetime are used to be consistent with the development of cancer slope factors.
(j) Suggested Tier 1B/Tier 2 value represents the total skin surface area for head and hands, assuming that a worker wears long sleeve shirts,long pants and shoes. This value may be adjusted based on the following body part-specific surface area (mean, in cm^2), as provided in Table 6-4 of the *Exposure Factors Handbook* (US EPA, 1997). The skin surface area of 3,300 cm^2 is recommended by USEPA for industrial workers (Exhibit 3-5, RAGS, Part E, USEPA, 1997).

	Men	Women
Head	1,180	1,100
Hands	840	746
Forearms	1,140	1,360
Lower Legs	2,070	1,940
Feet	1,120	975

(k) Recommended default values for a construction worker. Exhibit 3-3 in RAGS Part E. (USEPA, 2001a).
(l) US EPA, 1997. Exposure Factors Handbook, Volume 1, Table 5-23. Short-term exposures for outdoor workers, moderate activity.
(m) US EPA, 1997. Exposure Factors Handbook, Volume 1, Table 5-23. Hourly average for short-term exposures for outdoor workers.
(n) US EPA, 1997. Table 15-68 of Exposure Factors Handbook, Volume 3, 50th percentile value for time spent at work (males and females, all ages).
(o) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

Table C-3
Exposure Parameters--Maintenance/Utility Workers

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	50	(a)	100	(b)
	EF	Exposure Frequency (d/yr)	(c)	--	(c)	--
	ED	Exposure Duration (years)	(d)	--	(d)	--
	FI	Fraction Ingested (unitless)(site-/SWMA-specific)	(e)		(e)	
	BW	Body Weight (kg)	70	(g,h,i)	70	(g,h,i)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	(f)		(f)	
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(g,h,i)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	1,930	(j)	1,930	(j)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.02	(k)	0.1(Maintenance) 0.2 (Utility)	(k)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	(c)	--	(c)	--
	ED	Exposure Duration (years)	(d)	--	(d)	--
	BW	Body Weight (kg)	70	(g,h,i)	70	(f,g,h)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	(f)		(f)	
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(f,g,h)
Inhalation of Soil Derived Chemicals or Groundwater VOCs	IR	Inhalation Rate (m^3/hour)	1.3	(m)	1.5	(l)
	ET	Exposure Time (hr/d)	8	(n)	8	(n)
	EF	Exposure Frequency (d/yr)	(c)	--	(c)	--
	ED	Exposure Duration (years)	(d)	--	(d)	--
	BW	Body Weight (kg)	70	(g,h,i)	70	(g,h,i)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	(f)		(f)	
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(g,h,i)	25,550	(g,h,i)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1997. Table 1-2 of Exposure Factors Handbook, Volume I based on mean or average value for adults.
(b) US EPA, 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.
(c) Site-/Area-specific values.
(d) Site-/Area-specific value to be developed based on US EPA, 1997,*Exposure Factors Handbook*, Volume I, and site-/area-specific information.
(e) Site-/Area-specific values will be derived and presented in each site-/area-specific risk assessment.
(f) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).
(g) US EPA, 1991. *Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors.*
(h) US EPA, 1989. RAGS, Volume I, *Human Health Evaluation Manual (Part A).*
(i) 70 kg body weight and 70 year lifetime are used to be consistent with the development of cancer slope factors.
(j) Recommended surface area for industrial receptors. Exhibit 3-5 in RAGS Part E. (USEPA, 2001a).
(j) Suggested Tier 1B/Tier 2 value represents the total skin surface area for head and hands, assuming that a worker wears long sleeve shirts,long pants and shoes. This value may be adjusted based on the following body part-specific surface area (mean, in cm^2), as provided in Table 6-4 of the *Exposure Factors Handbook* (US EPA, 1997). The skin surface area of 3,300 cm^2 is recommended by USEPA for industrial workers (Exhibit 3-5, RAGS, Part E, USEPA, 1997).

	Men	Women
Head	1,180	1,100
Hands	840	746
Forearms	1,140	1,360
Lower Legs	2,070	1,940
Feet	1,120	975

(k) USEPA's recommended default values for groundskeepers (Exhibit 3-3 in RAGS Part E, USEPA, 2001a) were adopted for maintenance workers and the recommended default for a high-end soil contact activity (Exhibit 3-5 in RAGS, Part E, 2001a) were adopted for utility workers.
(l) US EPA, 1997. *Exposure Factors Handbook*, Volume 1, Table 5-23. Short-term exposures for outdoor workers, moderate activity.
(m) US EPA, 1997. *Exposure Factors Handbook*, Volume 1, Table 5-23. Hourly average for short-term exposures for outdoor workers.
(n) US EPA, 1997. Table 15-68 of *Exposure Factors Handbook*, Volume 3, 50th percentile value for time spent at work (males and females of all ages).

Table C-4
Exposure Parameters--Recreational Children (Age 0 to 6)

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	100	(a)	400	(b)
	EF	Exposure Frequency (d/yr)	40	(c)	52	(c)
	ED	Exposure Duration (years)	6	(d)	6	(d)
	FI	Fraction Ingested (unitless)	(e)		(e)	
	BW	Body Weight (kg)	15	(f)	15	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,190	(n)	2,190	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	2,800	(i)	2,800	(i)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.20	(j)	0.20	(j)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	40	(c)	52	(c)
	ED	Exposure Duration (years)	6	(d)	6	(d)
	BW	Body Weight (kg)	15	(f)	15	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,190	(n)	2,190	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Inhalation of Soil Derived Chemicals	IR	Inhalation Rate (m^3/hour)	1	(k)	1.2	(l)
	ET	Exposure Time (hr/d)	2	(m)	2	(m)
	EF	Exposure Frequency (d/yr)	40	(c)	52	(c)
	ED	Exposure Duration (years)	6	(d)	6	(d)
	BW	Body Weight (kg)	15	(f)	15	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	2,190	(n)	2,190	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1997. *Exposure Factors Handbook* . The mean soil ingestion rate for children under 6 years of age over a short duration.
(b) US EPA, 1997. *Exposure Factors Handbook* . The upperbound soil ingestion rate for children under 6 years of age over a short duration.
(c) Conservative assumption for CTE (2 days/week during June, July, and August and 1 day/week during April, May, September, and October) and RME (3 days/week during June, July, and August and 1 day/week during April, May, September, and October) Site-specific inofrmation will be used, if available.
(d) Recreational children is assumed to range in age from 0 to 6. Therefore, total exposure duration is 6 years.
(e) Site-/Area-specific values will be derived and presented in each site-/area-specific risk assessment.
(f) US EPA, 1997. *Exposure Factors Handbook* . Body weight is the average weght for children.
(g) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)* .
(h) 70 year lifetime is used to be consistent with the development of cancer slope factors.
(i) US EPA, 2003. *RAGS, Part E* . Recommended default skin surface area for children.
(j) Recommended soil to skin adherence factor for older children. Exhibit 3-5 in RAGS, Part E. (USEPA, 2003).
(k) US EPA, 1997. *Exposure Factors Handbook* . Mean inhalation rate for children at light activity level. Table 5-23.
(l) US EPA, 1997. *Exposure Factors Handbook* . Mean inhalation rate for children at moderate activity level. Table 5-23.
(m) Each recreational event is assumed to last for 2 hours, based on the estimated time spent on outdoor activities (US EPA, 1997).
(n) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

Table C-5
Exposure Parameters--Recreational Adolescent (Age 7 to 18)

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	50	(a)	50	(a)
	EF	Exposure Frequency (d/yr)	40	(b,c)	52	(b,c)
	ED	Exposure Duration (years)	12	(d)	12	(d)
	FI	Fraction Ingested (unitless)	(e)		(e)	
	BW	Body Weight (kg)	47	(f)	47	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	4,380	(n)	4,380	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	4,373	(i)	4,373	(i)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.01	(j)	0.07	(j)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	(c)		(c)	
	ED	Exposure Duration (years)	12	(d)	12	(d)
	BW	Body Weight (kg)	47	(f)	47	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	4,380	(n)	4,380	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Inhalation of Soil Derived Chemicals	IR	Inhalation Rate (m^3/hour)	0.52	(k)	1.0	(l)
	ET	Exposure Time (hr/d)	2	(n)	2	(n)
	EF	Exposure Frequency (d/yr)	(c)		(c)	
	ED	Exposure Duration (years)	12	(d)	12	(d)
	BW	Body Weight (kg)	47	(f)	47	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	4,380	(n)	4,380	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1997. *Exposure Factors Handbook* . The mean soil ingestion rate for children over 6 years of age.
(b) Conservative assumption for CTE (2 days/week during June, July, and August and 1 day/week during April, May, September, and October)
(c) Conservative assumption for CTE (2 days/week during June, July, and August and 1 day/week during April, May, September, and October) and RME (3 days/week during June, July, and August and 1 day/week during April, May, September, and October) Site-specific inofrmation will be used, if available.
(d) Recreational adolescent is assumed to range in age from 7 to 18. Therefore, total exposure duration is 12 years.
(e) Site-/Area-specific values will be derived and presented in each site-/area-specific workplan.
(f) US EPA, 1997. *Exposure Factors Handbook* . Body weight is the average of males and females aged 7 to 18.
(g) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)* .
(h) 70 year lifetime is used to be consistent with the development of cancer slope factors.
(i) US EPA, 1997. *Exposure Factors Handbook* . Average surface area of head, hands, forearms, and lower legs of males and females aged 7-18.
(j) Recommended soil to skin adherence factor for older children and adults, >6 years of age. Exhibit 3-5 in RAGS, Part E. (USEPA, 2001a).
(k) US EPA, 1997. *Exposure Factors Handbook* . Average inhalation rate of males and females aged 7 to 18. Table 5-23.
(l) US EPA, 1997. *Exposure Factors Handbook* . Inhalation rate for short-term exposure, light activity (adults and children). Table 5-23.
(m) Each recreational event is assumed to last for 2 hours, based on the estimated time spent on outdoor activities (US EPA, 1997).
(n) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

Table C-6
Exposure Parameters--Recreational Adults

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Soil Ingestion	IR	Soil Ingestion Rate (mg/d)	50	(a)	50	(a)
	EF	Exposure Frequency (d/yr)	40	(b,c)	52	(b,c)
	ED	Exposure Duration (years)	9	(d)	30	(d)
	FI	Fraction Ingested (unitless)	(e)		(e)	
	BW	Body Weight (kg)	70	(f)	70	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	3,285	(n)	10,950	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Dermal Contact with Soil	SA	Skin Surface Area Exposed (cm^2)	4,373	(i)	4,373	(i)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.01	(j)	0.07	(j)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	40	(b,c)	52	(b,c)
	ED	Exposure Duration (years)	9	(d)	30	(d)
	BW	Body Weight (kg)	70	(f)	70	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	3,285	(n)	10,950	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)
Inhalation of Soil Derived Chemicals	IR	Inhalation Rate (m^3/hour)	0.52	(k)	1.0	(l)
	ET	Exposure Time (hr/d)	2	(m)	2	m)
	EF	Exposure Frequency (d/yr)	40	(b,c)	52	(b,c)
	ED	Exposure Duration (years)	9	(d)	30	(d)
	BW	Body Weight (kg)	70	(f)	70	(f)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	3,285	(n)	10,950	(n)
	AT_c	Averaging Time for Carcinogenic Effects (days)	25,550	(b,g,h)	25,550	(b,g,h)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1997. Table 1-2 of *Exposure Factors Handbook* , Volume I based on mean or average value.
(b) US EPA, 1997. *Exposure Factors Handbook* . The upperbound soil ingestion rate for children under 6 years of age over a short duration.
(c) Site-/Area-specific value.
(d) Recreational adolescent is assumed to range in age from 7 to 18. Therefore, total exposure duration is 12 years.
(e) Site-/Area-specific values will be derived and presented in each site-/area-specific workplan.
(f) US EPA, 1997. *Exposure Factors Handbook* . Body weight is the average of males and females aged 7 to 18.
(g) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)* .
(h) 70 year lifetime is used to be consistent with the development of cancer slope factors.
(i) US EPA, 1997. *Exposure Factors Handbook* . Average surface area of head, hands, forearms, and lower legs of males and females aged 7-18.
(j) Recommended soil to skin adherence factor for older children and adults, >6 years of age. Exhibit 3-5 in RAGS, Part E. (USEPA, 2001a).
(k) US EPA, 1997. *Exposure Factors Handbook* . Average inhalation rate of males and females aged 7 to 18. Table 5-23.
(l) US EPA, 1997. *Exposure Factors Handbook* . Inhalation rate for short-term exposure, light activity (adults and children). Table 5-23.
(m) Each recreational event is assumed to last for 2 hours, based on the estimated time spent on outdoor activities (US EPA, 1997).
(n) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

Table C-7
Exposure Parameters--Swimmer/Wader (Age 7 to 18)

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Surface Water Ingestion	$IR_{swimming}$	Surface Water Ingestion Rate (L/hour)	0.01	(a)	0.05	(b)
	IR_{wading}	Surface Water Ingestion Rate (L/hour)	0.01	(a)	0.01	(a)
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	12	(e)	12	(e)
	ET	Exposure Time (hours/event)	1 (swimming) 2 (wading)	(f)	1 (swimming) 2 (wading)	(f)
	BW	Body Weight (kg)	47	(g)	47	(g)
	ATn_c	Averaging Time for Non-Carcinogenic Effects (days)	4,380	(l)	4,380	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Dermal Contact with Surface Water	$SA_{swimming}$	Skin Surface Area Exposed (cm^2)	13,533	(k)	13,533	(k)
	SA_{wading}	Skin Surface Area Exposed (cm^2)	6,767	(k)	6,767	(k)
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	12	(e)	12	(e)
	ET	Exposure Time (hours/event)	1 (swimming) 2 (wading)	(f)	1 (swimming) 2 (wading)	(f)
	BW	Body Weight (kg)	47	(g)	47	(g)
	ATn_c	Averaging Time for Non-Carcinogenic Effects (days)	4,380	(l)	4,380	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Incidental Sediment Ingestion	SIR	Sediment Ingestion Rate (mg/d)	(m)		(m)	
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	12	(e)	12	(e)
	BW	Body Weight (kg)	47	(g)	47	(g)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	4,380	(l)	4,380	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Dermal Contact with Sediment	SA	Skin Surface Area Exposed (cm2)	3,259	(n)	4,046	(n)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.5	(o)	1	(o)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	12	(e)	12	(e)
	BW	Body Weight (kg)	47	(d)	47	(d)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	4,380	(e)	4,380	(e)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)

Notes:
CTE - Central Tendency Evaluation
RME - Reasonable Maximum Exposure.

(a) US EPA, 1989. *Risk Assessment Guidance for Superfund, Volume I* . Value is one-fifth of that assumed to occur during a swimming event.
(b) US EPA, 1989. *Risk Assessment Guidance for Superfund, Volume I* . Value for a swimming event.
(c) One event per month for the 6 warmest months of the year.
(d) Two events per month for the 6 warmest months of the year.
(e) Recreational adolescent is assumed to range in age from 7 to 18. Therefore, total exposure duration is 12 years.
(f) The exposure frequency of 1 event/month and exposure time of 1 hr/event for swimming represent the values recommended in the *Exposure Factors Handbook* (US EPA, 1997, Table 1-2.) The exposure time of 2 hrs/event for wading is based on the estimated time spent on outdoor activities (*Exposure Factors Handbook* . US EPA, 1997).
(g) US EPA, 1997. *Exposure Factors Handbook* . Body weight is the average of males and females aged 7 to 18.
(h) 70 year lifetime is used to be consistent with the development of cancer slope factors.
(i) US EPA, 1991. *Standard Default Exposure Factors* . Value for adult.
(j) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)* .
(k) Value represents average total body surface area of males and females aged 7 to 18. Assumes 100% of skin surface exposed while swimming. The wader's skin surface area is 50% of the swimming value.
(l) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).
(m) Will be calculacted using the following equation: Sediment Ingestion Rate (mg/day) = Surface water ingestion rate (ml/day) x total solids (mg/ml).
(n) The RME skin surface area represents the sum of the surface area for forearms, hadnds, lower legs and feet. The CTE skin surface area represents the sum of the skin surface area fro hands, lower legs and feet.
(o) - Using loadings for the hands, arms, and legs for the irrigation worker reported in USEPA (1997), a weighted soil-to-skin adherence factor of 2.0 mg/cm2 was calculated. One-half this value (1.0 mg/cm2) used as RME assuming some washoff; 0.5 mg/cm2 used for MLE.

Table C-8
Exposure Parameters--Swimmer/Wader (Adults)

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Incidental Surface Water Ingestion	$IR_{swimming}$	Surface Water Ingestion Rate (L/hour)	0.01	(a)	0.05	(b)
	IR_{wading}	Surface Water Ingestion Rate (L/hour)	0.01	(a)	0.01	(a)
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	9	(e)	30	(e)
	ET	Exposure Time (hours/event)	1 (swimming) 2 (wading)	(f)	1 (swimming) 2 (wading)	(f)
	BW	Body Weight (kg)	70	(g)	70	(g)
	ATn_c	Averaging Time for Non-Carcinogenic Effects (days)	3,285	(l)	10,950	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Dermal Contact with Surface Water	$SA_{swimming}$	Skin Surface Area Exposed (cm^2)	18,000	(k)	18,000	(k)
	SA_{wading}	Skin Surface Area Exposed (cm^2)	9,000	(k)	9,000	(k)
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	9	(e)	30	(e)
	ET	Exposure Time (hours/event)	1 (swimming) 2 (wading)	(f)	1 (swimming) 2 (wading)	(f)
	BW	Body Weight (kg)	70	(g)	70	(g)
	ATn_c	Averaging Time for Non-Carcinogenic Effects (days)	3,285	(l)	10,950	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Incidental Sediment Ingestion	SIR	Sediment Ingestion Rate (mg/d)	(m)		(m)	
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	9	(e)	30	(e)
	BW	Body Weight (kg)	70	(g)	70	(g)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	3,285	(l)	10,950	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)
Dermal Contact with Sediment	SA	Skin Surface Area Exposed (cm2)	4,499	(n)	5,672	(n)
	SSAF	Soil to Skin Adherence Factor (mg/cm^2)	0.5	(0)	1	(0)
	CF	Conversion Factor (kg/mg)	1.00E-06	--	1.00E-06	--
	EF	Exposure Frequency (d/yr)	6	(c)	12	(d)
	ED	Exposure Duration (years)	9	(e)	30	(e)
	BW	Body Weight (kg)	70	(g)	70	(g)
	ATnc	Averaging Time for Non-carcinogenic Effects (days)	3,285	(l)	10,950	(l)
	AT_c	Averaging Time Carcinogens (days)	25,550	(h,i, j)	25,550	(h,i, j)

Notes:

CTE - Central Tendency Evaluation

RME - Reasonable Maximum Exposure.

(a) US EPA, 1989. *Risk Assessment Guidance for Superfund, Volume I*. Value is one-fifth of that assumed to occur during a swimming event.

(b) US EPA, 1989. *Risk Assessment Guidance for Superfund, Volume I*. Value for a swimming event.

(c) One event per month for the 6 warmest months of the year.

(d) Two events per month for the 6 warmest months of the year.

(e) The default values for a residential adult, assuming the individual resides in the same residence for 9 (average) or 30 years (upperbound).

(f) The exposure frequency of 1 event/month and exposure time of 1 hr/event for swimming represent the values recommended in the *Exposure Factors Handbook* (US EPA, 1997, Table 1-2.) The exposure time of 2 hrs/event for wading is based on the estimated time spent on outdoor activities *Exposure Factors Handbook*. US EPA, 1997).

(g) US EPA, 1997. *Exposure Factors Handbook*. Body weight is the average of adult males and females

(h) 70 year lifetime is used to be consistent with the development of cancer slope factors.

(i) US EPA, 1991. *Standard Default Exposure Factors*. Value for adult.

(j) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)*.

(k) Value represents recommended skin surface area (100% for for swimmers and 50% for waders).

(l) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

(m) Will be calculacted using the following equation: Sediment Ingestion Rate (mg/day) = Surface water ingestion rate (ml/day) x total solids (mg/ml).

(n) The RME skin surface area represents the sum of the surface area for forearms, hadnds, lower legs and feet. The CTE skin surface area represents the sum of the skin surface area fro hands, lower legs and feet.

(o) - Using loadings for the hands, arms, and legs for the irrigation worker reported in USEPA (1997), a weighted soil-to-skin adherence factor of 2.0 mg/cm2 was calculated. One-half this value (1.0 mg/cm2) used as RME assuming some washoff; 0.5 mg/cm2 used for MLE.

Table T C-10
Exposure Parameters--Fisher

Exposure Pathway	Parameter	Description	Exposure Parameters			
			CTE	Source	RME	Source
Ingestion of Fish	IR	Fish Ingestion Rate (g/d)	17.2	(a)	81	(a)
	FI	Fraction Ingested (unitless)	(b)		(b)	
	EF	Exposure Frequency (events/yr)	350	(c)	350	(c)
	ED	Exposure Duration (years)	9	(d)	30	(d)
	BW	Body Weight (kg)	70	(e,f)	70	(e,f)
	ATn_c	Averaging Time for Non-Carcinogenic Effcets (days)	3,285	(g)	10,950	(g)
	AT_c	Averaging Time for Carcinogenic Effcets (days)	25,550	(h)	25,550	(h)

Notes:

CTE - Central Tendency Evaluation

RME - Reasonable Maximum Exposure

(a) US EPA, 1997. *Exposure Factors Handbook* . The RME value is US EPA's recommended mean intake values for subsistence fisher and the CTE value is the recommended mean intake for sport anglers.

(b) Site-/Area-specific information.

(c) US EPA's current guidance indicates that the fish ingestion rates are expressed in terms of daily ingestion over a long period.

(d) US EPA, 1997. *Exposure Factors Handbook.* Recommended average (9 years) and 95th percentile (30 years) for time residing in a household. Table 1-2.

(e) US EPA, 1989. *RAGS, Volume I, Human Health Evaluation Manual (Part A)* .

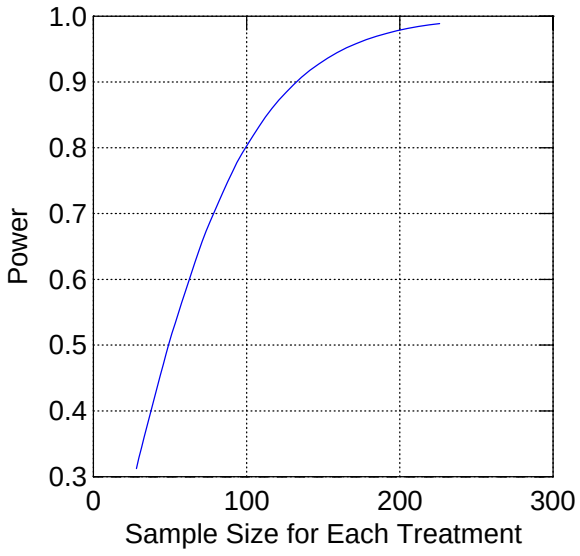
(f) 70 kg body weight and 70 year lifetime are used to be consistent with the development of cancer slope factors.

(g) Averaging Time for noncarcinogens is equal to ED (year) x 365 days/year (US EPA, 1989).

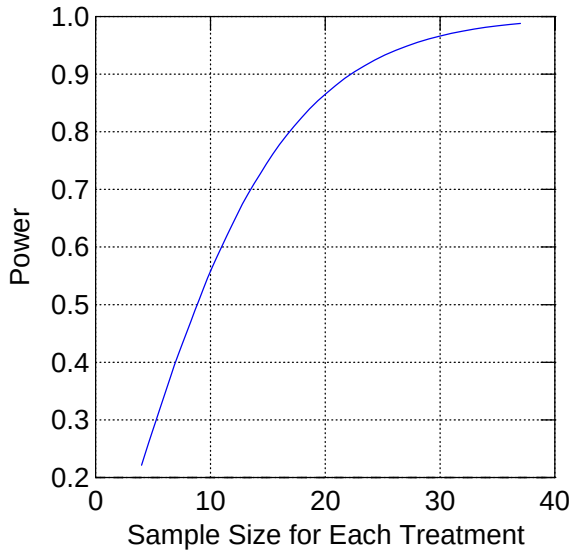
(h) Averaging time for carcinogenic effects is equal to 70 year (laverage life expectancy) x 365 days/year (USEPA, 1989).

Appendix D

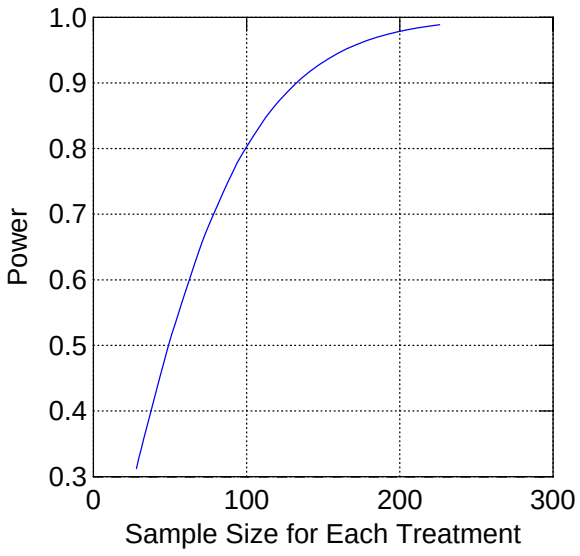
Power Analysis Results
One Way ANOVA (alpha=0.05)s



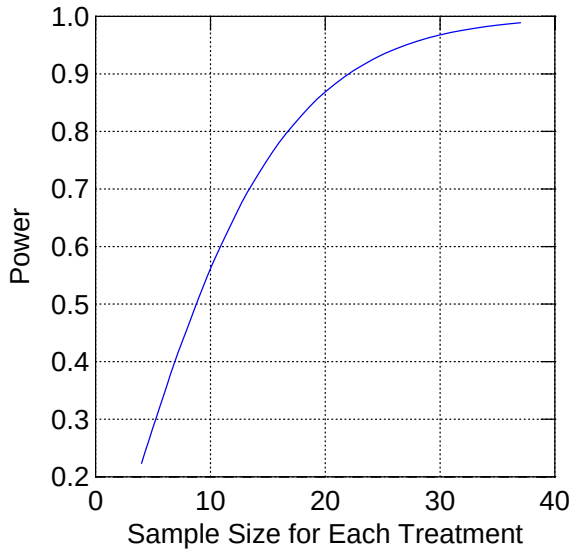
D1. Molluscs and Crustaceans (M+C), Small Effect (0.2sd)



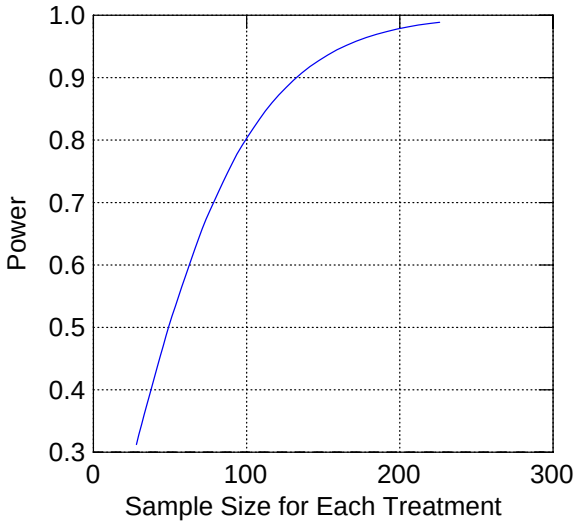
D2. Molluscs and Crustaceans (M+C), Moderate Effect (0.5sd)



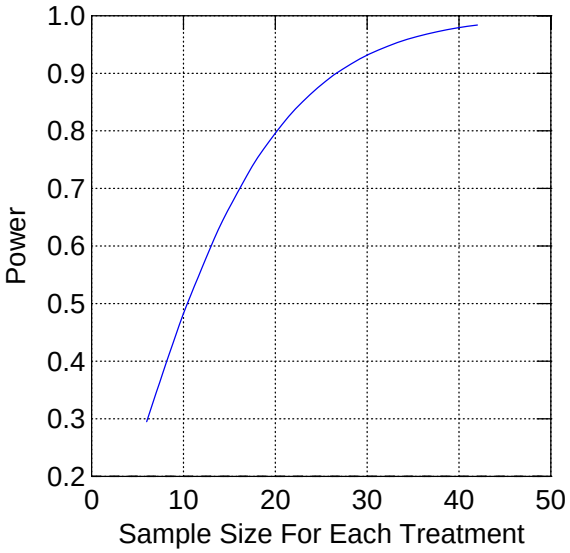
D3. Species Richness (S), Small Effect (0.2sd)



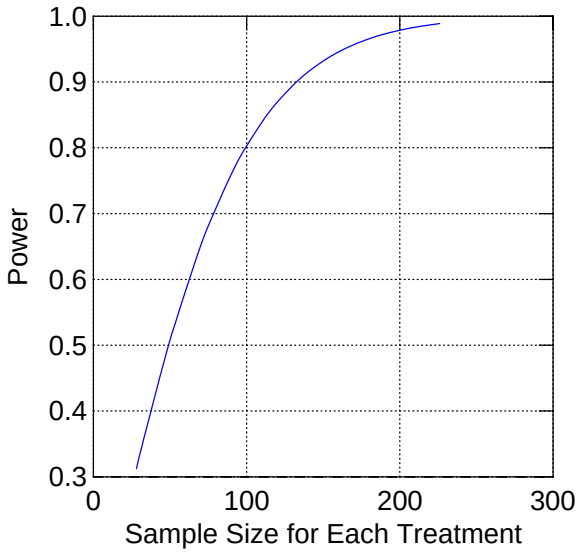
D4. Species Richness (S), Moderate Effect (0.5sd)



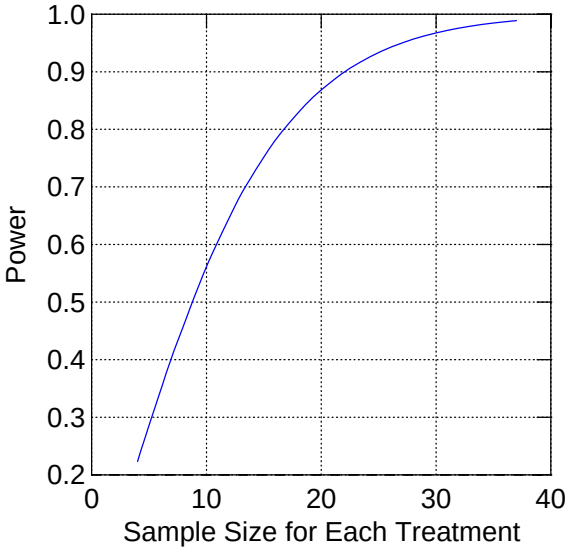
D5. Total Abundance (N), Small Effect (sd=0.2)



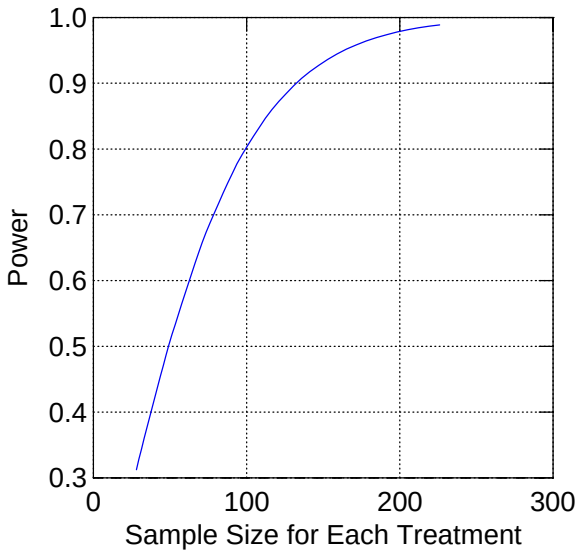
D6. Total Abundance (N), Moderate Effect (sd=0.5)



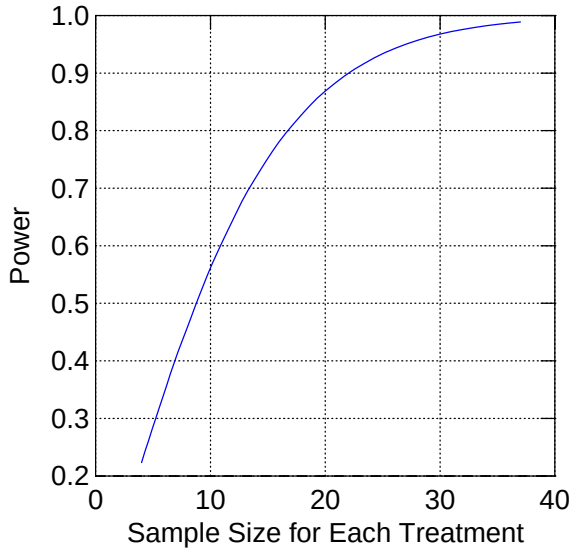
D7. Ranked Molluscs and Crustaceans (M+C), Small Effect (0.2sd)



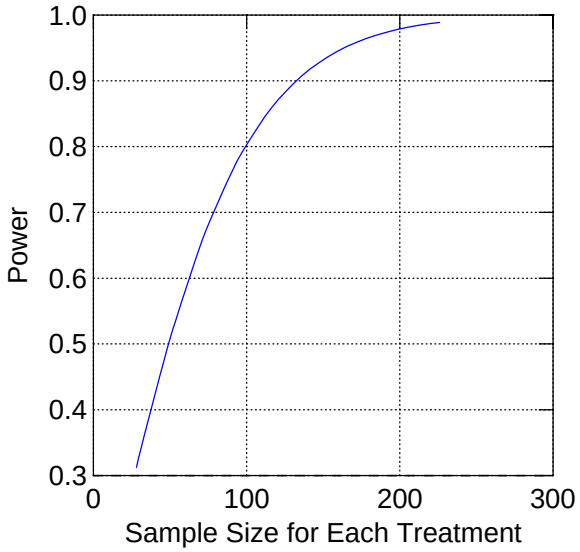
D8. Ranked Molluscs and Crustaceans (M+C), Moderate Effect (0.5sd)



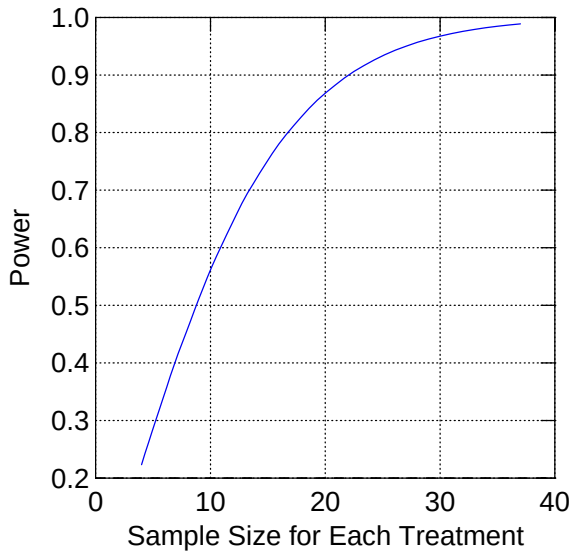
D9. Ranked Species Richness (S), Small Effect (0.2sd)



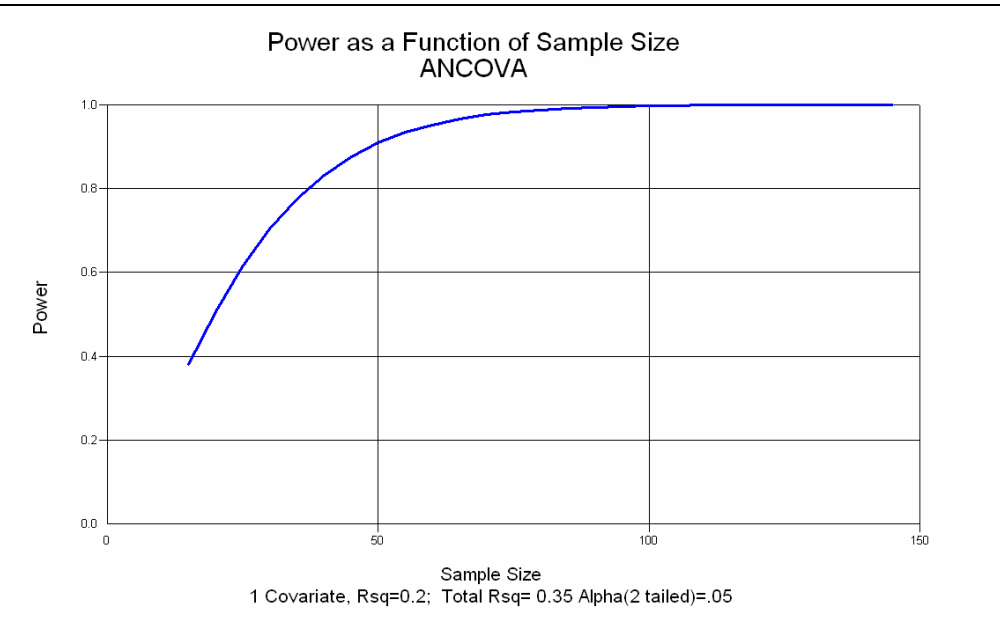
D10. Ranked Species Richness (S), Moderate Effect (0.5sd)



D11. Ranked Total Abundance (N), Small Effect (sd=0.2)



D12. Ranked Total Abundance (N), Moderate Effect (sd=0.5)

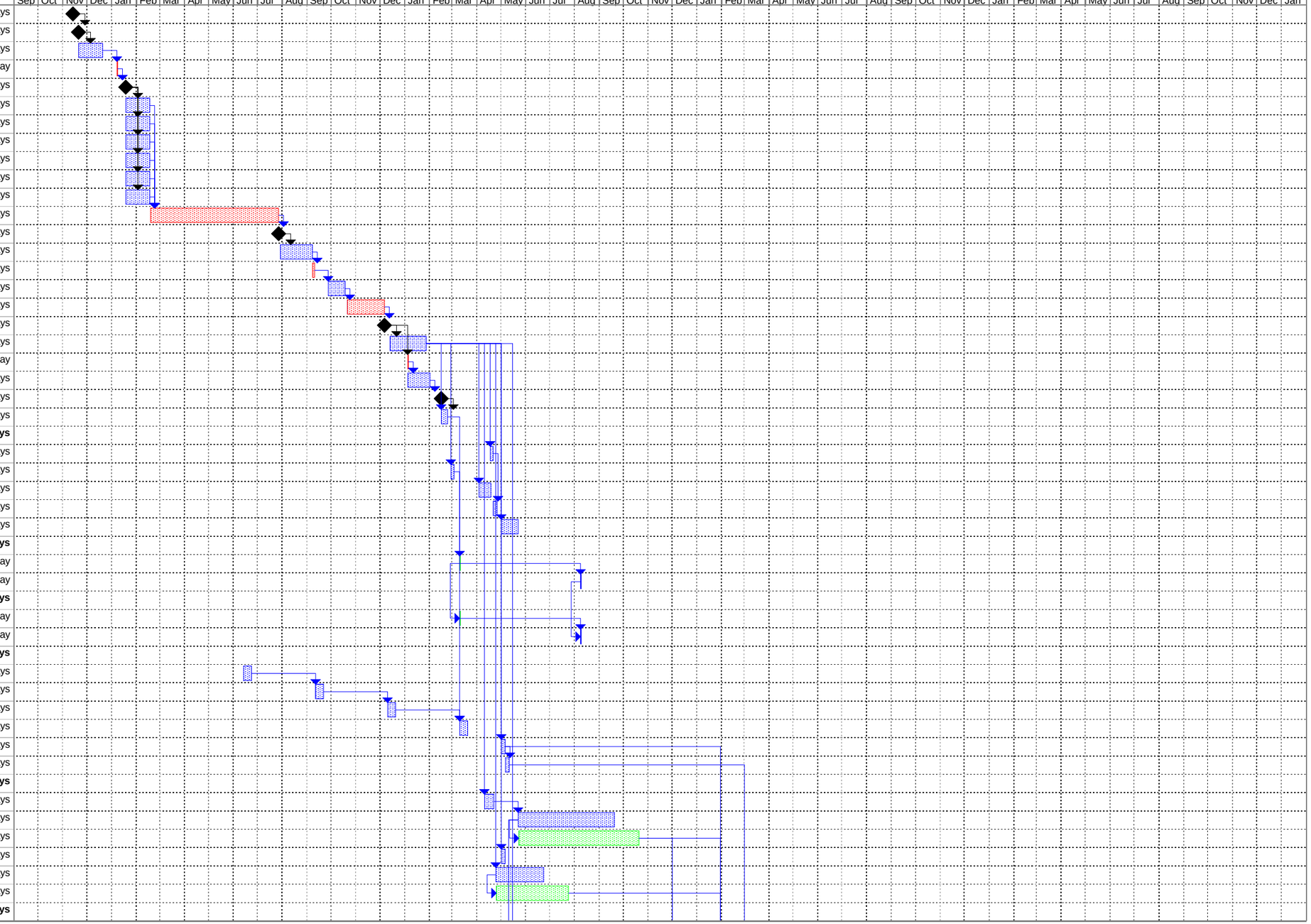


D13. Power in Analysis of Covariance (Hypothetical example: see text).

Appendix E

Ashland/NSP Lakefront Superfund Site
RI/FS Schedule

ID	Task Name	Duration
1	**Sign AOC (11/14/2003)**	0 days
2	WDNR/SEH Work Plan	0 days
3	Technical Letter Report	30 days
4	Technical Scoping Meeting	1 day
5	Technical Scoping Meeting EPA Summary	0 days
6	RI/FS Workplan Revision 01	30 days
7	QAPP	30 days
8	FSP	30 days
9	HASP	30 days
10	QMP	30 days
11	DMP/PMP	30 days
12	Agency Review of Plans	160 days
13	Agency Comments on Plans	0 days
14	Review and Revise Workplan and Planning Documents	40 days
15	Meeting with Agency & Trustees	3 days
16	Revise and Resubmit Plans	21 days
17	Agency review	46 days
18	**Agency Approval (12/7/2004)**	0 days
19	Mobilization/Subcontractor Selection	45 days
20	Conference Call to Discuss Approval Conditions	1 day
21	Revise and Submit Errata Sheets and Workplan Addenda	28 days
22	Approval of Workplan Addenda	0 days
23	Monitoring Well Abandonment and Replacement	8 days
24	**Upland & Kreher Park Investigation**	**422 days**
25	Surface Soil	4 days
26	Soil Vapor Probe Installation	4 days
27	Subsurface Soil (Geoprobe)	15 days
28	Geophysics	5 days
29	Test Pits	21 days
30	**Soil Vapor Sampling**	**152 days**
31	Round 1	1 day
32	Round 2	1 day
33	**Vapor Intrusion Sampling**	**152 days**
34	Round 1	1 day
35	Round 2	1 day
36	**Groundwater Sampling**	**280 days**
37	Round 1	10 days
38	Round 2	10 days
39	Round 3	10 days
40	Round 4	10 days
41	**Wildlife Habitat Survey**	5 days
42	**Wetland Survey and Functional Values Analysis**	5 days
43	**Sediment Quality Triad Investigation**	**193 days**
44	Reconnaisance Survey	12 days
45	Sediment Quality Triad Sampling	120 days
46	Laboratory Analysis	150 days
47	UV Light Measurements	5 days
48	**Fish Tissue Sample Collection**	60 days
49	Laboratory Analysis	90 days
50	**Suface Water Sample Collection**	**123 days**



Project: RIFS Schedule for WSB
Date: Fri 1/28/05

NSPW Task | Agency Task | Lab Task | Split | Progress | Milestone | Deadline

RI/FS Workplan, Rev. 02
APPENDIX E

Ashland/NSP Lakefront Superfund Site
PROJECT SCHEDULE

ID	Task Name	Duration
51	Round 1	1 day
52	Laboratory Analysis	30 days
53	Round 2	1 day
54	Laboratory Analysis	30 days
55	**Sediment Stability Studies**	**165 days**
56	Sample Collection	60 days
57	ADCP Deployment	30 days
58	Laboratory Analysis & Analytical Modeling	90 days
59	Sediment Stability Evaluation Report	60 days
60	**BERA Report**	180 days
61	Revised ERA Report	30 days
62	**HHRA Report**	160 days
63	Revised HHRA Report	30 days
64	**RI Report**	180 days
65	Presentation of Data	1 day
66	Agency Review	45 days
67	Meeting	1 day
68	**Agency Comments**	0 days
69	Revised RI Report	30 days
70	Remedial Action Objectives Technical Memorandum	30 days
71	Agency Review	30 days
72	Alternative Screening Technical Memorandum	30 days
73	Agency Review	30 days
74	Comparative Analysis of Alternatives Memorandum	60 days
75	Agency Review	30 days
76	**FS Report**	45 days
77	Agency review	30 days
78	Revised FS Report	30 days
79	**Agency approval**	0 days
80	**Treatability Study Work Plan (if warranted)**	45 days
81	Candidate Technologies and Testing Needs Technical Memorandur	30 days
82	EPA Review of Technical Memorandum	30 days
83	EPA Notice of Need for Treatability Testing	0 days
84	**Treatability Testing Work Plan and SAP**	30 days
85	Treatability Study HASP	30 days
86	Agency Review	30 days
87	Agency Comments	0 days
88	Revised Treatability Study Work Plan	15 days
89	Agency Review of Revised Treatability Study Work Plan	15 days
90	**Approve Revised Treatability Study Work Plan**	0 days
91	Pre Treatability Study Activities	60 days
92	Perform Treatability Study	180 days
93	Receive Analytical Results	30 days
94	Treatability Study Evaluation Report	60 days
95	**FS Report (if treatability study completed)**	90 days
96	Agency review	30 days
97	Revised FS Report	30 days
98	**Agency approval**	0 days
99	**Progress reports**	**1646 days**

Project: RIFS Schedule for WSB
Date: Fri 1/28/05

NSPW Task | Agency Task | Lab Task | Split | Progress | Milestone | Deadline