TETRA TECH

C-NAVY-05-10-3628W

May 14, 2010

Project Number G02574

Ms. Ginny Lombardo
U.S. EPA Region I
5 Post Office Square
Suite 100 (OSRR 07-3)
Boston, Massachusetts 02109-3912

Mr. Paul Kulpa
Rhode Island Department of Environmental Management
235 Promenade Street
Providence, Rhode Island 02908-5767

Reference: CLEAN Contract No. N62470-08-D-1001
Contract Task Order No. WE52

Subject: Responses to Comments, Final Technical Memorandum, Recreational Risk Assessment Additional Investigation, MRP Site 1, Carr Point, NAVSTA Newport, Portsmouth, Rhode Island

Dear Ms. Lombardo, Mr. Kulpa:

On behalf of Winoma Johnson, U.S. Navy NAVFAC, Tetra Tech NUS, Inc. (TtNUS) is providing responses to comments (RTCs) received from the U.S. Environmental Protection Agency (EPA) on the draft Technical Memorandum, Recreational Risk Evaluation, MRP Site 1, Carr Point, NAVSTA Newport, Rhode Island. No comments were received from Rhode Island Department of Environmental Management. The change noted in the RTCs has been incorporated into the document. The final Technical Memorandum is enclosed along with the RTCs.

If you have any questions regarding this material, please do not hesitate to contact me.

Very truly yours,

Thomas Campbell

Thomas Campbell
Project Manager

TAC/lh

Encl.

c: D. Barclift, NAVFAC Mid-Atlantic (1, w/encl.)
W. Johnson, NAVFAC Mid-Atlantic (1, w/encl.)
P. Golonka, Gannett Fleming (2, w/encl.)
C. Mueller, NAVSTA (2, w/encl.)
NAVSTA Administrative Record (c/o G. Wagner, TtNUS) (w/encl.)
J. Trepanowski (w/encl.)
G. Glenn, TtNUS (w/o encl.)
L. Sinagoga, TtNUS (w/ encl.)
File 2574-3.2 (w/o encl.) File 2574-8.0 (w/encl.)

Tetra Tech NUS, Inc.
55 Jonspin Road, Wilmington, MA 01887-1020
Tel 978.474.8400 Fax 978.474.8499 www.ttnus.com

Technical Memorandum
Recreational Risk Evaluation
MRP Site 1, Carr Point
NAVSTA Newport, Rhode Island

1.0 INTRODUCTION

This Technical Memorandum was prepared by Tetra Tech, NUS (Tetra Tech), for the U.S. Department of Navy (Navy) to evaluate potential risk to human health at the MRP Site 1, Carr Point, NAVSTA Newport, Portsmouth, Rhode Island. The Technical Memorandum documents the findings of a focused risk evaluation for the recreational vehicle camping park (RVCP) portion of the MRP Site 1. MRP Site 1, Carr Point is part of Naval Station (NAVSTA) Newport, and is located within the Town of Portsmouth, Rhode Island. This memorandum was completed on behalf of the Navy's Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, under the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62470-08-D-1001, Contract Task Order (CTO) WE52.

The RVCP is utilized by Navy and Department of Defense (DOD) personnel between Memorial Day and October 30. The park is the former location of firing arcs where a recreational skeet range was based. The RVCP is a grass covered area with six water and electricity hook-up areas for RVs and is currently scheduled to re-open in May 2010 (Figure 1-1).

A Site Investigation (SI) was completed for the Carr Point Site in 2009. SI sampling analytical data collected in the RVCP (two soil borings SB-01 and SB-09) indicates the presence of elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and lead in the surface soil at the three former firing areas. It is suspected that the source of the PAHs is clay targets which were historically manufactured with petroleum pitch, and were blended with clay. Fragments of broken targets were observed at several of the SI soil sample locations in the RVCP. Please see the SI report for more detailed information on this investigation.

As part of the SI report, a Human Health Screening Evaluation (Tetra Tech, 2009a) was conducted for the entire Carr Point Site using the SI data set. PAHs including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were identified as carcinogenic risk drivers in surface soil with individual risk estimates exceeding 1E-6. Lead was also retained as a contaminant of potential concern.

This focused risk assessment was conducted to evaluate human health risk specifically in the RVCP. Samples collected during the 2009 SI and additional samples collected in January 2010 were evaluated. The 2009 SI samples included in this evaluation are two soil borings conducted in the RVCP, SB-01 and

SB-09. Analytical data from the surficial interval, 0 to 1 foot below ground surface (bgs), were evaluated (Table 1-1). Multi increment (MI) samples collected from the firing arcs in 2009 were not included in this risk assessment because of their sample interval (0 to 2 inches bgs) and because of their composite sample characteristic.

To augment the SI samples, 36 additional surficial soil samples were collected in January 2010. Samples were collected from a sample grid consisting of 24 locations in the RVCP. The approximate size of the sample grid was 3,600 ft^2, consisting of 24 equally sized squares. Samples were collected at the intersections of each grid line using a combination of stainless steel trowel and a hand auger; the 0-6 inch interval was collected using the trowel while the 6-12 inch interval was collected using the hand auger. Twenty-four samples were collected from 0 - 6 inches bgs (one at each location), and 12 samples were collected from the 6-12 inch interval (one at every other location). The sample material collected was placed into a disposable aluminum pan and homogenized; grass was removed, roots remained, and as much as possible clay pigeon fragments and gravel were removed. Soil characteristics and field observations were logged on field data sheets and are summarized in Table 1-2. Figure 1-2 shows locations of surface soil samples from the 2010 event.

All samples were sent to Empirical Laboratories in Nashville, TN, and were analyzed for PAHs and lead.

Samples collected in January 2010 were submitted for PAH and lead analysis. Detected compounds and lead are summarized in Table 1-3. The distribution of benzo(a)pyrene and lead concentrations are shown in Figures 1-3 and 1-4. Concentrations of contaminants were compared to Rhode Island Department of Environmental Management (RIDEM) Residential Direct Exposure Criteria (RISORES). The distribution of contaminant concentrations places the highest concentrations in the western grid row. In addition, samplers observed clay pigeon fragments in sample locations from the west row.

2.0 SECTION: FOCUSED HUMAN HEALTH RISK ASSESSMENT

Section 2 presents the results of a focused Human Health Risk Assessment (HHRA) of chemical concentrations detected in the surface soils in the vicinity of the RVCP located within MRP Site 1, Carr Point at NAVSTA Newport. Background soil concentrations published in the 2008 Basewide Background Study Report for Naval Station Newport (Tetra Tech, July 2008) are referenced in this HHRA.

This HHRA is limited to an evaluation of receptors exposed to surface soils as a result of the current, limited recreational use of the RVCP area. The assessment is not a comprehensive baseline HHRA and is not intended to provide an evaluation of all receptors (and land use scenarios) typically evaluated in a baseline HHRA prepared for a CERCLA site. (Such an assessment will be completed during the preparation of the remedial investigation [RI] report for MRP Site 1.) This assessment is specifically intended to assess risks to current recreational receptors (campers, RV users) and to identify areas that may be targeted for an interim action so that the RVCP may open for the 2010 summer season. Information on the selection of chemicals of potential concern (COPC), exposure assessment, toxicity assessment, risk characterization, uncertainty analysis, and summary and conclusions for the risk screening are contained in Sections 2.1, 2.2, 2.3 2.4, 2.5, and 2.6, respectively.

2.1 CHEMICALS OF POTENTIAL CONCERN SELECTION

COPCs are target analytes detected in an environmental media that are selected for evaluation in a risk assessment. A chemical was selected as a COPC for the surface soils of the RVCP area if the maximum detected concentration exceeded screening criteria derived from the risk-based regional screening levels (RSLs). The RSLs were developed and are maintained through a cooperative agreement between Oak Ridge National Laboratory and USEPA's Office of Superfund, and are considered to be USEPA screening criteria (USEPA, December 2009). The RSLs are chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1 [adverse non-carcinogenic health effects are not anticipated] for non-carcinogenic chemicals or an incremental lifetime cancer risk of 1E-06 [i.e., a one-in-one million probability of developing cancer] for carcinogenic chemicals). One-tenth the RSL is typically recommended by U.S. EPA Region 1 as the COPC screening criteria for non-carcinogenic compounds to account for the potential cumulative effects of multiple compounds affecting the same target organ or producing the same target effect. The RSL is the COPC screening criteria recommended by U.S. EPA Region 1 for carcinogens. Conservatively, RSLs based on the residential land use scenario are the basis of the COPC screening criteria.

Table 2-1 presents the results of the COPC selection conducted for surface soils in the RVCP area. The screening is based on analytical data available for the surface soils samples listed in Table 2-2. The

following chemicals were selected as COPCs based on a comparison of maximum detected concentrations to the COPC screening criteria:

Summary of Surface Soil COPCs

Chemical	Maximum Concentration (mg/kg)	COPC Screening Level (mg/kg)	Basewide Background Concentration (mg/kg)
Benzo(a)pyrene Equivalents (BaP_{equiv})	425	0.015 C	NA
Benzo(ghi)perylene	223	170 N	NA
Fluoranthene	332	230 N	NA
Naphthalene	8.21	3.6 C	NA
Phenanthrene	208	170 N	NA
Pyrene	316	170 N	NA
Aluminum	13400	7700 N	11800
Arsenic	15.1	0.39 C	4.03
Chromium	19.4	0.29 C	9.87
Cobalt	15.3	2.3 N	2.87
Iron	31200	5500 N	13800
Lead	572	400	10.8
Manganese	543	180 N	141

The following carcinogenic PAHs (cPAHs) listed in Table 2-1 are presented above in terms of benzo(a)pyrene equivalents (BaP_{equiv}) concentrations: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, and indeno(1,2,3-CD)pyrene. Toxicity equivalency factors (TEFs) were used to convert the concentrations of these cPAHs into equivalent concentrations of benzo(a)pyrene which were then summed (on a per sample basis) to represent the BaP_{equiv} concentrations evaluated in the HHRA (USEPA, 1993).

2.2 EXPOSURE ASSESSMENT

This section presents the exposure assessment component of the HHRA for the surface soils at the RVCP. Receptors are identified and the methodology used to determine chemical intake resulting from exposure to surface soils is presented.

Two types of receptors were considered in this HHRA based on the current, limited recreational use of the area:

- ***Individuals or families (including small children) renting camping space at the RVCP.*** Based on information provided by the Facility, these campers typically rent space for one or two weeks during the summer season (May through September). The Facility further indicates that some families may return for multiple years (e.g., a five-year utilization rate is not atypical for the campers at the RVCP).

- ***Workers performing maintenance activities (e.g., mowing the grass) or other duties (e.g., collecting rents) at the RVCP.*** Typically, these duties require the worker to visit the RVCP on an infrequent basis (i.e., approximately one day a week during the warm weather months).

It was assumed that these receptors would be exposed to COPCs in surface soils as a result of direct contact exposure to soils (i.e., incidental ingestion of small amounts of soils and dermal contact with soils) or as a consequence of the inhalation of soil particulates (dusts) emitted into the air. The worker was assumed to be an adult receptor. However, because families utilize the RVCP, three different receptor age groups were evaluated for the recreational user:

- A young child in the 0 to 6 year age group.
- An older child in the 7 to 16 year age group.
- An adult.

It was assumed that an individual from any one of these age groups could return to the RVCP for five consecutive years. These receptors are referred to as the “child recreational”, “older child recreational”, and “adult recreational” user in this narrative. As an alternate case, it was assumed that an individual living in the New England region may routinely visit the RVCP *many years* over the course of a lifetime [e.g., 6 years as a young child and 24 years as an adult]. This receptor is referred to as the “lifetime recreational user” receptor in this narrative. It should be noted that a 30-year exposure duration (assuming 6 years exposure as a small child and 24 years exposure as an adult) is typically recommended by EPA when evaluating a residential land use scenario. Consequently, it is a conservative assumption when evaluating a recreational land use scenario.

The exposure factor assumptions used to quantitatively estimate COPC intake are summarized in Tables 2-3 and 2-4. Both Reasonable Maximum Exposure (RME) (Table 2-3) and Central Tendency Exposure (CTE) (Table 2-4) cases were evaluated. (The RME case is intended to represent a reasonable upper-bound case scenario whereas the CTE case is intended to represent an average case scenario.) With the following exceptions, the exposure factor assumptions are those recommended in standard EPA risk assessment guidance documents:

1. The exposure frequency assumptions for the recreational user were 7 days per year and 14 days per year for the CTE and RME case, respectively, and were based on Facility information that recreational users rent a camp site for one or two weeks during the warm weather months.

2. The exposure frequency assumption for the worker was 26 days per year for both the RME and CTE case, and is based on the assumption that a maintenance worker would mow the grass in the RVCP area approximately one day per week for six months.

The equations used to estimate COPC intake are presented in Attachment A. These equations are used in the HHRA for the evaluation of all COPCs with the exception of lead. The risk evaluation of lead is further addressed in Section 2.4, Risk Characterization.

The exposure point concentration (EPC) is the COPC concentration to which the receptor is exposed. Per U.S. EPA guidance, the arithmetic mean concentration is recommended as the EPC for lead and the 95 percent upper confidence limit (UCL) on the arithmetic mean is recommended as the EPC for other chemicals. EPCs are calculated following *U.S. EPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (U.S. EPA, 2002) and using U.S. EPA Pro-UCL Version 4.00.04. Table 2-5 presents the EPCs for all chemicals selected as COPCs.

2.3 TOXICITY ASSESSMENT

The toxicity assessment component of a HHRA identifies the potential adverse health effects of the COPCs. More specifically, the toxicity assessment presents quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects for each COPC. These quantitative estimates of toxicity or toxicity criteria (presented in terms of reference doses [RfDs] and reference concentrations [RfCs] for potential non-cancer effects, and cancer slope factors [CSFs] and inhalation unit risks [IURs] for cancer effects) are summarized for the RVCP COPCs in Table A-1 (Attachment A). These toxicity criteria are more formally defined in Attachment A. However, in brief, an RfD/RfC is the dose/concentration at which or below which adverse non-carcinogenic health effects are not anticipated. The lower the RfD/RfC the more potent/hazardous the chemical is in terms of the potential to produce non-cancer health effects. The CSFs/IURs are estimates/indicators of the potency of a carcinogenic chemical. The higher the CSF/IUR the more potent the carcinogen is predicted to be (i.e., the more likely it is a receptor exposed to the chemical will develop cancer).

2.4 RISK CHARACTERIZATION

The risk characterization of the COPCs selected for the surface soils at the RVCP is presented in Tables 2-6 and 2-7 for the RME and CTE case, respectively. Cancer risk estimates (i.e., the probability of developing cancer) and non-cancer hazard indices (an indicator of the potential for adverse non-cancer effects) were developed based on the intakes calculated per the methodology referenced in Section 2.2 and the toxicity criteria referenced in Section 2.3. The equations used to calculate the cancer risk estimates (i.e., the probability of developing cancer) and non-cancer hazard indices (HIs) are presented in Attachment A. The RAGS Part D tables are presented in Attachment B. A summary of the risk characterization results is provided in the following table:

Summary of Cancer and Non-Cancer Risk Estimates for Recreational and Worker Exposure to COPCs in Surface Soil at the RVCP

Receptor	Total Cancer Risk Estimate - RME Case	Total Non-Cancer Hazard Index (HI) - RME Case	Total Cancer Risk Estimate - CTE Case	Total Non-Cancer Hazard Index (HI) - CTE Case
Maintenance Worker	**2E-05** (cPAHs)	<1	4E-06	<1
Child Recreational User	**6E-04** (cPAHs)	<1	**1E-04** (cPAHs)	<1
Older Child Recreational User	**5E-05** (cPAHs)	<1	1E-05	<1
Adult Recreational User	**1E-05** (cPAHs)	<1	2E-06	<1
Lifetime Recreational User	**7E-04** (cPAHs)	NA	**6E-05** (cPAHs)	NA

1 Bolded carcinogenic risk estimates exceed the State of Rhode Island cancer risk limit of 1E-05. A chemical name presented in parentheses indicates the ***primary*** chemical driving risk. Specifically, a chemical with risk estimates exceeding the State of Rhode Island cancer risk benchmark of 1E-05.

HIs developed for all receptors are less than one indicating that adverse non-carcinogenic health effects are not anticipated under the conditions established in the exposure assessment. However, cancer risk estimates developed for all receptors exceed 1E-05 (i.e., a one-in-one-hundred thousand probability of developing cancer), the State of Rhode Island cumulative cancer risk benchmark. Additionally, the

cancer risk estimates developed for the child recreational user and the lifetime recreational user exceed the U.S.EPA target risk range of 1E-04 to 1E-06 (i.e., a one-in-ten thousand to one-in-one million probability of developing cancer). However, only the risk estimates developed for the cPAHs exceed 1E-05. As noted above, the cPAHs were evaluated in terms of BaP_{equiv} concentrations.

The cancer and non-cancer risk estimates developed in the preceding table are based on the evaluation of the EPC calculated for the study area as detailed in Section 2.2. Alternatively, Figure 2-1 displays cancer risk estimates on a location-by-location basis. Locations with cancer risk estimates exceeding 1E-04 are color-coded with red dots; locations with cancer risk estimates exceeding 1E-05 but less than 1E-04 are color coded with blue dots. The cancer risk estimates for all other locations are less than 1E-05. The results presented on Figure 2-1 indicate that risk estimates are highest for locations closest to Narragansett Bay and lowest at locations distant from the Bay. These results are as expected based on the cPAH concentration distribution described in Section 1.

As noted above, this assessment is limited to the evaluation of receptors associated with the current recreational use of the RVCP. However, the following comparisons of EPCs to reference points such as the U.S.EPA RSLs and State of Rhode Island criteria provide additional perspective for the cPAH concentrations detected:

- The EPC for the cPAHs (in terms of BaP_{equiv} concentrations) is 266 mg/kg and is orders of magnitude greater than the EPA RSLs for the hypothetical future resident (0.015 mg/kg) or the typical industrial worker (0.21 mg/kg). This indicates that risk estimates for these receptors would exceed 1E-04 if such receptors were evaluated using the risk assessment methodology used to develop the U.S.EPA RSLs.

- The EPC for the cPAHs (in terms of BaP_{equiv} concentrations) is also orders of magnitude greater than the State of Rhode Island direct contact criteria for the industrial and residential land use scenario (0.8 and 0.4 mg/kg, respectively).

As noted above, lead was selected as a COPC for the RVCP because the maximum detected concentration (572 mg/kg) exceeds both the U.S.EPA RSL (400 mg/kg) and the State of Rhode Island direct contact criterion (150 mg/kg) for soil assuming residential land use scenario. However, per U.S.EPA risk assessment protocol, the arithmetic mean concentration should be selected as the EPC when evaluating exposure to lead. As noted in Table 2-5, the arithmetic mean lead concentration in the surface soils of the RVCP 130 mg/kg does not exceed 400 mg/kg. As expected, an assessment of this arithmetic mean lead concentration via the typical EPA risk assessment models for lead does not result in

risk assessment results at variance with stated EPA goals regarding receptor exposure to lead (see model outputs presented in Attachment B).

2.5 UNCERTAINTY ANALYSIS

The most significant source of uncertainty in this HHRA is the fact that fragments of clay targets used at the old skeet range are the likely source of the cPAHs detected in the surface soils at the RVCP. Based on information in the technical articles presented in Attachment C, cPAHs associated with the clay matrix of targets are tightly bound to that matrix. Consequently, the cPAHs are anticipated to be less bioavailable than is generally assumed by current U.S.EPA risk assessment guidance documents for the evaluation of receptor exposure to cPAHs in soils. In fact, a review of the scientific literature (Attachment C) as well as guidelines published by the Massachusetts Department of Environmental Protection (MassDEP) demonstrates that the absorption of cPAHs in contaminated soils (not to mention the clay fragments) may differ from the absorption observed in the toxicity studies used to develop the toxicity criteria for the cPAHs. Specifically, MassDEP used relative absorption factors (RAFs) in the development of their MCP Method 1 Standards for soils. These RAFs were incorporated into MCP Method 1 Standards in order to adjust for differences in chemical absorption efficiencies between different environmental matrices and exposure routes/matrices evaluated in the laboratory versus environmental exposures (MassDEP April 1994). Toxicity information and the resultant toxicity criteria based on laboratory experiments, and the exposure routes (e.g., oral, dermal, inhalation) and matrices (e.g., oil, food) used in the laboratory may differ from anticipated exposure routes/matrices anticipated for human exposures at a site. The RAFs recommended by the MassDEP are intended to make the site exposures evaluated comparable to the available laboratory toxicity data (MassDEP July 1995).

The process used for RAF development is similar to the “Adjustment for Absorption Efficiency” guidance that is presented in Appendix A of the USEPA (1989) Risk Assessment Guidance for Superfund. MassDEP calculated RAFs according to the following equation (MassDEP July 1995):

$$RAF = \frac{Absorption\ Efficiency_{SITE\ route/medium\ of\ exposure}}{Absorption\ Efficiency_{STUDY\ route/medium\ of\ exposure}}$$

MassDEP has developed the following RAF values for PAHs in soil:

Exposure Route	RAF
Oral	0.36 (noncarcinogenic)
	0.28 (carcinogenic)
Dermal	0.1 (noncarcinogenic)
	0.02 (carcinogenic)

These RAFs are based on laboratory toxicological evaluations (MassDEP July 1995). Magee *et al.* (1996) (Attachment C) incorporated similar toxicological study results into the development of absorption adjustment factors (AAFs) for PAHs and obtained AAFs that were similar to the MassDEP RAFs for the carcinogenic PAHs via oral and dermal exposure pathways and noncarcinogenic PAHs via the dermal pathway. Cancer risk estimates developed for the RVCP site based on the MassDEP RAFs for the RME and CTE scenarios are presented in Tables 2-8 and 2-9 respectively. The total cancer risk estimate for the lifetime recreational user developed using the RAFs for the RME scenario is 2E-04; the total cancer risk estimate for the lifetime recreational user developed without use of the RAFs for the RME scenario (Table 2-6) is 7E-04. The total cancer risk estimate for the lifetime recreational user developed using the RAFs for the CTE scenario is 2E-05; the total cancer risk estimate for the lifetime recreational user developed without use of the RAFs for the CTE scenario (Table 2-7) is 6E-05.

Figure 2-2 displays cancer risk estimates on a location-by-location basis based on the MassDEP RAFs. Locations with cancer risk estimates exceeding 1E-04 are color-coded with red dots; locations with cancer risk estimates exceeding 1E-05 but less than 1E-04 are color coded with blue dots. The cancer risk estimates for all other locations are less than 1E-05. The results presented on Figure 2-2 indicate that risk estimates are highest for locations closest to Narragansett Bay and lowest at locations distant from the Bay.

The use of the MassDEP RAFs for PAH intake calculations at Carr Point may still result in an overestimation of human health risk to PAHs in site soil. As stated above, this is because the PAHs present at the site are largely a result of the clay targets previously used in the former skeet range. A toxicity evaluation of a former skeet range conducted by Baer *et al.* (1995) found that although trap and skeet shooting targets contained substantial levels of PAHs, PAH concentrations measured in the sediment and marine animals at the site were not higher, and in some instances lower, than surrounding areas. It was concluded that PAHs were likely bound to the petroleum pitch and limestone matrix of the targets and were not likely to be available in the environment (Baer *et al*. 1995). Similarly, a risk assessment conducted at a former skeet range at Alameda Point evaluated PAH contamination from clay targets and determined that PAHs in clay targets were not the source of PAHs detected in site sediments. This conclusion was reached because the PAHs concentrations in site sediment were chemically distinct from the PAHs detected in the clay targets (Battelle, September 2005). Based on these findings, the use of the MassDEP RAFs for PAHs in the Carr Point risk evaluation should still provide conservative risk estimates. (The referenced scientific literature is presented in Attachment C).

<u>Note:</u> The use of the RAFs is MassDEP methodology, not U.S. EPA Region I endorsed risk assessment methodology. U.S. EPA risk guidance does not recommend the use of RAFs in human health risk assessment.

2.6 SUMMARY AND CONCLUSIONS

This technical memorandum presents the results of a focused HHRA of chemical concentrations detected in the surface soils at the RVCP located within MRP Site 1, Carr Point at NAVSTA Newport. The assessment was limited to an evaluation of receptors exposed as a result of the current, limited recreational use of the area (i.e., recreational users renting camp sites at the RVCP and maintenance workers) and was based on surface soil data collected in 2009 and 2010. This assessment is specifically intended to assess risks to these receptors and to identify areas that may be targeted for an interim action so that the RVCP may open for the 2010 summer season. Several organic and inorganic chemicals were selected as COPCs. However, cPAHs are the predominant COPCs and only the cancer risk estimates developed for the cPAHs exceed the U.S.EPA target cancer risk range of 1E-04 to 1E-06 and the State of Rhode Island cumulative cancer risk benchmark of 1E-05. The observed cPAH contamination is not uniform across the area of concern. All of the locations demonstrating cancer risk estimates exceeding 1E-04 are situated within approximately 50 to 100 feet of the Narragansett Bay shoreline and are associated with locations where clay target fragments were found (see Figure 2-1). Cancer risk estimates for most locations more distant from the Narragansett Bay shoreline do not exceed 1E-05; none of the locations more distant from Narragansett Bay shoreline exceed 1E-04. A significant source of uncertainty in this HHRA is the fact that fragments of clay targets used at the old skeet range are the likely source of the cPAHs detected in the surface soils at the RVCP. A review of the scientific literature suggests that these cPAHs are tightly bound to the clay matrix of the targets and bioavailability to human or ecological receptors is limited. Consequently, the risk estimates presented in this technical memorandum should be viewed as very conservative and likely overestimate the true potential for risks to persons using the site for passive recreation.

TABLES

TABLE 1-1
ANALYTICAL RESULTS - DETECTED COMPOUNDS IN SURFACE SOIL
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID	PAL	RES RSL	CRP-SB01-0001	CRP-SB09-0001
LOCATION ID			CRP-SB01	CRP-SB09
SAMPLE DATE			05/12/09	05/12/09
TOP DEPTH			0 FT	0 FT
BOTTOM DEPTH			1 FT	1 FT
QC			NORMAL	NORMAL
VOLATILES (UG/KG)				
2-BUTANONE	10000000	2800000	72 UJ	80 UJ
ACETONE	7800000	6100000	72 UJ	80 UJ
BENZENE	2500	1100	7.2 U	8 U
BROMODICHLOROMETHANE	10000	280	7.2 U	8 U
CARBON DISULFIDE		67000	7.2 U	8 U
CHLOROFORM	1200	300	7.2 U	8 U
CIS-1,2-DICHLOROETHENE	630000	78000	7.2 U	8 U
ETHYLBENZENE	71000	5700	7.2 U	8 U
ISOPROPYLBENZENE	27000	220000	7.2 U	8 U
METHYL CYCLOHEXANE			7.2 U	8 U
METHYLENE CHLORIDE	45000	11000	14 U	16 U
TETRACHLOROETHENE	12000	570	7.2 U	8 U
TOLUENE	190000	500000	7.2 U	8 U
TOTAL 1,2-DICHLOROETHENE		70000	7.2 U	8 U
TOTAL XYLENES	110000	60000	7.2 U	8 U
TRICHLOROETHENE	13000	2800	7.2 U	8 U
VINYL CHLORIDE	20	60	14 U	16 U
SEMIVOLATILES (UG/KG)				
1,1-BIPHENYL	800	390000	2000 U	300 J
2-METHYLNAPHTHALENE	29000	31000	2000 U	1400 J
ACENAPHTHENE	29000	340000	2000 U	15000
ACENAPHTHYLENE	23000	340000	2000 U	2000 U
ANTHRACENE	29000	1700000	2000 U	16000 J
BENZO(A)ANTHRACENE	900	150	1100 J	91000 J
BENZO(A)PYRENE	400	15	1700	120000
BENZO(B)FLUORANTHENE	900	150	1200 J	130000
BENZO(G,H,I)PERYLENE	800	170000	1300 J	78000
BENZO(K)FLUORANTHENE	900	1500	280 J	47000
CARBAZOLE			4000 U	11000
CHRYSENE	400	15000	1600 J	100000 J
DIBENZO(A,H)ANTHRACENE	400	15	400 U	22000 J
DIBENZOFURAN			2000 U	3500
FLUORANTHENE	20000	230000	870 J	110000 J
FLUORENE	28000	230000	2000 U	6100
INDENO(1,2,3-CD)PYRENE	900	150	1400 J	81000
NAPHTHALENE	29000	3900	2000 U	3700
N-NITROSODIPHENYLAMINE		99000	2000 U	2000 U
PHENANTHRENE	29000	170000	620 J	63000
PYRENE	1100	170000	1500 J	120000

PAL=PROJECT ACTION LIMIT-SEE TEXT;RES RSL=RESIDENTIAL REGIONAL SCREENING LEVEL (USEPA)
BLACK SHADING-EXCEEDS AT LEAST ONE CRITERION;GRAY SHADING-DETECTED;U-NOT DETECTED;
J-QUANTITATION APPROXIMATE; R-REJECTED; NA-NOT ANALYZED

TABLE 1-1
ANALYTICAL RESULTS - DETECTED COMPOUNDS IN SURFACE SOIL
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID	PAL	RES RSL	CRP-SB01-0001	CRP-SB09-0001
LOCATION ID			CRP-SB01	CRP-SB09
SAMPLE DATE			05/12/09	05/12/09
TOP DEPTH			0 FT	0 FT
BOTTOM DEPTH			1 FT	1 FT
QC			NORMAL	NORMAL
PESTICIDES/PCBS (UG/KG)				
4,4'-DDD		2000	1.2 J	3.6 J
4,4'-DDE		1400	1.2	30
4,4'-DDT	21	1700	3.4 J	62
ALPHA-BHC		77	0.4 U	0.41 U
ALPHA-CHLORDANE	500	1600	0.4 U	0.41 U
AROCLOR-1260	371	220	19	20 U
DIELDRIN	4.9	30	3 UJ	7 UJ
ENDOSULFAN I		37000	0.4 U	0.41 U
ENDOSULFAN II		37000	0.8 U	0.81 U
ENDOSULFAN SULFATE		37000	0.8 U	0.81 U
ENDRIN		1800	0.8 U	0.81 U
ENDRIN ALDEHYDE		1800	0.8 U	0.81 U
ENDRIN KETONE		1800	0.8 U	0.81 U
GAMMA-BHC (LINDANE)		520	0.79	5.3
GAMMA-CHLORDANE	500	1600	0.4 U	0.41 U
HEPTACHLOR EPOXIDE		53	0.4 U	0.41 U
PROPELLANTS (MG/KG)				
2,4-DINITROTOLUENE	0.9	1.6	NA	NA
NITROGLYCERIN	6.1	0.61	NA	NA
METALS (MG/KG)				
ALUMINUM		7700	13400 J	11100 J
ANTIMONY	0.27	3.1	1.8 UJ	2.2 J
ARSENIC	7	0.39	13.6 J	15.1 J
BARIUM	330	1500	25.9 J	37 J
BERYLLIUM	0.4	16	0.33 J	0.36 J
CADMIUM	0.36	7	0.45	0.5
CALCIUM			2310 J	14200 J
CHROMIUM	26	280	19.4 J	13.4 J
COBALT	13	2.3	15.3	8.5
COPPER	28	310	25.2	22.5
IRON		5500	31200	20100
LEAD	11	400	438 J	572 J
MAGNESIUM			3810 J	4590 J
MANGANESE	220	180	543	311
MERCURY	0.1	0.43	0.03 J	0.067
NICKEL	38	150	31.3	16.5
POTASSIUM			338 J	497 J
SELENIUM	0.52	39	0.44	0.63
SILVER	4.2	39	0.18 U	0.1 J
SODIUM			292 U	301 U
VANADIUM	7.8	39	18.8	19.2
ZINC	46	2300	124	217
PETROLEUM HYDROCARBONS (MG/KG)				
DIESEL RANGE ORGANICS	500		200	5600
GASOLINE RANGE ORGANICS	500		3.2 U	3.5 U

PAL=PROJECT ACTION LIMIT-SEE TEXT;RES RSL=RESIDENTIAL REGIONAL SCREENING LEVEL (USEPA)
BLACK SHADING-EXCEEDS AT LEAST ONE CRITERION;GRAY SHADING-DETECTED;U-NOT DETECTED;
J-QUANTITATION APPROXIMATE; R-REJECTED; NA-NOT ANALYZED

TABLE 1-2
FIELD OBSERVATIONS - JANUARY 2010
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID		DEPTH INTERVAL	CLAY PIGEON FRAGMENTS
WEST ROW	CRP-SS100-0006	0-6"	MANY
	CRP-SS100-0612	6-12"	FEW
	CRP-SS101-0006	0-6"	SOME
	CRP-SS102-0006	0-6"	SOME
	CRP-SS102-0612	6-12"	NONE
	CRP-SS103-0006	0-6"	SOME
	CRP-SS104-0006	0-6"	FEW
	CRP-SS104-0612	6-12"	TRACE
	CRP-SS105-0006	0-6"	FEW
	CRP-SS106-0006	0-6"	FEW
	CRP-SS106-0612	6-12"	NONE
	CRP-SS107-0006	0-6"	TRACE
MIDDLE ROW	CRP-SS108-0006	0-6"	NONE
	CRP-SS108-0612	6-12"	NONE
	CRP-SS109-0006	0-6"	TRACE
	CRP-SS110-0006	0-6"	NONE
	CRP-SS110-0612	6-12"	NONE
	CRP-SS111-0006	0-6"	NONE
	CRP-SS112-0006	0-6"	NONE
	CRP-SS112-0612	6-12"	NONE
	CRP-SS113-0006	0-6"	NONE
	CRP-SS114-0006	0-6"	NONE
	CRP-SS114-0612	6-12"	NONE
	CRP-SS115-0006	0-6"	NONE
EAST ROW	CRP-SS116-0006	0-6"	NONE
	CRP-SS116-0612	6-12"	NONE
	CRP-SS117-0006	0-6"	NONE
	CRP-SS118-0006	0-6"	NONE
	CRP-SS118-0612	6-12"	NONE
	CRP-SS119-0006	0-6"	NONE
	CRP-SS120-0006	0-6"	NONE
	CRP-SS120-0612	6-12"	NONE
	CRP-SS121-0006	0-6"	NONE
	CRP-SS122-0006	0-6"	NONE
	CRP-SS122-0612	6-12"	NONE
	CRP-SS123-0006	0-6"	NONE

Quantities of fragments (many, some, few and trace) were estimated in represent a calculated percentage of fragments observed

MANY > 50%

SOME = 50-30%

FEW = 30-10%

TRACE = 1-10%

NONE = no fragments observed

TABLE 1-3
ANALYTICAL RESULTS - DETECTED COMPOUNDS IN SURFACE SOIL (JANUARY 2010)
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID		CRP-SS100-0006	CRP-SS100-0612	CRP-SS101-0006	CRP-SS101-0006-D	CRP-SS101-0006-AVG	CRP-SS102-0006	CRP-SS102-0612	CRP-SS103-0006	CRP-SS104-0006	CRP-SS104-0612	CRP-SS105-0006	CRP-SS106-0006	CRP-SS106-0612	CRP-SS107-0006	CRP-SS108-0006
LOCATION ID		CRP-SS100	CRP-SS100	CRP-SS101	CRP-SS101	CRP-SS101	CRP-SS102	CRP-SS102	CRP-SS103	CRP-SS104	CRP-SS104	CRP-SS105	CRP-SS106	CRP-SS106	CRP-SS107	CRP-SS108
SAMPLE DATE		01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10
TOP DEPTH		0 FT	0.5 FT	0 FT	0 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT
BOTTOM DEPTH		0.5 FT	1 FT	0.5 FT	0.5 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT
SACODE		NORMAL	NORMAL	ORIG	DUP	AVG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG
QC TYPE	RISO RES	NM	NM	NM	FD	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
POLYCYCLIC AROMATIC HYDROCARBONS (MG/KG)																
2-METHYLNAPHTHALENE	123	3.13 J	1.19 J	0.793 J	0.669 J	0.731 J	3.11 J	2.68 J	2.9 J	1.26 J	0.17 U	2.02	0.292 J	0.164 U	0.174 U	0.189 U
ACENAPHTHENE	43	35	15.7	6.42	6.23	6.325	26.2	37.1	18.4	14.4	0.436	20.9	0.919	0.164 U	0.174 U	0.244 J
ACENAPHTHYLENE	23	4.78 U	0.247 J	0.795 U	1.01 U	0.9025 U	4.33 U	4.26 U	4.36 U	0.88 U	0.17 U	0.935 U	0.1 J	0.0982 J	0.071 J	0.189 U
ANTHRACENE	35	45.1	22.8	10.1	10.8	10.45	35	57.1	28.2	23.4	0.701	32.6	2.07	0.115 J	0.15 J	0.471
BAP EQUIVALENT-HALFND		425.406	158.6957	111.2742	116.239	113.7566	357.701	378.535	323.099	160.661	7.76604	284.021	44.0369	0.892311	0.514072	5.45913
BAP EQUIVALENT-POS		425.406	158.6957	111.2742	116.239	113.7566	357.701	378.535	323.099	160.661	7.76604	284.021	44.0369	0.892311	0.514072	5.45913
BENZO(A)ANTHRACENE	0.9	258	93.2	76.2	78.4	77.3	242	239	223	114	4.65	207	40	0.609	0.441	3.55 J
BENZO(A)PYRENE	0.4	293	107	76.5	81.9	79.2	244	260	223	107	5.28	191	33.1	0.624	0.342 J	3.85 J
BENZO(B)FLUORANTHENE	0.9	264	115	62.6	72.4	67.5	222	270	172	108	4.95	185	16.5	0.585	0.364	3.34 J
BENZO(G,H,I)PERYLENE	0.8	223	87.2	52.5	50.3	51.4	169	178	144	71.8	3.98	114	14.3	0.411	0.224 J	2.49 J
BENZO(K)FLUORANTHENE	0.9	89	40	21.8	25.1	23.45	80.1	108	59.6	39.2	1.86	66.7	4.63	0.241 J	0.154 J	1.21 J
CHRYSENE	0.4	316	95.7	96.2	108 J	102.1 J	300	255	303	129	6.44	254	54.6	0.901	0.632	5.03 J
DIBENZO(A,H)ANTHRACENE	0.4	57.9	21.1	15.6	13.7	14.65	49.9	46.1	47.3	23	1.12	40.6	4.43	0.109 J	0.0672 J	0.674
FLUORANTHENE	20	277	137	64.1	73.6	68.85	214	332	165	128	5.1	178	11	0.74	0.761	3.2
FLUORENE	28	18	9.88	4.01	3.47	3.74	13.1	23.8	12.3	9.79	0.255 J	14.4	0.527	0.164 U	0.0526 J	0.164 J
INDENO(1,2,3-CD)PYRENE	0.9	211	92.8	49.8	52	50.9	163	202	124	79.4	3.81	123	7.56	0.366	0.222 J	2.29 J
NAPHTHALENE	54	8.21 J	3.2	1.31 J	2.24	1.775 J	7.49 J	5.44 J	8.21 J	1.9	0.0878 J	2.5	0.43	0.164 U	0.174 U	0.0686 J
PHENANTHRENE	40	184	90.1	43.7	41.9	42.8	129	208	112	85.1	3	118	13	0.406	0.612	1.91 J
PYRENE	13	316	126	77.9	83.8	80.85	258	296	227	124	5.28	195	41.8	0.884	0.81	3.91 J
METALS (MG/KG)																
LEAD	150	150	112	272	304	288	181	158	183	208	63.1	265	502	154	63.4	76

BLACK SHADING-EXCEEDS AT LEAST ONE CRITERION; GRAY SHADING-DETECTED;
U-NOT DETECTED; J-QUANTITATION APPROXIMATE; R-REJECTED; NA-NOT ANALYZED

TABLE 1-3
ANALYTICAL RESULTS - DETECTED COMPOUNDS IN SURFACE SOIL (JANUARY 2010)
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID		CRP-SS108-0006-D	CRP-SS108-0006-AVG	CRP-SS108-0612	CRP-SS109-0006	CRP-SS110-0006	CRP-SS110-0612	CRP-SS111-0006	CRP-SS112-0006	CRP-SS112-0612	CRP-SS113-0006	CRP-SS114-0006	CRP-SS114-0612	CRP-SS115-0006	CRP-SS115-0006-D	CRP-SS115-0006-AVG
LOCATION ID		CRP-SS108	CRP-SS108	CRP-SS108	CRP-SS109	CRP-SS110	CRP-SS110	CRP-SS111	CRP-SS112	CRP-SS112	CRP-SS113	CRP-SS114	CRP-SS114	CRP-SS115	CRP-SS115	CRP-SS115
SAMPLE DATE		01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10
TOP DEPTH		0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0 FT
BOTTOM DEPTH		0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	0.5 FT
SACODE		DUP	AVG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	DUP	AVG
QC TYPE	RISO RES	FD	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	FD	NM
POLYCYCLIC AROMATIC HYDROCARBONS (MG/KG)																
2-METHYLNAPHTHALENE	123	0.186 U	0.1875 U	0.174 U	0.108 J	0.176 U	0.156 U	0.184 U	0.162 U	0.0472 J	0.176 U	0.165 U	0.148 U	0.164 U	0.195 U	0.1795 U
ACENAPHTHENE	43	0.157 J	0.2005 J	0.174 U	0.976	0.133 J	0.142 J	0.184 U	0.0834 J	0.283 J	0.147 J	0.165 U	0.148 U	0.164 U	0.195 U	0.1795 U
ACENAPHTHYLENE	23	0.186 U	0.1875 U	0.174 U	0.181 U	0.176 U	0.156 U	0.184 U	0.162 U	0.156 U	0.176 U	0.059 J	0.148 U	0.369 D	0.118 J	0.2435 J
ANTHRACENE	35	0.227 J	0.349 J	0.0722 J	1.81	0.237 J	0.256 J	0.184 U	0.148 J	0.5	0.262 J	0.165 U	0.148 U	0.194 J	0.0676 J	0.1308 J
BAP EQUIVALENT-HALFND		2.39469	3.92691	1.26845	16.9985	2.58242	2.85622	0.373063	1.61829	11.2408	2.37021	0.415036	0.151696	1.17533	0.45443	0.81488
BAP EQUIVALENT-POS		2.39469	3.92691	1.26845	16.9985	2.58242	2.85622	0.373063	1.61829	11.2408	2.37021	0.415036	0.076956	1.17533	0.35693	0.76613
BENZO(A)ANTHRACENE	0.9	1.35 J	2.45 J	0.949	10.6	1.57	1.77 J	0.202 J	0.948 J	9.31 J	1.33 J	0.264 J	0.0592 J	0.823 J	0.251 J	0.537 J
BENZO(A)PYRENE	0.4	1.7 J	2.775 J	0.854	11.6	1.8	1.98	0.25 J	1.12	7.47	1.66	0.287 J	0.0592 J	0.785 J	0.277 J	0.531 J
BENZO(B)FLUORANTHENE	0.9	1.67 J	2.505 J	0.607	11	1.7	1.87	0.245 J	1.01	5.03	1.7	0.282 J	0.0697 J	0.92 J	0.341 J	0.6305 J
BENZO(G,H,I)PERYLENE	0.8	1.17 J	1.83 J	0.542	7.77	1.25	1.49	0.254 J	0.83	4.18	1.29	0.203 J	0.0632 J	0.553	0.216 J	0.3845 J
BENZO(K)FLUORANTHENE	0.9	0.658 J	0.934 J	0.184 J	4.22	0.617	0.672	0.0818 J	0.399	1.25	0.651	0.114 J	0.148 U	0.36	0.112 J	0.236 J
CHRYSENE	0.4	2.11 J	3.57 J	2.21	14.3	2.25	2.5 J	0.345 J	1.5 J	21.3 J	1.7 J	0.396 J	0.106 J	1.53 J	0.51 J	1.02 J
DIBENZO(A,H)ANTHRACENE	0.4	0.268 J	0.471 J	0.217 J	2.37	0.324 J	0.374	0.0557 J	0.216 J	2.04	0.263 J	0.0518 J	0.148 U	0.154 J	0.195 U	0.154 J
FLUORANTHENE	20	1.92	2.56	0.48	10.9	1.72	1.94	0.291 J	1.07	3.74	1.9	0.365	0.0904 J	1.85 J	0.534 J	1.192 J
FLUORENE	28	0.0846 J	0.1243 J	0.174 U	0.651	0.0782 J	0.083 J	0.184 U	0.162 U	0.166 J	0.0832 J	0.165 U	0.148 U	0.078 J	0.195 U	0.078 J
INDENO(1,2,3-CD)PYRENE	0.9	1.16 J	1.725 J	0.378	8.12	1.23	1.29	0.215 J	0.81	2.63	1.36	0.201 J	0.0476 J	0.569	0.191 J	0.38 J
NAPHTHALENE	54	0.186 U	0.0686 J	0.174 U	0.15 J	0.176 U	0.156 U	0.184 U	0.162 U	0.0582 J	0.176 U	0.165 U	0.148 U	0.164 U	0.195 U	0.1795 U
PHENANTHRENE	40	1.03 J	1.47 J	0.309 J	6.73	0.908	1.01	0.153 J	0.592	2.59	0.953	0.17 J	0.148 U	1.42 J	0.29 J	0.855 J
PYRENE	13	1.92 J	2.915 J	0.708	11	1.82	2.11	0.306 J	1.18	6.9	1.78	0.442	0.0996 J	2.26 J	0.651 J	1.4555 J
METALS (MG/KG)																
LEAD	150	60.1	68.05	31.6	222	116	109	60.4	58	47.4	49.3	75.7	25.7	64.2	72.7	68.45

BLACK SHADING-EXCEEDS AT LEAST ONE CRITERION; GRAY SHADING-DETECTED;
U-NOT DETECTED; J-QUANTITATION APPROXIMATE; R-REJECTED; NA-NOT ANALYZED

TABLE 1-3
ANALYTICAL RESULTS - DETECTED COMPOUNDS IN SURFACE SOIL (JANUARY 2010)
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID		CRP-SS116-0006	CRP-SS116-0612	CRP-SS117-0006	CRP-SS118-0006	CRP-SS118-0612	CRP-SS119-0006	CRP-SS120-0006	CRP-SS120-0612	CRP-SS121-0006	CRP-SS122-0006	CRP-SS122-0006-D	CRP-SS122-0006-AVG	CRP-SS122-0612	CRP-SS123-0006
LOCATION ID		CRP-SS116	CRP-SS116	CRP-SS117	CRP-SS118	CRP-SS118	CRP-SS119	CRP-SS120	CRP-SS120	CRP-SS121	CRP-SS122	CRP-SS122	CRP-SS122	CRP-SS122	CRP-SS123
SAMPLE DATE		01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10	01/19/10
TOP DEPTH		0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0.5 FT	0 FT	0 FT	0 FT	0 FT	0.5 FT	0 FT
BOTTOM DEPTH		0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	1 FT	0.5 FT	0.5 FT	0.5 FT	0.5 FT	1 FT	0.5 FT
SACODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	DUP	AVG	NORMAL	NORMAL
QC TYPE	RISO RES	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	FD	NM	NM	NM
POLYCYCLIC AROMATIC HYDROCARBONS (MG/KG)															
2-METHYLNAPHTHALENE	123	0.192 U	0.172 U	0.221 U	0.174 U	0.188 U	0.168 U	0.176 U	0.152 U	0.149 U	0.166 U	0.173 U	0.1695 U	0.162 U	0.149 U
ACENAPHTHENE	43	0.192 U	0.172 U	0.221 U	0.174 U	0.188 U	0.168 U	0.176 U	0.152 U	0.149 U	0.166 U	0.173 U	0.1695 U	0.162 U	0.149 U
ACENAPHTHYLENE	23	0.192 U	0.172 U	0.221 U	0.174 U	0.188 U	0.168 U	0.176 U	0.152 U	0.0499 J	0.314 J	0.201 J	0.2575 J	0.162 U	0.0733 J
ANTHRACENE	35	0.192 U	0.172 U	0.221 U	0.09 J	0.0676 J	0.168 U	0.0762 J	0.152 U	0.0522 J	0.218 J	0.128 J	0.173 J	0.162 U	0.0958 J
BAP EQUIVALENT-HALFND		0.278354	0.244679	0.525839	0.726172	0.489487	0.408762	0.600235	0.218876	0.756981	1.06166	0.668005	0.864833	0.20004	0.741116
BAP EQUIVALENT-POS		0.182354	0.158679	0.415339	0.726172	0.489487	0.324762	0.600235	0.142876	0.756981	1.06166	0.668005	0.864833	0.11904	0.741116
BENZO(A)ANTHRACENE	0.9	0.14 J	0.137 J	0.318 J	0.45 J	0.349 J	0.25 J	0.361 J	0.118 J	0.559 J	0.878 J	0.423 J	0.6505 J	0.0828 J	0.507 J
BENZO(A)PYRENE	0.4	0.141 J	0.121 J	0.324 J	0.504	0.333 J	0.249 J	0.412	0.109 J	0.528	0.713	0.439	0.576	0.0923 J	0.521
BENZO(B)FLUORANTHENE	0.9	0.159 J	0.14 J	0.353 J	0.582	0.377	0.301 J	0.476	0.129 J	0.58	0.885	0.596	0.7405	0.11 J	0.568
BENZO(G,H,I)PERYLENE	0.8	0.105 J	0.0887 J	0.219 J	0.361	0.235 J	0.184 J	0.305 J	0.0909 J	0.382	0.52	0.341 J	0.4305 J	0.0715 J	0.353
BENZO(K)FLUORANTHENE	0.9	0.0654 J	0.0603 J	0.15 J	0.225 J	0.148 J	0.12 J	0.176 J	0.0608 J	0.255 J	0.326 J	0.208 J	0.267 J	0.0499 J	0.233 J
CHRYSENE	0.4	0.2 J	0.206 J	0.439 J	0.622 J	0.507 J	0.362 J	0.575 J	0.168 J	0.731 J	1.3 J	0.725 J	1.0125 J	0.151 J	0.686 J
DIBENZO(A,H)ANTHRACENE	0.4	0.192 U	0.172 U	0.221 U	0.0788 J	0.0596 J	0.168 U	0.0714 J	0.152 U	0.0737 J	0.115 J	0.0913 J	0.10315 J	0.162 U	0.0758 J
FLUORANTHENE	20	0.241	0.284 J	0.481	0.678	0.52	0.384	0.582	0.221 J	0.857	1.47	0.889	1.1795	0.156 J	0.81
FLUORENE	28	0.192 U	0.172 U	0.221 U	0.174 U	0.188 U	0.168 U	0.176 U	0.152 U	0.149 U	0.0602 J	0.173 U	0.0602 J	0.162 U	0.149 U
INDENO(1,2,3-CD)PYRENE	0.9	0.106 J	0.0917 J	0.223 J	0.373	0.223 J	0.191 J	0.308 J	0.084 J	0.381	0.528	0.33 J	0.429 J	0.0681 J	0.338
NAPHTHALENE	54	0.192 U	0.172 U	0.221 U	0.174 U	0.188 U	0.168 U	0.176 U	0.152 U	0.149 U	0.166 U	0.173 U	0.1695 U	0.162 U	0.149 U
PHENANTHRENE	40	0.113 J	0.15 J	0.202 J	0.338 J	0.24 J	0.183 J	0.291 J	0.0778 J	0.299	0.84 J	0.467 J	0.6535 J	0.0758 J	0.295 J
PYRENE	13	0.218 J	0.259 J	0.502	0.633	0.524	0.375	0.548	0.197 J	0.891	1.81 J	1.06 J	1.435 J	0.19 J	0.955
METALS (MG/KG)															
LEAD	150	48.5	28.5	96.6	118	82.5	61.9	59.5	45.2	23.2	100	157	128.5	22.7	36

BLACK SHADING-EXCEEDS AT LEAST ONE CRITERION; GRAY SHADING-DETECTED;
U-NOT DETECTED; J-QUANTITATION APPROXIMATE; R-REJECTED; NA-NOT ANALYZED

TABLE 2-1
CHEMICAL OF POTENTIAL CONCERN (COPC) SELECTION - SURFACE SOIL IN RECREATIONAL VEHICLE AREA
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Parameter	FOD	Minimum Detected Concentration[1]	Maximum Detected Concentration[1]	Location Maximum Detected Concentration	Average Positive Detects	Average all Concentrations[2]	EPA Residential Regional Screening Level [3]	RIDEM Soil Direct Expsure Screening Level	Background Concentration	COPC
Metals(mg/kg)										
ALUMINUM	2/2	11100	13400	CRP-SB01-0001	12000	12000	**7700**	NA	**11800**	YES
ANTIMONY	1/2	2.2	2.2	CRP-SB09-0001	2.2	1.6	3.1 N	10	NA	NO
ARSENIC	2/2	13.6	15.1	CRP-SB09-0001	14	14	**0.39**	**7**	**4.03**	YES
BARIUM	2/2	25.9	37	CRP-SB09-0001	31	31	1500 N	5500	**22.4**	NO
BERYLLIUM	2/2	0.33	0.36	CRP-SB09-0001	0.34	0.34	16 N	0.4	0.419	NO
CADMIUM	2/2	0.45	0.5	CRP-SB09-0001	0.47	0.47	7 N	39	ND	NO
CALCIUM	2/2	2310	14200	CRP-SB09-0001	8300	8300	NA	NA	**323**	NO
CHROMIUM	2/2	13.4	19.4	CRP-SB01-0001	16	16	**0.29**	390 [6]	**9.87**	YES
COBALT	2/2	8.5	15.3	CRP-SB01-0001	12	12	**2.3**	NA	**2.87**	YES
COPPER	2/2	22.5	25.2	CRP-SB01-0001	24	24	310 N	3100	**6.84**	NO
IRON	2/2	20100	31200	CRP-SB01-0001	26000	26000	**5500** N	NA	**13800**	YES
LEAD	38/38	22.7	572	CRP-SB09-0001	130	130	**400**	**150**	**10.8**	YES
MAGNESIUM	2/2	3810	4590	CRP-SB09-0001	4200	4200	NA	NA	**1520**	NO
MANGANESE	2/2	311	543	CRP-SB01-0001	430	430	**180** N	**390**	**141**	YES
MERCURY	2/2	0.03	0.067	CRP-SB09-0001	0.049	0.049	2.3 N	23	**0.0271**	NO
NICKEL	2/2	16.5	31.3	CRP-SB01-0001	24	24	150 N	1000	**7.7**	NO
POTASSIUM	2/2	338	497	CRP-SB09-0001	420	420	NA	NA	494	NO
SELENIUM	2/2	0.44	0.63	CRP-SB09-0001	0.54	0.54	39 N	390	**0.251**	NO
SILVER	1/2	0.1	0.1	CRP-SB09-0001	0.1	0.095	39 N	200	NA	NO
VANADIUM	2/2	18.8	19.2	CRP-SB09-0001	19	19	39 N	NA	**17**	NO
ZINC	2/2	124	217	CRP-SB09-0001	170	170	2300 N	600	**22**	NO
Semivolatiles(mg/kg)										
1,1-BIPHENYL	1/2	0.3	0.3	CRP-SB09-0001	0.3	0.65	390 N	0.8	NA	NO
2-METHYLNAPHTHALENE	12/38	0.0472	3.13	CRP-SS100-0006	1.6	0.58	31 N	123	NA	NO
ACENAPHTHENE	18/38	0.015	37.1	CRP-SS102-0612	9.9	4.7	340 N	43	NA	NO
ACENAPHTHYLENE	9/38	0.0499	0.369	CRP-SS115-0006	0.13	0.4	340 [7]N	23	NA	NO
ANTHRACENE	28/38	0.0522	57.1	CRP-SS102-0612	9.9	7.4	1700 N	35	NA	NO
BAP EQUIVALENT-HALFND[11]	38/38	0.152	425.4	CRP-SS100-0006	65	65	**0.015** [8]C	**0.4**	NA	YES
BAP EQUIVALENT-POS[12]	38/38	0.0770	425.4	CRP-SS100-0006	65	65	**0.015** [8]C	**0.4**	NA	YES
BENZO(A)ANTHRACENE	38/38	0.0592	258	CRP-SS100-0006	43	43	**0.15** C	**0.9**	NA	YES
BENZO(A)PYRENE	38/38	0.0592	293	CRP-SS100-0006	45	45	**0.015** C	**0.4**	NA	YES
BENZO(B)FLUORANTHENE	38/38	0.0697	270	CRP-SS102-0612	42	42	**0.15** C	**0.9**	NA	YES
BENZO(G,H,I)PERYLENE	38/38	0.0632	223	CRP-SS100-0006	31	31	**170** [9]N	**0.8**	NA	YES
BENZO(K)FLUORANTHENE	37/38	0.0499	108	CRP-SS102-0612	15	15	**1.5** C	**0.9**	NA	YES
CARBAZOLE	1/2	11	11000	CRP-SB09-0001	11	6.5	NA	NA	NA	NO
CHRYSENE	38/38	0.106	316	CRP-SS100-0006	52	52	**15** C	**0.4**	NA	YES
DIBENZO(A,H)ANTHRACENE	30/38	0.0518	57.9	CRP-SS100-0006	11	8.8	**0.015** C	**0.4**	NA	YES
DIBENZOFURAN	1/2	3.5	3.5	CRP-SB09-0001	3.5	2.2	7.8 N	NA	NA	NO
FLUORANTHENE	38/38	0.0904	332	CRP-SS102-0612	44	44	**230** N	**20**	NA	YES
FLUORENE	20/38	0.0526	23.8	CRP-SS102-0612	5.7	3	230 N	28	NA	NO
INDENO(1,2,3-CD)PYRENE	38/38	0.0476	211	CRP-SS100-0006	31	31	**0.15**	NA	NA	YES
NAPHTHALENE	14/38	0.0582	8.21	CRP-SS100-0006	3.1	1.2	**3.6**	54	NA	YES
PHENANTHRENE	37/38	0.0758	208	CRP-SS102-0612	29	28	**170**	**13**	NA	YES
PYRENE	38/38	0.0996	316	CRP-SS100-0006	48	48	**170**	**13**	NA	YES

TABLE 2-1
CHEMICAL OF POTENTIAL CONCERN (COPC) SELECTION - SURFACE SOIL IN RECREATIONAL VEHICLE AREA
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

TOTAL PAHS	2/2	11.57	1004200	CRP-SB09-0001	510	510	NA	NA		NA	NO
Pesticides/PCBs(ug/kg)											
4,4'-DDD	2/2	1.2	3.6	CRP-SB09-0001	2.4	2.4	2000 C	NA		NA	NO
4,4'-DDE	2/2	1.2	30	CRP-SB09-0001	16	16	1400 C	NA		NA	NO
4,4'-DDT	2/2	3.4	62	CRP-SB09-0001	33	33	1700 C	NA		NA	NO
AROCLOR-1260	1/2	19	19	CRP-SB01-0001	19	14	220 C	10000 (10)		NA	NO
GAMMA-BHC (LINDANE)	2/2	0.79	5.3	CRP-SB09-0001	3	3	520 C	NA		NA	NO
TOTAL AROCLOR	1/2	19	19	CRP-SB01-0001	19	14	NA	10000 (10)		NA	NO
TOTAL DDD/DDE/DDT	2/2	5.8	95.6	CRP-SB09-0001	51	51	NA	NA		NA	NO
Petroleum Hydrocarbons(mg/kg)											
DIESEL RANGE ORGANICS	2/2	200	5600	CRP-SB09-0001	2900	2900	NA	NA		NA	NO

Shaded criterion indicates that the maximum detected concentration exceeds the screening criteria and was retained as a COPC.

Notes:

(1) Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentration detected and as one sample when determining the frequency of detection and average results.
(2) Average of all analytical results is calculated using half of the detection limit for non-detects.
(3) EPA Regional Screening Level (ORNL, December 2009). Non-carcinogenic values were divided by ten.
(4) Rhode Island Screening Level (February 2004).
(5) Average surface soil concentration from Basewide Background Study Report, Naval Station Newport, Newport RI. Tetra Tech NUS For NAVFAC MID ATLANTIC CTO 402. Final document, July 2008.
(6) Chromium VI value used.
(7) Acenaphthene used as a surrogate concentration for Acenaphthylene.
(8) Benzo(a)pyrene used as a surrogate concentration.
(9) Pyrene used as a surrogate concentration for Benzo(g,h,i)perylene and Phenanthrene.
(10) Polychlorinated biphenyls used as a surrogate concentration.
(11) Benzo(a)pyrene equivalent concentrations calculated using one half the detection limit for non-detected values.
(12) Benzo(a)pyrene equivalent concentrations calculated using only positively detected values.

C = Carcinogen
EPA = Environmental Protection Agency
N = Noncarcinogen
NA = Not Available
ND = Non-detect
RIDEM = Rhode Island Department of Environmental Managemer

TABLE 2-2
SAMPLE LOCATION LIST
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

SAMPLE ID
CRP-SB01-0001
CRP-SB09-0001
CRP-SS100-0006
CRP-SS100-0612
CRP-SS101-0006
CRP-SS101-0006-D
CRP-SS102-0006
CRP-SS102-0612
CRP-SS103-0006
CRP-SS104-0006
CRP-SS104-0612
CRP-SS105-0006
CRP-SS106-0006
CRP-SS106-0612
CRP-SS107-0006
CRP-SS108-0006
CRP-SS108-0006-D
CRP-SS108-0612
CRP-SS109-0006
CRP-SS110-0006
CRP-SS110-0612
CRP-SS111-0006
CRP-SS112-0006
CRP-SS112-0612
CRP-SS113-0006
CRP-SS114-0006
CRP-SS114-0612
CRP-SS115-0006
CRP-SS115-0006-D
CRP-SS116-0006
CRP-SS116-0612
CRP-SS117-0006
CRP-SS118-0006
CRP-SS118-0612
CRP-SS119-0006
CRP-SS120-0006
CRP-SS120-0612
CRP-SS121-0006
CRP-SS122-0006
CRP-SS122-0006-D
CRP-SS122-0612
CRP-SS123-0006

TABLE 2-3
SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURE
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

EXPOSURE PARAMETER		RECREATIONAL USER					WORKER
		CHILD	OLDER CHILD	ADULT	LIFETIME EXPOSURE		
					CHILD	ADULT	
All Exposures							
C_{soil}(mg/kg)	Exposure concentration for soil	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]
ED (years)	Exposure duration	5	5	5	6[2]	24[2]	25[2]
BW (kg)	Body weight	15[2]	45[3]	70[2]	15[2]	70[2]	70[2]
AT_n(days)	Averaging time for noncarcinogenic effects	1825[4]	1825[4]	1825[4]	2190[2]	8760[2]	9125[2]
AT_c(days)	Averaging time for carcinogenic effects	25550[4]	25550[4]	25550[4]	25550[4]	25550[4]	25550[4]
Incidential Ingestion/Dermal Contact with Soil							
IR (mg/day)	Ingestion rate (soil)	200[2]	100[2]	100[2]	200[2]	100[3]	100[2]
EF-Soil (days/year)	Exposure frequency	14	14	14	14	14	26
FI (unitless)	Fraction ingested from contaminated source	1	1	1	1	1	0.125[a]
SA (cm^2/event)	Skin surface area available for contact	2800[5]	5700[5]	5700[5]	2800[5]	5700[5]	3300[5]
EV (events/day)	Events per day	1	1	1	1	1	0.125[a]
AF (mg/cm2)	Soil-to-skin adherence factor	0.2[5]	0.07[5]	0.07[5]	0.2[5]	0.07[5]	0.2[5]
ABS (unitless)	Absorption factor	chemcial specific [5,6]	chemcial specific [5,6]	chemcial specific [5,6]	chemcial specific [5,6]	chemcial specific [5,6]	chemcial specific [5,6]
CF (kg/mg)	Conversion factor	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
Inhalation Fugitive Dust/Volatile Emissions from Surface Soil							
ET (hours/day)	Exposure time	24	24	24	24	24	1[a]
EF(days/year)	Exposure frequency	14	14	14	14	14	26

Notes:

1- USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2- USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Devault Exposure Factors. OSWER 9285.6-03.
3- USEPA, 1997: Exposure Factors Handbook, EPA/600/P-95/002F a-c.
4- USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
5- USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/0.
6- MADEP, 2008: relative absorbtion factors in Method 3 Risk Assessment Short Form Excel spreadsheets, available online at http://www.mass.gov/dep/service/compliance/riskasmt.htm
a- Assumes exposure 1 hour out of 8 hour work day, so FI is 1/8 or 0.125.
Assumptions without footnotes are based on professional judgement with consideration of site-specific circumstances

TABLE 2-4
SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURE
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

EXPOSURE PARAMETER		RECREATIONAL USER					WORKER
		CHILD	OLDER CHILD	ADULT	LIFETIME EXPOSURE		
					CHILD	ADULT	
All Exposures							
C_{soil}(mg/kg)	Exposure concentration for soil	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]	Maximum or 95% UCL [1]
ED (years)	Exposure duration	5	5	5	2[2,a]	7[2,b]	9[2]
BW (kg)	Body weight	15[3]	45[4]	70[3]	15[3]	70[3]	70[3]
AT_n(days)	Averaging time for noncarcinogenic effects	1825[5]	1825[5]	1825[5]	730[5]	2555[5]	3285[5]
AT_c(days)	Averaging time for carcinogenic effects	25550[3]	25550[3]	25550[3]	25550[3]	25550[3]	25550[3]
Incidential Ingestion/Dermal Contact with Soil							
IR (mg/day)	Ingestion rate (soil)	100[6]	50[6]	50[6]	100[6]	50[6]	50[6]
EF-Soil (days/year)	Exposure frequency	7	7	7	7	7	26
FI (unitless)	Fraction ingested from contaminated source	1	1	1	1	1	0.125[c]
SA (cm^2/day)	Skin surface area available for contact	2800[2]	5700[4]	5700[4]	2800[4]	5700[4]	3300[4]
EV (events/day)	Events per day	1	1	1	1	1	0.125[c]
AF (mg/cm2)	Soil-to-skin adherence factor	0.04[2]	0.01[2]	0.01[2]	0.04[2]	0.01[2]	0.02[2]
ABS (unitless)	Absorption factor	chemcial specific [2,7]	chemcial specific [2,7]	chemcial specific [2,7]	chemcial specific [2,7]	chemcial specific [2,7]	chemcial specific [2,7]
CF (kg/mg)	Conversion factor	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
Inhalation Fugitive Dust/Volatile Emissions from Surface Soil							
ET (hours/day)	Exposure time	24	24	24	24	24	1[c]
EF(days/year)	Exposure frequency	7	7	7	7	7	26

Notes:

1- USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.
2- USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. PA/540/R/99/0.
3- USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Devault Exposure Factors. OSWER 9285.6-03.
4- USEPA, 1997: Exposure Factors Handbook, EPA/600/P-95/002F a-c.
5- USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.
6- USEPA, 1993: Superfund's Default Exposure Factors for the Central Tendency and Reasonalbe Maximum Exposure.
7- MADEP, 2008: relative absorbtion factors in Method 3 Risk Assessment Short Form Excel spreadsheets, available online at http://www.mass.gov/dep/service/compliance/riskasmt.htm
a- Exposure duration is assumed to be 1 year for ages 0-2 and 1 year for ages 2-6.
b- Exposure duration is assumed to be 2 years for ages 6-16 and 5 years for ages 16-30.
c- Assumes exposure 1 hour out of 8 hour work day, so FI is 1/8 or 0.125.
Assumptions without footnotes are based on professional judgement with consideration of site-specific circumstances

TABLE 2-5
EXPOSURE POINT CONCENTRATION SUMMARY
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
MRP SITE 1	BAP - Equivalents Half ND	mg/kg	65	266 (NP)	425.4	266	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
MRP SITE 1	Benzo(g,h,i)perylene	mg/kg	31	126 (NP)	223	126	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
MRP SITE 1	Fluoranthene	mg/kg	44	182 (NP)	332	182	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
MRP SITE 1	Naphthalene	mg/kg	1.2	1.9 (G)	8.2	1.9	mg/kg	95% KM(t)	Pro UCL 4.00.04
MRP SITE 1	Phenanthrene	mg/kg	28	117 (NP)	208	117	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
MRP SITE 1	Pyrene	mg/kg	48	196 (NP)	316	196	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
MRP SITE 1	Aluminum	mg/kg	12000	NA	13400	13400	mg/kg	Maximum	Only 2 Concentrations
MRP SITE 1	Arsenic	mg/kg	14	NA	15.1	15.1	mg/kg	Maximum	Only 2 Concentrations
MRP SITE 1	Chromium	mg/kg	16	NA	19.4	19.4	mg/kg	Maximum	Only 2 Concentrations
MRP SITE 1	Cobalt	mg/kg	12	NA	15.3	15.3	mg/kg	Maximum	Only 2 Concentrations
MRP SITE 1	Iron	mg/kg	26000	NA	31200	31200	mg/kg	Maximum	Only 2 Concentrations
MRP SITE 1	Lead	mg/kg	130	NA	572	130	mg/kg	Arithmetic Mean	USEPA Guidance
MRP SITE 1	Manganese	mg/kg	430	NA	543	543	mg/kg	Maximum	Only 2 Concentrations

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

1. Exposure point concentration is the value recommended by USEPA's ProUCL. The maximum detected concentration is used if the recommended UCL is greater than the maximum or if the dataset contains less than 10 samples.

G = Gamma Distribution
NA = Not Applicable
NP = Nonparametric Distribution

TABLE 2-6
SUMMARY OF CANCER RISKS AND HAZARD INDICES
REASONABLE MAXIMUM EXPOSURES
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an Target Organ HI > 1
Workers	Surface Soil	Incidental Ingestion	9E-06	- -	- -	cPAHs	0.002	- -
		Dermal Contact	8E-06	- -	- -	cPAHs	0.0003	- -
		Inhalation	1E-09	- -	- -	- -	0.00004	- -
		Total	**2E-05**	- -	cPAHs	- -	0.003	- -
Child Recreational Users	Surface Soil	Incidental Ingestion	4E-04	cPAHs	- -	Chromium	0.1	- -
		Dermal Contact	1E-04	- -	cPAHs	- -	0.006	- -
		Inhalation	6E-09	- -	- -	- -	0.0005	- -
		Total	**6E-04**	cPAHs	- -	Chromium	0.1	- -
Older Child Recreational Users	Surface Soil	Incidental Ingestion	4E-05	- -	cPAHs	- -	0.02	- -
		Dermal Contact	2E-05	- -	cPAHs	- -	0.001	- -
		Inhalation	5E-09	- -	- -	- -	0.0005	- -
		Total	**5E-05**	- -	cPAHs	- -	0.02	- -
Adult Recreational Users	Surface Soil	Incidental Ingestion	8E-06	- -	- -	cPAHs	0.01	- -
		Dermal Contact	4E-06	- -	- -	cPAHs	0.0009	- -
		Inhalation	4E-09	- -	- -	- -	0.0005	- -
		Total	**1E-05**	- -	- -	cPAHs	0.01	- -
Lifelong Recreational User (Child and Adult)	Surface Soil	Incidental Ingestion	5E-04	cPAHs	- -	Chromium	NA	- -
		Dermal Contact	2E-04	cPAHs	- -	- -	NA	- -
		Inhalation	3E-08	- -	- -	- -	NA	- -
		Total	**7E-04**	cPAHs	- -	Arsenic, Chromium	NA	- -

Notes:
NA - Not applicable.

TABLE 2-7
SUMMARY OF CANCER RISKS AND HAZARD INDICES
CENTRAL TENDENCY EXPOSURES
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an Target Organ HI > 1
Workers	Surface Soil	Incidental Ingestion	2E-06	- -	- -	cPAHs	0.001	- -
		Dermal Contact	2E-06	- -	- -	cPAHs	0.0003	- -
		Inhalation	5E-10	- -	- -	- -	0.00004	- -
		Total	4E-06	- -	- -	cPAHs	0.002	- -
Child Recreational Users	Surface Soil	Incidental Ingestion	1E-04	- -	cPAHs	- -	0.02	- -
		Dermal Contact	1E-05	- -	- -	cPAHs	0.0006	- -
		Inhalation	3E-09	- -	- -	- -	0.0003	- -
		Total	**1E-04**	- -	cPAHs	- -	0.02	- -
Older Child Recreational Users	Surface Soil	Incidental Ingestion	9E-06	- -	- -	cPAHs	0.004	- -
		Dermal Contact	1E-06	- -	- -	- -	0.0001	- -
		Inhalation	2E-09	- -	- -	- -	0.0003	- -
		Total	1E-05	- -	- -	cPAHs	0.004	- -
Adult Recreational Users	Surface Soil	Incidental Ingestion	2E-06	- -	- -	cPAHs	0.003	- -
		Dermal Contact	3E-07	- -	- -	- -	0.00006	- -
		Inhalation	2E-09	- -	- -	- -	0.0003	- -
		Total	2E-06	- -	- -	cPAHs	0.003	- -
Lifelong Recreational Users (Child and Adult)	Surface Soil	Incidental Ingestion	5E-05	- -	cPAHs	- -	NA	- -
		Dermal Contact	7E-06	- -	- -	cPAHs	NA	- -
		Inhalation	4E-09	- -	- -	- -	NA	- -
		Total	**6E-05**	- -	cPAHs	- -	NA	- -

Notes:
NA - Not applicable.

TABLE 2-8
SUMMARY OF CANCER RISKS AND HAZARD INDICES - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an Target Organ HI > 1
Workers	Surface Soil	Incidental Ingestion	3E-06	- -	- -	cPAHs	0.002	- -
		Dermal Contact	1E-06	- -	- -	- -	0.0003	- -
		Inhalation	1E-09	- -	- -	- -	0.00004	- -
		Total	4E-06	- -	- -	cPAHs	0.003	- -
Child Recreational Users	Surface Soil	Incidental Ingestion	1E-04	- -	cPAHs	Chromium	0.09	- -
		Dermal Contact	2E-05	- -	cPAHs	- -	0.005	- -
		Inhalation	6E-09	- -	- -	- -	0.0005	- -
		Total	**1E-04**	- -	cPAHs	Chromium	0.1	- -
Older Child Recreational Users	Surface Soil	Incidental Ingestion	1E-05	- -	- -	cPAHs	0.02	- -
		Dermal Contact	3E-06	- -	- -	cPAHs	0.001	- -
		Inhalation	5E-09	- -	- -	- -	0.0005	- -
		Total	1E-05	- -	- -	cPAHs	0.02	- -
Adult Recreational Users	Surface Soil	Incidental Ingestion	2E-06	- -	- -	cPAHs	0.01	- -
		Dermal Contact	6E-07	- -	- -	- -	0.0008	- -
		Inhalation	4E-09	- -	- -	- -	0.0005	- -
		Total	3E-06	- -	- -	cPAHs	0.01	- -
Lifelong Recreational User (Child and Adult)	Surface Soil	Incidental Ingestion	1E-04	- -	cPAHs	Chromium	NA	- -
		Dermal Contact	3E-05	- -	cPAHs	- -	NA	- -
		Inhalation	3E-08	- -	- -	- -	NA	- -
		Total	**2E-04**	cPAHs	- -	Arsenic, Chromium	NA	- -

Notes:
NA - Not applicable.

TABLE 2-9
SUMMARY OF CANCER RISKS AND HAZARD INDICES - RELATIVE ABSORPTION FACTORS
CENTRAL TENDENCY EXPOSURES
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-5}$	Hazard Index	Chemicals Contributing to an Target Organ HI > 1
Workers	Surface Soil	Incidental Ingestion	5E-07	- -	- -	- -	0.001	- -
		Dermal Contact	3E-07	- -	- -	- -	0.0002	- -
		Inhalation	5E-10	- -	- -	- -	0.00004	- -
		Total	8E-07	- -	- -	- -	0.003	- -
Child Recreational Users	Surface Soil	Incidental Ingestion	3E-05	- -	cPAHs	- -	0.02	- -
		Dermal Contact	2E-06	- -	- -	cPAHs	0.0005	- -
		Inhalation	3E-09	- -	- -	- -	0.0003	- -
		Total	3E-05	- -	cPAHs	- -	0.02	- -
Older Child Recreational Users	Surface Soil	Incidental Ingestion	3E-06	- -	- -	cPAHs	0.004	- -
		Dermal Contact	2E-07	- -	- -	- -	0.00008	- -
		Inhalation	2E-09	- -	- -	- -	0.0003	- -
		Total	3E-06	- -	- -	cPAHs	0.02	- -
Adult Recreational Users	Surface Soil	Incidental Ingestion	6E-07	- -	- -	- -	0.002	- -
		Dermal Contact	4E-08	- -	- -	- -	0.00005	- -
		Inhalation	2E-09	- -	- -	- -	0.0003	- -
		Total	6E-07	- -	- -	- -	0.003	- -
Lifelong Recreational Users (Child and Adult)	Surface Soil	Incidental Ingestion	1E-05	- -	- -	cPAHs	NA	- -
		Dermal Contact	1E-06	- -	- -	- -	NA	- -
		Inhalation	4E-09	- -	- -	- -	NA	- -
		Total	2E-05	- -	cPAHs	- -	NA	- -

Notes:
NA - Not applicable.

FIGURES

GRAPHIC SCALE

0' 1 MILE 2 MILES

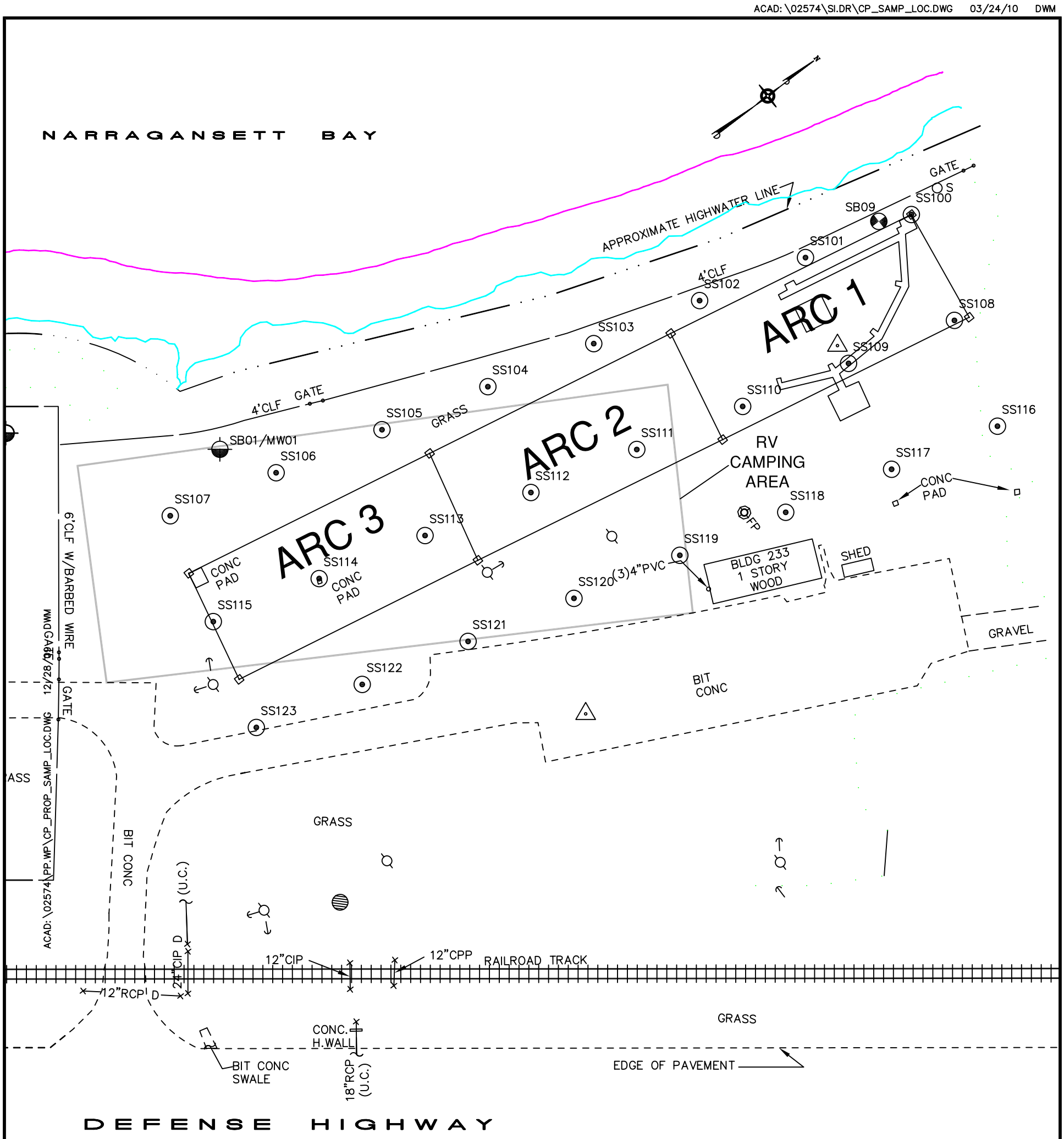
NOTES:

1. BASE MAP IS A PORTION OF THE USGS PRUDENCE ISLAND QUADRANGLE MAP (7.5 X 15 MINUTES), DATED: 1955 (PHOTOREVISED 1970 & 1975).
2. ALL LOCATIONS TO BE CONSIDERED APPROXIMATE.

SITE LOCUS	FIGURE 1–1
ADDITIONAL INVESTIGATION	TETRA TECH NUS, INC.
MRP SITE 1, CARR POINT, NAVSTA NEWPORT, RI	

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 24, 2010
SCALE:	AS SHOWN	ACAD NAME:	\02574\SI.DR\CP_LOCUS.DWG

55 Jonspin Road Wilmington, MA 01887
(978)658–7899



LEGEND

△	TRAVERSE STATION
•	PK. REBAR, NAIL, SPIKE
	GUARDRAIL
	TREE LINE
	CHAIN LINK FENCE
CLF	CHAIN LINK FENCE
	CURBING(TYPE)
BIT CONC	BITUMINOUS CONCRETE
GRAN	GRANITE
←	GUY WIRE
	UTILITY POLE OR LIGHT POLE
DMH	DRAIN MAN HOLE
	HYD
R=	RIM
I=	INVERT
SS100	PROPOSED SOIL SAMPLE LOCATION

	APPROXIMATE LOW WATER LINE
	APPROXIMATE HIGH WATER LINE MARKED VIA GPS JUNE 2009
	APPROXIMATE HIGH WATER LINE ESTIMATED BY SURVEYOR
RCP	REINFORCED CONCRETE PIPE
PVC	POLYVINYLCHLORIDE PIPE
CPP	CORRUGATED PLASTIC PIPE
CIP	CAST IRON PIPE
MP	MARKER POST
WP	WOOD POST
GP	GUARD POST
H.WALL	HEAD WALL
(TYP.)	TYPICAL
FP	FLAGPOLE
(U.C.)	UNDETERMINED CONNECTION
SB#	BOREHOLE
TP#	TEST PIT
MW	MONITORING WELL
SS	SOIL SAMPLE AT OUTFALL

GRAPHIC SCALE

0' 50' 100'

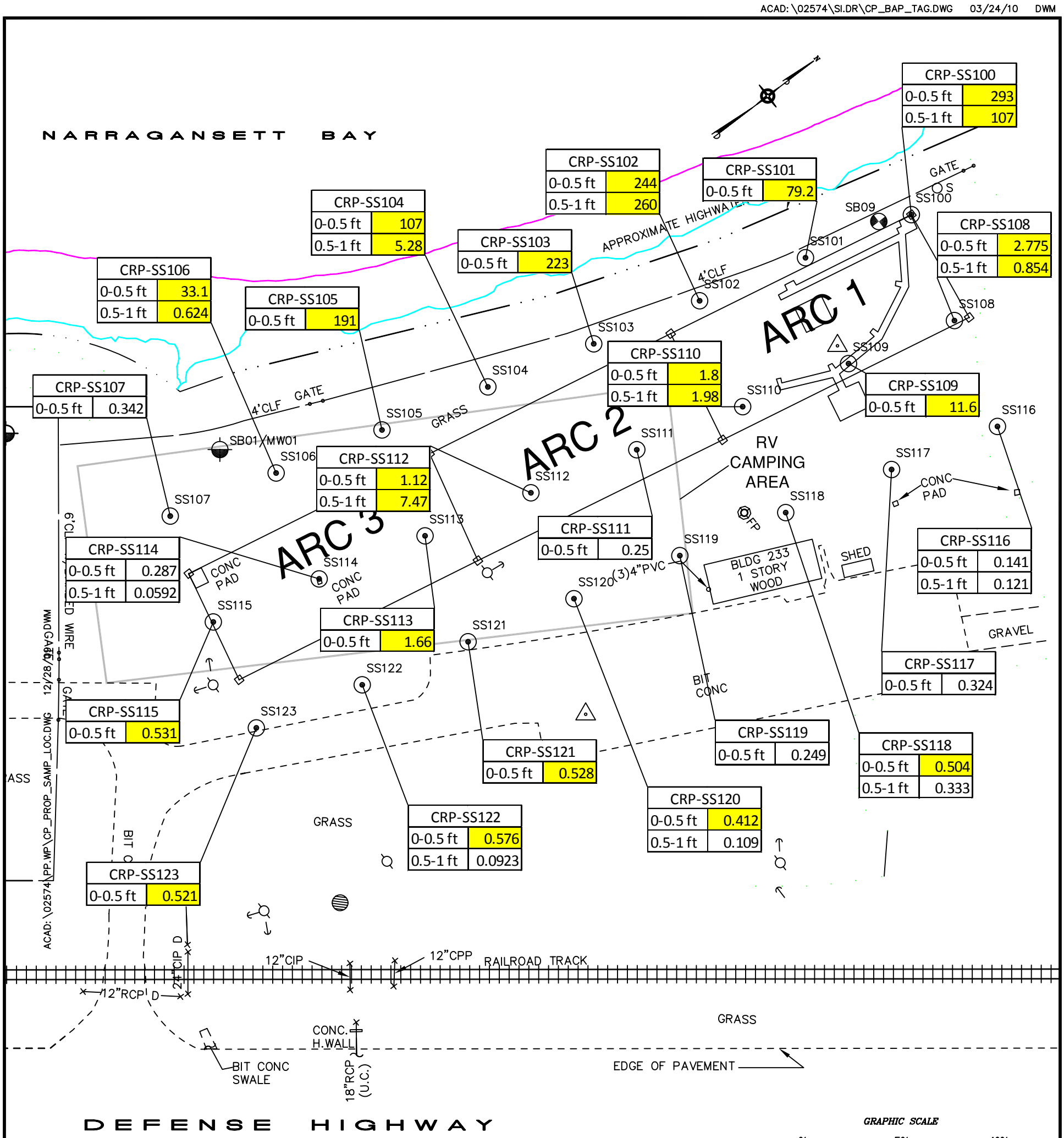
NOTES

1. COORDINATES, IN U.S. SURVEY FEET, ARE IN THE RHODE ISLAND COORDINATE SYSTEM, REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, CORS ADJUSTMENT (NAD 83/CORS), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS MADE JUNE 17, 2009 USING THE KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS).
2. ELEVATIONS, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS, MADE JUNE 17, 2009, USING The KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS). THE OBSERVED ELEVATIONS HAVE BEEN CONVERTED TO NGVD 29, USING A CONVERSION FACTOR 0.87' FROM THE GPS DERIVED NAVD88 VALUE.
3. NO SUBSURFACE UTILITY LINES HAVE BEEN COMPILED FOR THIS PLAN, READILY VISIBLE DRAIN LINES WERE LOCATED AND SHOWN ON THIS PLAN. SMC ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES NOT SHOWN.
4. BEFORE DESIGNING FUTURE CONNECTIONS, THE APPROPRIATE UTILITIES MUST BE CONSULTED.
5. BEFORE CONSTRUCTION, ALL UTILITIES, PUBLIC AND PRIVATE, MUST BE NOTIFIED (SEE RHODE ISLAND GENERAL LAWS, SECTION 39-1.2). CALL "DIG SAFE" 1-888-DIG-SAFE (888-344-7233).
6. NO PORTSMOUTH, RI, MAP AND PARCEL NUMBERS WERE OBTAINED FOR THIS SURVEY.

TETRA TECH NUS, INC.

SAMPLE LOCATIONS
ADDITIONAL INVESTIGATION
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

FILE	SCALE
\..\CP_SAMP_LOC.DWG	AS NOTED
FIGURE NUMBER 1-2	REV 0 / DATE 03/24/10



LEGEND

△	TRAVERSE STATION
•	PK. REBAR, NAIL, SPIKE
	GUARDRAIL
	TREE LINE
	CHAIN LINK FENCE
CLF	CHAIN LINK FENCE
	CURBING(TYPE)
BIT CONC	BITUMINOUS CONCRETE
GRAN	GRANITE
←	GUY WIRE
	UTILITY POLE OR LIGHT POLE
DMH	DRAIN MAN HOLE
	HYD
R=	RIM
I=	INVERT
SS100	PROPOSED SOIL SAMPLE LOCATION

	APPROXIMATE LOW WATER LINE
	APPROXIMATE HIGH WATER LINE MARKED VIA GPS JUNE 2009
	APPROXIMATE HIGH WATER LINE ESTIMATED BY SURVEYOR
RCP	REINFORCED CONCRETE PIPE
PVC	POLYVINYLCHLORIDE PIPE
CPP	CORRUGATED PLASTIC PIPE
CIP	CAST IRON PIPE
MP	MARKER POST
WP	WOOD POST
GP	GUARD POST
H.WALL	HEAD WALL
(TYP.)	TYPICAL
FP	FLAGPOLE
(U.C.)	UNDETERMINED CONNECTION
SB#	BOREHOLE
TP#	TEST PIT
MW	MONITORING WELL
SS	SOIL SAMPLE AT OUTFALL

SAMPLE LOCATION IDENTIFIER

CRP-SS122	
0-0.5 ft	0.576
0.5-1 ft	0.0923

DEPTH OF SAMPLE

ANALYTICAL RESULT ABOVE EXCEEDANCE LIMIT (0.4 mg/kg)

ANALYTICAL RESULT BELOW EXCEEDANCE LIMIT (0.4 mg/kg)

NOTES

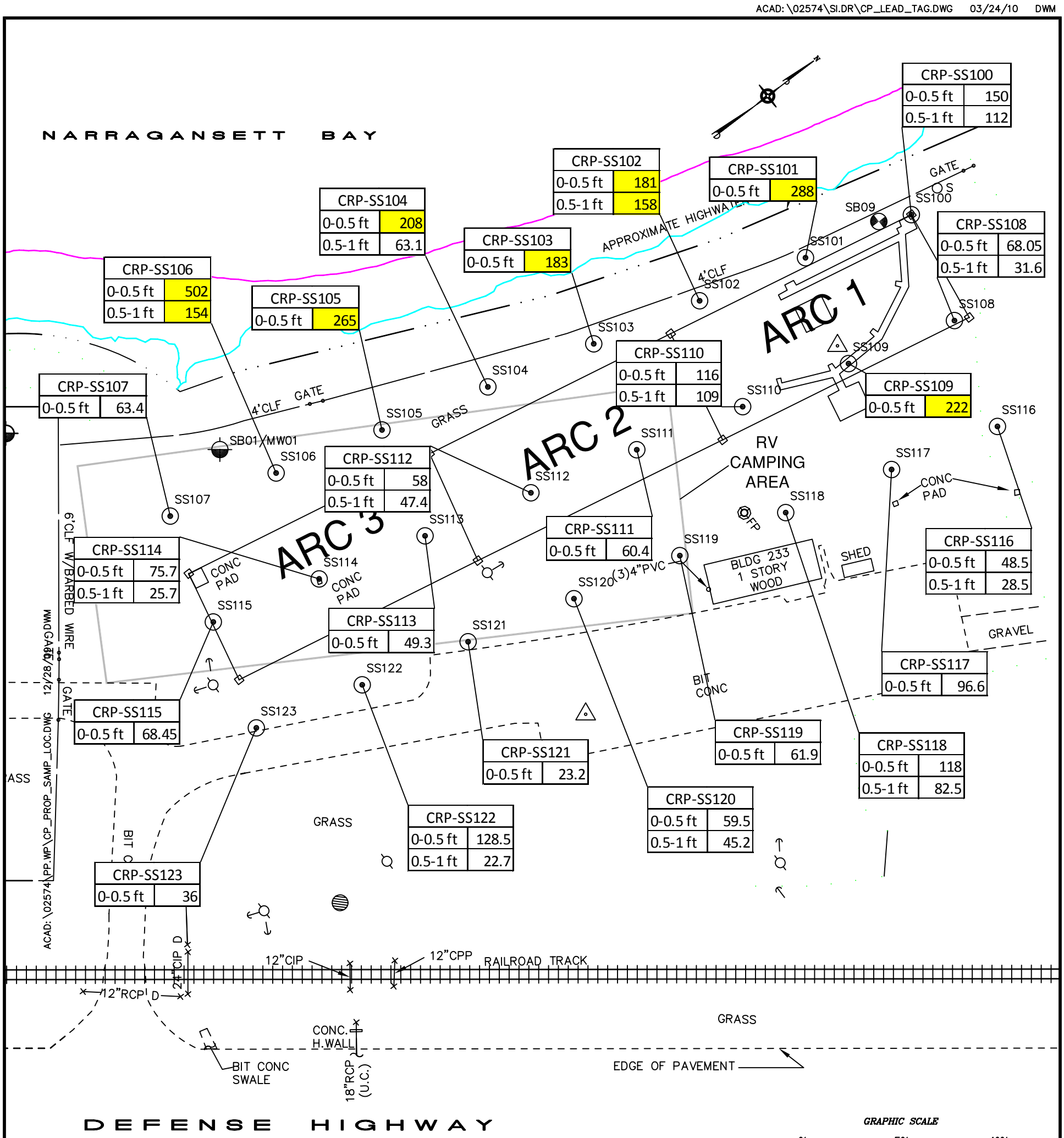
1. COORDINATES, IN U.S. SURVEY FEET, ARE IN THE RHODE ISLAND COORDINATE SYSTEM, REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, CORS ADJUSTMENT (NAD 83/CORS), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS MADE JUNE 17, 2009 USING THE KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS).
2. ELEVATIONS, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS, MADE JUNE 17, 2009, USING The KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS). THE OBSERVED ELEVATIONS HAVE BEEN CONVERTED TO NGVD 29, USING A CONVERSION FACTOR 0.87' FROM THE GPS DERIVED NAVD88 VALUE.
3. NO SUBSURFACE UTILITY LINES HAVE BEEN COMPILED FOR THIS PLAN, READILY VISIBLE DRAIN LINES WERE LOCATED AND SHOWN ON THIS PLAN. SMC ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES NOT SHOWN.
4. BEFORE DESIGNING FUTURE CONNECTIONS, THE APPROPRIATE UTILITIES MUST BE CONSULTED.
5. BEFORE CONSTRUCTION, ALL UTILITIES, PUBLIC AND PRIVATE, MUST BE NOTIFIED (SEE RHODE ISLAND GENERAL LAWS, SECTION 39-1.2). CALL "DIG SAFE" 1-888-DIG-SAFE (888-344-7233).
6. NO PORTSMOUTH, RI, MAP AND PARCEL NUMBERS WERE OBTAINED FOR THIS SURVEY.
7. EXCEEDANCE LIMIT BASED ON RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA.

TETRA TECH NUS, INC.

BENZO(A)PYRENE IN SOIL
ADDITIONAL INVESTIGATION
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

FILE	SCALE
\..\CP_BAP_TAG.DWG	AS NOTED
FIGURE NUMBER 1-3	REV 0 / DATE 03/24/10

ACAD: \02574\SI.DR\CP_LEAD_TAG.DWG 03/24/10 DWM



LEGEND

△	TRAVERSE STATION
•	PK. REBAR, NAIL, SPIKE
	GUARDRAIL
	TREE LINE
	CHAIN LINK FENCE
CLF	CHAIN LINK FENCE
	CURBING(TYPE)
BIT CONC	BITUMINOUS CONCRETE
GRAN	GRANITE
←	GUY WIRE
	UTILITY POLE OR LIGHT POLE
○ DMH	DRAIN MAN HOLE
	HYD
R=	RIM
I=	INVERT
SS100	PROPOSED SOIL SAMPLE LOCATION

	APPROXIMATE LOW WATER LINE
	APPROXIMATE HIGH WATER LINE MARKED VIA GPS JUNE 2009
	APPROXIMATE HIGH WATER LINE ESTIMATED BY SURVEYOR
RCP	REINFORCED CONCRETE PIPE
PVC	POLYVINYLCHLORIDE PIPE
CPP	CORRUGATED PLASTIC PIPE
CIP	CAST IRON PIPE
MP	MARKER POST
WP	WOOD POST
GP	GUARD POST
H.WALL	HEAD WALL
(TYP.)	TYPICAL
FP	FLAGPOLE
(U.C.)	UNDETERMINED CONNECTION
SB#	BOREHOLE
TP#	TEST PIT
MW	MONITORING WELL
SS	SOIL SAMPLE AT OUTFALL

SAMPLE LOCATION IDENTIFIER

CRP-SS104	
0-0.5 ft	208
0.5-1 ft	63.1

ANALYTICAL RESULT ABOVE EXCEEDANCE LIMIT (150 mg/kg)

ANALYTICAL RESULT BELOW EXCEEDANCE LIMIT (150 mg/kg)

DEPTH OF SAMPLE

NOTES

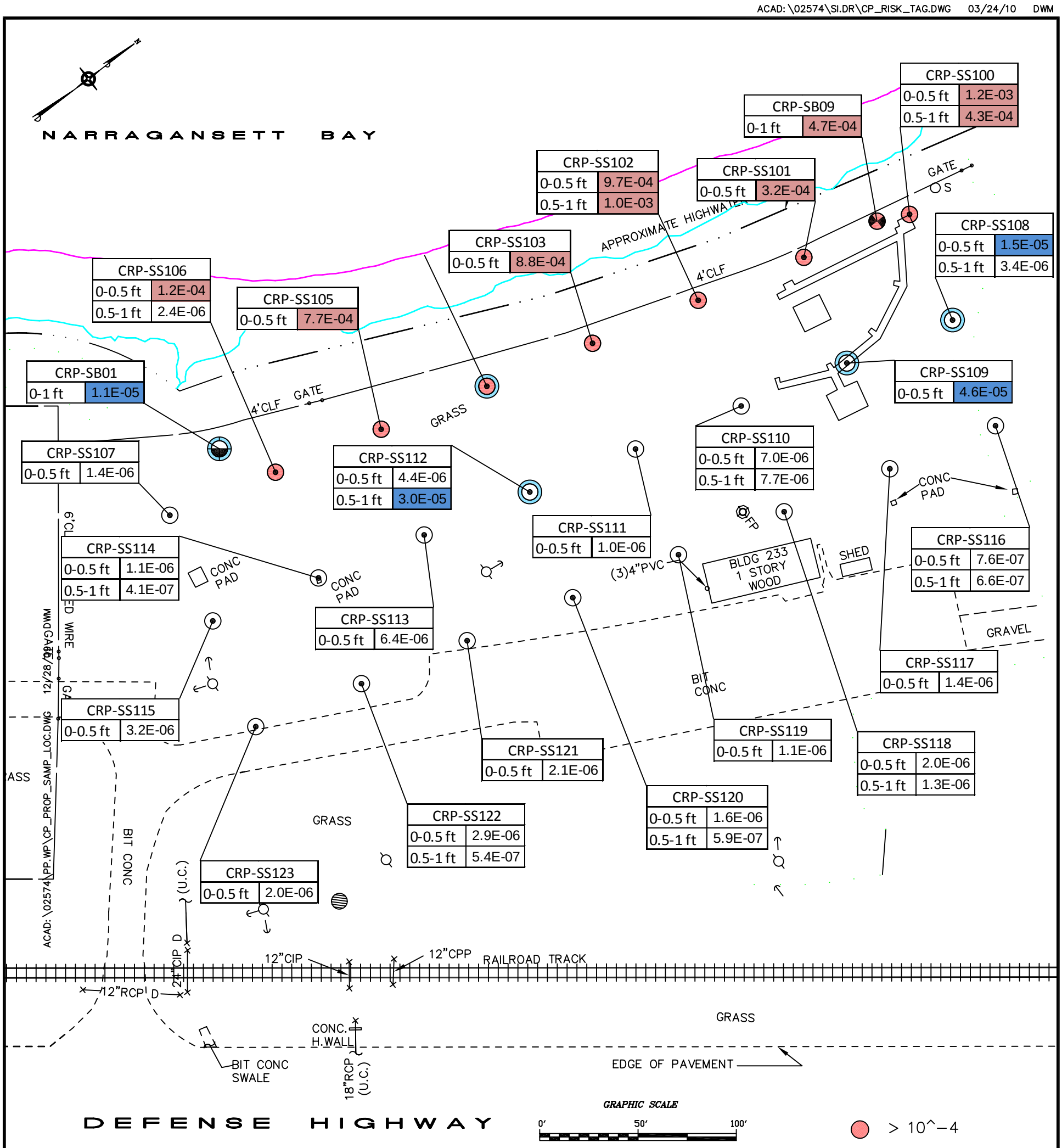
1. COORDINATES, IN U.S. SURVEY FEET, ARE IN THE RHODE ISLAND COORDINATE SYSTEM, REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, CORS ADJUSTMENT (NAD 83/CORS), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS MADE JUNE 17, 2009 USING THE KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS).
2. ELEVATIONS, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS, MADE JUNE 17, 2009, USING The KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS). THE OBSERVED ELEVATIONS HAVE BEEN CONVERTED TO NGVD 29, USING A CONVERSION FACTOR 0.87' FROM THE GPS DERIVED NAVD88 VALUE.
3. NO SUBSURFACE UTILITY LINES HAVE BEEN COMPILED FOR THIS PLAN, READILY VISIBLE DRAIN LINES WERE LOCATED AND SHOWN ON THIS PLAN. SMC ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES NOT SHOWN.
4. BEFORE DESIGNING FUTURE CONNECTIONS, THE APPROPRIATE UTILITIES MUST BE CONSULTED.
5. BEFORE CONSTRUCTION, ALL UTILITIES, PUBLIC AND PRIVATE, MUST BE NOTIFIED (SEE RHODE ISLAND GENERAL LAWS, SECTION 39-1.2). CALL "DIG SAFE" 1-888-DIG-SAFE (888-344-7233).
6. NO PORTSMOUTH, RI, MAP AND PARCEL NUMBERS WERE OBTAINED FOR THIS SURVEY.
7. EXCEEDANCE LIMIT BASED ON RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA.

TETRA TECH NUS, INC.

LEAD IN SOIL
ADDITIONAL INVESTIGATION
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

FILE	SCALE
\..\CP_LEAD_TAG.DWG	AS NOTED
FIGURE NUMBER 1-4	REV 0 / DATE 03/24/10

ACAD: \02574\SI.DR\CP_RISK_TAG.DWG 03/24/10 DWM



LEGEND

△	TRAVERSE STATION
•	PK. REBAR, NAIL, SPIKE
	GUARDRAIL
	TREE LINE
	CHAIN LINK FENCE
CLF	CHAIN LINK FENCE
	CURBING(TYPE)
BIT CONC	BITUMINOUS CONCRETE
GRAN	GRANITE
←	GUY WIRE
	UTILITY POLE OR LIGHT POLE
DMH	DRAIN MAN HOLE
	HYD
R=	RIM
I=	INVERT
⊙	PROPOSED SOIL SAMPLE LOCATION

	APPROXIMATE LOW WATER LINE
	APPROXIMATE HIGH WATER LINE MARKED VIA GPS JUNE 2009
	APPROXIMATE HIGH WATER LINE ESTIMATED BY SURVEYOR
RCP	REINFORCED CONCRETE PIPE
PVC	POLYVINYLCHLORIDE PIPE
CPP	CORRUGATED PLASTIC PIPE
CIP	CAST IRON PIPE
MP	MARKER POST
WP	WOOD POST
GP	GUARD POST
H.WALL	HEAD WALL
(TYP.)	TYPICAL
FP	FLAGPOLE
(U.C.)	UNDETERMINED CONNECTION
SB#	BOREHOLE
TP#	TEST PIT
MW	MONITORING WELL
SS	SOIL SAMPLE AT OUTFALL

SAMPLE LOCATION IDENTIFIER

CRP-SS104	
0-0.5 ft	4.4E-04
0.5-1 ft	2.1E-05

DEPTH OF SAMPLE

CANCER RISK ABOVE 10^-4 OR 10^-5 LIMIT

CANCER RISK ABOVE 10^-5 LIMIT

NOTES

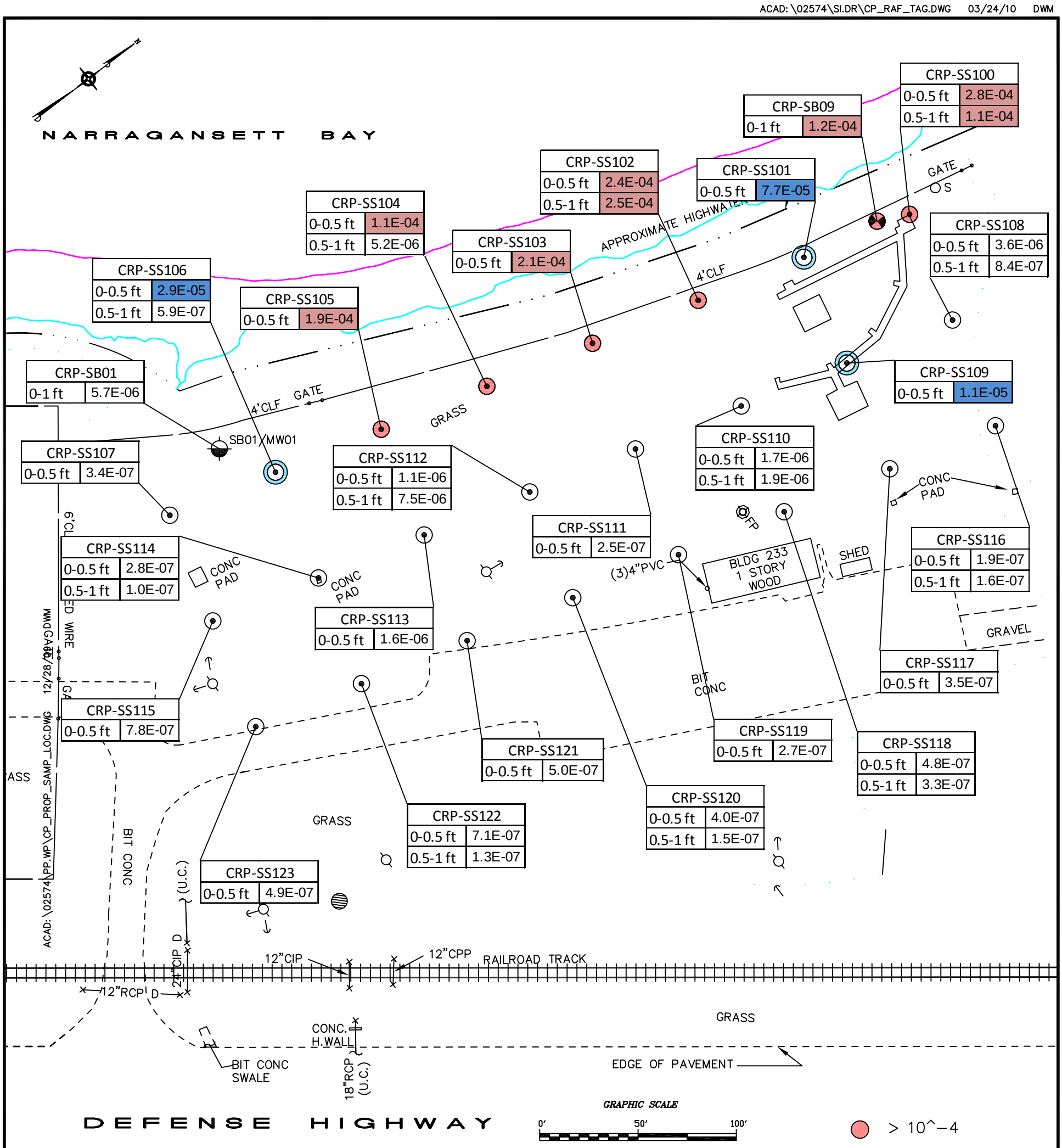
1. COORDINATES, IN U.S. SURVEY FEET, ARE IN THE RHODE ISLAND COORDINATE SYSTEM, REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, CORS ADJUSTMENT (NAD 83/CORS), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS MADE JUNE 17, 2009 USING THE KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS).
2. ELEVATIONS, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS, MADE JUNE 17, 2009, USING The KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS). THE OBSERVED ELEVATIONS HAVE BEEN CONVERTED TO NGVD 29, USING A CONVERSION FACTOR 0.87' FROM THE GPS DERIVED NAVD88 VALUE.
3. NO SUBSURFACE UTILITY LINES HAVE BEEN COMPILED FOR THIS PLAN, READILY VISIBLE DRAIN LINES WERE LOCATED AND SHOWN ON THIS PLAN. SMC ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES NOT SHOWN.
4. BEFORE DESIGNING FUTURE CONNECTIONS, THE APPROPRIATE UTILITIES MUST BE CONSULTED.
5. BEFORE CONSTRUCTION, ALL UTILITIES, PUBLIC AND PRIVATE, MUST BE NOTIFIED (SEE RHODE ISLAND GENERAL LAWS, SECTION 39-1.2). CALL "DIG SAFE" 1-888-DIG-SAFE (888-344-7233).
6. NO PORTSMOUTH, RI, MAP AND PARCEL NUMBERS WERE OBTAINED FOR THIS SURVEY.
7. EXCEEDANCE LIMIT BASED ON RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA.

TETRA TECH NUS, INC.

LIFETIME RECREATIONAL USER CANCER RISK
REASONABLE MAXIMUM EXPOSURE CASE
ADDITIONAL INVESTIGATION
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

FILE	SCALE
\..\CP_RISK_TAG.DWG	AS NOTED
FIGURE NUMBER 2-1	REV 0 / DATE 03/24/10

ACAD: \02574\SI.DR\CP_RAF_TAG.DWG 03/24/10 DWM



LEGEND

	TRAVERSE STATION
	PK. REBAR, NAIL, SPIKE
	GUARDRAIL
	TREE LINE
	CHAIN LINK FENCE
CLF	CHAIN LINK FENCE
	CURBING(TYPE)
BIT CONC	BITUMINOUS CONCRETE
GRAN	GRANITE
	GUY WIRE
	UTILITY POLE OR LIGHT POLE
DMH	DRAIN MAN HOLE
	HYD
R=	RIM
I=	INVERT
	PROPOSED SOIL SAMPLE LOCATION

	APPROXIMATE LOW WATER LINE
	APPROXIMATE HIGH WATER LINE MARKED VIA GPS JUNE 2009
	APPROXIMATE HIGH WATER LINE ESTIMATED BY SURVEYOR
RCP	REINFORCED CONCRETE PIPE
PVC	POLYVINYLCHLORIDE PIPE
CPP	CORRUGATED PLASTIC PIPE
CIP	CAST IRON PIPE
MP	MARKER POST
WP	WOOD POST
GP	GUARD POST
H.WALL	HEAD WALL
(TYP.)	TYPICAL
FP	FLAGPOLE
(U.C.)	UNDETERMINED CONNECTION
SB#	BOREHOLE
TP#	TEST PIT
MW	MONITORING WELL
SS	SOIL SAMPLE AT OUTFALL

NOTES

1. COORDINATES, IN U.S. SURVEY FEET, ARE IN THE RHODE ISLAND COORDINATE SYSTEM, REFERENCED TO THE NORTH AMERICAN DATUM OF 1983, CORS ADJUSTMENT (NAD 83/CORS), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS MADE JUNE 17, 2009 USING THE KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS).
2. ELEVATIONS, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29), AS DETERMINED BY SMC'S G.P.S. OBSERVATIONS, MADE JUNE 17, 2009, USING The KeyNetGPS VIRTUAL REFERENCE SYSTEM (VRS). THE OBSERVED ELEVATIONS HAVE BEEN CONVERTED TO NGVD 29, USING A CONVERSION FACTOR 0.87' FROM THE GPS DERIVED NAVD88 VALUE.
3. NO SUBSURFACE UTILITY LINES HAVE BEEN COMPILED FOR THIS PLAN, READILY VISIBLE DRAIN LINES WERE LOCATED AND SHOWN ON THIS PLAN. SMC ASSUMES NO RESPONSIBILITY FOR DAMAGES INCURRED AS A RESULT OF UTILITIES NOT SHOWN.
4. BEFORE DESIGNING FUTURE CONNECTIONS, THE APPROPRIATE UTILITIES MUST BE CONSULTED.
5. BEFORE CONSTRUCTION, ALL UTILITIES, PUBLIC AND PRIVATE, MUST BE NOTIFIED (SEE RHODE ISLAND GENERAL LAWS, SECTION 39-1.2). CALL "DIG SAFE" 1-888-DIG-SAFE (888-344-7233).
6. NO PORTSMOUTH, RI, MAP AND PARCEL NUMBERS WERE OBTAINED FOR THIS SURVEY.
7. EXCEEDANCE LIMIT BASED ON RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA.

TETRA TECH NUS, INC.

LIFETIME RECREATIONAL USER CANCER RISK
REASONABLE MAXIMUM EXPOSURE CASE (RAF)
ADDITIONAL INVESTIGATION
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, RHODE ISLAND

FILE	SCALE
\..\CP_RAF_TAG.DWG	AS NOTED
FIGURE NUMBER 2-2	REV 0 / DATE 03/24/10

REFERENCES

REFERENCES

Baer et al. 1995. Toxicity evaluation of trap and skeet shooting targets to aquatic test species. Ecotoxicology 4,385-392.

Batelle. September 2005. Final Record of Decision Skeet Range Alameda Point, Alameda, California.

MADEP (Massachusetts Department of Environmental Protection). April 1994. Background Documentation for the Development of the MCP Numerical Standards.

MADEP. July 1995. Guidance for Disposal Site Risk Characterization. Interim Final Policy WSC/ORS-95-141.

Magee, et al. 1996. Absorption adjustment factor (AAF) distributions for polycyclic aromatic hydrocarbons (PAHS), Human and Ecological Risk Assessment: An International Journal,2:4,841 – 873.

Tetra Tech. July 2008. 2008 Basewide Background Study Report for Naval Station Newport.

USEPA (U.S. Environmental Protection Agency), 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual, Part A. Interim Final. December.

USEPA (U.S. Environmental Protection Agency), 1993. Provisional Guidance for Quantitative Risk Assessment for Polycyclic Aromatic Hydrocarbons. Office of Research and Development. Washington, D.C. EPA/600/R-93-089. July.

USEPA (U.S. Environmental Protection Agency), 1997. Health Effects Assessment Summary Table (HEAST). July.

USEPA (U.S. Environmental Protection Agency), 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10. Office of Emergency and Remedial Response, Washington, D.C, December.

USEPA (U.S. Environmental Protection Agency), 2002b. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), Publication EPA530-D-F02-052, November.

USEPA (U.S. Environmental Protection Agency), 2002c. Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites, OSWER 9355.4-24, Office of Solid Waste and Emergency Response Washington, D.C., December.

USEPA (U.S. Environmental Protection Agency), 2003. Human Health Toxicity Values in Superfund Risk Assessments. Office of Superfund Remediation and Technology Innovation, OSWER 9285.7-53, Washington, DC. December.

USEPA (U.S. Environmental Protection Agency), 2004. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment). Office of Emergency and Remedial Response, Washington, D.C., July.

USEPA (U.S. Environmental Protection Agency), 2005. Guidelines for Carcinogen Risk Assessment. EPA/630/P-03/001B. Risk Assessment Forum, Washington, D.C. March.

USEPA (U.S. Environmental Protection Agency), 2005b. Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens. EPA/630/R-03/003F. Risk Assessment Forum, Washington, DC. March.

USEPA (U.S. Environmental Protection Agency), 2009. Regional Screening Levels for Chemical Contaminants at Superfund Sites prepared by Oak Ridge National Laboratory. December. http://epa-prgs.ornl.gov/chemicals/index.shtml. December.

USEPA (U.S. Environmental Protection Agency), 2009b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final. Office of Superfund Remediation and Technology Innovation, Washington, D.C. 20460 EPA-540-R-070-002, OSWER 9285.7-82, January.

Regional Screening Levels for Chemical Contaminants at Superfund Sites prepared by Oak Ridge National Laboratory. December. http://epa-prgs.ornl.gov/chemicals/index.shtml. December.

Acronyms and Abbreviations

AAFs	Absorption Adjustment Factors
ABS	Absorption Factor
ADAF	Age-Dependent Adjustment Factors
AF	Skin Adherence Factor
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
BaP_{equiv}	Benzo(a)pyrene Equivalents
BW	Body Weight
Cal/EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Chemical of Potential Concern
cPAH	Carcinogenic Polycyclic Aromatic Hydrocarbon
CF	Conversion Factor
CSF	Cancer Slope Factors
CTE	Central Tendency Exposure
EC	Exposure Concentration
ED	Exposure Duration
EF	Exposure Frequency
EPC	Exposure Point Concentration
ET	Exposure Time
FI	Fraction Ingested from contaminated source
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HIs	Hazard Indices
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risks
IR	Ingestion Rate
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
MADEP	Massachusetts Department of Environmental Protection
NCEA	National Center for Environmental Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PEF	Particulate Emissions Factor
PPRTVs	Provisional Peer Reviewed Toxicity Values
RAF	Relative Absorption Factor
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Residential Screening Levels
RVCP	Recreational Vehicle Camping Park
SA	Skin Surface Area Available for Contact
TEF	Toxicity Equivalency Factors
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
VF	Volatilization Factor

Attachment A

ATTACHMENT A

A.1 CHEMICAL INTAKE ESTIMATION

The methodologies and techniques used to estimate exposure intakes are presented in this section. Exposure assumptions for the RME and CTE scenarios are presented in Tables 4-3 and 4.4, respectively. Most of the exposure assumptions used to estimate chemical intakes from incidental ingestion of soil, dermal contact with soil and inhalation of soil are based on default assumptions described in the standard USEPA guidance. The following paragraph briefly discusses non-default, receptor-specific exposure assumptions that were used.

An exposure duration of five consecutive years was assumed for the child, older child, and adult recreational user based on the typical recreational usage information provided by the Facility. The exposure frequency assumptions for the recreational users were 7 days per year and 14 days per year under the CTE and RME cases, respectively. These frequencies were based on Facility Information that recreational users rent a camp site for one or two weeks during the warm weather months. The exposure frequency assumption for the worker was 26 days per year, and is based on the assumption that a maintenance worker would mow the grass approximately one day per week during warm weather months.

A.1.1 Incidental Ingestion of Soil

Direct physical contact with surface soils in the vicinity of the recreational vehicle camping park (RVCP) may result in the incidental ingestion of chemicals. Chemical intake for the incidental ingestion of soil is estimated in the following manner (USEPA, 1989):

$$\text{Intake} = \frac{(C_s)(IR)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

Intake	=	intake of chemical from soil (mg/kg/day)
C_s	=	concentration of chemical in soil (mg/kg)
IR	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
CF	=	conversion factor (1×10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days); for noncarcinogens, AT = ED x 365 days/yr; for carcinogens, AT = 70 yr x 365 days/yr

A.1.2 Dermal Contact with Soil

Direct physical contact with soil may result in the dermal absorption of chemicals. Exposure associated with dermal contact with soil is estimated in the following manner (USEPA, 1989):

$$\text{Intake} = \frac{(C_s)(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

Intake	=	amount of chemical absorbed during contact with soil(mg/kg/day)
C_s	=	concentration of chemical in soil (mg/kg)
SA	=	skin surface area available for contact (cm^2)
AF	=	skin adherence factor (mg/cm^2-event)
ABS	=	absorption factor (dimensionless)
CF	=	conversion factor (1×10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

To the extent possible, chemical-specific dermal absorption factors provided in RAGS Part E were used to evaluate the COPCs for soil. However, dermal absorption factors are only available for the short list of chemicals listed in Exhibit 3-4 of RAGS Part E.

For the chemicals identified as COPCs in soil, chemical specific dermal absorption factors provided in RAGS E were used to evaluate the COPCs for soil. Values used in this risk assessment are presented in Table A-1.

A.1.3 Inhalation of Air Containing Fugitive Dust/Volatiles Emitted from Soil

The quantitative risk from inhalation of air and fugitive dust was evaluated for soil. The same equation is used for both particulates and vapors/gases (USEPA, 2009b):

$$EC = \frac{(C_{air})(ET)(EF)(ED)}{(AT)(24\ \text{hr/day})}$$

where:

EC	=	Exposure concentrations (mg/m^3)
C_{air}	=	concentration of chemical in air (mg/m^3)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
AT	=	averaging time (days);
	=	for noncarcinogens, AT = ED x 365 days/yr;
	=	for carcinogens, AT = 70 yr x 365 days/yr

The concentrations of chemicals in air resulting from emissions from soil are developed following procedures presented in USEPA Soil Screening Guidance (USEPA, 2002b). The chemical concentration in air is calculated from:

$$C_{air} = C_{soil} \times \left[\frac{1}{PEF} + \frac{1}{VF} \right]$$

where:

C_{air}	=	chemical concentration in air, mg/m^3
C_{soil}	=	chemical concentration in soil, mg/kg
PEF	=	Particulate emission factor, m^3/kg
VF	=	volatilization factor, m^3/kg

The particulate emissions factor, particulate emission factor (PEF), relates the concentration of the chemical in soil with the concentration of dust particles in air. A PEF value of 1.1 x 10^{+10} m^3/kg was obtained from USEPA's Soil Screening Internet site located at http://rais.ornl.gov/epa/ssl1.shtml. This is the default value for Hartford, Connecticut. Sample calculations for the PEFs are presented at the end of Attachment A.

Ambient air concentrations resulting from the volatilization of COPCs from soil are chemical dependent and were calculated using the following equation from USEPA's Soil Screening Guidance:

$$VF = \frac{Q/C \times (3.14 \times D_a \times T)^{0.5} \times 10^{-4} \ (m^2 / cm^2)}{(2 \times \rho_b \times D_a)}$$

and

$$D_a = \frac{[(\theta_a^{10/3} \times D_i \times H' + \theta_w^{10/3} \times D_w)/n^2]}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

where:

VF	=	volatilization factor (m^3-air/kg-soil)
Q/C	=	inverse of the mean concentration at the center of source (gm/m^2-sec per kg/m^3)
D_a	=	apparent diffusivity, chemical specific, (cm^2/sec)
T	=	exposure interval, exposure specific, (sec)
ρ_b	=	dry bulk soil particle density (g/cm^3)
θ_a	=	air-filled soil porosity (L_{air}/L_{soil})
D_i	=	diffusivity in air, chemical specific, (cm^2/sec)
n	=	total soil porosity (L_{pore}/L_{soil})
θ_w	=	water-filled soil porosity (L_{air}/L_{soil})
D_w	=	diffusivity in water, chemical specific, (cm^2/sec)
K_d	=	soil-water partition coefficient, chemical specific
H'	=	dimensionless Henry's law constant, chemical specific

Chemical properties were obtained from the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002c) and the USEPA RSL table, and are presented in Table A-2. Input assumptions for the calculation of VF are presented in Table A-3.

A.2 ACCESSING CANCER RISKS FROM EARLY LIFE EXPOSURES

USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005) recommends making adjustments to the toxicity of carcinogenic chemicals which act via the mutagenic mode of action when evaluating early life exposures. The guidance recommends using age-dependent adjustment factors (ADAFs) combined with age-specific exposure estimates when assessing cancer risks. In the absence of chemical-specific data the supplemental guidance recommends the following default adjustments which reflect that cancer risks are generally higher from early-life exposures than from similar exposures later in life:

- For exposures before 2 years of age (i.e., spanning a 2-year interval from the first day of birth up until a child's second birthday), a 10-fold adjustment.
- For exposures between 2 and less than 16 years of age (i.e., spanning a 14-year time interval from a child's second birthday up until their sixteenth birthday), a 3-fold adjustment.
- For exposures after turning 16 years of age, no adjustment.

The adjustments were applied using the same method as that is used by USEPA in the development of the RSLs. Children were evaluated as two age groups, ages 0 to 2 years and ages 2 to 6 years; recreational users were evaluated as one age group, 6 to 16 years of age; and adults were evaluated as one age group, ages 16 to 30 years of age. Using this approach, the intakes for child recreational users and adult recreational users were calculated as follows:

$$\text{Intake}_{\text{Child}} = \text{Intake}_{(\text{ages } 0-2 \text{ years})} \times 10 + \text{Intake}_{(\text{ages } 2-6 \text{ years})} \times 3$$
$$\text{Intake}_{\text{Adolescent}} = \text{Intake}_{(\text{age } 6-16 \text{ years})} \times 3$$
$$\text{Intake}_{\text{Adult}} = \text{Intake}_{(\text{ages } 16-30 \text{ years})} \times 1$$

The above approach was used only for those chemicals which are identified as mutagenic in the USEPA RSL screening table (e.g., cPAHs and chromium). Additionally, the lifelong recreational user receptor was evaluated. The risks for these receptors are sums of the cancer risks for the individual child, adolescent, and adult receptors. Therefore, lifelong cancer risks for chemicals that act via the mutagenic pathway are assessed through the lifelong recreational user receptors.

A.3 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to identify the potential adverse health effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects are defined for the identified constituents of concern. Quantitative toxicity values determined during this component of the risk assessment are integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The toxicity value used to evaluate noncarcinogenic health effects for ingestion and dermal exposures is the reference dose (RfD). The reference concentration (RfC) is used to evaluate noncarcinogenic health effects for inhalation exposures. The RfD and RfC are estimates of the daily exposure level for the human population that is likely to be without appreciable risk during a portion or all of a lifetime. It is based on a review of available animal and/or human toxicity data, with adjustments for various uncertainties associated with the data. Carcinogenic effects are quantified using the cancer slope factor (CSF) for ingestion and dermal exposures and inhalation unit risks (IUR) for inhalation exposure, which are plausible upper-bound estimates of the probability of development of cancer per unit intake of chemical over a lifetime. These are typically based on available dose-response data from human and/or animal studies.

A.3.1 Toxicity Criteria for Oral and Inhalation Exposures

Oral RfDs and CSFs and inhalation RfCs and IURs used in the RVCP risk assessment were obtained from the following primary USEPA literature sources (USEPA, 2003):

- Integrated Risk Information System (IRIS).
- USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by USEPA's Superfund program.
- Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal/EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR), and the Annual Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997).

Although toxicity criteria can be found in several toxicological sources, USEPA's IRIS online database is the preferred source of toxicity values. This database is continuously updated, and the presented values have been verified by USEPA. The USEPA RSL table may also be used as a source of toxicity criteria. This table is updated several times a year and reflects recent changes in IRIS. The toxicity criteria for the constituents selected as COPCs for the RVCP are presented in Table A-1 and in the Rags Part D Tables 5 and 6 presented in Attachment B.

A.3.2 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature are typically expressed as administered (not absorbed) doses. Therefore, these values are considered to be inappropriate for estimating the risks associated with the dermal route of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made.

When the oral absorption is essentially complete (i.e., 100 percent), the absorbed dose is equivalent to the administered dose, and therefore no toxicity adjustment is necessary. Conversely, when the gastrointestinal absorption of a chemical is poor (e.g., 1 percent), the absorbed dose is smaller than the administered dose; thus, toxicity factors based on absorbed dose should be adjusted to account for the difference in the absorbed dose relative to the administered dose. USEPA (2004) recommends a cut-off of 50 percent absorption to reflect the intrinsic variability in the analysis of absorption studies. Therefore, the adjustment from administered to absorbed dose was only performed when the chemical-specific gastrointestinal absorption efficiency was less than 50 percent. The adjustment from administered to absorbed dose was made using chemical-specific gastrointestinal absorption efficiencies published in available guidance [e.g.,, USEPA 2004 (the primary reference); IRIS; ATSDR toxicological profiles, etc.] and the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$
$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where: ABS_{GI} = absorption efficiency in the gastrointestinal tract
RfD_{dermal} = reference dose for the dermal route of exposure
RfD_{oral} = reference dose for the oral route of exposure
CSF_{dermal} = cancer slope factor for the dermal route of exposure
CSF_{oral} = cancer slope factor of the oral route of exposure

As noted above, the preceding adjustment of the oral toxicity criteria (i.e., reference doses, cancer slope factors) is necessary so that the dermal route of exposure may be quantitatively evaluated in the baseline risk assessment. Further explanation of this procedure and the need for this procedure are presented in Appendix A of USEPA RAGS Part A.

A.3.3 Toxicity of Chromium

Toxicity criteria are available for different forms of chromium, which is considered to be more toxic in the hexavalent state. Chromium was selected as a COPC for soils. Risks associated with chromium were assessed assuming that 100 percent of the reported total chromium result is attributable to hexavalent chromium. This results in an overestimation of the risk estimates for chromium; but, does not impact the overall conclusions of the HHRA.

A.3.4 Toxicity Criteria for the Carcinogenic Effect of PAHs

Limited toxicity values are available to evaluate the carcinogenic effects from exposure to PAHs. The most extensively studied PAH is benzo(a)pyrene, which is classified by the USEPA as a probable human carcinogen. Although CSFs are available for benzo(a)pyrene, insufficient data are available to calculate CSFs for other cPAHs. Toxic effects for these chemicals were evaluated using toxicity equivalency

factors (TEFs) based on the potency of each compound relative to that of benzo(a)pyrene, as presented in current USEPA guidance (USEPA, 1993). The TEFs are used to convert each individual cPAH concentration into an equivalent concentration of benzo(a)pyrene.

A.3.5 Carcinogens that Act Via the Mutagenic Mode of Action

USEPA's Guidelines for Carcinogen Risk Assessment (USEPA, 2005) and Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005b) specifies the use of ADAFs for carcinogens that act via a mutagenic mode of action. Carcinogenic PAHs and chromium are included in the group of chemicals that have been determined to act via the mutagenic mode of action. No chemical-specific ADAFs have been derived for cPAHs and chromium; therefore, the following default ADAFs were used: 10 for ages 0 to 2, 3 for ages 2 to 16, and 1 (no adjustment) for ages 16 to 70. The ADAFs were used in evaluating exposures to cPAHs and chromium for recreational users.

A.4 QUANTITATIVE ANALYSIS OF CHEMICALS OTHER THAN LEAD

Quantitative estimates of risk for chemicals other than lead were calculated according to risk assessment methods outlined in USEPA guidance (USEPA, 1989). Lifetime cancer risks are expressed in the form of dimensionless probabilities, referred to as incremental lifetime cancer risks (ILCRs), based on CSFs and IURs. Noncarcinogenic risk estimates are presented in the form of HQs that are determined through a comparison of intakes with published RfDs and RfCs.

ILCR estimates for ingestion and dermal exposures are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$\text{ILCR} = (\text{Estimated Exposure Intake})(\text{CSF})$$

If the above equation results in an ILCR greater than 0.01, the following equation is used:

$$\text{ILCR} = 1\text{-}[\exp(\text{-Estimated Exposure Intake})(\text{CSF})]$$

ILCRs estimates for inhalation exposures are generated for each COPC using estimated exposure concentrations and published IURs, as

$$\text{ILCR} = (\text{IUR})(\text{Exposure Concentration})(1000\ \mu\text{g/mg})$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, noncarcinogenic risks were assessed using the concept of HQs and HIs. The HQ for a COPC is the ratio of the estimated intake to the RfD and is calculated for ingestion and dermal exposures, as follows:

$$HQ = (\text{Estimated Exposure Intake})/(\text{RfD})$$

For inhalation exposures, the HQ is calculated as follows:

$$HQ = (\text{Exposure Concentration})/(\text{RfC})$$

An HI was generated by summing the individual HQs for all COPCs. The HI is not a mathematical prediction of the severity of toxic effects and therefore is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

A.5 INTERPREATION OF RISK ASSESSMENT RESULTS

To interpret the quantitative risk estimates and to aid risk managers in determining the need for remediation, quantitative risk estimates are compared to typical USEPA risk benchmarks. Calculated ILCRs are interpreted using the USEPA's target cancer risk range (1×10^{-4} to 1×10^{-6}) and the State of Rhode Island cumulative risk benchmark of 1×10^{-5}; HIs are evaluated using a value of 1.0. Current USEPA policy regarding lead exposures is to limit the childhood risk of exceeding a 10 µg/dL blood-lead level to 5 percent.

USEPA has defined the range of 1×10^{-4} to 1×10^{-6} as the ILCR target range for hazardous waste facilities addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and RCRA. Individual or cumulative ILCRs greater than 1×10^{-4} are generally considered to be "unacceptable" by the USEPA. Risk management decisions are necessary when the ILCR is within 1×10^{-4} to 1×10^{-6}. Remediation is typically not required by the USEPA when the cumulative ILCR does not exceed 1×10^{-6}. As noted above the State of Rhode Island cumulative cancer risk benchmark is 1×10^{-5}.

An HI exceeding unity (1.0) indicates that there may be noncarcinogenic health risks associated with exposure. If an HI exceeds unity, target organ effects associated with exposure to COPCs are considered. Only those HQs for chemicals that affect the same target organ(s) or exhibit similar critical effect(s) are regarded as truly additive. Consequently, it may be possible for the cumulative HI to exceed 1.0, but no adverse health effects are anticipated if the COPCs do not affect the same target organ or exhibit the same critical effect (i.e., target-organ/critical effect-specific HIs do not exceed 1).

As a general guideline, a "no further action" recommendation will be made, if the cancer risk estimates and total HIs (developed on a target organ/target effect basis) for receptors of concern do not exceed 1×10^{-5} and 1, respectively, and if the USEPA risk benchmark for risks associated with lead exposure is not

exceeded. However, the 1×10^{-5} risk benchmark should not be viewed as a discrete limit. Risks slightly greater than 1×10^{-5} may be considered to be acceptable (i.e., protective) if justified based on site-specific conditions, including any uncertainties about the nature and extent of contamination and associated risks. Consequently, a "no further action" recommendation may be made to risk managers for review and discussion when the 1×10^{-5} risk benchmark is exceeded. The following factors will be considered in this determination:

- The magnitude of the media-specific risk estimates.
- Significant uncertainties in the baseline HHRA that would tend to overestimate baseline risk assessment results.
- Significant uncertainties in the EPC estimates that would tend to overestimate baseline risk assessment results.

TABLE A-1
TOXICITY CRITERIA
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, PORTSMOUTH, RHODE ISLAND

	Oral to Dermal Adjustment Factor	Oral Cancer Slope Factor	Adjusted Dermal Cancer Slope Factor	Inhalation Cancer Unit Risk	Chronic			Soil Absorption Factor	Primary Target Organ		Age-dependent adjustment factors			
					Oral RfD Value	Dermal RfD	Inhalation RfC		Oral/ Dermal	Inhalation	0 - 2	2 - 6	6 - 16	>16
PAHs														
Benzo(a)pyrene Equivalent	1	7.3E+00	7.3E+00	1.1E-03	NA	NA	NA	0.13	NA	NA	10	3	3	1
Benzo(g,h,i)perylene	1	NA	NA	NA	3.0E-02	3.0E-02	NA	0.13	Liver	NA	1	1	1	1
Fluoranthene	1	NA	NA	NA	4.0E-02	4.0E-02	NA	0.13	Liver	NA	1	1	1	1
Naphthalene	1	NA	NA	3.4E-05	2.0E-02	2.0E-02	3.0E-03	0.13	Body Weight	Nasal	1	1	1	1
Phenanthrene	1	NA	NA	NA	3.0E-02	3.0E-02	NA	0.13	Kidney	NA	1	1	1	1
Pyrene	1	NA	NA	NA	3.0E-02	3.0E-02	NA	0.13	Kidney	NA	1	1	1	1
Explosives														
Nitroglycerin	1	1.7E-02	1.7E-02	NA	1.0E-04	1.0E-04	NA	0.1	CVS		1	1	1	1
Inorganics														
Aluminum	1	NA	NA	NA	1.0E+00	1.0E+00	5.0E-03	0	CNS	CNS	1	1	1	1
Arsenic	1	1.5E+00	1.5E+00	4.3E-03	3.0E-04	3.0E-04	1.5E-05	0.03	Skin, CVS	NA	1	1	1	1
Chromium	0.025	5.0E-01	2.0E+01	8.4E-02	3.0E-03	7.5E-05	1.0E-04	0	Fetotoxicity, GS, Bone	NA	10	3	3	1
Cobalt	1	NA	NA	9.0E-03	3.0E-04	3.0E-04	6.0E-06	0	Blood	Lungs	1	1	1	1
Iron	1	NA	NA	NA	7.0E-01	7.0E-01	NA	0	GS	NA	1	1	1	1
Lead	1	NA	NA	NA	NA	NA	NA	0	NA	NA	1	1	1	1
Manganese	0.04	NA	NA	NA	1.4E-01	5.6E-03	5.0E-05	0	CNS	CNS	1	1	1	1

TABLE A-2
CHEMICAL PROPERTIES FOR VOLATILIZATION FROM SOIL TO OUTDOOR AIR MODELS
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical	Molecular Weight (g/mole)	Organic Carbon Partition Coefficient (cm^3/g)	Air Diffusivity (cm^2/sec)	Water Diffusivity (cm^2/sec)	Solubility Limit (mg/L)	Henry's Law Constant	
						(Dimensionless)	(atm-m^3/mol)
Naphthalene	1.28E+02	1.84E+03	6.00E-02	8.40E-06	1.84E+03	1.80E-02	4.40E-04
Phenanthrene	1.66E+02	4.80E+03	2.72E-02	7.24E-06	1.15E+00	3.92E-02	9.55E-04

Source:
USEPA 2009: USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites, December, 2009.

TABLE A-3
INPUT PARAMETERS FOR CALCULATION OF THE VOLATILIZATION FROM SOIL TO OUTDOOR AIR MODELS
MRP SITE 1, CARR POINT
NAVSTA NEWPORT, PORTSMOUTH, RHODE ISLAND

Parameter	Definition	Value	Reference
Q/C	Inverse of mean concentration at center of source (g/m^2-s per kg/m^3).	73.95045	USEPA, 2010
T	Exposure interval (seconds).	9.5E+08	USEPA, 2002
pb	Dry soil bulk density (g/cm^3).	1.5	USEPA, 2002
ps	Soil particle density (g/cm^3).	2.65	USEPA, 2002
θw	Water-filled soil porosity (L_{pore}/L_{soil}).	0.15	USEPA, 2002
n	Total soil porosity (L_{pore}/L_{soil}).	0.434	USEPA, 2002
Di	Diffusivity in air (cm^2/sec).	Chemical specific	USEPA, 2009
H'	Dimensionless Henry's Law Constant.	Chemical specific	USEPA, 2009
S	Solubility limit (mg/L)	Chemical specific	USEPA, 2009
Dw	Diffusivity in water (cm^2/sec).	Chemical specific	USEPA, 2009
Koc	Soil organic carbon partition coefficient (cm^3/g).	Chemical specific	USEPA, 2009
foc	Fraction organic carbon in soil (g/g).	0.006	USEPA, 2002

Notes:
Chemical specific values are presented in Table A-2
USEPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
USEPA, 2009: USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites, December 2009.
USEPA, 2010: Soil Screening Guidance calculation Internet site at http://risk.lsd.ornl.gov/calc_start.htm.
Site-specific values for Hartford, Connecticut.

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL WORKERS		
BASED ON: USEPA, DECEMBER 1989		
BY: R. JUPIN	**CHECKED BY:** Matthew Dorrance	**DATE:** 3/22/2010

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from incidental ingestion of surface soil.

EQUATION:

$$IEX = \frac{CS \times IR \times EF \times ED \times FI \times CF}{BW \times AT}$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
IR	=	incidental ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
FI	=	fraction ingested from contaminated source (unitless)
CF	=	conversion factor (1.0E-6 kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)
RfDo	=	oral noncarcinogenic reference dose (mg/kg/day)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFo (mg/kg/day)-1
HQ (Noncarcinogens) = Intake (mg/kg/day) / RFDo (mg/kg/day)

ASSUMPTIONS:

Cs	=	15.1	mg/kg	Chemical: Arsenic
IR	=	100	mg/day	
EF	=	26	days/year	
ED	=	25	years	
FI	=	0.125		
CF	=	1.0E-06	kg/mg	
BW	=	70	kg	
ATc	=	25550	days	
ATnc	=	9125	days	
CSFo	=	1.5E+00	$(mg/kg/day)^{-1}$	
RfDo	=	3.0E-04	(mg/kg/day)	

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL WORKERS		
BASED ON: USEPA, DECEMBER 1989		
BY: R. JUPIN	CHECKED BY: Matthew Nale	DATE: 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$IEXc = \frac{15.1 \text{ mg/kg} \times 100 \text{ mg/day} \times 26 \text{ days/year} \times 25 \text{ years} \times 0.125 \times 1.0E\text{-}06 \text{ kg/mg}}{70 \text{ kg} \times 25550 \text{ days}}$$

IEXc = 6.86E-08 mg/kg/day

ILCR = 6.86E-08 mg/kg/day x 1.50E+00 (mg/kg/day)-1 = Incremental Lifetime Cancer Risk

ILCR = 1.0E-07

EXAMPLE NONCARCINOGENIC CALCULATION

$$IEXnc = \frac{15.1 \text{ mg/kg} \times 100 \text{ mg/day} \times 26 \text{ days/year} \times 25 \text{ years} \times 0.125 \times 1.0E\text{-}06 \text{ kg/mg}}{70 \text{ kg} \times 9125 \text{ days}}$$

IEXnc = 1.92E-07 mg/kg/day

HQ = 1.92E-07 mg/kg/day / 3.00E-04 (mg/kg/day) = Hazard Quotient

HQ = 6.4E-04

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL WORKERS		
BASED ON: USEPA, JULY 2004		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from dermal contact with surface soil.

EQUATION:

$$DEX = \frac{Cs \times CF \times SA \times AF \times ABS \times EV \times EF \times ED}{BW \times AT}$$

Where:

DEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
CF	=	conversion factor (1.0E-6 kg/mg)
SA	=	skin surface available for contact (cm^2/day)
ABS	=	absorption factor (unitless)
AF	=	adherence factor (mg/cm^2-event)
EV	=	event frequency (events/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
CSFd	=	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$)
RfDd	=	dermal noncarcinogenic reference dose (mg/kg/day)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFd (mg/kg/day)-1
HQ (Noncarcinogens) = Intake (mg/kg/day) / RFDd (mg/kg/day)

ASSUMPTIONS:

Cs	=	15.1	mg/kg	Chemical: Arsenic
CF	=	1.0E-06	kg/mg	
SA	=	3300	cm^2	
AF	=	0.2	mg/cm^2-event	
ABS	=	0.03		
EV	=	0.125	events/day	
EF	=	26	days/year	
ED	=	25	years	
BW	=	70	kg	
ATc	=	25550	days	
ATnc	=	9125	days	
CSFd	=	1.5E+00	$(mg/kg/day)^{-1}$	
RfDd	=	3.0E-04	(mg/kg/day)	

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL WORKERS		
BASED ON: USEPA, JULY 2004		
BY: R. JUPIN	CHECKED BY:	DATE: 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$DEXc = \frac{15.1 \text{ mg/kg} \times 1.0E\text{-}06 \text{ kg/mg} \times 3300 \text{ cm2} \times 0.2 \text{ mg/cm2-event} \times 0.03 \times 0.125 \text{ events/day} \times 26 \text{ days/year} \times 25 \text{ years}}{70 \text{ kg} \times 25550 \text{ days}}$$

DEXc = 1.36E-08 mg/kg/day

ILCR = 1.36E-08 mg/kg/day x 1.50E+00 (mg/kg/day)-1 = Incremental Lifetime Cancer Risk

ILCR = 2.0E-08

EXAMPLE NONCARCINOGENIC CALCULATION

$$DEXnc = \frac{15.1 \text{ mg/kg} \times 1.0E\text{-}06 \text{ kg/mg} \times 3300 \text{ cm2} \times 0.2 \text{ mg/cm2-event} \times 0.03 \times 0.125 \text{ events/day} \times 26 \text{ days/year} \times 25 \text{ years}}{70 \text{ kg} \times 9125 \text{ days}}$$

DEXnc = 3.80E-08 mg/kg/day

HQ = 3.80E-08 mg/kg/day / 3.00E-04 (mg/kg/day) = Hazard Quotient

HQ = 1.3E-04

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS WORKERS		
BASED ON: USEPA, JANUARY 2009		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake, carcinogenic and noncarcinogenic risks from inhalation of surface soil.

EQUATION:

$$EC = \frac{Ca \times ET \times EF \times ED}{AT \times 24 \text{ hours/day}}$$

Where:

EC	=	exposure concentration (mg/m3)
Ca	=	exposure point concentration in air (mg/m3)
	=	Cs x 1/PEF
Cs	=	exposure point concentration in soil (mg/kg)
PEF	=	particulate emission factor (m3/kg)
ET	=	exposure time (hrs/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
IURi	=	inhalation unit risk ($(ug/m3)^{-1}$)
RfCi	=	inhalation reference concentration (mg/m3)

RISKS:

ILCR (Carcinogens) = Exposure Concentratin (mg/m3) x IURi (ug/m3)-1 x 1000 ug/mg
HQ (Noncarcinogens) = Exposure Concentration (mg/m3) / RFCi (mg/m3)

ASSUMPTIONS:

Cs	=	15.1	mg/kg	Chemical: Arsenic
PEF	=	1.10E+10	m3/kg	
Ca	=	1.37E-09	mg/m3	
ET	=	1	hour/day	
EF	=	26	days/year	
ED	=	25	years	
ATc	=	25550	days	
ATnc	=	9125	days	
IURi	=	4.3E-03	$(ug/m3)^{-1}$	
RfCi	=	1.5E-05	(mg/m3)	

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS WORKERS		
BASED ON: USEPA, JANUARY 2009		
BY: R. JUPIN	CHECKED BY:	DATE: 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$IEXc = \frac{1.37E\text{-}09 \text{ mg/m3} \times 1 \text{ hour/day} \times 26 \text{ days/year} \times 25 \text{ years}}{25550 \text{ days} \times 24 \text{ hours/day}}$$

IEXc = 1.46E-12 mg/m3

ILCR = 1.46E-12 mg/m3 x 4.30E-03 (ug/m3)-1 x 1000 ug/mg = Incremental Lifetime Cancer Risk

ILCR = 6.3E-12

EXAMPLE NONCARCINOGENIC CALCULATION

$$IEXnc = \frac{1.37E\text{-}09 \text{ mg/m3} \times 1 \text{ hour/day} \times 26 \text{ days/year} \times 25 \text{ years}}{9125 \text{ days} \times 24 \text{ hours/day}}$$

IEXnc = 4.07E-12 mg/m3

HQ = 4.07E-12 mg/m3 / 1.50E-05 (mg/m3) = Hazard Quotient

HQ **2.7E-07**

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF THE PARTICULATE EMISSION FACTOR (PEF)		
BASED ON: SUPPLEMENTAL GUIDANCE FOR DEVELOPING SOIL SCREENING LEVELS FOR SUPERFUND SITES (USEPA, DECEMBER, 2002)		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To calculate the particulate emission factor for residential and commercial/industrial exposure scenarios.

EQUATIONS:

$$PEF = Q/C_{wind} \times \frac{3600 \text{ sec/hr}}{0.036 \times (1 - V) \times (U_m/U_t)^3 \times F(x)}$$

$$Q/C_{wind} = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$$

Where:

PEF	=	particulate emission factor (m^3/kg)
Q/C_{wind}	=	Inverse of mean conc. at center of source (g/m^2-s per kg/m^3).
V	=	fraction of vegetative cover (unitless)
U_m	=	mean annual windspeed (m/sec)
U_t	=	equivalent threshold value of windspeed at 7m (m/sec)
F(x)	=	function dependent on Um/Ut derived using Cowherd et al. (1985) (unitless)
A,B,C	=	constants based on air dispersion modeling for specific climate zones
A_{site}	=	areal extent of the site or contamination (acres)

ASSUMPTIONS:

V	=	0.5	unitless	
U_m	=	3.84	m/sec	Values are for Hartford, Connecticut
U_t	=	11.32	m/sec	
F(x)	=	0.0345	unitless	
A	=	12.5907	unitless	
B	=	18.8368	unitless	
C	=	215.4377	unitless	
A_{site}	=	0.5	acres	

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF THE PARTICULATE EMISSION FACTOR (PEF) 0		
BASED ON: SUPPLEMENTAL GUIDANCE FOR DEVELOPING SOIL SCREENING LEVELS FOR SUPERFUND SITES (USEPA, DECEMBER, 2002)		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CALCULATION FOR Q/C_{wind}

Q/C_{wind} = 12.5907 x exp[(ln(0.5) - 18.8368)^2 / 215.4377]

Q/C_{wind} = 73.95045 g/m2-s per kg/m3

EXAMPLE CALCULATION FOR PEF

$$PEF = 73.95045 \times \frac{3600}{0.036 \times (1 - 0.5) \times (3.84/11.32)^3 \times 0.0345}$$

PEF = 1.10E+10 m^3/kg

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from incidental ingestion of surface soil.

EQUATION:

$$IEX = \frac{CS \times IR \times EF \times ED \times FI \times CF}{BW \times AT} \times ADAF$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
IR	=	incidental ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
FI	=	fraction ingested from contaminated source (unitless)
CF	=	conversion factor (1.0E-6 kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFo (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
IR	=	200	mg/day	
EF	=	14	days/year	
ED_1	=	2	years	
ED_2	=	3	years	
FI	=	1		
CF	=	1.0E-06	kg/mg	
BW	=	15	kg	
AT	=	25550	days	
CSFo	=	7.3E+00	$(mg/kg/day)^{-1}$	
$ADAF_1$	=	10		
$ADAF_2$	=	3		

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	CHECKED BY: Matthew O'Haus	DATE: 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$IEX_1 = \frac{266 \text{ mg/kg} \times 200 \text{ mg/day} \times 14 \text{ days/year} \times 2 \text{ years} \times 1 \times 1.0\text{E-06 kg/mg}}{15 \text{ kg} \times 25550 \text{ days}} \times 10$$

IEX_1 = 3.89E-05 mg/kg/day

$$IEX_2 = \frac{266 \text{ mg/kg} \times 200 \text{ mg/day} \times 14 \text{ days/year} \times 3 \text{ years} \times 1 \times 1.0\text{E-06 kg/mg}}{15 \text{ kg} \times 25550 \text{ days}} \times 3$$

IEX_2 = 1.75E-05 mg/kg/day

ILCR = (3.89E-05 mg/kg/day + 1.75E-05 mg/kg/day) x 7.30E+00 (mg/kg/day)-1

ILCR = 4.1E-04

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS CHILD RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from dermal contact with surface soil.

EQUATION:

$$DEX = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT} \times ADAF$$

Where:

DEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
CF	=	conversion factor (1.0E-6 kg/mg)
SA	=	skin surface available for contact (cm^2/day)
ABS	=	absorption factor (unitless)
AF	=	adherence factor (mg/cm^2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFd	=	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFd (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
CF	=	1.0E-06	kg/mg	
SA	=	2800	cm^2/day	
AF	=	0.2	mg/cm^2	
ABS	=	0.13		
EF	=	14	days/year	
ED_1	=	2	years	
ED_2	=	3	years	
BW	=	15	kg	
AT	=	25550	days	
CSFd	=	7.3E+00	$(mg/kg/day)^{-1}$	
$ADAF_1$	=	10		
$ADAF_2$	=	3		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS CHILD RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:** Matthew O'Shaw	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$DEXc = \frac{266\ mg/kg \times 1.0E\text{-}06\ kg/mg \times 2800\ cm2/day \times 0.2\ mg/cm2 \times 0.13 \times 14\ days/year \times 2\ years}{15\ kg \times 25550\ days} \times 10$$

DEXc = 1.41E-05 mg/kg/day

$$DEXc = \frac{266\ mg/kg \times 1.0E\text{-}06\ kg/mg \times 2800\ cm2/day \times 0.2\ mg/cm2 \times 0.13 \times 14\ days/year \times 3\ years}{15\ kg \times 25550\ days} \times 3$$

DEXc = 6.37E-06 mg/kg/day

ILCR = (1.41E-05 mg/kg/day + 6.37E-06 mg/kg/day) x 7.30E+00 (mg/kg/day)-1

ILCR = 1.5E-04

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR MUTAGENIC CHEMICALS - CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:** Matthew D Nunes	**DATE:** 3/22/2010

PURPOSE: To estimate intake, carcinogenic risks for mutagenic chemicals from inhalation of surface soil.

EQUATION:

$$EC = \frac{Ca \times ET \times EF \times ED}{AT \times 24\ hours/day} \times ADAF$$

Where:

EC	=	exposure concentration (mg/m3)
Ca	=	exposure point concentration in air (mg/m3)
	=	Cs x 1/PEF
Cs	=	exposure point concentration in soil (mg/kg)
PEF	=	particulate emission factor (m3/kg)
ET	=	exposure time (hrs/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
IURi	=	inhalation unit risk($(ug/mg)^{-1}$)

RISKS:

ILCR = Exposure concentration (mg/m3) x IURi (ug/m3)-1 x 1000 ug/mg

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
PEF	=	1.10E+10	m3/kg	
Ca	=	2.42E-08	mg/m3	
ET	=	24	hr/day	
EF	=	14	days/year	
ED_1	=	2	years	
ED_2	=	3	years	
ATc	=	25550	days	
IURi	=	1.1E-03	$(ug/m3)^{-1}$	
$ADAF_1$	=	10		
$ADAF_2$	=	3		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR MUTAGENIC CHEMICALS - CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:** Matthew D. Mann	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$EC = \frac{2.42E\text{-}08\ mg/m3 \times 24\ hr/day \times 14\ days/year \times 2\ years}{25550\ days \times 24\ hours/day} \times 10$$

$$EC = 2.65E\text{-}10\ mg/m3$$

$$EC = \frac{2.42E\text{-}08\ mg/m3 \times 24\ hr/day \times 14\ days/year \times 3\ years}{25550\ days \times 24\ hours/day} \times 3$$

$$EC = 1.19E\text{-}10\ mg/m3$$

$$ILCR = (2.65E\text{-}10\ mg/m3 + 1.19E\text{-}10\ mg/m3) \times 1.10E\text{-}03\ (ug/m3)\text{-}1 \times 1000\ ug/mg$$

$$\mathbf{ILCR = 4.2E\text{-}10}$$

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:** Matthew Mauro	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from incidental ingestion of surface soil.

EQUATION:

$$IEX = \frac{CS \times IR \times EF \times ED \times FI \times CF}{BW \times AT} \times ADAF$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
IR	=	incidental ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
FI	=	fraction ingested from contaminated source (unitless)
CF	=	conversion factor (1.0E-6 kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFo (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
IR	=	100	mg/day	
EF	=	14	days/year	
ED	=	5	years	
FI	=	1		
CF	=	1.0E-06	kg/mg	
BW	=	45	kg	
AT	=	25550	days	
CSFo	=	7.3E+00	$(mg/kg/day)^{-1}$	
ADAF	=	3		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$IEX_1 = \frac{266\ \text{mg/kg} \times 100\ \text{mg/day} \times 14\ \text{days/year} \times 5\ \text{years} \times 1 \times 1.0\text{E-06}\ \text{kg/mg}}{45\ \text{kg} \times 25550\ \text{days}} \times 3$$

IEX_1 = 4.86E-06 mg/kg/day

ILCR = 4.86E-06 mg/kg/day x 7.30E+00 (mg/kg/day)-1

ILCR = 3.5E-05

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from dermal contact with surface soil.

EQUATION:

$$DEX = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT} \times ADAF$$

Where:

DEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
CF	=	conversion factor (1.0E-6 kg/mg)
SA	=	skin surface available for contact (cm^2/day)
ABS	=	absorption factor (unitless)
AF	=	adherence factor (mg/cm^2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFd	=	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFd (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
CF	=	1.0E-06	kg/mg	
SA	=	5700	cm^2/day	
AF	=	0.07	mg/cm^2	
ABS	=	0.13		
EF	=	14	days/year	
ED	=	5	years	
BW	=	45	kg	
AT	=	25550	days	
CSFd	=	7.3E+00	$(mg/kg/day)^{-1}$	
ADAF	=	3		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$DEXc = \frac{266\ mg/kg \times 1.0E\text{-}06\ kg/mg \times 5700\ cm2/day \times 0.07\ mg/cm2 \times 0.13 \times 14\ days/year \times 5\ years}{45\ kg \times 25550\ days} \times 3$$

DEXc = 2.52E-06 mg/kg/day

ILCR = 2.52E-06 mg/kg/day x 7.30E+00 (mg/kg/day)-1

ILCR = 1.8E-05

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - ADULT RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from incidental ingestion of surface soil.

EQUATION:

$$IEX = \frac{CS \times IR \times EF \times ED \times FI \times CF}{BW \times AT} \times ADAF$$

Where:

IEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
IR	=	incidental ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
FI	=	fraction ingested from contaminated source (unitless)
CF	=	conversion factor (1.0E-6 kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFo	=	oral carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFo (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
IR	=	100	mg/day	
EF	=	14	days/year	
ED	=	5	years	
FI	=	1		
CF	=	1.0E-06	kg/mg	
BW	=	70	kg	
AT	=	25550	days	
CSFo	=	7.3E+00	$(mg/kg/day)^{-1}$	
ADAF	=	1		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISL		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INCIDENTAL INGESTION OF SOIL FOR MUTAGENIC CHEMICALS - ADULT RECREATIONAL USERS		
BASED ON: USEPA, DECEMBER 1989, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$IEX_1 = \frac{266\ \text{mg/kg} \times 100\ \text{mg/day} \times 14\ \text{days/year} \times 5\ \text{years} \times 1 \times 1.0\text{E-06}\ \text{kg/mg}}{70\ \text{kg} \times 25550\ \text{days}} \times 1$$

IEX_1 = 1.04E-06 mg/kg/day

ILCR = 1.04E-06 mg/kg/day x 7.30E+00 (mg/kg/day)-1

ILCR = 7.6E-06

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, MARCH 2005, JANUARY 2009		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake, carcinogenic risks for mutagenic chemicals from inhalation of surface soil.

EQUATION:

$$EC = \frac{Ca \times ET \times EF \times ED}{AT \times 24\ hours/day} \times ADAF$$

Where:

EC	=	exposure concentration (mg/m3)
Ca	=	exposure point concentration in air (mg/m3)
	=	Cs x 1/PEF
Cs	=	exposure point concentration in soil (mg/kg)
PEF	=	particulate emission factor (m3/kg)
IR	=	inhlation rate (m3/hr)
ET	=	exposure time (hrs/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
IURi	=	inhalation unit risk($(ug/mg)^{-1}$)

RISKS:

ILCR = Exposure concentration (mg/m3) x IURi (ug/m3)-1 x 1000 ug/mg

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
PEF	=	1.10E+10	m3/kg	
Ca	=	2.42E-08	mg/m3	
ET	=	24	hr/day	
EF	=	14	days/year	
ED	=	5	years	
ATc	=	25550	days	
IURi	=	1.1E-03	$(ug/m3)^{-1}$	
ADAF	=	3		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR CHEMICALS - OLDER CHILD RECREATIONAL USERS		
BASED ON: USEPA, MARCH 2005, JANUARY 2009		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$EC = \frac{2.42E\text{-}08\ mg/m3 \times 24\ hr/day \times 14\ days/year \times 5\ years}{25550\ days \times 24\ hours/day} \times 3$$

EC = 1.99E-10 mg/m3

ILCR = 1.99E-10 mg/m3 x 1.10E-03 (ug/m3)-1 x 1000 ug/mg

ILCR = 2.2E-10

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS ADULT RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

PURPOSE: To estimate intake and cancer risks for mutagenic chemicals from dermal contact with surface soil.

EQUATION:

$$DEX = \frac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT} \times ADAF$$

Where:

DEX	=	estimated exposure intake (mg/kg/day)
Cs	=	exposure point concentration in soil (mg/kg)
CF	=	conversion factor (1.0E-6 kg/mg)
SA	=	skin surface available for contact (cm^2/day)
ABS	=	absorption factor (unitless)
AF	=	adherence factor (mg/cm^2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
CSFd	=	dermal carcinogenic slope factor ($(mg/kg/day)^{-1}$)

RISKS:

ILCR (Carcinogens) = Intake (mg/kg/day) x CSFd (mg/kg/day)-1

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
CF	=	1.0E-06	kg/mg	
SA	=	5700	cm^2/day	
AF	=	0.07	mg/cm^2	
ABS	=	0.13		
EF	=	14	days/year	
ED	=	5	years	
BW	=	70	kg	
AT	=	25550	days	
CSFd	=	7.3E+00	$(mg/kg/day)^{-1}$	
ADAF	=	1		

CALCULATION WORKSHEET

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		**JOB NUMBER:** 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM DERMAL CONTACT WITH SOIL FOR MUTAGENIC CHEMICALS ADULT RECREATIONAL USERS		
BASED ON: USEPA, JULY 2004, MARCH 2005		
BY: R. JUPIN	**CHECKED BY:**	**DATE:** 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$DEXc = \frac{266 \text{ mg/kg} \times 1.0E\text{-}06 \text{ kg/mg} \times 5700 \text{ cm2/day} \times 0.07 \text{ mg/cm2} \times 0.13 \times 14 \text{ days/year} \times 5 \text{ years}}{70 \text{ kg} \times 25550 \text{ days}} \times 1$$

DEXc = 5.40E-07 mg/kg/day

ILCR = 5.40E-07 mg/kg/day x 7.30E+00 (mg/kg/day)-1

ILCR = 3.9E-06

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR MUTAGENIC CHEMICALS - ADULT RECREATIONAL USERS		
BASED ON: USEPA, MARCH 2005, JANUARY 2009		
BY: R. JUPIN	CHECKED BY:	DATE: 3/22/2010

PURPOSE: To estimate intake, carcinogenic risks for mutagenic chemicals from inhalation of surface soil.

EQUATION:

$$EC = \frac{Ca \times ET \times EF \times ED}{AT \times 24\ hours/day} \times ADAF$$

Where:

EC	=	exposure concentration (mg/m3)
Ca	=	exposure point concentration in air (mg/m3)
	=	Cs x 1/PEF
Cs	=	exposure point concentration in soil (mg/kg)
PEF	=	particulate emission factor (m3/kg)
IR	=	inhlation rate (m3/hr)
ET	=	exposure time (hrs/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)
ADAF	=	age-dependent adjustment factor
IURi	=	inhalation unit risk($(ug/mg)^{-1}$)

RISKS:

ILCR = Exposure concentration (mg/m3) x IURi (ug/m3)-1 x 1000 ug/mg

ASSUMPTIONS:

Cs	=	266	mg/kg	Chemical: Benzo(a)pyrene Equivalents
PEF	=	1.10E+10	m3/kg	
Ca	=	2.42E-08	mg/m3	
ET	=	24	hr/day	
EF	=	14	days/year	
ED	=	5	years	
ATc	=	25550	days	
IURi	=	1.1E-03	$(ug/m3)^{-1}$	
ADAF	=	1		

CLIENT: MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND		JOB NUMBER: 2574
SUBJECT: CALCULATION OF INTAKE/RISK FROM INHALATION OF FUGATIVE DUST EMISSIONS FOR MUTAGENIC CHEMICALS - ADULT RECREATIONAL USERS		
BASED ON: USEPA, MARCH 2005, JANUARY 2009		
BY: R. JUPIN	CHECKED BY:	DATE: 3/22/2010

EXAMPLE CARCINOGENIC CALCULATION

$$EC = \frac{2.42E\text{-}08 \text{ mg/m3} \times 24 \text{ hr/day} \times 14 \text{ days/year} \times 5 \text{ years}}{25550 \text{ days} \times 24 \text{ hours/day}} \times 1$$

EC = 6.63E-11 mg/m3

ILCR = 6.63E-11 mg/m3 x 1.10E-03 (ug/m3)-1 x 1000 ug/mg

ILCR = 7.3E-11

Attachment B

Lead Model

LEAD MODEL FOR WINDOWS Version 1.1

==========

Model Version: 1.1 Build9 (Page 1 of 3)
Location: Carr Point, Portsmouth, Rhode Island
Site Name: MRP Site 1 Camping Area
Date: 03/16/2010
Run Mode: Site Risk Assessment

Soil/Dust Data
Average concentration of lead in soil = 150 mg/kg.

==========

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(µg/day)
.5-1	2.260
1-2	1.960
2-3	2.130
3-4	2.040
4-5	1.950
5-6	2.050
6-7	2.220

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 µg Pb/L

Model Version: 1.1 Build9
Location: Carr Point, Portsmouth, Rhode Island
Site Name: MRP Site 1 Camping Area
Date: 03/16/2010
Run Mode: Site Risk Assessment

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 115.000 µg/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
.5-1	150.000	115.000
1-2	150.000	115.000
2-3	150.000	115.000
3-4	150.000	115.000
4-5	150.000	115.000
5-6	150.000	115.000
6-7	150.000	115.000

****** Alternate Intake ******

Age	Alternate (µg Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

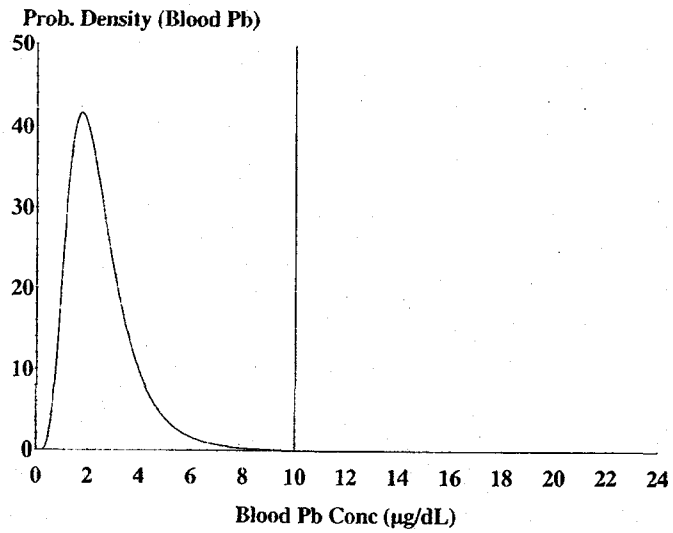
Maternal Blood Concentration: 1.000 µg Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
.5-1	0.021	1.072	0.000	0.380
1-2	0.034	0.923	0.000	0.942
2-3	0.062	1.011	0.000	0.987
3-4	0.067	0.975	0.000	1.014
4-5	0.067	0.945	0.000	1.066
5-6	0.093	0.998	0.000	1.129
6-7	0.093	1.083	0.000	1.152

Year	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
.5-1	3.164	4.637	2.5
1-2	4.987	6.886	2.9
2-3	5.026	7.086	2.7
3-4	5.064	7.119	2.5
4-5	3.800	5.877	2.1
5-6	3.436	5.657	1.8
6-7	3.254	5.582	1.6

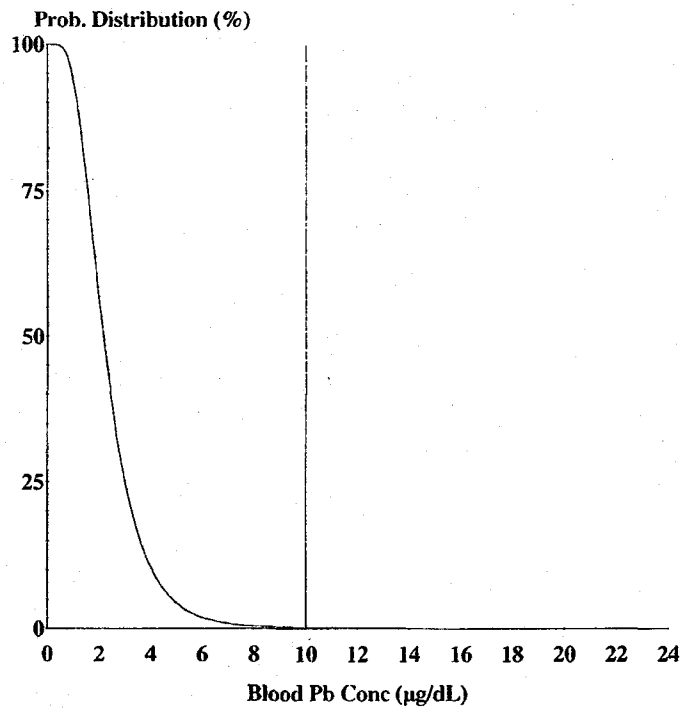
Model Version: 1.1 Build9
Location: Carr Point, Portsmouth, Rhode Island
Site Name: MRP Site 1 Camping Area
Date: 03/16/2010
Run Mode: Site Risk Assessment



Cutoff = 10.000 µg/dl
Geo Mean = 2.271
GSD = 1.600
% Above = 0.081
% Below = 99.919

Age Range = 0 to 84 months

Run Mode = Research
Comment = Lead concentration = 150 mg/kg



Cutoff = 10.000 µg/dl
Geo Mean = 2.271
GSD = 1.600
% Above = 0.081

Age Range = 0 to 84 months

Run Mode = Site Risk Assessment
Comment = Lead concentration = 150 mg/kg

SITE NAME: CARR POINT, PORTSMOUTH, RHODE ISLAND
LOCATION: MRP SITE 1 CAMPING AREA
RECEPTOR: WORKERS
MEDIA: SURFACE SOIL
DATE: MARCH 16, 2010

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	150
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S,D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S,D}$	Exposure frequency (same for soil and dust)	days/yr	26
$AT_{S,D}$	Averaging time (same for soil and dust)	days/yr	180
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.1**
$PbB_{fetal,0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	2.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.003%**

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

RAGS Part D Tables

TABLE 3.1.RME
EXPOSURE POINT CONCENTRATION SUMMARY
MRP SITE 1, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
MRP SITE 1	Benzo(a)pyrene Equivalents	mg/kg	65	266 (NP)	425.4	266	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
	Benzo(g,h,i)perylene	mg/kg	31	126 (NP)	223	126	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
	Fluoranthene	mg/kg	44	182 (NP)	332	182	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
	Naphthalene	mg/kg	1.2	1.9 (G)	8.2	1.9	mg/kg	95% KM(t)	Pro UCL 4.00.04
	Phenanthrene	mg/kg	28	117 (NP)	208	117	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
	Pyrene	mg/kg	48	196 (NP)	316	196	mg/kg	99% Chebyshev (Mean, SD)	Pro UCL 4.00.04
	Aluminum	mg/kg	12000	NA	13400	13400	mg/kg	Maximum	Only 2 Concentrations
	Arsenic	mg/kg	14	NA	15.1	15.1	mg/kg	Maximum	Only 2 Concentrations
	Chromium	mg/kg	16	NA	19.4	19.4	mg/kg	Maximum	Only 2 Concentrations
	Cobalt	mg/kg	12	NA	15.3	15.3	mg/kg	Maximum	Only 2 Concentrations
	Iron	mg/kg	26000	NA	31200	31200	mg/kg	Maximum	Only 2 Concentrations
	Lead	mg/kg	130	NA	572	130	mg/kg	Arithmetic Mean	USEPA Guidance
	Manganese	mg/kg	430	NA	543	543	mg/kg	Maximum	Only 2 Concentrations

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

1. Exposure point concentration is the value recommended by USEPA's ProUCL. The maximum detected concentration is used if the recommended UCL is greater than the maximum or if the dataset contains less than 10 samples.

G = Gamma Distribution
NP = Nonparametric Distribution

LIST OF TABLES
RAGS PART D TABLE 4
VALUES USED FOR DAILY INTAKE CALCULATIONS

Table No.	
	Reasonable Maximum Exposures
4.1.RME	Workers Exposed to Surface Soil/Subsurface Soil
4.2.RME	Workers Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.3.RME	Child Recreational Users Exposed to Surface Soil/Subsurface Soil
4.4.RME	Child Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.5.RME	Older Child Recreational Users Exposed to Surface Soil/Subsurface Soil
4.6.RME	Older Child Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.7.RME	Adult Recreational Users Exposed to Surface Soil/Subsurface Soil
4.8.RME	Adult Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.9.RME	Lifelong Recreational Users Exposed to Surface Soil/Subsurface Soil
4.10.RME	Lifelong Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
	Central Tendency Exposures
4.1.CTE	Workers Exposed to Surface Soil/Subsurface Soil
4.2.CTE	Workers Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.3.CTE	Child Recreational Users Exposed to Surface Soil/Subsurface Soil
4.4.CTE	Child Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.5.CTE	Older Child Recreational Users Exposed to Surface Soil/Subsurface Soil
4.6.CTE	Older Child Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.7.CTE	Adult Recreational Users Exposed to Surface Soil/Subsurface Soil
4.8.CTE	Adult Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil
4.9.CTE	Lifelong Recreational Users Exposed to Surface Soil/Subsurface Soil
4.10.CTE	Lifelong Recreational Users Exposed to Air Emissions from Surface Soil/Subsurface Soil

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - WORKERS - SOIL

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Workers	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.125	unitless	(1)	BW x AT
				EF	Exposure Frequency	26	days/year	(2)	
				ED	Exposure Duration	25	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1991	
Dermal	Workers	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	0.125	events/day	(1)	
				EF	Exposure Frequency	26	days/year	(2)	
				ED	Exposure Duration	25	years	USEPA, 1991	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1991	

Sources:

1 - Assumes exposure 1 hour out of 8 hour workday.

2 - Professional judgment.

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

USEPA, 1991: Human Health Evaluation Manual, Supplemental uidance: Standard Default Exposure Factors. OSWER 9285.6-03.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 4.54E-09 Cancer Dermal Intake = 2.40E-07

Noncancer Ingestion Intake = 1.27E-08 Noncancer Dermal Intake = 6.72E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - WORKERS - SOIL TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Workers	Adult	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	1	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	26	days/year	(2)	AT x 24 hours/day
				ED	Exposure Duration	25	years	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1991	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	

Notes:

1 - Length of typical work day.

2 - Professional judgment.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental uidance: Standard Default Exposure Factors. OSWER 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 1.06E-03 Noncancer Inhalation Intake = 2.97E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.3.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - CHILD RECREATIONAL USERS - SOILS
MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	200	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	14	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
Dermal	Recreational User	Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	14	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(3), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(3), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	

Notes:
1 - Professional judgment.
2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:
USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.
USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)
Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals
Cancer Ingestion Intake (Age 0 - 6) = 3.65E-08 Cancer Dermal Intake (Age 0 - 6) = 1.02E-07

Mutagenic Chemicals
Cancer Ingestion Intake (Age 0 - 2) = 1.46E-08 Cancer Dermal Intake (Age 0 - 2) = 4.09E-08
Cancer Ingestion Intake (Age 2 - 6) = 2.19E-08 Cancer Dermal Intake (Age 2 - 6) = 6.14E-08

Noncarcinogenic Chemicals
Noncancer Ingestion Intake = 5.11E-07 Noncancer Dermal Intake = 1.43E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor
Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor
Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose
Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Child	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	14	days/year	(1)	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(2), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1991	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Professional judgment.

2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 6) = 2.74E-03 Noncancer Inhalation Intake = 3.84E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 1.10E-03

Cancer Inhalation Intake (Age 2 - 6) = 1.64E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.5.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - OLDER CHILD RECREATIONAL USERS - SOILS

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Older Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	14	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	45	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
Dermal	Recreational User	Older Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	14	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	45	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	

Notes:

1 - Professional judhment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 6.09E-09 Cancer Dermal Intake = 2.43E-08

Mutagenic Chemicals

Cancer Ingestion Intake = 6.09E-09 Cancer Dermal Intake = 2.43E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 8.52E-08 Noncancer Dermal Intake = 3.40E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.6.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - OLDER CHILD RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Older Child	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	14	days/year	(1)	AT x 24 hours/day
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Professional judgment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 2.74E-03 Noncancer Inhalation Intake = 3.84E-02

Mutagenic Chemicals

Cancer Inhalation Intake = 2.74E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.7.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USERS - SOILS
MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	14	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	
Dermal	Recreational User	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	14	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	

Notes:
1 - Professional judgment.
2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:
USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.
USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.
USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)
Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals
Cancer Ingestion Intake = 3.91E-09 Cancer Dermal Intake = 1.56E-08

Mutagenic Chemicals
Cancer Ingestion Intake = 3.91E-09 Cancer Dermal Intake = 1.56E-08

Noncarcinogenic Chemicals
Noncancer Ingestion Intake = 5.48E-08 Noncancer Dermal Intake = 2.19E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor
Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor
Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose
Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.8.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Adult	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	14	days/year	(1)	AT x 24 hours/day
				ED	Exposure Duration	5	years	(2), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Professional judgment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 2.74E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 3.84E-02

Mutagenic Chemicals

Cancer Inhalation Intake = 2.74E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.9.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference	Value	Rationale/ Reference	Intake Equation/ Model Name
							Child		Adult		
Ingestion	Lifelong Recreational User	Lifelong	MRP Site 1	CS	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002a	Max or 95% UCL	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	mg/day	200	USEPA, 1991	100	USEPA, 1997	
				CF3	Conversion Factor 3	kg/mg	0.000001	--	0.000001	--	Cs x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	unitless	1	--	1	--	BW x AT
				EF	Exposure Frequency	days/year	14	(1)	14	(1)	
				ED1	Exposure Duration	years	2	(2), USEPA, 1989, 2005	10	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration	years	4	(2), USEPA, 1989, 2005	14	(2), USEPA, 1989, 2005	
				BW	Body Weight	kg	15	USEPA, 1991	70	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1991	8,760	USEPA, 1991	
Dermal	Lifelong Recreational User	Lifelong	MRP Site 1	CS	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002	Max or 95% UCL	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	kg/mg	0.000001	--	0.000001	--	
				SA	Skin Surface Available for Contact	cm2	2,800	USEPA, 2004	5,700	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EF x ED
				SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.20	USEPA, 2004	0.07	USEPA, 2004	BW x AT
				DABS	Absorption Factor	unitless	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
				EV	Events Frequency	events/day	1	USEPA, 2004	1	USEPA, 2004	
				EF	Exposure Frequency	days/year	14	(1)	14	(1)	
				ED1	Exposure Duration	years	2	(2), USEPA, 1989, 2005	10	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration	years	4	(2), USEPA, 1989, 2005	14	(2), USEPA, 1989, 2005	
				BW	Body Weight	kg	15	USEPA, 1991	70	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	days	2,190	USEPA, 1991	8,760	USEPA, 1991	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

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

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Carcinogenic Chemicals

Cancer Ingestion Intake (Age 0-2) = 1.46E-08	Cancer Dermal Intake (Age 0-2) = 4.09E-08
Cancer Ingestion Intake (Age 2-6) = 2.92E-08	Cancer Dermal Intake (Age 2-6) = 8.18E-08
Cancer Ingestion Intake (Age 6-16) = 7.83E-09	Cancer Dermal Intake (Age 6-16) = 3.12E-08
Cancer Ingestion Intake (Age 16-30) = 1.10E-08	Cancer Dermal Intake (Age 16-30) = 4.37E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 5.11E-07	Noncancer Dermal Intake = 1.43E-06

TABLE 4.10.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference	Value	Rationale/ Reference	Intake Equation/ Model Name
							Child		Adult		
Inhalation	Lifelong Recreational User	Lifelong	MRP Site 1	CA	Chemical concentration in air	mg/m3	Calculated	USEPA, 2002a	Calculated	USEPA, 2002a	Exposure Concentration (mg/m3) =
				Cs	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002b	Max or 95% UCL	USEPA, 2002b	
				ET	Exposure Time	hours/day	24	USEPA, 1991	24	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	days/year	14	(1)	14	(1)	AT x 24 hours/day
				ED1	Exposure Duration	years	2	(2), USEPA, 1989, 2005	10	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration	years	4	(2), USEPA, 1989, 2005	14	(2), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	days	2190	USEPA, 1991	8760	USEPA, 1991	
				PEF	Particulate Emission Factor	m3/kg	1.10E+10	USEPA 2004	1.10E+10	USEPA 2010	
				VF	Volatilization Factor	m3/kg	Chemical-specific	USEPA, 2002a	Chemical-specific	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	g/m2-s per kg/m3	73.95045	USEPA 2008	73.95045	USEPA 2008	
				F_D	dispersion correction factor	unitless	1	USEPA, 2002	1	USEPA, 2002	
				Ut	Equivalent threshold of wind velocity at 7m.	m/sec	11.32	USEPA 2008	11.32	USEPA 2008	
				Um	Mean annual windspeed	m/sec	3.84	USEPA 2008	3.84	USEPA 2008	
				V	Fraction of vegetative cover	unitless	0.5	USEPA 2008	0.5	USEPA 2008	
				F(x)	Function dependent of Um/Ut	unitless	0.0345	USEPA 2008	0.0345	USEPA 2008	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://risk.lsd.ornl.gov/calc_start.htm. Site-specific values for Hartford, Connecticut.

Unit Intake Calculations

Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Carcinogenic Chemicals

Cancer Inhalation Intake (Ages 0-2) = 1.10E-03
Cancer Inhalation Intake (Ages 2-6) = 2.19E-03
Cancer Inhalation Intake (Ages 6-16) = 5.48E-03
Cancer Inhalation Intake (Ages 16-30) = 7.67E-03

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - WORKERS - SOIL

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Workers	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.125	unitless	(1)	BW x AT
				EF	Exposure Frequency	26	days/year	(2)	
				ED	Exposure Duration	9	years	USEPA, 2004	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	
Dermal	Workers	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 1997	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.02	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	(1)	
				EF	Exposure Frequency	26	days/year	(2)	
				ED	Exposure Duration	9	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	

Notes:

1 - Assumes exposure 1 hour out of 8 hour workday.

2 - Professional judgment.

Sources:

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

USEPA, 1991: Human Health Evaluation Manual, Supplemental uidance: Standard Default Exposure Factors. OSWER 9285.6-03.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EV x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 8.18E-10 Cancer Dermal Intake = 8.64E-09

Noncancer Ingestion Intake = 6.36E-09 Noncancer Dermal Intake = 6.72E-08

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.2.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - WORKERS - SOIL TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Workers	Adult	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	1	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	26	days/year	(2)	AT x 24 hours/day
				ED	Exposure Duration	9	years	USEPA, 2004	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Assumes exposure 1 hour out of 8 hour workday.

2 - Professional judgment.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental uidance: Standard Default Exposure Factors. OSWER 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 3.82E-04 Noncancer Inhalation Intake = 2.97E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.3.CTE
VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - CHILD RECREATIONAL USERS - SOILS
MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CSs x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	7	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1,2) USEPA, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(1,2) USEPA, 2005	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
Dermal	Recreational User	Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.04	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	(1)	
				EF	Exposure Frequency	7	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1,2) USEPA, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(1,2) USEPA, 2005	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 9.13E-09 Cancer Dermal Intake = 1.02E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 3.65E-09 Cancer Dermal Intake (Age 0 - 2) = 4.09E-09

Cancer Ingestion Intake (Age 2 - 6) = 5.48E-09 Cancer Dermal Intake (Age 2 - 6) = 6.14E-09

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.28E-07 Noncancer Dermal Intake = 1.43E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.4.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CHILD RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Child	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	7	days/year	(1)	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1,2) USEPA, 2005	
				ED2	Exposure Duration (Age 2 - 6)	3	years	(1,2) USEPA, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1991	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Professional judgment.

2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 1.37E-03 Noncancer Inhalation Intake = 1.92E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 5.48E-04

Cancer Inhalation Intake (Age 2 - 6) = 8.22E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.5.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - OLDER CHILD RECREATIONAL USERS - SOILS

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Older Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CSs x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	7	days/year	(1)	
				ED	Exposure Duration	5	years	(1,2), USEPA, 2005	
				BW	Body Weight	45	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
Dermal	Recreational User	Older Child	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 1997	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	7	days/year	(1)	
				ED	Exposure Duration	5	years	(1,2), USEPA, 2005	
				BW	Body Weight	45	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	

Notes:

1 - Professional judhment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 1.52E-09 Cancer Dermal Intake = 1.74E-09

Mutagenic Chemicals

Cancer Ingestion Intake = 1.52E-09 Cancer Dermal Intake = 1.74E-09

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 2.13E-08 Noncancer Dermal Intake = 2.43E-08

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.6.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - OLDER CHILD RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Older Child	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	7	days/year	(1)	AT x 24 hours/day
				ED	Exposure Duration	5	years	(1,2) USEPA, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1991	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2010	

Notes:

1 - Professional judgment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 1.37E-03 Noncancer Inhalation Intake = 1.92E-02

Mutagenic Chemicals

Cancer Inhalation Intake = 1.37E-03

Cancer Inhalation Intake = 0.00E+00

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.7.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RECREATIONAL USERS - SOILS

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	7	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 2005	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	
Dermal	Recreational User	Adult	MRP Site 1 Camping Area	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 1997	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	7	days/year	(1)	
				ED	Exposure Duration	5	years	(2), USEPA, 2005	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1,825	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 9.78E-10 Cancer Dermal Intake = 1.12E-09

Mutagenic Chemicals

Cancer Ingestion Intake = 9.78E-10 Cancer Dermal Intake = 1.12E-09

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.37E-08 Noncancer Dermal Intake = 1.56E-08

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

TABLE 4.8.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RECREATIONAL USERS - SOILS TO AIR

MRP SITE 1 CAMPING AREA, CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Adult	MRP Site 1 Camping Area	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	7	days/year	(1)	AT x 24 hours/day
				ED	Exposure Duration	5	years	(2), USEPA, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	1825	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.10E+10	m3/kg	USEPA 2004	

Notes:

1 - Professional judgment.

2 - For chemicals that act via the mutagenic mode of action the intake will be multiplied by the appropriate age-dependent adjustment factor in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/epa/ssl1.shtml. Site-specific value for Hartford, Connecticut.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 1.37E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 1.92E-02

Mutagenic Chemicals

Cancer Inhalation Intake = 1.37E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

TABLE 4.9.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference	Value	Rationale/ Reference	Intake Equation/ Model Name
							Child		Adult		
Ingestion	Lifelong Recreational User	Lifelong	MRP Site 1	CS	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002	Max or 95% UCL	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	mg/day	100	USEPA, 1993	50	USEPA, 1993	
				CF3	Conversion Factor 3	kg/mg	0.000001	--	0.000001	--	Cs x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	unitless	1	--	1	--	BW x AT
				EF	Exposure Frequency	days/year	7	(1)	7	(1)	
				ED1	Exposure Duration (Age 6 - 16)	years	1	(1,2) USEPA, 2005	2	(2), USEPA, 2005	
				ED2	Exposure Duration (Age 16 - 30)	years	1	(1,2) USEPA, 2005	5	(2), USEPA, 2005	
				BW	Body Weight	kg	15	USEPA, 1991	70	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	days	730	USEPA, 1991	2,555	USEPA, 1989	
Dermal	Lifelong Recreational User	Lifelong	MRP Site 1	CS	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002	Max or 95% UCL	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	kg/mg	0.000001	--	0.000001	--	
				SA	Skin Surface Available for Contact	cm2	2,800	USEPA, 1997	5,700	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EF x ED
				SSAF	Soil to Skin Adherence Factor	mg/cm2/event	0.04	USEPA, 2004	0.01	USEPA, 2004	BW x AT
				DABS	Absorption Factor	unitless	Chemical Specific	USEPA, 2004	Chemical Specific	USEPA, 2004	
				EV	Events Frequency	events/day	1	USEPA, 2004	1	USEPA, 2004	
				EF	Exposure Frequency	days/year	7	(1)	7	(1)	
				ED1	Exposure Duration (Age 6 - 16)	years	1	(1,2) USEPA, 2005	2	(2), USEPA, 2005	
				ED2	Exposure Duration (Age 16 - 30)	years	1	(1,2) USEPA, 2005	5	(2), USEPA, 2005	
				BW	Body Weight	kg	15	USEPA, 1991	70	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1989	25,550	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	days	730	USEPA, 1991	2,555	USEPA, 1989	

Notes:

2 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

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

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Carcinogenic Chemicals

Cancer Ingestion Intake (Age 0-2) = 1.83E-09 Cancer Dermal Intake (Age 0-2) = 2.05E-09

Cancer Ingestion Intake (Age 2-6) = 1.83E-09 Cancer Dermal Intake (Age 2-6) = 2.05E-09

TABLE 4.10.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Units	Value	Rationale/ Reference	Value	Rationale/ Reference	Intake Equation/ Model Name
							Child		Adult		
Inhalation	Lifelong Recreational User	Lifelong	MRP Site 1	CA	Chemical concentration in air	mg/m3	Calculated	USEPA, 2002a	Calculated	USEPA, 2002a	Exposure Concentration (mg/m3) =
				Cs	Chemical concentration in soil	mg/kg	Max or 95% UCL	USEPA, 2002b	Max or 95% UCL	USEPA, 2002b	
				ET	Exposure Time	hours/day	24	(1)	24	(1)	CA x ET x EF x ED
				EF	Exposure Frequency	days/year	7	(1)	7	(1)	AT x 24 hours/day
				ED1	Exposure Duration	years	1	(2), USEPA, 2005	2	(1,2) USEPA, 2005	
				ED2	Exposure Duration	years	1	(2), USEPA, 2005	5	(1,2) USEPA, 2005	
				AT-C	Averaging Time (Cancer)	days	25,550	USEPA, 1991	25,550	USEPA, 1991	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	days	730	USEPA, 1989	2555	USEPA, 1989	
				PEF	Particulate Emission Factor	m3/kg	1.10E+10	USEPA 2010	1.10E+10	USEPA 2010	
				VF	Volatilization Factor	m3/kg	Chemical-specific	USEPA, 2002a	Chemical-specific	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	g/m2-s per kg/m3	73.95045	USEPA 2008	73.95045	USEPA 2008	
				F_D	dispersion correction factor	unitless	1	USEPA, 2002	1	USEPA, 2002	
				Ut	Equivalent threshold of wind velocity at 7m.	m/sec	11.32	USEPA 2008	11.32	USEPA 2008	
				Um	Mean annual windspeed	m/sec	3.84	USEPA 2008	3.84	USEPA 2008	
				V	Fraction of vegetative cover	unitless	0.5	USEPA 2008	0.5	USEPA 2008	
				F(x)	Function dependent of Um/Ut	unitless	0.0345	USEPA 2008	0.0345	USEPA 2008	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2010: Soil Screening Guidance calculation Internet site at http://risk.lsd.ornl.gov/calc_start.htm. Site-specific values for Hartford, Connecticut.

Unit Intake Calculations

Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Carcinogenic Chemicals

Cancer Inhalation Intake (Ages 0-2) = 2.74E-04

Cancer Inhalation Intake (Ages 2-6) = 2.74E-04

Cancer Inhalation Intake (Ages 6-16) = 5.48E-04

Cancer Inhalation Intake (Ages 16-30) = 1.37E-03

LIST OF TABLES
RAGS PART D TABLE 5
NON-CANCER TOXICITY DATA

Table No.	
5-1	Non-Cancer Toxicity Data - Oral/Dermal
5-2	Non-Cancer Toxicity Data - Inhalation

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
MRP SITE 1
CARR POINT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds										
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene[3]	Chronic	3.0E-02	mg/kg/day	1	3.0E-02	mg/kg/day	Kidney	3000/1	IRIS	3/8/2010
Fluoranthene	Chronic	4.0E-02	mg/kg/day	1	4.0E-02	mg/kg/day	Liver	3000/1	IRIS	3/8/2010
Naphthalene	Chronic	2.0E-02	mg/kg/day	1	2.0E-02	mg/kg/day	Body Weight	3000/1	IRIS	3/8/2010
Phenanthrene[3]	Chronic	3.0E-02	mg/kg/day	1	3.0E-02	mg/kg/day	Kidney	3000/1	IRIS	3/8/2010
Pyrene	Chronic	3.0E-02	mg/kg/day	1	3.0E-02	mg/kg/day	Kidney	3000/1	IRIS	3/8/2010
Explosives										
Nitroglycerin	Chronic	1.0E-04	mg/kg/day	1	1.0E-04	mg/kg/day	Cardiovascular System	NA	PPRTV	12/2009
Inorganics										
Aluminum	Chronic	1.0E+00	mg/kg/day	1	1.0E+00	mg/kg/day	Central Nervous System	100	PPRTV	10/23/2006
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, Cardiovascular System	3/1	IRIS	3/8/2010
Chromium[4]	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	Fetotoxicity, Gastrointestinal System, Bone	300/3	IRIS	3/8/2010
Cobalt	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Blood	NA	PPRTV	12/2009
Iron	Chronic	7.0E-01	mg/kg/day	1	7.0E-01	mg/kg/day	Gastrointestinal System	1.5	PPRTV	9/11/2006
Manganese[5]	Chronic	2.4E-02	mg/kg/day	0.04	9.6E-04	mg/kg/day	Central Nervous System	1	IRIS	3/8/2010

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005.
2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.
3 - Values are for pyrene.
4 - Values are for hexavalent chromium.
5 - Adjusted IRIS value in accordance with USEPA Region I Risk Update Number 4, November 1996.
Unless otherwise noted PPRTV values are from the USEPA Regions 3, 6, and 9 Regional Screening Level Table, December, 2009.

Definitions:
IRIS = Integrated Risk Information System.
NA = Not Available.
PPRTV = Provisional Peer Reviewed Toxicity Values.

TABLE 5.2
NON-CANCER TOXICITY DATA -- INHALATION
MRP SITE 1
CARR POINT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD[1]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds									
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	Chronic	3.0E-03	mg/m^3	8.6E-04	(mg/kg/day)	Respiratory	3000/1	IRIS	3/8/2010
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Explosives									
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics									
Aluminum	Chronic	5.0E-03	mg/m^3	1.4E-03	(mg/kg/day)	Central Nervous System	300	PPRTV	10/23/2006
Arsenic	Chronic	1.5E-05	mg/m3	4.3E-06	(mg/kg/day)	NA	NA	Cal EPA	12/2009
Chromium[2]	Chronic	1.0E-04	mg/m^3	2.9E-05	(mg/kg/day)	Lungs	300/1	IRIS	3/8/2010
Cobalt	Chronic	6.0E-06	mg/m^3	1.7E-06	(mg/kg/day)	Lungs	NA	PPRTV	12/2009
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	5.0E-05	mg/m^3	1.4E-05	(mg/kg/day)	Central Nervous System	1000/1	IRIS	3/8/2010

Notes:
1 - Extrapolated RfD = RfC *$20m^3$/day / 70 kg
2 - Values are for hexavalent chromium.
Definitions:
IRIS = Integrated Risk Information System
NA = Not Applicable
PPRTV = Provisional Peer Reviewed Toxicity Values.
Cal EPA = California Environmental Protection Agency.
Unless otherwise noted Cal EPA and PPRTV values are from the USEPA Regions 3, 6, and 9 Regional Screening Level Table, December, 2009.

LIST OF TABLES
RAGS PART D TABLE 6
CANCER TOXICITY DATA

Table No.

6-1 Cancer Toxicity Data - Oral/Dermal
6-2 Cancer Toxicity Data - Inhalation

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
MRP SITE 1
CARR POINT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds								
Benzo(a)pyrene[3]	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2 / Probable human carcinogen	IRIS	3/8/2010
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Fluoranthene	NA	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Naphthalene	NA	NA	NA	NA	NA	C / Inadequate data of carcinogenicity in humans	IRIS	3/8/2010
Phenanthrene	NA	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Pyrene	NA	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Explosives								
Nitroglycerin	1.7E-02	$(mg/kg/day)^{-1}$	1	1.7E-02	$(mg/kg/day)^{-1}$	NA	PPRTV	12/2009
Inorganics								
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	3/8/2010
Chromium	5.0E-01	$(mg/kg/day)^{-1}$	0.025	2.0E+01	$(mg/kg/day)^{-1}$	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	D (Not classifiable as to human carcinogenicity)	IRIS	3/8/2010

Notes:
1 - USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.
3 - The carcinogenic PAHs are considered to act via the mutagenic mode of action. These chemicals are evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).
IRIS = Integrated Risk Information System.
NA = Not Available.
PPRTV = Provisional Peer Reviewed Toxicity Values.

TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
MRP SITE 1
CARR POINT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor[1]		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Semivolatile Organic Compounds							
Benzo(a)pyrene[2]	1.1E-03	$(ug/m^3)^{-1}$	3.9E+00	$(mg/kg/day)^{-1}$	B2 / Probable human carcinogen	Cal EPA	12/2009
Benzo(g,h,i)perylene	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Fluoranthene	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Naphthalene	3.4E-05	$(ug/m3)^{-1}$	1.2E-01	$(mg/kg/day)^{-1}$	C/ Possible Human Carcinogen	Cal EPA	12/2009
Phenanthrene	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Pyrene	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010
Explosives							
Nitroglycerin	NA	NA	NA	NA	NA	NA	NA
Inorganics							
Aluminum	NA	NA	NA	NA	NA	NA	NA
Arsenic	4.3E-03	$(ug/m^3)^{-1}$	1.5E+01	$(mg/kg/day)^{-1}$	A / Known human carcinogen	IRIS	3/8/2010
Chromium[3]	8.4E-02	$(ug/m^3)^{-1}$	2.9E+02	$(mg/kg/day)^{-1}$	A / Known human carcinogen	IRIS	3/8/2010
Cobalt	9.0E-03	$(ug/m^3)^{-1}$	3.2E+01	$(mg/kg/day)^{-1}$	NA	PPRTV	12/2009
Iron	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	D / Not classifiable as to human carcinogenicity	IRIS	3/8/2010

Notes:

1 - Inhalation CSF = Unit Risk * 70 kg / $20m^3$/day x 1000 ug/mg.

2 - The carcinogenic PAHs are considered to act via the mutagenic mode of action. These chemicals are evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

3 - Values are for hexavalent chromium.

Definitions:

IRIS = Integrated Risk Information System.

NA = Not Available.

Unless otherwise noted Cal EPA and PPRTV values are from the USEPA Regions 3, 6, and 9 Regional Screening Level Table, December, 2009.

LIST OF TABLES
RAGS PART D TABLE 7
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

Table No.	
	REASONABLE MAXIMUM EXPOSURES
7.1.RME	Workers
7.2.RME	Child Recreational Users
7.3.RME	Older Child Recreational Users
7.4.RME	Adult Recreational Users
7.5.RME	Lifelong Recreational Users
	CENTRAL TENDENCY EXPOSURES
7.1.CTE	Workers
7.2.CTE	Child Recreational Users
7.3.CTE	Older Child Recreational Users
7.4.CTE	Adult Recreational Users
7.5.CTE	Lifelong Recreational Users

TABLE 7.1.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.2E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	8.8E-06	3.4E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	5.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00005
				Fluoranthene	182	mg/kg	8.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00006
				Naphthalene	1.90	mg/kg	8.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.4E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000001
				Phenanthrene	117	mg/kg	5.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.5E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00005
				Pyrene	196	mg/kg	8.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00008
				Aluminum	13400	mg/kg	6.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0002
				Arsenic	15.1	mg/kg	6.9E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.0E-07	1.9E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0006
				Chromium	19.4	mg/kg	8.8E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	4.4E-08	2.5E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00008
				Cobalt	15.3	mg/kg	7.0E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.9E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0006
				Iron	31200	mg/kg	1.4E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0006
				Lead	130	mg/kg	5.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.5E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00005
			Exp. Route Total								9.0E-06					0.002
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	1.0E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	7.6E-06	2.9E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.4E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00005
				Fluoranthene	182	mg/kg	7.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00005
				Naphthalene	1.90	mg/kg	7.4E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.1E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000001
				Phenanthrene	117	mg/kg	4.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00004
				Pyrene	196	mg/kg	7.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.1E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00007
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	1.4E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	2.0E-08	3.8E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0001
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								7.6E-06					0.0003
		Exposure Point Total									1.7E-05					0.003
	Exposure Medium Total										1.7E-05					0.003
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	2.6E-11	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.8E-11	7.2E-11	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-11	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	1.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.9E-11	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	3.7E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.3E-09	1.0E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.00003
				Phenanthrene	3.5E-4	mg/m^3	3.7E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.0E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	1.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.3E-11	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.6E-09	(mg/m^3)	5.0E-03	(mg/m^3)	0.0000007
				Arsenic	1.4E-9	mg/m^3	1.5E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	6.3E-12	4.1E-12	(mg/m^3)	1.5E-05	(mg/m^3)	0.0000003
				Chromium	1.8E-9	mg/m^3	1.9E-12	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.6E-10	5.2E-12	(mg/m^3)	1.0E-04	(mg/m^3)	0.00000005
				Cobalt	1.4E-9	mg/m^3	1.5E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.3E-11	4.1E-12	(mg/m^3)	6.0E-06	(mg/m^3)	0.0000007
				Iron	2.8E-6	mg/m^3	3.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	8.4E-09	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.5E-11	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	5.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.000003
			Exp. Route Total								1.5E-09					0.00004
		Exposure Point Total									1.5E-09					0.00004
	Exposure Medium Total										1.5E-09					0.00004
Medium Total											1.7E-05					0.003
										Total of Receptor Risks Across All Media	1.7E-05				Total of Receptor Hazards Across All Media	0.003

TABLE 7.2.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	5.6E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	4.1E-04	1.4E-04	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.4E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.002
				Fluoranthene	182	mg/kg	6.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.3E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.002
				Naphthalene	1.90	mg/kg	6.9E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.7E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.00005
				Phenanthrene	117	mg/kg	4.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.0E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.002
				Pyrene	196	mg/kg	7.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-04	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.003
				Aluminum	13400	mg/kg	4.9E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.007
				Arsenic	15.1	mg/kg	5.5E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	8.3E-07	7.7E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.03
				Chromium	19.4	mg/kg	4.1E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.1E-06	9.9E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.003
				Cobalt	15.3	mg/kg	5.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.8E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.03
				Iron	31200	mg/kg	1.1E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-02	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.02
				Lead	130	mg/kg	4.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.6E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.0E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-04	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.002
			Exp. Route Total								4.1E-04					0.10
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	2.1E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.5E-04	5.0E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0008
				Fluoranthene	182	mg/kg	2.4E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.4E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0008
				Naphthalene	1.90	mg/kg	2.5E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.5E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.00002
				Phenanthrene	117	mg/kg	1.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.2E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0007
				Pyrene	196	mg/kg	2.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.6E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.001
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	4.6E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	7.0E-08	6.5E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								1.5E-04					0.006
		Exposure Point Total									5.6E-04					0.1
	Exposure Medium Total										5.6E-04					0.1
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	3.8E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	4.2E-10	9.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	3.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	4.5E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	9.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	3.3E-09	1.3E-06	(mg/m^3)	3.0E-03	(mg/m^3)	0.0004
				Phenanthrene	3.5E-4	mg/m^3	9.5E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.3E-05	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	4.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.8E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	3.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.7E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000009
				Arsenic	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.6E-11	5.3E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000004
				Chromium	1.8E-9	mg/m^3	2.8E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	2.4E-09	6.8E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000007
				Cobalt	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.4E-11	5.3E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000009
				Iron	2.8E-6	mg/m^3	7.8E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.1E-07	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	3.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.5E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.4E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.9E-09	(mg/m^3)	5.0E-05	(mg/m^3)	0.00004
			Exp. Route Total								6.1E-09					0.0005
		Exposure Point Total									6.1E-09					0.0005
	Exposure Medium Total										6.1E-09					0.0005
Medium Total											5.6E-04					0.1
										Total of Receptor Risks Across All Media	5.6E-04				Total of Receptor Hazards Across All Media	0.1

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.3.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	4.9E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	3.5E-05	2.3E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	7.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0004
				Fluoranthene	182	mg/kg	1.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0004
				Naphthalene	1.90	mg/kg	1.2E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000008
				Phenanthrene	117	mg/kg	7.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0003
				Pyrene	196	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0006
				Aluminum	13400	mg/kg	8.2E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.001
				Arsenic	15.1	mg/kg	9.2E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.4E-07	1.3E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.004
				Chromium	19.4	mg/kg	3.5E-07	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	1.8E-07	1.7E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0006
				Cobalt	15.3	mg/kg	9.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.3E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.004
				Iron	31200	mg/kg	1.9E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.004
				Lead	130	mg/kg	7.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	3.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.6E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0003
			Exp. Route Total								3.6E-05					0.02
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	2.5E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.8E-05	1.2E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	5.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Fluoranthene	182	mg/kg	5.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.0E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0002
				Naphthalene	1.90	mg/kg	6.0E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.4E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000004
				Phenanthrene	117	mg/kg	3.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	5.2E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Pyrene	196	mg/kg	6.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0003
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	1.1E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.7E-08	1.5E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0005
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								1.8E-05					0.001
		Exposure Point Total									5.4E-05					0.02
	Exposure Medium Total										5.4E-05					0.02
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	2.0E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.2E-10	9.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	3.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	4.5E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	9.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	3.3E-09	1.3E-06	(mg/m^3)	3.0E-03	(mg/m^3)	0.0004
				Phenanthrene	3.5E-4	mg/m^3	9.5E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.3E-05	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	4.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.8E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	3.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.7E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000009
				Arsenic	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.6E-11	5.3E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000004
				Chromium	1.8E-9	mg/m^3	1.4E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.2E-09	6.8E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000007
				Cobalt	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.4E-11	5.3E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000009
				Iron	2.8E-6	mg/m^3	7.8E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.1E-07	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	3.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.5E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.4E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.9E-09	(mg/m^3)	5.0E-05	(mg/m^3)	0.00004
			Exp. Route Total								4.8E-09					0.0005
		Exposure Point Total									4.8E-09					0.0005
	Exposure Medium Total										4.8E-09					0.0005
Medium Total											5.4E-05					0.02
										Total of Receptor Risks Across All Media	5.4E-05				Total of Receptor Hazards Across All Media	0.02

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.4.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.0E-06	(mg/kg/day)	7.3E+00	(mg/kg/day)-1	7.6E-06	1.5E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.9E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	6.9E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Fluoranthene	182	mg/kg	7.1E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.0E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0002
				Naphthalene	1.90	mg/kg	7.4E-09	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.0E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000005
				Phenanthrene	117	mg/kg	4.6E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	6.4E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Pyrene	196	mg/kg	7.7E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.1E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0004
				Aluminum	13400	mg/kg	5.2E-05	(mg/kg/day)	NA	(mg/kg/day)-1	- -	7.3E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0007
				Arsenic	15.1	mg/kg	5.9E-08	(mg/kg/day)	1.5E+00	(mg/kg/day)-1	8.9E-08	8.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.003
				Chromium	19.4	mg/kg	7.6E-08	(mg/kg/day)	5.0E-01	(mg/kg/day)-1	3.8E-08	1.1E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0004
				Cobalt	15.3	mg/kg	6.0E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	8.4E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.003
				Iron	31200	mg/kg	1.2E-04	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.7E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.002
				Lead	130	mg/kg	5.1E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	7.1E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.1E-06	(mg/kg/day)	NA	(mg/kg/day)-1	- -	3.0E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0002
			Exp. Route Total								7.7E-06					0.01
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	5.4E-07	(mg/kg/day)	7.3E+00	(mg/kg/day)-1	3.9E-06	7.6E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	2.6E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	3.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Fluoranthene	182	mg/kg	3.7E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	5.2E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0001
				Naphthalene	1.90	mg/kg	3.9E-09	(mg/kg/day)	NA	(mg/kg/day)-1	- -	5.4E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000003
				Phenanthrene	117	mg/kg	2.4E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	3.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Pyrene	196	mg/kg	4.0E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	5.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	7.1E-09	(mg/kg/day)	1.5E+00	(mg/kg/day)-1	1.1E-08	9.9E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								4.0E-06					0.0009
		Exposure Point Total									1.2E-05					0.01
	Exposure Medium Total										1.2E-05					0.01
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m3	6.6E-11	(mg/m3)	1.1E-03	(ug/m3)-1	7.3E-11	9.3E-10	(mg/m3)	NA	(mg/m3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m3	3.1E-11	(mg/m3)	NA	(ug/m3)-1	- -	4.4E-10	(mg/m3)	NA	(mg/m3)	--
				Fluoranthene	1.7E-8	mg/m3	4.5E-11	(mg/m3)	NA	(ug/m3)-1	- -	6.3E-10	(mg/m3)	NA	(mg/m3)	--
				Naphthalene	3.5E-5	mg/m3	9.6E-08	(mg/m3)	3.4E-05	(ug/m3)-1	3.3E-09	1.3E-06	(mg/m3)	3.0E-03	(mg/m3)	0.0004
				Phenanthrene	3.5E-4	mg/m3	9.5E-07	(mg/m3)	NA	(ug/m3)-1	- -	1.3E-05	(mg/m3)	NA	(mg/m3)	--
				Pyrene	1.8E-8	mg/m3	4.9E-11	(mg/m3)	NA	(ug/m3)-1	- -	6.8E-10	(mg/m3)	NA	(mg/m3)	--
				Aluminum	1.2E-6	mg/m3	3.3E-09	(mg/m3)	NA	(ug/m3)-1	- -	4.7E-08	(mg/m3)	5.0E-03	(mg/m3)	0.000009
				Arsenic	1.4E-9	mg/m3	3.8E-12	(mg/m3)	4.3E-03	(ug/m3)-1	1.6E-11	5.3E-11	(mg/m3)	1.5E-05	(mg/m3)	0.000004
				Chromium	1.8E-9	mg/m3	4.8E-12	(mg/m3)	8.4E-02	(ug/m3)-1	4.1E-10	6.8E-11	(mg/m3)	1.0E-04	(mg/m3)	0.0000007
				Cobalt	1.4E-9	mg/m3	3.8E-12	(mg/m3)	9.0E-03	(ug/m3)-1	3.4E-11	5.3E-11	(mg/m3)	6.0E-06	(mg/m3)	0.000009
				Iron	2.8E-6	mg/m3	7.8E-09	(mg/m3)	NA	(ug/m3)-1	- -	1.1E-07	(mg/m3)	NA	(mg/m3)	--
				Lead	1.2E-8	mg/m3	3.2E-11	(mg/m3)	NA	(ug/m3)-1	- -	4.5E-10	(mg/m3)	NA	(mg/m3)	--
				Manganese	4.9E-8	mg/m3	1.4E-10	(mg/m3)	NA	(ug/m3)-1	- -	1.9E-09	(mg/m3)	5.0E-05	(mg/m3)	0.00004
			Exp. Route Total								3.8E-09					0.0005
		Exposure Point Total									3.8E-09					0.0005
	Exposure Medium Total										3.8E-09					0.0005
Medium Total											1.2E-05					0.01
										Total of Receptor Risks Across All Media	1.2E-05				Total of Receptor Hazards Across All Media	0.01

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.5.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	7.1E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	5.2E-04					
				Benzo(g,h,i)perylene	126	mg/kg	7.9E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	1.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	1.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	7.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	1.2E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	8.4E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	9.5E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.4E-06					
				Chromium	19.4	mg/kg	5.2E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.6E-06					
				Cobalt	15.3	mg/kg	9.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	2.0E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	8.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	3.4E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								5.2E-04					
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	2.7E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.0E-04					
				Benzo(g,h,i)perylene	126	mg/kg	3.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	4.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	4.9E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	3.0E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	5.0E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	9.0E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.3E-07					
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -					
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								2.0E-04					
		Exposure Point Total									7.2E-04					
	Exposure Medium Total										7.2E-04					
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.0E-09	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.1E-09					
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Fluoranthene	1.7E-8	mg/m^3	2.7E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Naphthalene	3.5E-5	mg/m^3	5.8E-07	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	2.0E-08					
				Phenanthrene	3.5E-4	mg/m^3	5.7E-06	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Pyrene	1.8E-8	mg/m^3	2.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Aluminum	1.2E-6	mg/m^3	2.0E-08	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Arsenic	1.4E-9	mg/m^3	2.3E-11	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	9.7E-11					
				Chromium	1.8E-9	mg/m^3	7.3E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	6.2E-09					
				Cobalt	1.4E-9	mg/m^3	2.3E-11	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	2.1E-10					
				Iron	2.8E-6	mg/m^3	4.7E-08	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Lead	1.2E-8	mg/m^3	1.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Manganese	4.9E-8	mg/m^3	8.1E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
			Exp. Route Total								2.7E-08					
		Exposure Point Total									2.7E-08					
	Exposure Medium Total										2.7E-08					
Medium Total											7.2E-04					
										Total of Receptor Risks Across All Media	7.2E-04					

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.1.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	2.2E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.6E-06	1.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.0E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00003
				Fluoranthene	182	mg/kg	1.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00003
				Naphthalene	1.90	mg/kg	1.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000006
				Phenanthrene	117	mg/kg	9.6E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.4E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00002
				Pyrene	196	mg/kg	1.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00004
				Aluminum	13400	mg/kg	1.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.5E-05	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.00009
				Arsenic	15.1	mg/kg	1.2E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.9E-08	9.6E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Chromium	19.4	mg/kg	1.6E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	7.9E-09	1.2E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00004
				Cobalt	15.3	mg/kg	1.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.7E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Iron	31200	mg/kg	2.6E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0003
				Lead	130	mg/kg	1.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.3E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	4.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.5E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00002
			Exp. Route Total								1.6E-06					0.001
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	3.0E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.2E-06	2.3E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00004
				Fluoranthene	182	mg/kg	2.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00004
				Naphthalene	1.90	mg/kg	2.1E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000008
				Phenanthrene	117	mg/kg	1.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00003
				Pyrene	196	mg/kg	2.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00006
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	3.9E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	5.9E-09	3.0E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0001
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.2E-06					0.0003
		Exposure Point Total									3.8E-06					0.001
	Exposure Medium Total										3.8E-06					0.001
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	9.2E-12	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.0E-11	7.2E-11	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	4.4E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-11	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	6.3E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.9E-11	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	1.3E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	4.5E-10	1.0E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.00003
				Phenanthrene	3.5E-4	mg/m^3	1.3E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.0E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	6.8E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.3E-11	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	4.6E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.6E-09	(mg/m^3)	5.0E-03	(mg/m^3)	0.0000007
				Arsenic	1.4E-9	mg/m^3	5.2E-13	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	2.3E-12	4.1E-12	(mg/m^3)	1.5E-05	(mg/m^3)	0.0000003
				Chromium	1.8E-9	mg/m^3	6.7E-13	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	5.7E-11	5.2E-12	(mg/m^3)	1.0E-04	(mg/m^3)	0.00000005
				Cobalt	1.4E-9	mg/m^3	5.3E-13	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	4.8E-12	4.1E-12	(mg/m^3)	6.0E-06	(mg/m^3)	0.0000007
				Iron	2.8E-6	mg/m^3	1.1E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	8.4E-09	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	4.5E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.5E-11	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.000003
			Exp. Route Total								5.3E-10					0.00004
		Exposure Point Total									5.3E-10					0.00004
	Exposure Medium Total										5.3E-10					0.00004
Medium Total											3.8E-06					0.002
										Total of Receptor Risks Across All Media	3.8E-06				Total of Receptor Hazards Across All Media	0.002

TABLE 7.2.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.4E-05	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.0E-04	3.4E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0005
				Fluoranthene	182	mg/kg	1.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0006
				Naphthalene	1.90	mg/kg	1.7E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.4E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.00001
				Phenanthrene	117	mg/kg	1.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.5E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0005
				Pyrene	196	mg/kg	1.8E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0008
				Aluminum	13400	mg/kg	1.2E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.002
				Arsenic	15.1	mg/kg	1.4E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	2.1E-07	1.9E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.006
				Chromium	19.4	mg/kg	1.0E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	5.1E-07	2.5E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0008
				Cobalt	15.3	mg/kg	1.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.007
				Iron	31200	mg/kg	2.8E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.006
				Lead	130	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	5.0E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0005
			Exp. Route Total								1.0E-04					0.02
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	2.1E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.5E-05	5.0E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00008
				Fluoranthene	182	mg/kg	2.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.4E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00008
				Naphthalene	1.90	mg/kg	2.5E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.5E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000002
				Phenanthrene	117	mg/kg	1.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.2E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00007
				Pyrene	196	mg/kg	2.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	4.6E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	7.0E-09	6.5E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								1.5E-05					0.0006
		Exposure Point Total									1.2E-04					0.02
	Exposure Medium Total										1.2E-04					0.02
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.9E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.1E-10	4.6E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	2.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	4.8E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.6E-09	6.7E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.0002
				Phenanthrene	3.5E-4	mg/m^3	4.8E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.7E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	2.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.7E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000005
				Arsenic	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	8.1E-12	2.6E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000002
				Chromium	1.8E-9	mg/m^3	1.4E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.2E-09	3.4E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000003
				Cobalt	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.7E-11	2.7E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000004
				Iron	2.8E-6	mg/m^3	3.9E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.4E-08	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	6.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	9.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.00002
			Exp. Route Total								3.0E-09					0.0003
		Exposure Point Total									3.0E-09					0.0003
	Exposure Medium Total										3.0E-09					0.0003
Medium Total											1.2E-04					0.02
										Total of Receptor Risks Across All Media	1.2E-04				Total of Receptor Hazards Across All Media	0.02

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.3.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.2E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	8.9E-06	5.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00009
				Fluoranthene	182	mg/kg	2.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.9E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00010
				Naphthalene	1.90	mg/kg	2.9E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000002
				Phenanthrene	117	mg/kg	1.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00008
				Pyrene	196	mg/kg	3.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.2E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Aluminum	13400	mg/kg	2.0E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.9E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0003
				Arsenic	15.1	mg/kg	2.3E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	3.4E-08	3.2E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Chromium	19.4	mg/kg	8.9E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	4.4E-08	4.1E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0001
				Cobalt	15.3	mg/kg	2.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Iron	31200	mg/kg	4.7E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.6E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0009
				Lead	130	mg/kg	2.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	8.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00008
			Exp. Route Total								8.9E-06					0.004
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	1.8E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.3E-06	8.4E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	2.8E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00001
				Fluoranthene	182	mg/kg	4.1E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	5.7E-07	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00001
				Naphthalene	1.90	mg/kg	4.3E-10	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.0E-09	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000003
				Phenanthrene	117	mg/kg	2.6E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.7E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00001
				Pyrene	196	mg/kg	4.4E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.2E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00002
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	7.9E-10	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.2E-09	1.1E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.00004
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								1.3E-06					0.00010
		Exposure Point Total									1.0E-05					0.004
	Exposure Medium Total										1.0E-05					0.004
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	9.9E-11	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.1E-10	4.6E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	2.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	4.8E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.6E-09	6.7E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.0002
				Phenanthrene	3.5E-4	mg/m^3	4.8E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.7E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	2.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.7E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000005
				Arsenic	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	8.1E-12	2.6E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000002
				Chromium	1.8E-9	mg/m^3	7.2E-12	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	6.1E-10	3.4E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000003
				Cobalt	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.7E-11	2.7E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000004
				Iron	2.8E-6	mg/m^3	3.9E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.4E-08	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	6.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	9.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.00002
			Exp. Route Total								2.4E-09					0.0003
		Exposure Point Total									2.4E-09					0.0003
	Exposure Medium Total										2.4E-09					0.0003
Medium Total											1.0E-05					0.004
										Total of Receptor Risks Across All Media	1.0E-05				Total of Receptor Hazards Across All Media	0.004

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.4.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	2.6E-07	(mg/kg/day)	7.3E+00	(mg/kg/day)-1	1.9E-06	3.6E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.2E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00006
				Fluoranthene	182	mg/kg	1.8E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.5E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00006
				Naphthalene	1.90	mg/kg	1.9E-09	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.6E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000001
				Phenanthrene	117	mg/kg	1.1E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00005
				Pyrene	196	mg/kg	1.9E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00009
				Aluminum	13400	mg/kg	1.3E-05	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.8E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0002
				Arsenic	15.1	mg/kg	1.5E-08	(mg/kg/day)	1.5E+00	(mg/kg/day)-1	2.2E-08	2.1E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0007
				Chromium	19.4	mg/kg	1.9E-08	(mg/kg/day)	5.0E-01	(mg/kg/day)-1	9.5E-09	2.7E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00009
				Cobalt	15.3	mg/kg	1.5E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.1E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0007
				Iron	31200	mg/kg	3.1E-05	(mg/kg/day)	NA	(mg/kg/day)-1	- -	4.3E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0006
				Lead	130	mg/kg	1.3E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	1.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	5.3E-07	(mg/kg/day)	NA	(mg/kg/day)-1	- -	7.4E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00005
			Exp. Route Total								1.9E-06					0.003
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	3.9E-08	(mg/kg/day)	7.3E+00	(mg/kg/day)-1	2.8E-07	5.4E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.8E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.6E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.000009
				Fluoranthene	182	mg/kg	2.6E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	3.7E-07	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.000009
				Naphthalene	1.90	mg/kg	2.8E-10	(mg/kg/day)	NA	(mg/kg/day)-1	- -	3.9E-09	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000002
				Phenanthrene	117	mg/kg	1.7E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	2.4E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.000008
				Pyrene	196	mg/kg	2.8E-08	(mg/kg/day)	NA	(mg/kg/day)-1	- -	4.0E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00001
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	5.1E-10	(mg/kg/day)	1.5E+00	(mg/kg/day)-1	7.6E-10	7.1E-09	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.00002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)-1	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.8E-07					0.00006
		Exposure Point Total									2.2E-06					0.003
	Exposure Medium Total										2.2E-06					0.003
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m3	3.3E-11	(mg/m3)	1.1E-03	(ug/m3)-1	3.6E-11	4.6E-10	(mg/m3)	NA	(mg/m3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m3	1.6E-11	(mg/m3)	NA	(ug/m3)-1	- -	2.2E-10	(mg/m3)	NA	(mg/m3)	--
				Fluoranthene	1.7E-8	mg/m3	2.3E-11	(mg/m3)	NA	(ug/m3)-1	- -	3.2E-10	(mg/m3)	NA	(mg/m3)	--
				Naphthalene	3.5E-5	mg/m3	4.8E-08	(mg/m3)	3.4E-05	(ug/m3)-1	1.6E-09	6.7E-07	(mg/m3)	3.0E-03	(mg/m3)	0.0002
				Phenanthrene	3.5E-4	mg/m3	4.8E-07	(mg/m3)	NA	(ug/m3)-1	- -	6.7E-06	(mg/m3)	NA	(mg/m3)	--
				Pyrene	1.8E-8	mg/m3	2.4E-11	(mg/m3)	NA	(ug/m3)-1	- -	3.4E-10	(mg/m3)	NA	(mg/m3)	--
				Aluminum	1.2E-6	mg/m3	1.7E-09	(mg/m3)	NA	(ug/m3)-1	- -	2.3E-08	(mg/m3)	5.0E-03	(mg/m3)	0.000005
				Arsenic	1.4E-9	mg/m3	1.9E-12	(mg/m3)	4.3E-03	(ug/m3)-1	8.1E-12	2.6E-11	(mg/m3)	1.5E-05	(mg/m3)	0.000002
				Chromium	1.8E-9	mg/m3	2.4E-12	(mg/m3)	8.4E-02	(ug/m3)-1	2.0E-10	3.4E-11	(mg/m3)	1.0E-04	(mg/m3)	0.0000003
				Cobalt	1.4E-9	mg/m3	1.9E-12	(mg/m3)	9.0E-03	(ug/m3)-1	1.7E-11	2.7E-11	(mg/m3)	6.0E-06	(mg/m3)	0.000004
				Iron	2.8E-6	mg/m3	3.9E-09	(mg/m3)	NA	(ug/m3)-1	- -	5.4E-08	(mg/m3)	NA	(mg/m3)	--
				Lead	1.2E-8	mg/m3	1.6E-11	(mg/m3)	NA	(ug/m3)-1	- -	2.3E-10	(mg/m3)	NA	(mg/m3)	--
				Manganese	4.9E-8	mg/m3	6.8E-11	(mg/m3)	NA	(ug/m3)-1	- -	9.5E-10	(mg/m3)	5.0E-05	(mg/m3)	0.00002
			Exp. Route Total								1.9E-09					0.0003
		Exposure Point Total									1.9E-09					0.0003
	Exposure Medium Total										1.9E-09					0.0003
Medium Total											2.2E-06					0.003
										Total of Receptor Risks Across All Media	2.2E-06				Total of Receptor Hazards Across All Media	0.003

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.5.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	6.9E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	5.0E-05					
				Benzo(g,h,i)perylene	126	mg/kg	6.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	9.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	9.5E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	5.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	9.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	6.7E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	7.6E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.1E-07					
				Chromium	19.4	mg/kg	5.0E-07	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.5E-07					
				Cobalt	15.3	mg/kg	7.7E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	1.6E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	6.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	2.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								5.1E-05					
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	1.0E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	7.3E-06					
				Benzo(g,h,i)perylene	126	mg/kg	9.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	1.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	1.4E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	8.6E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	1.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	2.6E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	3.8E-09					
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -					
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								7.3E-06					
		Exposure Point Total									5.8E-05					
	Exposure Medium Total										5.8E-05					
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.6E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.7E-10					
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	2.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Fluoranthene	1.7E-8	mg/m^3	4.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Naphthalene	3.5E-5	mg/m^3	8.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	2.9E-09					
				Phenanthrene	3.5E-4	mg/m^3	8.6E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Pyrene	1.8E-8	mg/m^3	4.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Aluminum	1.2E-6	mg/m^3	3.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Arsenic	1.4E-9	mg/m^3	3.4E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.5E-11					
				Chromium	1.8E-9	mg/m^3	1.2E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	9.7E-10					
				Cobalt	1.4E-9	mg/m^3	3.4E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.1E-11					
				Iron	2.8E-6	mg/m^3	7.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Lead	1.2E-8	mg/m^3	2.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Manganese	4.9E-8	mg/m^3	1.2E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
			Exp. Route Total								4.1E-09					
		Exposure Point Total									4.1E-09					
	Exposure Medium Total										4.1E-09					
Medium Total											5.8E-05					
										Total of Receptor Risks Across All Media	5.8E-05					

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

LIST OF TABLES
RAGS PART D TABLE 9
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

Table No.	
	REASONABLE MAXIMUM EXPOSURES
9.1.RME	Workers
9.2.RME	Child Recreational Users
9.3.RME	Older Child Recreational Users
9.4.RME	Adult Recreational Users
9.5.RME	Lifelong Recreational Users
	CENTRAL TENDENCY EXPOSURES
9.1.CTE	Workers
9.2.CTE	Child Recreational Users
9.3.CTE	Older Child Recreational Users
9.4.CTE	Adult Recreational Users
9.5.CTE	Lifelong Recreational Users

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	9E-06	--	8E-06	--	2E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00005	- -	0.00005	0.00010
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00006	- -	0.00005	0.0001
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000001	- -	0.000001	0.000002
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00005	- -	0.00004	0.00009
			Pyrene	- -	--	- -	--	- -	Kidney	0.00008	- -	0.00007	0.0002
			Aluminum	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Arsenic	1E-07	--	2E-08	--	1E-07	Skin, CVS	0.0006	- -	0.0001	0.0008
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.00008	- -	--	0.00008
			Cobalt	- -	--	- -	--	- -	Blood	0.0006	- -	--	0.0006
			Iron	- -	--	- -	--	- -	GS	0.0006	- -	--	0.0006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00005	- -	--	0.00005
			Chemical Total	9E-06	--	8E-06	--	2E-05		0.002	--	0.0003	0.003
		Exposure Point Total						2E-05					0.003
	Exposure Medium Total							2E-05					0.003
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	3E-11	--	--	3E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	1E-09	--	--	1E-09	Nasal	- -	0.00003	- -	0.00003
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.0000007	- -	0.0000007
			Arsenic	--	6E-12	--	--	6E-12	NA	- -	0.0000003	- -	0.0000003
			Chromium	--	2E-10	--	--	2E-10	NA	- -	0.00000005	- -	0.00000005
			Cobalt	--	1E-11	--	--	1E-11	Lungs	- -	0.0000007	- -	0.0000007
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.000003	- -	0.000003
			Chemical Total	--	1E-09	--	--	1E-09		- -	0.00004	- -	0.00004
		Exposure Point Total						1E-09					0.00004
	Exposure Medium Total							1E-09					0.00004
Medium Total								2E-05					0.003
Receptor Total							Receptor Risk Total	2E-05				Receptor HI Total	0.003

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	4E-04	--	1E-04	--	6E-04	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.002	- -	0.0008	0.003
			Fluoranthene	- -	--	- -	--	- -	Liver	0.002	- -	0.0008	0.003
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.00005	- -	0.00002	0.00007
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.002	- -	0.0007	0.003
			Pyrene	- -	--	- -	--	- -	Kidney	0.003	- -	0.001	0.005
			Aluminum	- -	--	- -	--	- -	CNS	0.007	- -	--	0.007
			Arsenic	8E-07	--	7E-08	--	9E-07	Skin, CVS	0.03	- -	0.002	0.03
			Chromium	2E-06	--	- -	--	2E-06	Fetotoxicity, GS, Bone	0.003	- -	--	0.003
			Cobalt	- -	--	- -	--	- -	Blood	0.03	- -	--	0.03
			Iron	- -	--	- -	--	- -	GS	0.02	- -	--	0.02
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.002	- -	--	0.002
			Chemical Total	4E-04	--	1E-04	--	6E-04		0.10	--	0.006	0.1
		Exposure Point Total						6E-04					0.1
	Exposure Medium Total							6E-04					0.1
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	4E-10	--	--	4E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	2E-09	--	--	2E-09	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	6E-09	--	--	6E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						6E-09					0.0005
	Exposure Medium Total							6E-09					0.0005
Medium Total								6E-04					0.1
Receptor Total							Receptor Risk Total	6E-04				Receptor HI Total	0.1

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.3.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	4E-05	--	2E-05	--	5E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0004	- -	0.0002	0.0005
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0004	- -	0.0002	0.0006
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000008	- -	0.000004	0.00001
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0003	- -	0.0002	0.0005
			Pyrene	- -	--	- -	--	- -	Kidney	0.0006	- -	0.0003	0.0008
			Aluminum	- -	--	- -	--	- -	CNS	0.001	- -	--	0.001
			Arsenic	1E-07	--	2E-08	--	2E-07	Skin, CVS	0.004	- -	0.0005	0.005
			Chromium	2E-07	--	- -	--	2E-07	Fetotoxicity, GS, Bone	0.0006	- -	--	0.0006
			Cobalt	- -	--	- -	--	- -	Blood	0.004	- -	--	0.004
			Iron	- -	--	- -	--	- -	GS	0.004	- -	--	0.004
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0003	- -	--	0.0003
			Chemical Total	4E-05	--	2E-05	--	5E-05		0.02	--	0.001	0.02
		Exposure Point Total						5E-05					0.02
	Exposure Medium Total							5E-05					0.02
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	1E-09	--	--	1E-09	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	5E-09	--	--	5E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						5E-09					0.0005
	Exposure Medium Total							5E-09					0.0005
Medium Total								5E-05					0.02
Receptor Total							Receptor Risk Total	5E-05				Receptor HI Total	0.02

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.4.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	8E-06	--	4E-06	--	1E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0002	- -	0.0001	0.0003
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0002	- -	0.0001	0.0004
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000005	- -	0.000003	0.000008
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0002	- -	0.0001	0.0003
			Pyrene	- -	--	- -	--	- -	Kidney	0.0004	- -	0.0002	0.0005
			Aluminum	- -	--	- -	--	- -	CNS	0.0007	- -	--	0.0007
			Arsenic	9E-08	--	1E-08	--	1E-07	Skin, CVS	0.003	- -	0.0003	0.003
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.0004	- -	--	0.0004
			Cobalt	- -	--	- -	--	- -	Blood	0.003	- -	--	0.003
			Iron	- -	--	- -	--	- -	GS	0.002	- -	--	0.002
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Chemical Total	8E-06	--	4E-06	--	1E-05		0.01	--	0.0009	0.01
		Exposure Point Total						1E-05					0.01
	Exposure Medium Total							1E-05					0.01
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	7E-11	--	--	7E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	4E-10	--	--	4E-10	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	4E-09	--	--	4E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						4E-09					0.0005
	Exposure Medium Total							4E-09					0.0005
Medium Total								1E-05					0.01
Receptor Total							Receptor Risk Total	1E-05				Receptor HI Total	0.01

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.5.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	5E-04	--	2E-04	--	7E-04					
			Benzo(g,h,i)perylene	- -	--	- -	--	- -					
			Fluoranthene	- -	--	- -	--	- -					
			Naphthalene	- -	--	- -	--	- -					
			Phenanthrene	- -	--	- -	--	- -					
			Pyrene	- -	--	- -	--	- -					
			Aluminum	- -	--	- -	--	- -					
			Arsenic	1E-06	--	1E-07	--	2E-06					
			Chromium	3E-06	--	- -	--	3E-06					
			Cobalt	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Chemical Total	5E-04	--	2E-04	--	7E-04					
		Exposure Point Total						7E-04					
	Exposure Medium Total							7E-04					
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-09	--	--	1E-09					
			Benzo(g,h,i)perylene	--	- -	--	--	- -					
			Fluoranthene	--	- -	--	--	- -					
			Naphthalene	--	2E-08	--	--	2E-08					
			Phenanthrene	--	- -	--	--	- -					
			Pyrene	--	- -	--	--	- -					
			Aluminum	--	- -	--	--	- -					
			Arsenic	--	1E-10	--	--	1E-10					
			Chromium	--	6E-09	--	--	6E-09					
			Cobalt	--	2E-10	--	--	2E-10					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Chemical Total	--	3E-08	--	--	3E-08					
		Exposure Point Total						3E-08					
	Exposure Medium Total							3E-08					
Medium Total								7E-04					
Receptor Total							Receptor Risk Total	7E-04					

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.1.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	2E-06	--	2E-06	--	4E-06	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00003	- -	0.00004	0.00006
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00003	- -	0.00004	0.00007
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.0000006	- -	0.0000008	0.000001
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00002	- -	0.00003	0.00006
			Pyrene	- -	--	- -	--	- -	Kidney	0.00004	- -	0.00006	0.00010
			Aluminum	- -	--	- -	--	- -	CNS	0.00009	- -	--	0.00009
			Arsenic	2E-08	--	6E-09	--	2E-08	Skin, CVS	0.0003	- -	0.0001	0.0004
			Chromium	8E-09	--	- -	--	8E-09	Fetotoxicity, GS, Bone	0.00004	- -	--	0.00004
			Cobalt	- -	--	- -	--	- -	Blood	0.0003	- -	--	0.0003
			Iron	- -	--	- -	--	- -	GS	0.0003	- -	--	0.0003
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00002	- -	--	0.00002
			Chemical Total	2E-06	--	2E-06	--	4E-06		0.001	--	0.0003	0.001
		Exposure Point Total						4E-06					0.001
	Exposure Medium Total							4E-06					0.001
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-11	--	--	1E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	5E-10	--	--	5E-10	Nasal	- -	0.00003	- -	0.00003
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.0000007	- -	0.0000007
			Arsenic	--	2E-12	--	--	2E-12	NA	- -	0.0000003	- -	0.0000003
			Chromium	--	6E-11	--	--	6E-11	NA	- -	0.00000005	- -	0.00000005
			Cobalt	--	5E-12	--	--	5E-12	Lungs	- -	0.0000007	- -	0.0000007
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.000003	- -	0.000003
			Chemical Total	--	5E-10	--	--	5E-10		- -	0.00004	- -	0.00004
		Exposure Point Total						5E-10					0.00004
	Exposure Medium Total							5E-10					0.00004
Medium Total								4E-06					0.002
Receptor Total							Receptor Risk Total	4E-06				Receptor HI Total	0.002

TABLE 9.2.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	1E-04	--	1E-05	--	1E-04	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0005	- -	0.00008	0.0006
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0006	- -	0.00008	0.0007
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.00001	- -	0.000002	0.00001
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0005	- -	0.00007	0.0006
			Pyrene	- -	--	- -	--	- -	Kidney	0.0008	- -	0.0001	0.0010
			Aluminum	- -	--	- -	--	- -	CNS	0.002	- -	--	0.002
			Arsenic	2E-07	--	7E-09	--	2E-07	Skin, CVS	0.006	- -	0.0002	0.007
			Chromium	5E-07	--	- -	--	5E-07	Fetotoxicity, GS, Bone	0.0008	- -	--	0.0008
			Cobalt	- -	--	- -	--	- -	Blood	0.007	- -	--	0.007
			Iron	- -	--	- -	--	- -	GS	0.006	- -	--	0.006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0005	- -	--	0.0005
			Chemical Total	1E-04	--	1E-05	--	1E-04		0.02	--	0.0006	0.02
		Exposure Point Total						1E-04					0.02
	Exposure Medium Total							1E-04					0.02
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	1E-09	--	--	1E-09	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	3E-09	--	--	3E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						3E-09					0.0003
	Exposure Medium Total							3E-09					0.0003
Medium Total								1E-04					0.02
Receptor Total							Receptor Risk Total	1E-04				Receptor HI Total	0.02

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	9E-06	--	1E-06	--	1E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00009	- -	0.00001	0.0001
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00010	- -	0.00001	0.0001
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000002	- -	0.0000003	0.000002
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00008	- -	0.00001	0.00010
			Pyrene	- -	--	- -	--	- -	Kidney	0.0001	- -	0.00002	0.0002
			Aluminum	- -	--	- -	--	- -	CNS	0.0003	- -	--	0.0003
			Arsenic	3E-08	--	1E-09	--	4E-08	Skin, CVS	0.001	- -	0.00004	0.001
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.0001	- -	--	0.0001
			Cobalt	- -	--	- -	--	- -	Blood	0.001	- -	--	0.001
			Iron	- -	--	- -	--	- -	GS	0.0009	- -	--	0.0009
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00008	- -	--	0.00008
			Chemical Total	9E-06	--	1E-06	--	1E-05		0.004	--	0.00010	0.004
		Exposure Point Total						1E-05					0.004
	Exposure Medium Total							1E-05					0.004
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-10	--	--	1E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	6E-10	--	--	6E-10	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	2E-09	--	--	2E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						2E-09					0.0003
	Exposure Medium Total							2E-09					0.0003
Medium Total								1E-05					0.004
Receptor Total							Receptor Risk Total	1E-05				Receptor HI Total	0.004

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.4.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	2E-06	--	3E-07	--	2E-06	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00006	- -	0.000009	0.00007
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00006	- -	0.000009	0.00007
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000001	- -	0.0000002	0.000001
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00005	- -	0.000008	0.00006
			Pyrene	- -	--	- -	--	- -	Kidney	0.00009	- -	0.00001	0.0001
			Aluminum	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Arsenic	2E-08	--	8E-10	--	2E-08	Skin, CVS	0.0007	- -	0.00002	0.0007
			Chromium	9E-09	--	- -	--	9E-09	Fetotoxicity, GS, Bone	0.00009	- -	--	0.00009
			Cobalt	- -	--	- -	--	- -	Blood	0.0007	- -	--	0.0007
			Iron	- -	--	- -	--	- -	GS	0.0006	- -	--	0.0006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00005	- -	--	0.00005
			Chemical Total	2E-06	--	3E-07	--	2E-06		0.003	--	0.00006	0.003
		Exposure Point Total						2E-06					0.003
	Exposure Medium Total							2E-06					0.003
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	4E-11	--	--	4E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	2E-10	--	--	2E-10	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	2E-09	--	--	2E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						2E-09					0.0003
	Exposure Medium Total							2E-09					0.0003
Medium Total								2E-06					0.003
Receptor Total							Receptor Risk Total	2E-06				Receptor HI Total	0.003

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.5.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	5E-05	--	7E-06	--	6E-05					
			Benzo(g,h,i)perylene	- -	--	- -	--	- -					
			Fluoranthene	- -	--	- -	--	- -					
			Naphthalene	- -	--	- -	--	- -					
			Phenanthrene	- -	--	- -	--	- -					
			Pyrene	- -	--	- -	--	- -					
			Aluminum	- -	--	- -	--	- -					
			Arsenic	1E-07	--	4E-09	--	1E-07					
			Chromium	3E-07	--	- -	--	3E-07					
			Cobalt	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Chemical Total	5E-05	--	7E-06	--	6E-05					
		Exposure Point Total						6E-05					
	Exposure Medium Total							6E-05					
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10					
			Benzo(g,h,i)perylene	--	- -	--	--	- -					
			Fluoranthene	--	- -	--	--	- -					
			Naphthalene	--	3E-09	--	--	3E-09					
			Phenanthrene	--	- -	--	--	- -					
			Pyrene	--	- -	--	--	- -					
			Aluminum	--	- -	--	--	- -					
			Arsenic	--	1E-11	--	--	1E-11					
			Chromium	--	1E-09	--	--	1E-09					
			Cobalt	--	3E-11	--	--	3E-11					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Chemical Total	--	4E-09	--	--	4E-09					
		Exposure Point Total						4E-09					
	Exposure Medium Total							4E-09					
Medium Total								6E-05					
Receptor Total							Receptor Risk Total	6E-05					

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

LIST OF TABLES
RAGS PART D TABLE 7
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

Table No.

REASONABLE MAXIMUM EXPOSURES - RELATIVE ABSORPTION FACTORS

7.1.RME Workers
7.2.RME Child Recreational Users
7.3.RME Older Child Recreational Users
7.4.RME Adult Recreational Users
7.5.RME Lifelong Recreational Users

CENTRAL TENDENCY EXPOSURES - RELATIVE ABSORPTION FACTORS

7.1.CTE Workers
7.2.CTE Child Recreational Users
7.3.CTE Older Child Recreational Users
7.4.CTE Adult Recreational Users
7.5.CTE Lifelong Recreational Users

TABLE 7.1.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS

REASONABLE MAXIMUM EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.2E-06	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	2.5E-06	3.4E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	5.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00002
				Fluoranthene	182	mg/kg	8.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-06	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.00002
				Naphthalene	1.90	mg/kg	8.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.4E-08	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.0000004
				Phenanthrene	117	mg/kg	5.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.5E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00002
				Pyrene	196	mg/kg	8.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00003
				Aluminum	13400	mg/kg	6.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0002
				Arsenic	15.1	mg/kg	6.9E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.0E-07	1.9E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0006
				Chromium	19.4	mg/kg	8.8E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	4.4E-08	2.5E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00008
				Cobalt	15.3	mg/kg	7.0E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.9E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0006
				Iron	31200	mg/kg	1.4E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0006
				Lead	130	mg/kg	5.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.5E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00005
			Exp. Route Total								2.6E-06					0.002
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	1.6E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.2E-06	4.5E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	3.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00004
				Fluoranthene	182	mg/kg	5.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.5E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00004
				Naphthalene	1.90	mg/kg	5.7E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000008
				Phenanthrene	117	mg/kg	3.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.8E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00003
				Pyrene	196	mg/kg	5.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00005
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	1.4E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	2.0E-08	3.8E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0001
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								1.2E-06					0.0003
		Exposure Point Total									3.8E-06					0.003
	Exposure Medium Total										3.8E-06					0.003
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	2.6E-11	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.8E-11	7.2E-11	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-11	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	1.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.9E-11	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	3.7E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.3E-09	1.0E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.00003
				Phenanthrene	3.5E-4	mg/m^3	3.7E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.0E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	1.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.3E-11	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.6E-09	(mg/m^3)	5.0E-03	(mg/m^3)	0.0000007
				Arsenic	1.4E-9	mg/m^3	1.5E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	6.3E-12	4.1E-12	(mg/m^3)	1.5E-05	(mg/m^3)	0.0000003
				Chromium	1.8E-9	mg/m^3	1.9E-12	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.6E-10	5.2E-12	(mg/m^3)	1.0E-04	(mg/m^3)	0.00000005
				Cobalt	1.4E-9	mg/m^3	1.5E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.3E-11	4.1E-12	(mg/m^3)	6.0E-06	(mg/m^3)	0.0000007
				Iron	2.8E-6	mg/m^3	3.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	8.4E-09	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.5E-11	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	5.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.000003
			Exp. Route Total								1.5E-09					0.00004
		Exposure Point Total									1.5E-09					0.00004
	Exposure Medium Total										1.5E-09					0.00004
Medium Total											3.8E-06					0.003
										Total of Receptor Risks Across All Media	3.8E-06				Total of Receptor Hazards Across All Media	0.003

TABLE 7.2.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	5.6E-05	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	1.2E-04	1.4E-04	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.4E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0008
				Fluoranthene	182	mg/kg	6.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.3E-05	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.0008
				Naphthalene	1.90	mg/kg	6.9E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.7E-07	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.00002
				Phenanthrene	117	mg/kg	4.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.0E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0007
				Pyrene	196	mg/kg	7.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-04	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.001
				Aluminum	13400	mg/kg	4.9E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.007
				Arsenic	15.1	mg/kg	5.5E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	8.3E-07	7.7E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.03
				Chromium	19.4	mg/kg	4.1E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.1E-06	9.9E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.003
				Cobalt	15.3	mg/kg	5.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.8E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.03
				Iron	31200	mg/kg	1.1E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-02	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.02
				Lead	130	mg/kg	4.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.6E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.0E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-04	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.002
			Exp. Route Total								1.2E-04					0.09
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	3.2E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.3E-05	7.6E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.8E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0006
				Fluoranthene	182	mg/kg	1.9E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.6E-05	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0007
				Naphthalene	1.90	mg/kg	1.9E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-07	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.00001
				Phenanthrene	117	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0006
				Pyrene	196	mg/kg	2.0E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-05	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0009
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	4.6E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	7.0E-08	6.5E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.3E-05					0.005
		Exposure Point Total									1.4E-04					0.10
	Exposure Medium Total										1.4E-04					0.10
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	3.8E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	4.2E-10	9.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	3.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	4.5E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	9.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	3.3E-09	1.3E-06	(mg/m^3)	3.0E-03	(mg/m^3)	0.0004
				Phenanthrene	3.5E-4	mg/m^3	9.5E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.3E-05	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	4.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.8E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	3.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.7E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000009
				Arsenic	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.6E-11	5.3E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000004
				Chromium	1.8E-9	mg/m^3	2.8E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	2.4E-09	6.8E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000007
				Cobalt	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.4E-11	5.3E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000009
				Iron	2.8E-6	mg/m^3	7.8E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.1E-07	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	3.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.5E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.4E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.9E-09	(mg/m^3)	5.0E-05	(mg/m^3)	0.00004
			Exp. Route Total								6.1E-09					0.0005
		Exposure Point Total									6.1E-09					0.0005
	Exposure Medium Total										6.1E-09					0.0005
Medium Total											1.4E-04					0.10
										Total of Receptor Risks Across All Media	1.4E-04				Total of Receptor Hazards Across All Media	0.10

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.3.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	4.9E-06	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	9.9E-06	2.3E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	7.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0001
				Fluoranthene	182	mg/kg	1.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-05	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.0001
				Naphthalene	1.90	mg/kg	1.2E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-07	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.000003
				Phenanthrene	117	mg/kg	7.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0001
				Pyrene	196	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0002
				Aluminum	13400	mg/kg	8.2E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.001
				Arsenic	15.1	mg/kg	9.2E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.4E-07	1.3E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.004
				Chromium	19.4	mg/kg	3.5E-07	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	1.8E-07	1.7E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0006
				Cobalt	15.3	mg/kg	9.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.3E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.004
				Iron	31200	mg/kg	1.9E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.004
				Lead	130	mg/kg	7.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	3.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.6E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0003
			Exp. Route Total								1.0E-05					0.02
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	3.9E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.8E-06	1.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	3.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Fluoranthene	182	mg/kg	4.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.2E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.0002
				Naphthalene	1.90	mg/kg	4.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.5E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000003
				Phenanthrene	117	mg/kg	2.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Pyrene	196	mg/kg	4.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0002
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	1.1E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.7E-08	1.5E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0005
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.8E-06					0.001
		Exposure Point Total									1.3E-05					0.02
	Exposure Medium Total										1.3E-05					0.02
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	2.0E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.2E-10	9.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	3.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	4.5E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	9.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	3.3E-09	1.3E-06	(mg/m^3)	3.0E-03	(mg/m^3)	0.0004
				Phenanthrene	3.5E-4	mg/m^3	9.5E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.3E-05	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	4.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.8E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	3.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.7E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000009
				Arsenic	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.6E-11	5.3E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000004
				Chromium	1.8E-9	mg/m^3	1.4E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.2E-09	6.8E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000007
				Cobalt	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.4E-11	5.3E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000009
				Iron	2.8E-6	mg/m^3	7.8E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.1E-07	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	3.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.5E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.4E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.9E-09	(mg/m^3)	5.0E-05	(mg/m^3)	0.00004
			Exp. Route Total								4.8E-09					0.0005
		Exposure Point Total									4.8E-09					0.0005
	Exposure Medium Total										4.8E-09					0.0005
Medium Total											1.3E-05					0.02
										Total of Receptor Risks Across All Media	1.3E-05				Total of Receptor Hazards Across All Media	0.02

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.4.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.0E-06	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	2.1E-06	1.5E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	4.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00008
				Fluoranthene	182	mg/kg	7.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-05	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.00009
				Naphthalene	1.90	mg/kg	7.4E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.0E-07	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.000002
				Phenanthrene	117	mg/kg	4.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.4E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00008
				Pyrene	196	mg/kg	7.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.1E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0001
				Aluminum	13400	mg/kg	5.2E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.3E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0007
				Arsenic	15.1	mg/kg	5.9E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	8.9E-08	8.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.003
				Chromium	19.4	mg/kg	7.6E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	3.8E-08	1.1E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0004
				Cobalt	15.3	mg/kg	6.0E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.4E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.003
				Iron	31200	mg/kg	1.2E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.002
				Lead	130	mg/kg	5.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.1E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	2.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.0E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0002
			Exp. Route Total								2.3E-06					0.010
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	8.3E-08	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	6.1E-07	1.2E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	2.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00009
				Fluoranthene	182	mg/kg	2.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00010
				Naphthalene	1.90	mg/kg	3.0E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.2E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000002
				Phenanthrene	117	mg/kg	1.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.6E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00009
				Pyrene	196	mg/kg	3.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.0001
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	7.1E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.1E-08	9.9E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								6.2E-07					0.0008
		Exposure Point Total									2.9E-06					0.01
	Exposure Medium Total										2.9E-06					0.01
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	6.6E-11	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	7.3E-11	9.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	3.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	4.5E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	9.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	3.3E-09	1.3E-06	(mg/m^3)	3.0E-03	(mg/m^3)	0.0004
				Phenanthrene	3.5E-4	mg/m^3	9.5E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.3E-05	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	4.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.8E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	3.3E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.7E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000009
				Arsenic	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.6E-11	5.3E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000004
				Chromium	1.8E-9	mg/m^3	4.8E-12	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	4.1E-10	6.8E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000007
				Cobalt	1.4E-9	mg/m^3	3.8E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.4E-11	5.3E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000009
				Iron	2.8E-6	mg/m^3	7.8E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.1E-07	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	3.2E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.5E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.4E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.9E-09	(mg/m^3)	5.0E-05	(mg/m^3)	0.00004
			Exp. Route Total								3.8E-09					0.0005
		Exposure Point Total									3.8E-09					0.0005
	Exposure Medium Total										3.8E-09					0.0005
Medium Total											2.9E-06					0.01
										Total of Receptor Risks Across All Media	2.9E-06				Total of Receptor Hazards Across All Media	0.01

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.5.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	7.1E-05	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	1.5E-04					
				Benzo(g,h,i)perylene	126	mg/kg	7.9E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	1.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	1.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	7.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	1.2E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	8.4E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	9.5E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.4E-06					
				Chromium	19.4	mg/kg	5.2E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.6E-06					
				Cobalt	15.3	mg/kg	9.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	2.0E-03	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	8.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	3.4E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								1.5E-04					
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	4.2E-06	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	3.1E-05					
				Benzo(g,h,i)perylene	126	mg/kg	2.5E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	3.6E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	3.8E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	2.3E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	3.9E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	9.0E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.3E-07					
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -					
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								3.1E-05					
		Exposure Point Total									1.8E-04					
	Exposure Medium Total										1.8E-04					
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.0E-09	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.1E-09					
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Fluoranthene	1.7E-8	mg/m^3	2.7E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Naphthalene	3.5E-5	mg/m^3	5.8E-07	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	2.0E-08					
				Phenanthrene	3.5E-4	mg/m^3	5.7E-06	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Pyrene	1.8E-8	mg/m^3	2.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Aluminum	1.2E-6	mg/m^3	2.0E-08	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Arsenic	1.4E-9	mg/m^3	2.3E-11	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	9.7E-11					
				Chromium	1.8E-9	mg/m^3	7.3E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	6.2E-09					
				Cobalt	1.4E-9	mg/m^3	2.3E-11	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	2.1E-10					
				Iron	2.8E-6	mg/m^3	4.7E-08	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Lead	1.2E-8	mg/m^3	1.9E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Manganese	4.9E-8	mg/m^3	8.1E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
			Exp. Route Total								2.7E-08					
		Exposure Point Total									2.7E-08					
	Exposure Medium Total										2.7E-08					
Medium Total											1.8E-04					
										Total of Receptor Risks Across All Media	1.8E-04					

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.1.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	2.2E-07	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	4.4E-07	1.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.0E-07	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.000010
				Fluoranthene	182	mg/kg	1.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-06	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.00001
				Naphthalene	1.90	mg/kg	1.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-08	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.0000002
				Phenanthrene	117	mg/kg	9.6E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.4E-07	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.000009
				Pyrene	196	mg/kg	1.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00001
				Aluminum	13400	mg/kg	1.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.5E-05	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.00009
				Arsenic	15.1	mg/kg	1.2E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.9E-08	9.6E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Chromium	19.4	mg/kg	1.6E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	7.9E-09	1.2E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00004
				Cobalt	15.3	mg/kg	1.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	9.7E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0003
				Iron	31200	mg/kg	2.6E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0003
				Lead	130	mg/kg	1.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.3E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	4.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.5E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00002
			Exp. Route Total								4.7E-07					0.001
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	4.6E-08	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	3.4E-07	3.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	8.5E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00003
				Fluoranthene	182	mg/kg	1.6E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.2E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00003
				Naphthalene	1.90	mg/kg	1.6E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.3E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000006
				Phenanthrene	117	mg/kg	1.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.9E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00003
				Pyrene	196	mg/kg	1.7E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.3E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00004
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	3.9E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	5.9E-09	3.0E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0001
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								3.4E-07					0.0002
		Exposure Point Total									8.1E-07					0.001
	Exposure Medium Total										8.1E-07					0.001
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	9.2E-12	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.0E-11	7.2E-11	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	4.4E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-11	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	6.3E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	4.9E-11	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	1.3E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	4.5E-10	1.0E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.00003
				Phenanthrene	3.5E-4	mg/m^3	1.3E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.0E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	6.8E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.3E-11	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	4.6E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.6E-09	(mg/m^3)	5.0E-03	(mg/m^3)	0.0000007
				Arsenic	1.4E-9	mg/m^3	5.2E-13	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	2.3E-12	4.1E-12	(mg/m^3)	1.5E-05	(mg/m^3)	0.0000003
				Chromium	1.8E-9	mg/m^3	6.7E-13	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	5.7E-11	5.2E-12	(mg/m^3)	1.0E-04	(mg/m^3)	0.00000005
				Cobalt	1.4E-9	mg/m^3	5.3E-13	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	4.8E-12	4.1E-12	(mg/m^3)	6.0E-06	(mg/m^3)	0.0000007
				Iron	2.8E-6	mg/m^3	1.1E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	8.4E-09	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	4.5E-12	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.5E-11	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	1.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	1.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.000003
			Exp. Route Total								5.3E-10					0.00004
		Exposure Point Total									5.3E-10					0.00004
	Exposure Medium Total										5.3E-10					0.00004
Medium Total											8.1E-07					0.001
										Total of Receptor Risks Across All Media	8.1E-07				Total of Receptor Hazards Across All Media	0.001

TABLE 7.2.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.4E-05	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	2.9E-05	3.4E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0002
				Fluoranthene	182	mg/kg	1.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.3E-05	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.0002
				Naphthalene	1.90	mg/kg	1.7E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.4E-07	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.000004
				Phenanthrene	117	mg/kg	1.1E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.5E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0002
				Pyrene	196	mg/kg	1.8E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-05	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.0003
				Aluminum	13400	mg/kg	1.2E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-03	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.002
				Arsenic	15.1	mg/kg	1.4E-07	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	2.1E-07	1.9E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.006
				Chromium	19.4	mg/kg	1.0E-06	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	5.1E-07	2.5E-06	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0008
				Cobalt	15.3	mg/kg	1.4E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-06	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.007
				Iron	31200	mg/kg	2.8E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.0E-03	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.006
				Lead	130	mg/kg	1.2E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-05	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	5.0E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	6.9E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.0005
			Exp. Route Total								3.0E-05					0.02
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	3.2E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	2.3E-06	7.6E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.8E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00006
				Fluoranthene	182	mg/kg	1.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.6E-06	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00007
				Naphthalene	1.90	mg/kg	1.9E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-08	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.000001
				Phenanthrene	117	mg/kg	1.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00006
				Pyrene	196	mg/kg	2.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-06	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00009
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	4.6E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	7.0E-09	6.5E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.3E-06					0.0005
		Exposure Point Total									3.2E-05					0.02
	Exposure Medium Total										3.2E-05					0.02
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.9E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	2.1E-10	4.6E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	2.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	4.8E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.6E-09	6.7E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.0002
				Phenanthrene	3.5E-4	mg/m^3	4.8E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.7E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	2.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.7E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000005
				Arsenic	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	8.1E-12	2.6E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000002
				Chromium	1.8E-9	mg/m^3	1.4E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	1.2E-09	3.4E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000003
				Cobalt	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.7E-11	2.7E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000004
				Iron	2.8E-6	mg/m^3	3.9E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.4E-08	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	6.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	9.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.00002
			Exp. Route Total								3.0E-09					0.0003
		Exposure Point Total									3.0E-09					0.0003
	Exposure Medium Total										3.0E-09					0.0003
Medium Total											3.2E-05					0.02
										Total of Receptor Risks Across All Media	3.2E-05				Total of Receptor Hazards Across All Media	0.02

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.3.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	1.2E-06	(mg/kg/day)	2.0E+00	(mg/kg/day)$^{-1}$	2.5E-06	5.7E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.9E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	2.7E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00003
				Fluoranthene	182	mg/kg	2.8E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	3.9E-06	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.00003
				Naphthalene	1.90	mg/kg	2.9E-09	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	4.0E-08	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.0000007
				Phenanthrene	117	mg/kg	1.8E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	2.5E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00003
				Pyrene	196	mg/kg	3.0E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	4.2E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00005
				Aluminum	13400	mg/kg	2.0E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	2.9E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0003
				Arsenic	15.1	mg/kg	2.3E-08	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	3.4E-08	3.2E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Chromium	19.4	mg/kg	8.9E-08	(mg/kg/day)	5.0E-01	(mg/kg/day)$^{-1}$	4.4E-08	4.1E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.0001
				Cobalt	15.3	mg/kg	2.3E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	3.3E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.001
				Iron	31200	mg/kg	4.7E-05	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	6.6E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0009
				Lead	130	mg/kg	2.0E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	2.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	8.3E-07	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	1.2E-05	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00008
			Exp. Route Total								2.6E-06					0.004
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	2.8E-08	(mg/kg/day)	7.3E+00	(mg/kg/day)$^{-1}$	2.0E-07	1.3E-07	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	2.2E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	3.1E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00001
				Fluoranthene	182	mg/kg	3.2E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	4.4E-07	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.00001
				Naphthalene	1.90	mg/kg	3.3E-10	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	4.6E-09	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000002
				Phenanthrene	117	mg/kg	2.0E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	2.8E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.000009
				Pyrene	196	mg/kg	3.4E-08	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	4.8E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00002
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	7.9E-10	(mg/kg/day)	1.5E+00	(mg/kg/day)$^{-1}$	1.2E-09	1.1E-08	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.00004
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)$^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								2.0E-07					0.00008
		Exposure Point Total									2.8E-06					0.004
	Exposure Medium Total										2.8E-06					0.004
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	9.9E-11	(mg/m^3)	1.1E-03	(ug/m^3)$^{-1}$	1.1E-10	4.6E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	2.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	2.3E-11	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	3.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	4.8E-08	(mg/m^3)	3.4E-05	(ug/m^3)$^{-1}$	1.6E-09	6.7E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.0002
				Phenanthrene	3.5E-4	mg/m^3	4.8E-07	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	6.7E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	2.4E-11	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	3.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.7E-09	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	2.3E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000005
				Arsenic	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	4.3E-03	(ug/m^3)$^{-1}$	8.1E-12	2.6E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000002
				Chromium	1.8E-9	mg/m^3	7.2E-12	(mg/m^3)	8.4E-02	(ug/m^3)$^{-1}$	6.1E-10	3.4E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000003
				Cobalt	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	9.0E-03	(ug/m^3)$^{-1}$	1.7E-11	2.7E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000004
				Iron	2.8E-6	mg/m^3	3.9E-09	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	5.4E-08	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	2.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	6.8E-11	(mg/m^3)	NA	(ug/m^3)$^{-1}$	- -	9.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.00002
			Exp. Route Total								2.4E-09					0.0003
		Exposure Point Total									2.4E-09					0.0003
	Exposure Medium Total										2.4E-09					0.0003
Medium Total											2.8E-06					0.004
										Total of Receptor Risks Across All Media	2.8E-06				Total of Receptor Hazards Across All Media	0.004

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.4.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	2.6E-07	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	5.3E-07	3.6E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.2E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.7E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00002
				Fluoranthene	182	mg/kg	1.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.5E-06	(mg/kg/day)	1.1E-01	(mg/kg/day)	0.00002
				Naphthalene	1.90	mg/kg	1.9E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.6E-08	(mg/kg/day)	5.6E-02	(mg/kg/day)	0.0000005
				Phenanthrene	117	mg/kg	1.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.6E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00002
				Pyrene	196	mg/kg	1.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.7E-06	(mg/kg/day)	8.3E-02	(mg/kg/day)	0.00003
				Aluminum	13400	mg/kg	1.3E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.8E-04	(mg/kg/day)	1.0E+00	(mg/kg/day)	0.0002
				Arsenic	15.1	mg/kg	1.5E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	2.2E-08	2.1E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0007
				Chromium	19.4	mg/kg	1.9E-08	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	9.5E-09	2.7E-07	(mg/kg/day)	3.0E-03	(mg/kg/day)	0.00009
				Cobalt	15.3	mg/kg	1.5E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.1E-07	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.0007
				Iron	31200	mg/kg	3.1E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	4.3E-04	(mg/kg/day)	7.0E-01	(mg/kg/day)	0.0006
				Lead	130	mg/kg	1.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.8E-06	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	5.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	7.4E-06	(mg/kg/day)	1.4E-01	(mg/kg/day)	0.00005
			Exp. Route Total								5.6E-07					0.002
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	5.9E-09	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	4.3E-08	8.3E-08	(mg/kg/day)	NA	(mg/kg/day)	--
				Benzo(g,h,i)perylene	126	mg/kg	1.4E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.0E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.000007
				Fluoranthene	182	mg/kg	2.0E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	2.8E-07	(mg/kg/day)	4.0E-02	(mg/kg/day)	0.000007
				Naphthalene	1.90	mg/kg	2.1E-10	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.0E-09	(mg/kg/day)	2.0E-02	(mg/kg/day)	0.0000001
				Phenanthrene	117	mg/kg	1.3E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	1.8E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.000006
				Pyrene	196	mg/kg	2.2E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	3.1E-07	(mg/kg/day)	3.0E-02	(mg/kg/day)	0.00001
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	1.0E+00	(mg/kg/day)	--
				Arsenic	15.1	mg/kg	5.1E-10	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	7.6E-10	7.1E-09	(mg/kg/day)	3.0E-04	(mg/kg/day)	0.00002
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.5E-05	(mg/kg/day)	--
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	3.0E-04	(mg/kg/day)	--
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	7.0E-01	(mg/kg/day)	--
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	NA	(mg/kg/day)	--
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -	0.0E+00	(mg/kg/day)	5.6E-03	(mg/kg/day)	--
			Exp. Route Total								4.4E-08					0.00005
		Exposure Point Total									6.1E-07					0.002
	Exposure Medium Total										6.1E-07					0.002
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	3.3E-11	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	3.6E-11	4.6E-10	(mg/m^3)	NA	(mg/m^3)	--
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Fluoranthene	1.7E-8	mg/m^3	2.3E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.2E-10	(mg/m^3)	NA	(mg/m^3)	--
				Naphthalene	3.5E-5	mg/m^3	4.8E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	1.6E-09	6.7E-07	(mg/m^3)	3.0E-03	(mg/m^3)	0.0002
				Phenanthrene	3.5E-4	mg/m^3	4.8E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	6.7E-06	(mg/m^3)	NA	(mg/m^3)	--
				Pyrene	1.8E-8	mg/m^3	2.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	3.4E-10	(mg/m^3)	NA	(mg/m^3)	--
				Aluminum	1.2E-6	mg/m^3	1.7E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-08	(mg/m^3)	5.0E-03	(mg/m^3)	0.000005
				Arsenic	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	8.1E-12	2.6E-11	(mg/m^3)	1.5E-05	(mg/m^3)	0.000002
				Chromium	1.8E-9	mg/m^3	2.4E-12	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	2.0E-10	3.4E-11	(mg/m^3)	1.0E-04	(mg/m^3)	0.0000003
				Cobalt	1.4E-9	mg/m^3	1.9E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	1.7E-11	2.7E-11	(mg/m^3)	6.0E-06	(mg/m^3)	0.000004
				Iron	2.8E-6	mg/m^3	3.9E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	5.4E-08	(mg/m^3)	NA	(mg/m^3)	--
				Lead	1.2E-8	mg/m^3	1.6E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	2.3E-10	(mg/m^3)	NA	(mg/m^3)	--
				Manganese	4.9E-8	mg/m^3	6.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -	9.5E-10	(mg/m^3)	5.0E-05	(mg/m^3)	0.00002
			Exp. Route Total								1.9E-09					0.0003
		Exposure Point Total									1.9E-09					0.0003
	Exposure Medium Total										1.9E-09					0.0003
Medium Total											6.1E-07					0.003
										Total of Receptor Risks Across All Media	6.1E-07				Total of Receptor Hazards Across All Media	0.003

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 7.5.CTE
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS - RELATIVE ABSORPTION FACTORS
CENTRAL TENDENCY EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Soil	Surface Soil	MRP Site 1	Ingestion	Benzo(a)pyrene Equivalents	266	mg/kg	6.9E-06	(mg/kg/day)	2.0E+00	$(mg/kg/day)^{-1}$	1.4E-05					
				Benzo(g,h,i)perylene	126	mg/kg	6.3E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	9.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	9.5E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	5.9E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	9.8E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	6.7E-05	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	7.6E-08	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	1.1E-07					
				Chromium	19.4	mg/kg	5.0E-07	(mg/kg/day)	5.0E-01	$(mg/kg/day)^{-1}$	2.5E-07					
				Cobalt	15.3	mg/kg	7.7E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	1.6E-04	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	6.5E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	2.7E-06	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								1.4E-05					
			Dermal	Benzo(a)pyrene Equivalents	266	mg/kg	1.5E-07	(mg/kg/day)	7.3E+00	$(mg/kg/day)^{-1}$	1.1E-06					
				Benzo(g,h,i)perylene	126	mg/kg	7.1E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Fluoranthene	182	mg/kg	1.0E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Naphthalene	1.90	mg/kg	1.1E-09	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Phenanthrene	117	mg/kg	6.6E-08	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Pyrene	196	mg/kg	1.1E-07	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Aluminum	13400	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Arsenic	15.1	mg/kg	2.6E-09	(mg/kg/day)	1.5E+00	$(mg/kg/day)^{-1}$	3.8E-09					
				Chromium	19.4	mg/kg	0.0E+00	(mg/kg/day)	2.0E+01	$(mg/kg/day)^{-1}$	- -					
				Cobalt	15.3	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Iron	31200	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Lead	130	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
				Manganese	543	mg/kg	0.0E+00	(mg/kg/day)	NA	$(mg/kg/day)^{-1}$	- -					
			Exp. Route Total								1.1E-06					
		Exposure Point Total									1.6E-05					
	Exposure Medium Total										1.6E-05					
	Air	MRP Site 1	Inhalation	Benzo(a)pyrene Equivalents	2.4E-8	mg/m^3	1.6E-10	(mg/m^3)	1.1E-03	$(ug/m^3)^{-1}$	1.7E-10					
				Benzo(g,h,i)perylene	1.1E-8	mg/m^3	2.8E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Fluoranthene	1.7E-8	mg/m^3	4.1E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Naphthalene	3.5E-5	mg/m^3	8.6E-08	(mg/m^3)	3.4E-05	$(ug/m^3)^{-1}$	2.9E-09					
				Phenanthrene	3.5E-4	mg/m^3	8.6E-07	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Pyrene	1.8E-8	mg/m^3	4.4E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Aluminum	1.2E-6	mg/m^3	3.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Arsenic	1.4E-9	mg/m^3	3.4E-12	(mg/m^3)	4.3E-03	$(ug/m^3)^{-1}$	1.5E-11					
				Chromium	1.8E-9	mg/m^3	1.2E-11	(mg/m^3)	8.4E-02	$(ug/m^3)^{-1}$	9.7E-10					
				Cobalt	1.4E-9	mg/m^3	3.4E-12	(mg/m^3)	9.0E-03	$(ug/m^3)^{-1}$	3.1E-11					
				Iron	2.8E-6	mg/m^3	7.0E-09	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Lead	1.2E-8	mg/m^3	2.9E-11	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
				Manganese	4.9E-8	mg/m^3	1.2E-10	(mg/m^3)	NA	$(ug/m^3)^{-1}$	- -					
			Exp. Route Total								4.1E-09					
		Exposure Point Total									4.1E-09					
	Exposure Medium Total										4.1E-09					
Medium Total											1.6E-05					
										Total of Receptor Risks Across All Media	1.6E-05					

Notes:
1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

LIST OF TABLES
RAGS PART D TABLE 9
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

Table No.

REASONABLE MAXIMUM EXPOSURES - RELATIVE ABSORPTION FACTORS

9.1.RME Workers
9.2.RME Child Recreational Users
9.3.RME Older Child Recreational Users
9.4.RME Adult Recreational Users
9.5.RME Lifelong Recreational Users

CENTRAL TENDENCY EXPOSURES - RELATIVE ABSORPTION FACTORS

9.1.CTE Workers
9.2.CTE Child Recreational Users
9.3.CTE Older Child Recreational Users
9.4.CTE Adult Recreational Users
9.5.CTE Lifelong Recreational Users

TABLE 9.1.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

REASONABLE MAXIMUM EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	2E-06	--	1E-06	--	4E-06	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00002	- -	0.00004	0.00005
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00002	- -	0.00004	0.00006
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.0000004	- -	0.0000008	0.000001
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00002	- -	0.00003	0.00005
			Pyrene	- -	--	- -	--	- -	Kidney	0.00003	- -	0.00005	0.00008
			Aluminum	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Arsenic	1E-07	--	2E-08	--	1E-07	Skin, CVS	0.0006	- -	0.0001	0.0008
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.00008	- -	--	0.00008
			Cobalt	- -	--	- -	--	- -	Blood	0.0006	- -	--	0.0006
			Iron	- -	--	- -	--	- -	GS	0.0006	- -	--	0.0006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00005	- -	--	0.00005
			Chemical Total	3E-06	--	1E-06	--	4E-06		0.002	--	0.0003	0.003
		Exposure Point Total						4E-06					0.003
	Exposure Medium Total							4E-06					0.003
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	3E-11	--	--	3E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	1E-09	--	--	1E-09	Nasal	- -	0.00003	- -	0.00003
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.0000007	- -	0.0000007
			Arsenic	--	6E-12	--	--	6E-12	NA	- -	0.0000003	- -	0.0000003
			Chromium	--	2E-10	--	--	2E-10	NA	- -	0.00000005	- -	0.00000005
			Cobalt	--	1E-11	--	--	1E-11	Lungs	- -	0.0000007	- -	0.0000007
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.000003	- -	0.000003
			Chemical Total	--	1E-09	--	--	1E-09		- -	0.00004	- -	0.00004
		Exposure Point Total						1E-09					0.00004
	Exposure Medium Total							1E-09					0.00004
Medium Total								4E-06					0.003
Receptor Total							Receptor Risk Total	4E-06				Receptor HI Total	0.003

TABLE 9.2.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

REASONABLE MAXIMUM EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	1E-04	--	2E-05	--	1E-04	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0008	- -	0.0006	0.001
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0008	- -	0.0007	0.001
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.00002	- -	0.00001	0.00003
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0007	- -	0.0006	0.001
			Pyrene	- -	--	- -	--	- -	Kidney	0.001	- -	0.0009	0.002
			Aluminum	- -	--	- -	--	- -	CNS	0.007	- -	--	0.007
			Arsenic	8E-07	--	7E-08	--	9E-07	Skin, CVS	0.03	- -	0.002	0.03
			Chromium	2E-06	--	- -	--	2E-06	Fetotoxicity, GS, Bone	0.003	- -	--	0.003
			Cobalt	- -	--	- -	--	- -	Blood	0.03	- -	--	0.03
			Iron	- -	--	- -	--	- -	GS	0.02	- -	--	0.02
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.002	- -	--	0.002
			Chemical Total	1E-04	--	2E-05	--	1E-04		0.09	--	0.005	0.10
		Exposure Point Total						1E-04					0.10
	Exposure Medium Total							1E-04					0.10
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	4E-10	--	--	4E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	2E-09	--	--	2E-09	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	6E-09	--	--	6E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						6E-09					0.0005
	Exposure Medium Total							6E-09					0.0005
Medium Total								1E-04					0.10
Receptor Total							Receptor Risk Total	1E-04				Receptor HI Total	0.10

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.3.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

REASONABLE MAXIMUM EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	1E-05	--	3E-06	--	1E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0001	- -	0.0001	0.0003
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0001	- -	0.0002	0.0003
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000003	- -	0.000003	0.000006
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0001	- -	0.0001	0.0003
			Pyrene	- -	--	- -	--	- -	Kidney	0.0002	- -	0.0002	0.0004
			Aluminum	- -	--	- -	--	- -	CNS	0.001	- -	--	0.001
			Arsenic	1E-07	--	2E-08	--	2E-07	Skin, CVS	0.004	- -	0.0005	0.005
			Chromium	2E-07	--	- -	--	2E-07	Fetotoxicity, GS, Bone	0.0006	- -	--	0.0006
			Cobalt	- -	--	- -	--	- -	Blood	0.004	- -	--	0.004
			Iron	- -	--	- -	--	- -	GS	0.004	- -	--	0.004
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0003	- -	--	0.0003
			Chemical Total	1E-05	--	3E-06	--	1E-05		0.02	--	0.001	0.02
		Exposure Point Total						1E-05					0.02
	Exposure Medium Total							1E-05					0.02
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	1E-09	--	--	1E-09	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	5E-09	--	--	5E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						5E-09					0.0005
	Exposure Medium Total							5E-09					0.0005
Medium Total								1E-05					0.02
Receptor Total							Receptor Risk Total	1E-05				Receptor HI Total	0.02

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.4.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

REASONABLE MAXIMUM EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	2E-06	--	6E-07	--	3E-06	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00008	- -	0.00009	0.0002
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00009	- -	0.00010	0.0002
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000002	- -	0.000002	0.000004
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00008	- -	0.00009	0.0002
			Pyrene	- -	--	- -	--	- -	Kidney	0.0001	- -	0.0001	0.0003
			Aluminum	- -	--	- -	--	- -	CNS	0.0007	- -	--	0.0007
			Arsenic	9E-08	--	1E-08	--	1E-07	Skin, CVS	0.003	- -	0.0003	0.003
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.0004	- -	--	0.0004
			Cobalt	- -	--	- -	--	- -	Blood	0.003	- -	--	0.003
			Iron	- -	--	- -	--	- -	GS	0.002	- -	--	0.002
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Chemical Total	2E-06	--	6E-07	--	3E-06		0.010	--	0.0008	0.01
		Exposure Point Total						3E-06					0.01
	Exposure Medium Total							3E-06					0.01
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	7E-11	--	--	7E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	3E-09	--	--	3E-09	Nasal	- -	0.0004	- -	0.0004
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000009	- -	0.000009
			Arsenic	--	2E-11	--	--	2E-11	NA	- -	0.000004	- -	0.000004
			Chromium	--	4E-10	--	--	4E-10	NA	- -	0.0000007	- -	0.0000007
			Cobalt	--	3E-11	--	--	3E-11	Lungs	- -	0.000009	- -	0.000009
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00004	- -	0.00004
			Chemical Total	--	4E-09	--	--	4E-09		- -	0.0005	- -	0.0005
		Exposure Point Total						4E-09					0.0005
	Exposure Medium Total							4E-09					0.0005
Medium Total								3E-06					0.01
Receptor Total							Receptor Risk Total	3E-06				Receptor HI Total	0.01

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.5.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS
REASONABLE MAXIMUM EXPOSURES
CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	1E-04	--	3E-05	--	2E-04					
			Benzo(g,h,i)perylene	- -	--	- -	--	- -					
			Fluoranthene	- -	--	- -	--	- -					
			Naphthalene	- -	--	- -	--	- -					
			Phenanthrene	- -	--	- -	--	- -					
			Pyrene	- -	--	- -	--	- -					
			Aluminum	- -	--	- -	--	- -					
			Arsenic	1E-06	--	1E-07	--	2E-06					
			Chromium	3E-06	--	- -	--	3E-06					
			Cobalt	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Chemical Total	1E-04	--	3E-05	--	2E-04					
		Exposure Point Total						2E-04					
	Exposure Medium Total							2E-04					
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-09	--	--	1E-09					
			Benzo(g,h,i)perylene	--	- -	--	--	- -					
			Fluoranthene	--	- -	--	--	- -					
			Naphthalene	--	2E-08	--	--	2E-08					
			Phenanthrene	--	- -	--	--	- -					
			Pyrene	--	- -	--	--	- -					
			Aluminum	--	- -	--	--	- -					
			Arsenic	--	1E-10	--	--	1E-10					
			Chromium	--	6E-09	--	--	6E-09					
			Cobalt	--	2E-10	--	--	2E-10					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Chemical Total	--	3E-08	--	--	3E-08					
		Exposure Point Total						3E-08					
	Exposure Medium Total							3E-08					
Medium Total								2E-04					
Receptor Total							Receptor Risk Total	2E-04					

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.1.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Workers
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	4E-07	--	3E-07	--	8E-07	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.000010	- -	0.00003	0.00004
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00001	- -	0.00003	0.00004
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.0000002	- -	0.0000006	0.0000009
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.000009	- -	0.00003	0.00004
			Pyrene	- -	--	- -	--	- -	Kidney	0.00001	- -	0.00004	0.00006
			Aluminum	- -	--	- -	--	- -	CNS	0.00009	- -	--	0.00009
			Arsenic	2E-08	--	6E-09	--	2E-08	Skin, CVS	0.0003	- -	0.0001	0.0004
			Chromium	8E-09	--	- -	--	8E-09	Fetotoxicity, GS, Bone	0.00004	- -	--	0.00004
			Cobalt	- -	--	- -	--	- -	Blood	0.0003	- -	--	0.0003
			Iron	- -	--	- -	--	- -	GS	0.0003	- -	--	0.0003
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00002	- -	--	0.00002
			Chemical Total	5E-07	--	3E-07	--	8E-07		0.001	--	0.0002	0.001
		Exposure Point Total						8E-07					0.001
	Exposure Medium Total							8E-07					0.001
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-11	--	--	1E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	5E-10	--	--	5E-10	Nasal	- -	0.00003	- -	0.00003
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.0000007	- -	0.0000007
			Arsenic	--	2E-12	--	--	2E-12	NA	- -	0.0000003	- -	0.0000003
			Chromium	--	6E-11	--	--	6E-11	NA	- -	0.00000005	- -	0.00000005
			Cobalt	--	5E-12	--	--	5E-12	Lungs	- -	0.0000007	- -	0.0000007
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.000003	- -	0.000003
			Chemical Total	--	5E-10	--	--	5E-10		- -	0.00004	- -	0.00004
		Exposure Point Total						5E-10					0.00004
	Exposure Medium Total							5E-10					0.00004
Medium Total								8E-07					0.001
Receptor Total							Receptor Risk Total	8E-07				Receptor HI Total	0.001

TABLE 9.2.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	3E-05	--	2E-06	--	3E-05	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.0002	- -	0.00006	0.0003
			Fluoranthene	- -	--	- -	--	- -	Liver	0.0002	- -	0.00007	0.0003
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.000004	- -	0.000001	0.000006
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.0002	- -	0.00006	0.0002
			Pyrene	- -	--	- -	--	- -	Kidney	0.0003	- -	0.00009	0.0004
			Aluminum	- -	--	- -	--	- -	CNS	0.002	- -	--	0.002
			Arsenic	2E-07	--	7E-09	--	2E-07	Skin, CVS	0.006	- -	0.0002	0.007
			Chromium	5E-07	--	- -	--	5E-07	Fetotoxicity, GS, Bone	0.0008	- -	--	0.0008
			Cobalt	- -	--	- -	--	- -	Blood	0.007	- -	--	0.007
			Iron	- -	--	- -	--	- -	GS	0.006	- -	--	0.006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.0005	- -	--	0.0005
			Chemical Total	3E-05	--	2E-06	--	3E-05		0.02	--	0.0005	0.02
		Exposure Point Total						3E-05					0.02
	Exposure Medium Total							3E-05					0.02
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	1E-09	--	--	1E-09	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	3E-09	--	--	3E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						3E-09					0.0003
	Exposure Medium Total							3E-09					0.0003
Medium Total								3E-05					0.02
Receptor Total							Receptor Risk Total	3E-05				Receptor HI Total	0.02

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Older Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	2E-06	--	2E-07	--	3E-06	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00003	- -	0.00001	0.00004
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00003	- -	0.00001	0.00005
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.0000007	- -	0.0000002	0.0000010
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00003	- -	0.000009	0.00004
			Pyrene	- -	--	- -	--	- -	Kidney	0.00005	- -	0.00002	0.00007
			Aluminum	- -	--	- -	--	- -	CNS	0.0003	- -	--	0.0003
			Arsenic	3E-08	--	1E-09	--	4E-08	Skin, CVS	0.001	- -	0.00004	0.001
			Chromium	4E-08	--	- -	--	4E-08	Fetotoxicity, GS, Bone	0.0001	- -	--	0.0001
			Cobalt	- -	--	- -	--	- -	Blood	0.001	- -	--	0.001
			Iron	- -	--	- -	--	- -	GS	0.0009	- -	--	0.0009
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00008	- -	--	0.00008
			Chemical Total	3E-06	--	2E-07	--	3E-06		0.004	--	0.00008	0.004
		Exposure Point Total						3E-06					0.004
	Exposure Medium Total							3E-06					0.004
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	1E-10	--	--	1E-10	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	6E-10	--	--	6E-10	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	2E-09	--	--	2E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						2E-09					0.0003
	Exposure Medium Total							2E-09					0.0003
Medium Total								3E-06					0.004
Receptor Total							Receptor Risk Total	3E-06				Receptor HI Total	0.004

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.4.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Recreational Users
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	5E-07	--	4E-08	--	6E-07	NA	--	- -	--	--
			Benzo(g,h,i)perylene	- -	--	- -	--	- -	Liver	0.00002	- -	0.000007	0.00003
			Fluoranthene	- -	--	- -	--	- -	Liver	0.00002	- -	0.000007	0.00003
			Naphthalene	- -	--	- -	--	- -	Body Weight	0.0000005	- -	0.0000001	0.0000006
			Phenanthrene	- -	--	- -	--	- -	Kidney	0.00002	- -	0.000006	0.00003
			Pyrene	- -	--	- -	--	- -	Kidney	0.00003	- -	0.00001	0.00004
			Aluminum	- -	--	- -	--	- -	CNS	0.0002	- -	--	0.0002
			Arsenic	2E-08	--	8E-10	--	2E-08	Skin, CVS	0.0007	- -	0.00002	0.0007
			Chromium	9E-09	--	- -	--	9E-09	Fetotoxicity, GS, Bone	0.00009	- -	--	0.00009
			Cobalt	- -	--	- -	--	- -	Blood	0.0007	- -	--	0.0007
			Iron	- -	--	- -	--	- -	GS	0.0006	- -	--	0.0006
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.00005	- -	--	0.00005
			Chemical Total	6E-07	--	4E-08	--	6E-07		0.002	--	0.00005	0.002
		Exposure Point Total						6E-07					0.002
	Exposure Medium Total							6E-07					0.002
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	4E-11	--	--	4E-11	NA	- -	--	- -	--
			Benzo(g,h,i)perylene	--	- -	--	--	- -	NA	- -	--	- -	--
			Fluoranthene	--	- -	--	--	- -	NA	- -	--	- -	--
			Naphthalene	--	2E-09	--	--	2E-09	Nasal	- -	0.0002	- -	0.0002
			Phenanthrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Pyrene	--	- -	--	--	- -	NA	- -	--	- -	--
			Aluminum	--	- -	--	--	- -	CNS	- -	0.000005	- -	0.000005
			Arsenic	--	8E-12	--	--	8E-12	NA	- -	0.000002	- -	0.000002
			Chromium	--	2E-10	--	--	2E-10	NA	- -	0.0000003	- -	0.0000003
			Cobalt	--	2E-11	--	--	2E-11	Lungs	- -	0.000004	- -	0.000004
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	0.00002	- -	0.00002
			Chemical Total	--	2E-09	--	--	2E-09		- -	0.0003	- -	0.0003
		Exposure Point Total						2E-09					0.0003
	Exposure Medium Total							2E-09					0.0003
Medium Total								6E-07					0.003
Receptor Total							Receptor Risk Total	6E-07				Receptor HI Total	0.003

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

TABLE 9.5.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - RELATIVE ABSORPTION FACTORS

CENTRAL TENDENCY EXPOSURES

CARR POINT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Current
Receptor Population: Lifelong Recreational User
Receptor Age: Lifelong

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	MRP Site 1	Benzo(a)pyrene Equivalents	1E-05	--	1E-06	--	2E-05					
			Benzo(g,h,i)perylene	- -	--	- -	--	- -					
			Fluoranthene	- -	--	- -	--	- -					
			Naphthalene	- -	--	- -	--	- -					
			Phenanthrene	- -	--	- -	--	- -					
			Pyrene	- -	--	- -	--	- -					
			Aluminum	- -	--	- -	--	- -					
			Arsenic	1E-07	--	4E-09	--	1E-07					
			Chromium	3E-07	--	- -	--	3E-07					
			Cobalt	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Chemical Total	1E-05	--	1E-06	--	2E-05					
		Exposure Point Total						2E-05					
	Exposure Medium Total							2E-05					
	Air	MRP Site 1	Benzo(a)pyrene Equivalents	--	2E-10	--	--	2E-10					
			Benzo(g,h,i)perylene	--	- -	--	--	- -					
			Fluoranthene	--	- -	--	--	- -					
			Naphthalene	--	3E-09	--	--	3E-09					
			Phenanthrene	--	- -	--	--	- -					
			Pyrene	--	- -	--	--	- -					
			Aluminum	--	- -	--	--	- -					
			Arsenic	--	1E-11	--	--	1E-11					
			Chromium	--	1E-09	--	--	1E-09					
			Cobalt	--	3E-11	--	--	3E-11					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Chemical Total	--	4E-09	--	--	4E-09					
		Exposure Point Total						4E-09					
	Exposure Medium Total							4E-09					
Medium Total								2E-05					
Receptor Total							Receptor Risk Total	2E-05					

Notes:

1 - Mutagenic chemicals were evaluated in accordance with USEPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (2005).

Attachment C

FINAL

RECORD OF DECISION

SKEET RANGE ALAMEDA POINT, ALAMEDA, CALIFORNIA

Contract No. N47408-01-D-8207
Project No.: G486085

Prepared for:

SOUTHWEST DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
1220 Pacific Highway
San Diego, CA 92132

Prepared by:

BATTELLE
397 Washington St.
Duxbury, MA 02332

September 19, 2005

5090
BPMOW.CD\1226
September 19, 2005

Copy to

Ms. Anna-Marie Cook
U.S. EPA
Region IX
75 Hawthorne Street, (SFD-8-3)
San Francisco, CA 94105-3901

Ms. Marcia Liao
Department of Toxic Substances Control
700 Heinz Avenue, Suite 200
Berkeley, CA 94710

Ms. Judy Huang
Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 94612

Ms. Suzette Leith
US EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Ms. Debbie Potter
ARRA
950 Mall Square, Bldg 1
Alameda Point, CA 94501

Mr. Peter Russell
Russell Resources Inc
440 Nova Albion Way, Suite 1
San Rafael, CA 94903

Ms. Jean Sweeney
RAB Co-Chair
212 Santa Clara Drive
Alameda, CA 94501

Mr. Saul Bloom
Arc Ecology
4634 Third Street
San Francisco, CA 94124

Mr. Charlie Huang
Cal EPA/Dept. of Fish and Game
1700 K St., Rm 250
PO Box 944209
Sacrament, CA 94244

Ms. Laurie Sullivan
NOAA
c/o USEPA
75 Hawthorne St, (H-1-2)
San Francisco, CA 94105

Mr. Craig Hunter
Tetra Tech EMI
10860 Gold Center Drive, Suite 200
Rancho Cordova, CA 95610

DEPARTMENT OF THE NAVY
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
1224 COLUMBIA STREET, SUITE 1100
SAN DIEGO, CA 92101-8571

5090
BPMOW.CD\1226
September 19, 2005

Mr. Mark Ripperda
U.S. EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Dear Mr. Ripperda:

Subj: FINAL RECORD OF DECISION SKEET RANGE (IR SITE 29) ALAMEDA POINT, CALIFORNIA

This letter transmits the Final Record of Decision (ROD) for Skeet Range Alameda Point, California, The draft ROD was distributed to the agencies on April 18, 2005. The Skeet Range (IR Site 29) was determined by the Department of the Navy to require no further action for sediments that might have been affected by site-specific use. The Navy subsequently received concurrence on the Draft ROD for no further action from U.S. EPA, the San Francisco Regional Water Quality Control Board (RWQCB), the Department of Toxic Substances Control (DTSC).

Concurrent with the submittal of this ROD, a signatory page (page vii) is being forwarded for signatures to the EPA, RWQCB, and OTSC. Upon receipt of the signature page, the Navy will submit a replacement signatory page to the recipients of the ROD.

If you have any questions or comments, please call Ms. Claudia Domingo at (619) 532-0935 or me at (619) 532-0907.

Sincerely,

THOMAS L. MACCHIARELLA
BRAC Environmental Coordinator
By direction of the Director

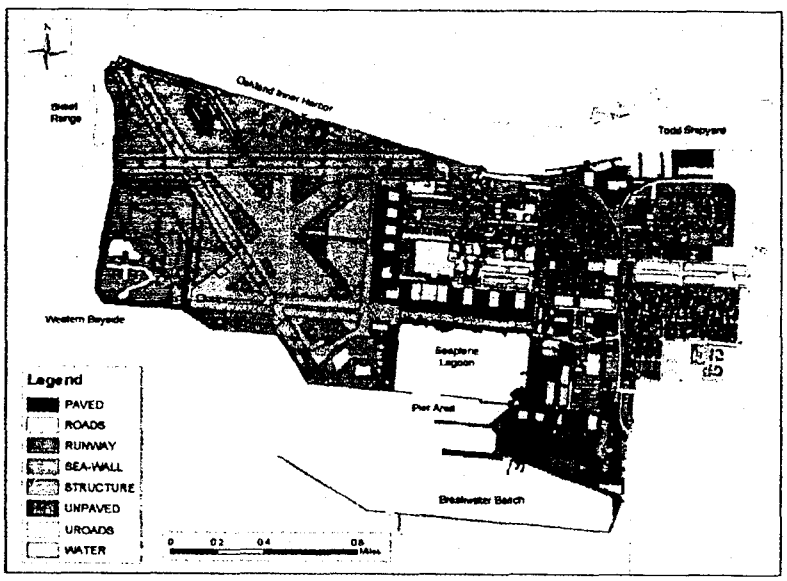
Encl: (1) Final Record of Decision Skeet Range Alameda Point, California

SFUND RECORDS CTR
2092251

FINAL

Record of Decision
Skeet Range

Alameda Point, Alameda, California



Prepared for:

SOUTHWEST DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
1220 Pacific Highway
San Diego, CA 92132

NAVFAC

Prepared by:

Battelle

The Business of Innovation

397 Washington St.
Duxbury, MA 02332

Contract No. N47408-01-D-8207
Project No.: G486085

September 2005

POOR LEGIBILITY

ONE OR MORE PAGES IN THIS DOCUMENT ARE DIFFICULT TO READ DUE TO THE QUALITY OF THE ORIGINAL

EPA/ROD/R09-05/058
2005

EPA Superfund
Record of Decision:

ALAMEDA NAVAL AIR STATION
EPA ID: CA2170023236
OU 10
ALAMEDA, CA
09/21/2005

TABLE OF CONTENTS

DECLARATION		v
1.0	SITE NAME, LOCATION, AND DESCRIPTION	1
	1.1 Site Name	1
	1.2 Site Location and Description	1
	1.3 Lead and Support Agencies	1
2.0	SITE HISTORY AND INVESTIGATION ACTIVITIES	5
3.0	HIGHLIGHTS OF COMMUNITY PARTICIPATION	11
4.0	SCOPE AND ROLE OF RESPONSE ACTION	13
5.0	SITE CHARACTERISTICS	17
	5.1 Site Overview	17
	5.2 Nature and Extent of Contamination	17
6.0	CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES	19
7.0	SUMMARY OF SITE RISKS	21
	7.1 Ecological Risk Assessment	22
	7.2 Evaluation of Potential Human Health Risks	23
8.0	DESCRIPTION OF NO ACTION ALTERNATIVE	25
9.0	DOCUMENTATION OF SIGNIFICANT CHANGES	27
10.0	RESPONSIVENESS SUMMARY	29
11.0	REFERENCES	35

TABLE

Table 1. Summary of Comments Received and Responses 30

FIGURES

Figure 1. Site Map of Alameda Point 2
Figure 2. Alameda Point Site Location Map 3
Figure 3. Sampling Stations from Collection Efforts in 1996 6
Figure 4. Sampling Stations from Collection Efforts in 1998 7
Figure 5. Site Map 15
Figure 6. Ecological Site Conceptual Exposure Model 22

ATTACHMENTS

Attachment A	Site Specific Administrative Record Index
Attachment B	Agency Agreement Letters
Attachment C	Transcript of Public Meeting and Comments Received on the Proposed Plan
Attachment D	List of Attendees, Proposed Plan Public Meeting, March 7, 2005
Attachment E	Public Notices

ABBREVIATIONS AND ACRONYMS

ARAR	applicable or relevant and appropriate requirements
ARRA	Alameda Reuse and Redevelopment Authority
AWQC	ambient water quality criteria
BERA	baseline ecological risk assessment
BRAC	Base Realignment and Closure Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Act Information System
cm	centimeter
cm/yr	centimeters per year
CNO	Chief of Naval Operations
COPC	chemicals of potential concern
CSM	conceptual site model
DON	United States Department of the Navy
DTSC	Department of Toxic Substances Control
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ER-L	effects range-low
ER-M	effects range-median
FFA	Federal Facilities Agreement
FS	feasibility study
ft	feet
FWS	United States Department of the Interior Fish and Wildlife Service
HPAH	high molecular-weight PAH
ID	identification
IR	installation restoration
LPAH	low molecular-weight PAH
m	meter
MLLW	mean lower low water
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contigency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCA	principal component analysis
PRC	PRC Environmental Management, Inc.
RAB	Restoration Advisory Board
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RI	remedial investigation

RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
TPH	total petroleum hydrocarbons
TtEMI	Tetra Tech EM, Inc.
USACE	United States Army Corps of Engineers
UTL	upper tolerance limit

DECLARATION

SITE NAME AND LOCATION

This decision document addresses the former Skeet Range (Installation Restoration [IR] Site 29) at the former Naval Air Station (NAS), now referred to as Alameda Point, in Alameda, California. The U.S. Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS) identification (ID) number is CA2170023236.

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedy, no further action, for the former Skeet Range (IR Site 29), in Alameda, California.

This document was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by Superfund Amendments and Reauthorization Act (SARA) of 1986 (Title 42 United States Code Section 9601, et seq.), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 Code of Federal Regulations Part 300).

This decision is based on information contained in the administrative record file (a site-specific administrative record index is included as Attachment A) as well as on extensive field investigations, laboratory analyses, interpretation of the data, review of current and future conditions, and thorough assessment of the potential human health and ecological risks. Based on these findings, there are no land use restrictions, environmental monitoring, or Resource and Recovery Act (RCRA) corrective action required at the site.

The U.S. Department of the Navy (DON), the San Francisco Regional Water Quality Control Board (RWQCB), the state of California Environmental Protection Agency, Department of Toxic Substances Control (DTSC), and the U.S. EPA concur on the selected remedy for this site. Agreement letters from the U.S. EPA, DTSC and the RWQCB are included as Attachment B.

ASSESSMENT OF THE SITE

The DON has concluded that remedial action is not required to protect public health or the environment on the basis of the following:

- site histories;
- field investigations;
- laboratory analytical results;
- evaluation of potential ecological and human health risks;
- current and reasonable anticipated future land use.

Results of investigations at the Skeet Range (IR Site 29) have verified that current and reasonably anticipated future land uses at the site do not pose a risk to human health or the environment. The human health risk assessment indicated that there are no complete pathways in which humans would be exposed to site-related contaminants of concern. Similarly, the ecological risk assessment concluded that there are no unacceptable ecological risks associated

with the sediments offshore of the former Skeet Range and that the ecological community is not impacted.

STATUTORY DETERMINATIONS

The DON has concluded that no remedial action is necessary at the site because the current and reasonably anticipated future land use and likely future use of the site is protective of human health and the environment and complies with federal and state requirements. A five-year status review will not be required because: 1) this remedy will not result in hazardous substances, pollutants, or contaminants remaining on-site at levels above those that allow for unlimited use and unrestricted exposure, and 2) as a result, a remedial action was not necessary or selected in this ROD.

1.0 SITE NAME, LOCATION, AND DESCRIPTION

This Record of Decision (ROD) presents the determination by the Department of the Navy (DON) that no remedial action is necessary at the former Skeet Range (Installation Restoration [IR] Site 29) at the former Naval Air Station (NAS), now referred to as Alameda Point, in Alameda, California. This ROD satisfies the Department of Toxic Substances Control (DTSC) requirements for a Remedial Action Plan (RAP) for hazardous substance release sites pursuant to California Health and Safety Code Section (() 25356.1.

This document was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by Superfund Amendments and Reauthorization Act (SARA) of 1986 (Title 42 *United States Code* Section [§] 9602 *et seq.*), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 *Code of Federal Regulations* § 300 *et seq.*). The decision for this site is based on information contained in the administrative record file (a site-specific administrative record index is included as Attachment A) as well as on extensive field investigations, laboratory analyses, interpretation of the data, review of current and anticipated future conditions, and thorough assessment of the potential human health and ecological risks. Based on these findings, there are also no land use restrictions, environmental monitoring, or Resource and Recovery Act (RCRA) corrective action required at the site.

1.1 Site Name

This decision document addresses the former Skeet Range (IR Site 29) at the former NAS, now referred to as Alameda Point, in Alameda, California.

1.2 Site Location and Description

The former Skeet Range (IR Site 29) is located on the northwestern corner of the former NAS (see Figure 1), now referred to as Alameda Point, in Alameda, California. The Skeet Range (IR Site 29) extends offshore into the San Francisco Bay with dimensions of about 1,300 feet (ft) by 800 ft. The primary site-related contaminants (lead shot and polycyclic aromatic hydrocarbons [PAHs] from the clay targets) are located approximately 80 ft offshore, in water depths averaging 5 ft or greater. Figure 2 depicts Alameda Point in relation to San Francisco Bay.

1.3 Lead and Support Agencies

Since 1993, the Alameda Point Base Realignment and Closure (BRAC) Cleanup Team (BCT) has coordinated cleanup and closure activities for Alameda Point to support the transfer and redevelopment of the offshore property by the Alameda Reuse and Redevelopment Authority (ARRA). The BCT consists of representatives from the Navy, U.S. EPA Region 9, DTSC, and California Regional Water Quality Control Board (RWQCB). The DON is the lead agency for environmental restoration at the site and U.S. EPA is the lead regulatory agency providing oversight. A Federal Facility Agreement (FFA) between the DON and U.S. EPA was signed on July 5, 2001. The FFA defines the DON's corrective action and response obligations under RCRA and CERCLA.

AUTHORIZING SIGNATURES

Thomas L. Macchiarella
Base Realignment and Closure Environmental Coordinator
Navy Base Realignment and Closure Program Office West
Department of the Navy

9-30-2005
Date

Kathleen Johnson
Chief, Superfund Federal Facility and Site Cleanup Branch
U.S. Environmental Protection Agency, Region IX

9/21/05
Date

Non- FFA Signatory
Regulatory Agency Signatures

The following signatures indicate that these regulatory agencies have reviewed this document and their comments have been addressed.

Anthony J. Landis, P.E.
Chief
Northern California Operations
Office of Military Facilities

9-26-05
Date

Bruce H. Wolfe,
Executive Officer
San Francisco Regional Water Quality Control Board

9/22/05
Date

2005 SEP 30 P 1:38
BRAC OFFICE

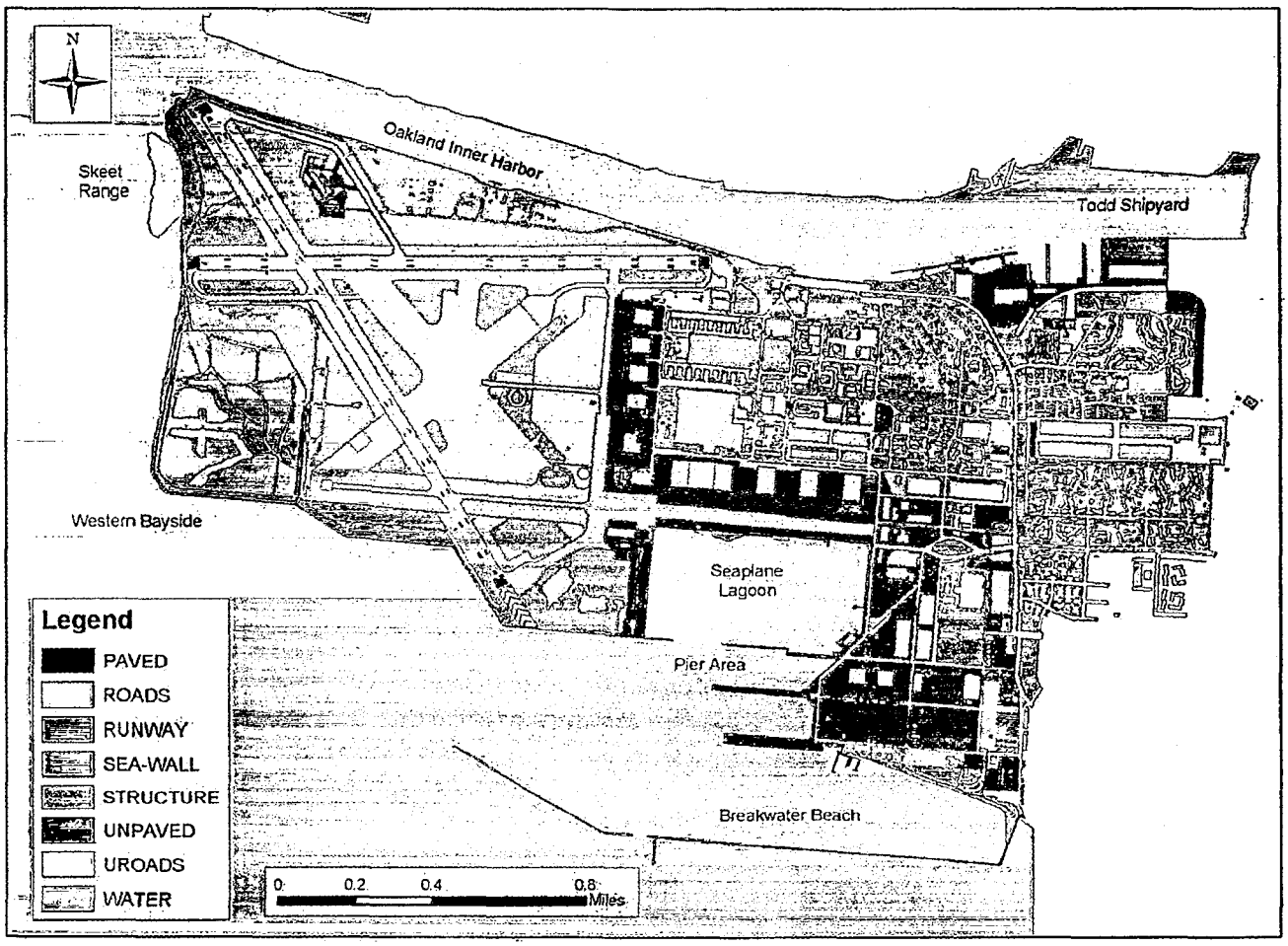


Figure 1. Site Map of Alameda Point

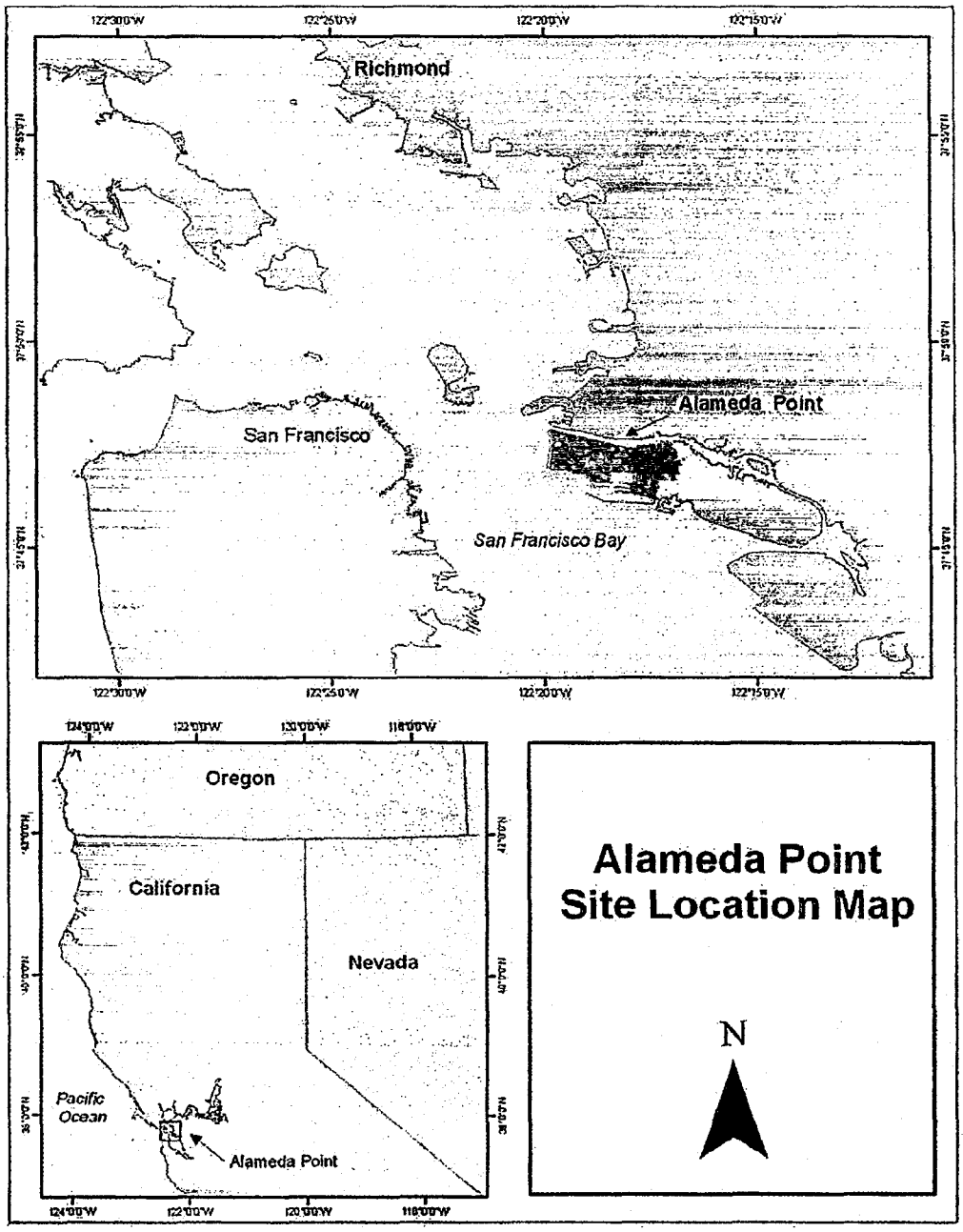


Figure 2. Alameda Point Site Location Map

2.0 SITE HISTORY AND INVESTIGATION ACTIVITIES

Historically, the Skeet Range consisted of two main shooting ranges (northern and southern) that were actively used for 30-40 years until their closure in 1993. Lead shot were discharged from guns toward clay pigeon targets projected westerly over San Francisco Bay. As a result, lead shot and clay target fragments reside in the sediment adjacent to the Skeet Range (IR Site 29), concentrated in an area located 80 ft offshore in average water depths ranging from 5- to 12-ft deep. The clay pigeon targets were bound together with petroleum products that contain PAHs. Based on these historical activities, concerns were raised about possible adverse effects to humans and wildlife resulting from exposure to lead and PAHs in the offshore area.

The Skeet Range was initially identified as a specific area of concern based on the results of sediment sampling conducted as part of the 1994 Ecological Assessment for former NAS Alameda. One of five study areas evaluated in the Ecological Assessment was Western Bayside, a region of open bay water adjacent to the northern and western edges of the former NAS Alameda. Of the 13 Western Bayside sample stations, two were located within the Skeet Range (IR Site 29) study area (i.e., Stations B03 and B04) and confirmed the presence of lead shot and PAHs. Additional sampling and analysis was conducted in 1996 as a follow-on to the draft Operable Unit (OU) 4 (Western Bayside) Ecological Risk Assessment (ERA) (PRC, 1996) and in 1998 as a part of the *Ecological Assessment of the Alameda Point Skeet Range Area* (TtEMI, 2000). A summary of these investigations, which led to the designation of the Skeet Range as an IR site in August 2000 during the development of the Site Management Plan for the Federal Facilities Agreement (FFA), is provided below.

1996 OU4 Ecological Assessment

Based on the results presented in the 1994 Ecological Assessment, PRC (subsequently called TtEMI) performed additional sampling and analysis as follow-on to the draft *OU4 Ecological Risk Assessment* (PRC, 1996). Initially, a full reconnaissance of the site was performed where grab samples were collected every 45 ft along five transects (A through E) covering an angle of 90 degrees outward from each of the two (northern and southern) shooting ranges (Figure 3). The transects from each range were labeled A through E in a north to south direction from their point of origin (N-A through N-E in the northern shooting range, S-A through S-E in the southern shooting range). The approximate origin of each transect corresponded to the shooting stand of each range, and extended out to a distance of roughly 1,000 ft. Grab samples were sieved and weighted for lead shot and used to determine the approximate spatial distribution (i.e., fall zone) of lead shot over the site. Using the distributions, a series of arcs representing contaminant distribution were established for the northern and southern regions of the Skeet Range, which were used to develop the sampling plan. These arcs represented:

- The region of the Skeet Range at which shot density was greatest (middle arc)
- The inshore boundary of the Skeet Range at which shot density decreases (inner arc)
- The offshore boundary at which shot density decreases (outer arc).

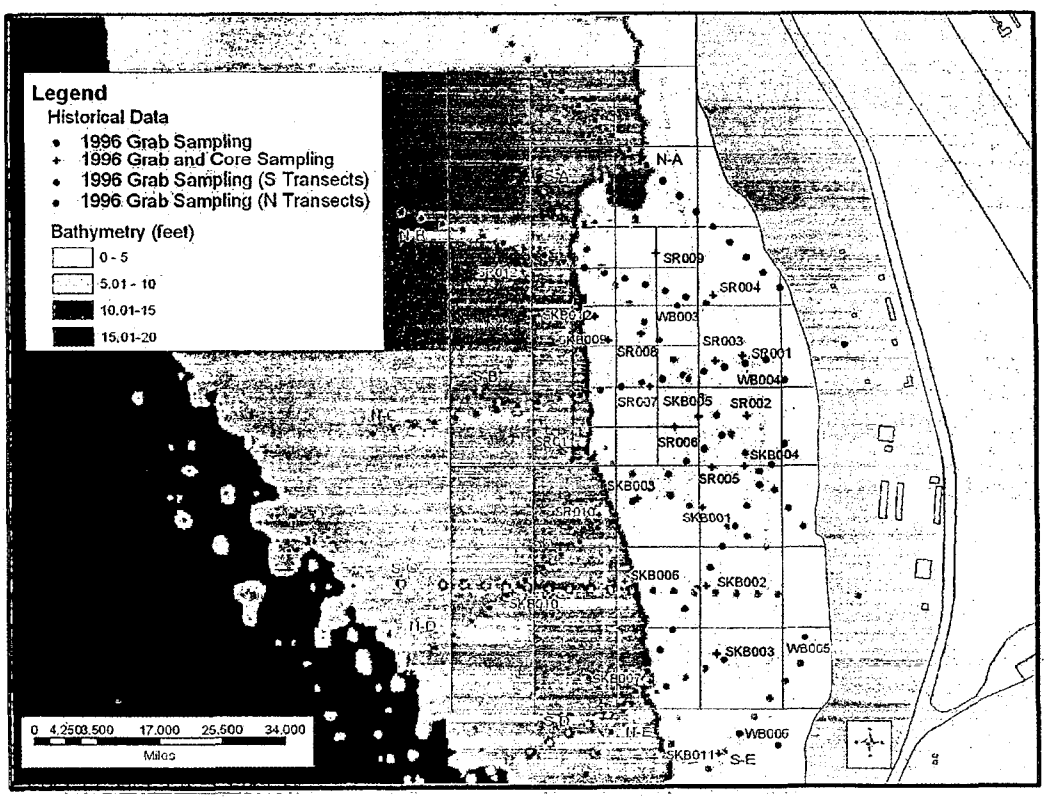


Figure 3. Sampling Stations from Collection Efforts in 1996

Based on the results of the field reconnaissance, 12 sediment core locations were sampled from select stations in the northern and southern ranges. Samples were analyzed for lead and PAHs to characterize the vertical extent of contamination. The data collected from these samples are presented in the *Chemical Data Summary Report for Offshore Sediment* (TtEMI, 1998).

1998 Supplemental Sampling

In 1998, additional sediment core samples were collected at the Skeet Range (IR Site 29) to further delineate the distribution of lead shot found at depth (TtEMI, 2000). Based on the 1996 investigation, the area of maximum lead shot density was located in the vicinity of sampling location SKB009 with decreasing density extending 10 acres from the shooting ranges. Ten sediment core samples were randomly collected from this area of highest lead shot density (see Figure 4). Only lead and PAHs were identified as constituents of concern based on the historical activities at the site.

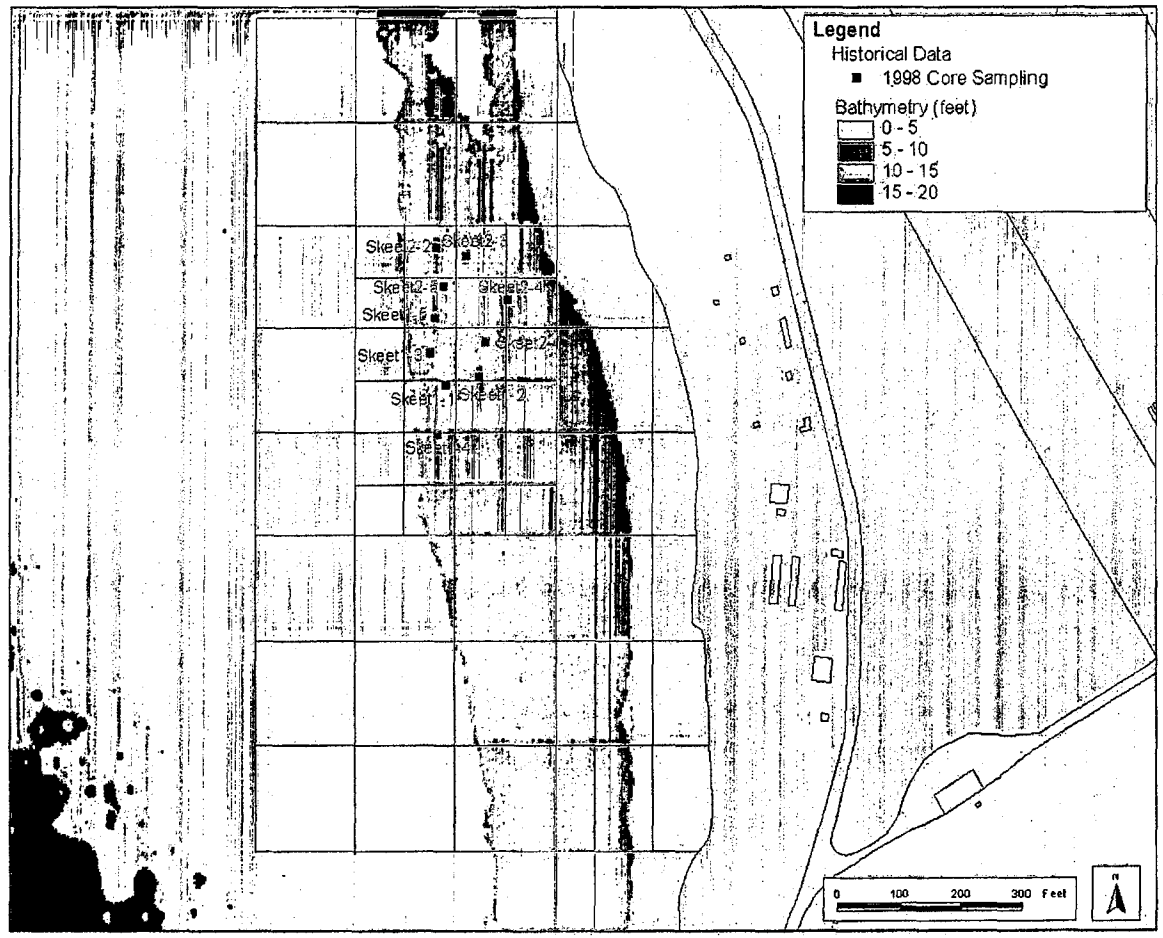


Figure 4. Sampling Stations from Collection Efforts in 1998

Results of the lead shot depth distribution analysis showed that the concentration of lead shot generally increases with depth to about 20 centimeters (cm), with maximum concentration occurring between 4 and 20 cm. Lead shot was not detected in the 40- to 45-cm depth interval, indicating that the shot only occurs in the top 0.5 meter (m) of sediment. Lead shot was not typically found in the top 4 cm of sediment, suggesting that settling and sedimentation are leading to shot burial.

Ecological Assessment

The 1996 study results were integrated with the 1998 investigation and presented in the *Ecological Assessment,* which was submitted to the BCT on February 20, 2000 (TtEMI, 2000). Based on the 1996 investigation, density of lead shot was highest in the area that overlaps the two shooting ranges. The study also included an investigation of the degree of dissolution of lead in sediment and porewater from lead pellets to determine if lead dissolving from the shot is biologically available. The results indicated that lead from the lead shot is not dissolving in quantities that would be considered to be biologically of concern based on ambient water quality criteria (AWQC) and is not present at concentrations that could cause adverse ecological effects (TtEMI, 2000). Therefore, additional investigations focused on exposure to PAHs and to the lead shot.

PAH concentrations from sediment and porewater were also compared against San Francisco Bay reference stations and to toxicity benchmarks, specifically the effects range-low (ER-L). Although some PAH compounds were found to exceed ER-Ls, the data show that the concentrations of total PAHs found in the Skeet Range are comparable to concentrations measured from ambient locations. Concentrations within the Skeet Range either are relatively uniform with depth or (in several locations) increase with depth. Maximum concentrations of PAHs in some samples were found at depths greater than lead shot, suggesting that clay targets or Skeet Range (IR. Site 29) activities might not be responsible for the PAHs found in sediment.

Incorporating the results from both the 1996 and 1998 investigations, the *Ecological Assessment* (TtEMI, 2000) concluded that the bulk and dissolved concentrations of lead and PAHs are below AWQC and reflect ambient concentrations. In addition, the *Ecological Assessment* (TtEMI, 2000) suggested, based on the lead shot depth distribution, that sediment was accumulating and burying the lead shot, rendering it unavailable for diving birds and that PAHs within the study area might not be attributable to historical site operations.

The RWQCB identified several significant concerns regarding the conclusions of the *Ecological Assessment.* Specifically, the RWQCB disagreed with the finding that levels of lead and PAHs in sediments were within the range of ambient concentrations. The RWQCB also expressed concern about the relevance of applying results from the United States Army Corps of Engineers (USACE) sediment accumulation studies to the Skeet Range (IR Site 29). Finally, the RWQCB disagreed with the low significance of exposure and risks to diving birds from ingestion of shot as stated in the ERA. To address these concerns, the DON conducted a field investigation in November 2001 to further characterize the spatial extent of lead shot distribution, determine the source of the PAH contamination, and develop sediment depositional rates.

2001 Skeet Range Site Evaluation

The primary objectives of the 2001 evaluation were to: 1) further define the lateral and vertical extent of lead shot in sediments to determine the potential for exposures to human and ecological receptors; 2) evaluate the extent of vertical mixing of lead shot based on the sedimentation rate; and 3) determine if PAHs present at the site are associated with fragments of the clay pigeon targets. To achieve these objectives, 40 surface sediment samples and 25 sediment cores were collected within the area and analyzed for lead shot and PAHs. Samples were evaluated to determine the vertical distribution of lead shot throughout the sediments. In addition clay target fragments were collected from the sediment and analyzed to determine the PAH composition for comparison to the PAHs present in sediments. The results of this field investigation were presented in the 2004 Remedial Investigation (RI) Report (Battelle et al., 2004).

Remedial Investigation

The primary objectives of the RI report were to evaluate the offshore sediment quality at the Skeet Range (IR Site 29) to identify areas of unacceptable risk based on the human health and ecological risk assessments conducted using the data collected from the 2001 field effort. Adjacent onshore and nearshore areas will be addressed as part of the IR Site Iinvestigation and through evaluation of Western Bayside as described in the Offshore Sediment Core Study Workplan (Battelle, 2005; Battelle et al., 2005). The RI focused on PAHs and lead shot as the primary chemicals of potential concern (COPCs). Based on the RI it was concluded that:

- PAH concentrations in sediment were chemically distinct from PAHs found in clay targets. This result indicates that abrasions or leaching of any organic binder from clay targets was not the source of hydrocarbons in sediment, including PAHs.

- The estimated net sediment accumulation rate was estimated to be between 0.65 and 1.0 centimeters per year (cm/yr). The horizontal and vertical distribution of shot supports the hypothesis that lead shot has not been transported significant distances and that gradual burial is occurring.

- Risks to ecological receptors were low based on potential exposures to lead shot and PAHs.

- The human health conceptual site model (CSM) indicated that there were no complete direct exposure pathways based on current and proposed future land uses. Indirect exposures to PAHs through fishing or clamming may be possible; however, no evidence has been found which suggests that PAHs biomagnify and bioaccumulate in the environment. In addition, the data indicate that the PAHs in sediments are primarily associated with background sources.

Based on the ecological and human health assessments, no unacceptable risks are associated with exposures at the Skeet Range. Because the PAH levels are indicative of background levels and the majority of the lead shot is being gradually buried, exposures to sediment do not pose a health threat to current or future human receptors and the environment. Consequently, a no further action determination was recommended for this site. Based on the conclusions of the RI and the recommendation of no further action, there were no sediments proposed for further evaluation in a Feasibility Study (FS), therefore, an FS was not completed.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

A Restoration Advisory Board (RAB) was established for Alameda Point to give community members an opportunity to participate in environmental restoration activities at Navy facilities. The Board is co-chaired by a community member and a representative from the DON. Other Board members include representatives from the U.S. EPA, San Francisco RWQCB, DTSC, the general public and the Sierra Club.

RAB meetings are held monthly in Alameda and are advertised in local newspapers. They are devoted to environmental restoration activities throughout the entire Alameda site. A number of RAB meetings have had discussions devoted to investigation activities at the former Skeet Range (IR Site 29). As a result, the public has had opportunities to review and comment on the RI Report (July, 2004) and the Proposed Plan (February, 2005). The notice of availability of these two documents was published February 11, 2005 in the Oakland Tribune and Alameda Journal. In addition, a public meeting regarding the Proposed Plan was held on March 7, 2005 in Alameda, CA. A transcript of the meeting is included in Attachment C. The public comment period for the Proposed Plan extended from February 15, 2005 to March 18, 2005. Copies of each report can be found in the administrative record file and at the information repositories maintained at:

Alameda Point 950 West Mall Square Building 1 Alameda, California	Alameda Public Library 2200 A Central Ave Alameda, California

The DON's response to public comments received during the Proposed Plan comment period is included in Section 10, the Responsiveness Summary.

4.0 SCOPE AND ROLE OF RESPONSE ACTION

The former NAS at Alameda Point encompasses 35 IR Sites (IR Site 18 was removed from the program). IR Site 29 is located at the western boundary o f the facility just offshore of IR 1 (see Figure 5). IR Site 1 was a disposal/landfill area that is located east of the range and was historically part of the open bay until fill materials were deposited from the early 1940s to 1956 (PRC, 1996). IR Site 1 is being addressed independently from IR Site 29 and will address the adjacent shoreline and nearshore areas (Battelle, 2005). In addition, although not identified as an IR site, the area along the western and southern edge of Alameda Point, referred to as Western Bayside, will be evaluated in a Data Summary Memorandum as described in the Offshore Sediment Core Study Work Plan (Battelle et al., 2005).

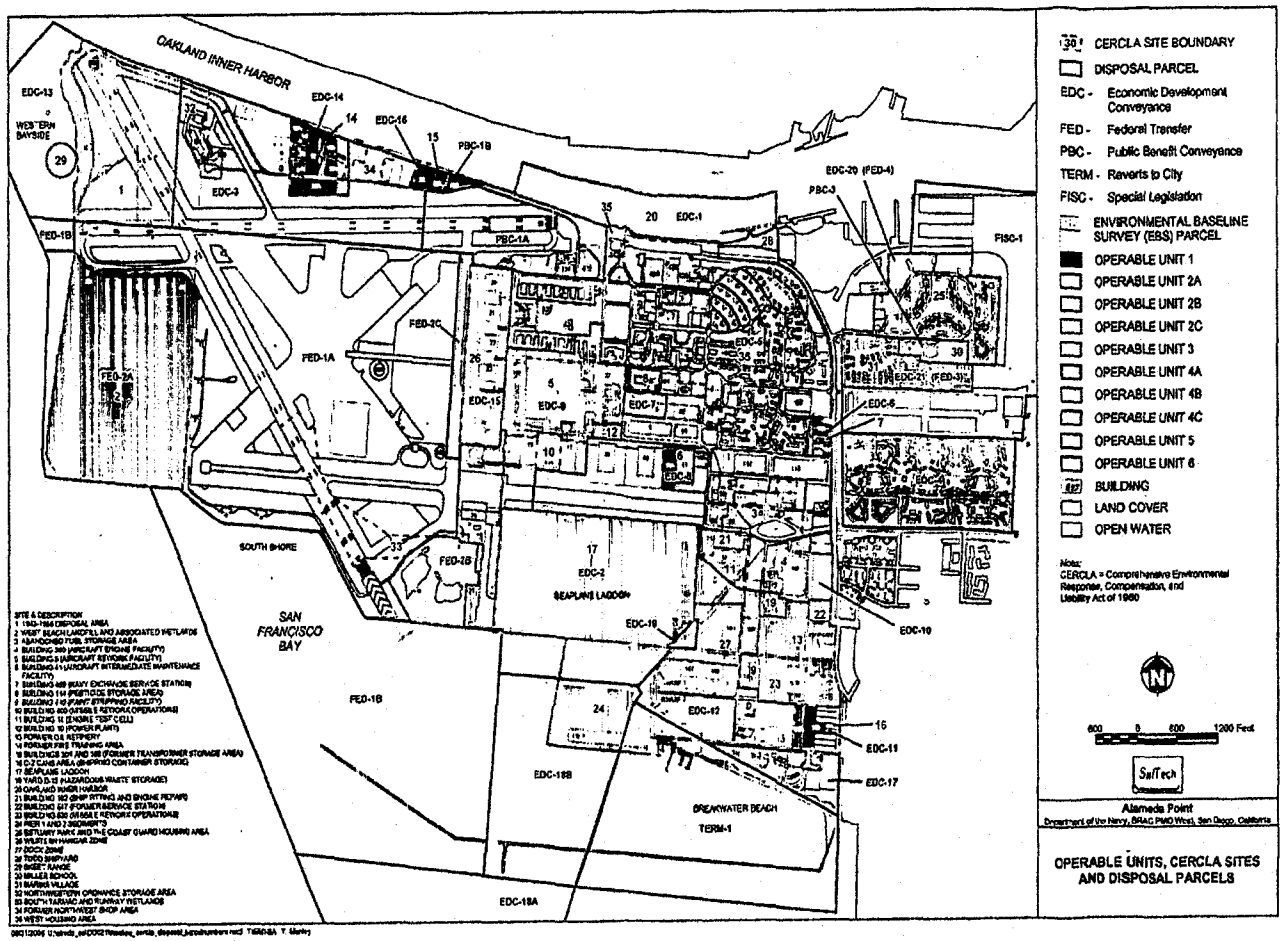


Figure 5. Site Map

5.0 SITE CHARACTERISTICS

This section briefly describes the physical characteristics of the Skeet Range (IR Site 29) and the nature and extent of contamination at the site.

5.1 Site Overview

As previously described, the former Skeet Range (IR Site 29) is located on the northwestern corner of the former NAS Alameda (see Figure 1). The Skeet Range extends to approximately 800 ft offshore into the San Francisco Bay with dimensions of about 1,300 ft by 800 ft. The area is exposed to wind and wave action from San Francisco Bay (TtEMI, 2000). Based on a current bathymetry map of the Skeet Range from 2001 acoustic imaging, the bottom of the range is a broadly uniform, gentle slope with water depths ranging from <5 ft (<1.5 m) to about 12 ft (3.7 m). The majority of the Skeet Range fall zone is 80 ft offshore in water between <5 to <10 ft (1.5 to 3 m) deep. The adjacent onshore area consists of fill material dredged from San Francisco Bay coastal mudflats, marshlands, and sloughs in the 1930s and 1940s. The onshore area has relatively flat topography and most of the shoreline is lined with riprap and former concrete ramp. No significant streams, rivers or other surface water bodies discharge into the bay in the vicinity of the Skeet Range.

5.2 Nature and Extent of Contamination

As described in Section 2, the primary COPC associated with activities at the Skeet Range (IR Site 29) are lead shot and PAHs potentially associated with the clay target fragments.

Based on the investigations conducted in 1996, 1998, 2000, and 2001 it has been demonstrated that the density of lead shot is highest in the area that overlaps the two shooting ranges. Lead from the lead shot is not dissolving in quantities that would be considered to be biologically of concern based on AWQC and is not present at concentrations that could cause adverse ecological effects (TtEMI, 2000). Vertically, the concentration of lead shot generally increases with depth to about 20 cm, with maximum concentration occurring between 4 and 20 cm. Lead shot was not detected in the 40- to 45-cm depth interval, indicating that the shot only occurs in the top 0.5 m of sediment. Lead shot was not typically found in the top 4 cm of sediment, suggesting that settling and sedimentation are leading to shot burial. A radioisotope study of the area estimated a sediment accumulation rate of between 0.65 and 1 cm/yr, confirming that the majority of lead shot at the site are likely to be buried below 5 cm.

As part of the 1996 investigation, PAH concentrations from sediment and porewater were compared against risk-based sediment screening benchmarks, i.e., ER-Ls and ER-Ms (Long et al., 1995); and to San Francisco Bay ambient upper tolerance limits (UTLs) for sediments of <100% fines (RWQCB, 1998). In general, concentrations of total PAHs found in the Skeet Range (IR Site 29) are comparable to concentrations measured from ambient locations. In addition, only three stations along the northern edge of the Skeet Range (IR Site 29) had concentrations above the risk-based screening benchmarks. Concentrations within the Skeet Range (IR Site 29) either are relatively uniform with depth or (in several locations) increase with depth. Maximum concentrations of PAHs in some samples were found at depths greater than

lead shot, suggesting that clay targets or Skeet Range (IR Site 29) activities are not responsible for the PAHs found in sediment. As part of the RI, PAH fingerprinting techniques were employed to characterize the unique signature of PAH constituents within the clay target fragments in comparisons to measured levels of PAHs in sediment. The chemical composition of sediment and fragment samples were then evaluated using a Principal Component Analysis (PCA), which groups chemical similarities or differences, without any preclassification as to their nature/source(s). The PCA revealed that nearly all of the sediment samples were chemically distinct from the chemical composition of clay target fragments, which led to the conclusion that the organic binder in clay fragments was not the source of PAHs in the sediment at the site.

6.0 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

This section discusses the current and reasonably anticipated future land uses at the Skeet Range (IR Site 29). The site and resource uses help determine realistic exposure scenarios.

Access to the site from onshore is currently restricted along IR Site 1. The entire perimeter of the property is fenced and closed to public use. All of the historical structures related to the shooting ranges have been removed from the property. The sandy beach located on the western boundary of IR Site 1 facing the Skeet Range (IR Site 29) contains riprap and remnants of a former concrete ramp. Access to the site by vessel is limited as there is no usable boat ramp or mooring available.

The proposed future land uses of the onshore property adjacent to the Skeet Range (IR Site 29) will involve no infrastructure development (e.g. pier construction) that could result in excavation or dredging of the sediments. Proposed future land uses of the onshore areas adjacent to the site will consist of recreation and open space including a Bay Trail, shoreline park, and Point Alameda Regional Park (ARRA, 1996). The Bay Trail is the main feature planned to run the length of Oakland Alameda Estuary to allow full public access to the shoreline, whereas the tip of Alameda Point will be preserved as a regional park for fishing and other recreational uses. South of the point, the open areas will be used for recreational sports including potential construction of soccer and baseball fields and a golf course. The offshore area of the site will remain open-water with no further development in the future.

7.0 SUMMARY OF SITE RISKS

Risk assessments provide evaluations of the potential threats to human health and/or the environment in the absence of any remedial action. They form the basis for determining whether remedial actions are necessary and the justification for performing remedial actions (US EPA, 1988). Ecological and human health risk assessments were conducted for the Skeet Range (IR Site 29) as part of the RI (Battelle et al., 2004). A summary of these assessments is provided below.

7.1 Ecological Risk Assessment

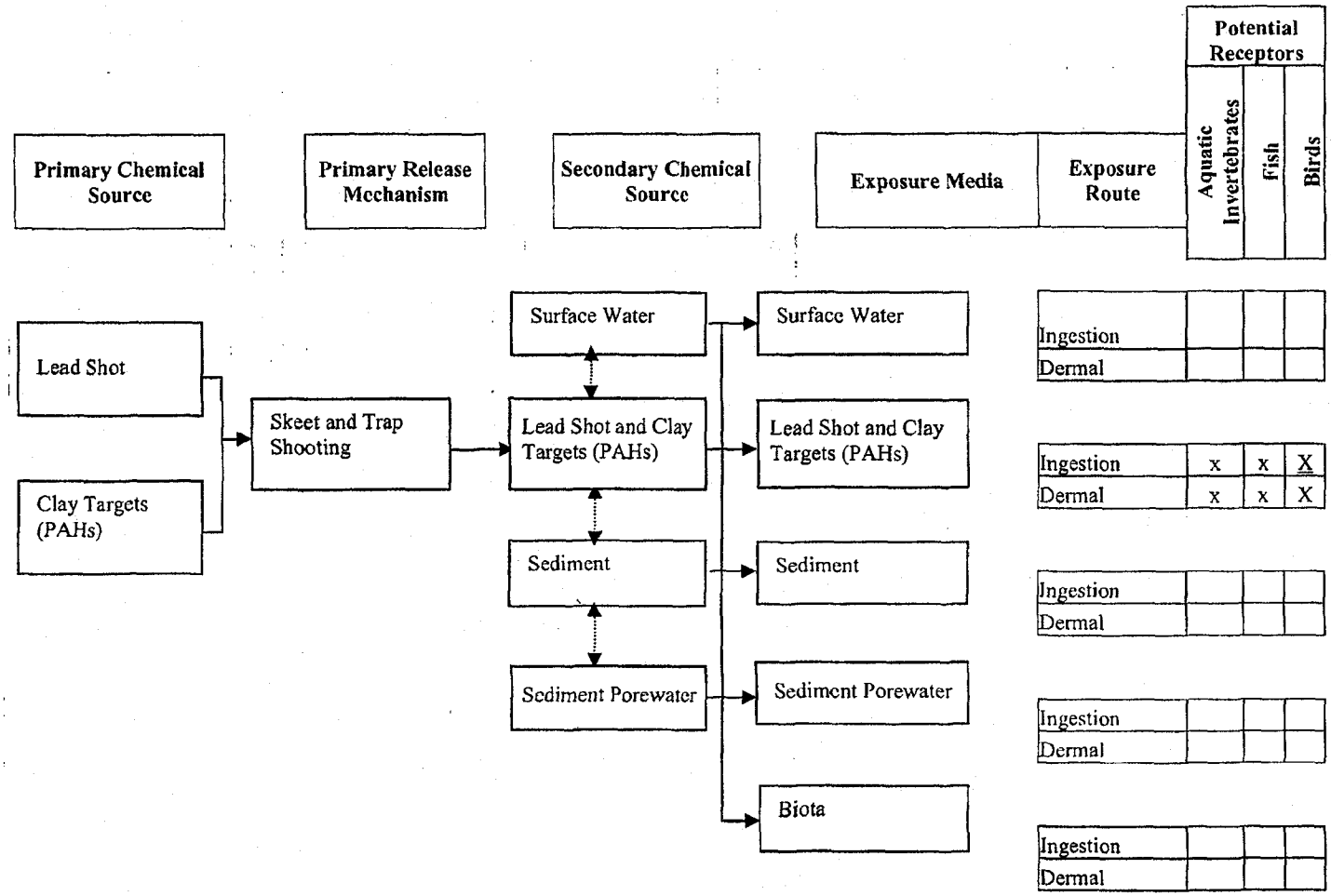
The ecological risk assessment was conducted following U.S. EPA (1992, 1997) and Navy (CNO, 1999) guidelines. Lead shot and PAHs were identified as preliminary COPCs and, based on the CSM developed for the site (Figure 6), birds were identified as the primary receptors of concern.

Although earlier data demonstrated that the lead from the lead shot was not dissolving into the surrounding sediment, diving ducks were identified as potential receptors of concern because they may be exposed by ingesting lead shot in the sediment during typical foraging activities. Diving ducks generally dive into the water and forage for organisms living in the top 5 cm of sediment and may inadvertently or intentionally select lead shot as grit (i.e., shellhash) from sediment for grinding down shellfish in their gizzard resulting in potential toxicity (Sanderson and Bellrose, 1986; Scheuhammer and Norris, 1995; Pain, 1996).

As part of the screening-level risk assessment, a site-specific probability model was developed to determine the likelihood that diving ducks may ingest lead shot while foraging for grit in sufficient quantity to cause harm. The model took into account the probability of ingesting a lead shot in a single probe, the number of dives per day a bird makes to get grit, how often the bird forages at the site relative to the time it spends at other locations, and the number of shot needed to be consumed before adverse effects would occur.

To determine the number of shot required to impair the health of waterfowl such as the diving ducks, a literature review was conducted to estimate a No Observable Adverse Effects Level (NOAEL). NOAELs refer to the maximum concentration of a particular contaminant that will not cause adverse effects in exposed species; in other words, concentrations below the NOAEL are assumed to be 'safe' while concentrations above may be associated with health effects.

Using the field collected lead shot data, the NOAEL, and conservative exposure factors including the assumption that diving ducks spend 100% of their time in one location, the model suggested that there was elevated risk to diving ducks at approximately half of the locations. Because of the conservatism inherent in this model, a Baseline Ecological Risk Assessment (BERA) was conducted to better characterize the natural variability in model exposure parameters. The BERA relied on distributions to describe each parameter rather than a single value.



x = Complete exposure pathway of limited significance.
X = Complete exposure pathway of primary significance.
Blank squares indicate incomplete exposure pathways

Figure 6. Ecological Site Conceptual Exposure Model

The BERA showed that approximately 96% of the time less than 1 in 1,000 birds foraging at the site would potentially be at risk, indicating that there is a very limited chance for birds at Alameda Point to be exposed to lead shot at harmful levels. Exposure of diving ducks to lead shot may even be more limited given the thick mats of Ampelisca (worm) tubes found on the surface of all samples collected from the 2001 investigations.

In summary, the ecological risk assessment determined that there are no significant risks in the sediments offshore of the former Skeet Range that would impact the ecological community based on current or reasonably anticipated future land use.

7.2 Evaluation of Potential Human Health Risks

To evaluate the potential risks to human health, a CSM was developed to identify the potential exposure pathways through which likely human receptors might come in contact with impacted sediment at the site. Under both current and future site conditions, the likely human receptors at the site would be on-site workers (current), recreational users (future) and off-site outdoor maintenance workers (future). However, the primary site-related contaminants (lead shot and PAHs from the clay targets) are located approximately 80 ft offshore, in water depths of 5 ft or greater. As a result, direct human exposures (such as dermal contact or ingestion of sediment) are very limited under current or future conditions and no complete direct exposure pathways were identified in the CSM.

It is also possible for humans to be exposed through indirect exposure pathways, such as by eating fish that have been exposed to site-related contaminants. However, neither lead nor PAHs are known to be retained in the edible tissues of exposed fish. As a result, the CSM also did not identify any complete indirect exposure pathways for humans.

To ensure that potential risks to human receptors were not underestimated, a preliminary screening evaluation was conducted at the western and southern boundary of Alameda Point. This screening considered exposures through direct contact with sediment (via wading) as well as consumption of shellfish (mussels or clams) and included data collected from the shoreline of Alameda Point in the vicinity of the Skeet Range (IR Site 29). The results indicated that the potential risks based on exposures to the site-related contaminants were similar to those associated with background locations in San Francisco Bay. Further evaluation of the onshore area and the nearshore sediments will be conducted as part of the investigation for IR Site 1 and for Western Bayside (Battelle 2005; Battelle et al., 2005).

Based on this evaluation, it was concluded that there are no current or future human health risks associated with the sediments offshore of the former Skeet Range based on current or reasonably anticipated future land uses.

8.0 DESCRIPTION OF NO ACTION ALTERNATIVE

The Skeet Range (IR Site 29) site was determined to require no further action for sediments that might have been affected by site-specific uses. This determination was based on the results of previous investigations, lab analyses, interpretation of data, review of current and potential future uses at the site and a thorough ecological and human health risk assessment. Results showed the site does not pose unacceptable risk to human health or the environment. Accordingly, no remedial action is appropriate for the site.

The DON's determination that no remedial action is necessary reflects the conclusion that there are no threats to human health or the environment. Under the no action alternative, monitoring, periodic reviews, deed restrictions (including deed notification) and CERCLA 5-year reviews are not required. The U.S. EPA, DTSC, and RWQCB agree with this determination. This no further action ROD constitutes site closeout in the Defense Environmental Restoration Program.

Section 121(d) of CERCLA states that remedial actions at CERCLA sites must, upon completion, meet any federal (or state, if more stringent) environmental standards, requirements, criteria, or limitations that are determined to be applicable or relevant and appropriate requirements (ARARs). ARARs do not apply unless remedial action is being taken at a site; therefore, they do not apply to the no further action remedy for IR Site 29 addressed in this ROD.

9.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for IR Site 29 was released for public comment on February 15, 2005. The Proposed Plan identified no further action as the appropriate response for the site. The DON has reviewed all written and verbal comments submitted during the public comment period and determined that no significant changes to the selected remedy of no further action were necessary or appropriate.

10.0 RESPONSIVENESS SUMMARY

The Proposed Plan for IR Site 29 was released for public comment on February 15, 2005. The comment period extended from February 15 to March 18, 2005. A public meeting was held on March 7, 2005. All comment letters received on the Proposed Plan as well as a transcript of the March 7 public meeting are presented in Attachment C. A summary of the comments received and the DON responses are provided in Table 1.

Table 1. Summary of Comments Received and Responses

Comment No.	Comment	Response
Comments from the Alameda Reuse and Redevelopment Authority (dated March 17, 1005)		
1	Land use plans for Alameda Point include a future, public beach in the vicinity of the Skeet Range. Remediation of this area must be sufficiently thorough to allow unrestricted recreational land use, without unacceptable human health risks. The Proposed Plan does not acknowledge this remedial goal. Please state clearly that both the beach area and the submerged lands shoreward of the footprint addressed by this Proposed Plan will be included in the remedial decision making for IR Site 1. The Proposed Plan states "lead shot as well as clay target fragments...reside in the offshore sediment adjacent to the Skeet Range, concentrated in an offshore area approximately 1,300 feet by 800 feet in average water depths ranging from 5 to 12 feet mean [lower] low water. The adjacent shoreline beach areas will be investigated as part of IR Site 1". (page 2) Further, "the primary site-related contaminants (lead shot and PAHs from clay targets) are located approximately 80 feet offshore, in water depths averaging 5 ft or greater." (page 5). The *Proposed Plan* does not clearly state that the scope of remedial decision making for IR Site 1 includes not only the "shoreline beach areas" but also the submerged area within 80 feet of the shoreline. If contaminated sediments are present in relatively-shallow near-shore areas, unacceptable human health risks may occur from residential use.	Previous investigations (TtEMI, 2000) evaluated the presence of Skeet Range related contaminants in sediments from the nearshore area. As described in Section 1.1.3.1 of the Skeet Range Remedial Investigation Report, transects every 45 ft extending 1,000 ft offshore covering an angle of 90 degrees outward from each of the two shooting ranges were evaluated for lead shot, metals, PAHs, and semi-volatile compounds. Additional samples were also analyzed for total petroleum hydrocarbons, pesticides, and PCBs. Based on this information, there is no evidence to suggest that adjacent onshore areas or submerged areas within 80 feet of the shoreline were significantly impacted by historical activities at the Skeet Range. Therefore, the detailed risk evaluations for IR Site 29 focused on the offshore areas with the highest concentration of site-related COPC. In addition to the historical evaluations (TtEMI, 2000), the nearshore areas will be further investigated as described below. In March 2005, 12 soil borings were collected along a roughly north-south oriented transect near the western shoreline of the IR Site 1 Beach Area (see *Expedited Field Sampling Work Plan at IR Sites 1 and 15, Alameda Point*, March 11, 2005). Borings were completed to 10 ft bgs, or until groundwater was encountered. As part of that sampling event, 12 sediment cores were also collected immediately offshore of the Beach Area and directly perpendicular to the locations of the onshore soil boring, to a depth of 4 ft below the sediment surface. As part of the Offshore Sediment Core Study currently planned for June 2005, three four-ft sediment cores will be collected parallel to the shoreline as close to shore as safely possible at high tide to address concerns about the submerged area within 80 ft of the shoreline. These data will be presented in a revised Data Summary Memorandum for Western Bayside/Breakwater Beach, currently scheduled to be completed in the fall of 2005.

Table 1. Summary of Comments Received and Responses (continued)

Comment No.	Comment	Response
	Comments from Mr. George B. Humphreys (dated March 20, 2005)	
1	What has been the total dollar expenditure made by the Navy to date in investigations, sampling, and conducting probabilisitic risk assessments at the Skeet Range IR Site 29? From the information presented by Mr. Michael Pound at the RAB Meeting on March 5, 2003, it appears that the area of the Skeet Range containing lead shot densities in the range of 11 to 50 shots per liter of sediment is approximately 300 ft by 600 ft. The estimated sedimentation rate at the site is 1 cm per year. In 30 years, the deposition of sediment would be approximately 1 ft (30 cm = 1ft). Thus most of the lead shot should be located in the top foot of sediment. This represents about 6,000 cu yds of sediment. What would be the cost of scooping up and disposing of 6,000 cu yds of contaminated sediment? I suspect that it might be less than what the Navy has already spent trying to demonstrate that no action is necessary.	The data collected and analyses performed tor IR Site 29 were necessary to adequately delineate and describe the conditions at the site and were done in the most cost effective manner possible. The primary objectives of the Remedial Investigation (RI) were to characterize the nature and extent of contamination at the site and to delineate those areas potentially posing unacceptable risk to humans and the environment. The investigations at IR Site 29 focused on evaluating the potential risks to human and ecological receptors according to the CERCLA process. Remedial Action Objectives (RAO) and Remedial Alternatives, inclusive of costs, are developed in the Feasibility Study (FS) step of the CERCLA process. Because the no further action determination was made in the Remedial Investigation (RI) step of the CERCLA process, an FS was not completed. Therefore, costs of remediation are unknown. In support of the environmental program for the Skeet Range, the Navy has expended approximately $500,000.
2	In performing the environmental risk assessment, the Navy evaluated the effect on two types of diving birds (scaups and surf scoters). The technical complexity of the binomial probabilisitic risk assessment employed is indeed mind boggling. The credibility of the results is fraught with uncertainty because of the large number of assumptions which are used as inputs. One factor used is the 'Site Utilization Factor' (SUF) or the fraction of the time the birds would be feeding at the former skeet range. From Mr. Pound's presentation, an SUF of 0.1 apparently was used. If it is acceptable to leave this material in place, there could be any number of other former skeet ranges around the bay and the affected birds could be ingesting shot at each of those locations when they aren't foraging at Alameda. An example would be the Chevron-Texaco gun club near Pt. Molate in Richmond. Therefore the conclusion that "96% of the time, less than 1 in 1,000 birds" would be at risk may underestimate the cumulative impact of allowing these types of untreated sediments to remain in place.	As discussed on p. 106 of the Skeet Range Remedial Investigation report (Battelle et al., 2004), the possibility that lead shot exposure could occur off site was considered as part of the evaluation. However, with the exception of the skeet range at Clipper Cove off of Treasure Island, there were no other subtidal skeet ranges identified within the foraging ranges of the scaup and surf scoter. The lead shot at Clipper Cove is buried under clean sediment and unavailable to foraging ducks, therefore, the exposure from that site is minimal. Thus, the assumption that exposure to lead shot for diving ducks is limited to the Alameda Point Skeet Range is reasonable.

Table 1. Summary of Comments Received and Responses (continued)

Comment No.	Comment	Response
Comments from Mr. George B. Humphreys (dated March 20, 2005) (continued)		
3	One bottom feeding fish present in the waters offshore at Alameda is the sturgeon. These fish are very long-lived. Have you evaluated how much lead might be ingested by sturgeon over a 50-60 year period and what the human health risk would be of humans eating such fish or their roe.	As described on p.8 of the Draft Final Skeet Range Remedial Investigation Report, the data indicate that lead is not dissolving from the lead shot in quantities that would be considered to be biologically of concern based on AWQC and is not present at concentrations that could cause adverse ecological effects. Based on this information, it is unlikely that fish from the site are exposed to elevated levels o f lead from the presence of lead shot. In addition, lead does not accumulate in edible tissues of fish, rather it preferentially partitions into bones, therefore, risks to humans consuming fish from the site would be very low.
Comments from Mr. Patrick Lynch Recorded at the Proposed Plan Public Meeting (dated March 7, 2005)		
1	...It really raises an environmental justice concern to me when we see resources being spent on this offshore area again without addressing contamination that exists on the fence line and potentially off site....You know, I don't see the point in spending limited cleanup dollars performing this kind of research at this facility when there is no meaningful cleanup occurring.	See the response to Comment #1 from Mr. George B. Humphreys and Comment #1 from the ARRA, The investigations conducted at IR Site 29 have been performed in accordance with the CERCLA process for the purpose of identifying sediments potentially requiring remediation. Based on these evaluations, there are no site-related contaminants that pose an unacceptable risk to human health or the environment, therefore, no remediation is necessary.
2	And you know, I'm also concerned that this is a proposal to leave this contamination at the site of a proposed public beach. We'll spend between 150 million and 500 million dollars, largely to prevent contamination on this base from making its way into the bay.	Based on the results of the ecological and human health risk assessments, there is no contamination at the site that poses an adverse health affect to either humans or the environment. To confirm that exposures at the proposed beach are minimal, additional sampling will be conducted (see response to Comment #1 from ARRA).

Table 1. Summary of Comments Received and Responses (continued)

Comment No.	Comment	Response
Comments from Mr. Patrick Lynch Recorded at the Proposed Plan Public Meeting (dated March 7, 2005) (continued)		
3	...We have clearly-defined contamination in the bay, and we're not willing to remove it. Maybe it's too expensive. But we don't know that, because we're not willing to do a Feasibility Study and produce a cost estimate of what it would cost to do that remediation, And it might be that this contamination will pose a risk in the future, but because we're not going to do a Record of Decision where we recognize we're leaving toxic material in the bay, there's not going to be a five-year follow-up. And so, you know, I really think that we need to do the complete step. We need to do the Feasibility Study, demonstrate that this is cost prohibitive. And I think we need to reach a Record of Decision where there will be some review of the decision.	As stated in the Proposed Plan, the Navy's recommendation of no further action for IR Site 29 was based on the evidence from previous investigations that current and anticipated future conditions at the site do not present an unacceptable risk to humans or the environment and that no remediation is required. Following a thorough review of this information, the Alameda Point Base Realignment and Closure (BRAC) cleanup team (BCT) concurs with the Navy's proposed determination. Per the CERCLA process, a Feasibility Study (FS) is not warranted because no remedial action is proposed. The Record of Decision will memorialize the BCTs decision following Navy and agency review and concurrance.
Comments from Mr. Peter Russell Recorded at the Proposed Plan Public Meeting (dated March 7, 2005)		
1	The gist is a single comment; that is, that the shoreline is slated to be a public beach and we want to make sure there are no gaps in the evaluation so that recreational use would be compromised. There are two brief passages out of the Proposal Plan that I would like to read that leave me with a little bit of wonder about whether that is going to be fully addressed by either IR Site 29 or IR Site 1. The first is on Page 2 – and I will quote it – in the righthand side column. "As a result, lead shot, as well as clay target fragments, reside in the offshore sediment adjacent to the Skeet Range concentrated in an offshore area approximately by 1300 by 800 feet in average water depths ranging from 5 to 12 feet mean low low water." It should be "lower low water," but that's not..."The adjacent shoreline beach areas will be investigated as part of IR Site 1". Then on page 5 in the lefthand column, there's a sentence, "However the primary site-related contaminants (lead shot and PAHs from the clay targets) are located approximately 80 feet offshore in water depths ranging – averaging 5 feet or greater. So I think the possible gap is not the beach itself, which I think, quite clearly, will be picked up by IR 1, but the water that is 5 feet deep and shallower that runs from the beach itself out the 80 feet offshore where the IR 29 proper begins. I think that needs to be looked at to verify that there are no unacceptable health hazards – human health hazards – for recreational land use.	See the response to Comment #1 from the ARRA.

11.0 REFERENCES

Alameda Reuse and Redevelopment Authority (ARRA). 1996. NAS *Alameda Community Reuse Plan*. Prepared by EDAW, Inc. In association with Bay Area Economics, Fehr & Peers, Wittler-Brochier & Associates, Zander and Associates, Baseline Environmental, Moffatt & Nichol Engineers, YEI Engineers Inc., Harris & Associates, and McLaren/Hart.

Battelle. 2001. Letter report: EFR for Site 25. Submitted to TtEMI. March 12.

Battelle. 2002a. Alameda *Skeet Range Grit and Lead Shot Count Data*. Contract No. GS-10F-0275I4. October 4.

Battelle, BBL, Inc., and Neptune and Company. 2004. Draft Final Remedial Investigation Report Skeet Range Alameda Point, California. Prepared for Department of the Navy, Southwest Division Naval Facilities Engineering Command. Contract No. GS-10F-0275K. June 11.

Battelle. 2005. Final Expedited Sampling Work Plan at IR Sites 1 & 15, Alameda Point, California. Prepared for Department of the Navy, Southwest Division Naval Facilities Engineering Command. Contract No. N68711-01-D-6009. March 11, 2005.

Battelle, BBL, Inc., and Neptune and Company. 2005. Draft Offshore Sediment Core Study Work Plan at Oakland Inner Harbor, Pier Area, Todd Shipyard, and Western Bayside Alameda Point, California. Prepared for Department of the Navy, Southwest Division Naval Facilities Engineering Command. Contract No. GS-10F-0275K. May.

National Oceanic and Atmospheric Administration (NOAA). 2004. Tide and Current Tables for San Francisco Bay. Web site available at: http://unr.edu/homegage/edc/tides/.

Naval Energy and Environmental Support Activity (NEESA). 1983. *Initial Assessment Study of Naval Air Station, Alameda, California*. Department of the Navy, Facilities Engineering Command. Port Hueneme, CA. April.

Pain, D. 1996. "Lead in Waterfowl." In: Beyer, W.N., G.H. Heinz, and A.W. Redmon (Eds.), *Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations*. CRC Press, Inc,, Boca Raton, FL.

PRC Environmental Management, Inc. (PRC). 1996. *Draft Naval Air Station Alameda, California, Operable Unit 4, Ecological Risk Assessment: Revision 2* (two volumes). Prepared under CLEAN I Contract No. N62474-88-D-5086, Modification No. 14. July.

Regional Water Quality Control Board, San Francisco Bay Area (RWQCB). 1998. *Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments*. May.

Sanderson, G.C., and F.C. Bellrose. 1986. "A Review of the Problem of Lead Poisoning in Waterfowl." Illinois Natural History Survey, Special Publications No. 4.

Scheuhammer, A.M., and S.L. Norris. 1995. "A Review of the Environmental Impacts of Lead Shotshell Ammunition and Lead Fishing Weights in Canada." Canadian Wildlife Service, Occasional Paper No. 88.

Tetra Tech EM, Inc. (TtEMI). 2000. Technical Memorandum Draft: *Ecological Assessment of the Alameda Point Skeet Range Area*. Prepared for Department of the Navy, Southwest Division Naval Facilities Engineering Command. February 20.

United States Army Corps of Engineers (USACE) and Port of Oakland. 1998. *Oakland Harbor Navigation Improvement (-50 Foot) Project Final Environmental impact Statement/Report*. Prepared by the U.S. Army Corps of Engineers San Francisco District and Port of Oakland. May.

United States Environmental Protection Agency (U.S. EPA). 1989. *Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A)*. EPA/540/1-89/002. Prepared by Office of Emergency and Remedial Response, Washington, DC.

Attachment A

Site Specific Administrative Record Index

ALAMEDA POINT NAS

DRAFT ADMINISTRATIVE RECORD FILE INDEX - UPDATE (SORTED BY RECORD DATE/RECORD NUMBER)

SITE 29 - SKEET RANGE

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 000205 G477703 & SWDIV SER 06CA.MB/0707 PLAN GS-10F-0275K 00240	07-12-2001 07-10-2001 NONE	BATTELLE NAVFAC - SOUTHWEST DIVISION	DRAFT SKEET RANGE EVALUATION WORK PLAN - INCLUDES SWDIV TRANSMITTAL LETTER BY M. MCCLELLAND [A PORTION OF THE MAILING LIST IS CONFIDENTIAL]	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	DQO TPH WORK PLAN	029	FRC - LAGUNA NIGEL 181-03-0179 10 OF 46 MF104521
N00236 / 002082 NONE CORRESP NONE 00001	08-19-2005 08-15-2001 NONE	U.S. EPA - SAN FRANCISCO A. COOK NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND	REVIEW AND NO ADDITIONAL COMMENTS ON THE SKEET RANGE EVALUATION WORK PLAN (WP)	ADMIN RECORD	COMMENTS WP	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002083 NONE CORRESP NONE 00004	08-19-2005 08-15-2001 NONE	CRWQCB - OAKLAND B. JOB NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND	COMMENTS ON THE DRAFT SKEET RANGE EVALUATION WORK PLAN (WP)(PORTION OF MAILING LIST IS CONFIDENTIAL)	ADMIN RECORD CONFIDENTIAL	COMMENTS WP	029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002084 NONE CORRESP NONE 00005	08-19-2005 **08-16-2001** NONE	DFG - SACRAMENTO C. HUANG NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND	COMMENTS ON THE DRAFT SKEET RANGE EVALUATION WORK PLAN (WP)	ADMIN RECORD	COMMENTS WP	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002085 NONE CORRESP NONE 00002	08-19-2005 **08-17-2001** NONE	FISH & WILDLIFE - SACRAMENTO J. HAAS NAVFAC - SOUTHWEST DIVISION M. MCLELLAND	COMMENTS ON THE DRAFT SKEET RANGE EVALUATION WORK PLAN (WP)	ADMIN RECORD	COMMENTS WP	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002086 NONE CORRESP NONE 00004	08-19-2005 **09-06-2001** NONE	DTSC - BERKELEY D. MURPHY NAVFAC - SOUTHWEST DIVISION M. MCLELLAND	COMMENTS ON THE FORMER SKEET RANGE DRAFT SAMPLING PLAN FOR ECOLOGICAL RISK ASSESSMENT (ERA)	ADMIN RECORD	COMMENTS ERA	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 000278 G477703 PLAN GS-10F-0275K 00050	11-02-2001 **10-19-2001** NONE	BATTELLE NAVFAC - SOUTHWEST DIVISION	DRAFT SKEET RANGE EVALUATION SITE SPECIFIC HEALTH AND SAFETY PLAN	ADMIN RECORD INFO REPOSITORY	BTEX FSP PAH PCB RI SHSP TPH	029	FRC - LAGUNA NIGEL 181-03-0179 13 OF 46 MF104521

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 000268 G477703 & SWDIV SER 06CM.MB/1075 & 1167 PLAN GS-10F-0275K 00100	11-02-2001 **11-01-2001** NONE	BATTELLE NAVFAC - SOUTHWEST DIVISION	FINAL SKEET RANGE EVALUATION WORK PLAN INCLUDES SWDIV TRANSMITTAL LETTER BY M. BLOOM. ***COMMENTS: THE "DRAFT FINAL" DATED 10/16/01, BECAME "FINAL" ON 11/01/01 - NEW COVER PAGE HAS BEEN INSERTED INTO THE DOCUMENT TO REFLECT THE CHANGE***	ADMIN RECORD INFO REPOSITORY	BCT FSP OU PAH PCB RI TPH-DRO	029	FRC - LAGUNA NIGEL 181-03-0179 13 OF 46 MF104521
N00236 / 000280 PROJECT NO. G477703 PLAN N47408-95-D-0730 00225	11-30-2001 **11-27-2001** NONE	BATTELLE H. KITCHEN NAVFAC - SOUTHWEST DIVISION	SKEET RANGE EVALUATION - SITE-SPECIFIC HEALTH AND SAFETY PLAN	ADMIN RECORD INFO REPOSITORY	BTEX COPEC DATA H&SP ORDNANCE PAH PCB SEDIMENTS SSHP TPH UXO	029	FRC - LAGUNA NIGEL 181-03-0179 13 OF 46 MF104521
N00236 / 002087 NONE CORRESP NONE 00008	08-19-2005 **07-02-2002** NONE	ENTRIX J. HOLDER NAVFAC - SOUTHWEST DIVISION M. BLOOM	MEMORANDUM - SENSITIVITY ANALYSIS ON EXPOSURE PARAMETERS FOR THE SKEET RANGE BINOMIAL PROBABILITY MODEL AND EXPLORATION OF THE IMPACT OF CORRECTED VS. UNCORRECTED AMPHIPOD DATA ON THE WEIGHT OF EVIDENCE (WOE) APPROACH	ADMIN RECORD	COMMENTS WOE	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 000270 PROJ. NO. G477703 RPT GS-10F-0275K 00120	02-06-2003 **01-28-2003** NONE	VARIOUS AGENCIES NAVFAC - SOUTHWEST DIVISION	DRAFT REMEDIAL INVESTIGATION REPORT FOR SKEET RANGE - INCLUDES ELECTRONIC APPENDICES	ADMIN RECORD INFO REPOSITORY	HPAH LPAH PAH PCB TOC TPH TPH-DRO	029 OU 4	FRC - LAGUNA NIGEL 181-03-0188 1 OF 17 RF5258

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002088 NONE CORRESP NONE 00008	08-19-2005 **04-11-2003** NONE	DTSC - BERKELEY M. LIAO NAVFAC - SOUTHWEST DIVISION A. DICK	REVIEW AND COMMENTS ON THE DRAFT REMEDIAL INVESTIGATION REPORT (RI) FOR THE SKEET RANGE	ADMIN RECORD	COMMENTS OU RI	029 OU 4B	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002089 NONE CORRESP NONE 00004	08-19-2005 **05-02-2003** NONE	FISH & WILDLIFE - SACRAMENTO D. HARLOW NAVFAC - SOUTHWEST DIVISION A. DICK	REVIEW AND COMMENTS ON THE DRAFT REMEDIAL INVESTIGATION (RI) FOR THE SKEET RANGE	ADMIN RECORD	COMMENTS RI	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002107 NONE COMMENTS NONE 00015	08-30-2005 **05-13-2003** NONE	EPA M. RIPPERDA NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND	E-MAIL PROVIDING EPA'S COMMENTS ON DRAFT SKEET RANGE REMEDIAL INVESTIGATION REPORT	ADMIN RECORD INFO REPOSITORY	COMMENTS RI	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002106 SWDIVSER 06CA.AD/1389 RESPONSE NONE 00025	08-30-2005 **10-14-2003** NONE	NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND VARIOUS AGENCIES	RESPONSE TO 14 MAY 2003 COMMENTS ON DRAFT SKEET RANGE REMEDIAL INVESTIGATION REPORT [PORTION OF MAILING LIST IS CONFIDENTIAL]	ADMIN RECORD INFO REPOSITORY	RESPONSE RI	029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002090 SWDIV SER 06CA.AD/1389 CORRESP NONE 00051	08-19-2005 **10-15-2003** NONE	NAVFAC - SOUTHWEST DIVISION M. MCCLELLAND U.S. EPA - SAN FRANCISCO M. RIPPERDA	RESPONSES TO REGULATORY AGENCY COMMENTS ON THE DRAFT REMEDIAL INVESTIGATION (RI) REPORT FOR THE SKEET RANGE {PORTION OF MAILING LIST IS CONFIDENTIAL}	ADMIN RECORD CONFIDENTIAL	COMMENTS RI	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 001754 G477703 & SWDIV SER 06CA.GL/1546 CORRESP GS-10F-0275K 00022	01-14-2004 **12-04-2003** NONE	NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA U.S. EPA - SAN FRANCISCO A. COOK	ADDITIONAL RESPONSES TO COMMENTS ON THE DRAFT REMEDIAL INVESTIGATION (RI) REPORTS FOR THE SEAPLANE LAGOON AND THE SKEET RANGE{PORTION OF MAILING LIST IS CONFIDENTIAL}	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	COMMENTS RI	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 001768 SWDIV SER 06CA.DN/0125 CORRESP NONE 00012	03-01-2004 **12-10-2003** NONE	NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA U.S. EPA - SAN FRANCISCO A. COOK	10 DECEMBER 2003 MEETING MINUTES TO DISCUSS THE NAVY'S RESPONSE TO AGENCY COMMENTS (RTC) ON THE DRAFT SKEET RANGE REMEDIAL INVESTIGATION	ADMIN RECORD INFO REPOSITORY	COMMENTS MTG MINS RI	001 017 029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002100 NONE RESPONSE NONE 00003	08-23-2005 **12-18-2003** NONE	DTSC - BERKELEY M. LIAO NAVFAC - SOUTHWEST DIVISION D. NEWTON	COMMENTS ON RESPONSE TO COMMENTS ON DRAFT REMEDIAL INVESTIGATION (RI) REPORT FOR SKEET RANGE AND OPERABLE UNIT	ADMIN RECORD INFO REPOSITORY	COMMENTS OU RESPONSE RI	029 OU 4B	SOUTHWEST DIVISION - BLDG. 1

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 001859 NONE LTR NONE 00004	08-16-2004 **06-11-2004** NONE	NAVFAC - SOUTHWEST DIVISION T. MACCHARELLA U.S. EPA - SAN FRANCISCO A. COOK	CHANGES MADE TO THE DRAFT FINAL REMEDIAL INVESTIGATION REPORT FOR SKEET RANGE [PORTION OF MAILING LIST IS CONFIDENTIAL]. ***COMMENTS: (W/O ENCLOSURE, DOCUMENT NOT RECEIVED IN AR)***	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	REPORT	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002099 NONE LTR NONE 00001	08-22-2005 **06-29-2004** NONE	U.S. FISH AND WILDLIFE SERVICE B. STANTON NAVFAC - SOUTHWEST DIVISION V. LAU	E-MAIL PROVIDING THE U.S. FISH AND WILDLIFE SERVICE CONCURRENCE WITH NO FURTHER ACTION (NFA) ON DRAFT FINAL REMEDIAL INVESTIGATION (RI) REPORTS FOR SEAPLANE LAGOON AND SKEET RANGE	ADMIN RECORD INFO REPOSITORY	NFA RI	017 029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 001903 SWDIV SER 06CA.DN\0716 & 06CA.DN\0610 RPT NONE 00100	12-06-2004 **07-01-2004** NONE	BATTELLE NAVFAC - SOUTHWEST DIVISION	FINAL REMEDIAL INVESTIGATION REPORT FOR THE SKEET RANGE {PORTION OF MAILING LIST IS CONFIDENTIAL, CD COPY ENCLOSED}. ***COMMENTS: DON IS ISSUING THE REPORT AS A FINAL. REPLACEMENT PAGES ISSUED FOR FINAL REMEDIAL INVESTIGATION REPORT DATED FOR 13 JULY 2004. REPLACED PAGES: REPORT COVER PAGE, TOC PAGE IX, X, XI, XII, PAGES 109 THROUGH 114.***	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	PCB TOC TPH VOC	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 001862 NONE LTR NONE 00004	08-16-2004 **07-13-2004** NONE	NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA U.S. EPA - SAN FRANCISCO A. COOK	REPLACEMENT PAGES FOR FINAL REMEDIAL INVESTIGATION (RI) REPORT FOR SKEET RANGE [PORTION OF MAILING LIST IS CONFIDENTIAL]. ***COMMENTS: (W/O ENCLOSURE, REPLACEMENT PAGES NOT RECEIVED IN AR)***	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY		029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 001889 SER BPMOW.DN\0044 RPT NONE 00009	10-27-2004 **10-25-2004** NONE	BRAC - SAN DIEGO R. PLASEIED USEPA - SAN FRANCISCO A. COOK	DRAFT PROPOSED PLAN FOR FORMER SKEET RANGE	ADMIN RECORD INFO REPOSITORY	IRP PAH	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002091 NONE COMMENTS NONE 00002	08-22-2005 **12-18-2004** NONE	EPA - SAN FRANCISCO M. RIPEPERDA NAVFAC - SOUTHWEST DIVISION D. NEWTON	COMMENTS ON THE DRAFT PROPOSED PLAN FOR THE SKEET RANGE AND CONCURRENCE FOR NO FURTHER ACTION (NFA) AT THIS SITE	ADMIN RECORD INFO REPOSITORY	COMMENTS NFA	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002097 NONE RPT NONE 00006	08-22-2005 **02-01-2005** NONE	NAVFAC - SOUTHWEST DIVISION NAS - ALAMEDA POINT	PROPOSED PLAN FOR FORMER SKEET RANGE	ADMIN RECORD INFO REPOSITORY	ARRA IR	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002093 NONE COMMENTS NONE 00004	08-22-2005 **02-09-2005** NONE	DTSC - BERKELEY M. LIAO NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA	COMMENTS ON PROPOSED PLAN FOR FORMER SKEET RANGE	ADMIN RECORD INFO REPOSITORY	COMMENTS	029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002094 NONE PUB NOTICE NONE 00001	08-22-2005 **02-11-2005** NONE	ALAMEDA JOURNAL GENERAL PUBLIC	PUBLIC NOTICE: PUBLIC MEETING AND COMMENT PERIOD FROM 15 FEBRUARY TO 18 MARCH 2005 ON PROPOSED PLAN FOR FORMER SKEET RANGE (DOCUMENT ORIGINATED FROM NAVFAC - SOUTHWEST DIVISION)	ADMIN RECORD INFO REPOSITORY	COMMENTS PUBNOT	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002095 NONE PUB NOTICE NONE 00001	08-22-2005 **02-11-2005** NONE	THE OAKLAND TRIBUNE GENERAL PUBLIC	PUBLIC NOTICE: PUBLIC MEETING AND COMMENT PERIOD FROM 15 FEBRUARY TO 18 MARCH 2005 ON PROPOSED PLAN FOR FORMER SKEET RANGE (DOCUMENT ORIGINATED FROM NAVFAC - SOUTHWEST DIVISION)	ADMIN RECORD INFO REPOSITORY	PUBNOT	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002096 NONE COMMENTS NONE 00003	08-22-2005 **03-20-2005** NONE	RAB MEMBER G. HUMPHREYS NAVFAC - SOUTHWEST DIVISION	COMMENTS ON PROPOSED PLAN FOR FORMER SKEET RANGE (INCLUDES PUBLIC COMMENT FORM)	ADMIN RECORD INFO REPOSITORY	COMMENTS	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002092 NONE LTR NONE 00002	08-22-2005 **03-23-2005** NONE	CRWQCB - SAN FRANCISCO J. HUANG NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA	CONCURRENCE WITH NO FURTHER ACTION (NFA) ON PROPOSED PLAN FOR FORMER SKEET RANGE (PORTION OF MAILING LIST IS CONFIDENTIAL)	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	NFA	029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002115 SWDIV SER BPMOW.DN\0615 LTR NONE 00002	09-12-2005 04-12-2005 NONE	NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA EPA - SAN FRANCISCO A. COOK	SHCEDULE EXTENTION REQUEST FOR SKEET RANGE DRAFT RECORD OF DECISION (ROD)	ADMIN RECORD INFO REPOSITORY	ROD	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002014 PROJ NO. G486085 & SWDIV SER BPMOW.DN/0619 RPT N47408-01-D-8207 00075	04-19-2005 04-18-2005 NONE	BATTELLE NAVFAC - SOUTHWEST DIVISION	DRAFT RECORD OF DECISION (ROD) FOR THE SKEET RANGE	ADMIN RECORD INFO REPOSITORY	PAH ROD TPH	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002102 NONE CORRESP NONE 00001	08-23-2005 06-13-2005 NONE	U.S. EPA - SAN FRANCISCO M. RIPPERDA NAVFAC - SOUTHWEST DIVISION D. NEWTON	COMMENTS ON DRAFT RECORD OF DECISION (ROD) FOR THE SKEET RANGE	ADMIN RECORD INFO REPOSITORY	COMMENTS ROD	029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002101 NONE COMMENTS NONE 00001	08-23-2005 06-16-2005 NONE	CRWQCB - SAN FRANCISCO J. HUANG NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA	CONCURRENCE WITH NO FURTHER ACTION (NFA) ON THE DRAFT RECORD OF DECISION (ROD) FOR SKEET RANGE	ADMIN RECORD INFO REPOSITORY	IR NFA ROD	029	SOUTHWEST DIVISION - BLDG. 1

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

UIC No. / Rec. No. Doc. Control No. Record Type Contr./Guid. No. Approx. # Pages	Prc. Date Record Date CTO No. EPA Cat. #	Author Affil. Author Recipient Affil. Recipient	Subject/Comments	Classification	Keywords	Sites	Location FRC Access. No. FRC/SWDIV Box No. FRC Warehouse Loc. CD No.
N00236 / 002103 NONE LTR NONE 00003	08-23-2005 **06-23-2005** NONE	DTSC - SACRAMENTO A. LANDIS NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA	NO FURTHER ACTION (NFA) ON THE DRAFT RECORD OF DECISION (ROD) FOR SKEET RANGE	ADMIN RECORD CONFIDENTIAL INFO REPOSITORY	NFA RI	001 029	SOUTHWEST DIVISION - BLDG. 1
N00236 / 002114 NONE LTR NONE 00008	09-12-2005 **08-26-2005** NONE	CRWQCB - SAN FRANCISCO J. HUANG NAVFAC - SOUTHWEST DIVISION T. MACCHIARELLA	TRANSMITTAL OF TENTATIVE ORDER (RESCISSION OF SITE CLEANUP REQUIREMENTS) FOR SKEET RANGE AND TRAP CLUB	ADMIN RECORD INFO REPOSITORY	CLEANUP RESCISSION	029	SOUTHWEST DIVISION - BLDG. 1

Total Estimated Record Page Count: 1,126

Total - Administrative Records: 37

((SUBJECT Like "*skeet*" And SUBJECT Like "*range*")) AND [UIC NUMBER]='N00236'

This Administrative Record (AR) Index includes references to documents which cite bibliography sources. These bibliographic citations are considered to be part of this AR but may not be cited separately in the index.

Attachment B

Agency Agreement Letters

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

December 18, 2004

Mr. Darren Newton
Department of the Navy
Program Management Office West
1230 Columbus Street, Suite 1100
San Diego, CA 92101-8571

Dear Darren:

Subject: EPA Comments on the Draft Proposed Plan for the Skeet Range at Alameda Point.

EPA has reviewed the Proposed Plan for the Skeet Range at Alameda Point and we concur with the Navy's proposal of No Further Action at this site. We do not expect the lead shot to pose an unacceptable risk to diving birds nor other ecological receptors. In addition, the shot does not pose a threat to human health.

The document is generally well written and effective. We do have the following comments on the text of the document.

1. In the future, please send the text draft before putting it in lay-out. This is an important issue that our community involvement coordinators raise with almost every proposed plan. They want to comment on the text before the layout starts to make modifications difficult.

2. The order of presentation at the beginning does not encourage public participation. The current first sentence is a bit too full of information, but the comment invitation isn't until the third paragraph. Also, the current first paragraph is loaded with acronyms that readers will likely not be able to remember as they read further. This first paragraph could begin something like:

> "The US Navy encourages the public to comment on its Proposed Plan for no further action at the Alameda NAS Skeet Range (IR Site 29). The public comment period... The public meeting to receive written and verbal comments is..."
>
> A second paragraph could contain the references to the RI, i.e., "...the Navy looked extensively at the contaminants, their location and their potential affect on plant, animals and humans in a study called a remedial investigation (RI)."

3. Some phrasing in the second paragraph does not encourage public participation: "...BRAC Cleanup Team...has determined through consultation with F&W..." This is pre-decisional language, The above sentence is also quite long (11 lines long).

4. Regarding the map, there are two yellow boxes on the western boundary that are confusing, since they have nothing to do with this proposed action. Instead, please highlight the Skeet Range.

5. There is a small formatting issue on Page 2, where the last line of the sentence seems to get lost on the second column.

6. The discussion of ecological risk assessment on pages 3 and 4 is confusing. The difference between screening and base-line risk assessments is difficult to present in a short proposed plan, and a probability distribution model is almost impossible to explain. Perhaps retain paragraphs 1 through 4, but change paragraph 5 to: "Models which took into account the field collected lead shot data, the NOAEL and exposure factors such as the amount of time that a bird spends at the site predict that an unacceptable risk is not posed to diving birds at this site". The rest of this section (except for the italicized conclusion) could then be deleted.

7. On Page 5, there is a reference to the documents being at the information repositories. Please add "(see locations listed on Page 1)".

8. The public meeting date should be held well after the holiday season is over.

9. The first page headline in red font does not encourage public participation. Although it does not use explicit pre-decisional language (instead it uses "indicate"), it does potentially send a similar message. Something like "Navy Proposes No Further Action at Skeet Range" or "Navy Comment Period Begins for Skeet Range" are possibilities.

10. The document states in a couple places that the conditions at the site do not present "a significant risk." More appropriate language based on EPA's ROD guidance is whether a site presents "an unacceptable risk".

11. The human health risk assessment section concludes that: "Risks along the adjacent shoreline are comparable to background". If this is also an acceptable risk, then please add a statement to that affect.

Please call me at (415) 972-3028 if you would like to discuss our comments on the Proposed Plan.

Sincerely,

Mark Ripperda
Remedial Project Manager

Terry Tamminen
Agency Secretary
Cal/EPA

Department of Toxic Substances Control

Edwin F. Lowry, Director
700 Heinz Avenue, Suite 200
Berkeley, California 94710-2721

Arnold
Schwarzenegg
Governor

February 9, 2005

Mr. Thomas L. Macchiarella
Southwest Division Naval Facilities Engineering Command
Attn: Code 06CA.TM
1220 Pacific Highway
San Diego, CA 92132-5190

PROPOSED PLAN, FORMER SKEET RANGE (IR SITE 29), ALAMEDA POINT, ALAMEDA, CALIFORNIA

Dear Mr. Macchiarella:

The Department of Toxic Substances Control (DTSC) appreciates the opportunity to review the advanced copy of the Proposed Plan for the above referenced site and offers the following comments.

1. The Proposed Plan should make it clear that the shoreline/beach area is not part of IR Site 29 and that it will be investigated as part of the adjoining IR Site 1.

2. DTSC does not object to a No Further Action (NFA) decision for IR Site 29 based on the information currently available as well as the relatively small size, marginal habitat, and Navy's acknowledgment that the shoreline/beach area will be investigated.

3. DTSQ does not necessarily agree to certain technical issues in evaluating lead shot as part of an ecological risk assessment. Our position is outlined in the attached January 26, 2005 memorandum prepared by the Human and Ecological Risk Division (HERD).

4. DTSC considers all action pursuant to the Health and Safety Code (HSC), Chapter 6,5, Section 25200.10 and the California Code of Regulation (CCR), Title 22, 5ection 66264.801 have been taken at IR Site 29.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our website at www.dtsc.ca.gov.

Printed on Recycled Paper

Please contact me at 510-540-3767 or mliao@dtsc.ca.gov if you have any questions.

Sincerely,

Marcia L. Liao

Marcia Liao
Remedial Project Manager
Office of Military Facilities

Attachment

Cc (via US Mail and email):

Mr. Mark Ripperda
Remedial Project Manager
U.S. EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Ms. Judy Huang, P.E.
Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612

Cc (via email):

Greg Lorton, SWDiv, Gregory.Lorton@navy.mil
Darren Newton, SWDiv, Darren.Newton@navy.mil
Elizabeth Johnson, City of Alameda, ejohnson@ci.alameda.ca.us
Peter Russel, Russel Resources, peter@russellresources.com
Jean Sweeney, RAB Co-Chair, jean_sweeney@juno.com
Lea Loizos, Arc Ecology, lealoizos@mindspring.com

an C. Lloyd, Ph.D.
Agency Secretary
CalEPA

Department of Toxic Substances Control

700 Heinz Avenue, Suite 200
Berkeley, California 94710-2721

Arnold Schwarzene
Governor

TO: Marcia Liao, Project Manager
OMF Berkeley Office
700 Heinz Street, Second Floor
Berkeley, CA 94704

FROM: James M. Polisini, Ph.D.
Staff Toxicologist, HERD
1011 North Grandview Avenue
Glendale, CA 91201

DATE: January 26, 2005

SUBJECT: NAVAL AIR STATION ALAMEDA (ALAMEDA POINT) FORMER SKEET RANGE PROPOSAL FOR NO FURTHER ACTION
[SITE 201209-18 PCA 18040 H:22]

BACKGROUND

All the documents listed below were reviewed by HERD over the past month. HERD received 4 electronic documents for review regarding the Skeet Range at Naval Air Station (NAS) Alameda on January 11, 2006. These documents were:

1. Draft Skeet Range Remedial Investigation Report, Additional Response to Comments, California Department of Interior Fish and Wildlife Service, dated June 11, 2004 (fnl SKR RI AppF-3 DTSC.pdf).
2. Draft Skeet Range Remedial Investigation Report, Additional Response to Comments, U.S. Department of Interior Fish and Wildlife Service, dated December 4, 2003 (fnl SKR RI AppF-2 RTC USFWS.pdf).
3. Draft Skeet Range Remedial Investigation Report, Response to Comments (fnl SKR RI AppF-1 several.pdf), cover-page dated September 30, 2003 with a header of October 15, 2003, containing:
   a. Draft Skeet Range Remedial Investigation Report, Response to Comments, U.S. EPA Region IX dated May 14, 2003;
   b. Draft Skeet Range Remedial Investigation Report, Response to Comments, California Department of Toxic Substances Control dated March 5, 2003;
   c. Draft Skeet Range Remedial investigation Report, Response to Comments, California Regional Water Quality Control Board dated June 24, 2003 including Attachment A for the Binomial Model;

HERD also received an electronic copy of a No Further Action Briefing (Site 29 NFA Briefing.doc) complete with maps. The file has a date stamp of January 16, 2005.

The minutes of the RTC meeting December 10, 2003 regarding the NAS Alameda Skeet Range subsequently were delivered via facsimile copy on January 19, 2005.

NAS Alameda was an active naval facility from 1940 to 1997. Operations included aircraft, engine, gun and avionics maintenance; fueling activities; and metal plating, stripping and painting. An unconfined landfill exists on the margin of San Francisco Bay in the western bayside area of NAS Alameda. In addition to skeet range activities, linked storm water and industrial wastewater lines discharged to the Seaplane Lagoon in the Northwest and Northeast comers, as well as the Oakland Inner Harbor Channel side of NAS Alameda.

The skeet range is located on the northwestern boundary of Naval Air Station (NAS) Alameda and was developed offshore as two active shooting ranges (northern and southern) and operated for approximately 30 to 40 years. The skeet range was closed in 1993. The Contaminants of Concern (COCs) are lead in sediment and lead shot in addition to polycyclic aromatic hydrocarbons (PAHs) associated with clay targets and clay target fragments.

GENERAL COMMENTS

This memorandum outlines only the remaining technical concerns regarding the assessment of the ecological hazard posed by lead shot at the NAS Alameda Skeet Range. These comments are meant to define HERD's position, for the administrative record, on the major technical issues in evaluating lead shot as part of an ecological risk assessment. No response is required of the Navy or Navy contractors.

SPECIFIC COMMENTS

1. Toxicity of lead shot. There are no toxicity experiments for diving ducks, which the regulators or the Navy were able to locate, that mimic the daily exposure which would occur in the wild. Best scientific judgment was employed separately both by the Navy and HERD to develop a number of shot which would approximate a No Observable Adverse Effect Level (NOAEL) with daily intake. The Navy estimate is 2 to 9 (number 7 ½ to 9 shot), the HERD estimate is 3 to 5 (number 7 ½ to 9 shot), The Navy incorporates a 'residence time' factor for the time lead would remain circulating in the blood. HERD views the 3 to 5 shot as a single dose NOAEL (i.e. 3 to 5 number 7 ½ to 9 shot per bird). Subsequent intake of 3 to 5 shot could most likely be tolerated once lead from the initial intake cleared the bird, that is the blood lead mobile in the tissues of the bird has dropped to pre-exposure concentrations. This clearance time would be related to the 'residence time' proposed by the Navy, but HERD is uncertain of the range of values which would be appropriate for a clearance time.

   Another factor in evaluating the toxicity of lead shot is the rate or possibility of clearance. None of the references reviewed by HERD indicated whether ingested shot was cleared from the bird gastrointestinal (GI) tract. If some or all lead shot cleared the Gl tract of the experimental birds demonstrating adverse effects, those adverse effects would be related to the smaller absorbed dose of lead, not the total ingested dose of lead, and the toxicity of lead shot would be greater than that estimated.

HERO notes that the median of the Navy-derived NOAEL is 3 number 7 ½ to 9 shot, similar to the HERD-derived NOAEL of 3 to 5 number 7 ½ to 9 shot. However, considerable uncertainty is inherent in the extrapolation of the dose schedule of the exposure experiments to field intake rates, retention times in the GI tract and the proportion of dives made specifically to ingest grit-size material. Because of this uncertainty, HERD continues to regard a single intake of 3 to 5 number 7 ½ to 9 lead shot as a NOAEL dose of diving ducks and other similar bottom-feeding avian

2. The population effect level. A population effect level of $1x10^{-3}$ (1 in a thousand birds) is used in the Navy assessment of the NAS Alameda Skeet Range. The USFWS agrees with the $1x10^{-3}$ population level effect, as presented in the minutes of the December 10, 2003 meeting. The San Francisco Regional Water Quality Control Board (SFRWQCB) has previously used $1x10^{-4}$ (4 in ten thousand) as a population level effect at the Castro Cove site on the Chevron Richmond Refinery. However, the SFRWQCB agreed to a determination of No Further Action (NFA) for the NAS Alameda Skeet Range based on 'limited impact on the avian population' (minutes of December 10, 2003 meeting). HERD defers to the USFWS, SFRWQCB and U.S. EPA staff members attending the December 10, 2003 meeting regarding the acceptability of the $1x10^{-3}$ level as reflective of an adverse population effect level.

3. Calculation of Site Use Factor (SUF). HERD agrees with the point made by the USFWS representative, in the minutes of the December 10, 2003 meeting, that the SOF is not related to the distance a bird travels to feed, but to the suitable habitat within that distance. The habitat suitable for feeding is not a dependent variable related to the geometric area encompassed by a circle with a radius of some estimate of travel distance related to feeding. HERD recommends that any SUF for birds be calculated as the fraction the site habitat represents compared to the available feeding habitat within the distance the bird species is known to travel to feed. The response that the water depth of the majority of the NAS Alameda Skeet Range is of a depth utilized by the representative species does not address the point raised, The majority of the habitat within a mean foraging range of 168 km^2 (Attachment A, Table 1) is certainly not of a depth normally foraged upon by the representative receptor group. The Navy should investigate methods to estimate a more ecologically-based SUF for future Ecological Risk Assessments. No response is required from the Navy or the Navy contractors is required for this comment.

4. Natural Mortality. HERO does not necessarily agree with the comparison of natural mortality, presented as 31% of the population per year, to the estimated mortality due to ingestion of lead shot (minutes of December 10, 2003 meeting). If the age-class of the group constituting the 31% annual mortality includes mostly non-reproductive older individuals the population effect of this loss is minimal or negligible.

5. HERD does not object to a finding of No Further Action for ths NAS Alameda Skeet Range. This decision is based on the USFWS description of the Skeet Range as 'exposed and windy' and unlikely to serve as a foraging area for scaups and scoters for extended periods (minutes of the December 10, 2003 meeting}, a personal visit to the NAS Skeet Range on one of those days described and the concurrence of the other regulatory agencies to the ERA for lead shot for the NFA decision.

CONCLUSIONS

HERD does not object to a NFA decision for the NAS Alameda Skeet range based on ths information currently available as well as the relatively small size and marginal habitat of the NAS Alameda Skeet Range.

HERD Internal Review: Michael Anderson
Human and Ecological Risk Division

cc: Sonce DeVries, BTAG Member
U.S. EPA Region IX
Superfund Technical Assistance
75 Hawthorne (SFD-8-B)
San Francisco, CA 94105

Charlie Huang, BTAG Member
California Department of Fish and Game
5700 K Street, Suits 250
P.O. Box 944209
Sacramento, CA 94244-2090

James Haas, BTAG Member
U.S. Fish and Wildlife
Environmental Contaminants Section
2800 Cottage Way (W-2605)
Sacramento, CA 95825

Laurie Sullivan, BTAG Member
Coastal Resources Coordinator (H-1-2)
c/o U.S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

Denise Klimas, BTAG Member
8810 Folsom Blvd., 2nd Floor
P.O. Box 806
Sacramento, California 95812-0806

Ms. Julie Menack
California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612

California Regional Water Quality Control Board
San Francisco Bay Region

Lloyd, Ph.D.
cretary for
vironmental
Protection

1515 Clay Street, Suite 1400, Oakland, California 94612
(510) 622-2300 • Fax (510) 622-2460
http://www.waterboards.ca.gov/sanfranciscobay

Arnold Schwarzenegger
Governor

2005 MAR 28 A 9:09
BRAC OFFICE

Date: MAR 23 2005
File: 2199:9285(JCH)

Mr. Thomas L. Macchiarella
BRAC PMO
Attn: Code 06CA.TM
1220 Pacific Highway
San Diego, CA 92132-5190

Subject: Concurrence on No Further Action, Proposed Plan For Former Skeet Range (IR Site 29), Alameda Point, Alameda, California

Dear Mr. Macchiarella:

The San Francisco Bay Regional Water Quality Control Board (Water Board) staff reviewed the *Proposed Plan For Former Skeet Range (IR Site 29), Alameda Point, Alameda, California*, dated February 2005 (Proposed Plan). Based on discussions with Navy and City of Alameda representatives it is staff's understanding that:

1. There will be no future development at this offshore parcel. The site will remain open water.
2. The western boundary for Site 29 ends at the lower low water line. Area above lower low water, including the beach area, will be investigated, and if necessary, remediated as part of IR Site 1.

With the condition that all information presented to the Board is representative of site conditions, staff concurs that no further action is necessary at the former skeet.

Please contact me at (510) 622-2363 or email jchuang@waterboards.ca.gov if you have any questions.

Sincerely,

Judy C. Huang

Judy C. Huang, P.E.
Associate Water Resource Control Engineer
Groundwater Protection and Waste Containment Division

Cc (via US Mail and email):

Ms. Mark Ripperda
Project Manager
U.S. EPA Region IX
75 Hawthorne Street, (SFD-8-2)
San Francisco, CA 94105-3901

Ms. Marcia Liao
Department of Toxic Substances Control
700 Heinz Avenue, Suite 200
Berkeley, CA 94710

Dr. James Polisini
DTSC, Human & Ecological Risk
Division
1011 N. Grandview Avenue
Glendale, CA 91201

Ms. Jean Sweeney
RAB Community Co-Chair
212 Santa Clara Drive
Alameda, CA 94501

Mr. Darren Newton
U.S. Navy
Southwest Division
1230 Columbia Street, Suite 1100
San Diego, CA 92101-8517

Mr. Doug Davenport
Tetra Tech EMI
135 Main Street, Suite 1800
San Francisco, CA 94105

Mr. Dan Baden
Shaw Environment and Infrastructure
4005 Port Chicago Highway
Concord, CA 94520-1120

Ms. Elizabeth Johnson
Alameda Reuse and Redevelopment
Authority
950 West mall Square, Building 1
Alameda, CA 94501

Mr. Peter Russell
Russell Resources
440 Nova Albion Way
San Rafael, CA 94903

Mr. Charlie Huang
Department of Fish and Game
1700 K Street, Room 250
P.O. Box 9444204
Sacramento, CA 94244-2090

Ms. Laurie Sullivan
NOAA
C/O U.S. EPA Region IX
75 Hawthorne Street, (H-1-2)
San Francisco, CA 94105-3901

Newton, Darren CIV (NFECSW)

From: Beckye_Stanton@fws.gov
Sent: Tuesday, June 29, 2004 10:18 AM
To: Lau, Virginia
Cc: black.ned@epa.gov; chuang@OSPR.DFG.CA.GOV; Cook.Anna-Marie@epamail.epa.gov; Newton, Darren CONT (NFECSW); EJohnson@ci.alameda.ca.us; Gunster, Donald G; james_haas@fws.gov; Judy Huang; jp_one@ix.netcom.com; KBrasaemle@TechLawInc.com; laurie.sullivan@noaa.gov; jim leather; Greg Lorton; Pound, Michael J CIV NFECSW, (EFDSW); mliao@dtsc.ca.gov; Nlf@rb2.swrcb.ca.gov; Peter.Russell@NgEnviro.com; pleinwan@dhs.ca.gov; ripperda.mark@epa.gov; ted.splitter@NgEnviro.com; Macchiarella, Thomas L CIV BRAC, (EFDSW); Tom_Suchanek@fws.gov
Subject: Re: Draft Final RI reports for Seaplane Lagoon (IR Site 17) and Skeet Range (IR Site 29)

As stated in the December 10, 2003 meeting, I concur with the Navy's determination of no further action for the skeet range and appreciate the Navy addressing our concerns through the additional Monte Carlo analysis. Thanks, Beckye

****
Beckye Stanton, Ph.D.
Environmental Contaminants Division
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825
916-414-6733 (phone), 414-6713 / -6712 (fax)
Beckye_Stanton@fws.gov

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO RAY REGION

ORDER NO. 93-129

SITE CLEANUP REQUIREMENTS FOR:

ALAMEDA NAVAL AIR STATION
ALAMEDA NAVAL AIR STATION SKEET AND TRAP CLUB
ALAMEDA, ALAMEDA COUNTY

The California Regional Water Quality Control Board, San Francisco Bay Region e (hereinafter called the Board) finds that

1. Site Description - The Alameda Naval Air Station (hereinafter called the Discharger) operated a skeet and trap club at the station. The club is located on the west side of the City of Alameda, adjacent to San Francisco Bay and near the northwest tip of the city (see Figure 1).

2. Site History - The club had been in operation for about 30 to 40 years, but shooting ceased in April 1993. There are signs posted stating that no lead shot is to be used at the club, and it is the intention of the Discharger to eliminate any further discharge of lead into the bay.

3. Source of Pollution - There are two shooing ranges, each with skeet and trap apparatus. The shooting positions are about 100 feet from the bay and face west toward San Francisco. The pellets can land a considerable distance, 300 to 400 feet, from the shooting positions. At this time, no estimate can be given of how much lead is in the bay. Broken clay targets also have been deposited into the bay.

4. Environmental Concerns - The two primary areas of concern are lead and clay target deposition. 3he potential effects of lead from shotgun clubs are well documented. Direct ingestion of lead pellets causes waterfowl deaths. In the San Francisco Bay area, dabbling ducks are at special risk In both fresh and marine water, lead becomes available to biota through the transformation precess of oxidation. Clay targets contain asphaltenes, which in turn can contain polynuclear aromatic hydrocarbons. These types of hydrocarbons are classified as carcinogenic.

5. Scope of this Order - This Order contains prohibitions and tasks that require the Discharger to: 1) cease the deposition of lead shot into waters of the State or waters of the United States; 2) define the extent of lead pollution in waters of the State or waters of the United States; 3) determine the degree to which the lead is biologically available; 4) develop a remedial action plan to cleanup or manage the lead pollution; and 5) implement the remedial action plan.

6. On October 28, 1968, the State Board adopted Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality Waters in California," This policy calls for maintaining the existing high quality of State waters unless it is demonstrated that any change would be consistent with the maximum public benefit and not unreasonably affect beneficial uses. The discharge of waste to the surface water at this site is in violation of this policy. Therefore, the surface water quality needs to be restored to its original quality to the extent reasonable.

7. The Board adopted a revised Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) aa September 16, 1992. The Basin Plan contains water quality objectives and beneficial uses for San Francisco Bay and contiguous surface waters.

8. The existing and potential beneficial uses of central San Francisco Bay and contiguous surface waters include:

   a. Industrial service supply
   b. Industrial process supply
   c. Navigation
   d. Water contact recreation
   e. Non-contact water recreation
   f. Ocean commercial and sport fishing
   g. Wildlife habitat
   h. Preservation of rare and endangered species
   i. Fish migration
   j. Fish spawning
   k Shellfish harvesting
   l. Estuarine habitat

9. The Discharger Las caused or permitted, and threatens to cause or permit, waste to be discharged or deposited where it is or probably will be discharged to waters of the State and creates a condition of pollution or nuisance.

10. This action is an Order to enforce the laws and regulations administered by the Board. This action is categorically exempt from the provisions of the CEQA, pursuant to Section 15321 of the Resources Agency Guidelines.

11. The Board has notified the Discharger and interested agencies and persons of its intent under California Water Code Section l3304 to prescribe Site Cleanup Requirements for the discharge and has provided them with the opportunity for a public hearing and an opportunity to submit their written views and recommendations.

12. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

IT IS HEREBY ORDERED, pursuant to Section 13304 of the California Water Code, that the Discharger shall cleanup and abate the effects described in the above findings as follows:

A. **PROHIBITIONS**

l. The discharge of wastes or hazardous materials in a manner which will degrade, or threaten to degrade, water quality or adversely affect, or threaten to adversely affect, the beneficial uses of the waters of the State or waters of the United States is prohibited.

2. Specifically, the discharge or deposition of lead shot into waters of the State or waters of the United States is prohibited.

B. **PROVISIONS**

1. The Discharger shall perform all investigation and cleanup work in accordance with the requirements of this Order. All technical reports submitted in compliance with this Order shall be satisfactory to the Executive Officer, and, if necessary, the Discharger may be required to submit additional information.

2. To comply with all Prohibitions of this Order, the Discharger shall meet the following compliance task and time schedule:

COMPLIANCE DATE AND TASKS

a. **COMPLIANCE DATE: December 1, 1993**

WORKPLAN FOR BIOLOGICAL CHARACTERIZATION:
Submit a technical report acceptable to the Executive Officer containing a proposal, including a time schedule, to characterize the biology in the area where the lead has been deposited, and determine whether the lead has become biologically available and is affecting, or can potentially affect, plants or animals.

b. **COMPLIANCE DATE. To be established by Executive Officer based on proposal submitted pursuant to Provision 2.a.**

COMPLETION OF BIOLOGICAL CHARACTERIZATION:
Submit a technical report acceptable to the Executive Officer documenting completion of the necessary tasks identified in the technical report acceptable for Provision 2.a.

c. **COMPLIANCE DATE; May 2, 1994**

WORKPLAN FOR SEDIMENT POLLUTION CHARACTERIZATION:
Submit a technical report acceptable to the Executive Officer containing a proposal, including a time schedule, to define the horizontal and vertical extent of lead sediment pollution, including both pellet and finely divided forms.

d. **COMPLIANCE DATE. To be established by Executive Officer based on proposal submitted pursuant to Provision 2.c.**

COMPLETION OF SEDIMENT CHARACTERIZATION: Submit a technical report acceptable to the Executive Officer documenting completion of the necessary tasks identified in the technical report acceptable for Provision 2.c.

e. **COMPLIANCE DATE. To be established by Executive Officer based on proposal submitted pursuant to Provision 2.b. and 2.d.**

REMEDIAL ACTION PLAN: Submit a technical report acceptable to the Executive Officer containing a remedial action plan and an implementation time schedule. This report shall evaluate the removal of lead deposits in San Francisco Bay and, possibly, the adjacent land areas. Removal evaluation shall consider pellet and sediment phases, and the degree of removal may be based on biological data.

f. **COMPLIANCE DATE. To be established by Executive Officer based on proposal submitted pursuant to Provision 2.e.**

COMPLETION OF REMEDIAL ACTION: Submit a technical report acceptable to the Executive Officer documenting the completion of the necessary tasks identified in the technical report acceptable for Provision 2.e.

3. If the Discharger is delayed, interrupted or prevented from meeting one or more of the compliance dates specified in this Order, the Discharger shall promptly notify the Executive Officer, and the Board may consider revisions to this Order.

4. The Discharger shall file a report with the Board at least 30 days in advance of any changes in occupancy or ownership associated with the Site described in this Order.

5. The Board will review this Order periodically and may revise the requirements or compliance schedule when necessary.

I, Steven R. Ritchie, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an Order adopted by the California Regional Water Quality Control Board, San Francisco Region, on October 20, 1993.

Steven R. Ritchie
Executive Officer

Attachments: Figure 1 – Site Map

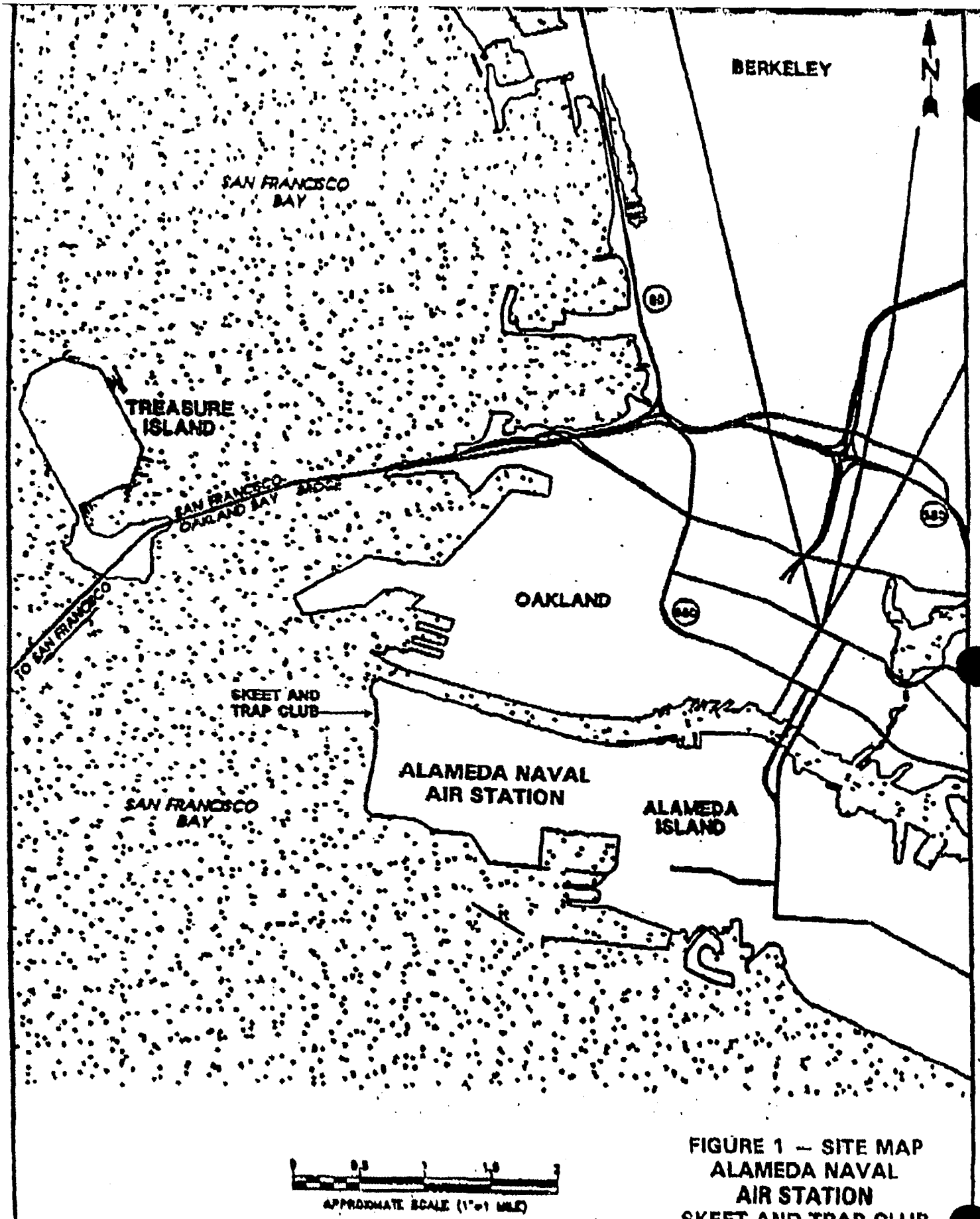


FIGURE 1 — SITE MAP
ALAMEDA NAVAL
AIR STATION
SKEET AND TRAP CLUB

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

June 13, 2005

Mr. Darren Newton
Department of the Navy
Program Management Office West
1230 Columbus Street, Suite 1100
San Diego, CA 92101-8571

Dear Darren:

Subject: EPA Comments on the Draft Record of Decision for the Skeet Range at Alameda Point.

EPA has reviewed the Draft Record of Decision for the Skeet Range at Alameda Point and we concur with the Navy's proposal of No Further Action at this site. The results of the Remedial Investigation and Risk Assessments have shown that the lead shot and polycyclic aromatic hydrocarbons (PAHs) found at this site do not pose an unacceptable risk to either humans or potential ecological receptors such as diving water fowl. The type and concentration levels of the PAHs are similar to surrounding ambient conditions and the lead. shot is found approximately 80 feet offshore. The lead shot is not breaking down and hence, is not readily bio-available. Diving water fowl are not expected to ingest a sufficient quantity of whole pellets to be adversely affected.

The document follows the format of the EPA guidance: *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, and includes all of the necessary elements for a No Further Action Record of Decision.

Please call me at (415) 972-3028 if you would like to discuss this Draft Record of Decision.

Sincerely,

Mark Ripperda
Remedial Project Manager

cc. Marcia Lau, DTSC
Judy Huang, RWQCB
Peter Russell, Russell Resources

California Regional Water Quality Control Board
San Francisco Bay Region

Ian [illegible]d, Ph.D.
Se[illegible]y for
Environmental
Protection

1515 Clay Street, Suite 1400, Oakland, California 94612
(510) 622-2300 • Fax (510) 622-2460
http://www.waterboards.ca.gov/sanfranciscobay

Arnold Schwarzenegger
Governor

Date: JUN 16 2005
File: 2199.9285(JCH)

Mr. Thomas L. Macchiarella
BRAC PMO
Attn. Code 06CA.TM
1220 Pacific Highway
San Diego, CA 92132-5190

Subject: Comments on the Draft Recor6 of Decision for Skeet Range (Installation Restoration Site 29), Alameda Point, Alameda, California

Dear Mr. Macchiarella:

The San Francisco Bay Regional Water Quality Control Board (Water Board) staff reviewed the *Draft Record of Decision for Skeet Range (Installation Restoration Site 29), Alameda Point, Alameda, California*, dated April 20, 2005 (Draft ROD) and concurs with the conclusion that no further action is needed at this site.

The Installation Restoration (IR) Site 29 is located on the northwestern corner of former NAS Alameda. IR Site 29 extends offshore into the San Francisco Bay with dimensions of about 1,300 feet by 800 feet. The primary site-related contaminants are lead shots and polycyclic aromatic hydrocarbons (PAHs) from the clay targets located approximately 80 feet offshore. The results of the Remedial Investigation and Risk Assessments have shown that the lead shot and PAHs found at this site do not pose an unacceptable risk to either humans or potential ecological receptors such as diving waterfowl.

Staff intends to recommend to the Executive Officer of the Water Board to sign the Record of Decision, provided Department of Toxic Substances Control, the lead State Agency for Alameda Point, does not have significant and substantial comments. Please contact me at (510) 622-2363 or email jchuang@waterboards.ca.gov if you have any questions.

Sincerely,

Judy C. Huang

Judy C. Huang, P.E.
Associate Water Resource Control Engineer
Groundwater Protection and Waste
Containment Division

Cc (via US Mail and email):

Mr. Mark Ripperda
Project Manager
U.S. EPA Region IX
75 Hawthorne Street, (SPD-8-2)
San Francisco, CA 94105-3901

Ms. Marcia Liao
Department of Toxic Substances Control
700 Heinz Avenue, Suite 200
Berkeley, CA 94710

Mr. Darren Newton
U.S. Navy
Southwest Division
1230 Columbia Street, Suite 1100
San Diego, CA 92101-8517

Department of Toxic Substances Control

Alan C. Lloyd, Ph.D.
Agency Secretary
Cal/EPA

8800 Cal Center Drive
Sacramento, California 95826-3200

Arnold Schwarzenegger
Governor

June 23, 2005

Mr. Thomas L. Macchiarella
Southwest Division Naval Facilities Engineering Command
Code 06CA.TM
1220 Pacific Highway
San Diego, California 92132-5190

DETERMINATION OF NO FURTHER ACTION, INSTALLATION RESTORATION SITE 29, SKEET RANGE, ALAMEDA POINT, ALAMEDA, CALIFORNIA

Dear Mr. Macchiarella:

The Department of Toxic Substances Control (DTSC) has reviewed the draft Record of Decision (ROD), dated April 20, 2005, for Installation Restoration (IR) Site 29 at Alameda Point. The draft ROD documents the Navy's conclusion that the site does not pose unacceptable risk to human health or the environment, and that no remedial action is needed at this site.

DTSC, based on the review of the Remedial Investigation Report dated July 2004, has determined that the site characterization conducted to date supports the conclusion that no further action (NFA) is appropriate for IR Site 29, This determination is based on the following understanding that

- IR Site 29 will remain open water and there will be no future development at this offshore parcel.
- The shoreline and nearshore areas adjacent to IR Site 29 will be addressed as part of IR Site 1 and the Offshore Sediment Study.

Please be advised that this NFA determination is based on existing information available to DTSC at this time. In the event that new information indicating environmental concerns is identified, DTSC reserves the right to require additional investigation and possible remediation as the situation warrants.

Please feel free to contact Marcia Liao, of my staff, at (510) 540-3767 or mliao@dtsc.ca.gov should you have any questions.

Sincerely

Anthony J. Landis, P.E.
Chief
Northern California Operations
Office of Military Facilities

cc: Ms. Elizabeth Johnson
950 W. Mall Square, Building 1
Alameda Point
Alameda, California 94501

Dr. Peter Russell
Russell Resources, Inc.
440 Nova Albion Way, Suite 4
San Rafael, California 94903-3634

Ms. Lea Loizos
Arc Ecology
833 Market Street, Suite 1107
San Francisco, California 94103

Mr. Greg Lorton
Southwest Division Naval Facilities Engineering Command
Code 06CA.GL
1220 Pacific Highway
San Diego, California 92132-5190

Mr. Darren Newton
Southwest Division Naval Facilities Engineering Command
Code 06CA.DN
1220 Pacific Highway
San Diego, California 92132-5190

Mr. and Mrs. Jim Sweeney
RAB Community Co-Chair
212 Santa Clara Avenue
Alameda, California 94501

Mr. Mark Ripperda
US Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, California 94105

Ms. Judy Huang
Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, California 94612

Attachment C

Transcript of Public Meeting and Comments Received on the Proposed Plan

PROPOSED PLAN FOR FORMER SKEET RANGE (IR SITE 29)

ALAMEDA POINT, CALIFORNIA

PUBLIC MEETING

Monday, March 7, 2005

Alameda City Hall West
950 W. Mall Square
Building 1
Community Conference Room
Alameda Point, California

Reported by: Valerie E. Jensen, CSR No. 4401

JAN BROWN & ASSOCIATES
CERTIFIED SHORTHAND REPORTERS
476 Jackson Street, 2nd Floor
San Francisco, California 94111
(415) 981-3498

1 P A R T I C I P A N T S

2

3 PRESENTERS:

4 THOMAS MACCHIARELLA, Navy BRAC Environmental Coordinator

5 DARREN NEWTON, Navy Remedial Project Manager

6

7 OTHER AGENCY, NAVY STAFF AND CONSULTANT REPRESENTATIVES:

8 JENNIFER HOLDER, Ph.D., Blasland, Bouck & Lee, Inc.
JILL VOTAW, Navy Public Affairs Officer
9 MARCIA LIAO, Department of Toxic Substances Control
JUDY HUANG, Regional Mater Quality Control Board
10 MARK RIPPERDA., Environmental Protection Agency
DAVID COOPER, Environmental Protection Agency
11 PETER RUSSELL, Russell Resources, Inc. (ARRA)

12

13 COMMUNITY MEMBERS AND INTERESTED PARTIES:

14 PATRICK LYNCH, Alameda Resident

15

16 TETRA TECH SUPPORT STAFF:

17 TOMMIE JEAN DAMREL, Tetra Tech EMI
DOUG DAVENPORT, Tetra Tech EMI
18 JARED SMITH, Tetra Tech EMI
CRAIG HUNTER, Tetra Tech EMI
19

20

21

22

23

24

25

1 MARCH 7, 2005 6:45 P.M.

2

3 MR. MACCHIARELLA: Okay. Let's go ahead

4 and get started..

5 Welcome, everybody, to the Site 29, or

6 Skeet Range, public meeting for the Proposed Plan.

7 There were some handouts at the door. I

8 hope you all got them — an agenda, public comment

9 form, the Proposed Plan itself.

10 I'd like to mention that the meeting is

11 being recorded, and a transcript will appear in the

12 admin record and information repositories. And,

13 also, please sign in.

14 My name is Thomas Macchiarella, and I

15 represent the Navy through the BRAC Program Management

16 Office West. We report to the Assistant Secretary of

17 the Navy Installations and Environment

18 I've been delegated the authority and

19 responsibility for conducting the environmental

20 restoration activities through the Installation

21 Restoration Program here at Alameda Point. And I

22 really want to thank you for taking your time to be

23 here tonight.

24 Now, the Installation Restoration Program

25 for Alameda Point is managed by the BRAC PMO West,

1 as I mentioned. We also have significant support
2 from the Navy' s Facilities Engineering Command,
3 Southwest Division, which. is essentially a large
4 group of engineers and specialists who provide
5 expertise to Naval shore facilities.
6 Before I go any deeper, let ma walk
7 through the agenda.
8 Right now we're going through an overview
9 of the Navy's Installation Restoration Program.
10 Right after that we're going to go into a more
11 detailed summary of the Proposed Plan by Mr. Darren
12 Newton.
13 And then, after that, we'll open it up for
14 clarifying questions. We can address any questions
15 that you have on the Proposed Plan or the facts leading
16 up to the Proposed Plan for Site 29.
17 Then, after that, we'll convert into listening
18 mode and accept public comment. And, again, those will
19 still be recorded. And those public comments will be
20 addressed in the Navy's Responsiveness Summary in the
21 Record of Decision. And we'll be here until 8 o'clock
22 accepting comments.
23 The purpose of the Navy's IR program and
24 what is the Installation Restoration Program.
25 Basically, it boils down to we identify,

1 investigate, assess and characterize hazardous
2 substances and clean them up where necessary at
3 this facility, Alameda Point.
4 You may have heard of Superfund. That is
5 essentially CERCLA, the Comprehensive Environmental
6 Response, Compensation and Liability Act. We'll
7 be using that "CERCLA" term a few times in the
8 presentation. Essentially, we want to get all our
9 sites into a site complete or site closeout mode.
10 Here is the CERCLA process or the Installation
11 Restoration Program.
12 It should show up in your handout. Hopefully,
13 you can see it from there. The
14 Preliminary Assessment is the initial
15 steps. Sometimes it's combined with the SI. The
16 Preliminary Assessment, or PA, is where we identify an
17 area that could have some environmental concerns through
18 research of all types.
19 A Site Inspection is where we verify whether or
20 not there has been a release there through initial soil
21 sampling.
22 The Remedial Investigation and Feasibility
23 Studies are sometimes combined. The RI is where we
24 conduct detailed site studies and completely investigate
25 a site, completely delineate the plumes and also conduct

1 Human and Ecological Risk Assessments.

2 The Feasibility Study comes right after

3 that. That's where we develop cleanup solutions or

4 alternatives and evaluate the alternatives against a

5 set of criteria, a consistent set of criteria.

6 And the Proposed Plan, which is where we

7 are right now with Site 29, is where we propose

8 an alternative or a solution, and the public and

9 regulatory agencies provide input.

10 The Record of Decision is an official

11 document that both the Navy and the EM will sign

12 in this case of Alameda Point. In some instances,

13 perhaps other regulatory agencies. The Record of

14 Decision documents the selected remedy which was

15 chosen.

16 After the ROD, the Remedial Design/Remedial

17 Action phases are where we conduct the cleanup action

18 or monitoring or engineering controls or land use

19 controls. And remedial actions could consist of

20 long-term maintenance. And eventually all of the

21 sites will achieve a site completion and a no further

22 action or site closeout designation.

23 We're still talking about the Installation

24 Restoration Program in general of Alameda Point, so

25 you can put Site 29 in context. At Alameda Point

1 we have 35 specific sites listed in the Installation
2 Restoration Program ranging from a Landfill, to service
3 stations, to debris areas.
4 Alameda Point., previously known. as the
5 Naval Air Station Alameda, is listed on the National
6 Priorities List. Therefore, the United States EPA
7 is the lead regulatory agency. In cases where the
8 facilities are not on the National Priorities List,
9 California EPA would likely be the lead regulatory
10 agency.
11 Being listed on the NPL, we also have the
12 Federal Facilities Agreement between the U.S. EPA
13 and the Navy. This FFA essentially spells out how
14 the EPA and the Navy interact in conducting the
15 response actions and outlines processes for items
16 such as funding, prioritization and time tables.
17 The Alameda Point has a BRAC Cleanup Team
18 which consists of four members — a member from the
19 Navy, the U.S. EPA, the California Department of Toxic
20 Substances Control and the San Francisco Bay Regional
21 Water Quality Control Board. Those members are in this
22 room tonight.
23 Also, for Alameda Point Base, on the EPA's
24 requirements, we have a site management plan, which is
25 essentially a detailed schedule for all of our sites

1 in the IR program.

2 Yearly updates for that schedule are required.

3 And we often do them more frequently for the benefit of

4 the BRAC Cleanup Team.

5 Back to Site 29.

6 The Proposed Plan is where we are now. The

7 proposed Plan provides for community involvement. At

8 Alameda Point we have additional areas for community

9 involvement; namely, the Restoration Advisory Board,

10 which meets monthly. That's above and beyond what is

11 required for CERCLA.

12 The Proposed Plan proposes a decision and

13 leads to the Record of Decision. Of course, we'll go

14 into more detail on the specifics of Site 29 in the

15 next presentation.

16 So I'd like to point out that our RAB

17 meetings are open to the public, and they are typically

18 held on the first Thursday of the month downstairs in

19 this building. The purpose of the RAB is to provide

20 advice to the BRAC Cleanup Team and to the Navy and to

21 also act as a conduit of information to the community

22 at large.

23 We have our Navy environmental web site

24 listed on many of our handouts and fact sheets, and

25 you can find out more information about the Restoration

1 Advisory Board there.

2 Before we move on to the next item on the

3 agenda, which is the Proposed Plan Summary, are there

4 any questions on the general Installation Restoration

5 Program?

6 Thank you.

7 Mr. Darren Newton.

8 MR. NEWTON: Thank you.

9 Thank you all for coming this evening.

10 I am Darren Newton. I'm the remedial project

11 manager for the BRAC Program Management Office West, and

12 I'm here to talk about the Installation Restoration for

13 the Site 29 Proposed. Plan. And I'm going to provide a

14 Proposed Plan Summary.

15 There are a couple poster boards over there

16 to be viewed, if you would like.

17 I'd like to go over a short agenda.

18 I want to talk about where the location is,

19 the history of the site, a brief summary of previous

20 investigations and then the site-specific IR process.

21 I'll talk about the complete CERCLA

22 (indicating) process and talk about the site specific.

23 Then I'll discuss briefly the ecological risk

24 assessment, which will then lead me, to the Human

25 Health Risk Assessment, and then, following, the

1 conclusions based on the previous investigations
2 and then end with the next steps.
3 So this is the site location, This is
4 an aerial photograph from the U.S. Geological Survey
5 downloaded from the web site. That is at the bottom,
6 terraserver@rnicrosoft.com. It's from 1993. It's on
7 the northwestern side of Alameda Its approximate
8 location is depicted here on this photograph.
9 A. short history of the site.
10 The site is located on the northwest corner
11 of Alameda. There were two main shooting ranges — the
12 northern and southern range They were actively used
13 for 30 to 40 years.
14 Lead shot and clay target fragments are
15 present in offshore sediments. Lead shot discharged
16 from guns towards clay pigeons projected westerly over
17 the San Francisco Bay. They're concentrated offshore
18 approximately 1300 by 800 feet in water depths ranging
19 from 5 to 12 feet mean low low water
20 Identified as a site-specific concern
21 following the 1994 Ecological Assessment were
22 concerns about wildlife exposure to polynuclear
23 aromatic hydrocarbons -- also known as PAHs – and
24 lead.
25 Let me go through the 1996 and 1998 Skeet

1 Range Site Evaluations.

2 The purpose was to evaluate the density of

3 lead shot in sediment samples collected throughout

4 the site and determine whether lead from the shot is

5 biologically available. The conclusions were density

6 is highest where the shooting ranges overlap and

7 lead is not dissolving in quantities that would cause

8 adverse impacts to the environment.

9 Following along with the 2001 Skeet Range

10 Site Evaluation.

11 The purpose was to evaluate the vertical

12 distribution of lead shot and determine if PAHs present

13 at the site are associated with clay pigeon fragments.

14 The conclusion of that study is the majority of lead

15 shot is buried below five centimeters, and the PAHs

16 in sediments are primarily associated with other

17 background sources from throughout the San Francisco

18 Bay Area and not associated with the clay targets.

19 The 2004 remedial Investigation was

20 performed under CERCLA and included the Human Health

21 and Ecological Risk Assessment.

22 The site-specific IR process.

23 As Tom talked about. earlier, we started

24 with a PA/SI and reviewed the potential contamination

25 at Alameda Point, identified specific areas of concern

1 following the 1994 Ecological Assessment. That fell on
2 to the Remedial Investigation that was conducted from
3 1992 through 2004.
4 At the and of that we reviewed the
5 Ecological and Human Health Risk Assessments. And
6 based on the Human Health Risk Assessments, potential
7 current and future risks associated with exposure
8 to the sediments at the site are insignificant.
9 Therefore, a Feasibility Study was not applicable
10 and was not conducted.
11 So we are here. We're at the No Further
12 Action Proposed Plan, slash, Public Comment Meeting.
13 At this point the public has the opportunity to comment
14 on the Navy's recommendation for no further action.
15 And then to be done is the Record of Decision. And the
16 final decision for the CERCLA and the responses to the
17 public comments are documented in the final Record. of
18 Decision.
19 The Ecological Risk Assessment was conducted,
20 and a conceptual site model was developed to identify
21 ecological receptors, exposure pathways and chemicals
22 of concerns. Diving ducks were identified as the
23 primary ecological receptor. Lead shot and PAHs were
24 identified as the Preliminary Chemicals of Potential
25 Concern. That's COPC.

1 A detailed analysis was conducted to
2 evaluate the potential for diving ducks to ingest
3 lead shot while foraging. And the results demonstrated
4 that less than one in one thousand birds would be at
5 risk.
6 The conclusion of the Ecological Risk
7 Assessment is there are no unacceptable ecological
8 risks in the sediments offshore of the former Skeet
9 Range and the ecological community is not impacted.
10 The Human Health Risk Assessment was
11 conducted.
12 A conceptual site model was developed to
13 identify potential exposure pathways through which
14 humans might be exposed. We have recreational users
15 and workers.
16 The conclusion is no complete exposure
17 pathways identified. Direct human exposures, such
18 as dermal contact or ingestion of sediment, are
19 very limited because site-related contaminants
20 are located approximately 80 feet offshore in
21 water depths of greater than 5 feet. And the
22 indirect human exposure, such as eating fish exposed
23 to the site–related contaminants, is unlikely because
24 neither lead nor PAHs are known to be retained. in the
25 edible tissues of exposed fish.

1 The conclusions, based on previous
2 investigations, are future and current conditions at
3 the site do not pose an unacceptable risk to humans or
4 the environment. Therefore, no land use restrictions,
5 environmental monitoring or RCRA corrective actions
6 are required at the site.
7 The Navy, together with the EPA, the
8 Department of Toxic Substance Control and the Regional
9 Water Quality Control Board recommend no further action
10 is warranted. The Navy's Proposed Decision is no
11 further action for the site.
12 The next steps.
13 This is an opportunity for the community's
14 involvement. We have this public meeting, March 7,
15 2005, and the public comment period for the Proposed
16 Plan February 15 through March 18, 2005. Following
17 the public meeting, we will move into the Record of
18 Decision, which will include consideration of public
19 comments.
20 And that's it for my site-specific Proposed
21 Plan Summary.
22 MR. MACCHIARELLA: Thank you, Mr. Newton.
23 The next item is clarifying questions
24 Do we have any questions before we move on
25 to public comments? We can try our bast to answer them.

1 No questions.

2 Okay. The next item is public comment.

3 Between now and 8 o'clock we'll be here, in listening

4 mode, receiving public comments. We'll record them,

5 of course, and address them in our Responsive Summary.

6 Do we have any comments right now?

7 Please stand up and allow the court reporter

8 to hear.

9 MR. LYNCH: It was in July of 1999 that

10 this site was listed on the National Priorities List,

11 primarily to expedite cleanup that was not occurring

12 under the BRAC Cleanup Program that was initiated in

13 1983.

14 I'm really disappointed that the first

15 Proposed Plan for this site is a location that

16 couldn't be further away from neighboring residential

17 neighborhoods. It really raises an environmental

18 justice concern to me when we see resources being

19 spent on this offshore area again without addressing

20 contamination that exists on the fence line and

21 potentially off site.

22 I took a quote from a document called

23 "Defense Conversion, A Road Map For Communities."

24 This was produced by the East Bay Conversion and

25 Reinvestment Commission in 1996 I think it really

1 states very eloquently why I have a problem with this
2 Proposed Plan.
3 "Environmental justice has not been
4 served by so-called scientific studies and technical
5 risk assessments; in part, because they have not
6 incorporated a meaningful role for effective
7 communities."
8 I'm not surprised that I'm the only
9 community member here. Who's going to come in here
10 and discuss Monte Carlo simulations and probability?
11 I mean, those are things that were discussed at a
12 SeaTac conference in 2003, where they gave a
13 presentation on the work here. They were also
14 presented at a 2004 international conference in Venice,
15 Italy.
16 You know, I don't see the point in spending
17 limited cleanup dollars performing this kind of research
18 at this facility when there is no meaningful cleanup
19 occurring.
20 And, you know, I'm also concerned that this
21 is a proposal to leave this contamination at the site
22 of a proposed public beach. We'll spend between 150
23 million and 500 million dollars, largely to prevent
24 contamination on this base from making its way into
25 the bay.

1 We have clearly-defined contamination in
2 the bay, and we're not willing to remove it. Maybe
3 it's too expensive. But we don't know that, because
4 we're not willing to do a Feasibility Study and
5 produce a cost estimate of what it would cost to do
6 that remediation
7 And it might be that this contamination will
8 pose a risk in the future, but because we're not going
9 to do a Record of Decision where we recognize we're
10 leaving toxic material in the bay, there's not going to
11 be a five-year follow-up.
12 And so, you know, I really think that we need
13 to do the complete step. We need to do the Feasibility
14 Study, demonstrate that this is cost prohibitive. And
15 I think we need to reach a Record of Decision where
16 there will be some review of the decision.
17 I've been involved in a lot of clean-ups,
18 sites where — one of the base cleanup members here
19 on another Navy base, DTSC closed a waste oil tank,
20 and then it was discovered that waste oil tank is the
21 source of contamination over a large area of the base.
22 So, again, you know, people make mistakes.
23 I think, for that reason, there really needs to be a
24 five-year review on this particular site.
25 MR. MACCHIARELLA: Thank you, sir.

1 Would you like to state your name and
2 address for the record?
3 MR. LYNCH: It's Patrick Lynch, Alameda,
4 California.
5 MR. MACCHIARELLA: Any other comments?
6 Sir?
7 MR. RUSSELL: My name is Peter Russell.
8 I'm an environmental advisor for the Alameda Reuse
9 and Redevelopment Authority. Most people call it
10 "ARRA." It' s easier to handle.
11 We're going to be submitting written
12 comments, and I'm simply going to paraphrase them now
13 The gist is a single comment; that is, that
14 the shoreline is slated to be a public beach, and we
15 want to make sure there are no gaps in the evaluation
16 so that recreational use would be compromised.
17 There are two brief passages out of the
18 Proposed Plan that I would like to read that leave
19 me with a little bit of wonder about whether that is
20 going to be fully addressed by either IR 29 or IR 1.
21 The first is on Page 2 -- and I will quote it — in
22 the righthand side column. "As a result, lead shot, as
23 well as clay target fragments, reside in the offshore
24 sediment adjacent to the Skeet Range concentrated in
25 an offshore area approximately 1300 feet by 800 feet in

1 average water depths ranging from 5 to 12 feet mean low
2 low water."
3 It should be "lower low water," but that's
4 not...
5 "The adjacent shoreline beach areas will be
6 investigated as part of IR Site 1."
7 Then on Page 5 in the lefthand column
8 there's a sentence, "However, the primary site-related
9 contaminants (lead shot and PAHs from the clay targets)
10 are located approximately 80 feet offshore in water
11 depths ranging — averaging 5 feet or greater."
12 So I think the possible gap is not the
13 beach itself, which I think, quite clearly, will be
14 picked up by IR 1, but the water that is 5 feet deep
15 and shallower that runs from the beach itself out to
16 the 80 feet offshore where the IR 29 proper begins
17 I think that needs to be looked at to verify that
18 there are no unacceptable health hazards — human
19 health hazards — for recreational land use.
20 MR. MACCHIARELLA: Thank you.
21 MR. RUSSELL: The written comments would be
22 sufficient. You don't have to respond to both sets.
23 MR. MACCHIARELLA: Thank you.
24 Any other comments?
25 Okay. Then I think we can sort of rest.

1 We'll be here until 8 o'clock if any other

2 public members come in and want to comment.

3 (Off the record at 7:06 p.m.)

4 ///

5 ///

6 ///

7 (Back on the record at 8 p.m.)

8 MR. MACCHIARELLA: Let the record show that

9 we, at 8 o'clock, completed the public comment period

10 of this meeting. And public comments will be accepted

11 until March 18th.

12 Thank you, everyone, for coming.

13 (Off the record at 8 p m.)

14

15

16

17

18

19

20

21

22

23

24

25

1 STATE OF CALIFORNIA SS.

2 I do hereby certify that the meeting

3 was held. at the time and place therein stated; that

4 the statements made were reported by me, a certified

5 shorthand reporter and disinterested. person, and were,

6 under my supervision, thereafter transcribed into

7 typewriting.

8 And I further certify that I am

9 not of counsel or attorney for either or any of the

10 participants in said hearing nor in any way personally

11 interested or involved in the matters therein discussed.

12 IN WITNESS WHEREOF, I have hereunto set

13 my hand and affixed my seal of office this 9th day of

14 March 2005.

15

16

17

18 ----------

19 VALERIE E. JENSEN

20 Certified Shorthand Reporter

21

22

23

24

25

Alameda Reuse and Redevelopment Authority

Alameda Point/NAS Alameda
950 W. Mall Square - Building 1
Alameda, CA 94501-5012

(510) 749-5800
Fax: (510) 521-3764

Governing Body

Beverly Johnson
Mayor, City of Alameda
City of Alameda

Marie Gilmore
Councilmember/Community Improvement Commissioner
City of Alameda

Tony Daysog
Councilmember/Community Improvement Commissioner
City of Alameda

Frank Matarrese
Councilmember/Community Improvement Commissioner
City of Alameda

Doug deHaan
Councilmember/Community Improvement Commissioner
City of Alameda

William C. Norton
Acting City Manager/
Executive Director

March 17, 2005

Mr. Thomas Macchiarella
BRAC Environmental Coordinator
Program Management Office West
1230 Columbia Street, Suite 1100
San Diego, CA 92101-8571

Re: Proposed Plan for Skeet Range (IR Site 29), Alameda Point, Alameda

Dear Mr. ~~Macchiarella~~ Thomas:

The Alameda Reuse and Redevelopment Authority (ARRA) is pleased to have this opportunity to comment on Navy's February 2005 *Proposed Plan for Skeet Range (IR Site 29), Alameda Point, Alameda*. It is gratifying for this site to have reached the Proposed Plan milestone, near the end of the CERCLA decision-making process. ARRA has one comment, as detailed below.

Land use plans for Alameda Point include a future, public beach in the vicinity of the Skeet Range. Remediation of this area must be sufficiently thorough to allow unrestricted recreational land use, without unacceptable human health risks. The *Proposed Plan* does not acknowledge this remedial goal.

Please state clearly that both the beach area and the submerged lands shoreward of the footprint addressed by this Proposed Plan will be included in the remedial decisionmaking for IR Site 1.

The *Proposed Plan* states "lead shot as well as clay target fragments ... reside in the offshore sediment adjacent to the Skeet Range, concentrated in an offshore area approximately 1,300 feet by 800 feet in average water depths ranging from 5 to 12 feet mean [lower] low water. The adjacent shoreline beach areas will be investigated as part of IR Site 1." (page 2) Further, "the primary site-related contaminants (lead shot and PAHs from the clay targets) are located approximately 80 feet offshore, in water depths averaging 5 ft or greater." (page 5) The *Proposed Plan* does not clearly state that the scope of remedial decisionmaking for IR Site 1 includes not only the "shoreline beach areas" but also the submerged area within 80 feet of the shoreline. If contaminated sediments are present in relatively-shallow near-shore areas, unacceptable human health risks may occur from recreational use.

If you have any questions or need additional information, please call me or Dr. Peter Russell at (415)492-0540.

Sincerely,

Debbie Potter

Debbie Potter
Base Reuse and Redevelopment Manager

cc: Peter Russell, Ph.D., P.E., Russell Resources, Inc.
Elizabeth Johnson, City of Alameda
Mark Ripperda, EPA
Judy Huang, RWQCB
Marcia Liao, DTSC

Public Comment Form

Proposed Plan – Site 29, Former Skeet Range
Alameda Point, California

2005 MAR 20 P 12 FICE

There are several ways to offer comments on the Proposed Plan for Site 29 Former Skeet Range. You may provide verbal comments at tonight's meeting, or you may provide written comments by March 18, 2005. To provide written comments, you may use this form and drop it at the registration desk at tonight's meeting ~~or~~:

- Mail to Mr. Thomas Macchiarella, 1230 Columbia Street, Suite 1100, San Diego, CA 92101-8517
- Fax to Mr. Thomas Macchiarella at (619) 532-0940

Mailed comments must be postmarked no later than March 18, 2005.

(SEE ATTACHED)

Use reverse side or additional sheet, if necessary.

OPTIONAL:

Name: GEORGE B. HUMPHREYS
Address: 25 CAPTAINS DRIVE
City/State/Zip: ALAMEDA, CA 94502-6417

E-mail:
Affiliation:
Phone Number:

☒ Local Resident; years lived in the area: 20
☒ RAB Member
☐ Environmental Organization

☒ Public Official HOUSING & BUILDING CODE HEARING & APPEALS BOARD
☐ Federal/State/Local Government Agency
☐ Other (please specify)

Would you like to be added to the Alameda Point mailing list? ___ Yes ___ No
If yes, please make sure to complete address above.

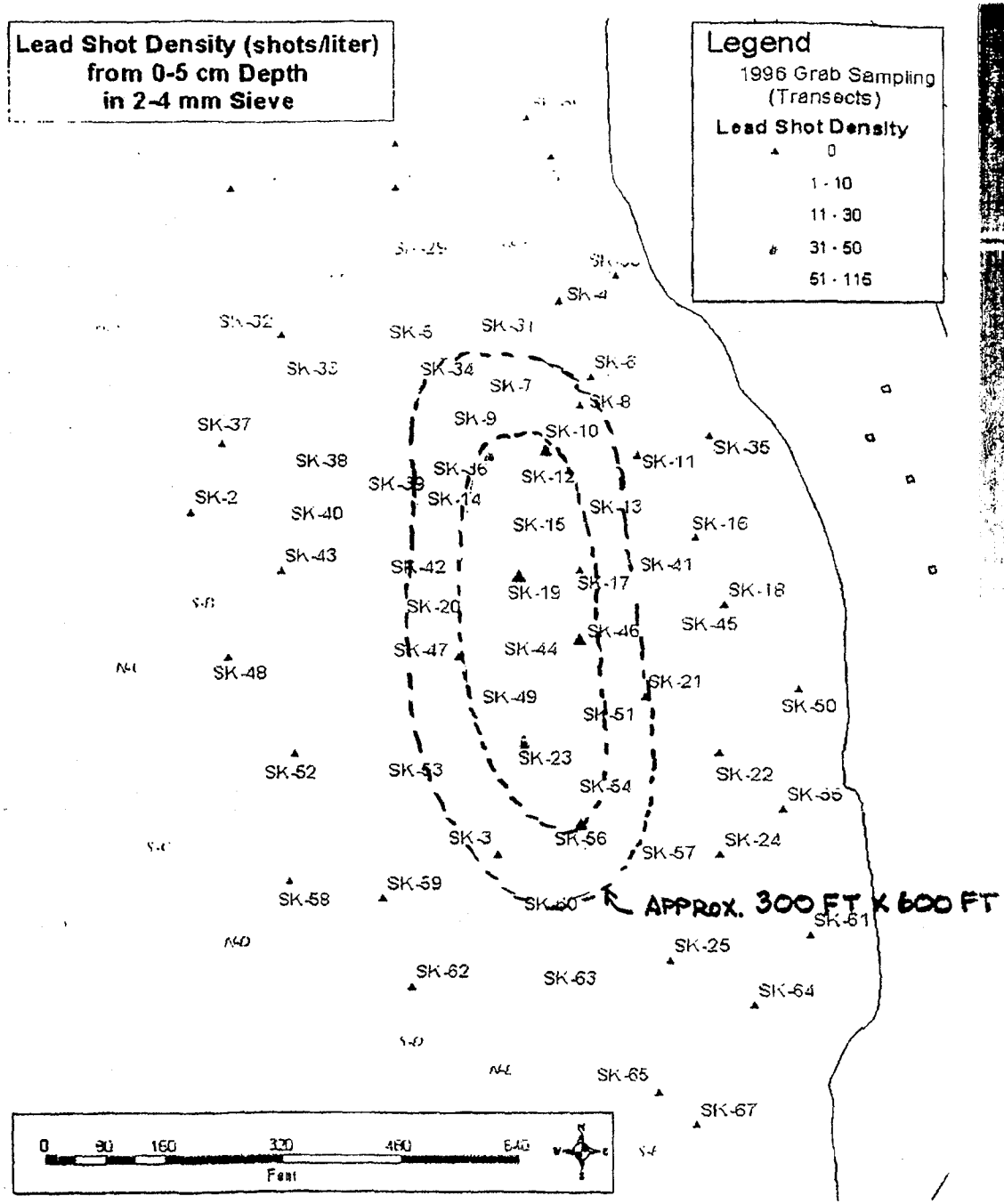
COMMENTS ON PROPOSED PLAN FOR FORMER SKEET RANGE (IR SITE 29) ALAMEDA POINT, CALIFORNIA

1. What has been the total dollar expenditure made by the Navy to date in investigations, sampling. and conducting probabilistic risk assessments at the Skeet Range IR Site 29? From the information presented by Mr. Michael Pound at the RAB Meeting on March 5, 2003, it appears that the area of the skeet range containing lead shot densities in the range of 11 to 50 shots per liter of sediment is approximately 300 ft by 600 ft. The estimated sedimentation rate at the site is 1 cm per year. In 30 years, the deposition of sediment would he approximately 1 ft (30 cm = 1 ft). Thus, most of the lead shot should be located in the top foot of sediment. This represents about 6,000 cu yds of sediment. What would be the cost of scooping up and disposing of 6,000 cu yds of contaminated sediment? I suspect that it might be less than what the Navy has already spent trying to demonstrate that no action is necessary.

2. In performing the environmental risk assessment, the Navy evaluated the effect on two types of diving birds (scaups and surf scoters). The technical complexity of the binomial probabilistic risk assessment employed is indeed mind boggling. The credibility of the results is fraught with uncertainty because of the large number of assumptions which are used as inputs. One factor used is the 'Site Utilization Factor" (SUF), or the fraction of the time the birds would be feeding at the former skeet range. From Mr. Pound's presentation, an SUF of 0.10 apparently was used. If it is acceptable to leave this material in place, there could be any number of other former skeet ranges around the bay and the affected birds could be ingesting lead shot at each of those locations when they aren't foraging at Alameda. An example would be the Chevron-Texaco gun club near Pt. Molate in Richmond. Therefore, the conclusion that "96% of the time, less than 1 in 1,000 birds" would be at risk may underestimate the cumulative impact of allowing these types of untreated sediments to remain in place.

3. One bottom feeding fish present in the waters offshore at Alameda is the sturgeon. These fish are very long-lived. Have you evaluated how much lead might be ingested by sturgeon over a 50-60 year period and what the human health risk would be of humans eating such fish or their roe?

Lead Shot Density (shots/liter) from 0-5 cm Depth in 2-4 mm Sieve



Attachment D

List of Attendees, Proposed Plan

Public Meeting, March 7, 2005

Sign-In Sheet Public Meeting for Former Skeet Range (Site 29), Alameda Point, California – March 7, 2005

Name Resident or Affiliation	Address (Optional)	How Did you Hear About this Meeting? (✓)				
		Mailer	Notice in the Alameda Journal	Notice in the Oakland Tribune	Word of Mouth	Other (Please list)
Name: Tammie Jean Damrel Tetra Tech EMI	Street: 135 Main St. Ste 1800 City, State and Zip: SF, CA 94105					Navy Contractor
Name: Marcia Liao DTSC	Street: 700 Heinz Ave. City, State and Zip: Berkeley, CA					DTSC
Name: Thomas Macchiarella Navy	Street: City, State and Zip:					Navy
Name: Judy C. Huang SF Bay RWQCB	Street: 1515 CLAY ST. ST. 1400 City, State and Zip: OAKLAND, CA 94612					Water Board
Name: Jennifer Holder BBL	Street: 1135 Eugenia Pl City, State and Zip: Carpinteria CA 93013					Navy Consultant
Name: Mark Ripperda USEPA	Street: City, State and Zip:					EPA
Name: Peter Russell RRI for ARRA	Street: 440 Nova Albion Way City, State and Zip: San Rafael, CA 94903					ARRA Advisor
Name: Pat Lynch 	Street: 305 Spencer St City, State and Zip: Alameda, CA					
Name: Damon Newton 	Street: 1230 Columbia St. #1100 City, State and Zip: San Diego, CA 92101					Navy

Sign-In Sheet Public Meeting for Former Skeet Range (Site 29), Alameda Point, California – March 7, 2005

Name Resident or Affiliation	**Address** (Optional)	How Did you Hear About this Meeting? (✓)				
		Mailer	Notice in the Alameda Journal	Notice in the Oakland Tribune	Word of Mouth	Other (Please list)
Name David Cooper USEPA	Street City, State and Zip					EPA
Name Jared Smith TECMI	Street 135 Main St #1900 City, State and Zip SF, CA 94105					Navy Contractor
Name	Street City, State and Zip					
Name	Street City, State and Zip					
Name	Street City, State and Zip					
Name	Street City, State and Zip					
Name	Street City, State and Zip					
Name	Street City, State and Zip					
Name	Street City, State and Zip					

Attachment E

Public Notices

NOTICE OF PROPOSED PLAN AND PUBLIC COMMENT PERIOD

Proposal of No Further Action at Former Skeet Range
Alameda Point, California

The U.S. Navy, in coordination with state and environmental regulatory agencies, encourages the public to comment on its Proposed Plan for no further action at the former skeet range, identified as Installation Restoration (IR) Site 29 at the former Alameda Naval Air Station, now referred to as Alameda Point, in Alameda, California.

The former skeet range is located on the northwestern corner of Alameda Point. The site was used by the Navy as a skeet range and areas of offshore sediment contain lead shot, clay fragments, and polycyclic aromatic hydrocarbons (PAHs). The Proposed Plan provides a summary of investigations performed at the site including a remedial investigation and human health and ecological risk assessments. Based on data collected and analyzed for these investigations, the proposed determination is that no further environmental work is necessary because the potential for humans and/or animals to be exposed to offshore sediment was insignificant. This finding supports the eventual transfer and redevelopment of the offshore property to the Alameda Reuse and Redevelopment Authority.

PUBLIC COMMENT PERIOD

The Navy invites interested members of the public to review and comment on the Proposed Plan during the 30-day public comment period which is from February 15th to March 18th, 2005. Public comments must be submitted in writing and postmarked or e-mailed no later than March 18, 2005, or attend the public meeting on March 7, 2005. Please send all comments to: Mr. Thomas Macchiarella, BRAC Environmental Coordinator, Program management Office West, 1230 Columbia Street, Suite 1100, San Diego, California 92101, Thomas.macchiarella@navy.mil, (619) 532-0907, fax (619) 532-0940.

PUBLIC MEETING

The Navy will host a public meeting to discuss the Proposed Plan, answer questions and accept public comments.

Date: Monday, March 7, 2005
Time: 6:30 p.m. to 8:00 p.m.
Location: 950 West Mall Square, Building 1, Room 201, Alameda Point, CA

FOR MORE INFORMATION

A copy of the Proposed Plan, Remedial Investigation, Ecological and Human Health Risk Assessment and other site documents are available for review at:

Alameda Point
950 West Mall Square
Building 1
Alameda Point, California

Alameda Public Library
2200 A Central Avenue
Alameda, California

If you have any questions or wish to discuss the skeet range project, please contact Mr. Thomas Macchiarella, BRAC Environmental Coordinator, at (619) 532-0907, fax (619) 532-0940.

0047061

Please recycle this newspaper

Free Appraisal Clinic
Wednesday, February 16th
10am-1pm (limit 5 items)
AUCTIONS BY THE BAY, INC.
2751 Todd Street, Alameda, CA
For more info: www.auctionsbythebay.com or call 800-380-9822 or 510-740-0220

NAVFAC

NOTICE OF PROPOSED PLAN AND PUBLIC COMMENT PERIOD

Proposal of No Further Action at Former Skeet Range Alameda Point, California

The U.S. Navy, in coordination with state and environmental regulatory agencies, encourages the public to comment on its Proposed Plan for no further action at the former skeet range, identified as Installation Restoration (IR) Site 29 at the former Alameda Naval Air Station, now referred to as Alameda Point, in Alameda, California.

The former skeet range is located on the northwestern corner of Alameda Point. The site was used by the Navy as a skeet range and areas of offshore sediment contain lead shot, clay fragments, and polycyclic aromatic hydrocarbons (PAHs). The Proposed Plan provides a summary of investigations performed at the site including a remedial investigation and human health and ecological risk assessments. Based on data collected and analyzed for these investigations, the proposed determination is that no further environmental work is necessary because the potential for humans and/or animals to be exposed to offshore sediment was insignificant. This finding supports the eventual transfer and redevelopment of the offshore property to the Alameda Reuse and Redevelopment Authority.

PUBLIC COMMENT PERIOD

The Navy invites interested members of the public to review and comment on the Proposed Plan during the 30-day public comment period which is from February 15th to March 18th, 2005. Public comments must be submitted in writing and postmarked or e-mailed no later than March 18, 2005, or attend the public meeting on March 7, 2005. Please send all comments to: Mr. Thomas Macchiarella, BRAC Environmental Coordinator, Program management Office West, 1230 Columbia Street, Suite 1100, San Diego, California 92101, Thomas.macchiarella@navy.mil, (619) 532-0907, fax (619) 532-0940.

PUBLIC MEETING

The Navy will host a public meeting to discuss the Proposed Plan, answer questions and accept public comments.
Date: Monday, March 7, 2005
Time: 6:30 p.m. to 8:00 p.m.
Location: 950 West Mall Square, Building 1, Room 201, Alameda Point, CA

FOR MORE INFORMATION

A copy of the Proposed Plan, Remedial Investigation, Ecological and Human Health Risk Assessment and other site documents are available for review at:

Alameda Point
950 West Mall Square
Building 1
Alameda Point, California

Alameda Public Library
2200 A Central Avenue
Alameda, California

If you have any questions or wish to discuss the skeet range project, please contact Mr. Thomas Macchiarella, BRAC Environmental Coordinator, at (619) 532-0907, fax (619) 532-0940.

Find us online at TheAlamedaJournal.com

Ecotoxicology **4**, 385–392 (1995)

Toxicity evaluation of trap and skeet shooting targets to aquatic test species

KEVIN N. BAER[1], DAVID G. HUTTON[1], ROBERT L. BOERI[2], TIMOTHY J. WARD[2] and RALPH G. STAHL, Jr[1]*

[1]*E.I. du Pont de Nemours and Company, Haskell Laboratory, Newark, DE 19898, USA*
[2]*T.R. Wilbury Laboratories, Inc., 40 Doaks Lane, Marblehead, MA, USA*

Received 3 June 1994; accepted 5 October 1994

Large quantities of trap and skeet clay targets are used in shooting activities around the United States. For example, the number of targets used since 1970 has averaged approximately 560 million a year. A number of acute and chronic tests were performed to determine the toxicity of Remington Arms Company Blue Rock® trap and skeet target fragments upon selected freshwater and marine organisms. These studies were undertaken in support of an environmental impact study of trap and skeet shooting activities at a major gun club in the northeast United States. Targets were composed of approximately 67% dolomitic limestone, 32% petroleum pitch and 1% fluorescent aqueous paint (painted targets only). The majority of samples were painted, new targets obtained from the manufacturer and painted and aged targets collected around a shooting range. Additional tests were conducted using non-painted, new targets and leachates prepared from both painted, new and aged targets. Targets were crushed to small fragments and were either directly added to the test vessels at extremely high concentrations ranging from 670 to 600 000 mg l^{-1} or used in leachate tests. In direct tests all target materials were essentially non-toxic to marine and freshwater organisms, except for the non-painted new targets which exhibited minimal acute toxicity to *Daphnia magna* (48 h EC_{50} = 2200 mg l^{-1}). In leachate tests, the leachate was not-toxic to mysid shrimp, the only organism tested. Additional samples of crushed targets were analysed for the presence of selected priority pollutants (EP toxicity test) and polycyclic aromatic hydrocarbons (PAHs). The targets did not exhibit the characteristics of toxicity as determined by the EP toxicity test but did contain substantial amounts of PAHs. However, results from new and aged targets suggest that PAH are tightly bound in the petroleum pitch and limestone matrix and are unlikely to be readily available in the environment. The potential impact of targets on the environment is further discussed.

Keywords: trap and skeet targets; aquatic toxicity; PAH.

Introduction

There have been large numbers of clay targets used for shooting activities in the United States, dating back to 1925. Since 1970, the quantity of targets used has averaged approximately 560 million a year (Table 1). Recently, concern has been expressed about the potential environmental impact of activities related to clay trap and skeet target shooting. For example, a major shooting club located in the northeast United States was used as a trap and skeet shooting range starting in the mid-1920s. Because of the large quantities of lead shot used over the years, there was concern over the possible impact of lead shot on the surrounding area. As a result, an evaluation of the

*To whom correspondence should be addressed.

0963-9292 © 1995 Chapman & Hall

Table 1. Consumption of clay targets[a]

Five year period	Mean yearly quantity ($\times 10^7$)	Percentage increase (+) or decrease (−) over preceding 5 year period
1925–1929	7.01	–
1930–1934	5.16	−26.34
1935–1939	7.88	+52.78
1940–1944	5.03	−36.14
1945–1949	11.2	+122.90
1950–1954	10.4	−7.23
1955–1959	12.7	+21.81
1960–1964	21.5	+69.48
1965–1969	39.5	+83.79
1970–1974	58.3	+47.58
1975–1979	57.4	−1.60
1980–1984	46.4	−19.15
1985–1989	58.7	+26.48

[a]Five year mean shown for the period 1925–1990 (war years 1944–1945 omitted).

lead content of sediments, seawater and plant and animal species at the site was conducted (ERCO 1986; Battelle Ocean Sciences 1987). Results of the study indicated that the area was impacted by lead shot and remediation will be implemented.

During this time, attention focused on the possible environmental impact of clay trap and skeet target fragments distributed in large amounts in the waters adjacent to the shooting range. These targets are composed of approximately 67% dolomitic limestone, 32% petroleum pitch and 1% fluorescent aqueous paint. The main concern was due to the presence of polycyclic aromatic hydrocarbons (PAHs) which are present in the petroleum pitch. Consequently, PAH could possibly be released to the environment during remediation of the lead shot and if so there could be potential bioaccumulation of PAHs in the tissues of local aquatic organisms inhabiting the area.

Prior to this time, there was little or no information on the toxicity of trap and skeet targets to aquatic organisms; the only toxicity information available was from laboratory and field studies in swine (Graham *et al.* 1940; Fenstermacher *et al.* 1945; Libke and Davis 1967; Davis and Libke 1968). In the 1930s, several herds, particularly young hogs, exhibited periodic episodes of disease characterized clinically by lethargy, loss of appetite, incoordination and, finally, death (Graham *et al.* 1940). Subsequent examinations of dead and dying animals revealed severe liver necrosis, anaemia, jaundice and other signs of liver injury. The cause of disease was ultimately traced to consumption of trap and skeet target fragments in pasture areas where animals were foraging. Laboratory studies utilizing young pigs force-fed ground up targets exhibited the same clinical signs of toxicity as was noted in field evaluations. Coal-tar pitch, used as target binder, was ultimately identified as the toxic component. Recently, petroleum pitch has replaced coal-tar pitch in targets. However, the toxicity of petroleum pitch to swine or other animals is currently unknown.

In view of these considerations, a number of acute and chronic tests were performed to determine the toxicity of trap and skeet fragments to selected freshwater and marine

organisms. Targets also were analysed for selected priority pollutants and PAHs. The results of these toxicology and chemical analyses are discussed in the context of an environmental impact study of trap and skeet activities at the shooting range.

Methods

Test material and sample preparation

Painted and non-painted new Blue Rock® clay trap and skeet targets were obtained from Remington Arms Manufacturing Plant in Findlay, Ohio. The composition of the targets was as follows: approximately 67% Dolomitic limestone, approximately 32% petroleum pitch (Trolumen® 250) and approximately 1% fluorescent aqueous paint (painted targets only). The targets or fragments were mechanically crushed and sifted through a 5 mm mesh stainless steel wire screen to obtain a size range of 2–5 mm. The desired amount of test material was then placed directly into the test vessels and used immediately. In additional experiments, a leachate of the crushed material was obtained. The leachate was formulated by combining the crushed material and dilution water in a 1:4 ratio by volume, mixing the slurry for 24 h on a rotary shaker, allowing the solids to settle for 1 h and decanting the supernatant. The lechate was then used immediately for testing.

Toxicity tests (leachate versus direct testing)

Acute toxicity tests were performed by E.I. du Pont de Nemours and Company, Haskell Laboratory, Newark, DE or Enseco Inc., Marblehead, MA. Fathead minnow, *Pimephales promelas*, 96 h LC_{50}, static, acute tests and *Daphnia magna* 48 h EC_{50}, static acute tests were performed by the Haskell Laboratory following modified EPA methods (Zucker 1985a,b). Opossum shrimp/mysid, *Mysidopsis bahia*, 96 h LC_{50}, static acute tests (ASTM 1980a), silverside, *Menidia menidia*, 96 h LC_{50}, static acute tests (ASTM 1980a), eastern oyster, *Crassostrea virginica*, embryo/larvae 48 h EC_{50}, static acute tests (ASTM 1980b) and marine diatom, *Skeletonema costatum*, 96 h EC_{50}, static tests (USEPA 1978), were conducted by Enseco, Inc. A mysid 7 day chronic test was also conducted by Enseco, Inc. following EPA methods (Weber *et al.* 1988).

Fathead and daphnid screening tests were conducted by using a control and three concentrations (670–66 700 $mg\,l^{-1}$; ten animals per concentration). In the definitive daphnid test, ten daphnids in two replicates were exposed to each of 11 concentrations (in the range 1000–66 700 $mg\,l^{-1}$) and a control. In the marine tests, at least five concentrations and a control were used (in the range 25 000–600 000 $mg\,l^{-1}$). In the silverside and mysid acute tests, two replicates per concentration with ten animals per replicate were used. The oyster embryo/larvae test employed at least three replicates, each containing 30 000 embryos per litre at the test start. The algal and diatom acute tests employed three replicates of 10 000 cells per millilitre per replicate at the test start. The measured end-points were mortality for fish and mysids, immobility for daphnids, reduction in cell count for diatoms and reduction in normal embryo/larvae for oysters.

Chronic 7 day toxicity tests were conducted using mysids. Five mysids in eight replicates were exposed to each of five concentrations and a control. The measured end-points were survival, weight and fecundity.

Chemical analyses

Additional clay targets were obtained from Remington Arms Company, Inc., Ada, OK and were subjected to an EP toxicity test (USEPA 1986a). The analysis was conducted at the Environmental Consultants Laboratory, Oklahoma City, OK. Analyses of selected PAHs in new and aged targets were performed at Battelle, Ocean Sciences, Duxbury, MA.

Statistical analysis

Results of the toxicity tests were interpreted by standard statistical techniques (C.E. Stephan personal communication). When possible a probit method (Finney 1971) was used to calculate the EC_{50} or LC_{50} and its associated fiducial interval.

Results

The trap and skeet targets exhibited very low acute toxicity to aquatic organisms (Table 2). For marine organisms, LC_{50} or EC_{50} values were in the range 52 000–434 000 mg l^{-1}, with the marine diatom, *S. costatum*, being more sensitive than the other organisms tested. Generally the aged, painted targets were less toxic than new, painted targets. This was especially evident for the eastern oyster, *C. virginica*. For example, the 48 h EC_{50}s based on oyster larval shell development using painted, new and aged targets were 186 000 mg l^{-1} and >600 000 mg l^{-1}, respectively. For freshwater organisms, all values were >66 700 mg l^{-1}, except for new, non-painted targets to *D. magna*. The 48 h EC_{50} was 2200 mg l^{-1} and the difference in responses to painted and non-painted targets may be attributed to the lot-to-lot variation in target composition. Both the 100% leachates from the aged and new targets were not toxic to mysid shrimp, *M. bahia*.

Table 2. Acute and chronic toxicity of trap and skeet targets

	Description of test material				
	Crushed targets[a]			Leachates[b]	
Species	Aged painted	New painted	New non-painted	Aged painted	New painted
D. magna	>66 700	>66 700	2200	–	–
P. promelas	>66 700	>66 700	>66 700	–	–
M. bahia	229 000[c]	122 000[c]	160 000	>100%[d]	>100%[d]
M. bahia[e]	250 000[f]	100 000	–	–	–
M. menidia	105 000	303 000	434 000	–	–
C. virginica	>600 000	186 000	–	–	–
S. costatum	95 000	52 000	–	–	–

[a]Results listed as individual LC_{50} or EC_{50}s, mg l^{-1}, except were indicated otherwise.
[b]Results listed as individual LC_{50}s, leachate (%, v/v).
[c]Mean of three studies, standard deviations are 28 746 and 17 500 mg l^{-1} for painted, aged and new targets, respectively.
[d]Mean of two studies.
[e]Seven day chronic test, NOEC, mg l^{-1}.
[f]NOEC is for survival only, weight was statistically significant at 60 000 mg l^{-1}, the lowest concentration tested.

Mysid tests using painted targets and leachates were repeated to assess the reproducibility of the results. For all tests, the coefficient of variation was low (7–8%).

Results from a mysid shrimp 7 day chronic test using painted, new targets also indicate low toxicity. The no-observed-effect concentration (NOEC) was 100 000 mg l^{-1}, based on both survival and weight. However, the NOEC for aged, painted targets was not obtained. The NOEC, based on survival, was 250 000 mg l^{-1}, but 60 000 mg l^{-1}, the lowest concentration tested, exhibited a statistically significant decrease in weight.

Results from an EP toxicity test are presented in Table 3. The sample did not exhibit the characteristic of toxicity by exceeding the established threshold limits for the EP toxicity test. However, there were considerable levels of PAHs analysed in the targets (Table 4). The data indicate that there is very little difference in absolute and relative PAH concentrations between new and aged clay targets. The total PAH concentrations were 1076 and 1053 $\mu g\, g^{-1}$ (p.p.m.) for new and aged clay targets, respectively (approximately 0.1% by weight PAH concentration).

Discussion

The present study focused on the toxicity of Remington Arms Company Blue Rock® trap and skeet target fragments to aquatic organisms. All target materials exhibited very low acute toxicity to selected freshwater and marine organisms. Freshwater species included daphnids and fathead minnows and marine species included mysid shrimp, silverside minnows, oyster larvae and diatoms. In addition, leachates prepared from targets were not acutely toxic to mysid shrimp. Target materials were relatively non-toxic to a marine shrimp in a chronic bioassay. Generally, concentrations were far in excess of the concentration normally tested in aquatic bioassays.

Trap and skeet targets are composed predominately of dolomitic limestone and petroleum pitch, bound together under heat and pressure. Petroleum pitch is composed mainly of petrogenic hydrocarbons that are relatively insoluble in water and have low

Table 3. EP toxicity test results for trap and skeet targets

Constituent	Concentration (mg l^{-1})
Arsenic	<0.01
Barium	<0.05
Cadmium	<0.004
Chromium	<0.005
Lead	0.046
Mercury	<0.001
Selenium	<0.030
Silver	<0.002
Endrin	<0.0015
Lindane	<0.001
Methoxychlor	<0.0035
Toxaphene	<0.015
2,3-Dichlorophehyoxyacetic acid (2,4-D)	<1000
2,3,5-Trichlorophenyoxypropionic acid	<100

Table 4. Analysis of new and aged clay targets – PAH concentrations (ERCO 1986)

	Concentration (ng g^{-1} dry weight)						
	New targets			Aged targets			
Compound	Number 1	Number 2	Mean	Number 1	Number 2	Number 3	Mean
Naphthalene	236	135	185	407	379	381	389
2-Methylnaphthalene	1847	1142	1495	2614	1304	2625	2181
1-Methylnaphthalene	575	342	459	1263	657	1159	1026
Biphenyl	ND	ND	NA	ND	ND	ND	NA
2,6-Dimethylnaphthalene	2566	1672	2119	2672	1710	3023	2468
Acenaphthylene	ND	ND	NA	ND	ND	ND	NA
Acenaphthene	260	158	209	223	4847	294	259
2,3,5-Trimethylnaphthalene	868	513	690	876	644	1026	849
Fluorene	827	571	699	802	4017	1052	927
Phenanthrene	32 392	21 778	27 085	26 377	77 524	39 232	32 805
Anthracene	6064	4083	5074	3953	10 548	5851	6784
1-Methylphenanthrene	13 670	10 414	12 042	12 893	16 192	17 922	15 669
Fluoranthene	11 394	9778	10 586	10 195	78 455	16 400	13 298
Pyrene	129 979	123 085	126 532	109 191	163 545	179 384	150 707
Benz(a)anthracene	145 530	219 202	182 366	175 991	195 765	241 288	204 348
Chrysene	306 091	287 020	296 556	242 409	238 822	294 660	258 630
Benzo(b)fluoranthene	69 659	63 110	66 384	48 651	78 696	69 464	65 604
Benzo(k)fluoranthene	ND	ND	NA	ND	ND	ND	NA
Benzo(e)pyrene	149 901	105 941	127 921	88 376	122 503	123 207	111 362
Benzo(a)pyrene	135 440	91 669	113 554	69 070	126 759	102 251	99 360
Perylene	36 906	24 129	30 518	19 599	34 193	26 701	26 831
Indeno(1,2,3-c,d)pyrene	11 507	7005	9256	4378	21 577	7076	11 010
Dibenz(a,h)anthracene	30 025	17 267	23 646	13 810	19 854	18 658	17 441
Benzo(g,h,i)perylene	48 646	28 667	38 657	22 242	39 890	32 255	31 463
Total PAH	1 134 383	1 017 681	1 076 032	855 992	1 237 884	1 183 909	1 053 410

Significant contamination/interference was evident for acenaphthene, fluorene, phenanthrene and fluoranthene for aged sample number 2. The results for these analytes were therefore not used when calculating the mean concentration. ND, not detected. NA, not applicable. Sample weights were 1.269, 1.011, 1.106, 1.066 and 1.176 for new targets number 1 and number 2 and old targets numbers 1, 2, and 3, respectively.

acute aquatic toxicity. Since the hydrocarbons in the pitch are bound under heat and pressure with dolomitic limestone, relatively inert biologically, it is unlikely that PAHs would leach from the target matrix. Acute toxicity studies using mysid shrimp and target leachates showed no toxicity. Targets subjected to the EP toxicity test did not show toxic characteristics.

The available data for PAHs indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as $0.30\,mg\,l^{-1}$ (USEPA 1986b). There is limited freshwater aquatic toxicity data for PAHs. However, the available data for naphthalene indicate that acute toxicity to freshwater aquatic life could occur at concentrations as low as $2.3\,mg\,l^{-1}$ (USEPA 1986c). Although PAHs were not measured in the water during toxicity testing, it was again unlikely that the PAHs leached from the target materials in any significant amounts, based on the results of the toxicity tests.

An extensive study was conducted to determine the composition and concentrations of PAH in clay targets, sediments and organisms at the shooting range located in the northeast United States (Battelle Ocean Sciences 1990) and to determine the potential release of PAHs from the site sediments during the remediation process for the lead shot. It was determined that clay targets contained high concentrations of PAHs and that the clay targets were a probable source of PAHs to the surface and subsurface sediments around the range. However, the PAH concentrations measured in sediment and marine animals around the site were no higher and in many instances were lower, than would be expected for the area in general (data not shown). PAHs are known to be ubiquitous trace components of terrestrial, aquatic and marine environments. It was concluded that the PAH concentrations measured in sediment around the site and the PAH concentrations potentially suspended in the water column during remediation work, are sufficiently low so that no long-term environmental effects would be expected.

While acute aquatic toxicity data suggest there is little or no hazard associated with these materials, it is advisable to minimize shooting activities near aquatic areas. This is based on the paucity of chronic toxicity data with freshwater species, as well as the lack of additional tests which measure effects on sensitive life stages, e.g. daphnid chronic, fish embryo-larval, etc.

Acknowledgement

The authors would like to thank Debbie Terry for her assistance in the preparation of this manuscript.

References

ASTM (1980a) *Standard Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians*. Philadelphia, PA: ASTM Committee on Standards.

ASTM (1980b) *Standard Practice for Conducting Acute Toxicity Tests with Larvae of Four Species of Bivalve Mollusks*. Philadelphia, PA: ASTM Committee on Standards.

Battelle Ocean Sciences (1987) *Remington Gun Club Remediation Alternatives Study: Summary Report and Appendices*. Wilmington, DE: Remington Arms Company, Inc.

Battelle Ocean Sciences (1990) *Remington Gun Club Environmental Assessment of Clay Targets: Final Report*. Stratford, CT: Remington Arms Company, Inc.

Davis, J.W. and Libke, K.G. (1968) Hematologic studies in pigs fed clay pigeon targets. *J. Am. Vet. Med. Assoc.* **152**, 382–4.

ERCO (1986) *Aquatic Hazard Evaluation for Lead Shot Deposited in the Estuarine Environment at Lordship Point, Stratford, CT*. Wilmington, DE: E.I. du Pont de Nemours and Company.

Fenstermacher, R., Pomeroy, B.S. and Kernkamp, H.C.H. (1945) Pitch poisoning in swine. *Proceedings of the 49th Annual Meeting of the U.S. Livestock Association*, pp. 86–91.

Finney, D.J. (1971) *Probit Analysis*, third edition, p. 333. Cambridge University Press.

Graham, R., Hester, H.R. and Henderson, J.A. (1940) Coal-tar-pitch poisoning in pigs. *J. Am. Vet. Med. Assoc.* **96**, 135–40.

Libke, K.G. and Davis, J.W. (1967) Hepatic necrosis in swine caused by feeding clay pigeon targets. *J. Am. Vet. Med. Assoc.* **151**, 426–9.

USEPA (1978) *Bioassay Procedures for the Ocean Disposal Permit Program*. Gulf Breeze, FL: US Environmental Protection Agency.

USEPA (1986a) *Test Methods for Evaluating Solid Waste. Laboratory Manual of Physical/ Chemical Methods*. Washington, DC: Environmental Protection Agency, Office of Solid Waste and Emergency Response.

USEPA (1986b) *Ambient Water Quality Criteria for Polynuclear Aromatic Hydrocarbons (PAHs)*. Washington, DC: Environmental Protection Agency, Office of Water Regulations and Standards, Criteria and Standards Division.

USEPA (1986c) *Ambient Water Quality Criteria for Naphthalene*. Washington, DC: Environmental Protection Agency, Office of Water Regulations and Standards, Criteria and Standards Division.

Weber, C.I., Horning, W.B., II, Klemm, D.J., Neiheisel, T.I., Lewis, P.A., Robinson, E.L., Menkedick, J. and Kessler, F. (1988) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estimate Organisms*. Cincinnati, OH: US Environmental Protection Agency.

Zucker, E. (1985a) *Hazard Evaluation Division, Standard Evaluation Procedure: Acute Toxicity Test for Freshwater Invertebrates*. Washington, DC: US Environmental Protection Agency Office of Pesticide Programs.

Zucker, E. (1985b) *Hazard Evaluation Division, Standard Evaluation Procedure: Acute Toxicity Test for Freshwater Fish*. Washington, DC: US Environmental Protection Agency Office of Pesticide Programs.

Note: This document has been converted from an Adobe Acrobat file and may contain some unusual formatting,, especially in tables.

BACKGROUND DOCUMENTATION FOR THE DEVELOPMENT OF THE MCP NUMERICAL STANDARDS

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup
and
Office of Research and Standards

April 1994

Archived Document

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Goals 1
1.2 Categories of Standards 1
1.3 Chemicals For Which There Are No Standards 5
1.4 Environmental Media For Which There Are No Standards 5

2.0 DOSE-RESPONSE INFORMATION 12

2.1 Threshold Effects 12
2.2 Carcinogenic Effects 13
2.3 Relative Absorption Factors 14
2.4 Toxicity Information 14

3.0 CONSIDERATION OF PQL, BACKGROUND, SOLUBILITY, ODOR AND CEILING CONCENTRATIONS 24

3.1 Practical Quantitation Limits 24
3.2 Background 24
3.3 Solubility 26
3.4 Odor 26
3.5 Ceiling Concentrations 26

4.0 GROUNDWATER 35

4.1 Category GW-1: Drinking Water 35
4.2 Category GW-2: Volatilization 43
4.3 Category GW-3: Environmental Concerns 46
4.4 Upper Concentration Limits 53

5.0 SOIL 54

5.1 Human Exposure Categories S-1, S-2 and S-3 55
5.2 Soil Leaching To Groundwater 74
5.3 Upper Concentration Limits 75
5.4 Example 2 76

APPENDICES

APPENDIX A: Derivation of Soil S-1 Ingestion and Dermal Contact Rates
APPENDIX B: Derivation of Soil S-2 Ingestion and Dermal Contact Rates
APPENDIX C: Derivation of Soil S-3 Ingestion and Dermal Contact Rates
APPENDIX D: Soils Levels Which Trigger An Imminent Hazard Evaluation
APPENDIX E: Reportable Concentrations In Groundwater and Soil

Archived Document

APPENDIX F: Development of Dilution/Attenuation Factors (DAFs) for the Leaching-Based Soil Standards
APPENDIX G: Selection of Practical Quantitation Limits for Method 1 Chemicals

TABLES

Table 1.1 MCP Numerical Standards 6
Table 2.1 Toxicity Information 15
Table 3.1 PQLs, Background, Solubility, Odor Data & Other Physical Constants 29
Table 4.1 GW-1 Derivation 40
Table 4.2 GW-2 Derivation 47
Table 4.3 GW-3 Derivation 50
Table 5.1 Summary of Soil Ingestion and Dermal Contact Rates 59
Table 5.2 Method 2 Direct Contact S-1 Derivation 62
Table 5.3 Method 2 Direct Contact S-2 Derivation 66
Table 5.4 Method 2 Direct Contact S-3 Derivation 71
Table 5.5 Method 1 Soil Standards 77

Appendices

Table A-1 Indoor-Only Soil Ingestion Exposure A-1
Table A-2 Calculation of Age-Specific Soil Ingestion Rates A-2
Table A-3 Calculation of Time-Weighted Average Daily Soil Ingestion Exposures Normalized to Bodyweight A-3
Table A-4 Calculation of the Normalized Daily Soil Intake Rates Used for Method 1 Standard Setting A-4
Table A-5 Indoors Only - Dermal Contact A-6
Table A-6 Indoors & Outdoors - Dermal Contact A-7
Table A-7 Calculation of Age-Specific Soil Dermal Contact Rates A-8
Table A-8 Calculation of Time-Weighted Daily Soil Dermal Contact Exposures Normalized to Bodyweight A-9
Table A-9 Calculation of the Normalized Daily Soil Contact Rates Used for S-1 Standard Setting A-10

Table B-1 Calculation of Age-Specific Soil Ingestion Rates B-1
Table B-2 Calculation of the Time-Weighted Daily Soil Ingestion Exposures Normalized to Bodyweight B-2
Table B-3 Calculation of the Normalized Daily Soil Intake Rates Used to Calculate S-2 Soil Standards B-3
Table B-4 Outdoors - Dermal Only B-4
Table B-5 Calculation of Age-Specific Soil Dermal Contact Rates B-5
Table B-6 Calculation of Time-Weighted Average Daily Soil Dermal Contact Exposures Normalized to Bodyweight B-6
Table B-7 Calculation of the Normalized Daily Soil Dermal Contact Rates Used to Calculate S-2 Standards B-7

Table C-1 Soil S-3: Calculation of Age-Specific Soil Ingestion Rates C-1

Table C-2 Calculation of Time-Weighted Average Daily Soil Ingestion Exposures Normalized to Bodyweight C-2
Table C-3 Calculation of the Normalized Daily Soil Intake Rates Used to Calculate S-3 Soil Standards C-3
Table C-4 Outdoor - Dermal Contact C-4
Table C-5 Calculation of Age-Specific Soil Dermal Contact Rates C-5
Table C-6 Calculation of Time-Weighted Average Daily Soil Dermal Contact Exposures Normalized to Bodyweight C-5
Table C-7 Calculation of the Normalized Daily Soil Dermal Contact Rates Used to Calculate S-3 Standards C-6

Table E-1 Reportable Concentrations (RCs) in Groundwater and Soil E-5

Table F-1 Climate Parameter Values for the SESOIL Model F-4
Table F-2 Soil Parameter Values for the SESOIL Model F-4
Table F-3 Applications Data for SESOIL Model F-5
Table F-4 Chemical Data for SESOIL Model F-5
Table F-5 AT123D Model Input Parameter Values F-6
Table F-6 Model Output Draft DAFs Comparison and Soil Levels F-6
Table F-7 Comparison Between Model DAFs and Linear Regression DAFs Based on Oregon DAFs F-8
Table F-8 Results of the Multiple Linear Regression Equation for H and Koc F-8
Table F-9 Results of the Biodegradation Runs F-9

FIGURES

Figure 1-1 Soil Category Selection Matrix - Human Exposure Potential 3
Figure 1-2 A Simple Guide to Method 1 Standards - Example #1 4
Figure 4-1 Derivation of GW-1 Standards 37
Figure 4-2 Derivation of GW-2 Standards 44
Figure 4-3 Derivation of GW-3 Standards 49
Figure 5-1 Derivation of Method 2 Direct Contact Soil Standards 56
Figure 5-2 Derivation of Method 1 Soil Standards 57
Figure 5-3 Combinations of Soil-Groundwater Leaching-Based Standards 75
Figure 5-4 Example #2 80

Appendices

Figure E-1 Relationship Between the Method 1 Standards & the Reportable Concentrations (RCs) for Groundwater and Soil E-4
Figure F-1 Conceptual Setting F-2

Archived Document

1.0 INTRODUCTION

The development of chemical-specific cleanup standards for use under the revised Massachusetts Contingency Plan represents an important piece of the effort to streamline the site assessment and remediation program. The MCP Numerical Standards provide a simple means to determine whether remediation is necessary at a site and when no further remedial response action is necessary. This document describes the factors which have been considered in the generation of these standards.

The development of the MCP Method 1 Standards is best considered within the framework of the regulations which allow flexibility in the characterization of the risk of harm to health, safety, public welfare and the environment. The regulations retain site-specific risk assessment as an optional means (Method 3) to establish the need for remediation and to determine cleanup goals. The time and cost of preparing such assessments may not be warranted at many of the M.G.L. c.21E sites, however. Promulgated standards provide an option which is simple to use and results in predictable outcomes. The Department is also offering a hybrid methodology (Method 2) which allows limited modification of the Method 1 Standards based upon site-specific information. All three Methods address the potential risk of harm to health, public welfare and the environment. Risk to safety is considered separately.

In addition to the main body of this document which describes the derivation of the Method 1 Standards, there are a number of appendices which examine related issues. Appendices A, B, and C explain the derivation of the Method 1 Soil 1, 2, and 3 (S-1, S-2, and S-3) ingestion and skin contact rates. Appendix D describes soil levels which trigger an imminent hazard evaluation under the MCP. An explanation of the Reportable Concentrations contained in the MCP is given in Appendix E. The dilution/attenuation factors (DAFs) used to develop the leaching-based Method 1 soil standards are explained in Appendix F. Finally, Appendix G examines the selection of Practical Quantitation Limits (PQLs) for Method 1 chemicals.

1.1. GOALS

The MCP Method 1 Standards are intended to represent levels of oil or hazardous materials at which no further remedial response actions would be required based upon the risk of harm posed by these chemicals. The standards must be protective of public health, public welfare, and the environment (i.e., represent a condition of "no significant risk"), given the exposures assumed, and must be measurable.

Method 1 standards are, by nature, generic, and are derived in a manner to be protective at a wide range of disposal sites across the state. The use of such generic standards is one risk characterization option in the Massachusetts Contingency Plan. It is important to remember that the flexibility exists under the MCP to use more site-specific risk characterization approaches under Methods 2 and 3.

1.2. CATEGORIES OF STANDARDS

This document describes the development of standards in soil and in groundwater based upon assumptions made for the current and foreseeable uses of the site and surrounding environment. These use categories are described in the regulations by specific criteria to

determine the applicable categories.

The groundwater standards described in section 4 of this document include:

Category GW-1:	Concentrations based upon the use of the groundwater as drinking water, either currently or in the foreseeable future.
Category GW-2:	Concentrations based upon the potential for volatile materials to migrate into indoor air.
Category GW-3:	Concentrations based upon potential environmental impacts of contaminated groundwater discharging to surface water.
Upper Concentration Limits:	Concentrations promulgated for the protection of groundwater as a future resource and considering the social costs of degraded aquifers.

The soil standards described in section 5 of this document include:

Category S-1	Concentrations based upon sensitive uses of the property and accessible soil, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils
Category S-2:	Concentrations based upon property uses associated with moderate exposure and accessible soils, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils.
Category S-3:	Concentrations based upon restricted access property with limited potential for exposure, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils.
Upper Concentration Limits:	Concentrations promulgated to minimize potential risks associated with uncontrolled environmental contamination, and the costs associated with cumulative anthropogenic contributions to background.

Figure 1-1, extracted from the regulations, provides an outline of the applicability of the soil standards. Figure 1-2 provides an example of how to use the tables of standards once the applicable soil and groundwater categories have been determined.

FIGURE 1-1

SOIL CATEGORY SELECTION MATRIX - HUMAN EXPOSURE POTENTIAL

Accessibility of Soil	RECEPTOR CHARACTERISTICS							
	CHILDREN PRESENT				ADULTS PRESENT			
	HIGH FREQUENCY		LOW FREQUENCY		HIGH FREQUENCY		LOW FREQUENCY	
	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity
ACCESSIBLE (SURFICIAL) SOIL 0 -> 3' (unpaved	CATEGORY S-1			S-2	S-1	CATEGORY S-2		
POTENTIALLY ACCESSIBLE SOIL 0 -> 15' (paved) - or - 3 -> 15' (unpaved)	CATEGORY S-2				S-2	CATEGORY S-3		
ISOLATED SUB-SURFACE SOILS > 15' or under the footprint of a building or permanent structure	CATEGORY S-3							

Archived Document

FIGURE 1-2

A SIMPLE GUIDE TO METHOD 1 STANDARDS

EXAMPLE: ***Based on the criteria in the MCP, the groundwater at the disposal site is determined to be Category GW-3 only, and the soil of concern is categorized as S-2. The applicable standards (shaded below) under MCP Method 1 would be the GW-3 concentrations in groundwater (µg/liter, or ppb) and the S-2/GW-3 concentrations in soil (µg/gram, or ppm). In the MCP these standards are located on Tables 1 and 3, respectively.***

If the Groundwater Category is: **GW-1** **GW-2** **GW-3**

Table 1: 40.0974(2)

Then these Groundwater Standards apply AND the Soil Standards directly below them are potentially applicable: ->	GW-1 µg/liter	GW-2 µg/liter	GW-3 µg/liter

If the Soil Category is: **Then these Soil Standards are applicable, depending upon the Groundwater Category:**

Table 2; 40.0975(6)(a)

S-1	S-1/GW-1 µg/gram	S-1/GW-2 µg/gram	S-1/GW-3 µg/gram

T

able 3: 40.0975(6)(b)

S-2	S -2/GW-1 µg/gram	S-2/GW-2 µg/gram	S-2/GW-3 µg/gram

Table 4: 40.0975(6)(c)

S-3	S -3/GW-1 µg/gram	S-3/GW-2 µg/gram	S-3/GW-3 µg/gram

Archive Document

The specific assumptions which determine the concentration of oil or hazardous materials for each of these categories are described in the remainder of this document.

Each category is intended to represent a wide range of sites, and the risk assessment which is the basis for the numerical standard should not be expected to exactly describe each site determined to be in that category. In other words, even though the Soil S-1 concentrations are based upon a residential exposure scenario, the Department intends the S-1 standards to be potentially applicable at all locations where children have frequent or intense contact with the soil, *or may have such contact in the foreseeable future.* Thus S-1 standards may be called for in areas where the soil is not currently accessible, but where it is considered to be *potentially accessible.*

The exposure assumptions for each category have intentionally not been chosen to describe the "*worst-case*" exposure for that scenario. They are meant to be representative of the class of exposures expected for that category.

1.3 CHEMICALS FOR WHICH THERE ARE NO STANDARDS

Standards have been developed for one hundred and four chemicals or groups of chemicals most commonly reported at c.21E sites. If oil or hazardous material is confirmed to be present in soil or groundwater at a site, but there is not a promulgated Method 1 Standard for that chemical, then a standard may be developed using procedures outlined in the regulations (310 CMR 40.0983 and 40.0984). The development and use of such a standard is considered to be a Method 2 approach.

1.4 ENVIRONMENTAL MEDIA FOR WHICH THERE ARE NO STANDARDS

Standards have been developed for those environmental media which are most commonly found to be contaminated at c.21E sites: soil and groundwater. If oil or hazardous material is either confirmed or suspected to be in other media (i.e., surface water, air, sediments), then the Department considers the site to be sufficiently complex for a more detailed (Method 3) approach to risk characterization.

TABLE 1.1 CONTAINS THE MCP NUMERICAL STANDARDS

Groundwater Standards are found in Table 1 (310 CMR 40.0974(2)) of the MCP.

Soil Standards are found in Tables 2, 3 and 4 (310 CMR 40.0975(6)(a), (b), (c)) of the MCP.

Direct Contact Soil Standards are found in Table 5 (310 CMR 40.0985(6)) of the MCP.

Upper Concentration Limits in Groundwater and Soil are found in Table 6 (310 CMR 40.0996(4)) of the MCP.

TABLE 1.1
MCP NUMERICAL STANDARDS

TABLE 1-1 MCP NUMERICAL STANDARDS	Method 1 Groundwater Standards 310 CMR 40.0974 (2)			Method 1 S-1 Soil Standards 310 CMR 40.0975(6)(a)			Method 1 S-2 Soil Standards 310CMR40.0975(6)(b)		
OIL AND/OR HAZARDOUS MATERIAL	GW-1 STANDARD ug/L	GW-2 STANDARD ug/L	GW-3 STANDARD ug/L	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW3 mg/kg
ACENAPHTHENE	20		2000	20	1000	1000	20	2500	200
ACENAPHTHYLENE	300		2000	100	100	100	100	2500	800
ACETONE	3000	50000	50000	3	60	60	3	60	60
ALDRIN	0.5	0.5	9	0.03	0.03	0.03	0.04	0.04	0.04
ANTHRACENE	600		600	1000	1000	1000	1000	2500	1000
ANTIMONY	6		300	10	10	10	40	40	40
ARSENIC	50		400	30	30	30	30	30	30
BENZENE	5	2000	7000	10	30	30	10	60	60
BENZO(a)ANTHRACENE	0.2		5	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(a)PYRENE	0.2		2	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	0.2		7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO (g,h, i) PERYLENE	0.5		0.1	100	1000	30	100	2500	30
BENZO(k)FLUORANTHENE	0.2		0.4	0.7	0.7	0.7	0.7	0.7	0.7
BERYLLIUM	4		50	0.4	0.4	0.4	0.8	0.8	0.8
BIPHENYL, 1,1-	400		4000	1	1000	10	1	2500	10
BIS(2-CHLOROETHYL)ETHER	30	100	50000	0.7	0.7	0.7	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	30	400	50000	0.7	2	2	0.7	3	3
BIS(2-ETHYLHEXYL)PHTHALATE	6	700	30	100	100	100	100	300	300
BROMODICHLOROMETHANE	5		50000	0.1	10	10	0.1	20	20
BROMOFORM	5	800	50000	0.1	20	100	0.1	20	200
BROMOMETHANE	10	2	50000	10	3	50	10	3	200
CADMIUM	5		10	30	30	30	80	80	80
CARBON TETRACHLORIDE	5	20	50000	1	4	7	1	4	10
CHLORDANE	5		2	1	1	1	2	2	2
CHLOROANILINE, p-	30		50000	1	100	30	1	400	30
CHLOROBENZENE	100	1000	500	8	80	40	8	80	40
CHLOROFORM	5	400	10000	0.1	10	100	0.1	10	200
CHLOROPHENOL, 2-	10		40000	0.7	100	20	0.7	200	20
CHROMIUM (TOTAL)	100		2000	1000	1000	1000	2500	2500	2500
CHROMIUM (III)	100		2000	1000	1000	1000	2500	2500	2500
CHROMIUM (VI)	50		100	200	200	200	600	600	600
CHRYSENE	0.2		3	0.7	0.7	0.7	0.7	0.7	0.7
CYANIDE	200		10	100	100	100	100	100	100
DIBENZO (a,h)ANTHRACENE	0.2		0.3	0.7	0.7	0.7	0.7	0.7	0.7
DIBROMOCHLOROMETHANE	5		50000	0.09	10	10	0.09	20	20
DICHLOROBENZENE, 1,2- (o-DCB)	600	10000	8000	100	100	100	200	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	600	10000	8000	100	100	100	200	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	5	30000	8000	2	40	40	2	60	60
DICHLOROBENZIDINE, 3,3 ' -	80		2000	1	1	1	1	1	1
DICHLORODIPHENYL DICHLOROETHANE, P	0D.1D		6	2	2	2	3	3	3
DICHLORODIPHENYLDICHLOROETHYLENE,P	0D.1E		20	2	2	2	2	2	2
DICHLORODIPHENYLTRICHLOROETHANE, P	0D.D3		0.3	2	2	2	2	2	2
DICHLOROETHANE, 1,1-	70	9000	50000	3	100	100	3	400	500
DICHLOROETHANE, 1,2-	5	20	50000	0.05	0.2	10	0.05	0.2	20
DICHLOROETHYLENE, 1,1-	7	1	50000	0.7	0.1	1	0.7	0.1	2
DICHLOROETHYLENE, CIS-1,2-	70		50000	2	100	100	2	500	500

Archived Document

Table 1.1, continued...

TABLE 1-1 | | Method 1 | | M

MCP NUMERICAL STANDARDS OIL AND/OR HAZARDOUS MATERIAL	Groundwater Standards 310 CMR 40.0974(2) GW-1 STANDARDS ug/L	GW-2 STANDARDS ug/L	GW-3 STANDARD ug/L	S-1 Soil Standards 310 CMR 40.0975(6)(a) S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2 Soil Standards 310 CMR 40.0975(6)(b) S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg
DICHLOROETHYLENE, TRANS-1,2-	100		50000	4	500	500	4	1000	1000
DICHLOROPHENOL, 2,4-	10		4000	10	40	40	10	90	90
DICHLOROPROPANE, 1,2-	5	9	30000	0.1	0.2	8	0.1	0.2	10
DICHLOROPROPENE, 1,3-	0.5	5	2000	0.01	0.1	3	0.01	0.1	5
DIELDRIN	0.1		0.1	0.03	0.03	0.03	0.04	0.04	0.04
DIETHYL PHTHALATE	6000		30	100	1000	0.7	100	2500	0.7
DIMETHYL PHTHALATE	50000		30	30	1000	0.7	30	2500	0.7
DIMETHYLPHENOL, 2,4-	100		20000	0.7	400	10	0.7	900	10
DINITROPHENOL, 2,4-	200		2000	3	40	6	3	90	6
DINITROTOLUENE, 2,4-	30		2000	0.7	1	1	0.7	2	2
DIOXIN	3E-05		1E-04	4E-06	4E-06	4E-06	6E-06	6E-06	6E-06
ENDOSULFAN	0.4		0.1	0.2	1	0.05	0.2	3	0.05
ENDRIN	2		5	0.6	6	1	0.6	10	1
ETHYLBENZENE	700	30000	4000	80	500	500	80	1000	500
ETHYLENE DIBROMIDE	0.02	3	50000	0.005	0.01	0.01	0.005	0.02	0.02
FLUORANTHENE	100		100	600	900	600	600	2000	600
FLUORENE	300		1000	400	900	900	400	2000	1000
HEPTACHLOR	0.4		1	0.1	0.1	0.1	0.2	0.2	0.2
HEPTACHLOR EPOXIDE	0.2		2	0.06	0.06	0.06	0.09	0.09	0.09
HEXACHLOROBENZENE	1		40	0.7	0.7	0.7	0.8	0.8	0.8
HEXACHLOROBUTADIENE	0.6	1	90	3	3	7	3	3	10
HEXACHLOROCYCLOHEXANE, GAMMA (gamm|a| -	0.2		0.8	0.1	0.4	0.4	0.1	0.6	0.5
HEXACHLOROETHANE	8	10	5000	6	6	6	10	10	10
INDENO (1,2,3-cd) PYRENE	0.2		0.3	0.7	0.7	0.7	0.7	0.7	0.7
LEAD	15		30	300	300	300	600	600	600
MERCURY	2		1	10	10	10	60	60	60
METHOXYCHLOR	40		2	100	100	30	300	300	30
METHYL ETHYL KETONE	350	50000	50000	0.30	40	40	0.3	40	40
METHYL ISOBUTYL KETONE	350	50000	50000	0.5	70	70	0.5	70	70
METHYL MERCURY	2		0.1	7	7	7	20	20	20
METHYL TERT BUTYL ETHER	700	50000	50000	3	100	100	3	200	200
METHYLENE CHLORIDE	5	50000	50000	0.1	100	100	0.1	200	200
METHYLNAPHTHALENE, 2-	10	10000	3000	0.7	20	7	0.7	20	7
NAPHTHALENE	20	6000	6000	4	100	100	4	1000	1000
NICKEL	100		80	300	300	300	700	700	700
PENTACHLOROPHENOL	1		80	5	7	7	5	10	10
PHENANTHRENE	300		50	700	1000	100	700	2500	100
PHENOL	4000	50000	30000	60	500	500	60	800	500
POLYCHLORINATED BIPHENYLS	0.5		0.3	2	2	2	2	2	2
PYRENE	80		80	500	700	500	500	2000	500
SELENIUM	50		80	300	300	300	2500	2500	2500
SILVER	40		7	100	100	100	200	200	200
STYRENE	100	900	50000	2	20	20	2	20	30
TETRACHLOROETHANE, 1,1,1,2-	5	6	50000	0.4	0.5	4	0.4	0.5	5
TETRACHLOROETHANE, 1,1,2,2-	2	20	20000	0.02	0.2	0.5	0.02	0.2	0.6
TETRACHLOROETHYLENE	5	3000	5000	0.5	200	200	0.5	300	300

Archive Document

Table 1.1, continued...

MCP NUMERICAL STANDARDS	TABLE 1-1 Method 2 Methods 2 & 12 Groundwater Standards 310 CMR 40.0974 (2)			Method 1 S-1 Soil Standards 310 CMR 40.0975 (6) (a)			S-2 Soil Standards 310 CMR 40.0975 (6)(b)		
--------	GW-1	GW-2	GW-3						
OIL AND/OR HAZARDOUS MATERIAL	STANDARD ug/L	STANDARD ug/L	STANDARD ug/L	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg
THALLIUM	2		400	8	8	8	30	30	30
TOLUENE	1000	6000	50000	90	500	500	90	500	1000
TOTAL PETROLEUM HYDROCARBONS	1000		50000	500	500	500	2500	2500	2500
TRICHLOROBENZENE, 1,2,4-	70	600	500	100	400	400	100	900	800
TRICHLOROETHANE, 1,1,1-	200	4000	50000	30	100	100	30	500	500
TRICHLOROETHANE, 1,1,2-	5	20000	50000	0.3	2	2	0.3	3	3
TRICHLOROETHYLENE	5	300	20000	0.4	20	70	0.4	20	100
TRICHLOROPHENOL, 2,4,5-	200		100	3	1000	2	3	2500	2
TRICHLOROPHENOL 2,4,6-	10	40000	10000	3	40	40	3	60	60
VINYL CHLORIDE	2	2	600	0.3	0.3	0.3	0.4	0.3	0.5
XYLENES	10000	6000	50000	500	500	500	800	500	1000
ZINC	2000		900	2500	2500	2500	2500	2500	2500

Archived Document

Table 1.1, continued...

TABLE 1-1 | | Method 1 | | Me

MCP NUMERICAL STANDARDS	S-3 Soil Standards 310 CMR 40.0975 (6) (c)			Direct Contact Soil Standards 310CMR40.0985(6)			Upper Concentration Limits (UCLs) 310CMR40.0996(4)	
OIL AND/OR HAZARDOUS	S-3/GW-3 mg/kg	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-1 mg/kg	S-2 mg/kg	S- mg/k	Groundwate µg/L	Soil µg/g
ACENAPHTHENE	20	5000	2000	1000	2500	500	2000	10000
ACENAPHTHYLENE	100	2500	800	100	2500	250	2000	10000
ACETONE	3	60	60	500	1000	250	100000	10000
ALDRIN	0.1	0.1	0.1	0.03	0.04	0.	9	1
ANTHRACENE	1000	5000	1000	1000	2500	500	600	10000
ANTIMONY	40	40	40	10	40	4	3000	400
ARSENIC	30	30	30	30	30	3	4000	300
BENZENE	10	100	200	30	60	20	70000	2000
BENZO(a)ANTHRACENE	0.7	0.7	0.7	0.7	0.7	0.	5	7
BENZO(a)PYRENE	0.7	0.7	0.7	0.7	0.7	0.	2	7
BENZO (b) FLUORANTHENE	0. 7	0. 7	0 .	0 .	0 .	0.	7	7
BENZO (g, h, i) PERYLENE	100	2500	30	1000	2500	250	0.5	10000
BENZO(k)FLUORANTHENE	0.7	0.7	0.7	0.7	0.7	0.	0.4	7
BERYLLIUM	3	3	3	0.4	0.8		500	30
BIPHENYL,1,1-	1	3000	10	1000	2500	300	4000	10000
BIS (2-CHLOROETHYL)ETHER	0.7	0.7	0.7	0.7	0.7	0.	100000	7
BIS (2-CHLOROISOPROPYL) ETHER	0.7	4	9	2	3		100000	90
BIS (2-ETHYLHEXYL) PHTHALATE	100	1000	500	100	300	100	700	10000
BROMODICHLOROMETHANE	0.1	90	90	10	20	9	100000	900
BROMOFORM	0.1	20	700	100	200	70	100000	7000
BROMOMETHANE	10	3	700	50	200	70	100000	7000
CADMIUM	80	80	80	30	80	8	100	800
CARBON TETRACHLORIDE	1	4	40	7	10	4	100000	400
CHLORDANE	5	5	5	1	2		50	50
CHLOROANILINE,p-	1	400	30	100	400	40	100000	4000
CHLOROBENZENE	8	80	40	500	1000	250	10000	10000
CHLOROFORM	0.1	10	300	100	200	50	100000	5000
CHLOROPHENOL, 2-	0.7	1000	20	100	200	100	100000	10000
CHROMIUM (TOTAL)	5000	5000	5000	1000	2500	500	20000	10000
CHROMIUM (III)	5000	5000	5000	1000	2500	500	20000	10000
CHROMIUM (VI)	1000	1000	1000	200	600	100	1000	10000
CHRYSENE	0.7	0.7	0.7	0.7	0.7	0.	3	7
CYANIDE	400	400	400	100	100	40	2000	4000
DIBENZO(a,h)ANTHRACENE	0.8	0.8	0.8	0.7	0.7	0.	0.3	8
DIBROMOCHLOROMETHANE	0.09	70	70	10	20	7	100000	700
DICHLOROBENZENE, 1,2-(o-	200	500	500	100	500	50	100000	5000
DICHLOROBENZENE, 1,3-(m-	200	500	500	100	500	50	100000	5000
DICHLOROBENZENE, 1,4-(p-	2	200	200	40	60	20	40000	2000
DICHLOROBENZIDINE, 3,3'-	3	3	3	1	1		2000	30
DICHLORODIPHENYL P,	1000	10	10	2	3	1	60	100
DICHLORODIPHENYLDICHLOROETHYLENE,P, P	98	9	9	2	2		20	90
DICHLORODIPHENYLTRICHLOROETHANE, P,	97	9	9	2	2		3	90
DICHLOROETHANE, 1,1-	3	400	500	100	500	50	100000	5000
DICHLOROETHANE, 1,2-	0.05	0.2	60	10	20	6	100000	600
DICHLOROETHYLENE, 1,1-	0.7	0.1	9	1	2		100000	90
DICHLOROETHYLENE, CIS-1,2-	2	500	500	100	500	50	100000	5000

Archived Document

Table 1.1, continued...

TABLE 1-1 MCP NUMERICAL STANDARDS	Method 1 S-3 Soil Standards 310 CMR 40.0975(6)(c)			Method 2 Direct Soil Contact Standards 310 CMR 40.0985(6)			Methods 2 & 3 Upper Concentration Limits (UCLs) 310 CMR 40.0996(4)	
OIL AND/OR HAZARDOUS MATERIAL	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg	S-1 mg/kg	S-2 mg/kg	S-3 mg/kg	Groundwate µg/L	Soil µg/g
DICHLOROETHYLENE, TRANS-1,	4	2500	2000	500	1000	2500	100000	10000
DICHLOROPHENOL, 2,4-	10	90	90		40	90	40000	900
DICHLOROPROPANE, 1,2-	0.1	0.2	40		8	40	100000	400
DICHLOROPROPENE, 1,3-	0.01	0.1	20		3	20	20000	200
DIELDRIN	0.1	0.2	0.1	0.03	0.04	0.2	1	2
DIETHYL PHTHALATE	100	5000	0.7	1000	2500	5000	60000	10000
DIMETHYL PHTHALATE	30	5000	0.7	1000	2500	5000	100000	10000
DIMETHYLPHENOL, 2,4-	0.7	4000	10		400	4000	100000	10000
DINITROPHENOL, 2,4-	3	90	6		40	90	20000	900
DINITROTOLUENE, 2,4-	0.7	7	7		1	7	20000	70
DIOXIN	2E-05	2E-05	2E-05	4E-06	6E-	2E-05	1E-03	2E-04
ENDOSULFAN	0.2	6	0.05		1	6	4	60
ENDRIN	0.6	10	1		6	10	50	100
ETHYLBENZENE	80	2500	500	500	1000	2500	100000	10000
ETHYLENE DIBROMIDE	0.005	0.04	0.07	0.01	0.02	0.07	100000	0.7
FLUORANTHENE	600	5000	600	900	2000	5000	100	10000
FLUORENE	400	5000	1000	900	2000	5000	1000	10000
HEPTACHLOR	0.7	0.7	0.7		0.1	0.7	10	7
HEPTACHLOR EPOXIDE	0.3	0.3	0.3	0.06	0.09	0.3	20	3
HEXACHLOROBENZENE	3	3	3		0.7	3	60	30
HEXACHLOROBUTADIENE	3	3	40		7	40	900	400
HEXACHLOROCYCLOHEXANE, (gamm|a| -	0.1	2	0.5		0.4	2	8	20
HEXACHLOROETHANE	30	30	50		6	50	50000	500
INDENO(1,2,3-cd)PYRENE	0.7	0.7	0.7		0.7	0.7	0.3	7
LEAD	600	600	600		300	600	300	6000
MERCURY	60	60	60		10	60	20	600
METHOXYCHLOR	300	300	30		100	300	40	3000
METHYL ETHYL KETONE	0.3	40	40	500	1000	2500	100000	10000
METHYL ISOBUTYL KETONE	0.5	70	70		100	1000	100000	10000
METHYL MERCURY	20	20	20		7	20	20	200
METHYL TERT BUTYL ETHER	3	200	200		100	500	100000	5000
METHYLENE CHLORIDE	0.1	700	700		100	700	100000	7000
METHYLNAPHTHALENE, 2-	0.7	20	7	1000	2500	2500	10000	10000
NAPHTHALENE	4	1000	1000	100	2500	2500	20000	10000
NICKEL	700	700	700		300	700	1000	7000
PENTACHLOROPHENOL	5	40	40		7	40	800	400
PHENANTHRENE	700	2500	100	1000	2500	2500	400	10000
PHENOL	60	800	500	500	1000	2500	100000	10000
POLYCHLORINATED BIPHENYLS	2	2	2		2	2	5	100
PYRENE	500	5000	500	700	2000	5000	80	10000
SELENIUM	2500	2500	2500	300	2500	2500	800	10000
SILVER	200	200	200		100	200	400	2000
STYRENE	2	20	100		20	100	100000	1000
TETRACHLOROETHANE, 1,1,1,2-	0.4	0.5	20		4	20	100000	200
TETRACHLOROETHANE, 1,1,2,2-	0.02	0.2	2		0.5	2	100000	20
TETRACHLOROETHYLENE	0.5	300	500		200	1000	50000	10000

Archived Document

TABLE 1-1

Table 1.1, continued...

MCP NUMERICAL STANDARDS	Method 1 S-3 Soil Standards 310 CMR 40.0975(6)			Method 2 Direct Contact Soil Standards 310 CMR 40.0985			Methods 2 & 3 Limits (UCLs) 310 CMR 40.0996	
OIL AND/OR HAZARDOUS MATERIAL	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg	S-1 mg/kg	S-2 mg/kg	S-3 mg/kg	Groundwate µg/L	Soil µg/g
THALLIUM	100	100	100	8	30	100	4000	1000
TOLUENE	90	500	2500	500	1000	2500	100000	10000
TOTAL PETROLEUM HYDROCARBONS	5000	5000	5000	500	2500	5000	100000	10000
TRICHLOROBENZENE, 1,2,4-	100	900	800	400	1000	1000	6000	10000
TRICHLOROETHANE, 1,1,1-	30	500	500	100	500	500	100000	5000
TRICHLOROETHANE, 1,1,2-	0.3	10	10	2	3	10	100000	100
TRICHLOROETHYLENE	0.4	20	500	70	100	500	100000	5000
TRICHLOROPHENOL, 2,4,5-	3	5000	2	1000	2500	5000	2000	10000
TRICHLOROPHENOL 2,4,6-	3	200	200	40	60	200	100000	2000
VINYL CHLORIDE	0.4	0.3	2	0.3	0.5	2	600	20
XYLENES	800	500	2500	500	1000	2500	100000	10000
ZINC	5000	5000	5000	2500	2500	5000	20000	10000

Archived Document

2.0 DOSE-RESPONSE INFORMATION

This section contains the dose-response information and physical constants for each of the oil or hazardous material for which MCP Method 1 Standards are derived. This information is coupled with the exposure information described in Sections 4 and 5 to develop the standards for each Groundwater and Soil Category.

The dose-response information is divided into three major categories:

- Toxicity information associated with threshold (non-carcinogenic) health effects.
- Toxicity information concerning carcinogenicity, either from human epidemiologic data or from laboratory studies.
- The *R*elative *Absorption F*actors (RAFs) used to relate the toxicity values from the literature to the exposure pathways of concern in this spreadsheet.

The classification of a chemical as a carcinogen does not preclude an evaluation of that same chemical for potential non-carcinogenic health risks.

2.1 THRESHOLD EFFECTS

For non-carcinogenic health effects it is believed that a dose level exists at and below which no adverse health effects would be expected. Such a level is referred to as a ***threshold dose.*** While it is impossible to specify a theoretical threshold dose for a given chemical, it is possible to estimate a human sub-threshold dose at which no adverse health effects would be expected. Such a value is typically derived from the No Observable Adverse Effects Level (NOAEL) of an animal study (although human data are used, when available) by application of uncertainty factors (UF) to account for interspecies variation, exposure duration and to protect sensitive populations. Important factors to consider when identifying and using such a sub-threshold dose include:

- the route of administration of the dose (inhalation, oral, dermal contact, etc...)
- the duration of exposure to that dose (lifetime, chronic, subchronic, or acute exposure)
- the absorption efficiency (if any) used to calculate that dose
- the age of the person receiving the dose.

Several types of "sub-threshold dose" values were used to develop the MCP Method 1 Standards. The sources of these values are described in general below, and Table 2.1 provides the specific values. The source for a specific toxicity value may be found using the references adjacent to each value in the table, and the list of references at the end of the table.

For oral and dermal exposures, the U.S. EPA-derived oral Reference Dose (RfD) was used when one was available for the chemical of concern. Chronic RfDs are available from the U.S. EPA's on-line database, the *Integrated Risk Information System* (IRIS). Subchronic RfDs from the U.S. EPA's *Health Effects Assessment Summary Tables* (HEAST) were used for the development of Soil Category S-3 Standards. HEAST also served as a source of US EPA derived chronic RfDs.

For inhalation exposures, the U.S. EPA-derived inhalation Reference Concentration (RfC) was

used when one was available for the chemical of concern. Chronic RfCs are available from the U.S. EPA's on-line database, the *Integrated Risk Information System* (IRIS) and the U.S. EPA's *Health Effects Assessment Summary Tables* (HEAST). In the absence of an RfC, the *"Allowable Threshold Concentration"* (MA DEQE, 1989a) was used. The Allowable Threshold Concentration (ATC) is a value derived from the Threshold Effects Exposure Limit (TEL) described in CHEM (MA DEP, 1990c). (The TEL value represents 20% of an allowable concentration, or ATC. Thus the ATC is equal to five times the TEL. The TEL was derived in a manner considering children to be the most sensitive potential receptors.) The inhalation pathway was evaluated only for volatile chemicals in the development of GW-2 standards.

For a limited number of chemicals, an analogous toxicity value was identified or developed by MA DEP Office of Research and Standards staff when a subchronic or chronic RfD or RfC was not available from IRIS or HEAST. The documentation for these values is published elsewhere (MA DEP, 1992a).

2.2 CARCINOGENIC EFFECTS

Unlike the non-carcinogenic health effects, it is generally assumed that there is no threshold dose for carcinogenicity, that there is no dose of a carcinogenic substance (other than no exposure) which is associated with zero risk. The ability of a chemical to increase the incidence of cancer in a target population is described by one of two measures: the ***cancer slope factor*** or the ***unit risk.*** The cancer slope factor was used to develop the MCP Method 1 Standards.

The cancer slope factor for a chemical is derived by the EPA's Cancer Assessment Group (CAG). Using data derived from animal studies, the slope factor is an estimate of the upper 95% Confidence Limit of the slope of the dose-response curve extrapolated to low doses. For some chemicals, human epidemiologic data is the basis of an estimate of the carcinogenic potency, although the most common basis of these values is an animal study. The slope factor is given in units of $(mg/kg/day)^{-1}$. It is based upon the concept of a lifetime average daily dose.

The inhalation Unit Risk is the upper 95% Confidence Limit of the mean incremental lifetime cancer risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of 1 $\mu g/m^3$.

The U.S. EPA derived oral cancer slope factor (CSF) was used to evaluate both oral and dermal exposure to carcinogens. The U.S. EPA's *IRIS* database and the *Health Effects Assessment Summary Tables* served as the primary and secondary sources of the slope factors. Inhalation Unit Risks (from the same sources) were used to evaluate the inhalation exposure pathway for volatile chemicals in the development of GW-2 standards only.

2.3 RELATIVE ABSORPTION FACTORS (RAFs)

The development of the MCP Method 1 Standards used *R*elative *A*bsorption *F*actors (RAFs) which have been determined or estimated for each chemical via each route of exposure.

The RAF addresses two major issues:

- the absorption efficiency for the chemical via the route and medium of exposure for which the standard is being developed, and

- the absorption efficiency for the route and medium of exposure in the experimental study which is the basis of the Reference Dose or the Cancer Slope Factor for the chemical in question.

Thus the RAF adjusts the dose (or exposure) estimates based on these ***two*** absorption efficiencies. MA DEQE (1989) and MA DEP (1992) describe the development of RAFs in detail. (The factors were called "*Bioavailability Adjustment Factors*", or "*BAFs*" in the 1989 document.) US EPA (1989a), Appendix A also provides guidance for the "Adjustments For Absorption Efficiency".

2.4 TOXICITY INFORMATION TABLE - Table 2.1.

The following summary table documents the selection and development of individual toxicity values. The list of references is provided at the end of the table.

Archived Document

TABLE 2.1
TOXICITY INFORMATION

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
ACENAPHTHENE	83329	6.0E-01	2	6.0E-02	1					
ACENAPHTHYLENE	208968	4.0E-02	2f	4.0E-02	2f				D	1
ACETONE	67641	1 .0E+00	2	1 .0E-01	1	8.0E+02	3		D	1
ALDRIN	309002	3.0E-05	2	3.0E-05	1			1 .70E+01	B2	1
ANTHRACENE	120127	3.0E+00	2	3.0E-01	1				D	1
ANTIMONY	7440360	4.0E-04	2	4.0E-04	1					
ARSENIC	7440382	3.0E-04	2	3.0E-04	1			1.75E+00	A	1f
BENZENE	71432	5.0E-02	4	5.0E-03	4	9.0E+00	3	2.90E-02	A	1
BENZO(a)ANTHRACENE	56553	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BENZO(a)PYRENE	50328	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1
BENZO(b)FLUORANTHENE	205992	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BENZO(g , h , i)PERYLENE	191242	4.0E-02	2f	4.0E-02	2f				D	1
BENZO(k)FLUORANTHENE	207089	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BERYLLIUM	7440417	5.0E-03	2	5.0E-03	1			4.30E+00	B2	1
BIPHENYL, 1,1-	92524	5.0E-02	2	5.0E-02	1				D	1
BIS(2-CHLOROETHYL)ETHER	111444	NA						1.10E+00	B2	1
BIS(2-CHLOROISOPROPYL)ETHER	39638329	4.0E-02	2	4.0E-02	1			7.00E-02	C	2
BIS(2-ETHYLHEXYL)PHTHALATE	117817	2.0E-02	2	2.0E-02	1	7.0E+00	3	1.40E-02	B2	1
BROMODICHLOROMETHANE	75274	2.0E-02	2	2.0E-02	1			6.20E-02	B2	1
BROMOFORM	75252	2.0E-01	2	2.0E-02	1			7.90E-03	B2	1
BROMOMETHANE	74839	1.4E-02	2	1.4E-03	1	5.0E+00	1		D	1
CADMIUM	7440439	5.0E-04	1a,1e	5.0E-04	1 a				ND	1
CARBON TETRACHLORIDE	56235	7.0E-03	2	7.0E-04	1	4.3E+02	3	1.30E-01	B2	1
CHLORDANE	57749	6.0E-05	2	6.0E-05	1	7.0E-01	3	1 .30E+00	B2	1
CHLOROANILINE, p-	106478	4.0E-03	2	4.0E-03	1					
CHLOROBENZENE	108907	2.0E-01	2	2.0E-02	1	2.0E+01	2		D	1
CHLOROFORM	67663	1 .0E-02	2	1 .0E-02	1	6.6E+02	3	6.10E-03	B2	1
CHLOROPHENOL, 2-	95578	5.0E-02	2	5.0E-03	1					
CHROMIUM(III)	16065831	1 .0E+00	2	1.0E+00	1					
CHROMIUM(VI)	18540299	2.0E-02	2	5.0E-03	1				ND	2
CHRYSENE	218019	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
CYANIDE	57125	2.0E-02	2	2.0E-02	1				D	1
DIBENZO(a,h)ANTHRACENE	53703	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
DIBROMOCHLOROMETHANE	124481	2.0E-01	2	2.0E-02	1			8.40E-02	C	1
DICHLOROBENZENE, 1 , 2- (o-DCB)	95501	9.0E-01	2	9.0E-02	1	2.0E+02	2		D	1
DICHLOROBENZENE, 1 , 3- (m-DCB)	541731	9.0E-01	2a	9.0E-02	1b				D	1
DICHLOROBENZENE, 1 , 4- (p-DCB)	106467	9.0E-01	2a			8.0E+02	2	2.40E-02	C	2
DICHLOROBENZIDINE, 3,3'-	91941	NA						4.50E-01	B2	1
DICHLORODIPHENYL DICHLOROETHANE, P , P'- (DD D	72548	NA						2.40E-01	B2	1
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD	72559	NA						3.40E-01	B2	1
DICHLORODIPHENYLTRICHLOROETHANE, P , P'- (D	50293	5.0E-04	2	5.0E-04	1			3.40E-01	B2	1
DICHLOROETHANE, 1 ,1-	75343	1 .0E+00	2	1 .0E-01	2	5.0E+02	2		C	1
DICHLOROETHANE, 1 , 2-	107062	2.0E-01	4	2.0E-02	4	5.5E+01	3	9.10E-02	B2	1
DICHLOROETHYLENE, 1,1-	75354	9.0E-03	2	9.0E-03	1	5.0E+00	3	6.00E-01	C	1
DICHLOROETHYLENE, CIS-1 , 2-	156592	1 .0E-01	2	1 .0E-02	2				D	1

Archived Document

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
DICHLOROETHYLENE, TRANS-1,2-		2.0E-01	2	2.0E-02	1					
DICHLOROPHENOL, 2,4-		3.0E-03	2	3.0E-03	1					
DICHLOROPROPANE, 1,2-		NA				4.0E+00	1	6.80E-02	B2	2
DICHLOROPROPENE, 1,3-		3.0E-03	2	3.0E-04	1	2.0E+01	1	1.80E-01	B2	2
DIELDRIN		5.0E-05	2	5.0E-05	1			1.60E+01	B2	1
DIETHYL PHTHALATE		8.0E+00	2	8.0E-01	1				D	1
DIMETHYL PHTHALATE		1.0E+00	2	1.0E+01	2				D	1
DIMETHYLPHENOL, 2,4-		2.0E-01	2	2.0E-02	1					
DINITROPHENOL, 2,4-		2.0E-03	2	2.0E-03	1					
DINITROTOLUENE, 2,4-		2.0E-03	2	2.0E-03	1			6.80E-01	B2	1h
DIOXIN		NA		NA				1.50E+05	B2	2
ENDOSULFAN		2.0E-04	2	5.0E-05	1j					
ENDRIN		3.0E-04	2	3.0E-04	1				D	1
ETHYLBENZENE		1.0E+00	2	1.0E-01	1	1.0E+03	1		D	1
ETHYLENE DIBROMIDE		2.0E-04	4	2.0E-05	4	2.0E-01	4	8.50E+01	B2	1
FLUORANTHENE		4.0E-01	2	4.0E-02	1				D	1
FLUORENE		4.0E-01	2	4.0E-02	1				D	1
HEPTACHLOR		5.0E-04	2	5.0E-04	1	7.0E-01	3	4.50E+00	B2	1
HEPTACHLOR EPOXIDE		1.3E-05	2	1.3E-05	1			9.10E+00	B2	1
HEXACHLOROBENZENE		8.0E-04	2	8.0E-04	1			1.60E+00	B2	1
HEXACHLOROBUTADIENE		2.0E-03	2	2.0E-03	1j			7.80E-02	C	1
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HC H	58899	3.0E-03	2	3.0E-04	1			1.30E+00	B2-C	2
HEXACHLOROETHANE		1.0E-02	2	1.0E-03	1	3.0E+00	3	1.40E-02	C	1
INDENO(1,2,3-cd)PYRENE		4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
LEAD		7.5E-04	4	7.5E-04	4				B2	1
MERCURY		3.0E-04	2	3.0E-04	2				D	1
METHOXYCHLOR		5.0E-03	2	5.0E-03	1				D	1
METHYL ETHYL KETONE		5.0E-01	2	6.0E-01	1	1.0E+03	1		D	1
METHYL ISOBUTYL KETONE		5.0E-01	2	5.0E-02	2	8.0E+01	2			
METHYL MERCURY		3.0E-04	2	3.0E-04	1					
METHYL TERT BUTYL ETHER		5.2E-02	4	1.0E-01	5	5.0E+02	1			
METHYLENE CHLORIDE		6.0E-02	2	6.0E-02	1	3.0E+03	2	7.50E-03	B2	1
METHYLNAPHTHALENE, 2-		4.0E-02	2f	4.0E-02	2f	7.1E+01	3b			
NAPHTHALENE		4.0E-02	2	4.0E-02	2	7.1E+01	3b		D	1
NICKEL		2.0E-02	2	2.0E-02	1				ND	2
PENTACHLOROPHENOL		3.0E-02	2	3.0E-02	1	7.0E-02	3	1.20E-01	B2	1
PHENANTHRENE		4.0E-02	2f	4.0E-02	2f				D	1
PHENOL		6.0E-01	2	6.0E-01	1	2.6E+02	3		D	1
POLYCHLORINATED BIPHENYLS (PCBs)		5.0E-06	4	2.0E-05	6	2.0E-02	3	7.70E+00	B2	1
PYRENE		3.0E-01	2	3.0E-02	1				D	1
SELENIUM		5.0E-03	2	5.0E-03	1				D	1
SILVER		5.0E-03	2	5.0E-03	1				D	1
STYRENE		2.0E+00	2	2.0E-01	1	1.0E+03	1	3.00E-02	B2	2k
TETRACHLOROETHANE, 1,1,1,2-		3.0E-02	2	3.0E-02	1			2.60E-02	C	1
TETRACHLOROETHANE, 1,1,2,2-		NA		NA		9.3E+01	3	2.00E-01	C	1

Archived Document

Table

TABLE 2-1

TOXICITY INFORMATION & RAFs

2.1, continued...

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
TETRACHLOROETHYLENE	[illegible]	1.0E-01	2	1.0E-02	1	4.6E+03	3	5.20E-03	C-B2	2h
THALLIUM	[illegible]	7.0E-04	2	7.0E-05	2					
TOLUENE	[illegible]	2.0E+00	2	2.0E-01	1	4.0E+02	1		D	1
TOTAL PETROLEUM HYDROCARBONS	[illegible]	3.0E-01								
TRICHLOROBENZENE, 1,2,4-	[illegible]	1.0E-02	2	1.0E-02	1	9.0E+00	2		D	1
TRICHLOROETHANE, 1,1,1-	[illegible]	9.0E-01	2	9.0E-02	2	1.0E+03	2		D	1
TRICHLOROETHANE, 1,1,2-	[illegible]	4.0E-02	2	4.0E-03	1	7.4E+01	3	5.70E-02	C	1
TRICHLOROETHYLENE	[illegible]	2.0E-02	4	2.0E-03	4	1.8E+02	3	1.10E-02	C-B2	2h
TRICHLOROPHENOL, 2,4,5-	[illegible]	1.0E+00	2	1.0E-01	1					
TRICHLOROPHENOL 2,4,6-	[illegible]	NA		NA				1.10E-02	B2	1
VINYL CHLORIDE	[illegible]	1.0E-03	4	1.0E-03	4	1.7E+01	3	1.90E+00	A	2
XYLENES (Mixed Isomers)	[illegible]	4.0E+00	2	2.0E+00	1	3.0E+02	2		D	1
ZINC	[illegible]	3.0E-01	2	3.0E-01	1				D	1

Archived Document

Table

TABLE 2-1
2.1, continued...

TOXICITY INFORMATION & RAFs	INHALATION CANCER UNIT RISK	CLASS	REF	RAF, SUB-CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
OIL AND/OR HAZARDOUS MATERIAL	1/(ug/cu m)				RELATIVE ABSORPTION FACTORS (RAFs)						
ACENAPHTHENE				1	0.2	1	0.2	NC	NC	1	NC
ACENAPHTHYLENE				0.91	0.18	0.91	0.18	NC	NC	0.91	NC
ACETONE		D	1	1	0.1	1	0.1	NC	NC	1	NC
ALDRIN	4.9E-03	B2	1	1	0.25	1	0.25	1	0.25	1	1
ANTHRACENE				1	0.29	1	0.29	NC	NC	1	NC
ANTIMONY				1	0.1	1	0.1	NC	NC	1	NC
ARSENIC				1	0.03	1	0.03	1	0.03	1	1
BENZENE	8.3E-06	A	1	1	0.08	1	0.08	1	0.08	1	1
BENZO(a)ANTHRACENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(a)PYRENE	1.7E-03		2	0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(b)FLUORANTHENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(g,h,i)PERYLENE				0.91	0.18	0.91	0.18	NC	NC	0.91	NC
BENZO(k)FLUORANTHENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BERYLLIUM				1	0.03	1	0.03	1	0.03	1	1
BIPHENYL, 1,1-				1	0.08	1	0.08	NC	NC	1	NC
BIS(2-CHLOROETHYL)ETHER	3.3E-04	B2	1	NC	NC	NC	NC	1	1	NC	1
BIS(2-CHLOROISOPROPYL)ETHER	1.0E-05	C	2	1	1	1	1	1	1	1	1
BIS(2-ETHYLHEXYL)PHTHALATE	1.3E-06		chem	1	0.02	1	0.02	1	0.02	1	1
BROMODICHLOROMETHANE				1	0.1	1	0.1	1	0.1	1	1
BROMOFORM	1.1E-06	B2	1	1	0.11	1	0.11	1	0.1	1	1
BROMOMETHANE				1	0.1	1	0.1	NC	NC	1	NC
CADMIUM				1	0.14	1	0.14	NC	NC	1	NC
CARBON TETRACHLORIDE	1.5E-05	B2	1	1	0.1	1	0.1	1	0.1	1	1
CHLORDANE	3.7E-04	B2	1	1	0.05	1	0.05	1	0.05	1	1
CHLOROANILINE, p-				1	0.1	1	0.1	NC	NC	1	NC
CHLOROBENZENE		D	1	1	0.1	1	0.1	NC	NC	1	NC
CHLOROFORM	2.3E-05	B2	1	1	0.1	1	0.1	1	0.1	1	1
CHLOROPHENOL, 2-				1	0.26	1	0.26	NC	NC	1	NC
CHROMIUM(III)				1	0.04	1	0.04	NC	NC	1	NC
CHROMIUM(VI)				1	0.09	1	0.09	NC	NC	1	NC
CHRYSENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
CYANIDE				1	0.3	1	0.3	NC	NC	1	NC
DIBENZO(a,h)ANTHRACENE				0.91	0.08	0.91	0.08	1	0.09	0.91	1
DIBROMOCHLOROMETHANE				1	0.1	1	0.1	1	0.1	1	1
DICHLOROBENZENE, 1,2-				1	0.1	1	0.1	NC	NC	1	NC
DICHLOROBENZENE, 1,3- (m-DCB)				NC	NC	1	0.1	NC	NC	1	NC
DICHLOROBENZENE, 1,4- (p-DCB)				NC	NC	1	0.1	1	0.1	NC	1
DICHLOROBENZIDINE, 3,3'-				NC	NC	NC	NC	1	0.54	NC	1
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD D				NC	NC	NC	NC	1	0.2	NC	1
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD				NC	NC	NC	NC	1	0.2	NC	1
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (D T	9.7E-	B2	1	1	0.2	1	0.2	1	0.2	1	1
DICHLOROETHANE, 1,1-		C	2	1.3	0.13	1.3	0.13	NC	NC	1.3	NC
DICHLOROETHANE, 1,2-	2.6E-05	B2	2	1	0.1	1	0.1	1	0.1	1	1
DICHLOROETHYLENE, 1,1-	5.0E-05	C	1	1	0.1	1	0.1	1.02	0.102	1	1.02
DICHLOROETHYLENE, CIS-1,2-				1	0.1	1	0.1	NC	NC	1	NC

Archived Document

Table 2.1, continued...

TABLE 2-1

TOXICITY INFORMATION & RAFs

RELATIVE ABSORPTION FACTORS (RAFs)

OIL AND/OR HAZARDOUS MATERIAL	INHALATION CANCER UNIT RISK 1/(ug/cu m)	CLASS	REF	CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
DICHLOROETHYLENE, TRANS-1,2-				1	0.1	1	0.1	NC	NC	1	NC
DICHLOROPHENOL, 2,4-					0.4	1	0.4	NC	NC	1	NC
DICHLOROPROPANE, 1,2-		B2	chem	NC	NC	NC	NC	1	0.2	NC	1
DICHLOROPROPENE, 1,3-		B2	2	1	0.2	1	0.2	1	0.2	1	1
DIELDRIN		B2	1	1	0.25	1	0.25	1	0.25	1	1
DIETHYL PHTHALATE				1	0.02	1	0.02	NC	NC	1	NC
DIMETHYL PHTHALATE				1	0.07	1	0.07	NC	NC	1	NC
DIMETHYLPHENOL, 2,4-					0.26	1	0.26	NC	NC	1	NC
DINITROPHENOL, 2,4-					0.26	1	0.26	NC	NC	1	NC
DINITROTOLUENE, 2,4-					0.13	1	0.13	1	0.13	1	1
DIOXIN		B2	2	NC	NC	NC	NC	1	0.2	NC	1
ENDOSULFAN				1	0.2	1	0.2	NC	NC	1	NC
ENDRIN				1	0.25	1	0.25	NC	NC	1	NC
ETHYLBENZENE		D	1	1	0.2	1	0.2	NC	NC	1	NC
ETHYLENE DIBROMIDE		B2	1	1	0.1	1	0.1	1	0.1	1	1
FLUORANTHENE				1	0.2	1	0.2	NC	NC	1	NC
FLUORENE				1	0.2	1	0.2	NC	NC	1	NC
HEPTACHLOR		B2	1	1	0.2	1	0.2	1	0.2	1	1
HEPTACHLOR EPOXIDE		B2	1	1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROBENZENE		B2	1	1	0.13	1	0.13	1	0.13	1	1
HEXACHLOROBUTADIENE		C	1	1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH				1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROETHANE		C	2	1	1	1	1	1	1	1	1
INDENO(1,2,3-cd)PYRENE					0.18	0.91	0.18	1	0.2	0.91	1
LEAD					0.006	0.5	0.006	NC	NC	0.5	NC
MERCURY					0.05	1	0.05	NC	NC	1	NC
METHOXYCHLOR					0.2	1	0.2	NC	NC	1	NC
METHYL ETHYL KETONE		D	1	1	0.1	1	0.1	NC	NC	1	NC
METHYL ISOBUTYL KETONE				1	0.1	1	0.1	NC	NC	1	NC
METHYL MERCURY					0.2	1	0.2	NC	NC	1	NC
METHYL TERT BUTYL ETHER					0.1	1	0.1	NC	NC	1	NC
METHYLENE CHLORIDE		B2	1	1	0.1	1	0.1	1	0.1	1	1
METHYLNAPHTHALENE, 2-					0.1	1	0.1	NC	NC	1	NC
NAPHTHALENE		D	1	1	0.1	1	0.1	NC	NC	1	NC
NICKEL					0.35	1	0.35	NC	NC	1	NC
PENTACHLOROPHENOL					0.11	1	0.11	1	0.11	1	1
PHENANTHRENE					0.18	0.91	0.18	NC	NC	0.91	NC
PHENOL					0.26	1	0.26	NC	NC	1	NC
POLYCHLORINATED BIPHENYLS (PCBs)					0.067	0.85	0.067	0.85	0.067	1	1
PYRENE				1	0.2	1	0.2	NC	NC	1	NC
SELENIUM					0.002	1	0.002	NC	NC	1	NC
SILVER					0.25	1	0.25	NC	NC	1	NC
STYRENE		B2	2	1	0.2	1	0.2	1	0.2	1	1
TETRACHLOROETHANE, 1,1,1,2-		C	1	1	1.4	1	1.4	1	1.4	1	1
TETRACHLOROETHANE, 1,1,2,2-		C	1	NC	NC	NC	NC	1	1.4	NC	1

Archived Document

Table 2.1, continued...

TOXICITY INFORMATION & RAFs OIL AND/OR HAZARDOUS MATERIAL	INHALATION CANCER UNI RISK 1/(ug/cu m)	CLASS	R	CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
TETRACHLOROETHYLENE	5.2E-07	C-B2	2h	1	0.1	1	0.1	1	0.1	1	1
THALLIUM				1	0.01	1	0.01	NC	NC	1	NC
TOLUENE		D	1	1	0.12	1	0.12	NC	NC	1	NC
TOTAL PETROLEUM HYDROCARBONS					1	1	1	NC	NC		
TRICHLOROBENZENE, 1,2,4-					0.08	1	0.08	NC	NC	1	NC
TRICHLOROETHANE, 1,1,1-		D	1	1	0.1	1	0.1	NC	NC	1	NC
TRICHLOROETHANE, 1,1,2-	1.6E-05	C	1	1	1	1	1	1	1	1	1
TRICHLOROETHYLENE	1.7E-06	C-B2	2h	1	0.1	1	0.1	1	0.1	1	1
TRICHLOROPHENOL, 2,4,5-					0.26	1	0.26	NC	NC	1	NC
TRICHLOROPHENOL 2,4,6-	3.1E-06	B2	1	NC	NC	NC	NC	1	0.26	NC	1
VINYL CHLORIDE	8.4E-05	A	2	1	0.1	1	0.1	1.53	0.16	1	1.53
XYLENES (Mixed Isomers)		D	1	1	0.12	1	0.12	NC	NC	1	NC
ZINC				1	0.02	1	0.02	NC	NC	1	NC

Archived Document

References for Toxicity Values and Constants on Spreadsheet

Reference #	Description
1.	U.S. EPA, Integrated Risk Information System (IRIS). On-line search: current as of July 1, 1993.
1.a.	The chronic oral RfD for drinking water (from IRIS) is listed here as the oral RfD for cadmium.
1.b.	The chronic oral RfD for 1,2-Dichlorobenzene has been used as the chronic oral RfD equivalent for 1,3-Dichlorobenzene.
1.e.	The chronic oral RfD (from IRIS) has been used here as a subchronic oral RfD equivalent.
1.f.	This oral Cancer Slope Factor equivalent for arsenic is back-calculated from a drinking water Unit Risk Value from IRIS.
1.g.	This Cancer Slope Factor or Unit Risk for benzo(a)pyrene (from IRIS) has been applied to the seven PAH compounds which are designated as category A, B1, B2 or C carcinogens.
1.h.	The oral cancer slope factor for a mix of 2,4- and 2,6- Dinitrotoluene (from IRIS) has been used as the cancer slope factor equivalent for pure 2,4-Dinitrotoluene.
1.j.	This value was recently withdrawn form IRIS, although many consultants may continue to use it, lacking any new information.
2.	U.S. EPA Health Effects Assessment Summary Tables (HEAST), Annual FY-1992. (OERR 9200.6-303 (92-1), NTIS No. PB92-921 199) January/July 1992.
2.a.	This subchronic oral RfD (from HEAST) for 1,2-Dichlorobenzene has been used as the subchronic oral RfD equivalent for 1,3- and 1,4- Dichlorobenzene.
2.b.	This subchronic oral RfD (from HEAST) for naphthalene has been used as the subchronic oral RfD equivalent for all PAH compounds for which subchronic oral RfDs are unavailable.
2.d.	Note!! HEAST lists TWO oral RfDs. Call for more information.
2.f.	The chronic oral RfD for naphthalene (from HEAST) has been used as the chronic RfD equivalent for all PAH compounds for which chronic oral RfDs are unavailable.
2.h.	This Cancer Slope Factor or Unit Risk was taken from a fact sheet distributed by the U.S. EPA Superfund Health Risk Technical Support Center at ECAO-Cincinnati, current as of September 2, 1992.
2.j.	HEAST has adopted the IRIS chronic oral RfD as the subchronic oral RfD.
2.k.	This value has been withdrawn from HEAST, although many consultants may continue to use it, lacking any new information. Consult HEAST for any additional information.
3.	Allowable Threshold Concentrations (ATCs) from MA DEQE (1989a), Guidance for Disposal Site Risk Characterization and Related Phase II Activities - In Support of the Massachusetts Contingency Plan.
3.b.	The ATC for 'total concentration of naphthalene and 2-methylnaphthalene' is used here as the ATC for this chemical.
3.c.	The chronic inhalation ATC for naphthalene has been used as the chronic inhalation RfC equivalent for all PAH compounds for which chronic inhalation RfCs are unavailable.
4.	Developed for the *Risk Assessment Sh ortForm - Residential Scenario* (MA DEP, 1992) by MA DEP staff. Documentation of this value may be found in that document.
5.	The chronic oral RfD for Methyl tert-Butyl Ether is based on Drinking Water Guidelines promulgated by the ORS in October, 1992.
6.	The chronic oral RfD for Arachlor 1254, developed by DEP ORS in a May 10, 1993 memo, has been used as the chronic oral RfD for PCBs as a group.
SES	These values have been developed using the SESOIL model.

Archive Document

Reference #	Description
NA	Not Available
NC	Not Calculated.

10. Owen, 1990. 'Literature Derived Absorption Coefficients for 39 Chemicals via Oral and Inhalation Routes of Exposure'; Regulatory Toxicology and Pharmacology; pp. 237-252; November, 1990.

11. United States Environmental Protection Agency (USEPA), 1986. 'Superfund Public Health Evaluation Manual'; U.S. Environmental Protection Agency; Office of Emergency and Remedial Response, EPA/540/1-86/060 (OSWER Directive 9285.4-1); Washington, D.C., October 1986.

12. USEPA, 1992. 'Dermal Exposure Assessment: Principles and Applications'; U.S. Environmental Protection Agency; Office of Research and Development, EPA/600/8-91/011B; Washington, D.C., January 1992.

13. ATSDR, 'Toxicological Profile for _____'; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. The ATSDR profile for the chemical of interest was used as a source of this value.

14. USEPA Test Methods for Evaluating Solid Waste, SW-846, Third Edition (Revision O), November 1986.
14.a. USEPA Method 8240.
14.b. USEPA Method 8080.
14.c. USEPA Method 8270.
14.d. USEPA Method 6010.
14.e. USEPA Method 525.1.
14.f. USEPA Method 524.1.
14.g. USEPA Method 524.2.
14.h. USEPA Method 7196.
14.i. USEPA Method 7470.

15. Guide to Environmental Analytical Methods, Robert E. Wagner, editor; Genium Publishing Corporation, Schenectady, NY; 1992.
15.a. USEPA Method 335.
15.b. USEPA Method 200.7.
15.c. USEPA Method 508.
15.d. USEPA Method 625.

16. From CLP Statement of Work for Inorganic Analytes, 8/90, Document Number ILM01.1

17. Standard Methods for the Examination of Water and Wastewater, 17th edition; Water Environment Federation.

18. Federal Register 40 CFR 141:23:3579 (January 30, 1991).

19. USEPA Method 1613.

20. U.S. Department of Defense, 1989

21. U.S. EPA Draft Health Advisory for Methyl t-Butyl Ether, 1989.

22. Oregon Department of Environmental Quality, Development of Generic Soil Cleanup Levels Based On Analysis Of The Leachate Pathway, May 12, 1992.

23. See Appendix G: Application of SESOIL Model

24. Handbook of Environmental Data on Organic Chemicals, 2nd edition, Karel Verschueren; Van Nostrand Reinhold Co. Inc., NY; 1983.

Archived Document

Reference # Description

25. Compilation of Odor and Taste Threshold Values Data, F.A. Fazzalari, editor; ASTM Data Service DS48A; 1978.

27. USEPA, 1992. "Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendment of 1990", U.S. Environmental Protection Agency; Office of Research and Development, EPA/600/R-92/047; Washington, D.C., March 1992.

28. USEPA, 1992. "Indoor Air Quality Database for Organic Compounds", U.S. Environmental Protection Agency; Research Triangle Park, NC, February 1992.

29. Risk Reduction Engineering Laboratory (RREL) Treatability Database, Version 4.0.

30. U.S. Department of Defense, 1991. "Defense Priority Model Users Manual", FY 1992 version; Washington, D.C.

calc Calculated value

Archived Document

3.0 CONSIDERATION OF PQL, BACKGROUND, SOLUBILITY, ODOR AND CEILING CONCENTRATIONS

The methodology for developing the MCP Numerical Standards considered the Practical Quantitation Limit (PQL) and background levels for the oil or hazardous material in each medium, the solubility of the chemical in water and, when available, the chemical's odor threshold and calculated odor index. In addition, *ceiling concentrations* were established to address non-quantifiable risks to public welfare and the environment.

3.1 PRACTICAL QUANTITATION LIMITS

The PQL is the lowest quantitation level of a chemical that can be reliably achieved among laboratories within the specified limits of precision and accuracy of a given analytical method during routine laboratory operating conditions. Table 3.1 lists the PQLs identified for each oil or hazardous material in soil and groundwater, referencing the specific analytical method. A discussion on the selection of PQLs is described in Appendix G.

The risk-based concentrations generated for each oil or hazardous material were compared to the PQL to insure that the Method 1 standard can be measured with reliability. Note that the PQLs selected are *not* the lowest quantitation limit: Method Detection Limits (MDLs) are lower, but the quantification of a chemical's concentration at those levels is less reliable.

3.2 BACKGROUND

The level of oil or hazardous material which would exist in the absence of the site ("background") is considered in a number of ways in the MCP, including a condition:

- If the concentration of an oil and/or hazardous material at the disposal site is at or below background levels, then that oil and/or hazardous material shall be considered to pose No Significant Risk. (310 CMR 40.0902(3))

In developing the Method 1 Standards, it was decided that, when the information is readily available, the numerical standards should not be set at a level less than an established background concentration. **This partially addresses the intent of the regulation paraphrased above.** As described below, the chosen background levels represent upper percentiles of a "natural" background distribution.

The use of background levels in this manner in the development of a limited number of standards does not eliminate the MCP requirement for identifying site-specific background levels (310 CMR 40.0904(2)(b)). The Department intends to issue more detailed guidance in this area.

Background may be chosen as the remedial goal primarily for three reasons:

> Remediation to background levels may be chosen to eliminate the risk characterization entirely (310 CMR 40.0901(3)), to minimize the complexity of the risk characterization process, or to achieve a Class A-1 Response Action Outcome (310 CMR 40.1036(1)).

> Remediation to background levels for all or some oil or hazardous materials may be chosen because background levels prevent the attainment of specified risk-based goals (310 CMR 40.0902(3)).

> The feasibility of remediation to background levels has been evaluated as part of a remedial response action, and it is determined to be feasible (310 CMR 40.0860).

There is not one concentration of a chemical, of course, which can correctly be labelled *the* background level. Hundreds of years of human activities have only broadened the range of concentrations reported as "background", and this range is best thought of as a statistical distribution. For the purposes of many environmental regulations, however, we often select point values from the range of representative background levels, and consider these to be representative of background. The use of such point-value "background" levels is essentially a short-cut method which allows consideration of background when little analytical data is available. When sufficient information has been collected (enough site-specific background and on-site samples to establish and describe distributions for each), comparisons to background can be accomplished through statistical tests of the sample populations. For the consideration of background at c.21E sites such an assessment should be the norm.

The listed point values have been chosen to represent concentrations consistent with the majority of "natural" background conditions, and they range from the 75th to 95th percentile values of the data sets examined (depending upon the information available for that data set). Given the wide ranges seen in distributions of background concentrations it is clear that the choice of a point value within that range balances the need to eliminate background chemicals with the need to retain for evaluation those chemicals whose presence is related to the disposal practices at the site but which are reported at relatively low to moderate concentrations. [The terms "low" to "moderate" are used here in a subjective sense to describe concentrations which may be in or slightly above the upper bounds of the background range. The terms imply nothing about potential risks.] It is inevitable that some chemicals which are unrelated to the site disposal but present at concentrations at the high end of the background range will not automatically be considered as "background" using these point values, and a site-specific background determination remains an option. Conversely, some chemicals which are related to the disposal practices at the site (and are not background) will be considered to be "background" using these point values, but it is expected that the number of such instances will be relatively small. The goal is to minimize both kinds of error.

The background concentrations in soil and groundwater listed in Table 3.1 are taken directly from the Documentation for the Residential ShortForm (MA DEP, 1992a), and the derivation of the values may be found therein. The background indoor air concentrations include those found in the ShortForm and data for additional chemicals from the same sources (Shah, 1988 and Stolwijk, 1990).

3.3 SOLUBILITY

Each oil or hazardous material considered in the development of the Method 1 standards is soluble in groundwater to a greater or lesser degree. From a practical aspect, solubility is a concern if the calculated allowable level (based upon an analysis of risk) is higher than what could be expected in the groundwater based upon the material's solubility.

As a general rule, if the calculated Method 1 groundwater standard is greater than the chemical's solubility, then a value of one-half the solubility is adopted as the Method 1 standard. The solubility of each OHM is listed in Table 3.1. Values are not listed for the metals due to compound-dependent variability.

This rule would not be necessary if environmental analyses never reported concentrations of oil or hazardous materials greater than their solubility. Occasionally, however, analytical results may be greater than the chemical's published solubility due to laboratory contamination of the sample, soil particulates in the water, or the presence of undissolved chemical (free product). Under such circumstances, the resulting concentrations may not be comparable to the Method 1 standards, and a more detailed investigation should follow.

3.4 ODOR

The potential for odor problems is often cited as a relevant public welfare issue at M.G.L. c.21E sites. Odor thresholds are therefore considered in the setting of groundwater and soil standards. When available, the odor thresholds for the oil and hazardous materials listed were identified and added as a limiting factor (in addition to risk-based concentration, solubility, background, and PQL) in the derivation of the numerical standards.

The odor threshold used here is the concentration at which 50% of the population can detect a compound's odor. Odor thresholds are identified for contaminants in water (µg/l) for the GW-1 standards, and for contaminants in air (ppm) for the GW-2 standards. (The GW-2 standards are based upon volatilization of OHM to air.)

For soil, a chemical's ***odor index*** is identified and used to determine the appropriate ceiling level to be applied in the calculation of the Method 1 soil standards. The odor index value is determined by dividing a compound's vapor pressure, in Torr at 20 - 30 degrees Celsius, by its odor threshold in ppm in air, thus providing a relative ranking of the chemical's potential for creating nuisance conditions due to the odor of volatilized material.

3.5 CEILING CONCENTRATIONS

Ceiling concentrations have been identified for contaminants in soil and groundwater. As described in the methodologies presented in Sections 4.0 and 5.0, these concentrations are used to limit excessive residual concentrations in situations where the health-risk calculations (which consider a limited number of exposure pathways and endpoints) result in relatively high allowable levels. Ceiling concentrations truncate the range of the numerical standards on the high end as background and Practical Quantitation Limits truncate the range on the low end.

3.5.1 Ceiling Concentrations in Groundwater

The ceiling concentrations in groundwater noted in the general methodologies described in Section 4.0 are set at a concentration of 50,000 μg/liter, or 0.005%. The ceiling concentration serves two main purposes. First, in areas of current or future drinking water sources, it serves to minimize potential organoleptic (taste, odor) effects. Second, the ceiling concentration provides an upper limit on allowable groundwater contamination which may pose a risk to public welfare and the environment. Such a ceiling will act to minimize continued degradation of the groundwater as a general resource and to minimize the incremental increases to anthropogenic background.

3.5.2 Ceiling Concentrations in Soil

The ceiling concentrations in soil noted in the general methodology presented in Section 5.0 are set considering the *odor index* of the chemical, the volatility of the chemical, and the soil category.

The odor index developed for a chemical is simply the ratio of the vapor pressure (VP) for the chemical, measured at approximately 20° to 30° Celsius, and the 50th percentile odor recognition threshold ($ORT_{50\%}$). Chemicals with a relatively high odor index have correspondingly lower ceiling concentrations.

$$\textit{Odor Index} = \frac{VP_{20^\circ - 30^\circ}}{ORT_{50\%}}$$

Volatile chemicals (i.e., those with vapor pressure greater than 1 Torr at approximately 20° to 30° Celsius) are also assigned relatively low ceiling concentrations.

The ceiling concentrations serve two main purposes. First, in high exposure potential areas (category S-1), the ceiling concentrations provide an upper limit for chemicals which may pose a risk to public health through an inhalation pathway. Second, the ceiling concentrations provide an upper limit on allowable soil contamination which may pose a risk to public welfare and the environment. Such a ceiling will act to minimize continued degradation of soil as a general resource and to minimize the incremental increases to anthropogenic background.

Archive Document

The following ceiling concentrations have been applied in the development of the Method 1 and Method 2 Soil Standards:

SOIL CATEGORY	CRITERIA	CEILING VALUE ADOPTED
Category S-	Odor Index ~ 100, *or* Vapor Pressure ~ 1 Torr	100 pg/g
	0.1 ~ Odor Index < 100	500 pg/g
	Odor Index < 0.1	1,000 pg/g
Category S-	Odor Index ~ 100, *or* Vapor Pressure ~ 1 Torr	500 pg/g
	0.1 ~ Odor Index < 100	1,000 pg/g
	Odor Index < 0.1	2,500 pg/g
Category S-	Vapor Pressure ~ 1 Torr	500 pg/g
	Odor Index ~ 100	1,000 pg/g
	0.1 ~ Odor Index < 100	2,500 pg/g
	Odor Index < 0.1	5,000 pg/g

Archived Document

TABLE 3.1

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS	CAS NUMBER	SOIL BACK-GROUND	GROUND WATER BACK-GROUND	INDOOR AIR BACK-GROUND	SOIL PQL	REF	WATER PQL	REF	ODOR THRESHOLD		REF	VAPOR PRESSURE	REF
OIL AND/OR HAZARDOUS MATERIAL		mg/kg	ug/L	ug/cu m	mg/kg		ug/L		ug/m3	ppm		(Torr@20-30C)	
ACENAPHTHENE	83329	0.5			0.66	14c	10	14c		0.08	13		
ACENAPHTHYLENE	208968	0.5			0.66	14c	0.5	14e				2.9E-02	13
ACETONE	67641			6	0.1	14a	100	14a	30862	13	13	270	29
ALDRIN	309002				0.00268	14b	0.5	14e	263		28	2.3E-05	29
ANTHRACENE	120127	0.5			0.66	14c	0.5	14e				1.7E-05	13
ANTIMONY	7440360				6.4	14d	32	15b					
ARSENIC	7440382	32	5.5		10.6	14d	50	17					
BENZENE	71432			21	0.005	14a	0.5	14f	4890	1.5	13	95	29
BENZO(a)ANTHRACENE	56553	0.5			0.66	14c	1	14e				5.0E-09	29
BENZO(a)PYRENE	50328	0.5			0.66	14c	0.5	14e				5.0E-09	29
BENZO(b)FLUORANTHENE	205992	0.5			0.66	14c	1	14e					
BENZO(g,h,i)PERYLENE	191242	0.5			0.66	14c	0.5	14e				1.0E-10	29
BENZO(k)FLUORANTHENE	207089	0.5			0.66	14c	1	14e				9.59E-11	29
BERYLLIUM	7440417				0.06	14d	0.3	15b					
BIPHENYL, 1,1-	92524				0.05	14c	0.1	14e	60	9.5E-03	27		
BIS(2-CHLOROETHYL)ETHER	111444				0.66	14c	28.5	15d	287	4.9E-02	13	7.1E-01	29
BIS(2-CHLOROISOPROPYL)ETHER	39638329				0.66	14c	28.5	15d	2240	0.32	24	8.5E-01	24
BIS(2-ETHYLHEXYL)PHTHALATE	117817				0.66	14c	4	14e					
BROMODICHLOROMETHANE	75274				0.005	14a	2.5	14f				50	29
BROMOFORM	75252				0.005	14a	3.5	14f	13450	1.3	13	5.6	29
BROMOMETHANE	74839				0.01	14a	0.55	14g	80000	20	13	1420	29
CADMIUM	7440439		4.2		0.8	14d	4	15b					
CARBON TETRACHLORIDE	56235			1	0.005	14a	1.5	14f	63000	10	13	113	29
CHLORDANE	57749				0.00938	14b	1.5	14e	8.4		28	1.0E-05	29
CHLOROANILINE, p-	106478				1.3	14c	20	14c				1.5E-02	29
CHLOROBENZENE	108907			10	0.005	14c	0.5	14f	1000	0.22	13	11.8	29
CHLOROFORM	67663			3	0.005	14a	1	14f	421600	85	13	160	29
CHLOROPHENOL, 2-	95578				0.66	14c	10	14c	19	3.6E-03	24		
CHROMIUM(III)	16065831				1.4	14d	7	14d					
CHROMIUM(VI)	18540299	105				14h	0.5	14h					
CHRYSENE	218019	0.5			0.66	14c	1.5	14e				6.3E-09	29
CYANIDE	57125				1	16	0.1	15a	652	0.58	13	620	24
DIBENZO(a,h)ANTHRACENE	53703	0.5			0.66	14c	0.5	14e				1.0E-10	13
DIBROMOCHLOROMETHANE	124481				0.005	14a	2	14f				76	13
DICHLOROBENZENE, 1,2- (o-DCB)	95501			1	0.66	14c	5	14f	305000	50	24	1.5	29
DICHLOROBENZENE, 1,3- (m-DCB)	541731				0.66	14c	0.6	14g					
DICHLOROBENZENE, 1,4- (p-DCB)	106467			0.5	0.66	14c	0.2	14g	1100	0.18	13	1.8	29
DICHLOROBENZIDINE, 3,3'-	91941				1.3	14c	82.5	15d				4.5E-09	13
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD D	72548				0.00737	14b	0.0125	15c				1.0E-06	29
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD	72559				0.00268	14b	0.05	15c				6.5E-06	29
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT	50293				0.00804	14b	0.3	15c				1.5E-07	29
DICHLOROETHANE, 1,1-	75343				0.005	14a	1	14f	125000	500	13	234	29
DICHLOROETHANE, 1,2-	107062				0.005	14a	1	14f	2424	6	13	79	29
DICHLOROETHYLENE, 1,1-	75354				0.005	14a	1	14f	125000	500	13	591	29
DICHLOROETHYLENE, CIS-1,2-	156592				0.005	14a	0.6	14g				202	29
DICHLOROETHYLENE, TRANS-1,2-	156605				0.005	14a	0.3	14g	67320	17	13	331	29
DICHLOROPHENOL, 2,4-	120832				0.66	14c	13.5	15d	1400.7	0.21	13	6.7E-02	13
DICHLOROPROPANE, 1,2-	78875				0.005	14a	1	14f	1190.5	0.25	13	42	29

Archived Document

Table 3.1, continued...

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SOIL BACK-GROUND mg/kg	GROUND WATER BACK-GROUND ug/L	INDOOR AIR BACK-GROUND ug/cu m	SOIL PQL mg/kg	REF	WATER PQL ug/L	REF	ODOR THRESHOLD ug/m3	ppm	REF	VAPOR PRESSURE (Torr@20-30C)	REF
DICHLOROPROPENE, 1,3-	542756				0.005	14a	5	14a	4610	1	13	43	29
DIELDRIN	60571				0.00134	14b	0.1	15c				1.8E-07	29
DIETHYL PHTHALATE	84662				0.66	14c	4	14e					
DIMETHYL PHTHALATE	131113				0.66	14c	1.5	14e					
DIMETHYLPHENOL, 2,4-	105679				0.66	14c	13.5	15d		1	24		
DINITROPHENOL, 2,4-	51285				3.3	14c	210	15d					
DINITROTOLUENE, 2,4-	121142				0.66	14c	28.5	15d				5.1E-03	13
DIOXIN	1746016				1.0E-06	19	1E-05	19				7.4E-10	29
ENDOSULFAN	115297				0.00938	14b	0.12	15c				1.0E-05	13
ENDRIN	72208				0.00402	14b	5	14e				2.0E-07	29
ETHYLBENZENE	100414			10	0.005	14a	0.3	14g	2000	2.3	13	10	29
ETHYLENE DIBROMIDE	106934				0.005	14a	0.3	14g	200000	26	24	12	29
FLUORANTHENE	206440	0.5			0.66	14c	11	15d				5.0E-06	13
FLUORENE	86737	0.5			0.66	14c	1	14e					
HEPTACHLOR	76448				0.00201	14b	1	14e	300	0.02	13	3.0E-04	29
HEPTACHLOR EPOXIDE	1024573				0.05561	14b	1.5	14e	300	0.019	13	2.6E-06	13
HEXACHLOROBENZENE	118741				0.66	14c	1	14e				1.09E-05	13
HEXACHLOROBUTADIENE	87683				0.66	14c	0.55	14g	12000		13	0.15	29
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-	58899				0.00268	14b	0.5	14e				9.4E-06	29
HEXACHLOROETHANE	67721				0.66	14b	8	15d				0.4	29
INDENO(1,2,3-cd)PYRENE	193395	0.5			0.66	14c	0.5	14e				1.0E-09	13
LEAD	7439921	69	8.8		8.4	14d	1	15b					
MERCURY	7439976	1	0.95		0.1	14i	0.2	14i				1.2E-03	29
METHOXYCHLOR	72435				0.11792	14b	1.5	14e				1.4E-06	13
METHYL ETHYL KETONE	78933			42	0.1	14a	100	14a	32000	11	24	100	29
METHYL ISOBUTYL KETONE	108101			2	0.05	14a	50	14a	9700	0.1	25	10	29
METHYL MERCURY	22967926												
METHYL TERT BUTYL ETHER	1634044				0.05	14f	0.5	14f				245	29
METHYLENE CHLORIDE	75092			600	0.005	14a	5	14f	540000	160	13	429	29
METHYLNAPHTHALENE, 2-	91576	0.5			0.66	14c	10	14c	68		28		
NAPHTHALENE	91203	0.5		5	0.66	14c	0.2	14g	440	0.084	13	8.2E-02	29
NICKEL	7440020	30			3	14d	15	15b					
PENTACHLOROPHENOL	87865				3.3	14c	15	14e				1.1E-04	29
PHENANTHRENE	85018	0.5			0.66	14c	1	14e	55		24	9.6E-04	13
PHENOL	108952				0.66	14c	10	14c	156.8	0.04	13	0.35	29
POLYCHLORINATED BIPHENYLS (PCBs)	1336363				0.04355	14b	0.325	14b					
PYRENE	129000	0.5			0.66	14c	0.5	14e				2.5E-06	13
SELENIUM	7782492				15	14d	75	15b					
SILVER	7440224		4.7		1.4	14d	7	15b					
STYRENE	100425			5	0.005	14a	0.3	14g	1360	0.3	13	5	29
TETRACHLOROETHANE, 1,1,1,2-	630206				0.005	14a	5	14a				10	29
TETRACHLOROETHANE, 1,1,2,2-	79345			0.01	0.005	14a	2	14f	10470	1.5	13	4	29
TETRACHLOROETHYLENE	127184			11	0.005	14a	1.5	14f	31730	4.68	13	19	29
THALLIUM	7440280				8	14d	40	15b					
TOLUENE	108883			29	0.005	14a	0.5	14f	30000	8	13	28	29
TOTAL PETROLEUM HYDROCARBONS	NA												
TRICHLOROBENZENE, 1,2,4-	120821			0.04	0.66	14c	1	14g	22000	2.96	27		
TRICHLOROETHANE, 1,1,1-	71556			30	0.005	14a	1.5	14f	65127	120	13	100	29

Archived Document

Table 3.1, continued...

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SOIL BACK-GROUND mg/kg	GROUND WATER BACK-GROUND ug/L	INDOOR AIR BACK-GROUND ug/cu.m	SOIL PQL mg/kg	REF	WATER PQL ug/L	REF	ODOR THRESHOLD ug/m3	ppm	REF	VAPOR PRESSURE (Torr@20-30C)	REF
TRICHLOROETHANE, 1,1,2-	79005			30	0.005	14a	0.5	14g				25	29
TRICHLOROETHYLENE	79016			5	0.005	14a	2	14f	1360000		28	77	29
TRICHLOROPHENOL, 2,4,5-	95954				0.66	14c	10	14c					
TRICHLOROPHENOL 2,4,6-	88062				0.66	14c	10	14c	0.3	2.6E-03	13		
VINYL CHLORIDE	75014				0.01	14a	1.5	14f	771244	3000	13	2580	29
XYLENES (Mixed Isomers)	1330207			3	0.005	14a	2.5	14f	441	0.1	13	6	29
ZINC	7440666	110			0.4	14d	2	15b					

Archived Document

Table 3.1, continued...

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS OIL AND/OR HAZARDOUS MATERIAL		ODOR THRESH	SOLUBILITY ug/L	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
ACENAPHTHENE			3.42E+03	29	2.41E-04	29	3.98	13	4.6E+03	13	154	13
ACENAPHTHYLENE			3.93E+03	13	1.45E-03	13	4.07	13	2.5E+03	13	154	13
ACETONE		20.77	1.00E+09	11	4.26E-05	13	-0.24	13	5.4E+00	13	58	13
ALDRIN		5.87E-06	1.70E+01	29	4.96E-04	29	3.01	13	4.9E+04	13	365	13
ANTHRACENE			1.29E+03	29	8.60E-05	29	4.45	13	1.4E+04	13	178	13
ANTIMONY			-		-	-	-	-	-	-	122	13
ARSENIC			-		-	-	-	-	-	-	75	13
BENZENE		63.33	1.78E+06	SES	5.50E-03	SES	2.13	13	8.3E+01	SES	78	13
BENZO(a)ANTHRACENE			1.00E+01	29	1.00E-06	13	5.61	13	2.0E+05	13	228	13
BENZO(a)PYRENE			3.80E+00	29	4.90E-07	29	6.06	13	5.5E+06	13	252	13
BENZO(b)FLUORANTHENE			1.40E+01	11	1.22E-05	13	6.06	13	5.5E+05	13	252	13
BENZO(g,h,i)PERYLENE			2.60E-01	29	1.44E-07	13	6.51	13	1.6E+06	13	276	13
BENZO(k)FLUORANTHENE			8.00E-01	20	3.87E-05	13	6.06	13	5.5E+05	11	252	13
BERYLLIUM					-	-	-	-	-	-	9	13
BIPHENYL,1,1-			7.50E+03	29	4.08E-04	29	-	-			154	11
BIS(2-CHLOROETHYL)ETHER		14.49	1.02E+07	29	1.30E-05	29	1.58	13	1.3E+01	13	143	13
BIS(2-CHLOROISOPROPYL)ETHER		2.66	1.70E+06	11	1.13E-04	11	2.1	11	6.1E+01	11	171	11
BIS(2-ETHYLHEXYL)PHTHALATE			1.30E+03	29	3.00E-07	29	5.11	13	1.0E+05	13	391	13
BROMODICHLOROMETHANE			4.50E+06	13	2.12E-03	29	2.1	13	6.3E+01	13	164	13
BROMOFORM		4.31	3.20E+06	29	5.32E-04	29	2.38	13	1.1E+02	13	253	13
BROMOMETHANE		71.00	1.75E+07	29	1.97E-01	13	1.1	13	5.9E+00	13	95	13
CADMIUM					-	-	-	-	-	-	112	13
CARBON TETRACHLORIDE		11.30	8.00E+05	29	2.93E-02	29	2.64	13	1.1E+02	13	154	13
CHLORDANE		7.12E-05	5.60E+01	29	4.79E-05	29	5.54	13	4.4E+04	13	410	13
CHLOROANILINE, p-			2.60E+06	20	3.31E-07	20	1.83	20	6.4E+01	calc	128	20
CHLOROBENZENE		53.64	4.88E+05	29	3.93E-03	29	2.84	13	3.3E+02	13	113	13
CHLOROFORM		1.88	9.30E+06	29	3.39E-03	29	1.97	13	3.1E+01	11	119	13
CHLOROPHENOL, 2-				29	1.03E-05	29	2.15	12	1.1E+02	calc	129	20
CHROMIUM(III)			-		-	-	-	-	-	-	52	13
CHROMIUM(VI)					-	-	-	-	-	-	52	13
CHRYSENE			6.00E+00	29	1.05E-06	29	5.61	13	2.0E+05	13	228	13
CYANIDE		1068.97	1000000000	11	1.90E+03	20	0.66	13	9.2E+00	calc	27	13
DIBENZO(a,h)ANTHRACENE			5.00E-01	29	7.30E-08	29	6.84	13	3.3E+06	13	278	13
DIBROMOCHLOROMETHANE			4.00E+06	13	7.83E-04	29	2.24	13	8.3E+01	13	208	13
DICHLOROBENZENE, 1,2-	(o-DCB)	0.03	1.45E+05	29	1.94E-03	29	3.38	12	1.7E+03	11	147	11
DICHLOROBENZENE, 1,3-	(m-DCB)		1.23E+05	29	2.63E-03	29	3.6	12	1.7E+03	11	147	11
DICHLOROBENZENE, 1,4-	(p-DCB)	10.00	7.90E+04	29	2.72E-03	29	3.52	13	1.8E+03	13	147	13
DICHLOROBENZIDINE, 3,3'-				29	8.33E-07	11	3.51	12	1.6E+03	11	253	11
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD |D|			1.60E+02	29	7.96E-06	11	6.2	13	7.8E+05	13	320	13
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (D |D|				29	6.80E-05	13	7	13	4.4E+06	13	318	13
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (D T			3.10E+00	29	3.89E-05	29	6.19	13	2.4E+05	13	354	13
DICHLOROETHANE, 1,1-		0.47	5.50E+06	29	5.45E-03	29	1.79	13	5.8E+01	13	99	13
DICHLOROETHANE, 1,2-		13.17	8.69E+06	29	1.10E-03	29	1.48	13	1.4E+01	13	99	13
DICHLOROETHYLENE, 1,1-		1.18	2.10E+05	29	1.49E-02	29	2.13	13	6.5E+01	13	97	13
DICHLOROETHYLENE, CIS-1,2-			8.00E+05	29	4.08E-03	29	1.86	13	4.9E+01	13	97	13
DICHLOROETHYLENE, TRANS-1,2-		19.47	6.00E+05	29	5.32E-03	29	2.09	13	4.9E+01	13	97	13
DICHLOROPHENOL, 2,4-		0.32	4.50E+06	29	2.80E-06	29	2.92	13	6.0E+03	13	163	13
DICHLOROPROPANE, 1,2-		168.00	2.70E+06	29	2.82E-03	29	1.99	13	4.7E+01	13	113	13

Archived Document

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	ODOR	SOLUBILITY ug/l	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
DICHLOROPROPENE, 1 , 3-	43.00	2.70E+06	29	3.50E-03	29	1.6	13	2.6E+01	13	111	13
DIELDRIN		1 .86E+02	29	5.84E-05	29	4.55	13	7.4E+03	13	381	29
DIETHYL PHTHALATE		8.96E+05	11	1 .14E-06	11	2.47	12	1.4E+02	11	222	11
DIMETHYL PHTHALATE		5.00E+06	29	1 .05E-07	20	1.56	12	1 .4E+02	calc	194	29
DIMETHYLPHENOL, 2 , 4-		7.87E+06	20	1 .70E-05	29	2.3	12	4.0E+01	calc	122	29
DINITROPHENOL, 2 , 4-		5.60E+06	29	6.45E-10	29	1.54	12	1.7E+01	11	184	11
DINITROTOLUENE, 2 , 4-		2.70E+05	29	4.50E-06	13	2	13	4.5E+01	13	182	13
DIOXIN		1 .93E-02	29	2.10E-03	29	6.8	12	3.3E+06	11	322	11
ENDOSULFAN		1 .50E+02	13	1 .00E-05	13	3.62	13	3.2E+03	13	407	13
ENDRIN		2.60E+02	29	4.00E-07	29	5.338	13	1.7E+03	13	381	13
ETHYLBENZENE	4.35	1.61 E+05	SES	3.43E-03	SES	3.13	13	5.8E+02	SES	106	13
ETHYLENE DIBROMIDE	0.46	4.30E+06	29	6.73E-04	11	1.96	13	4.4E+01	11	188	11
FLUORANTHENE		2.65E+02	29	6.50E-06	29	4.9	13	3.8E+04	13	202	13
FLUORENE		1 .90E+03	29	1 .17E-04	29	4.18	13	7.3E+03	13	166	13
HEPTACHLOR	0.01	5.60E+01	29	1 .48E-03	29	5.44	13	2.2E+04	13	374	13
HEPTACHLOR EPOXIDE	1 .37E-04	3.50E+02	29	3.16E-05	29	5.4	13	2.3E+04	13	389	13
HEXACHLOROBENZENE		1 .10E+02	29	1 .70E-03	29	6.18	13	1.2E+06	13	285	13
HEXACHLOROBUTADIENE	1.17E-03	2.00E+03	29	2.56E-02	29	4.78	12	2.9E+04	11	261	11
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HC H		7.00E+03	29	4.93E-07	29	3.61	13	3.7E+03	13	291	13
HEXACHLOROETHANE		5.00E+04	29	9.85E-03	29	3.93	12	2.0E+04	11	237	11
INDENO(1 , 2 , 3-cd)PYRENE		5.30E-01	11	6.95E-08	29	6.58	13	1.6E+06	13	276	13
LEAD				-	-	-	-	-	-	207	11
MERCURY		5.60E+01	29	-	29	-	-	-	-	201	13
METHOXYCHLOR		4.00E+01	29	1 .60E-05	13	5.08	13	7.9E+04	13	346	13
METHYL ETHYL KETONE	9.09	2.75E+08	29	2.74E-05	11	0.29	13	3.5E+00	13	72	13
METHYL ISOBUTYL KETONE	100.00	1.91 E+07	29	1 .38E-04	20	1.19	20	3.1E+00	calc	100	11
METHYL MERCURY				-	-	-	-	-	-	231	29
METHYL TERT BUTYL ETHER			29	5.91 E-04	calc	1.05	21	2.7E+01	calc	88	29
METHYLENE CHLORIDE	2.68	1 .67E+07	29	3.19E-03	29	1.3	13	8.8E+00	22	85	13
METHYLNAPHTHALENE, 2-			29	2.90E-04	20	3.86	20	7.2E+02	calc	142	13
NAPHTHALENE	0.98	3.10E+04	SES	1.18E-03	SES	3.29	13	1.3E+03	SES	128	13
NICKEL		-		-	-	-	-	-	-	59	13
PENTACHLOROPHENOL		1 .40E+04	29	2.80E-06	29	5.01	13	3.2E+04	13	266	13
PHENANTHRENE	2.4E-03	8.16E+02	29	3.93E-05	29	4.45	13	1 .4E+04	13	178	13
PHENOL	8.75	8.00E+07	29	1 .30E-06	29	1.46	13	9.1E+01	13	94	13
POLYCHLORINATED BIPHENYLS (PCBs)		5.90E+02	13	2.00E-03	13	6.5	13	5.3E+05	11	varies	
PYRENE		1 .60E+02	29	5.10E-06	29	4.88	13	3.8E+04	13	202	13
SELENIUM				-	-	-	-	-	-	79	13
SILVER		-		-	-	-	-	-	-	108	13
STYRENE	16.67	3.00E+05	29	2.61 E-03	13	2.95	13	3.1E+00	calc	104	13
TETRACHLOROETHANE, 1,1,1 , 2-			29	1 .10E-02	29	-	-	5.4E+01	11	168	11
TETRACHLOROETHANE, 1 ,1 , 2,2-	2.67	2.90E+06	29	3.80E-04	29	2.39	13	4.6E+01	13	168	13
TETRACHLOROETHYLENE	4.06	2.00E+05	SES	2.04E-03	SES	3.4	13	4.7E+02	SES	166	13
THALLIUM				-	-	-	-	-	-	204	13
TOLUENE	3.50	5.35E+05	SES	6.68E-03	SES	2.79	13	2.7E+02	SES	92	13
TOTAL PETROLEUM HYDROCARBONS		-				-	-			-	-
TRICHLOROBENZENE, 1 , 2,4-		1 .90E+04	29	1 .42E-03	29	3.98	12	9.2E+03	11	181	11
TRICHLOROETHANE, 1 ,1 , 1-	0.83	7.30E+05	SES	2.31 E-02	SES	2.49	13	1.6E+02	SES	133	13

Archive Document

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR

DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	ODOR	SOLUBILITY ug/L	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
TRICHLOROETHANE, 1,1,2-		4.50E+06	29	9.10E-04	13	2.42	13	3.1E+02	13	133	13
TRICHLOROETHYLENE		1.10E+06	SES	9.12E-03	SES	2.42	13	1.2E+02	SES	131	13
TRICHLOROPHENOL, 2,4,5-		1.19E+06	29	2.18E-04	11	3.72	11	8.9E+01	11	197	11
TRICHLOROPHENOL 2,4,6-		8.00E+05	29	4.00E-06	29	3.69	13	2.0E+03	13	197	13
VINYL CHLORIDE		1.10E+03	29	2.78E-02	29	1.36	13	9.8E+01	13	63	13
XYLENES (Mixed Isomers)		1.71E+05	SES	5.27E-03	SES	3.33	13	3.0E+02	SES	106	13
ZINC		-		-		-	-	-	-	65	13

Archived Document

4.0 GROUNDWATER

MCP Numerical Standards have been developed for four categories of groundwater, as described in the following subsections. The four categories were developed to address 3 major pathways of exposure to human and environmental receptors (Categories GW-1, GW-2 and GW-3), plus an "Upper Concentration Limit" to protect against general degradation of the Commonwealth's groundwater resources.

> ***Note that no one groundwater category is consistently more stringent than another, and that more than one category may be applicable at a given site.***

The applicability of a particular groundwater category depends upon the current and foreseeable future use(s) of the groundwater, as determined by criteria in the regulations (310 CMR 40.0932).

4.1 CATEGORY GW-1: DRINKING WATER

MCP Category GW-1 Standards (310 CMR 40.0974(2)) apply to groundwater which is considered either a current or a future source of drinking water. The regulatory criteria used to determine the applicability the GW-1 standards are based upon an issues paper developed jointly be the MA DEP Bureau of Waste Site Cleanup and the Bureau of Resource Protection (MA DEP, 1992b).

Drinking water standards are the most common type of environmental standard, and there is an established methodology which can be used to develop criteria for additional chemicals. In order to build upon the existing body of drinking water standards and guidelines, the Bureau of Waste Site Cleanup has determined that:

> Existing drinking water standards promulgated in 310 CMR 22.000 have been adopted as MCP GW-1 standards. There are thirty-five (35) such standards on the MCP GW-1 list.

> Existing drinking water guidelines developed by the MA DEP Office of Research and Standards for the MA DEP Division of Water Supply have been adopted as MCP GW-1 standards. There are twenty-nine (29) such standards on the MCP GW-1 list.

> MCP GW-1 Standards for chemicals without existing drinking water standards or guidelines have been developed in a manner consistent with the U.S. EPA and MA DEP Division of Water Supply methodology.

Archive Document

4.1.1 General Methodology

The sequential approach taken to the development of MCP GW-1 standards is as follows:

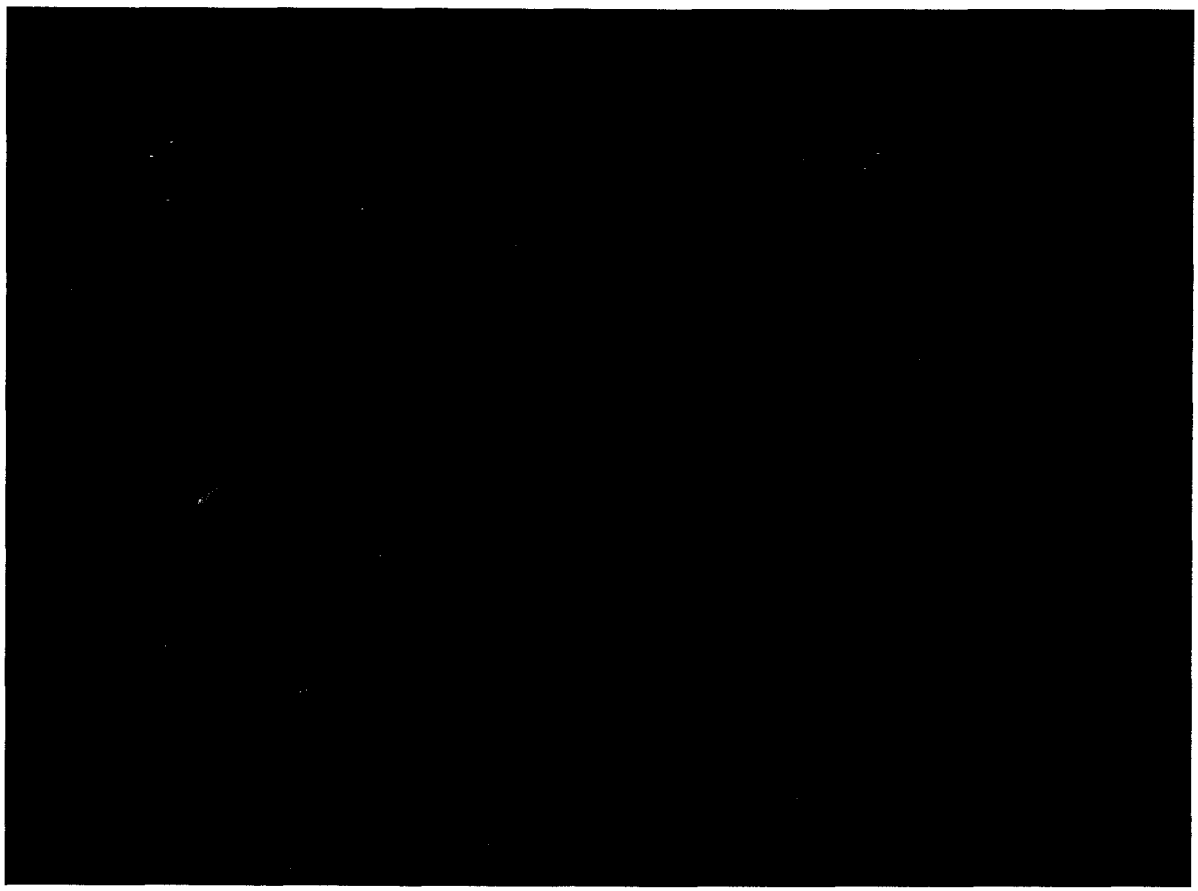
STEP	DESCRIPTION
1	Adopt an existing drinking water standard or guideline when one exists. If no such standard or guideline exists, follow steps 2 through 8.
2	Standard toxicity information and risk assessment, and odor threshold, if available, are used to identify risk/odor-based concentrations associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), (b) an excess lifetime cancer risk equal to one-in-one million, or (c) a 50% odor recognition threshold. The lowest of these three values is carried through the process.
3	A value of 1/2 the solubility of the chemical is identified.
4	A ceiling concentration of 0.005% (50,000 µg/l) is noted.
5	The lowest of the three values identified in steps 2, 3, and 4 is identified and carried through the process.
6	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
7	A "background" concentration is identified, if available.
8	The highest of the three values, identified in steps 5, 6, and 7 is chosen. This value is adopted as the MCP GW-1 standard

This process is diagramed in Figure 4-1.

Archived Document

FIGURE 4-1

DERIVATION OF GW-1 STANDARDS



4.1.2. Risk Assessment Equations

The equation used to identify a non-cancer risk-based concentration in drinking water is given as:

$$[OHM]_{dw} = \frac{0.2 \times RfD \times}{VI \times RAF} \qquad (2)$$

simplified to:

$$[OHM]_{dw} = \frac{7{,}000 \times RfD}{RAF} \qquad (3)$$

The equation used to evaluate potential carcinogenic effects associated with exposure to contaminated drinking water is given as:

$$[OHM]_{dw} = \frac{VI}{ELCR \times BW \times \times RAF \times F \times} \qquad (4)$$

simplified to:

$$[OHM]_{dw} = (5)\frac{0.035}{CSF \times RAF}$$

Where:

$[OHM]_{dw}$ = A risk-based (non-cancer or cancer risk) concentration, in drinking water, for the oil of hazardous material. In units: µg/liter.

0.2 = A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily intake of the oil or hazardous material may come from the ingestion of drinking water.

RfD = The oral Reference Dose or substitute toxicity value identified for the oil or hazardous material. In units of: mg/kg/day.

BW = The receptor's Body Weight: 70 kg.

D2 and AP = The Duration (D2) of the exposure period and the Averaging Period (AP). For the purposes of setting a MCP GW-1 standard, the drinking water exposures are assumed to occur over the receptor's lifetime: D2 = 70 years, AP = 70 years. The quotient of these two terms is equal to 1 and is dimensionless.

C = Units Conversion Factor: 10^3 µg/mg.

VI = Daily volume of drinking water ingested by the receptor of concern: 2 liters/day.

RAF = The Relative Absorption Factor for drinking water ingestion (A chemical- , route-, and health-endpoint- specific value). Dimensionless.

F and D1 = The Frequency (F) of exposure and the Duration (D1) of each exposure event. The receptors are assumed to be exposed to the drinking water each and every day, and that exposure occurs over the course of the day. F = 1 event/day and D1 = 1 day/event. The product of these terms is equal to 1, and it is dimensionless.

ELCR = Target Excess Lifetime Cancer Risk: one-in-one million, or 1×10^{-6} (dimensionless).

CSF = The oral Cancer Slope Factor for the oil or hazardous material. In units of: $(mg/kg/day)^{-1}$

4.1.3 Exposure Parameters

The exposure parameters chosen to develop the risk-based concentration by the formulae described above have been chosen to be consistent with the standardized methodology used by the U.S. Environmental Protection Agency and the MA DEP Division of Water Supply to set drinking water standards.

4.1.3.1. Water Volume Ingested, VI

The drinking water consumption rates of 2 liters/day for lifetime exposures is a standard assumption described by the U.S. Environmental Protection Agency (U.S. EPA 1989b & 1991). An individual's water intake may vary by age, sex, geography or level of activity. Estimates of mean tap water consumption rates for adults (of various ages) fall in the range of approximately 0.6 to 1.6 liters/day. Estimates of mean intakes for young children fall in the range of approximately 0.2 to 0.5 liters/day (Ershow and Cantor, 1989). The ratio of drinking water intake to body weight does not vary dramatically across age groups, however, as water intake increases as age (and thus body weight) increases.

4.1.3.2 Body Weight, BW

The assumption of an average body weight equal to 70 kg is the standard value (USEPA, 1989b).

4.1.3.3Duration of the Exposure Period, D2

A lifetime of water consumption is assumed in developing the risk-based concentration. While a receptor may not occupy the same house throughout their lifetime, it is not unlikely that someone may be served by the same water source (e.g., the Massachusetts Water Resource Authority). In addition, a receptor may drink from the same source in the home, at school, and in the workplace.

4.1.4. Derivation of Category GW-1 Standards

The numerical derivation of the Category GW-1 Standards is given in Table 4.1. The table includes the noncancer and cancer risk-based concentrations, any existing standard or guideline, and the concentration adopted as the GW-1 standard. The last column indicates the ultimate basis of the standard. The references indicated in this table are presented at the end of Table 2.1. The standards specifically derived for the MCP (i.e., *not* those adopted from the MADEP Division of Water Supply) have been rounded to one significant figure.

Archived Document

TABLE 4.1

TABLE 4-1

GW-1 DERIVATION 310 CMR 40.0974(2)	GW BACK-GROUND	WATER PQL	REF	ODOR THRESHOLD	REF	SOLU-BILITY	REF	Non-Cancer Risk-Based Concen.	Cancer Risk-Based Concen.	Existing Standard/ Guideline	Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded)	
OIL AND/OR HAZARDOUS MATERIAL	µg/L	µg/L		µg/L		µg/L		µg/L	µg/L	µg/L	Basis	ug/L BASIS
ACENAPHTHENE		10	14c	20	13	3.42E+03	29	4E+02				20 ODOR
ACENAPHTHYLENE		0.5	14e			3.93E+03	24	3E+02		300		Threshold
ACETONE		100	14a	20000	13	1.00E+09	11	7E+02		3000 ORSGL		3000 ORSGL
ALDRIN		0.5	14e	17	13	1.70E+01	29	2E-01	2E-03	0.5		PQL
ANTHRACENE		0.5	14e			1.29E+03	29	2E+03		600		Solubility
ANTIMONY		3	15b			-		3E+00		6 ORSGL		6 ORSGL
ARSENIC	5.5	50	17			-		2E+00	2E-02	50 MMCL		50 MMCL
BENZENE		0.5	14f	2000	13	1.78E+06	SES	4E+01	1E+00	5 MMCL		5 MMCL
BENZO(a)ANTHRACENE		1	14e			1.00E+01	29	3E+02	5E-03	0.2 ORSGL*		0.2 ORSGL*
BENZO(a)PYRENE		0.5	14e			3.80E+00	29	3E+02	5E-03	0.2 ORSGL		0.2 ORSGL
BENZO(b)FLUORANTHENE		1	14e			1.40E+01	13	3E+02	5E-03	0.2 ORSGL*		0.2 ORSGL*
BENZO(g,h,i)PERYLENE		0.5	14e			2.60E-01	29	3E+02		0.5		PQL
BENZO(k)FLUORANTHENE		1	14e			8.00E-01	30	3E+02	5E-03	0.2 ORSGL*		0.2 ORSGL*
BERYLLIUM		0.3	15b			-		4E+01	8E-03	4 ORSGL		4 ORSGL
BIPHENYL, 1,1-		0.1	14e			7.50E+03	29	4E+02		400		Threshold
BIS(2-CHLOROETHYL)ETHER		28.5	15d			1.02E+07	29		3E-02			30 PQL
BIS(2-CHLOROISOPROPYL)ETHER		28.5	15d	320	24	1.70E+06	24	3E+02	5E-01			30 PQL
BIS(2-ETHYLHEXYL)PHTHALATE		4	14e			1.30E+03	29	1E+02	3E+00	6 ORSGL		6 ORSGL
BROMODICHLOROMETHANE		2.5	14f			4.50E+06	13	1E+02	6E-01	5ORSGL**		5 ORSGL**
BROMOFORM		3.5	14f	510	13	3.20E+06	29	1E+02	4E+00	5ORSGL**		5 ORSGL**
BROMOMETHANE		0.55	14g			1.75E+07	29	1E+01		10 ORSGL		10 ORSGL
CADMIUM	4.2	4	15b			-		4E+00		5 MMCL		5 MMCL
CARBON TETRACHLORIDE		1.5	14f	520	13	8.00E+05	29	5E+00	3E-01	5 MMCL		5 MMCL
CHLORDANE		1.5	14e	2.5	24	5.60E+01	29	4E-01	3E-02	5 MMCL		5 MMCL
CHLOROANILINE, p-		20	14c			2.60E+06	30	3E+01		30		Threshold
CHLOROBENZENE		0.5	14f	50	13	4.88E+05	29	1E+02		100 MMCL		100 MMCL
CHLOROFORM		1	14f	2400	13	9.30E+06	29	7E+01	6E+00	5ORSGL**		5 ORSGL**
CHLOROPHENOL, 2-		10	14c	0.18	24	2.85E+07	29	4E+01				10 PQL
CHROMIUM						-				100 MMCL		100 MMCL
CHROMIUM(III)		7	14d			-		7E+03		100MMCL(TOTAL)		100 MMCL(TOTAL
CHROMIUM(VI)		0.5	14h			-		4E+01		50 MMCL		50 MMCL
CHRYSENE		1.5	14e			6.00E+00	29	3E+02	5E-03	0.2 ORSGL*		0.2 ORSGL*
CYANIDE		0.1	15a	170	13	1E+09	11	1E+02		200 ORSGL		200 ORSGL
DIBENZO(a,h)ANTHRACENE		0.5	14e			5.00E-01	29	3E+02	5E-03	0.2 ORSGL*		0.2 ORSGL*
DIBROMOCHLOROMETHANE		2	14f			4.00E+06	13	1E+02	4E-01	5ORSGL**		5 ORSGL**
DICHLOROBENZENE, 1,2- (o-DCB)		5	14f	10	24	1.45E+05	29	6E+02		600 MMCL		600 MMCL
DICHLOROBENZENE, 1,3- (m-DCB)		0.6	14g			1.23E+05	29	6E+02		600		Threshold
DICHLOROBENZENE, 1,4- (p-DCB)		0.2	14g	11	13	7.90E+04	29		1 E+00	5 MMCL		5 MMCL
DICHLOROBENZIDINE, 3,3'-		82.5	15d			3.10E+03	29		8E-02			80 PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD		0.0125	15c			1.60E+02	29		1E-01	0.1		Cancer
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD		0.05	15c			4.00E+01	29		1E-01	0.1		Cancer
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (D		0.3	15c	350	13	3.10E+00	29	4E+00	1E-01	T	0 .	3
DICHLOROETHANE, 1,1-		1	14f			5.50E+06	29	5E+02		70 ORSGL		70 ORSGL
DICHLOROETHANE, 1,2-		1	14f	20000	13	8.69E+06	29	1E+02	4E-01	5 MMCL		5 MMCL
DICHLOROETHYLENE, 1,1-		1	14f			2.10E+05	29	6E+01	6E-02	7 MMCL		7 MMCL
DICHLOROETHYLENE, CIS-1,2-		0.6	14g			8.00E+05	29	7E+01		70 MMCL		70 MMCL
DICHLOROETHYLENE, TRANS-1,2-		0.3	14g	260	13	6.00E+05	29	1E+02		100 MMCL		100 MMCL
DICHLOROPHENOL, 2,4-		13.5	15d	0.3	13	4.50E+06	29	2E+01				10 PQL

Archived Document

Table 4.1, continued...

GW-1 DERIVATION 310 CMR 40.0974(2) OIL AND/OR HAZARDOUS MATERIAL	GW-1 BASE GROUND µg/l	WATER PQL µg/L	REF	ODOR THRESHOLD µg/L	REF	SOLUBILITY µg/L	REF	Non-Cancer Risk-Based Concen. µg/l	Cancer Risk-Based Concen. µg/L	Existing Standard/ Guideline µg/L	Basis	Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	BASIS
DICHLOROPROPANE, 1,2-		114f		10	13	2.70E+06	29		5E-01	5 MMCL		5	MMCL
DICHLOROPROPENE, 1,3-		5	14a			2.70E+06	29	2E+00	2E-01	0.5 ORSGL		0.5	ORSGL
DIELDRIN		0.1	15c	41	13	1.86E+02	29	4E-01	2E-03	0.1			PQL
DIETHYL PHTHALATE		414e				8.96E+05	11	6E+03		6000			Threshold
DIMETHYL PHTHALATE		1.514e				5.00E+06	29	7E+04		50000			Ceiling
DIMETHYLPHENOL, 2,4-		13.5	15d	400	24	7.87E+06	30	1E+02		100			Threshold
DINITROPHENOL, 2,4-		210	15d			5.60E+06	29	1E+01				200	PQL
DINITROTOLUENE, 2,4-		28.5	15d			2.70E+05	29	1E+01	5E-02			30	PQL
DIOXIN		1E-05	19			1.93E-02	29		2E-07	3E-05	ORSGL	3E-05	ORSGL
ENDOSULFAN		0.12	15c			1.50E+02	13	4E-01		0.4			Threshold
ENDRIN		514e		41	13	2.60E+02	29	2E+00		2 MMCL		2	MMCL
ETHYLBENZENE		0.3	14g	29	13	1.61E+05	SES	7E+02		700	MMCL	700	MMCL
ETHYLENE DIBROMIDE		0.3	14g			4.30E+06	29	1E-01	4E-04	0.02	MMCL	0.02	MMCL
FLUORANTHENE		11	15d			2.65E+02	29	3E+02		100			Solubility
FLUORENE		1	14e			1.90E+03	29	3E+02		300			Threshold
HEPTACHLOR		114e		20	13	5.60E+01	29	4E+00	8E-03	0.4	MMCL	0.4	MMCL
HEPTACHLOR EPOXIDE		1.514e				3.50E+02	29	9E-02	4E-03	0.2	MMCL	0.2	MMCL
HEXACHLOROBENZENE		114e		3000	24	1.10E+02	29	6E+00	2E-02	1 ORSGL		1	ORSGL
HEXACHLOROBUTADIENE		0.5514g		6	24	2.00E+03	29	1E+01	4E-01			0.6	PQL
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH		0.514e		12000	13	7.00E+03	29	2E+00	3E-02	0.2	MMCL	0.2	MMCL
HEXACHLOROETHANE		8	15d	10	24	5.00E+04	29	7E+00	3E+00			8	PQL
INDENO(1,2,3-cd)PYRENE		0.5	14e			5.30E-01	11	3E+02	5E-03	0.2 ORSGL*		0.2	ORSGL*
LEAD		1	15b			-				15 AL-MCL		15	AL-MCL
MERCURY		0.214i				5.60E+01	29	2E+00		2 MMCL		2	MMCL
METHOXYCHLOR		1.514e		4700	13	4.00E+01	29	4E+01		40	MMCL	40	MMCL
METHYL ETHYL KETONE		100	14a	1000	24	2.75E+08	29	4E+03		350 ORSGL		350	ORSGL
METHYL ISOBUTYL KETONE		50	14a			1.91E+07	29	4E+02		350 ORSGL		350	ORSGL
METHYL MERCURY						-				2			Threshold
METHYL TERT BUTYL ETHER		0.514f				4.80E+07	29	7E+02		700 ORSGL		700	ORSGL
METHYLENE CHLORIDE		5	14f	9100	13	1.67E+07	29	4E+02	5E+00	5 ORSGL		5	ORSGL
METHYLNAPHTHALENE, 2-		10	14c	10	13	2.60E+04	29	3E+02				10	ODOR
NAPHTHALENE		0.2	14g	21	13	3.10E+04	SES	3E+02				20	ODOR
NICKEL		15	15b			-				100 ORSGL		100	ORSGL
PENTACHLOROPHENOL		1514e		587	13	1.40E+04	29	2E+02	3E-01	1	MMCL	1	MMCL
PHENANTHRENE		1	14e	1000	24	8.16E+02	29	3E+02		300			Threshold
PHENOL		10	14c	7900	13	8.00E+07	29	4E+03		4000			Threshold
POLYCHLORINATED BIPHENYLS		0.325	14b			3.10E+01	11	1E-01	5E-03	0.5	MMCL	0.5	MMCL
PYRENE		0.5	14e			1.60E+02	29	2E+02		80			Solubility
SELENIUM		75	15b			-				50	MMCL	50	MMCL
SILVER		7	15b			-				40			Threshold
STYRENE		0.314g		11	13	3.00E+05	29	1E+03	1E+00	100	MMCL	100	MMCL
TETRACHLOROETHANE, 1,1,1,2-		5	14a			2.00E+05	29	2E+02	1E+00			5	PQL
TETRACHLOROETHANE, 1,1,2,2-		214f		500	13	2.90E+06	29		2E-01			2	PQL
TETRACHLOROETHYLENE		1.5	14f	300	13	2.00E+05	SES	7E+01	7E+00	5 MMCL		5	MMCL
THALLIUM		40	15b			-				2 ORSGL		2	ORSGL
TOLUENE		0.5	14f	40	13	5.35E+05	SES	1E+03		1000	MMCL	1000	MMCL
TOTAL PETROLEUM HYDROCARBONS												1000	Default
TRICHLOROBENZENE, 1,2,4-		114g				1.90E+04	29	7E+01		70 ORSGL		70	ORSGL

Archived Document

Table 4.1, continued...

GW-1 DERIVATION 310 CMR 40.0974(2)	GW WATER BACK-GROUND	PQL	REF	ODOR THRESHOLD	REF	SOLU-BILITY	REF	Non-Cancer Risk-Based Concen.	Cancer Risk-Based Concen.	Existing Standard/ Guideline		Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded)	
OIL AND/OR HAZARDOUS MATERIAL	µg/L	µg/L		µg/L		µg/L		µg/L	µg/L	µg/L	Basis	ug/L	BASIS
TRICHLOROETHANE, 1,1,1-		1.5	14f	50000	24	7.30E+05	SES	6E+02		200	MMCL	200	MMCL
TRICHLOROETHANE, 1,1,2-		0.5	14g			4.50E+06	29	3E+01	6E-01	5	ORSGL	5	ORSGL
TRICHLOROETHYLENE		2	14f	10000	24	1.10E+06	SES	1E+01	3E+00	5	MMCL	5	MMCL
TRICHLOROPHENOL, 2,4,5-		10	14c	200	24	1.19E+06	29	7E+02				200	ODOR
TRICHLOROPHENOL 2,4,6-		10	14c	100	13	8.00E+05	29		3E+00			10	PQL
VINYL CHLORIDE		1.5	14f	3400	13	1.10E+03	29	7E+00	1E-02	2	MMCL	2	MMCL
XYLENES		2.5	14f	530	24	1.71E+05	SES	1E+04		10000	MMCL	10000	MMCL
ZINC		2	15b			-		2E+03				2000	Threshold

* = ORSGL of BENZO(a)PYRENE

** = ORSGL for Trihalomethanes

Archived Document

4.2 CATEGORY GW - 2: VOLATILIZATION

MCP Category GW-2 Standards (310 CMR 40.0974(2)) apply to groundwater which is considered both shallow and where there is currently (or there may in the future be) a structure built on the land above the groundwater. These standards are intended to address the potential migration of volatile oil or hazardous material from the groundwater into the indoor air, and are calculated for oil or hazardous materials exhibiting a vapor pressure equal to or greater than 0.01 Torr (measured at 20° to 30° C) where there is sufficient toxicological information available.

4.2.1 General Methodology

The sequential approach taken to the development of MCP GW-2 standards is:

STEP DESCRIPTION

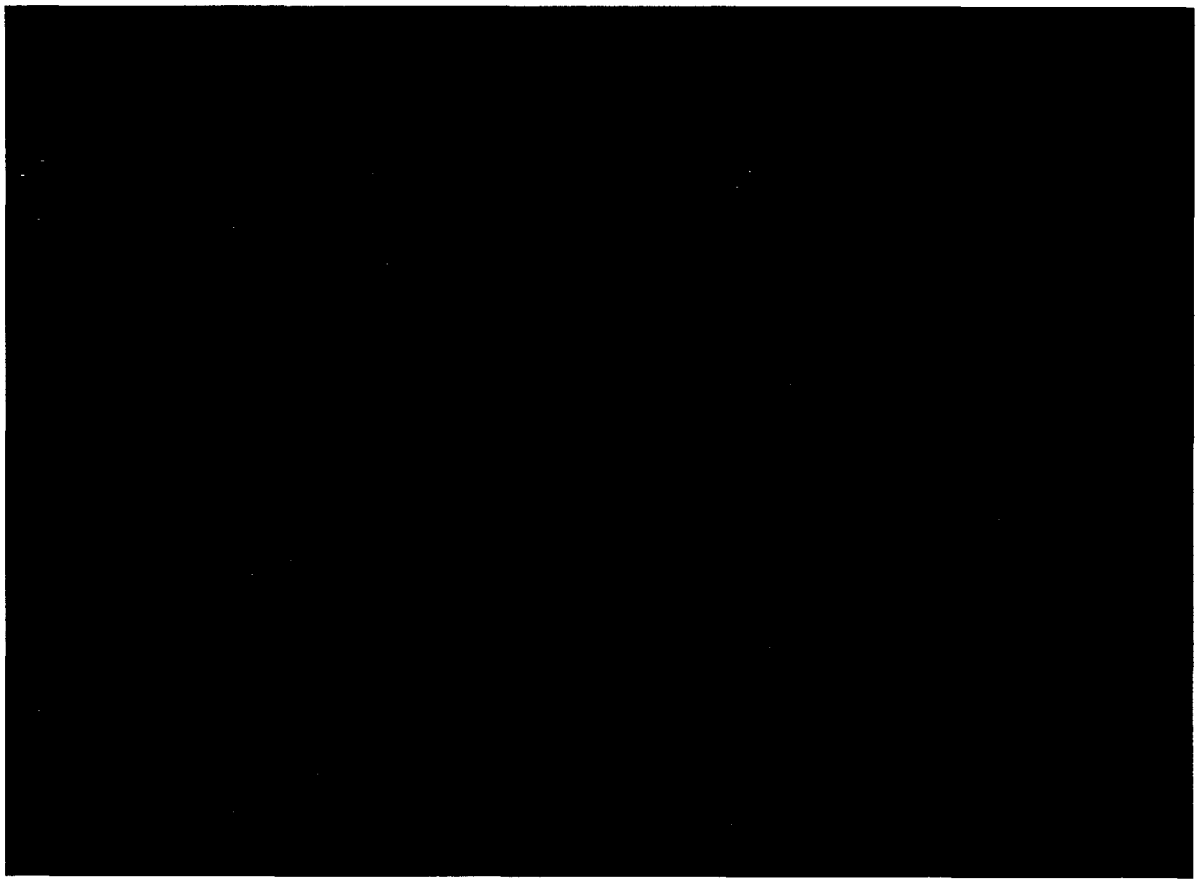
1 Standard toxicity information and risk assessment, and odor threshold, when available, are used to identify risk/odor-based indoor air concentrations associated with (a) 20% of an allowable daily exposure (based on non-cancer health effects), (b) an excess lifetime cancer risk equal to one-in-one million, or (c) a 50% odor recognition threshold. The lower of these three values is identified.
2 When the data is available, a background concentration of the chemical in indoor air is identified.
3 The higher of the two values identified in steps 1 and 2 is carried through the process.
4 A model is employed which considers the potential for the chemical to volatilize from the groundwater and migrate through the unsaturated zone. The model results in the identification of a groundwater concentration associated with the indoor air concentration identified in step 3.
5 A value of 1/2 the solubility of the chemical is identified.
6 A ceiling concentration of 0.005% (50,000 µg/l) is noted.
7 The lowest of the three values identified in steps 4, 5 and 6 is identified and carried through the process.
8 Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
9 A background concentration in groundwater is identified, if available.
10 The highest of the three values identified in steps 7, 8 and 9 is chosen. This value is adopted as the MCP GW-2 standard.

This process is diagramed in Figure 4-2.

Archive Document

FIGURE 4-2

DERIVATION OF GW-2 STANDARDS



4.2.2. Discussion

The volatilization of oil or hazardous material from contaminated groundwater and its infiltration to indoor air has proven to be a significant exposure pathway at some c.21E sites. Historically the transport of radon gas into indoor air has received a great deal of attention, but it is only recently that this migration pathway has been examined for the common volatile organic contaminants. Recent journal articles (Johnson and Ettinger, 1991; Little et al., 1992) provide discussions of this pathway and develop predictive models for its assessment.

The indoor air concentrations which result from the migration of these materials from the groundwater depend upon a large number of factors, including:

- depth to groundwater
- concentration of the material in groundwater
- partition coefficients
- groundwater flow
- building structure
- building ventilation rate

The model used to develop the MCP GW-2 standards adopts an attenuation factor ($a = 5 \times 10^{-4}$) identified from Johnson and Ettinger (1991) for highly permeable soils (fine to medium sand, 10^{-7} cm^2). In such permeable soil, Johnson and Ettinger demonstrate that the attenuation coefficient is only weakly dependent on the structure of the foundation, which simplifies the methodology. The attenuation factor relates the indoor air concentration (C_i) to the soil-gas concentration at the surface of the groundwater (C_{sg}): $a = C_i/C_{sg}$. The value of 5×10^{-4} used here is consistent with reported attenuation coefficients for radon of 16×10^{-4} (Little, et al., 1992).

4.2.3. Risk Assessment Equations

In the derivation of the GW-2 Standards, it is assumed that the receptors of concern are continually exposed to the indoor air under study. Site and Use specific information may be used to justify different exposure conditions in a Method 2 or Method 3 risk characterization.

The equation used to identify a non-cancer risk-based concentration in indoor air is given as:

$$[OHM]_{air} = 0.2 \times RfC \qquad (6)$$

The equation used to evaluate potential carcinogenic effects associated with exposure to contaminated indoor air is given as:

$$[OHM]_{air} = \frac{10^{-6}}{[redacted]} \qquad (7)$$

Where:

$[OHM]_{air}$ = A risk-based (non-cancer or cancer risk) concentration, in indoor air, for the oil of hazardous material. In units: $\mu g/m^3$.

0.2 = A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily exposure of the oil or hazardous material may come from the inhalation pathway.

RfC = The inhalation Reference Concentration or substitute toxicity value identified for the oil or hazardous material. In units of: $\mu g/m^3$.

10^{-6} = Target Excess Lifetime Cancer Risk of one-in-one million (dimensionless).

UR_{air} = The inhalation Unit Risk for the oil or hazardous material. In units of: $(\mu g/m^3)^{-1}$

Archived Document

4.2.4 Transport Model Equation

The equation used to estimate allowable groundwater concentrations based upon potential indoor air exposure is given as:

$$[OHM]_{gw} = \frac{[OHM]_{air}}{\text{[redacted]}} \quad (8)$$

Where:

$[OHM]_{air}$ = The target indoor air concentration, in units of: $\mu g/m^3$

$[OHM]_{gw}$ = The calculated groundwater concentration of the oil or hazardous material which would not result in an indoor air concentration greater than $[OHM]_{air}$. In units of μg/liter

a = A calculated attenuation factor which relates the indoor air concentration to the concentration in the soil gas directly above the groundwater source: 5×10^{-4}. Dimensionless.

d = A modification factor to convert theoretical groundwater:soil gas equilibrium concentrations to realistic environmental concentrations. This MADEP value is based upon observations and the professional judgement of MADEP staff. Dimensionless.

H = Henry's Law Constant, dimensionless form.

C = Units Conversion Factor, 1000 liter/m^3.

4.2.5. Derivation of Category GW-2 Standards

The derivation of the Category GW-2 Standards is given in Table 4.2. The table includes the noncancer and cancer risk-based indoor air concentrations, a preliminary concentration in groundwater, and the final concentration adopted as the GW-2 standard. The last column indicates the ultimate basis of the standard.

4.3 CATEGORY GW - 3: ENVIRONMENTAL CONCERNS

MCP Category GW-3 Standards (310 CMR 40.0974(2)) apply in all groundwater areas for a Method 1 risk characterization. These standards are intended to provide some protection against the migration and eventual discharge of groundwater contaminants to surface water at concentrations above an Ambient Water Quality Criterion. A dilution/attenuation factor of 10 is applied to allowable surface water concentrations to identify allowable groundwater concentrations.

For each oil or hazardous material the list of U.S. EPA Ambient Water Quality Criteria was examined, and the lowest environmentally-based (from among the Fresh Water Acute, Fresh Water Chronic, Marine Acute, and Marine Chronic) criterion was chosen and modified as described below.

> NOTE:
>
> Actual contamination in surface water may preclude the use of Method 1 to characterize risk (310 CMR 40.0942(1)(b)).

Archived Document

TABLE 4.2

Development of GW-2 Standards

TABLE 4-2

GW-2 DERIVATION 310 CMR 40.0974(2) IL AND/OR HAZARDOUS MATERIAL	20% RfC µg/cu m	1E-06 ELCR LEVEL µg/cu m	INDOOR AIR BACK-GROUND µg/cu m (VAPORS)	ODOR THRESHOLD µg/cu m	REF	WATER PQL µg/L	REF	SOLUBILITY µg/L	REF	Atten-uation Factor (alpha)	Source Dilution Factor (d)	HENRY'S LAW CONSTANT conc/conc	Units Conver-sion l/cu m	Existing Standard µg/L	Basis	Volatility Based31 Value µg/L	Method GROUNDWATER STANDA MR 40.09 Rounded) µg/L
ACETONE	2E+02		6	30862	13	100	14a	1.00E+09	11	0.0005	0.1	2E-03	1000	3000	ORSGL	1835568	50000
ALDRIN		2.04E-04		263	28	0.5	14e	1.70E+01	29	0.0005	0.1	2E-02	1000	3000	ORSGL	0	0.5
BENZENE	2E+00	1.20E-01	21	4890	13	0.5	14f	1.78E+06	SES	0.0005	0.1	2E-01	1000	5	MMCL	1866	2000
BIS(2-CHLOROETHYL)ETHER		3.03E-03		287	13	28.5	15d	1.02E+07	29	0.0005	0.1	5E-04	1000	3000	ORSGL	114	100
BIS(2-CHLOROISOPROPYL)ETHE		1.00E-01		2240	24	28.5	15d	1.70E+06	24	0.0005	0.1	5E-03	1000	3000	ORSGL	432	400
BIS(2-ETHYLHEXYL)PHTHALATE	1E+00	7.69E-01				4	14e	1.30E+03	29	0.0005	0.1	1E-05	1000	6	ORSGL	1253128	700
BROMOFORM		9.09E-01		13450	13	3.5	14f	3.20E+06	29	0.0005	0.1	2E-02	1000	5	ORSGL**	835	800
BROMOMETHANE	1E+00			80000	13	0.55	14g	1.75E+07	29	0.0005	0.1	8E+00	1000	10	ORSGL	2	2
CARBON TETRACHLORIDE	9E+01	6.67E-02	1	63000	13	1.5	14f	8.00E+05	29	0.0005	0.1	1E+00	1000	5	MMCL	17	20
CHLOROBENZENE	4E+00		10	1000	13	0.5	14f	4.88E+05	29	0.0005	0.1	2E-01	1000	100	MMCL	1244	1000
CHLOROFORM	1E+02	4.35E-02	3	421600	13	1	14f	9.30E+06	29	0.0005	0.1	1E-01	1000	5	ORSGL**	432	400
DICHLOROBENZENE, 1,2- (o-DCB)	4E+01		1	305000	24	5	14f	1.45E+05	29	0.0005	0.1	8E-02	1000	600	MMCL	10077	10000
DICHLOROBENZENE, 1,3- (m-DCB																	10000
DICHLOROBENZENE, 1,4- (p-DCB)	2E+02		0.5	1100	13	0.2	14g	7.90E+04	29	0.0005	0.1	1E-01	1000	5	MMCL	28748	30000
DICHLOROETHANE, 1,1-	1E+02			125000	13	1	14f	5.50E+06	29	0.0005	0.1	2E-01	1000	70	ORSGL	8967	9000
DICHLOROETHANE, 1,2-	1E+01	3.85E-02		2424	13	1	14f	8.69E+06	29	0.0005	0.1	5E-02	1000	5	MMCL	17	20
DICHLOROETHYLENE, 1,1-	1E+00	2.00E-02		125000	13	1	14f	2.10E+05	29	0.0005	0.1	6E-01	1000	7	MMCL	1	1
DICHLOROPROPANE, 1,2-	8E-01	5.35E-02		1190.5	13	1	14f	2.70E+06	29	0.0005	0.1	1E-01	1000	5	MMCL	9	9
DICHLOROPROPENE, 1,3-	4E+00	2.70E-02		4610	13	5	14a	2.70E+06	29	0.0005	0.1	1E-01	1000	0.5	ORSGL	4	5
ETHYLBENZENE	2E+02		10	2000	13	0.3	14g	1.61E+05	SES	0.0005	0.1	1E-01	1000	700	MMCL	28497	30000
ETHYLENE DIBROMIDE	4E-02	4.55E-03		200000	24	0.3	14g	4.30E+06	29	0.0005	0.1	3E-02	1000	0.02	MMCL	3	3
HEXACHLOROBUTADIENE		4.55E-02		12000	13	0.55	14g	2.00E+03	29	0.0005	0.1	1E+00	1000	3000	ORSGL	1	1
HEXACHLOROETHANE	6E-01	2.50E-01				8	15d	5.00E+04	29	0.0005	0.1	4E-01	1000	3000	ORSGL	12	10
METHYL ETHYL KETONE	2E+02		42	32000	24	100	14a	2.75E+08	29	0.0005	0.1	2E-03	1000	350	ORSGL	1694003	50000
METHYL ISOBUTYL KETONE	2E+01		2	9700	25	50	14a	1.91E+07	29	0.0005	0.1	6E-03	1000	350	ORSGL	56663	50000
METHYL TERT BUTYL ETHER	1E+02				0.5		14f	4.80E+07	29	0.0005	0.1	2E-02	1000	700	ORSGL	82694	50000
METHYLENE CHLORIDE	6E+02	2.13E+00	600	540000	13	5	14f	1.67E+07	29	0.0005	0.1	1E-01	1000	5	ORSGL	91922	50000
METHYLNAPHTHALENE, 2-	1E+01			68	28	10	14c	2.60E+04	29	0.0005	0.1	1E-02	1000	3000	ORSGL	23930	10000
NAPHTHALENE	1E+01		5	440	13	0.2	14g	3.10E+04	SES	0.0005	0.1	5E-02	1000	3000	ORSGL	5881	6000
PHENOL	5E+01			156.8	13	10	14c	8.00E+07	29	0.0005	0.1	5E-05	1000	3000	ORSGL	19548800	50000
STYRENE	2E+02	1.75E+00	5	1360	13	0.3	14g	3.00E+05	29	0.0005	0.1	1E-01	1000	100	MMCL	936	900
TETRACHLOROETHANE, 1,1,1,2-		1.35E-01				5	14a	2.00E+05	29	0.0005	0.1	5E-01	1000	3000	ORSGL	6	6
TETRACHLOROETHANE, 1,1,2,2-	2E+01	1.72E-02	0.01	10470	13	2	14f	2.90E+06	29	0.0005	0.1	2E-02	1000	3000	ORSGL	22	20
TETRACHLOROETHYLENE	9E+02	1.92E+00	11	31730	13	1.5	14f	2.00E+05	SES	0.0005	0.1	8E-02	1000	5	MMCL	2635	3000
TOLUENE	8E+01		29	30000	13	0.5	14f	5.35E+05	SES	0.0005	0.1	3E-01	1000	1000	MMCL	5853	6000
TRICHLOROBENZENE, 1,2,4-	2E+00		0.04	22000	27	1	14g	1.90E+04	29	0.0005	0.1	6E-02	1000	70	ORSGL	620	600
TRICHLOROETHANE, 1,1,1-	2E+02		30	65127	13	1.5	14f	7.30E+05	SES	0.0005	0.1	9E-01	1000	200	MMCL	4231	4000
TRICHLOROETHANE, 1,1,2-	1E+01	6.25E-02	30			0.5	14g	4.50E+06	29	0.0005	0.1	4E-02	1000	5	ORSGL	16112	20000
TRICHLOROETHYLENE	4E+01	5.88E-01	5	1360000	28	2	14f	1.10E+06	SES	0.0005	0.1	4E-01	1000	5	MMCL	268	300
TRICHLOROPHENOL 2,4,6-		3.23E-01		0.3	13	10	14c	8.00E+05	29	0.0005	0.1	2E-04	1000	3000	ORSGL	36654	40000
VINYL CHLORIDE	3E+00	1.19E-02		771244	13	1.5	14f	1.10E+03	29	0.0005	0.1	1E+00	1000	2	MMCL	0	2
XYLENES	6E+01		3	441	13	2.5	14f	1.71E+05	SES	0.0005	0.1	2E-01	1000	10000	MMCL	5564	6000

Archived Document

4.3.1 General Methodology

The sequential approach taken to the development of MCP GW-3 standards is as follows:

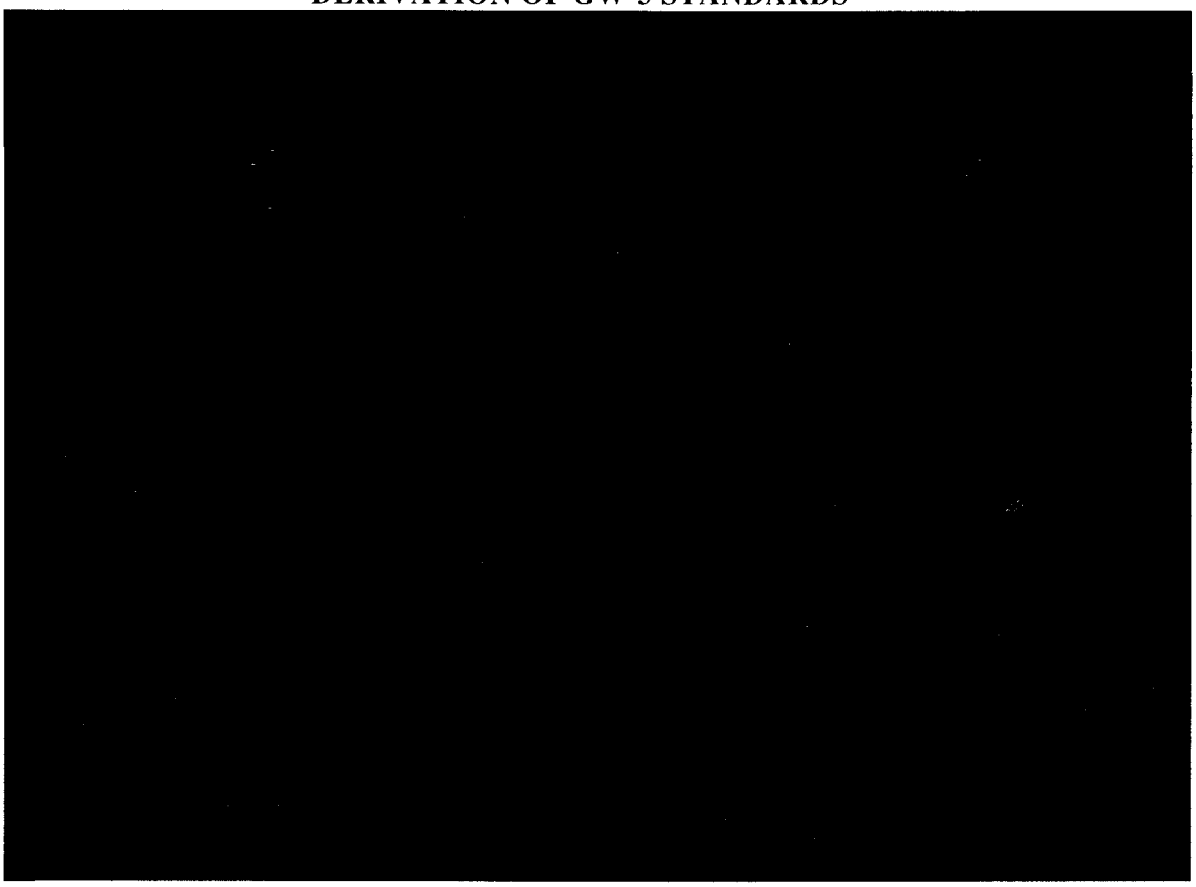
STEP	DESCRIPTION
1	The lowest of the ecologically-based U.S. EPA Ambient Water Quality Criteria is identified.
2	The lowest AWQC is multiplied by a dilution/attenuation factor of ten.
3	A value of 1/2 the solubility of the chemical is identified.
4	A ceiling concentration of 0.005% (50,000 µg/l) is noted.
5	The lowest of the three values identified in steps 2, 3, and 4 is chosen and carried through the process.
6	Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
7	A background concentration in groundwater is identified, if available.
8	The highest of the three values identified in steps 5, 6, and 7 is chosen. This value is adopted as the MCP GW-3 standard.

This process is diagramed in Figure 4-3.

Archived Document

FIGURE 4-3

DERIVATION OF GW-3 STANDARDS



4.3.5. Derivation of Category GW-3 Standards

The numerical derivation of the Category GW-3 Standards is given in Table 4.3. The table includes the Ambient Water Quality Criterion which is the basis of the standard, a preliminary concentration in groundwater, and the final concentration adopted as the GW-3 standard. The last column indicates the ultimate basis of the standard.

TABLE 4.3

DEVELOPMENT OF GW-3 STANDARDS

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATER IAL	GW BACK GROUND µg/L	WATER PQL µg/L	REF	Solu-bility µg/L	REF	Lowest Ambient Water Quality Criteria µg/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
ACENAPHTHENE		10	14c	3.42E+03	29	520	B	2000	Solubility
ACENAPHTHYLENE		0.5	14e	3.93E+03	24	300	C*	2000	Solubility
ACETONE		100	14a	1.00E+09	11			50000	Ceiling
ALDRIN		0.5	14e	1.70E+01	29	1.3	C	9	Solubility
ANTHRACENE		0.5	14e	1.29E+03	29	300	C*	600	Solubility
ANTIMONY		32	15b	-		30	PB	300	AWQC
ARSENIC	5.5	50	17	-		36	D	400	AWQC
BENZENE		0.5	14f	1.78E+06	SES	700	D	7000	AWQC
BENZO(a)ANTHRACENE		1	14e	1.00E+01	29	300	C*	5	Solubility
BENZO(a)PYRENE		0.5	14e	3.80E+00	29	300	C*	2	Solubility
BENZO(b)FLUORANTHENE		1	14e	1.40E+01	13	300	C*	7	Solubility
BENZO(g,h,i)PERYLENE		0.5	14e	2.60E-01	29	300	C*	0.1	Solubility
BENZO(k)FLUORANTHENE		1	14e	8.00E-01	30	300	C*	0.4	Solubility
BERYLLIUM		0.3	15b	-		5.3	B	50	AWQC
BIPHENYL,1,1-		0.1	14e	7.50E+03	29			4000	Solubility
BIS(2-CHLOROETHYL)ETHER		28.5	15d	1.02E+07	29	238000	A*	50000	Ceiling
BIS(2-CHLOROISOPROPYL)ETHER		28.5	15d	1.70E+06	24	238000	A*	50000	Ceiling
BIS(2-ETHYLHEXYL)PHTHALATE		4	14e	1.30E+03	29	3	B*	30	AWQC
BROMODICHLOROMETHANE		2.5	14f	4.50E+06	13	6400	D*	50000	Ceiling
BROMOFORM		3.5	14f	3.20E+06	29	6400	D*	50000	Ceiling
BROMOMETHANE		0.55	14g	1.75E+07	29	6400	D*	50000	Ceiling
CADMIUM	4.2	4	15b	-		1.1	B	10	AWQC
CARBON TETRACHLORIDE		1.5	14f	8.00E+05	29	35200	A	50000	Ceiling
CHLORDANE		1.5	14e	5.60E+01	29	0.004	B,D	2	PQL
CHLOROANILINE,		20	14c	2.60E+06	30			50000	Ceiling
CHLOROBENZENE		0.5	14f	4.88E+05	29	50	B*	500	AWQC
CHLOROFORM		1	14f	9.30E+06	29	1240	B	10000	AWQC
CHLOROPHENOL, 2-		10	14c	2.85E+07	29	4380	A	40000	AWQC
CHROMIUM				-				2000	AWQC(ChIII)
CHROMIUM(III)		7	14d	-		210	B	2000	AWQC
CHROMIUM(VI)		0.5	14h	-		11	B	100	AWQC
CHRYSENE		1.5	14e	6.00E+00	29	300	C*	3	Solubility
CYANIDE		0.1	15a	1000000000	11	1	C	10	AWQC
DIBENZO(a,h)ANTHRACENE		0.5	14e	5.00E-01	29	300	C*	0.3	Solubility
DIBROMOCHLOROMETHANE		2	14f	4.00E+06	13	6400	D*	50000	Ceiling
DICHLOROBENZENE, 1,2- (o-DCB)		5	14f	1.45E+05	29	763	B*	8000	AWQC
DICHLOROBENZENE, 1,3- (m-DCB)		0.6	14g	1.23E+05	29	763	B*	8000	AWQC
DICHLOROBENZENE, 1,4- (p-DCB)		0.2	14g	7.90E+04	29	763	B*	8000	AWQC
DICHLOROBENZIDINE,		82.5	15d	3.10E+03	29			2000	Solubility
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD|D|0.0125			15c	1.60E+02	29	0.6	A	6	AWQC
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD		0.05	15c	4.00E+01	29	14	C	20	Solubility
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DT0.3			15c	3.10E+00	29	0.001	B,D	0.3	PQL
DICHLOROETHANE,		1	14f	5.50E+06	29			50000	Ceiling
DICHLOROETHANE,		1	14f	8.69E+06	29	20000	B	50000	Ceiling

Archived Document

Table 4.3, continued...

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND µg/L	WATER PQL µg/L	REF	Solu-bility µg/L	REF	Lowest Ambient Water Quality Criteria µg/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
DICHLOROETHYLENE, 1,1-		1	14f	2.10E+05	29	11600	A*	50000	Ceiling
DICHLOROETHYLENE, CIS-1 ,2-		0.6	14g	8.00E+05	29	11600	A*	50000	Ceiling
DICHLOROETHYLENE, TRANS-1 ,2-		0.3	14g	6.00E+05	29	11600	A*	50000	Ceiling
DICHLOROPHENOL, 2,4-		13.5	15d	4.50E+06	29	365	B	4000	AWQ C
DICHLOROPROPANE, 1,2-		1	14f	2.70E+06	29	3040	D*	30000	AWQC
DICHLOROPROPENE, 1,3-		5	14a	2.70E+06	29	244	B*	2000	AWQC
DIELDRIN		0.1	15c	1 .86E+02	29	0.0019	B,D	0.1	PQL
DIETHYL PHTHALATE		4	14e	8.96E+05	11	3	B*	30	AWQ C
DIMETHYL PHTHALATE		1.5	14e	5.00E+06	29	3	B*	30	AWQ C
DIMETHYLPHENOL, 2,4-		13.5	15d	7.87E+06	30	2120	A	20000	AWQ C
DINITROPHENOL, 2,4-		210	15d	5.60E+06	29	150	B*	2000	AWQC
DINITROTOLUENE, 2,4-		28.5	15d	2.70E+05	29	230	B	2000	AWQ C
DIOXIN		1E-05	19	1 .93E-02	29	0.00001	B*	1 E-04	AWQ C
EN DOSU LFAN		0.12	15c	1 .50E+02	13	0.0087	D	0.1	PQL
ENDRIN		5	14e	2.60E+02	29	0.0023	B,D	5	PQL
ETHYLBENZENE		0.3	14g	1.61E+05	SES	430	C	4000	AWQC
ETHYLENE DIBROMIDE		0.3	14g	4.30E+06	29			50000	Ceiling
FLUORANTHENE		11	15d	2.65E+02	29	16	D	100	Solubility
F LUOREN E		1	14e	1 .90E+03	29	300	C *	1000	Solubility
H EPTACH LOR		1	14e	5.60E+01	29	0.0036	D	1	PQL
HEPTACHLOR EPOXIDE		1.5	14e	3.50E+02	29	0.0036	D	2	PQL
HEXACHLOROBENZENE		1	14e	1.10E+02	29	3.68	PB	40	AWQC
HEXACHLOROBUTADIENE		0.55	14g	2.00E+03	29	9.3	B	90	AWQC
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HC H		0.5	14e	7.00E+03	29	0.08	B	0.8	AWQC
H EXACHLOROETHANE		8	15d	5.00E+04	29	540	B	5000	AWQ C
INDENO(1 ,2,3-cd)PYRENE		0.5	14e	5.30E-01	11	300	C *	0.3	Solubility
LEAD	8.8	1	15b	-		3.2	B	30	AWQ C
MERCURY	0.95	0.2	14i	5.60E+01	29	0.012	B	1	Bckgrnd
METHOXYCHLOR		1.5	14e	4.00E+01	29	0.03	B,D	2	PQL
METHYL ETHYL KETON E		100	14a	2.75E+08	29			50000	Ceiling
METHYL ISOBUTYL KETONE		50	14a	1.91 E+07	29			50000	Ceiling
METHYL MERCURY				-		0.012	B	0.1	AWQC
METHYL TERT BUTYL ETHER		0.5	14f	4.80E+07	29	7000	E	50000	Ceiling
METHYLENE CHLORIDE		5	14f	1 .67E+07	29	6400	D*	50000	Ceiling
METHYLNAPHTHALENE, 2-		10	14c	2.60E+04	29	300	C*	3000	AWQ C
NAPHTHALENE		0.2	14g	3.10E+04	SES	620	B	6000	AWQC
NICKEL		15	15b	-		8.3	D	80	AWQC
PENTACHLOROPHENOL		15	14e	1.40E+04	29	7.9	D	80	AWQC
PHENANTHRENE		1	14e	8.16E+02	29	4.6	PD	50	AWQC
PHENOL		10	14c	8.00E+07	29	2560	B	30000	AWQC
POLYCHLORINATED BIPHENYLS		0.325	14b	3.10E+01	11	0.014	B	0.3	PQL
PYREN E		0.5	14e	1 .60E+02	29	300	C *	80	Solubility
SELENIUM		75	15b	-		5	B	80	PQL
SILVER	4.7	7	15b	-		0.12	B	7	PQL

Archived Document

Table 4.3,

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

continued...

OIL AND/OR HAZARDOUS MATERIAL	GW BACKGROUND ug/L	WATER PQL µg/L	REF	Solubility µg/L	REF	Lowest Ambient Water Quality Criteria µg/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
STYRENE		0.3	14g	3.00E+05	29			50000	Ceiling
TETRACHLOROETHANE, 1,1,1,2-		5	14a	2.00E+05	29	9320	A	50000	Ceiling
TETRACHLOROETHANE, 1,1,2,2-		2	14f	2.90E+06	29	2400	B	20000	AWQC
TETRACHLOROETHYLENE		1.5	14f	2.00E+05	SES	450	D	5000	AWQC
THALLIUM		40	15b	-		40	B	400	AWQC
TOLUENE		0.5	14f	5.35E+05	SES	5000	D	50000	AWQC
TOTAL PETROLEUM HYDROCARBONS								50000	Ceiling
TRICHLOROBENZENE, 1,2,4-		1	14g	1.90E+04	29	50	B*	500	AWQC
TRICHLOROETHANE, 1,1,1-		1.5	14f	7.30E+05	SES	18000	A	50000	Ceiling
TRICHLOROETHANE, 1,1,2-		0.5	14g	4.50E+06	29	9400	B	50000	Ceiling
TRICHLOROETHYLENE		2	14f	1.10E+06	SES	2000	C	20000	AWQC
TRICHLOROPHENOL, 2,4,5-		10	14c	1.19E+06	29	11	D	100	AWQC
TRICHLOROPHENOL 2,4,6-		10	14c	8.00E+05	29	970	B	10000	AWQC
VINYL CHLORIDE		1.5	14f	1.10E+03	29			600	Solubility
XYLENES		2.5	14f	1.71E+05	SES			50000	Ceiling
ZINC		2	15b	-		86	D	900	AWQC

BASIS OF AWQC:
A = FRESH WATER ACUTE CRITERIA
B = FRESH WATER CHRONIC CRITERIA
C = MARINE ACUTE CRITERIA
D = MARINE CHRONIC CRITERIA
* = WQC for a Group of Chemicals (such as "PAHs").
E = Derived by MA DEP/ORS
P = Proposed value

BASIS OF GW-3 STANDARDS IN TEXT

Archived Document

4.4 UPPER CONCENTRATION LIMITS

The Upper Concentration Limits (UCLs) in Groundwater (310 CMR 40.0996(4)) are applicable when risk characterization Method 2 or Method 3 is used to evaluate the potential risk of harm to health, public welfare and the environment. ***Upper Concentration Limits are not used in risk characterization Method 1*** as sites meeting the Method 1 Standards meet the Upper Concentration Limits, by definition.

The categorization scheme devised to determine the "current and foreseeable use(s)" of the groundwater essentially clarifies why the Department is concerned about contamination in groundwater and related human and/or ecological impacts. Our ability to comprehensively describe (qualitatively or quantitatively) potential impacts is limited, however, particularly impacts which may only become evident in the future. The revised MCP defines areas of particular interest (categories GW-1, GW-2 and GW-3), and allows some flexibility to establish alternative cleanup requirements using risk assessment in Methods 2 and 3. The Upper Concentration Limits identify contamination which may pose a significant risk of harm to public welfare and the environment in the future, and to minimize the incremental contributions to anthropogenic background. The Department views all groundwater as a resource of the Commonwealth and does not endorse the general degradation of the groundwater.

The revised MCP contains several features intended to provide protection to all groundwater, including: (a) the requirement to use the best remedial action management approaches (BRAMA) to characterize a site (310 CMR 40.019 1); (b) the requirement to eliminate all continuing sources of release to the environment (310 CMR 40.1003(5)); and (c) the list of Upper Concentration Limits applicable to all groundwater as public welfare environmental resource standards (310 CMR 40.0994(3) and 310 CMR 40.0995(5)).

A disposal site may qualify for a Class C Response Action Outcome (RAO), even if the concentrations of oil or hazardous material remaining at the disposal site exceed the Upper Concentration Limits. Exceedance of these standards is interpreted to indicate significant risk of harm to public welfare and/or environmental resources in the future, and thus a Class C RAO may be appropriate if, for current conditions, a level of no significant risk of harm to health, safety, public welfare and the environment exists or has been achieved.

The UCLs are simply 10 fold multiple of the highest exposure-related (GW-1, GW-2 or GW-3) standard, capped at a maximum concentration of 100,000 µg/L, or 0.01 % and adjusted for solubility. The Upper Concentration Limits in Groundwater are listed in Table 1.1.

5.0 SOIL

MCP Numerical Standards have been derived for three categories of soil, as described in the following subsections. The three categories were developed to address a broad range of potential human exposures (Categories S-1, S-2 and S-3), plus an "upper concentration limit" is identified to protect against general environmental degradation.

The applicability of a particular soil category depends upon both the accessibility of the soil (measured primarily by depth) and the human activities which may take place at the surface. Within a soil category there are further sub-categories which are identified by groundwater type: the soil standards within these sub-categories have been modified by the potential for a contaminant to leach and impact the site groundwater.

For Method 1 risk characterizations, the applicable soil standard is identified by the combination of soil and groundwater categories. These standards consider both the risks associated with direct contact (ingestion and dermal contact) exposures associated with the soil and the potential for material to leach from the soil and impact the groundwater. The Method 1 Soil Category S-1, S-2, and S-3 Standards are listed in Tables 2, 3 and 4 (respectively) of the Massachusetts Contingency Plan (310 CMR 40.0975(6)(a), (b) and (c)).

For Method 2 risk characterizations, the Method 1 Soil Standards may be adjusted considering site-specific soil leaching characteristics, but *not* to account for other exposure factors (310 CMR 40.0985). The direct contact component of the Method 1 Soil Standards is thus a limiting factor to the Method 2 modifications. These Direct Contact levels are listed in Table 5 (310 CMR 40.0985(6)) of the MCP.

Note that the derivation of the Direct Contact Standards is presented first in the following sections, then the derivation of the leaching-based soil concentrations is described. Both the direct contact and leaching-based concentrations are components of the Method 1 Standards. The direct contact values are common to both the Method 1 and Method 2 Soil Standards, so while these numbers are labelled the "Method 2 Standards", they are also the first step in the derivation of the Method 1 Soil Standards and, as a result, are presented first.

The soil exposure assessment described in this section is based upon an ongoing project within the Department to develop methodology for deriving soil advisory levels (MA DEP, 1991a).

Archive Copy

5.1 HUMAN EXPOSURE CATEGORIES: S-1, S-2 AND S-3

The derivation of MCP Soil Standards for Categories S-1, S-2 and S-3 share a common methodology which is detailed in this section. The specific exposure factors which were used for each category are described in later subsections.

The three human exposure categories are intended to describe a range of potential exposure situations which are commonly found at c.21E sites.

> **It is clear that there are as many specific exposure scenarios as there are sites, which is why the risk assessor, LSP and PRP have the option of characterizing the risk of harm to health by MCP Method 3.**

Given the need to generalize about exposure situations, there has been concern that the application of "typical" scenarios to a given site may result in standards which are "over-" or "under-protective". In practice, however, variations in the exposure assumptions do not produce dramatic changes in the resulting standards. The risk-based concentrations estimated for the three soil categories span approximately one order-of-magnitude (a factor of 10), despite the fact that the exposure scenarios are significantly different.

5.1.1 General Methodology

The **Method 2** Direct Contact standards for each soil category are derived in a sequential fashion, as follows:

STEP	DESCRIPTION
1	Standard toxicity information and risk assessment is used to identify risk-based concentrations which are associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), and (b) an excess lifetime cancer risk equal to one-in-one million. The lowest of these two factors is carried through the process.
2	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
3	A "background" concentration is identified, if available.
4	The highest of the three values (risk-based, PQL, background) is identified.
5	A ceiling concentration is noted. The ceiling concentration varies by category, as described below.
6	The lowest of the concentrations identified in steps 4 and 5 is the Method 2 Direct Contact soil standard.

Archived Document

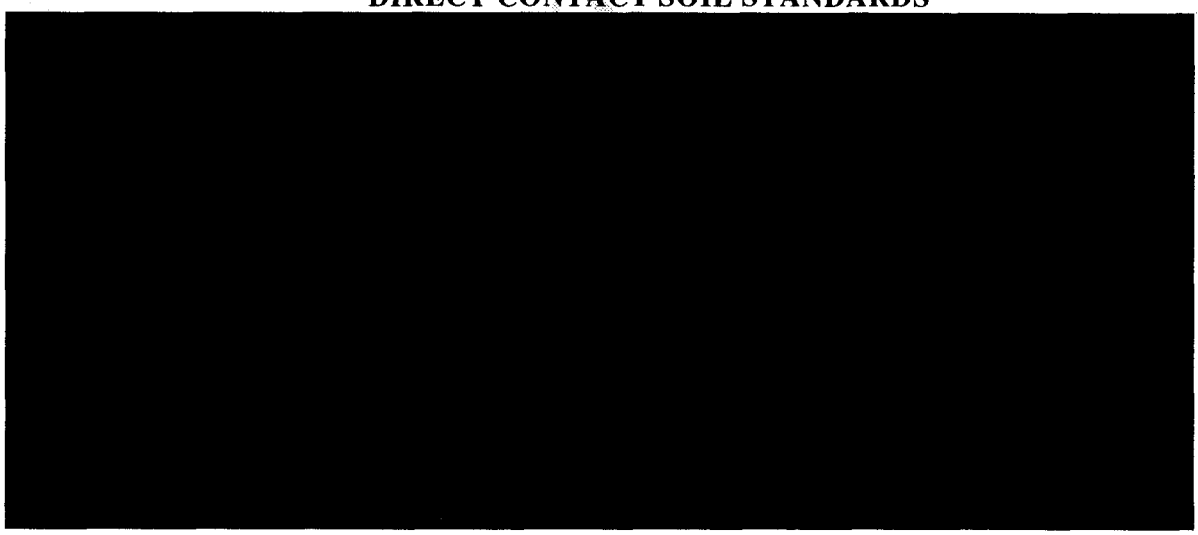
The **Method 1** Soil Standards, which consider leaching, are derived in a similar manner, but a leaching factor is incorporated in step (1):

STEP	DESCRIPTION
1	Standard toxicity information and risk assessment is used to identify risk-based concentrations which associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), and (b) an excess lifetime cancer risk equal to one-in-one million. The leaching-based concentration (i.e., a level in soil which is considered protective of the applicable groundwater standard is identified. (See Section 5.2) The lowest of these three factors is carried through the process.
2	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
3	A "background" concentration is identified, if available.
4	The highest of the three values (risk-/leaching-based, PQL, background) developed in steps 1, 2 and 3 is identified.
5	A ceiling concentration is noted. The ceiling concentration varies by category, as described below.
6	The lowest of the concentrations identified in steps 4 and 5 is becomes the Method 1 Soil Standard applicable in the specified groundwater area.

The general methodology for the development of Method 2 Direct Contact Soil Standards is outlined in Figure 5-1. The methodology for the development of the Method 1 Soil Standards (considering potential leaching to groundwater) is outlined in Figure 5-2.

FIGURE 5-1

DERIVATION OF METHOD 2
DIRECT CONTACT SOIL STANDARDS



Draft

FIGURE 5-2

DERIVATION OF METHOD 1 SOIL STANDARDS

[redacted]

5.1.2 Risk Assessment Equations

Incidental ingestion of and dermal contact with surface soils and dust have been identified as potential exposures of concern for both children and adults in the development of the soil standards. The receptor's exposure to contaminated soil and dust varies according to the activities by which the receptor comes into contact with the soil.

The exposure rate normalized to bodyweight is most often the expression of exposure which is of most toxicological significance. This concept is particularly important in the assessment of direct soil contact because the soil exposure rate normalized to bodyweight is not constant over the lifetime, but rather is relatively high in young children and falls off to a lower, fairly constant level in adults.

In developing the standards, chemical exposures were treated as a function of the concentration of an OHM in soil and the average soil exposure rate normalized to bodyweight for various exposure durations and receptor age groups. The concentrations of OHM were assumed to remain constant in soil over time. As described below, the soil ingestion rates and soil dermal contact rates used here incorporate the frequency and duration of exposure and the appropriate averaging period.

The equation used to develop risk-based concentrations considering potential non-carcinogenic effects associated with direct contact with contaminated surface soil is given as:

$$[OHM] = \frac{0.2 \times RfD \times C}{(NADSIR \times RAF_1) + (NADSCR \times RAF_2)} \quad (9)$$

The equation used to develop risk-based concentrations considering potential carcinogenic effects associated with direct contact exposure with contaminated surface soil is given as:

$$[OHM]_{soil} = \frac{ELCR \times C}{((NLADSIR \times RAF) + (NLADSCR \times RAF)) \times CSF}$$

Where:

$[OHM]_{soil}$ = A risk-based (non-cancer or cancer risk) concentration, in soil, for the oil of hazardous material. In units: mg/kg.

0.2 = A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily intake of the oil or hazardous material may come from exposure to the site soil.

RfD = The oral Reference Dose or substitute toxicity value identified for the oil or hazardous material. In units of: mg/kg/day.

C = Units Conversion Factor: 10^6 mg/kg

NADSIR = The Normalized Average Daily Soil Ingestion Rate (normalized to bodyweight) for the exposure period of concern. (Table 5.1) These values are rates of soil ingestion (not rates of OHM ingestion). In units: m g_{soil}/kg/day.

NADSCR = The Normalized Average Daily Soil Dermal Contact Rate (normalized to bodyweight) for the exposure period of concern. (Table 5.1) These values are rates of soil contact (not contact with OHM). In units: mg_{soil}/kg/day.

RAF = The Relative Absorption Factors for soil ingestion or dermal contact and threshold or cancer health effects (a chemical-, medium-, route- , and health endpoint-specific value). Dimensionless.

ELCR =Target Excess Lifetime Cancer Risk: 1×10^{-6} (dimensionless).

NLADSIR = Time-weighted Normalized Lifetime Average Daily Soil Ingestion Rate (normalized to bodyweight). (Table 5.1) This value represents the exposure during the exposure period averaged over a lifetime, not a lifetime exposure. In units: mg_{soil}/kg/day.

NLADSCR = Time-weighted Normalized Lifetime Average Daily Soil Dermal Contact Rate (normalized to bodyweight). (Table 5.1) This value represents the exposure during the exposure period averaged over a lifetime, not a lifetime exposure. In units: mg_{soil}/kg/day.

CSF = The oral Cancer Slope Factor for the oil or hazardous material. In units of: $(mg/kg/day)^{-1}$

The Normalized Average Daily Soil Ingestion Rate, (NADSIR) and the Normalized Average Daily Soil Contact Rate (NADSCR) were used to calculate the non-cancer risk-based concentrations. The Normalized Lifetime Average Daily Soil Ingestion Rates (NLADSIR) and the Normalized Lifetime Average Daily Soil Contact Rates (NLADSCR) are used to calculate the cancer risk-based concentrations. The numerical value for each of these soil exposure rates and for each of the soil Categories is shown in Table 5.1. Appendices A-C document in a step-by-step approach the derivation of the soil ingestion rates and the soil dermal contact rates summarized in Table 5.1. The average exposure rates can be reproduced from the information in these tables and the references cited. All of these exposure rates are based on a methodology described in the **DRAFT Development of Soil Advisory Levels, Technical Support Document** (MADEP, 1991a).

TABLE 5.1

SUMMARY OF SOIL INGESTION AND DERMAL CONTACT RATES

NON-CANCER EFFECTS

Soil Category	Normalized (to BW) Average Daily Soil Ingestion Rate (NADSIR)	Normalized (to BW) Average Daily Soil/Skin Contact Rate (NADSCR)
S-1	3.1	28.5
S-2		0.29 15.2
S-3	0.63	32.5

NON-THRESHOLD (CARCINOGENIC) EFFECTS

Soil Category	Normalized (to BW) Lifetime Average Daily Soil Ingestion Rate (NLADSIR) m g_{soil}/kg/day	Normalized (to BW) Lifetime Average Daily Soil/Skin Contact Rate (NLADSCR) m g_{soil}/kg/day
S-1		0.41 7.3
S-2		0.11 5.48

The derivations of these values are presented in Appendices A (S-1), B (S-2) and C (S-3).

5.1.3 Exceptions To This Methodology

For five chemicals the MCP Numerical Standards represent exceptions to the general methodology described in the previous sections. These chemicals are cyanide, lead, polychlorinated biphenyls (PCBs), Total Petroleum Hydrocarbons and zinc.

The Category S-1 cyanide standard is derived from an evaluation of potential acute effects associated with a *one-time* exposure to cyanide in soil. The derivation of this value is contained in an earlier MA DEP document (1990c).

For lead, PCBs and zinc, the exceptions arise from Massachusetts regulations (310 CMR 32) which allow the unrestricted land application of Type I sludge material at specific concentrations.

Archived Document

Consistent with the decision to adopt existing drinking water standards and guidelines as GW-1 standards, the Department has determined that, for these chemicals, MCP Method 1 standards are set at a concentration equal to the Type I sludge standards when that standard is *higher* than the value calculated following the MCP approach.

For zinc, the Category S-1 risk-based concentration derived using the MCP process is greater than the Type I sludge standard, but the ceiling concentration of 1,000 μg/gram which would normally be applied in this Category would render the S-1 standard more stringent than the Type I sludge standard. Therefore, for this chemical only, the ceiling concentration is not applied, and the Category S-1 standard is set at 2,500 μg/gram.

For lead, the Category S-1 risk-based concentration derived using the MCP process is less than the Type I sludge standard. The Type I sludge standard is therefore adopted as the Category S-1 lead standard on an interim basis while the Department reviews its policy on the regulation of this chemical.

For polychlorinated biphenyls (PCBs), the risk-based concentrations derived using the MCP process for all the soil categories are less than the Type I sludge standard. The Type I sludge standard is therefore adopted as the MCP soil standard on an interim basis while the Department reviews its policy on the regulation of this chemical.

For Total Petroleum Hydrocarbons (TPH) default standards were identified based upon the assignment of toxicity values to the alkane and aromatic/alkene fractions (each fraction is assumed to be approximately 50% of the mixture). Half the mixture was assumed to be composed of alkanes exhibiting toxicity similar to that of n-hexane (Reference Dose = 0.06 mg/kg/day) with the remainder of the mixture assumed to be composed of alkenes and/or aromatics exhibiting toxicity similar to that of pyrene (Reference Dose = 0.03 mg/kg/day). As n-hexane and pyrene are associated with effects on different target organs (the nervous system and the kidney, respectively), the risk-based concentrations for each fraction were summed to yield the standard for the TPH mixture. The development of the TPH standard takes a health protective approach in addressing the uncertainty which exists in the composition of a given TPH mixture by assigning conservative toxicity values to each fraction (alkanes and alkenes/aromatics). The toxicity of each of the hundreds of chemicals which comprise the mixture would be expected to be, on average, less than that of the reference compounds chosen. This approach was based upon initial efforts by MADEP to develop a health-based alternative to the TPH parameter. This draft policy (MADEP, 1993) will be part of the DEP BWSC comprehensive *Petroleum Policy,* which will address site investigation and analytical issues as well.

5.1.4 Soil Category S - 1

The Soil Category S-1 standards are based upon a residential exposure scenario in which the potential receptor may come into contact with the contaminated soil in their yard while playing or gardening.

For non-cancer health effects, the receptor of concern is a young child (aged 1 to 8 years) who comes into contact with house dust of soil origin (indoors) and the contaminated soil outdoors.

For carcinogenic effects, the receptor of concern is the resident (aged 0 to 30 years) who comes into contact with the soil as described for the youth and while working/gardening in their yard as an

adult.

FREQUENCY OF EXPOSURE:

* **The young child (1 to 6 years) is assumed to be in contact with the house dust every day from October through April (212 days).**

* **The child (1 to 8 years) is assumed to be in contact with the outdoor soil every day from May through September (153 days).**

* **The adult (9 - 30 years) is assumed to come into contact with the outdoor soil every day from May to September (153 days).**

INTENSITY OF EXPOSURE:

* **Household dust ingestion rates varied from 2 to 31 mg soil per day exposed (age dependent). This pathway was only evaluated for the 1 to 6 year old.**

* **Outdoors the child is assumed to ingests 100 mg of soil per day exposed (ages 1 to 6 years) and 50 mg of soil per day exposed (ages 6 to 8 years).**

* **Adults (9 to 30 years) are assumed to ingest 50 mg of soil per day exposed.**

* **Indoors in the winter, it is assumed that the hands of the 1 to 6 year old is exposed to the house dust.**

* **In the summer, it is assumed that the hands, arms, legs and feet of the child (1 to 18 years) are exposed to the soil.**

* **For the adult (18 to 30 years), only the hands, forearms, lower legs and feet are assumed to be exposed.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

The derivations of the Category S-1 soil ingestion and soil contact rates are given in Appendix A. Table 5.2 lists the S-1 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-1 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-1 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

Archived Document

TABLE 5.2

TABLE 5-2

METHOD 2 DIRECT CONTACT S-1 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	hod 2, Direct Contact OIL S-1 STANDARD 0 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			1000 Non-Odor	1.4E+03		1000	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	100 Non-Odor	1.0E+03		100	Ceiling
ACETONE		0.1	14a	20.77	270	500 Odor-2	3.4E+03		500	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	1000 Non-Odor	5.9E-01	0.03	0.03	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	1000 Non-Odor	5.3E+03		1000	Ceiling
ANTIMONY		6.4	14d			1000 Non-Odor	1.3E+01		10	Noncancer Risk
ARSENIC	32	10.6	14d			1000 Non-Odor	1.5E+01	0.91	30	Background
BENZENE		0.005	14a	63.33	95	500 Odor-2	1.9E+02	34.69	30	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	1000 Non-Odor	1.0E+03		1000	Ceiling
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
BERYLLIUM		0.06	14d			1000 Non-Odor	2.5E+02	0.37	0.4	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			1000 Non-Odor	1.9E+03		1000	Ceiling
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	500 Odor-2		0.12	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	500 Odor-2	2.5E+02	1.85	2	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			1000 Non-Odor	1.1E+03	128.47	100	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	100 Volatility	6.7E+02	14.15	10	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	500 Odor-2	6.4E+02	111.04	100	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	500 Odor-2	4.7E+01		50	Noncancer Risk
CADMIUM		0.8	14d			1000 Non-Odor	2.8E+01		30	Noncancer Risk
CARBON TETRACHLORIDE		0.005	14a	11.30	113	500 Odor-2	2.4E+01	6.75	7	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	1000 Non-Odor	2.7E+00	0.99	1	Cancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	100 Non-Odor	1.3E+02		100	Ceiling
CHLOROBENZENE		0.005	14c	53.64	11.8	500 Odor-2	6.7E+02		500	Ceiling
CHLOROFORM		0.005	14a	1.88	160	500 Odor-2	3.4E+02	143.80	100	Cancer Risk
CHLOROPHENOL, 2-		0.66	14c			1000 Non-Odor	9.5E+01		100	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	1000 Non-Odor	4.7E+04		1000	Ceiling
CHROMIUM(VI)	105		14h		NA	1000 Non-Odor	1.8E+02		200	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
CYANIDE		1	16	1068.97	620	100 Odor-1	* 1.0E+02		100	Noncancer Risk *
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	1000 Non-Odor	1.6E+03	0.13	0.7	PQL
DIBROMOCHLOROMETHANE		0.005	14a		76	100 Volatility	6.7E+02	10.44	10	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	100 Volatility	3.0E+03		100	Ceiling
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	100 Volatility(o-D	B 3.0E+03		100	Ceiling(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	500 Odor-2		36.55	40	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	1000 Non-Odor		0.51	1	PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD		0.00737	14b		1.00E-06	1000 Non-Odor		2.23	2	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD		0.00268	14b		6.50E-06	1000 Non-Odor		1.57	2	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT		0.00804	14b		1.50E-07	1000 Non-Odor	1.1E+01	1.57	2	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	100 Volatility	2.6E+03		100	Ceiling
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	500 Odor-2	6.7E+02	9.64	10	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	500 Odor-2	3.0E+02	1.43	1	Cancer Risk

Archived Document

TABLE 5-2

METHOD 2 DIRECT CONTACT
S-1 DERIVATION
310 CMR 40.0985(6)

OIL AND/OR HAZARDOUS MATERIAL	SOIL BACKGROUND mg/kg	SOIL PQL REF mg/kg	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	od 2, Direct Contact OIL S-1 STANDARD 0 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.00514a		202	100 Volatility	3.4E+02		100	Ceiling
DICHLOROETHYLENE, TRANS-1,2-		0.00514a	19.47	331	500 Odor-2	6.7E+02		500	Ceiling
DICHLOROPHENOL, 2,4-		0.6614c	0.32	6.70E-02	100 Non-Odor	4.1E+01		40	Noncancer Risk
DICHLOROPROPANE, 1,2-		0.00514a	168.00	42	100 Odor-1		7.86	8	Cancer Risk
DICHLOROPROPENE, 1,3-		0.00514a	43.00	43	500 Odor-2	6.8E+00	2.97	3	Cancer Risk
DIELDRIN		0.0013414b		1.80E-07	1000 Non-Odor	9.8E-01	0.03	0.03	Cancer Risk
DIETHYL PHTHALATE		0.6614c			1000 Non-Odor	4.4E+04		1000	Ceiling
DIMETHYL PHTHALATE		0.6614c			1000 Non-Odor	3.9E+04		1000	Ceiling
DIMETHYLPHENOL, 2,4-		0.6614c			1000 Non-Odor	3.8E+02		400	Noncancer Risk
DINITROPHENOL, 2,4-		3.314c		NA	1000 Non-Odor	3.8E+01		40	Noncancer Risk
DINITROTOLUENE, 2,4-		0.6614c		5.10E-03	1000 Non-Odor	5.9E+01	1.08	1	Cancer Risk
DIOXIN		1.0E-06	19	7.40E-10	1000 Non-Odor		0.00	4E-06	Cancer Risk
ENDOSULFAN		0.0093814b		1.00E-05	1000 Non-Odor	1.1E+00		1	Noncancer Risk
ENDRIN		0.0040214b		2.00E-07	1000 Non-Odor	5.9E+00		6	Noncancer Risk
ETHYLBENZENE		0.00514a	4.35	10	500 Odor-2	2.3E+03		500	Ceiling
ETHYLENE DIBROMIDE		0.00514a	0.46	12	100 Volatility	6.7E-01	0.01	0.01	Cancer Risk
FLUORANTHENE		0.6614c		5.00E-06	1000 Non-Odor	9.1E+02		900	Noncancer Risk
FLUORENE		0.6614c			1000 Non-Odor	9.1E+02		900	Noncancer Risk
HEPTACHLOR		0.0020114b	0.02	3.00E-04	1000 Non-Odor	1.1E+01	0.12	0.1	Cancer Risk
HEPTACHLOR EPOXIDE		0.0556114b	1.37E-04	2.60E-06	1000 Non-Odor	3.0E-01	0.06	0.06	Cancer Risk
HEXACHLOROBENZENE		0.6614c		1.09E-05	1000 Non-Odor	2.4E+01	0.46	0.7	PQL
HEXACHLOROBUTADIENE		0.6614c	1.17E-03	1.50E-01	100 Non-Odor	4.5E+01	6.86	7	Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH		0.0026814b		9.40E-06	1000 Non-Odor	6.8E+00	0.41	0.4	Cancer Risk
HEXACHLOROETHANE		0.6614b		4.00E-01	100 Non-Odor	6.3E+00	9.26	6	Noncancer Risk
INDENO(1,2,3-cd)PYRENE		0.6614c		1.00E-09	1000 Non-Odor	1.0E+03	0.07	0.7	PQL
LEAD		8.414d			1000 Non-Odor	8.7E+01		300	* Sludge Stnd
MERCURY		0.114i		1.20E-03	1000 Non-Odor	1.3E+01		10	Noncancer Risk
METHOXYCHLOR		0.1179214b		1.40E-06	1000 Non-Odor	1.1E+02		100	Noncancer Risk
METHYL ETHYL KETONE		0.114a	9.09	100	500 Odor-2	2.0E+04		500	Ceiling
METHYL ISOBUTYL KETONE		0.0514a	100.00	10	100 Odor-1	1.7E+03		100	Ceiling
METHYL MERCURY					1000 Non-Odor	6.8E+00		7	Noncancer Risk
METHYL TERT BUTYL ETHER		0.0514f		245	100 Volatility	1.7E+02		100	Ceiling
METHYLENE CHLORIDE		0.00514a	2.68	429	500 Odor-2	2.0E+03	116.96	100	Cancer Risk
METHYLNAPHTHALENE, 2-		0.6614c			1000 Non-Odor	1.3E+03		1000	Ceiling
NAPHTHALENE		0.6614c	0.98	8.20E-02	100 Non-Odor	1.3E+03		100	Ceiling
NICKEL		314d			1000 Non-Odor	3.1E+02		300	Noncancer Risk
PENTACHLOROPHENOL		3.314c		1.10E-04	1000 Non-Odor	9.6E+02	6.87	7	Cancer Risk
PHENANTHRENE		0.6614c	2.40E-03	9.60E-04	1000 Non-Odor	1.0E+03		1000	Ceiling
PHENOL		0.6614c	8.75	3.50E-01	500 Odor-2	1.1E+04		500	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.0435514b		NA	1000 Non-Odor	2.2E-01	0.2	2	* Sludge Stnd
PYRENE		0.6614c		2.50E-06	1000 Non-Odor	6.8E+02		700	Noncancer Risk
SELENIUM		1514d		NA	1000 Non-Odor	3.2E+02		300	Noncancer Risk
SILVER		1.414d			1000 Non-Odor	9.8E+01		100	Noncancer Risk
STYRENE		0.00514a	16.67	5	500 Odor-2	4.5E+03	17.83	20	Cancer Risk

Archived Document

Table 5.2, continued...

TABLE 5-2

METHOD 2 DIRECT CONTACT S-1 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	hod 2, Direct Contact OIL S-1 STANDARD 0 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-	0.005	14a		10	100 Volatility	1.4E+02	3.62	4	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-	0.005	14a	2.67	4	500 Odor-2		0.47	0.5	Cancer Risk
TETRACHLOROETHYLENE	0.005	14a	4.06	19	500 Odor-2	3.4E+02	168.69	200	Cancer Risk
THALLIUM	8	14d			1000 Non-Odor	4.1E+00		8	PQL
TOLUENE	0.005	14a	3.50	28	500 Odor-2	6.1E+03		500	Ceiling
TOTAL PETROLEUM HYDROCARBONS					1000 Non-Odor			500	* Default
TRICHLOROBENZENE, 1,2,4-	0.66	14c			1000 Non-Odor	3.7E+02		400	Noncancer Risk
TRICHLOROETHANE, 1,1,1-	0.005	14a	0.83	100	100 Volatility	3.0E+03		100	Ceiling
TRICHLOROETHANE, 1,1,2-	0.005	14a		25	100 Volatility	2.5E+01	2.28	2	Cancer Risk
TRICHLOROETHYLENE	0.005	14a	0.01	77	100 Volatility	6.7E+01	79.74	70	Noncancer Risk
TRICHLOROPHENOL, 2,4,5-	0.66	14c			1000 Non-Odor	1.9E+03		1000	Ceiling
TRICHLOROPHENOL 2,4,6-	0.66	14c			1000 Non-Odor		39.39	40	Cancer Risk
VINYL CHLORIDE	0.01	14a	0.86	2580	100 Volatility	3.4E+01	0.29	0.3	Cancer Risk
XYLENES (Mixed Isomers)	0.005	14a	60.00	6	500 Odor-2	6.1E+04		500	Ceiling
ZINC	0.4	14d			1000 Non-Odor	1.6E+04		2500	* Sludge Stnd

Archived Document

5.1.5 Soil Category S - 2

The Soil Category S-2 standards are based upon a an exposure scenario in which the potential receptor may come into contact with the contaminated soil in a work environment or in a passive recreational setting.

For both cancer and non-cancer health effects, the receptor of concern is worker (age 18 - 45 years) who comes into contact with soil as part of their employment. This evaluation considered passive recreational exposures to children and found that, given the exposure assumptions employed, the worker scenario described here is protective of those exposures.

FREQUENCY OF EXPOSURE:

* **The adult worker is not assumed to come into contact with the soil during the winter months (November through March) due to weather conditions (particularly frozen ground).**

* **During spring and summer months, the worker is assumed to come into contact with the material on a daily basis as part of their employment (5 days/week), less 30 additional days to account for alternative activities not involving the soil, vacations and inclement weather.**

INTENSITY OF EXPOSURE:

* **Adults (age 18 to 45 years) are assumed to ingest 50 mg of soil per day exposed.**

* **It is assumed that the hands, forearms, lower legs and feet of the receptor are exposed to the soil.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

The derivations of the Category S-2 soil ingestion and soil contact rates are given in Appendix B. Table 5.3 lists the S-2 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-2 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-2 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

Archived Document

TABLE 5.3

TABLE 5-3

METHOD 2 DIRECT CONTACT S-2 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Mhod 2, Direct Contact OIL S-2 STANDARD 10 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			2500 Non-Odor	3.6E+03		2500	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	2500 Non-Odor	2.7E+03		2500	Ceiling
ACETONE		0.1	14a	20.77	270	1000 Odor-2	1.1E+04		1000	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	2500 Non-Odor	1.5E+00	0.04	0.04	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	2500 Non-Odor	1.3E+04		2500	Ceiling
ANTIMONY		6.4	14d			2500 Non-Odor	4.4E+01		40	Noncancer Risk
ARSENIC	32	10.6	14d			2500 Non-Odor	8.0E+01	2.08	30	Background
BENZENE		0.005	14a	63.33	95	1000 Odor-2	6.6E+02	62.88	60	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	2500 Non-Odor	2.7E+03		2500	Ceiling
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
BERYLLIUM		0.06	14d			2500 Non-Odor	1.3E+03	0.85	0.8	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			2500 Non-Odor	6.6E+03		2500	Ceiling
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	1000 Odor-2		0.16	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	1000 Odor-2	5.2E+02	2.56	3	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			2500 Non-Odor	6.7E+03	325.27	300	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	500 Volatility	2.2E+03	24.51	20	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	1000 Odor-2	2.0E+03	192.37	200	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	1000 Odor-2	1.5E+02		200	Noncancer Risk
CADMIUM		0.8	14d			2500 Non-Odor	8.3E+01		80	Noncancer Risk
CARBON TETRACHLORIDE		0.005	14a	11.30	113	1000 Odor-2	7.7E+01	11.69	10	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	2500 Non-Odor	1.1E+01	2.00	2	Cancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	2500 Non-Odor	4.4E+02		400	Noncancer Risk
CHLOROBENZENE		0.005	14c	53.64	11.8	1000 Odor-2	2.2E+03		1000	Ceiling
CHLOROFORM		0.005	14a	1.88	160	1000 Odor-2	1.1E+03	249.14	200	Cancer Risk
CHLOROPHENOL, 2-		0.66	14c			2500 Non-Odor	2.4E+02		200	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	2500 Non-Odor	2.2E+05		2500	Ceiling
CHROMIUM(VI)	105		14h		NA	2500 Non-Odor	6.0E+02		600	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
CYANIDE		1	16	1068.97	620	500 Odor-1	8.2E+02		100	Noncancer Risk *
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	2500 Non-Odor	5.4E+03	0.23	0.7	PQL
DIBROMOCHLOROMETHANE		0.005	14a		76	500 Volatility	2.2E+03	18.09	20	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	500 Volatility	9.9E+03		500	Ceiling
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	500 Volatility(o-C	9.9E+03		500	Ceiling(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	1000 Odor-2		63.32	60	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	2500 Non-Odor		0.72	1	PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD D		0.00737	14b		1.00E-06	2500 Non-Odor		3.45	3	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD		0.00268	14b		6.50E-06	2500 Non-Odor		2.44	2	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT		0.00804	14b		1.50E-07	2500 Non-Odor	3.0E+01	2.44	2	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	500 Volatility	8.5E+03		500	Ceiling
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	1000 Odor-2	2.2E+03	16.70	20	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	1000 Odor-2	9.9E+02	2.48	2	Cancer Risk

TABLE 5-3

METHOD 2 DIRECT CONTACT
S-2 DERIVATION
310 CMR 40.0985(6)

OIL AND/OR HAZARDOUS MATERIAL	BACKGROUND mg/kg	SOIL PQL REF mg/kg	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact OIL S-2 STANDARD 10 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.00514a		202	500 Volatility	1.1E+03		500	Ceiling
DICHLOROETHYLENE, TRANS-1,2-		0.00514a	19.47	331	1000 Odor-2	2.2E+03		1000	Ceiling
DICHLOROPHENOL, 2,4-		0.6614c	0.32	6.70E-02	2500 Non-Odor	9.4E+01		90	Noncancer Risk
DICHLOROPROPANE, 1,2-		0.00514a	168.00	42	500 Odor-1		12.19	10	Cancer Risk
DICHLOROPROPENE, 1,3-		0.00514a	43.00	43	1000 Odor-2	1.8E+01	4.61	5	Cancer Risk
DIELDRIN		0.0013414b		1.80E-07	2500 Non-Odor	2.4E+00	0.04	0.04	Cancer Risk
DIETHYL PHTHALATE		0.6614c			2500 Non-Odor	2.7E+05		2500	Ceiling
DIMETHYL PHTHALATE		0.6614c			2500 Non-Odor	1.5E+05		2500	Ceiling
DIMETHYLPHENOL, 2,4-		0.6614c			2500 Non-Odor	9.4E+02		900	Noncancer Risk
DINITROPHENOL, 2,4-		3.314c		NA	2500 Non-Odor	9.4E+01		90	Noncancer Risk
DINITROTOLUENE, 2,4-		0.6614c		5.10E-03	2500 Non-Odor	1.8E+02	1.79	2	Cancer Risk
DIOXIN		1.0E-06 19		7.40E-10	2500 Non-Odor		0.00	6E-06	Cancer Risk
ENDOSULFAN		0.0093814b		1.00E-05	2500 Non-Odor	3.0E+00		3	Noncancer Risk
ENDRIN		0.0040214b		2.00E-07	2500 Non-Odor	1.5E+01		10	Noncancer Risk
ETHYLBENZENE		0.00514a	4.35	10	1000 Odor-2	6.0E+03		1000	Ceiling
ETHYLENE DIBROMIDE		0.00514a	0.46	12	500 Volatility	2.2E+00	0.02	0.02	Cancer Risk
FLUORANTHENE		0.6614c		5.00E-06	2500 Non-Odor	2.4E+03		2000	Noncancer Risk
FLUORENE		0.6614c			2500 Non-Odor	2.4E+03		2000	Noncancer Risk
HEPTACHLOR		0.0020114b	0.02	3.00E-04	2500 Non-Odor	3.0E+01	0.18	0.2	Cancer Risk
HEPTACHLOR EPOXIDE		0.0556114b	1.37E-04	2.60E-06	2500 Non-Odor	7.8E-01	0.09	0.09	Cancer Risk
HEXACHLOROBENZENE		0.6614c		1.09E-05	2500 Non-Odor	7.1E+01	0.76	0.8	Cancer Risk
HEXACHLOROBUTADIENE		0.6614c	1.17E-03	1.50E-01	2500 Non-Odor	1.2E+02	10.63	10	Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH		0.0026814b		9.40E-06	2500 Non-Odor	1.8E+01	0.64	0.6	Cancer Risk
HEXACHLOROETHANE		0.6614b		4.00E-01	2500 Non-Odor	1.3E+01	12.78	10	Cancer Risk
INDENO(1,2,3-cd)PYRENE		0.6614c		1.00E-09	2500 Non-Odor	2.7E+03	0.11	0.7	PQL
LEAD		8.414d			2500 Non-Odor	6.4E+02		600	Noncancer Risk
MERCURY		0.114i		1.20E-03	2500 Non-Odor	5.7E+01		60	Noncancer Risk
METHOXYCHLOR		0.1179214b		1.40E-06	2500 Non-Odor	3.0E+02		300	Noncancer Risk
METHYL ETHYL KETONE		0.114a	9.09	100	1000 Odor-2	6.6E+04		1000	Ceiling
METHYL ISOBUTYL KETONE		0.0514a	100.00	10	500 Odor-1	5.5E+03		500	Ceiling
METHYL MERCURY					2500 Non-Odor	1 .8E+01		20	Noncancer Risk
METHYL TERT BUTYL ETHER		0.0514f		245	500 Volatility	5.7E+02		500	Ceiling
METHYLENE CHLORIDE		0.00514a	2.68	429	1000 Odor-2	6.6E+03	202.63	200	Cancer Risk
METHYLNAPHTHALENE, 2-		0.6614c			2500 Non-Odor	4.4E+03		2500	Ceiling
NAPHTHALENE		0.6614c	0.98	8.20E-02	2500 Non-Odor	4.4E+03		2500	Ceiling
NICKEL		314d			2500 Non-Odor	7.1E+02		700	Noncancer Risk
PENTACHLOROPHENOL		3.314c		1.10E-04	2500 Non-Odor	3.1E+03	11.69	10	Cancer Risk
PHENANTHRENE		0.6614c	2.40E-03	9.60E-04	2500 Non-Odor	2.7E+03		2500	Ceiling
PHENOL		0.6614c	8.75	3.50E-01	1000 Odor-2	2.8E+04		1000	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.0435514b		NA	2500 Non-Odor	7.9E-01	0.3	2 *	Sludge Stnd
PYRENE		0.6614c		2.50E-06	2500 Non-Odor	1.8E+03		2000	Noncancer Risk
SELENIUM		1514d		NA	2500 Non-Odor	3.1E+03		2500	Ceiling
SILVER		1.414d			2500 Non-Odor	2.4E+02		200	Noncancer Risk
STYRENE		0.00514a	16.67	5	1000 Odor-2	1.2E+04	27.64	30	Cancer Risk

Archive Copy

TABLE 5-3

METHOD 2 DIRECT CONTACT S-2 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Risk-Based Concen. 0.2 mg/kg	CancerMhod 2, Direct Contact Risk-Based Concen. 1E-06 mg/kg	OIL S-2 STANDARD 10 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-		0.005	14a		10	500 Volatility	2.8E+02	4.94	5	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-		0.005	14a	2.67	4	1000 Odor-2		0.64	0.6	Cancer Risk
TETRACHLOROETHYLENE		0.005	14a	4.06	19	1000 Odor-2	1.1E+03	292.26	300	Cancer Risk
THALLIUM		8	14d			2500 Non-Odor	3.2E+01		30	Noncancer Risk
TOLUENE		0.005	14a	3.50	28	1000 Odor-2	1.9E+04		1000	Ceiling
TOTAL PETROLEUM HYDROCARBONS						2500 Non-Odor			2500*	Default
TRICHLOROBENZENE, 1,2,4-		0.66	14c			2500 Non-Odor	1.3E+03		1000	Noncancer Risk
TRICHLOROETHANE, 1,1,1-		0.005	14a	0.83	100	500 Volatility	9.9E+03		500	Ceiling
TRICHLOROETHANE, 1,1,2-		0.005	14a		25	500 Volatility	5.2E+01	3.14	3	Cancer Risk
TRICHLOROETHYLENE		0.005	14a	0.01	77	500 Volatility	2.2E+02	138.16	100	Cancer Risk
TRICHLOROPHENOL, 2,4,5-		0.66	14c			2500 Non-Odor	4.7E+03		2500	Ceiling
TRICHLOROPHENOL 2,4,6-		0.66	14c			2500 Non-Odor		59.23	60	Cancer Risk
VINYL CHLORIDE		0.01	14a	0.86	2580	500 Volatility	1.1E+02	0.50	0.5	Cancer Risk
XYLENES (Mixed Isomers)		0.005	14a	60.00	6	1000 Odor-2	1.9E+05		1000	Ceiling
ZINC	110	0.4	14d			2500 Non-Odor	1.0E+05		2500	Ceiling

Archived Document

5.1.6 Soil Category S - 3

The Soil Category S-3 standards are based upon a an exposure scenario in which the potential receptor may come into contact with the contaminated soil during a short but intense exposure, such as excavation work.

For non-cancer effects, it is assumed that the exposure occurs over a period of 3 months, but for carcinogenic effects it was felt that such a short exposure duration was beyond the limits of the cancer risk model to estimate risks. As a result, a 7 year exposure was used to evaluate potential cancer risk to the excavation/construction worker.

FREQUENCY OF EXPOSURE:

* **The adult worker is not assumed to come into contact with the soil during the winter months (November through March) due to weather conditions (particularly frozen ground).**

* **For non-cancer effects, the worker is assumed to come into contact with the material on a daily basis during the summer (5 days/week) as part of continuous excavation or construction work. The exposure is assumed to occur during the 92 days of June, July and August.**

* **For cancer risk-based concentrations, the worker is assumed to be exposed in a manner similar to the worker described for the S-2 standards (5 days/week during the spring and summer months) but for only 7 years duration.**

INTENSITY OF EXPOSURE:

* **Adults (age 18 to 45 years) are assumed to ingest 50 mg of soil per day exposed.**

* **It is assumed that the hands, forearms, lower legs and feet of the child (1 to 18 years) are exposed to the soil.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

Archived Document

The derivation of the S-3 soil ingestion and soil contact rates are given in Appendix C. The 3 month exposures calculated for the non-cancer risk-based concentrations are considered to be "subchronic" in nature, and the subchronic Reference Dose was used in the standard development process, when available. When the subchronic RfD was not available, the chronic RfD was used in its place, an assumption which is conservative (health protective) in nature. As a result of this necessary, conservative practice, an inconsistency developed where concentrations derived for the subchronic S-3 exposure were less than (approximately a factor of 2) the allowable chronic exposure identified for the S-2 standards. (In other words, you could work in the soil for 27 years, but you couldn't spend 3 months working in it.) In these limited number of cases, the S-3 standard was set equal to the S-2 standard.

Table 5.4 lists the S-3 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-3 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-3 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

Archived Document

TABLE 5.4

TABLE 5-4

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	hod 2, Direct Contact OIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			5000 Non-Odor	1.7E+04		5000	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	5000 Non-Odor	1.2E+03		2500	from S-2
ACETONE		0.1	14a	20.77	270	2500 Odor-2	5.2E+04		2500	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	5000 Non-Odor	6.9E-01	0.15	0.1	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	5000 Non-Odor	6.0E+04		5000	Ceiling
ANTIMONY		6.4	14d			5000 Non-Odor	2.1E+01		40	from S-2
ARSENIC	32	10.6	14d			5000 Non-Odor	3.7E+01	7.72	30	Background
BENZENE		0.005	14a	63.33	95	2500 Odor-2	3.1E+03	231.43	200	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	5000 Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	5000 Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	5000 Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	5000 Non-Odor	1.2E+03		2500	from S-2
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	5000 Non-Odor	1.2E+03	0.42	0.7	PQL
BERYLLIUM		0.06	14d			5000 Non-Odor	6.2E+02	3.14	3	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			5000 Non-Odor	3.1E+03		3000	Noncancer Risk
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	2500 Odor-2		0.59	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	2500 Odor-2	2.4E+02	9.34	9	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			5000 Non-Odor	3.1E+03	1210.65	1000	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	500 Volatility	1.0E+03	90.11	90	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	2500 Odor-2	9.5E+03	707.16	700	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	2500 Odor-2	7.2E+02		700	Noncancer Risk
CADMIUM		0.8	14d			5000 Non-Odor	1.9E+01		80	from S-2
CARBON TETRACHLORIDE		0.005	14a	11.30	113	2500 Odor-2	3.6E+02	42.97	40	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	5000 Non-Odor	5.3E+00	7.40	5	Noncancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	5000 Non-Odor	2.1E+02		400	from S-2
CHLOROBENZENE		0.005	14c	53.64	11.8	2500 Odor-2	1.0E+04		2500	Ceiling
CHLOROFORM		0.005	14a	1.88	160	2500 Odor-2	5.2E+02	915.83	500	Noncancer Risk
CHLOROPHENOL, 2-		0.66	14c			5000 Non-Odor	1.1E+03		1000	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	5000 Non-Odor	1.0E+05		5000	Ceiling
CHROMIUM(VI)	105		14h		NA	5000 Non-Odor	1.1E+03		1000	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	5000 Non-Odor	1.2E+03	0.42	0.7	PQL
CYANIDE		1	16	1068.97	620	1000 Odor-1	3.9E+02		400	Noncancer Risk
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	5000 Non-Odor	2.5E+03	0.84	0.8	Cancer Risk
DIBROMOCHLOROMETHANE		0.005	14a		76	500 Volatility	1.0E+04	66.51	70	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	500 Volatility	4.6E+04		500	from S-2
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	500 Volatility(o-DC	4.6E+04		500	from S-2(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	2500 Odor-2	4.6E+04	232.77	200	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	5000 Non-Odor		2.65	3	Cancer Risk
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DD D		0.00737	14b		1 .00E-06	5000 Non-Odor		12.66	10	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD		0.00268	14b		6.50E-06	5000 Non-Odor		8.94	9	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT		0.00804	14b		1.50E-07	5000 Non-Odor	1.4E+01	8.94	9	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	500 Volatility	4.0E+04		500	from S-2
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	2500 Odor-2	1.0E+04	61.39	60	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	2500 Odor-2	4.6E+02	9.13	9	Cancer Risk

Archived Document

TABLE 5-4

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	hod 2, Direct Contact OIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.005	14a		202	500 Volatility	5.2E+03			500 from S-2
DICHLOROETHYLENE, TRANS-1,2-		0.005	14a	19.47	331	2500 Odor-2	1.0E+04		2500	Ceiling
DICHLOROPHENOL, 2,4-		0.66	14c	0.32	6.70E-02	5000 Non-Odor	4.4E+01			90 from S-2
DICHLOROPROPANE, 1,2-		0.005	14a	168.00	42	1000 Odor-1		44.70		40 Cancer Risk
DICHLOROPROPENE, 1,3-		0.005	14a	43.00	43	2500 Odor-2	8.4E+01	16.89		20 Cancer Risk
DIELDRIN		0.00134	14b		1.80E-07	5000 Non-Odor	1.1E+00	0.15		0.2 Cancer Risk
DIETHYL PHTHALATE		0.66	14c			5000 Non-Odor	1.3E+06		5000	Ceiling
DIMETHYL PHTHALATE		0.66	14c			5000 Non-Odor	6.9E+04		5000	Ceiling
DIMETHYLPHENOL, 2,4-		0.66	14c			5000 Non-Odor	4.4E+03		4000	Noncancer Risk
DINITROPHENOL, 2,4-		3.3	14c		NA	5000 Non-Odor	4.4E+01			90 from S-2
DINITROTOLUENE, 2,4-		0.66	14c		5.10E-03	5000 Non-Odor	8.2E+01	6.57		7 Cancer Risk
DIOXIN		1.0E-06	19		7.40E-10	5000 Non-Odor		0.00	2E-05	Cancer Risk
ENDOSULFAN		0.00938	14b		1.00E-05	5000 Non-Odor	5.6E+00			6 Noncancer Risk
ENDRIN		0.00402	14b		2.00E-07	5000 Non-Odor	6.9E+00			10 from S-2
ETHYLBENZENE		0.005	14a	4.35	10	2500 Odor-2	2.8E+04		2500	Ceiling
ETHYLENE DIBROMIDE		0.005	14a	0.46	12	500 Volatility	1.0E+01	0.07	0.07	Cancer Risk
FLUORANTHENE	0.5	0.66	14c		5.00E-06	5000 Non-Odor	1.1E+04		5000	Ceiling
FLUORENE	0.5	0.66	14c			5000 Non-Odor	1.1E+04		5000	Ceiling
HEPTACHLOR		0.00201	14b	0.02	3.00E-04	5000 Non-Odor	1.4E+01	0.68	0.7	Cancer Risk
HEPTACHLOR EPOXIDE		0.05561	14b	1.37E-04	2.60E-06	5000 Non-Odor	3.6E-01	0.33		0.3 Cancer Risk
HEXACHLOROBENZENE		0.66	14c		1.09E-05	5000 Non-Odor	3.3E+01	2.79		3 Cancer Risk
HEXACHLOROBUTADIENE		0.66	14c	1.17E-03	1.50E-01	5000 Non-Odor	5.6E+01	38.97		40 Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH		0.00268	14b		9.40E-06	5000 Non-Odor	8.4E+01	2.34		2 Cancer Risk
HEXACHLOROETHANE		0.66	14b		4.00E-01	5000 Non-Odor	6.0E+01	46.72		50 Cancer Risk
INDENO(1,2,3-cd)PYRENE	0.5	0.66	14c		1.00E-09	5000 Non-Odor	1.2E+03	0.42		0.7 PQL
LEAD	69	8.4	14d			5000 Non-Odor	2.9E+02			600 from S-2
MERCURY	1	0.1	14f		1.20E-03	5000 Non-Odor	2.7E+01			60 from S-2
METHOXYCHLOR		0.11792	14b		1.40E-06	5000 Non-Odor	1.4E+02			300 from S-2
METHYL ETHYL KETONE		0.1	14a	9.09	100	2500 Odor-2	2.6E+04		2500	Ceiling
METHYL ISOBUTYL KETONE		0.05	14a	100.00	10	1000 Odor-1	2.6E+04		1000	Ceiling
METHYL MERCURY						5000 Non-Odor	8.4E+00			20 from S-2
METHYL TERT BUTYL ETHER		0.05	14f		245	500 Volatility	2.7E+03			500 from S-2
METHYLENE CHLORIDE		0.005	14a	2.68	429	2500 Odor-2	3.1E+03	744.88	700	Cancer Risk
METHYLNAPHTHALENE, 2-	0.5	0.66	14c			5000 Non-Odor	2.1E+03			2500 from S-2
NAPHTHALENE	0.5	0.66	14c	0.98	8.20E-02	5000 Non-Odor	2.1E+03			2500 from S-2
NICKEL	30	3	14d			5000 Non-Odor	3.3E+02			700 from S-2
PENTACHLOROPHENOL		3.3	14c		1.10E-04	5000 Non-Odor	1.4E+03	42.96		40 Cancer Risk
PHENANTHRENE	0.5	0.66	14c	2.40E-03	9.60E-04	5000 Non-Odor	1.2E+03			2500 from S-2
PHENOL		0.66	14c	8.75	3.50E-01	2500 Odor-2	1.3E+04		2500	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.04355	14b		NA	5000 Non-Odor	3.7E-01	1.0	2	Sludge Stnd
PYRENE	0.5	0.66	14c		2.50E-06	5000 Non-Odor	8.4E+03		5000	Ceiling
SELENIUM		15	14d		NA	5000 Non-Odor	1.4E+03			2500 from S-2
SILVER		1.4	14d			5000 Non-Odor	1.1E+02			200 from S-2
STYRENE		0.005	14a	16.67	5	2500 Odor-2	5.6E+04	101.32	100	Cancer Risk

Archived Document

TABLE 5-4

Table 5.4, continued...

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND Mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	thod 2, Direct Contact OIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-		0.005	14a		10	500 Volatility	1.3E+02	18.07	20	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-		0.005	14a	2.67	4	2500 Odor-2		2.35	2	Cancer Risk
TETRACHLOROETHYLENE		0.005	14a	4.06	19	2500 Odor-2	5.2E+03	1074.34	1000	Cancer Risk
THALLIUM		8	14d			5000 Non-Odor	1.5E+02		100	Noncancer Risk
TOLUENE		0.005	14a	3.50	28	2500 Odor-2	8.8E+04		2500	Ceiling
TOTAL PETROLEUM HYDROCARBONS						5000 Non-Odor			5000	* Default
TRICHLOROBENZENE, 1,2,4-		0.66	14c			5000 Non-Odor	6.2E+02		1000	from S-2
TRICHLOROETHANE, 1,1,1-		0.005	14a	0.83	100	500 Volatility	4.6E+04		500	from S-2
TRICHLOROETHANE, 1,1,2-		0.005	14a		25	500 Volatility	2.4E+02	11.47	10	Cancer Risk
TRICHLOROETHYLENE		0.005	14a	0.01	77	500 Volatility	1.0E+03	507.87	500	Ceiling
TRICHLOROPHENOL, 2,4,5-		0.66	14c			5000 Non-Odor	2.2E+04		5000	Ceiling
TRICHLOROPHENOL 2,4,6-		0.66	14c			5000 Non-Odor		216.97	200	Cancer Risk
VINYL CHLORIDE		0.01	14a	0.86	2580	500Volatility	5.2E+01	1.85	2	Cancer Risk
XYLENES (Mixed Isomers)		0.005	14a	60.00	6	2500 Odor-2	1.8E+05		2500	Ceiling
ZINC	110	0.4	14d			5000 Non-Odor	4.7E+04		5000	Ceiling

Archived Document

5.2 SOIL LEACHING TO GROUNDWATER

The MCP Method 1 Soil Standards are not based solely upon human health risk associated with direct contact exposures to the soil. Consideration is also being given to the potential for a chemical to leach from the soil and contaminate the underlying aquifer. It was the intent of the Department to promulgate soil standards which will not result in significant impacts to the groundwater. Such a philosophy is consistent with the definition of a permanent solution in the MCP.

The soil-to-groundwater migration is dependent upon a large number of factors, including: soil concentration of the contaminant, the mass and volume of contamination and its vertical location in the soil, groundwater flow, the precipitation which percolated through the contaminated soil, biodegradation, volatilization, physical characteristics of the soil, meteorological conditions, and physical characteristics of the chemical (including partitioning coefficients, solubility, etc...).

There are numerous soil leaching models available which consider these factors to establish a concentration of a chemical in soil protective of a specified groundwater concentration. These models vary in sophistication, and in some cases generalizations have been made simplify the approach. **The Department has employed the *SESOIL* model to develop such concentrations.** Appendix F describes the use of the *SESOIL* model to develop the dilution/attenuation factors used in this section.

By necessity the sophisticated models are dependent upon the parameters chosen to describe the "typical site" which is entered into the model. The analysis conducted by the Department makes such assumptions, with the understanding that site-specific soil-leaching models may be used using Risk Characterization Method 2 or 3.

5.2.1 Leaching Equations

The leaching-based soil concentrations are calculated using the equations

$$DAF_{OHM} = (6207 \times H_{OHM}) + (0.166 \times KOC_{OHM}) \qquad \textbf{(11)}$$

and

$$[OHM]_{soil} = DAF_{OHM} \times [OHM]_{gw} \times C \qquad \textbf{(12)}$$

Where:

DAF_{ohm} = The Dilution/Attenuation Factor calculated for the oil or hazardous material
H_{ohm} = The Henry's Law Constant for the oil or hazardous material, in units of atm-m^3/mol
Koc_{ohm} = The organic carbon partition coefficient for the oil or hazardous material, in units: ml/g
$[OHM]_{soil}$ = The leaching-based soil concentration, in units: mg/kg.
$[OHM]_{gw}$ = The target groundwater concentration of the oil or hazardous material. In units of µg/liter.
C = Units Conversion factor, 0.001 mg/µg.

The coefficients used to calculated the Dilution/Attenuation Factor are developed in Appendix F. The target groundwater concentrations used are the MCP Method 1 Groundwater Standards GW1, GW-2 and GW-3. Thus for a given oil or hazardous material, leaching-based concentrations were developed for nine combinations of soil:groundwater categories. These combinations are shown in Figure 5-3.

Archived Document

FIGURE 5-3
Combinations of Soil:Groundwater Leaching-Based Standards

[redacted]

5.2.2. Derivation of Leaching-Based Standards

Figure 5-2 described the general methodology for the consideration of the leaching-based concentrations in the development of the Method 1 standards. The leaching-based concentrations are compared to the risk-based concentrations calculated for each exposure scenario, and the lowest of these values is carried through the standard development process (see methodology, Section 5.1.1).

Table 5.5 contains the leaching-based soil concentrations for each of the target groundwater concentrations (by Groundwater Category) and the MCP Method 1 Soil Standards for each combination of soil and groundwater category. It is clear that for many compounds, the most sensitive factor in the development of Method 1 Standards is the potential for leaching to groundwater.

5.3 UPPER CONCENTRATION LIMITS

The Upper Concentration Limits (UCLs) in Soil (310 CMR 40.0996(4)) are applicable when risk characterization or Method 3 is used to evaluate the potential risk of harm to health, public welfare and the environment. ***The Upper Concentration Limits (UCLs) are not used in risk characterization Methods 1*** as sites meeting the Method 1 Standards meet the Upper Concentration Limits, by definition.

The categorization scheme devised to determine the "current and foreseeable use(s)" of the soil essentially clarifies why the Department is concerned about contamination in soil and related human and/or ecological impacts.

Our ability to comprehensively describe (qualitatively or quantitatively) potential impacts is limited, however, particularly impacts which may only become evident in the future. The MCP defines areas of particular interest based upon human exposure potential and allows some flexibility to establish alternative cleanup requirements using risk assessment in Methods 2 and 3. The Upper Concentration Limits identify contamination which may pose a significant risk of harm to public welfare and the environment in the future, and to minimize the incremental contributions to anthropogenic background. The Department does not endorse the general degradation of the soil.

The revised MCP contains several features intended to provide protection to all soil, including: (a)

the requirement to use the best remedial action management approaches (BRAMA) to characterize a site (310 CMR 40.019 1); (b) the requirement to eliminate all continuing sources of release to the environment (310 CMR 40.1003(5)); and (c) the list of Upper Concentration Limits applicable to all soil as public welfare environmental resource standards (310 CMR 40.0994(3) and 310 CMR 40.0995(5)).

A disposal site may qualify for a Class C Response Action Outcome (RAO), even if the concentrations of oil or hazardous material remaining at the disposal site exceed the Upper Concentration Limits. An exceedance of these standards is interpreted to indicate significant risk of harm to public welfare and/or environmental resources in the future, and thus a Class C RAO may be appropriate if, for current conditions, a condition of no significant risk of harm to health, safety, public welfare and the environment exists or has been achieved.

The UCLs are simply 10 fold multiple of the highest exposure-related (S-1, S-2 or S-3) standard, capped at a maximum concentration of 10,000 µg/gram, or 1 %. The Upper Concentration Limits in Soil are listed in Table 1.1.

5.4 EXAMPLE 2

The multiple soil/groundwater combinations result in a somewhat complex system where the applicability of a given standard is dependent upon may factors. Figure 5-4 provides a second example (Figure 1-2 contains the first) of how the Method 1 soil and groundwater standards would be applied to a hypothetical disposal site.

Archived Document

TABLE 5.5

TABLE 5-5

METHOD 1 SOIL STANDARDS

OIL AND/OR HAZARDOUS MATERIAL	LEACHING-BASED SOIL CONCENTRATIONS For Target Ground-water Categories GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	Method 1 S-1 Soil Standards NOT ROUNDED S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	Method 1 S-2 Soil Standards NOT ROUNDED S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	Method 1 S-3 Soil Standards NOT ROUNDED S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
ACENAPHTHENE	15		1530	15	1000	1000	15	2500	1530	15	5000	1530
ACENAPHTHYLENE	127		848	100	100	100	127	2500	848	127	2500	848
ACETONE	3	58	58	3	58	58	3	58	58	3	58	58
ALDRIN	4	4	73	0.03	0.03	0.03	0.04	0.04	0.04	0.15	0.146	0.146
ANTHRACENE	1395		1395	1000	1000	1000	1395	2500	1395	1395	5000	1395
ANTIMONY				10	10	10	40	40	40	40	40	40
ARSENIC				30	30	30	30	30	30	30	30	30
BENZENE	10	96	335	0.2	30	30	0.24	60	60	0	96	200
BENZO(a)ANTHRACENE	7		166	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(a)PYRENE	183		1826	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	18		639	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(g,h,i)PERYLENE	133		27	133	1000	27	133	2500	27	133	2500	27
BENZO(k)FLUORANTHENE	18		37	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BERYLLIUM				0.40	0.40	0.40	0.8	0.8	0.8	3	3	3
BIPHENYL, 1,1-	1.0		10	1.0	1000	10	1.0	2500	10	1.0	3000	10
BIS(2-CHLOROETHYL)ETHER	0.07	0.2	109	0.66	0.66	0.70	0.66	0.66	0.66	0.66	0.66	0.66
BIS(2-CHLOROISOPROPYL)ETHER	0.3	4	541	0.66	2	2	0.66	3	3	0.66	4	9
BIS(2-ETHYLHEXYL)PHTHALATE	100	11620	498	100	100	100	100	300	300	100	1000	498
BROMODICHLOROMETHANE	0.1		1182	0.12	10	10	0.12	20	20	0.12	90	90
BROMOFORM	0.1	18	1118	0.11	18	100	0.11	18	200	0.11	18	700
BROMOMETHANE	12	3	61188	12	3	50	12	3	200	12	3	700
CADMIUM				30	30	30	80	80	80	80	80	80
CARBON TETRACHLORIDE	1.0	4	10003	1.0	4	7	1.0	4	10	1.0	4	40
CHLORDANE	36		14	1.0	1.0	1.0	2	2	2	5	5	5
CHLOROANILINE, p-	0.02		26	1.3	100	26	1.3	400	26	1.3	400	26
CHLOROBENZENE	8	79	40	8	79	40	8	79	40	8	79	40
CHLOROFORM	0.1	10	262	0.13	10	100	0.13	10	200	0.13	10	262
CHLOROPHENOL, 2-	0.006		23	0.7	100	23	0.7	200	23	0.7	1000	23
CHROMIUM (TOTAL)												
CHROMIUM (III)				1000	1000	1000	2500	2500	2500	5000	5000	5000
CHROMIUM (VI)				200	200	200	600	600	600	1000	1000	1000
CHRYSENE	7		100	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
CYANIDE	2E+06		117933	100	100	100	100	100	100	400	400	400
DIBENZO(a,h)ANTHRACENE	110		164	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
DIBROMOCHLOROMETHANE	0.09		933	0.09	10	10	0.09	20	20	0.09	70	70
DICHLOROBENZENE, 1,2- (o-DCB)	177	2942	2354	100	100	100	177	500	500	177	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	179	2985	2388	100	100	100	179	500	500	179	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	2	9569	2552	2	40	40	2	60	60	2	200	200
DICHLOROBENZIDINE, 3,3'-	21		516	1.0	1.0	1.0	1.3	1.3	1.3	3	3	3
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (D D 1 9			773	2	2	2	3	3	3	10	10	10
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DD75 14492				2	2	2	2	2	2	9	9	9
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (D T	12		12	2	2	2	2	2	2	9	9	9
DICHLOROETHANE, 1,1-	3	390	2169	3	100	100	3	390	500	3	390	500
DICHLOROETHANE, 1,2-	0.05	0.2	456	0.05	0.18	10	0.05	0.18	20	0.05	0.18	60

Archived Document

Table 5.5, continued...

TABLE 5-5 METHOD 1 SOIL STANDARDS	LEACHING-BASED SOIL CONCENTRATIONS For Target Groundwater Categories			S-1 Soil Standards NOT ROUNDED		Method 1	S - 2 N O T	Method 1 Soil Standards ROUNDED		Method 1 S-3 Soil Standards NOT ROUNDED		
OIL AND/OR HAZARDOUS MATERIAL	GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
DICHLOROETHYLENE, 1,1-	0.7	0.1	5160	0.7	0.10	1.0	0.7	0.10	2	0.7	0.10	9
DICHLOROETHYLENE, CIS-1,2-	2		1673	2	100	100	2	500	500	2	500	500
DICHLOROETHYLENE, TRANS-1,2-	4		2058	4	500	500	4	1000	1000	4	2500	2058
DICHLOROPHENOL, 2,4-	10		4001	10	40	40	10	90	90	10	90	90
DICHLOROPROPANE, 1,2-	0.1	0.2	758	0.13	0.23	8	0.13	0.23	10	0.13	0.23	40
DICHLOROPROPENE, 1,3-	0.01	0.1	52	0.01	0.13	3	0.01	0.13	5	0.01	0.13	20
DIELDRIN	0.1		0.1	0.03	0.03	0.03	0.04	0.04	0.04	0.12	0.15	0.12
DIETHYL PHTHALATE	141		0.7	141	1000	0.7	141	2500	0.7	141	5000	0.7
DIMETHYL PHTHALATE	26		0.02	26	1000	0.7	26	2500	0.7	26	5000	0.7
DIMETHYLPHENOL, 2,4-	0.06		12	0.7	400	12	0.7	900	12	0.7	4000	12
DINITROPHENOL, 2,4-	0.6		6	3	40	6	3	90	6	3	90	6
DINITROTOLUENE, 2,4-	0.2		15	0.7	1.0	1.0	0.7	2	2	0.7	7	7
DIOXIN	0.02		0.05	4E-06	4E-06	4E-06	6E-06	6E-06	6E-06	2E-05	2E-05	2E-05
ENDOSULFAN	0.2		0.05	0.18	1.0	0.05	0.18	3	0.05	0.18	6	0.05
ENDRIN	0.6		1.4	0.6	6	1.4	0.6	10	1.4	0.6	10	1.4
ETHYLBENZENE	82	3502	467	82	500	467	82	1000	467	82	2500	467
ETHYLENE DIBROMIDE	2E-04	0.04	574	0.005	0.010	0.010	0.01	0.02	0.02	0.01	0.04	0.07
FLUORANTHENE	631		631	631	900	631	631	2000	631	631	5000	631
FLUORENE	364		1213	364	900	900	364	2000	1213	364	5000	1213
HEPTACHLOR	1.5		4	0.10	0.10	0.10	0.18	0.18	0.18	0.7	0.7	0.7
HEPTACHLOR EPOXIDE	0.8		8	0.06	0.06	0.06	0.09	0.09	0.09	0.33	0.33	0.33
HEXACHLOROBENZENE	200		7983	0.7	0.7	0.7	0.8	0.8	0.8	3	3	3
HEXACHLOROBUTADIENE	3	3	448	3	3	7	3	3	10	3	3	40
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HC H	0.1		0.5	0.12	0.40	0.40	0.12	0.6	0.49	0.12	2	0.49
HEXACHLOROETHANE	27	34	16906	6	6	6	10	10	10	27	34	50
INDENO(1,2,3-cd)PYRENE	53		80	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LEAD				---	---	---	600	600	600	600	600	600
MERCURY							60	60	60	60	60	60
METHOXYCHLOR	527		26	100	100	26	300	300	26	300	300	26
METHYL ETHYL KETONE	0.3	38	38	0.27	38	38	0.27	38	38	0.27	38	38
METHYL ISOBUTYL KETONE	0.5	68	68	0.48	68	68	0.48	68	68	0.48	68	68
METHYL MERCURY							20	20	20	20	20	20
METHYL TERT BUTYL ETHER	3	209	209	3	100	100	3	209	209	3	209	209
METHYLENE CHLORIDE	0.1	1063	1063	0.11	100	100	0.11	200	200	0.11	700	700
METHYLNAPHTHALENE, 2-	0.02	23	7	0.7	23	7	0.7	23	7	0.7	23	7
NAPHTHALENE	4	1327	1327	4	100	100	4	1327	1327	4	1327	1327
NICKEL				---	---	---	700	700	700	700	700	700
PENTACHLOROPHENOL	5		420	5	7	7	5	10	10	5	40	40
PHENANTHRENE	697		116	697	1000	116	697	2500	116	697	2500	116
PHENOL	61	757	454	61	500	454	61	757	454	61	757	454
POLYCHLORINATED BIPHENYLS	44		26	2	2	2	2	2	2	2	2	2
PYRENE	505		505	505	700	505	505	2000	505	505	5000	505
SELENIUM				300	300	300	2500	2500	2500	2500	2500	2500
SILVER				100	100	100	200	200	200	200	200	200

Archived Document

Table 5.5, continued...

TABLE 5-5 METHOD 1 SOIL STANDARDS	LEACHING-BASED SOIL CONCENTRATIONS For Target Ground-water Categories			Method 1 S-1 Soil Standards NOT ROUNDED			Method 1 NOT ROUNDED			Method 1 S-3 Soil Standards NOT ROUNDED		
OIL AND/OR HAZARDOUS MATERIAL	GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
STYRENE	2	15	836	2	15	20	2	15	30	2	15	100
TETRACHLOROETHANE, 1,1,1,2-	0.4	0.5	3862	0.39	0.46	4	0.39	0.46	5	0.39	0.46	20
TETRACHLOROETHANE, 1,1,2,2-	0.02	0.2	199	0.02	0.20	0.5	0.02	0.20	0.6	0.02	0.20	2
TETRACHLOROETHYLENE	0.5	271	452	0.45	200	200	0.45	271	300	0.45	271	452
THALLIUM							30	30	30	100	100	100
TOLUENE	86	518	4314	86	500	500	86	518	1000	86	518	2500
TOTAL PETROLEUM HYDROCARBONS							2500	2500	2500	5000	5000	5000
TRICHLOROBENZENE, 1,2,4-	108	922	768	108	400	400	108	922	768	108	922	768
TRICHLOROETHANE, 1,1,1-	34	678	8472	34	100	100	34	500	500	34	500	500
TRICHLOROETHANE, 1,1,2-	0.3	1139	2847	0.28	2	2	0.28	3	3	0.28	10	10
TRICHLOROETHYLENE	0.4	23	1544	0.39	23	70	0.39	23	100	0.39	23	500
TRICHLOROPHENOL, 2,4,5-	3		2	3	1000	2	3	2500	2	3	5000	2
TRICHLOROPHENOL 2,4,6-	3	13281	3320	3	40	40	3	60	60	3	200	200
VINYL CHLORIDE	0.4	0.3	113	0.30	0.28	0.30	0.38	0.28	0.5	0.38	0.28	2
XYLENES	828	497	4142	500	497	500	828	497	1000	828	497	2500
ZINC				2500	2500	2500	2500	2500	2500	5000	5000	5000

Archived Document

FIGURE 5-4

EXAMPLE #2: ***Based on the criteria in the MCP, the groundwater at the disposal site is determined to be drinking water (Category GW-1) <u>and, like all groundwater,</u> has the potential to eventually discharge to surface water (Category GW-3). The soil of concern is the top foot of soil in the backyard of a suburban residential location, and has been categorized as S-1. For each oil or hazardous material, the applicable standards (shaded below) under MCP Method 1 would be both the GW-1 and GW-3 concentrations in groundwater (µg/liter, or ppb) and both the lower of the S-1/GW-1 and the S-1/GW-3 concentrations in soil (µg/gram, or ppm). [Another way to say this is that the <u>lower</u> of the applicable groundwater standards and the <u>lower</u> of the applicable soil standards would be used.] In the regulations, these standards are located on Tables 1 and 2, respectively.***

If the Groundwater Category is: GW-1 | GW-2 | GW-3

Table 1: 40.0974(2)

Then these Groundwater Standards apply AND the Soil Standards directly below them are potentially applicable: ->	GW-1 µg/liter	GW-2 µg/liter	GW-3 µg/liter

If the Soil Category is:	Then these Soil Standards are applicable, depending upon the Groundwater Category:		

Table 2: 40.0975(6)(a)

S-1	S-1/GW-1 µg/gram	S-1/GW-2 µg/gram	S-1/GW-3 µg/gram

Table 3: 40.0975(6)(b)

S-2	S-2/GW-1 µg/gram	S-2/GW-2 µg/gram	S-2/GW-3 µg/gram

Table 4: 40.0975(6)(c)

S-3	S-3/GW-1 µg/gram	S-3/GW-2 µg/gram	S-3/GW-3 µg/gram

6.0 REFERENCES

c.21E Massachusetts Oil and Hazardous Material Release Prevention and Control Act, Massachusetts General Law Chapter 21E.

Ershow & Cantor (1989) Total Water and Tapwater Intake In the United States: Population Base Estimates of Quantities and Sources, Ershow, A.G. and Cantor, K.P., Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, MD (1989).

Hawley (1985) Hawley, J.K. (1985) *Assessment of Health Risk from Exposure to Contaminated Soil,* **Risk Analysis** 5(4).

HEAST Health Effects Assessment Summary Tables, U.S. Environmental Protection, Office of Research and Development, Office of Emergency and Remedial Response, Washington D.C. Published annually and updated periodically.

IRIS Integrated Risk Information System, U.S. Environmental Protection Agency on-line database.

Johnson & Ettinger (1991) Johnson, P.C. and Ettinger, R.A. (1991) *Heuristic Model for Predicting the Intrusion Rate of Contaminated Vapors into Buildings,* **Environmental Science and Technology** 25:1445-1452.

LaGoy (1987) LaGoy, P.K. (1987) *Estimated Soil Ingestion Rates for Use in Risk Assessment,* **Risk Analysis** 7(3).

Little (1992) Little, J.C., Daisey, J.M., and Nazaroff, W.W. (1992) *Transport of Subsurface Contaminants into Buildings,* **Environmental Science and Technology** 26(1 1):2058-2066.

MA DEQE (1985) Assessment of Potential Human Exposure from Dermal and Oral Ingestion of Contaminated Soil, Barbara G. Callahan, Ph.D. (December, 1985).

MA DEQE (1989) Guidance for Disposal Site Risk Characterization and Related Phase II Activities - In Support of the Massachusetts Contingency Plan, Massachusetts Department of Environmental Quality Engineering. [Policy No. WSC/ORS-141-89] (1989).

MA DEP (1990a) Guide to the Regulation of Toxic Chemicals in Massachusetts Waters, Massachusetts Department of Environmental Protection. [Office of Research and Standards Publication No. 90-2] (1990).

Archived Document

MA DEP (1990b) The Chemical Health Effects Assessment Methodology (CHEM) and the Method to Derive Allowable Ambient Limits (AAL), Volumes I & II, Massachusetts Department of Environmental Protection [Office of Research and Standards Publication No. 90-1] (1990).

MA DEP (1990c) Background Documentation For The Development Of An "Available" Cyanide Benchmark Concentration, Massachusetts Department of Environmental Protection, Office of Research and Standards, EXTERNAL REVIEW DRAFT (1990).

MA DEP (1991) Development of Soil Advisory Levels, Technical Support Document, Massachusetts Department of Environmental Protection, Office of Research and Standards, **DRAFT** (October 1991).

MA DEP (1992a) Documentation for the Risk Assessment ShortForm, Residential Scenario, Massachusetts Department of Environmental Protection. [Policy No. WSC/ORS-142-92] (1992).

MA DEP (1992b) Draft Discussion Document - Groundwater Cleanup Standards at 21E Sites, Massachusetts Department of Environmental Protection (October 8, 1992).

MADEP (1993) Petroleum Policy: Development of Health Based Alternative to the TPH Parameter DRAFT, Massachusetts Department of Environmental Protection, Office of Research and Standards and ABB Environmental Services, Inc, Wakefield MA. February 1993.

MCP Massachusetts Contingency Plan, 310 CMR 40.000. The Massachusetts Department of Environmental Protection. Originally promulgated in October, 1988 and revised July 30, 1993.

Shah (1988) Shah, J.J. and Singh, H.B. (1988) *Distribution of Volatile Organic Chemicals in Outdoor and Indoor Air,* **Environmental Science and Technology** 22(12):1381-1388.

Stolwijk (1990) Stolwijk, J.A.J. (1990) *Assessment of Population Exposure and Carcinogenic Risk Posed By Volatile Organic Compounds in Indoor Air,* **Risk Analysis** 10(1):49-57.

USEPA (1989a) Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A), U.S. Environmental Protection Agency, Office of Emergency and Remedial Response [EPA 540/1-89/002] (December 1989).

USEPA (1 989b) Exposure Factors Handbook, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment [EPA/600/8-89/043] (March 1989).

USEPA (1991) Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors", U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response [OSWER Directive 9285.6-03] (1991).

5.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Alternative 2 is the recommended removal action alternative for implementation at Site 30. Of the two alternatives, Alternative 2, Excavation and Off-yard Disposal is recommended because it is the only alternative that achieves the RAO.

As outlined in Section 4.0, the main components of this alternative would consist of the following components:

- Concrete Floor Removal – Currently there is a concrete floor that covers the former tank vault. After the removal of all Navy equipment (performed by the Navy during the welding school move) all remaining office equipment and welding equipment would be removed from the area above the former tank vault. Following the cleaning of the area the concrete floor over the former tank vault would be removed. For purposes of this EE/CA it is assumed that remaining office and welding equipment would be easily moved and that the removal of the concrete slab would be performed using equipment entering Building 184 with a pneumatic attachment. This material would be stockpiled for characterization and loaded into trucks for off-yard disposal. For purposes of this EE/CA it is assumed that this material would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Water Removal – Following, or prior to, the removal of the concrete slab above the former tank vault, the liquid in the tank vault would be removed using a well point. The removed water would be containerized for characterization and off-yard disposal. For purposes of this EE/CA it is assumed that this water would be disposed of as non-hazardous waste within a permitted, Navy approved, disposal/treatment facility.

- Excavation – Following the removal of the concrete floor and the removal of the liquid from within the former tank vault, the sandy material reportedly used to fill in the former tank vault would be excavated using a small excavator capable of entering Building 184. This material would be stockpiled for characterization and loaded into trucks for off-yard disposal. For purposes of this EE/CA it is assumed that this material would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Tank Vault Brick Liner Removal – Following the removal of the sandy material used to fill the former tank vault, the acid proof brick lining on the tank vault walls and floor would be removed, using equipment capable of entering Building 184. Based on construction drawings the tank vault walls and floors are concrete overlaid with one layer of acid proof bricks. The acid proof bricks

would be removed, stockpiled for characterization, and disposed off-yard. For purposes of this EE/CA, it is assumed that the acid proof brick would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Tank Vault Concrete Liner Inspection and Removal - Following the removal of the acid proof brick, the concrete floor and walls would be inspected for staining and to determine if any breaches in the acid proof brick have occurred. The concrete tank vault floor and the three walls in the interior of the building that do not act as part of the foundation would be removed, using equipment capable of entering Building 184. Portions of the concrete that show staining (if any) would be removed and stockpiled separately from the concrete not showing signs of staining. Both stockpiles would be characterized for off-yard disposal. For purposes of this EE/CA, it is assumed that the removed concrete floor and walls would show no signs of staining and would be disposed of within a permitted, Navy approved, off-yard solid waste disposal facility (non-hazardous). Following concrete tank vault floor removal the former drain piping, if found would be removed to the limits of the excavation, then plugged and capped.

- Wall Washing – Due to the construction of the building, the eastern tank vault concrete wall is also a portion of the Building 184 foundation wall. Therefore, the tank vault removal would not include the eastern concrete tank vault wall. This wall would be inspected and would be power washed if needed to remove any contamination. For the purposes of this EE/CA it is assumed that a structural engineer would take part in the inspection of this wall prior to the removal of other concrete tank vault walls and floor, to determine if portions of the north and south tank vault wall and portions of the tank vault floor would need to remain in place for building stability.

- Confirmation Sampling – Following the complete removal of the tank vault, confirmation samples will be collected from the exposed soil walls and floor to determine if additional action needs to be conducted. For the purposes of this EE/CA confirmation sampling would include the collection of one composite soil sample from the three exposed soil walls, and two composite soil samples from the exposed soil floor. Three wipe/chip samples would be collected from the remaining concrete wall. The samples would be analyzed for TAL Metals and TCLP. In the event that the results of confirmation sampling indicate that the soil under the tank has been impacted, the Navy and regulators would discuss if further actions would be required to achieve site closeout. A confirmation sampling plan would be prepared as part of the implementation of this alternative and this document would indicate the actual number and types of samples collected to verify the removal of the tank vault and associated contaminants.

- Characterization Sampling – Materials removed from within and around the former tank vault would be characterized for disposal using TCLP and any other methods required by the selected disposal facility or facilities. A characterization sampling plan would be prepared as part of the implementation of this alternative and this document would indicate the actual number and types of samples collected to determine the appropriate disposal methods.

- Restoration – Following confirmation of the tank vault removal and the removal of any associated contamination (if found), the excavation would be backfilled using certified clean common fill material and the concrete floor would be replaced.

4.0 IDENTIFICATION, DEVELOPMENT, AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

4.1 IDENTIFICATION AND DEVELOPMENT OF ALTERNATIVES

Several technologies and process options were evaluated to assemble alternatives that would achieve the RAOs for Site 30. Table 4-1 summarizes the technology screening process. The following is a summary of the technologies (with descriptions) retained from the technology screening process for development into removal action alternatives:

- **No action** - The no action response is retained as required by the NCP. The no action response provides a comparative baseline against which other alternatives can be evaluated. Under this response, no remedial action is taken. The contaminated medium is left "as is" without the implementation of any monitoring, land use controls, containment, removal, treatment, or other mitigating actions.

- **Removal (Excavation)** – Removal is used to remove a contaminated medium from its current location for treatment and return to the site, for treatment and disposal elsewhere, or for disposal elsewhere without treatment. Removal actions are combined with other technologies such as treatment or disposal to develop remedial alternatives.

- **Disposal (Off-yard Landfilling/Recycling)** - Disposal actions include placement of excavated materials within a permanent, approved, and permitted disposal facility. Disposal actions are combined with removal actions and could be combined with treatment actions to develop alternatives. Although the location of the contaminant may change, the toxicity, mobility, and volume of the contaminants are not reduced through the implementation of disposal without a treatment process.

These technologies were used to develop two removal action alternatives. These alternatives are discussed in the following sections. Because the RAO developed is to remediate Site 30 for un-restricted residential use and because of the types (fill, bricks, concrete) and small volume of contaminated material, excavation and disposal were the only available technologies to develop into remedial alternatives. Therefore, additional alternatives were not developed for evaluation.

4.1.1 Alternative 1 – No Action

It is assumed that no remedial action would be taken for this alternative at the former tank vault and that any occasional actions that may have been taken in the past (i.e., crystal growth removal) would not

continue. As outlined in CERCLA guidance for the evaluation of remedial alternatives, the No Action response provides a comparative baseline against which other alternatives can be evaluated. The contaminated media would be left in place, without the implementation of any additional containment, removal, treatment, or other mitigating actions. The No Action alternative does not provide for the implementation of administrative or institutional controls to reduce the potential for exposure.

4.1.2 Alternative 2 – Excavation and Off-yard Disposal

This alternative would involve the excavation and removal of all tank vault contents, lining materials, drain, and associated contaminated soil. Figure 4-1 depicts this conceptual layout of the alternative. Following excavation, the site would be backfilled and restored to the desired use or pre-removal action conditions. Quantity calculations (excavation/backfill volume estimates, site restoration area, and volume estimates, etc.) and excavation areas assumed for the costing of this alternative are provided in Appendix C. Specific design considerations would be provided in the removal action design document or removal action work plan document.

The main construction tasks used to implement Alternative 2 consist of the following:

- Concrete Floor Removal – Currently there is a concrete floor that covers the former tank vault. After the removal of all Navy equipment (performed by the Navy during the welding school move) all remaining office equipment and welding equipment would be removed from the area above the former tank vault. Following the cleaning of the area the concrete floor over the former tank vault would be removed. For purposes of this EE/CA it is assumed that remaining office and welding equipment would be easily moved and that the removal of the concrete slab would be performed using equipment capable of entering Building 184. This material would be stockpiled for characterization and loaded into trucks for off-yard disposal. For purposes of this EE/CA it is assumed that this material would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Water Removal – Following, or prior to, the removal of the concrete slab above the former tank vault, the liquid in the tank vault would be removed using a well point. The removed water would be containerized for characterization and off-yard disposal. For purposes of this EE/CA it is assumed that this water would be disposed of as non-hazardous waste within a permitted, Navy approved, disposal/treatment facility.

- Excavation – Following the removal of the concrete floor and the removal of the liquid from within the former tank vault, the sandy material reportedly used to fill in the former tank vault would be excavated using equipment capable of entering Building 184. This material would be stockpiled

for characterization and loaded into trucks for off-yard disposal. For purposes of this EE/CA it is assumed that this material would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Tank Vault Brick Liner Removal – Following the removal of the sandy material used to fill the former tank vault, the acid proof brick lining on the tank vault walls and floor would be removed, using equipment capable of entering Building 184. Based on construction drawings the tank vault walls and floors are concrete overlaid with one layer of acid proof bricks. The acid proof bricks would be removed, stockpiled for characterization, and disposed off-yard. For purposes of this EE/CA, it is assumed that the acid proof brick would be disposed of within a permitted, Navy approved, off-yard hazardous waste disposal facility.

- Tank Vault Concrete Liner Inspection and Removal - Following the removal of the acid proof brick, the concrete floor and walls would be inspected for staining and to determine if any breaches in the acid proof brick have occurred. The concrete tank vault floor and the three walls in the interior of the building that do not act as part of the foundation would be removed, using equipment capable of entering Building 184. Portions of the concrete that show staining (if any) would be removed and stockpiled separately from the concrete not showing signs of staining. Both stockpiles would be characterized for off-yard disposal. For purposes of this EE/CA, it is assumed that the removed concrete floor and walls would show no signs of staining and would be disposed of within a permitted, Navy approved, off-yard solid waste disposal facility (non-hazardous). Following concrete tank vault floor removal the former drain piping, if found would be removed to the limits of the excavation, then plugged and capped.

- Wall Washing – Due to the construction of the building, the eastern tank vault concrete wall is also a portion of the Building 184 foundation wall. Therefore, the tank vault removal would not include the eastern concrete tank vault wall. This wall would be inspected and would be power washed if needed to remove any contamination. For the purposes of this EE/CA it is assumed that a structural engineer would take part in the inspection of this wall prior to the removal of other concrete tank vault walls and floor, to determine if portions of the north and south tank vault wall and portions of the tank vault floor would need to remain in place for building stability.

- Confirmation Sampling – Following the complete removal of the tank vault, confirmation samples will be collected from the exposed soil walls and floor to determine if additional action needs to be conducted. For the purposes of this EE/CA confirmation sampling would include the collection of one composite soil sample from the three exposed soil walls, and two composite soil samples from the exposed soil floor. Three wipe/chip samples would be collected from the remaining

concrete wall. The samples would be analyzed for TAL Metals and TCLP. In the event that the results of confirmation sampling indicate that the soil under the tank has been impacted, the Navy and regulators would discuss if further actions would be required to achieve site closeout. A confirmation sampling plan would be prepared as part of the implementation of this alternative and this document would indicate the actual number and types of samples collected to verify the removal of the tank vault and associated contaminants.

- Characterization Sampling – Materials removed from within and around the former tank vault would be characterized for disposal using TCLP and any other methods required by the selected disposal facility or facilities. A characterization sampling plan would be prepared as part of the implementation of this alternative and this document would indicate the actual number and types of samples collected to determine the appropriate disposal methods.

- Restoration – Following confirmation of the tank vault removal and the removal of any associated contamination (if found), the excavation would be backfilled using certified clean common fill material and the concrete floor would be replaced.

The action-specific ARARs associated with Alternative 2 are presented in Table 4-2.

4.2 EVALUATION CRITERIA

The following criteria were used to evaluate the removal action alternatives (Alternatives 1 and 2):

- Effectiveness: Short-term and long-term protection of human health and the environment, the degree of protection achieved, and the reliability of the alternative.

- Implementability: The degree of difficulty of implementation, associated risks and limitations, feasibility, and limitations of the technology process.

- Cost: Removal action costs including capital cost and maintenance cost.

4.3 EVALUATION OF ALTERNATIVES

4.3.1 Alternative 1 – No Action

Effectiveness

The No Action alternative would not meet any of the RAOs for the site. The source of the crystals and impacted pit material would not be removed or treated; therefore, acidic constituents would continue to be

transported to the surface through crystal growth, thereby increasing risk to human receptors. Moreover, fill material within the tank vault and the tank vault lining material would continue to pose a future potential threat of release of contaminants to the groundwater at the site.

Implementability

The No Action alternative is immediately implementable. No implementability concerns exist.

Cost

No cost is associated with this alternative.

4.3.2 Alternative 2 – Excavation and Off-yard Disposal

Effectiveness

Alternative 2 would be effective in eliminating the source and mechanisms of crystalline growth and would effectively eliminate long-term risk to human health and the environment. All contaminated material would be removed and properly disposed.

Implementability

Removal of the floor slab and excavation of waste and associated contaminated soils is routinely performed by experienced contractors using commonly available equipment for site remediation work. Excavation is applicable to almost all site conditions. Depths from approximately 3 to 4 feet are being considered for removal at this site.

The complete removal of all facilities within the limits of the former tank vault and the excavation of all tank vault fill, acid-proof brick lining, concrete substructure, and concrete floor over the former tank vault would render the area unusable for the duration of the project. Complete excavation and restoration of the area would be expected to take two to three months. Full use of the interior and exterior of the building can be restored upon completion of this alternative.

Due to the implementation of the alternative within a building, the interior clearance within the building would create restrictions on the type of equipment use and the need to establish ventilation and a dust suppression system. Many effective pieces of smaller equipment could be used to perform this remedy and ventilation and dust suppression systems are commonly employed.

Cost

The estimated costs for Alternative 2 would be as follows:

Capital: $860,000
Operation and Maintenance (O&M): Not applicable
Present worth: $860,000

Details of the cost estimates are provided in Appendix D. Quantities and assumptions supporting the cost estimate are provided in Appendix C.

4.4 COMPARISON OF ALTERNATIVES

The removal action alternatives were compared to each other using the same criteria used in the evaluation of each alternative in the previous section (i.e., effectiveness, implementability, and cost).

4.4.1 Effectiveness

Alternative 1 would not meet either of the primary RAOs for Site 30. Alternative 2 would be the most effective alternative based on the complete excavation and removal of all former tank vault contents. Alternative 2 would minimize future crystal growth and reduce or eliminate the source of potential release of contaminants to groundwater thereby meeting the primary RAOs for the site.

4.4.2 Implementability

Alternative 1 would not require any implementation and would therefore be the easiest to implement. Alternative 2 would be more difficult to implement than Alternative 1; however, the facilities, equipment, and procedures required to implement Alternative 2 are readily available. Alternative 2 would require increased traffic through PNS but would not disturb any facility activities.

The interior clearance within the building would create restrictions to the use of large excavation equipment for Alternatives 2.

4.4.3 Cost

Alternative 1: $0
Alternative 2: $860,000
A summary of the comparison of the alternatives is provided in Table 4-3.

3.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

RAOs are developed to determine guidance for the removal action and to ensure that the action complies with regulatory requirements. This section provides an identification of Applicable or Relevant and Appropriate Requirements (ARARs), identification of RAOs, a discussion of the removal action scope, and a proposed schedule.

3.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are regulatory requirements and guidance that may potentially govern remedial activities and are defined as follows:

- any standard, requirement, criterion, or limitation under federal environmental law; or
- any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-siting law that is more stringent than the associated federal standard, requirement, criterion, or limitation, that either is legally applicable to the CERCLA hazardous substance(s) at the site or is relevant and appropriate under the circumstances of the hazardous substance release.

One of the primary concerns during the development of RAOs for hazardous waste sites under CERCLA or Superfund is the degree of human health and environmental protection afforded by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to ensure that CERCLA response actions are consistent with other pertinent federal and state environmental requirements.

Definitions of the two types of ARARs, as well as To Be Considered (TBC) criteria, are as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, although not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site, that their use is well suited (appropriate) to the particular site.

- TBC criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action alternatives and for determining action levels that are protective of human health and/or the environment. Examples of TBC criteria include USEPA Drinking Water Health Advisories, carcinogenic potency factors, and reference doses.

ARARs and TBCs can be divided into three categories, although many requirements are combinations of the three types of ARARs and TBCs. These categories are as follows:

- Chemical specific: Health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. In absence of ARARs, site-based criteria may be developed using guidance provided under USEPA risk Reference Dose (RfD) guidance or USEPA Human Health Assessment Group Cancer Slope Factor (CSFs).

- Location specific: Restrictions based on the concentrations of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of sites. Location-specific ARARs pertain to special site features. Examples of location-specific ARARs include historic preservation requirements for buildings.

- Action specific: Technology- or activity-based controls or restrictions on activities related to management of hazardous substances. Action-specific ARARs pertain to implementing a given remedy.

Chemical- and location-specific ARARs and TBCs for Site 30 are presented in Tables 3-1 and 3-2, respectively. Action-specific ARARs and TBCs are discussed with the removal action alternatives descriptions presented in Section 4.0.

3.2 REMOVAL ACTION OBJECTIVES

The following RAO for Site 30 was developed based on the potential risks as discussed in Section 2.5.

- Mitigate human health and environmental risks associated with the tank vault in a manner such that the property can be used for unrestricted use/unlimited exposure.

3.3 REMOVAL ACTION SCOPE

The focus of this EE/CA and a subsequent removal action is the former acid tank vault contents and the crystals growing within the building and former acid tank vault. Based on the physical dimensions provided in the 1943 as-built drawings and the results of the single test pit excavation, an estimated 400

cubic yards (cy) of former acid tank vault fill material, brick and concrete lining, existing concrete floor, and crystalline growth are expected to be present at Site 30. The estimate of tank vault contents is presented in the conceptual design calculations in Appendix C. The volume of existing crystals that may be present below the herculite liner is expected to be less than 1 cy.

3.4 REMOVAL ACTION SCHEDULE

Currently the Navy is in the process of moving personnel and required equipment from Building 184. It is anticipated that the move will be complete by the end of March 2010. Therefore, it is anticipated that work plans for the removal action would be prepared and submitted summer 2010 and that construction would commence fall or winter 2010/2011 pending funding.

REFERENCES

Dolph, James E. (Shipyard Historian) and Heather W. Hall (Assistant), September 1995. Industrial History of Building 184, Portsmouth Naval Shipyard, Portsmouth, New Hampshire.

MEDEP (Maine Department of Environmental Protection), and Maine Department of Human Services, June 1994. Guidance Manual for Human Health Risk Assessments at Hazardous Substance Sites.

Navy (U.S. Navy), March 2003. Draft Action Memorandum for Non-Time-Critical Removal Action for Site 30, Portsmouth Naval Shipyard, Kittery, Maine.

Navy, July 2003. Correspondence from F. Evans (Navy) to M. Audet (USEPA) and I. McLeod (MEDEP), on the Site 30 Action Memorandum, Portsmouth NSY, Kittery, Maine, dated July 25, 2003.

Shaw, July 2008. Contractor Closeout Report for Site 34 Shoreline Stabilization and Removal Action. Shaw Environmental, Inc., Norfolk, Virginia.

TtNUS (Tetra Tech NUS, Inc.), May 2000. Site Screening Report Site 30 (Building 184), Site 31 (West Timber Basin), and Site 32 (Topeka Pier) for Portsmouth Naval Shipyard, Kittery, Maine. Tetra Tech NUS, Inc., King of Prussia, Pennsylvania (see correspondence dated May 25, 2000 from M. Mengel, TtNUS to M. Cassidy [USEPA] and I. McLeod [MEDEP]).

TtNUS, May 2002. Test Pitting Investigation Report, Building 184, Site 30, March/April 2001 Activity, Portsmouth Naval Shipyard, Kittery, Maine. Tetra Tech NUS, Inc., King of Prussia, Pennsylvania.

TtNUS, December 2002 (Revision 0). Engineering Evaluation/Cost Analysis (EE/CA), Site 30 (Building 184), Portsmouth Naval Shipyard, Kittery, Maine, Revision 0. Tetra Tech NUS, Inc., King of Prussia, Pennsylvania.

TtNUS, August 2005 (Revision 1). Engineering Evaluation/Cost Analysis (EE/CA), Site 30 (Building 184), Portsmouth Naval Shipyard, Kittery, Maine, Revision 1. Tetra Tech NUS, Inc., King of Prussia, Pennsylvania.

USEPA (United States Environmental Protection Agency), August 1993. Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA, EPA 540-R-93-057.

APPENDIX B

GROUNDWATER TECHNICAL EVALUATION

APPENDIX C

QUANTITY CALCULATIONS AND ASSUMPTIONS FOR COSTING INPUT

APPENDIX D

COST ESTIMATES

APPENDIX E

RESPONSES TO COMMENTS

7.0 METHOD 3 - HUMAN HEALTH

This section provides guidance on conducting a Method 3 Human Health Risk Characterization. The human health evaluation is just one of *four* distinct assessments which comprise a complete Method 3 Risk Characterization: the risk to safety, public welfare and the environment must also be addressed. The most site-specific of the three risk characterization options available under the MCP, a Method 3 assessment is an option at all c.21E sites.

The specific regulations concerning the Method 3 risk characterization process begin at 310 CMR 40.0990 of the Massachusetts Contingency Plan. Readers are reminded that general requirements applicable or potentially applicable to all risk characterizations are found in 310 CMR 40.0900 through 40.0960, and are described in Section 1.0 through 4.0 of this guidance document.

A Method 3 Risk Characterization Is Complete If...

- Risk to Safety (Section 4.0)
- Risk to Human Health (Section 7.0)
- Risk to Public Welfare (Section 8.0)
- Risk to the Environment (Section 9.0)

...Are Evaluated

The scope and level of effort needed to complete each component of a Method 3 Risk Characterization will vary depending upon site conditions.

The Method 3 human health risk characterization approach involves five steps: hazard identification, dose-response assessment, exposure assessment, risk characterization and uncertainty analysis.

Hazard Identification determines whether a substance causes adverse effects and identifies those effects. This step describes why the substance is of regulatory concern.

The **Dose-Response Assessment** describes the relationship between the level of exposure and the likelihood and/or severity of an adverse effect. Simply speaking, the dose-response information describes the toxicity of the substance.

The **Exposure Assessment** involves identifying potential routes of exposure; characterizing the populations exposed; and determining the frequency, duration and extent of exposure.

The **Risk Characterization** combines information from the previous three steps to describe the type (e.g., carcinogenic or non-carcinogenic) and magnitude of risks to exposed populations. The resulting risks are then compared to the risk management criteria

promulgated in the regulations.

The **Uncertainty Analysis** identifies the nature and, when possible, the magnitude of the uncertainty and variability inherent in the characterization of risks. The results of any risk assessment reflect scientific uncertainty resulting from limitations in available data and assumptions that are made in the absence of such data, and the variability in exposure and toxicological response expected given the diversity within the human population. The assumptions and limitations which are a part of all risk characterizations should be explicitly discussed.

Each of these risk assessment steps is described in detail in the following sections of this document.

It is important to remember that risk estimates generated in the risk assessment are not measures of actual or absolute risks. Rather, risk assessments are a tool - a method of providing valuable information regarding potential risks to public health and the environment. Risk assessment is used throughout the regulatory process to provide such information, whether it is to determine "How clean is clean enough?" at a disposal site, to develop drinking water standards for public water supplies, or to evaluate a proposed facility seeking a source permit.

The MCP is explicit in its interpretation of the significance of the risk estimates. The risk management philosophy inherent in the establishment of the risk limits is to ensure that no potential receptor groups would experience an excess lifetime cancer risk greater than the risk limit, regardless of the number of chemicals or exposure routes that exist at a site. The noncancer risk limit reflects a risk management decision that multiple-chemical, multiple-route exposures related to a disposal site will not exceed an estimated "allowable" dose - a dose which would not result in adverse health effects.

Under Method 3, remediation of the disposal site is required if: (1) Exposure Point Concentrations exceed any applicable or suitably analogous public health standards, ***or*** (2) the estimated cancer or non-cancer risks associated with exposure to oil or hazardous material exceed the Cumulative Receptor Risk Limits (310 CMR 40.0993(6)). Remedial alternatives must be evaluated to determine if they eliminate "Significant Risk" as defined in the MCP.

7.1 HAZARD IDENTIFICATION

The Hazard Identification portion of an MCP Method 3 risk characterization describes the hazards associated with each OHM which has been selected as a Contaminant of Concern. More specifically, the Hazard Identification discusses whether exposure to a particular contaminant can cause an increase of a particular adverse health effect and whether the adverse health effect is likely to occur in humans.

The Hazard Identification section of the Risk Assessment should contain: an identification of the OHMs which have been selected as Contaminants of Concern, a summary of the analytical data which have been collected for these OHMs presented by specific environmental medium, and a description of the potential health effects which may be associated with exposure to each OHM.

The description of the potential health effects associated with each contaminant is provided in a ***Toxicity Profile***. A Toxicity Profile should be prepared for each Contaminant of Concern and presented in the documentation of the Risk Characterization.

Toxicity Profiles serve several purposes. They provide a summary of the potential adverse human health effects which may be associated with exposure to a particular contaminant and contain references for the dose-response assessment. Toxicity Profiles also serve as reference material for non-toxicologists who are involved with or interested in activities at the site and who want to understand the potential health impacts associated with contaminants at the site.

The information in Toxicity Profiles may also be used to group chemicals by health endpoint and mechanism of toxicity in order to estimate more detailed Hazard Indices. The reader should refer to Section 7.4.1 for more information on calculating endpoint-specific Hazard Indices.

In general, a Toxicity Profile is a comprehensive, in-depth profile of the toxicokinetics, human and animal mechanisms of toxicity, genotoxicity, carcinogenicity, and developmental/reproductive toxicity for the chemical of interest. A Toxicity Profile should also address Structure Activity relationships and interaction with other chemicals, as appropriate. In preparing the Toxicity Profile, the risk assessor should rely on credible, peer-reviewed sources of information such as controlled, epidemiologic investigations, clinical trials, experimental animal studies, metabolic and pharmacokinetic experiments, *in vitro* studies and structure-activity studies. All references should be provided to document the sources of information used to prepare the Toxicity Profile.

The scope and level of detail of a Toxicity Profile will vary depending upon the nature and quantity of information available for a particular chemical. For many substances (e.g., chemicals for which Method 1 standards have been developed) toxicological information is readily available from many sources, and repetition of that information in great detail in the Toxicity Profile is not necessary. For such cases a short descriptive summary of the known

health effects associated with the chemical of interest and the basis for any existing standards or guidelines would be sufficient. The primary purpose of such a descriptive summary is to provide information to the public in a readily available form.

7.2 DOSE RESPONSE ASSESSMENT

The dose-response assessment describes the observed effects in humans and/or laboratory animals associated with particular exposures (or doses) of the chemical of concern. This information is obtained from published literature describing epidemiologic or toxicologic studies involving the particular chemical. For most chemicals reported at c.21E disposal sites, the dose-response information needed to conduct a risk assessment may be found in secondary sources published by the USEPA or other government agencies, as described below.

The dose-response relationship(s) for each OHM which has been selected as a Chemical of Concern must be identified in the risk assessment report. This information is later coupled with knowledge of the nature and magnitude of potential exposures to characterize risk.

The dose-response information may be divided into three major categories:

- Toxicity information associated with threshold (non-carcinogenic) health effects.
- Toxicity information concerning carcinogenicity, either from human epidemiologic data or from laboratory studies.
- The Relative Absorption Factors (RAFs) used to relate the toxicity information identified from the literature to the exposure pathways of concern at the disposal site under investigation

> ***All*** the chemicals selected as Contaminants Of Concern should be evaluated for potential *non-carcinogenic* health effects. In addition, any substance considered to be a *known*, *probable*, or *possible* human carcinogen (as designated by EPA) should also evaluated for its potential carcinogenic effect. The classification of a chemical as a carcinogen does not preclude an evaluation of that same chemical for potential non-carcinogenic health risks.

7.2.1 Threshold Effects

For non-carcinogenic health effects, it is believed that a dose (or exposure) level exists at and below which no adverse health effects would be expected. Such a level is referred to as a ***threshold dose***. In theory, the threshold dose would be safe for all receptors who might be exposed at that level.

The goal of the dose response assessment is to identify the threshold dose, or a close approximation, given the toxicological information currently available. It may be impossible, however, to specify this theoretical threshold dose for a given chemical due to the inadequacy of the scientific data. Ideally, the threshold dose would be identified from large and well-run human epidemiological and toxicological studies. Unfortunately, such studies are uncommon as they are difficult to conduct, expensive, time-consuming, and often pose ethical concerns. It is possible to approximate this threshold dose in a health-protective manner that accounts for the data limitations by identifying a *sub-threshold* dose: such a value is typically derived from the ***No Observable Adverse Effects Level*** (NOAEL) of an animal study by application of uncertainty factors (UF) and a modifying factor (MF) (Farland and Dourson, 1992). Uncertainty Factors are applied to account for interspecies variation, exposure duration and protection of sensitive populations. Additional Uncertainty Factors may be applied if the toxicological study identified a ***Lowest Observable Adverse Effects Level***, or LOAEL, rather than a NOAEL. Each Uncertainty Factor is typically equal to a factor of ten, and the product of all the Uncertainty Factors may be as high as 10,000 (10 x 10 x 10 x 10). A Modifying Factor may be applied to reflect additional uncertainties in the critical study and the entire data base not addressed by the Uncertainty Factor. The value of the Modifying Factor is greater than zero and less than or equal to ten; the default value for the Modifying Factor is one. Important factors to consider when identifying and using such a sub-threshold dose include, at a minimum:

- the route of administration from the study (inhalation, oral, dermal contact, etc...);
- the duration of exposure to that dose (lifetime, chronic, subchronic, or acute exposure);
- the absorption efficiency (if any) used to calculate that dose; and
- the age of the person receiving the dose.

The subthreshold dose in units of mg/kg/day (with uncertainty spanning perhaps an order of magnitude or greater) to which daily exposure of a human population, including sensitive subgroups, is likely to be free of appreciable risk of deleterious effects during a lifetime is termed a ***Reference Dose*** (RfD) (Barnes and Dourson, 1988). The RfD is derived using the following equation:

$$RfD_{(mg/kg/day)} = \frac{NOAEL\ or\ LOAEL}{U.F.\ and/or\ MF} \quad \textbf{(7-1)}$$

USEPA (1991) has also proposed a **Reference Dose for developmental toxicity** (RfD_{DT}). The RfD_{DT} is based on a NOAEL derived from short-duration exposures typically used in developmental studies. Uncertainty factors for developmental toxicity generally include a tenfold factor for interspecies variation and a tenfold factor for intraspecies variation; in general an uncertainty factor is not applied to account for duration of exposure. Additional uncertainty factors may be applied due to a variety of uncertainties in the data base (Farland and Dourson, 1992).

A ***Reference Concentration*** (RfC, in units of mg/m^3) is the inhalation exposure concentration (with uncertainty spanning perhaps an order of magnitude or greater) to which daily exposure of a human population, including sensitive populations, is likely to be free of appreciable effects. Interim methods for development of inhalation reference concentrations (USEPA, 1990) describe the conversion of the experimental exposure NOAEL to human equivalent concentrations ($NOAEL_{HEC}$). The conversion is specific both to the type of inhaled agent (particle or gas) and to the observed effect (respiratory or systemic) and adjusts for dosimetric differences between various experimental species and humans. Once the $NOAEL_{HEC}$ is identified, the same equation used to estimate the RfD is used to calculate the inhalation RfC with the application of similar, although not identical, uncertainty factors (Farland and Dourson, 1992). Conversion of an RfC to an inhalation RfD (in units of mg/kg/day) is not recommended.

There are a number of different sources of subthreshold toxicity values. When selecting toxicity information for use in quantitative risk assessment, the risk assessor should ensure that the information is appropriate for the assessment being conducted and that it is up-to-date. Note that sources differ in the frequency at which they are updated and the level of review they receive. The Massachusetts Contingency Plan requires that primary consideration be given to information developed by the U.S. Environmental Protection Agency (310 CMR 40.0993(5)(a)).

The following presents a list of sources of toxicity information in the order of preference:

(1) **Integrated Risk Information System (IRIS)** - IRIS is an USEPA data base that contains only those RfDs/RfCs which represent a consensus judgement of USEPA RfD/RfC Workgroup which is composed of scientists from various EPA offices and the Office of Research and Development. It is the preferred source of toxicity information. The IRIS database is updated monthly and is available on-line. For information on how to access IRIS, call IRIS user support at (513) 569-7254.

(2) **Health Effects Assessment Summary Tables (HEAST)** - HEAST is prepared by USEPA's Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. HEAST contains almost entirely *provisional* toxicity values. These values have undergone review by individual USEPA program

offices, but are not recognized as agency-wide consensus values. HEAST is scheduled to be updated quarterly and can be obtained by contacting the National Technical Information Services (NTIS) Subscriptions Department at (703) 487-4630.

(3) **Other sources.** When information is not available in IRIS or HEAST, the following sources may be reviewed to determine whether comparable values exist and whether those values are appropriate for quantitative risk assessment.

Toxicity Values Developed by MADEP, ORS - The Office of Research and Standards develops chronic and subchronic RfDs and RfCs for some OHMs for which no values are available in IRIS or HEAST. These values are based on available toxicological data and standard USEPA approaches for developing reference doses for threshold effects. The list of chemicals includes a number of carcinogens for which USEPA has not derived non-cancer toxicity values. These values can be accessed through the MA DEP Bulletin Board.

Agency for Toxic Substances Disease Registry (ATSDR) - ATSDR produces Toxicological Profiles for 275 hazardous substances found at NPL sites. The priority list of hazardous substances is published in the Federal Register. An announcement of the release of draft Toxicological Profile documents appears in the Federal Register and the documents are available from ATSDR. Final toxicological profiles which incorporate reviewers comments, are available from the National Technical Information Service (NTIS) at (800) 553-6847 or (703) 487-4650.

In the toxicological profiles, ATSDR develops ***Minimal Risk Levels*** (MRLs) for threshold effects of some chemicals. These values are updated when the profiles are revised, if appropriate. An MRL is defined as an estimate of the daily human exposure to a substance that is likely to be free of appreciate risk of adverse noncancerous effects over a specified duration of exposure. MRLs are derived using the modified risk assessment methodology the U.S. EPA uses to derive reference doses and reference concentrations for lifetime exposure.

Allowable Threshold Concentration (ATC) - The "*Allowable Threshold Concentrations*" are values roughly equivalent to the reference concentration, but they are derived from the Threshold Effects Exposure Limit (TEL) described in CHEM (MA DEP, 1990). (The TEL value represents 20% of an allowable concentration, or ATC. Thus the ATC is equal to five times the TEL. The TEL was derived in a manner considering children to be the most sensitive potential receptors.) The ATC is a concentration of the chemical in air which would not be expected to result in adverse non-carcinogenic health effects. The ATC is derived considering acute and chronic threshold health endpoints, including reproductive effects. These values can be accessed through the MA DEP Bulletin Board.

Allowable Doses Back-Calculated From Drinking Water Standards and Guidelines - Drinking water standards and guidelines, which give the allowable concentration of a contaminant in drinking water supplies include: the Maximum Contaminant Level Goal (MCLG), the Maximum Contaminant Level (MCL), and Health Advisories (HAs). An allowable daily intake (ADI) comparable to an RfD may be obtained by back-calculation, using the same exposure assumptions used to develop the standard or guideline. It is imperative that the assumptions used to develop the standard or guideline be known before an RfD is calculated.

Back-calculating From Standards

When back-calculating from a concentration to a dose, the risk assessor must always use the exposure assumptions on which the concentration is based. For example, if a drinking water standard was derived using a body weight of 70 kg and a water intake rate of 2 liters/day, those factors must be used in back-calculating an allowable daily dose.

Site-specific exposure assumptions (such as a child's body weight and water intake rate) would then be considered in the risk assessment itself to evaluate the potential risk posed by the contamination.

A list of MCLs, MCLGs and HAs is available from USEPA by calling the Safe Drinking Water Hotline (1-800-426-4791). The list is updated twice per year. These values are also available in a chemical's IRIS file.

MCLGs - MCLGs are non-enforceable concentrations of a drinking water contaminant that are protective against adverse human health effects and allow an adequate margin of safety. MCLGs for substances considered to be carcinogenic are set at zero because USEPA assumes that any level of exposure is associated with some level of risk. MCLGs for substances not treated as known or probable human carcinogens are based upon chronic toxicity or other health data and applied uncertainty data. *Back calculation from the MCLG is only appropriate for use in the evaluation of compounds not considered Weight-of-Evidence Group A or B carcinogens.* Documentation for MCLGs is found in the preamble to the final rule for each OHM in the Federal Register.

MCLs - MCLs are the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. MCLs are enforceable standards that are set as close to MCLGs as feasible. MCLs consider factors which are not strictly health based, such as treatment technology and cost. Thus, the basis for an MCL must be carefully examined before an MCL is used to derive an RfD. Generally, an MCL is not used to derive an RfD.

Health Advisories - Health Advisories (HAs) describe concentrations of drinking water contaminants at which adverse non-carcinogenic health effects would not be expected to occur over specific exposure durations. HAs are developed for 1-day, 10-day, longer term (generally up to 2 years), and lifetime

exposures based only on data describing non-carcinogenic endpoints of toxicity. For those substances which are known or probable human carcinogens, HAs for lifetime exposure are not derived. The documentation for each HA should be consulted before proceeding with any calculations. Documentation for HAs is available through the Education Research Information Clearinghouse (ERIC), (614) 292-6717.

Allowable Doses Back-Calculated From Ambient Water Quality Criteria - Ambient Water Quality Criteria (AWQC) are developed by the USEPA Office of Water Regulations and Standards per Section 304(a)(1) of the Clean Water Act of 1977. The AWQC consider both toxicity to aquatic life and human health effects. The AWQC do not consider technical feasibility or cost and may be used to derive a chronic sub-threshold dose for use in a risk assessment. However, it must be noted that the AWQC incorporate factors which account for exposure via both drinking water ingestion and consumption of contaminated fish. The documentation for each AWQC should be consulted before proceeding with any calculations and are available through the National Technical Information Service (NTIS) at (800) 336-4700. Individual AWQC are listed in IRIS.

(4) **Calculation of a dose-response value using toxicity information from the literature.** Dose-response values may be derived by a qualified risk assessor or toxicologist if none of the above sources provides a toxicity value, but adequate toxicity studies are available, *or* if more recent, credible and relevant data becomes available. USEPA approaches to development of RfDs are described in *Risk Assessment Guidance for Superfund* (USEPA, 1989) and in Appendix A to IRIS. Approaches to the development of RfCs are described in *Interim Methods for Development of Inhalation Reference Doses* (USEPA, 1991). The review and approval by the Department of such a proposed value would depend upon the justification and documentation provided to support it. The development of an alternative value when a USEPA or MA DEP derived reference dose or reference concentration is available is rarely justifiable and the risk assessor should contact the MA DEP Office of Research and Standards early on in the site assessment process for prior approval before proceeding.

7.2.2 Carcinogenic Effects

Unlike non-carcinogenic health effects, the dose-response assessment for carcinogens assumes that there is no threshold dose for carcinogenicity; that there is no dose of a carcinogenic substance (other than no exposure) which is associated with zero risk. USEPA evaluates available toxicity data and, based on this evaluation, the chemical is assigned to a weight-of-evidence class. The system for characterizing the overall weight of evidence for a chemical's carcinogenicity developed by USEPA is based on the availability of animal, human, and other supportive data (USEPA, 1986). The weight-of-evidence classification rates the likelihood that an agent is a human carcinogen, and it may qualitatively affect the interpretation of potential health risks. Three major factors are

considered in characterizing the overall weight-of-evidence for carcinogenicity: (1) the quality of evidence from human studies, (2) the quality of evidence from animal studies, and (3) other supportive information, such as mutagenicity data and structure-activity data. The five categories of the USEPA's final classification scheme (adapted from an approach taken by the International Agency for Research on Cancer) are described in Table 7.1.

Table 7.1

USEPA Weight of Evidence Classification

Group A - Human Carcinogen: This category indicates there is sufficient evidence from epidemiological studies to support a causal association between an agent and human cancer.

Group B - Probable Human Carcinogen: This category generally indicates there is at least limited evidence from epidemiologic studies of carcinogenicity to humans (Group B1) or that, in the absence of data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

Group C - Possible Human Carcinogen: This category indicates that there is limited evidence of carcinogenicity in animals in the absence of data on humans.

Group D - Not Classified: This category indicates that the evidence for carcinogenicity in animals is inadequate, or no data are available.

Group E - No Evidence of Carcinogenicity to Humans: This category indicates that there is evidence of noncarcinogenicity in at least two adequate animal tests in different species or in both epidemiologic and animal studies.

The ability of a chemical to increase the incidence of cancer in a target population is described by one of two measures: the cancer ***slope factor*** or the ***unit risk***. Cancer Slope Factors or Unit Risks are typically calculated for chemicals in Groups A, B1 and B2. Slope factors for chemicals in Group C are calculated on a case-by-case basis.

The cancer Slope Factor (CSF) for a chemical is derived by the USEPA's Cancer Assessment Group (CAG). Using mathematical extrapolation models, commonly the linearized multistage model, the largest possible linear slope (within the 95% Confidence Limit) consistent with the available data is estimated at low extrapolated doses. For some chemicals, human epidemiologic data are the basis of an estimate of the carcinogenic potency, although the most common basis of these values is an animal study. The CSF is expressed as the risk per unit dose, and is typically given in units of $(mg/kg/day)^{-1}$. Use of the slope factor assumes that the calculated dose received is expressed as a lifetime average.

The Unit Risk (UR) is the upper 95% Confidence Limit of the mean incremental lifetime cancer risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of 1 $\mu g/m^3$ or in the drinking water at a concentration of 1 $\mu g/L$. These values are used in lieu of the chemical's slope factor when an estimate of a lifetime average concentration of the chemical is available.

There are a number of different sources of CSFs and URs. When selecting this information for use in quantitative risk assessment, the risk assessor should ensure that the information is appropriate for the assessment being conducted and that it is up-to-date. Note that sources differ in the frequency at which they are updated and the level of review they receive. The Massachusetts Contingency Plan requires that primary consideration be given to information developed by the U.S. Environmental Protection Agency (310 CMR 40.0993(5)(a)).

Preferred sources for cancer slope factors or unit risk values are:

(1) **Integrated Risk Information System (IRIS)** - The IRIS data base contains only those CSFs or URs which represent a consensus judgement of the USEPA Carcinogen Risk Assessment Verification Endeavor (CRAVE) which is composed of scientists from various EPA offices and the Office of Research and Development. It is the preferred source of toxicity information. The IRIS database is updated monthly and is available on-line. For information on how to access IRIS, call IRIS user support at (513) 569-7254.

(2) **Health Effects Assessment Summary Tables (HEAST)** - HEAST contains values that have received some form of review by USEPA, but have not been verified and are considered provisional. HEAST is prepared by USEPA's Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. HEAST is scheduled to be updated quarterly and can be obtained by contacting the National Technical Information Services (NTIS) Subscriptions Department at (703) 487-4630.

(3) **Other Sources** - When information is not available in IRIS or HEAST, the following sources may be reviewed to determine whether comparable values exist and whether those values are appropriate for quantitative risk assessment.

California Environmental Protection Agency (Cal/EPA) - Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA), Department of Pesticide Regulation (DPR) and Department of Toxic Substances Control (DTSC) develop or approve cancer potency factors for use in risk assessments and as the basis for regulatory action. A list of available cancer potency factors is revised semiannually and can be obtained from OEHHA's Hazardous Waste Toxicology Section, at (916) 324-7572.

Toxicity Values Developed by MA DEP/ORS - The Office of Research and Standards may develop CSFs and URs for chemicals for which no values are available in IRIS or HEAST. When available, these values can be accessed through the MA DEP Bulletin Board.

(4) **Calculation of a slope factor or unit risk value using toxicity information**

from the literature. CSFs and URs may be derived by a qualified risk assessor or toxicologist if none of the above sources provides a toxicity value, but adequate toxicity studies are available, *or* if more recent, credible and relevant data becomes available. USEPA approaches to development of cancer slope factors are described in several documents (USEPA, 1989a; USEPA, 1986) and in Appendix B to IRIS. The review and approval by the Department of such a proposed value would depend upon the justification and documentation provided to support it. The development of an alternative value when a USEPA derived CSF or UR is available in IRIS or HEAST is rarely justifiable and the risk assessor should contact the MA DEP Office of Research and Standards early on in the site assessment process for prior approval before proceeding.

7.2.3 Relative Absorption Factors (RAFs)

The *R*elative *A*bsorption *F*actor (RAF) is used to account for differences in the absorption of a COC under assumed exposure conditions at the site (exposure route and matrix) relative to the absorption of the COC under the experimental conditions upon which the dose-response value is based. RAFs are used *in lieu of absorption efficiencies* to ensure that the exposures evaluated at the disposal site are comparable to the toxicity information identified in the literature.

The reference doses, reference concentrations, slope factors and unit risks used in quantitative risk assessment are typically based upon controlled laboratory experiments in which animal test species are exposed in some manner to the chemical under study. Many important features vary from study to study: the test animal may vary (e.g., mice, rats, rabbits or even humans may be used); the chemical may be administered orally, dermally, via inhalation or injected; and the material may be administered in different matrices (e.g., neat, dissolved in oil or mixed with food). At disposal sites, the exposures of concern also vary widely and rarely correspond to the exact conditions under which the toxicity information was derived. Typical site-related exposure pathways include the incidental ingestion of contaminated soil by young children and the dermal absorption of a substance from surface water.

The RAF is used to adjust the calculated exposure (e.g., the soil ingestion exposure of a child) in such a way that it is comparable to the toxicity information (e.g., derived from a study in which rats were administered by gavage a chemical dissolved in olive oil).

A unique RAF should be determined or estimated for a chemical for each combination of toxicity value and route of exposure. This means that multiple RAFs may be required in order to conduct the quantitative risk assessment. To estimate an RAF, two factors must be identified:

- the absorption efficiency for the chemical via the route and medium of exposure being evaluated for the disposal site, and

- the absorption efficiency for the route and medium of exposure in the experimental study which is the basis of the dose-response value for the chemical in question.

Thus, the RAF adjusts the dose (or exposure) estimates based on these ***two*** absorption efficiencies. The RAF is calculated as follows:

$$RAF = \frac{Absorption\ Efficiency_{SITE\ route/medium\ of\ exposure}}{Absorption\ Efficiency_{STUDY\ route/medium\ of\ exposure}} \qquad \textbf{(7-2)}$$

It is *very* important to determine whether the toxicity value is based on a *absorbed* or *applied* dose. The above equation is for a dose response value based on an applied dose. If the dose response value has been derived from an absorbed dose, then the RAF is simply equal to the absorption efficiency via the route and medium under consideration.

An example of the calculation of an RAF for dermal exposure to benzo(a)pyrene (carcinogenic effects) in soil is presented in Example 7.1 (taken from MADEP, 1992b).

RAFs developed by MADEP Office of Research and Standards staff are available through the MA DEP's Risk Assessment Bulletin Board. A number of DEP derived RAFs are listed in the Toxicity Information section of the *Risk Assessment ShortForm - Residential Scenario* and accompanying documentation (MADEP, 1992b). USEPA's Risk Assessment Guidance for Superfund (1989a), Appendix A also provides guidance for the "Adjustments For Absorption Efficiency" - a process similar to the development of RAFs.

The risk assessor is reminded that an absorption efficiency (or absorption factor) which does not consider derivation of the toxicity values (Reference Dose, Reference Concentration, Slope Factor or Unit Risk) is <u>not</u> an RAF.

7.2.4 Groups of Chemicals

The discussion in this section has focused on the toxicity information available for specific chemicals. There are several groups of closely related compounds for which alternative approaches to the identification of dose-response values have been proposed and specific guidance has been requested. These groups include:

- Chlorinated dioxins and furans
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated Biphenyls (PCBs)
- Total Petroleum Hydrocarbons (TPH)

Approaches to evaluating the toxicity of each of these groups is described below.

Example 7.1

EXAMPLE DERIVATION:
RAF for the Cancer Risk Evaluation of Site Soil Dermal Exposures

The oral slope factor for benzo(a)pyrene (B[a]P) is listed in IRIS as 7.3 $(mg/kg/day)^{-1}$ and is based on a dietary study in mice. The oral absorption of ^{14}C-labeled B[a]P, dissolved in peanut oil and administered by gavage, was studied in rats (Hecht et al., 1979). Absorption was determined by recovery of label in urine and feces. Unchanged B[a]P recovered in feces was estimated at 9% of the total dose, with all other fecal radioactivity (85% of applied dose) recovered as metabolites. This suggests an oral absorption efficiency of 91%.

The percutaneous absorption of ^{14}C-B[a]P was studied in vivo in Swiss Webster mice (Sanders et al., 1986) and in Sprague-Dawley rats (Yang et al., 1986). Absorption was determined by analyzing radioactivity in urine, feces and tissues, and by analysis of residual label at the site of application. Dermal absorption efficiency was measured as 40% (in mice) and 6% (in rats) in 24 hrs. The higher value of 40% is selected as a protective estimate for human dermal exposure to pure compound. In vitro estimates are lower, ranging from 0.1%-15% in humans and animals (Kao et al., 1985; Kao et al., 1988) and are not considered applicable to human exposure. The in vivo percutaneous absorption of soil-adsorbed B[a]P was determined in rats by Yang et al. (1989). The range of absorbed doses was 1.3% - 9.2% depending on the amount of soil applied. More efficient absorption occurred at lower soil application rates. Wester et al. (1990) confirms a low absorption for soil-associated B[a]P in the rhesus monkey with a range of 9% - 18%. The upper limit of 18% is selected as a protective estimate for human exposure to B[a]P contaminated soil.

The dermal penetration of B[a]P, applied as a complex organic mixture, seems to be representative of the dermal penetration of other PAHs examined in this study (Dankovic et al., 1989) including pyrene, benzanthracene, benzofluorene, methylchrysene, chrysene, benzofluoranthene and benzo[e]pyrene. The disappearance half-life of B[a]P was 6.7 hours with the other PAHs ranging from 5.0 - 8.8 hours. The disappearance half-life of B[a]P was decreased to 3 hours when pure B[a]P was applied to skin in acetone. These data suggest a 50% decrease in dermal absorption of B[a]P when applied as an environmental mixture (20%) rather than as neat compound (40%). This compares closely with the upper limit of 18% dermal absorption efficiency selected from the study of Wester et al.(1990) for soil-associated B[a]P.

The RAF specific to the cancer risk evaluation of for soil dermal contact exposures would be the ratio:

$$\text{Absorption Efficiency}_{\text{B[a]P from soil via dermal contact}} \div \text{Absorption Efficiency}_{\text{B[a]P via oral exposure}}$$

$$RAF = 0.18 \div 0.91 = 0.2$$

7.2.4.1 Chlorinated Dioxins and Furans

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzifurans (PCDFs) comprise a family of chemicals containing 210 specific monochlorinated and polychlorinated congeners. In 1987, USEPA formally adopted an interim procedure for estimating risks associated with complex environmental mixtures containing PCDDs and PCDFs (Bellin and Barnes, 1987). The procedure used a set of **toxicity equivalency factors** (TEFs) to convert the concentration of congeners into an equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), the most toxic of the 210 congeners. The TEFs have been reviewed and updated periodically, the most recent update being USEPA (1989b) and MADEP (Silverman and Hutcheson, 1991).

A list of current TEFs is presented in Table 7.2. Documentation of the derivation of these toxicity equivalency factors is available from the MADEP Office of Research and Standards and may be accessed through the MA DEP Bulletin Board.

7.2.4.2 Polycylic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are a class of structurally similar chemical compounds characterized by the presence of fused aromatic rings. PAHs

Table 7.2
MADEP Derived Toxicity Equivalency Factors (TEFs) for Polychlorinated Dioxins and Dibenzofurans

Compound	TEF
DIOXINS:	
Mono-, Di- and Trichlorinated dibenzo-p-dioxins	0.001
2,3,7,8-Tetrachlorinated dibenzo-p-dioxin	1
Other tetrachlorinated dibenzo-p-dioxins	0.01
2,3,7,8-Pentachlorinated dibenzo-p-dioxins	0.5
Other Pentachlorinated dibenzo-p-dioxins	0.05
2,3,7,8-Hexachlorinated dibenzo-p-dioxins	0.1
Other Hexachlorinated dibenzo-p-dioxins	0.01
2,3,7,8-Heptachlorinated dibenzo-p-dioxins	0.1
Other Heptachlorinated dibenzo-p-dioxins	0.01
Octochlorinated dibenzo-p-dioxin	0.001
FURANS:	
Mono-, Di- and Trichlorinated dibenzofurans	0.001
2,3,7,8-Tetrachlorinated dibenzofuran	0.1
Other Tetrachlorinated dibenzofurans	0.01
2,3,7,8-Pentachlorinated dibenzofurans	0.5
Other Pentachlorinated dibenzofurans	0.05
2,3,7,8-Hexachlorinated dibenzofurans	0.1
Other Hexachlorinated dibenzofurans	0.01
2,3,7,8-Heptachlorinated dibenzofurans	0.1
Other Heptachlorinated dibenzofurans	0.01
Octochlorinated dibenzofurans	0.001

from MADEP (Silverman and Hutcheson, 1991)

are typically formed during the incomplete burning of organic material including coal, oil, gasoline and garbage. PAHs are also found in crude oil, coal tar, creosote and asphalt. PAHs are associated with human activities (the combustion of fossil fuels) and natural occurrences (such as forest fires), and they are considered to be ubiquitous in the environment at some level.

PAHs are often discussed as a group because they are commonly found as mixtures of two or more compounds in the environment. In addition, they are often treated similarly in risk assessments due to their similar structures and toxicities. It should be noted that, while PAHs are often discussed as a group, the individual chemicals are evaluated as separate chemicals in the risk characterization. There are over 100 chemicals in this family of compounds, although a smaller number are routinely reported at disposal sites (Table 7.3). ***The PAH's which are often present at sites but are unreported may result in the underestimation of potential risks.***

Table 7.3

PAH's Commonly Reported at c.21E Disposal Sites and Carcinogenicity Weight-of-Evidence Classifications

	USEPA[1]	IARC[2]
Acenaphthene	N/A	N/A
Acenaphthylene	D	N/A
Anthracene	D	3
Benz(a)anthracene	B2	2A
Benz(a)pyrene	B2	2A
Benzo(e)pyrene	N/A	3
Benzo(b)fluoranthene	B2	2B
Benzo(g,h,i)perylene	N/A	3
Benzo(j)fluoranthene	N/A	2B
Benzo(k)fluoranthene	B2	2B
Chrysene	B2	3
Dibenz(a,h,)anthracene	B2	N/A
Fluoranthene	D	3
Fluorene	N/A	3
Indeno(1,2,3-cd)pyrene	B2	2B
2-Methylnaphthalene	N/A	N/A
Naphthalene	D	3
Phenanthrene	D	3
Pyrene	D	3

1 - U.S. Environmental Protection Agency. **B2**: Probable Human Carcinogen; **D**: Not Classifiable
2 - International Agency for Research on Cancer. **2A**: Probable Human Carcinogen; **2B**: Possible Human Carcinogen; **3**: Not Classifiable
N/A - Not Available

Among the polycyclic aromatic hydrocarbons, the USEPA (IRIS, 1993) has classified seven chemicals as *probable human carcinogens* (identified in Table 7.3 as USEPA Class B2). The classification of PAHs by the International Agency for Research on Cancer (IARC) is fairly consistent with that of the EPA. PAH's which are considered unclassified (either N/A, D or 3 in Table 7.3) may also contribute to carcinogenic risk (Nisbet and LaGoy, 1992) and should not necessarily be assumed to be "*noncarcinogens*" which would be USEPA Class *E*.

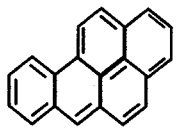
All PAHs identified as contaminants of concern should be evaluated in terms of potential noncancer risk. ***Remember that the carcinogenic PAHs may also be associated with noncancer health effects and must be included in this evaluation.***

Historically, risk assessments involving PAHs become problematic due to the general lack of toxicity information available for many of the compounds reported at disposal sites. The following paragraphs discuss the MA DEP recommended approaches for the evaluation of cancer and noncancer risk of harm posed by exposure to polycyclic aromatic hydrocarbons.

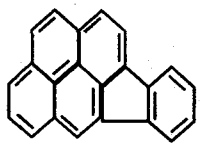
PAH Cancer Risk:

Until recently the only cancer slope factor the USEPA published for PAH's was for the chemical benzo[a]pyrene (B[a]P). In the absence of further chemical-specific information, the EPA and MADEP guidance instructed risk assessors to assign the B[a]P slope factor to all PAHs considered to be carcinogenic. This approach was considered to be protective of public health as benzo[a]pyrene is thought to be one of the most potent carcinogens among the PAH's. In 1993, USEPA formally adopted provisional guidance for estimating cancer risks associated with polycyclic aromatics hydrocarbons (USEPA, 1993). The procedure uses information from the scientific literature to estimate the carcinogenic potency of several PAHs relative to benz[a]pyrene. These **relative potencies** may be used to modify the CSF developed for benzo[a]pyrene for each PAH, or to calculate B[a]P-equivalent concentrations for each of the PAH's (which would then be used with the B[a]P slope factor). The latter approach is similar to that used for the evaluation of dioxins.

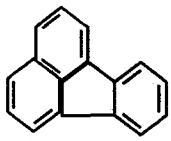
The relative potency values published by the USEPA and others (Chu and Chen, 1984; Clement, 1988; Nisbet and LaGoy, 1992) are being reviewed and may be adopted (perhaps in a modified form) by MA DEP Office of Research and Standards. A list of the USEPA relative potency values is presented in Table 7.4 for use in c.21E risk characterizations pending publication of MADEP recommended values (which will be available through the MA DEP Bulletin Board System).



Benzo[a]pyrene



Indeno[1,2,3-cd]pyrene



Fluoranthene

PAH Noncancer Risk:

While the USEPA has published (in *IRIS* and *HEAST*) threshold effects toxicity information for a number of polycyclic aromatic hydrocarbons, for many other members of this chemical family such information has not yet been developed. In order to adequately characterize the noncancer risks associated with these PAHs, MADEP recommends that the published reference dose, reference concentration, or analogous value for a structurally similar PAH be adopted for each compound for which sufficient chemical-specific toxicological information is unavailable.

Examples of how the potential toxicity of individual PAHs may be evaluated are described in Example 7.2.

7.2.4.3 Polychlorinated Biphenyls (PCBs).

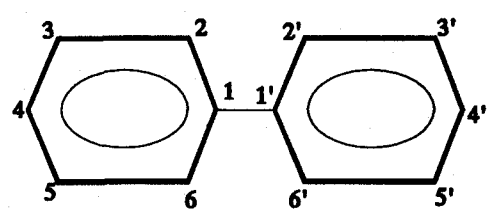
Polychlorinated biphenyls (PCBs) is the name given to the general class of compounds in which one or more chlorine atoms are bonded to a biphenyl structure (Figure 7.2). The PCB family is comprised of 209 different variants, or **congeners**, depending upon the number of chlorine atoms present and their position on the biphenyl structure. PCBs may also be described according to *isomeric groups*, which are families of PCBs having the same number of chlorine atoms and thus the same molecular weight. For example, 2,2'-Dichlorobiphenyl is one of 209 chlorinated biphenyl congeners and one of 12 possible dichlorobiphenyls; these 12 dichlorobiphenyls are considered **isomers** of each other.

Table 7.4
Relative Potency Values for Individual PAH's: (USEPA, 1993)

Compound	Relative Potency Factor
Acenaphthene	NA
Acenaphthylene	NA
Anthracene	NA
Benz(a)anthracene	0.1
Benz(a)pyrene	1
Benzo(b)fluoranthene	0.1
Benzo(g,h,i)perylene	NA
Benzo(k)fluoranthene	0.01
Chrysene	0.01
Dibenz(a,h,)anthracene	1
Fluoranthene	NA
Fluorene	NA
Indeno(1,2,3-cd)pyrene	0.1
2-Methylnaphthalene	NA
Naphthalene	NA
Phenanthrene	NA
Pyrene	NA

NA - Chemical is not currently considered to be carcinogenic by USEPA so no relative potency value is currently applicable.

PCBs are typically found in the environment as mixtures of different PCB congeners. These mixtures (also known as ***Aroclors***, a trade name of the Monsanto Corporation) are identified by a four digit numbering code in which the first two digits (12) indicate that the parent molecule (the biphenyl) has twelve carbon atoms, and the last two digits indicate the percent chlorine by weight. Thus, Aroclor 1260 is a chlorinated biphenyl mixture with an average chlorine content of 60%. [The only exception to this nomenclature is Aroclor 1016, which retains the name by which it was known during development. Aroclor 1016 is a mixture which has an average chlorine percentage of 41.5%, making it very similar to Aroclor 1242.] It is important to note that an Aroclor mixture may contain dozens of individual PCB congeners representing several isomeric groups.



The general chemical structure of
Polychlorinated Biphenyls

Example 7.2

EVALUATION OF POLYCYCLIC AROMATIC HYDROCARBONS (PAH's)

Cancer Risk

A polycyclic aromatic hydrocarbon for which a cancer slope factor has not been developed by USEPA may be evaluated using the relative potency values recommended by USEPA (Table 7.4). These values can be used in one of two ways which are mathematically equivalent. To illustrate, let's assume that **Indeno[1,2,3-cd]pyrene** was reported at a disposal site at a concentration of **2 mg/kg**.

- In the first approach, the relative potency factor for indeno[1,2,3-cd]pyrene (**0.1**, from Table 7.4) is used to estimate a cancer slope factor for this compound by adjusting the slope factor for benzo[a]pyrene (**7.3 mg/kg/day**, from USEPA *IRIS*, 1993):

$$CSF_{i[1,2,3\text{-}cd]p} = 0.1 \times 7.3\ (mg/kg/day)^{-1} = 0.73\ (mg/kg/day)^{-1}$$

- The second approach would be to adjust the concentration of indeno[1,2,3-cd]pyrene (**2 mg/kg**, in this example) by the relative potency value (**0.1**, from Table 7.4) to estimate a benzo[a]pyrene equivalent concentration, to which the B[a]P slope factor would be applied:

$$B[a]P_{equiv.\ conc.} = 0.1 \times 2\ mg/kg = 0.2\ mg/kg$$

Noncancer Risk

A polycyclic aromatic hydrocarbon for which a reference dose (RfD) has not been developed by USEPA may be evaluated using a reference dose from a structurally similar PAH. Using the example above, indeno[1,2,3-cd]pyrene (for which there is currently no RfD) is structurally similar to fluoranthene: both chemicals have a 5-carbon ring structure bound to three aromatic rings, although indeno[1,2,3-cd]pyrene has two additional aromatic rings (see Figure 7.1). The reference dose for fluoranthene is 0.04 mg/kg/day (USEPA *IRIS*, 1993). This value would be adopted to evaluate potential noncancer risks associated with indeno[1,2,3-cd]pyrene.

As described earlier in this section, MADEP relies heavily upon the work of the USEPA and its published collection of agency-reviewed toxicity information published primarily in the *Integrated Risk Information System* (IRIS) and the *Health Effects Assessment Summary Tables* (HEAST). While it is generally unnecessary to duplicate the USEPA's efforts in developing toxicity information, the DEP Office of Research and Standards has staff toxicologists to fill data gaps or review supplemental information. The following is a summary of MADEP's general approach to the selection of toxicity information:

- When it exists , MADEP recommends the use of USEPA toxicity information from *IRIS* or *HEAST* for a given chemical.

- For *mixtures* of chemicals, the USEPA may publish toxicity information for the mixture as a whole or for *some* constituents of the mixture. When information is only available for certain formulations of a mixture, or for a limited number of constituents of a mixture, MADEP must, *as a matter of science policy*, determine how the limited information should be extrapolated to (a) other formulations of the mixture, or (b) the mixture as a whole.

For the evaluation of polychlorinated biphenyls, MADEP has specific policies based upon the information available at the time that this document was prepared. The reader is urged to consult the MADEP Office of Research and Standards or the MADEP Risk Assessment Bulletin Board for the current status of this information. The MADEP/ORS recommends the following:

- the use of the USEPA derived CSF of 7.7 $(mg/kg/day)^{-1}$ for all PCB mixtures. "*Although it is known that PCB congeners vary greatly as to their potency in producing biological effects, for purposes of this carcinogenicity assessment, Aroclor 1260 is intended to be representative of all PCB mixtures.*" (USEPA *IRIS* file for PCBs, 1993)

- the use of the Aroclor-specific USEPA derived chronic, oral reference dose of 7×10^{-5} mg/kg/day for Aroclor 1016 (USEPA *IRIS* file for Aroclor 1016, 1993). This value may also be applicable to PCB mixtures containing similarly chlorinated congeners, such as Aroclor 1242.

- the use of the Aroclor-specific USEPA derived chronic, oral reference dose of 2×10^{-5} mg/kg/day for Aroclor 1254 (USEPA *IRIS* file for Aroclor 1254, 1994). This value may also be applicable to PCB mixtures containing similarly chlorinated congeners, such as Aroclor 1260.

- the use of other Aroclor-specific USEPA derived values, as they become available.

7.2.4.4 Total Petroleum Hydrocarbons.

The Total Petroleum Hydrocarbon (TPH) measure often reported for c.21E disposal sites is generally considered inadequate for the purposes of site specific risk assessment. The commonly used infra-red (IR) analysis technique does not identify individual compounds or related groups of constituents. The mixture of petroleum hydrocarbons reported as the TPH parameter includes a wide range of compounds of different toxicities. Thus, the health effects (or the risk of such effects) associated with exposure to particular concentrations of "TPH" cannot be determined.

The MADEP Bureau of Waste Site Cleanup is developing a "*Policy for the Investigation, Assessment and Remediation of Petroleum Releases*" (or the Petroleum Policy) which will include a section entitled "*Interim Final Petroleum Report: Development of a Health Based*

Alternative to the TPH Parameter." That document identifies an alternative to the TPH parameter which can be used to conduct site-specific risk assessments and the document will propose dose-response values to be used with the specified analytical parameters. The key element of the policy is that the proposed analytical technique would allow the quantification of several ranges of compounds (rather than a single TPH result) and each range would be assigned a "reference compound" whose toxicity would be representative for all chemicals in that range.

The interim final report, *Development of a Risk Based Alternative to the TPH Parameter* (MADEP, 1994a) is currently available through the MA DEP Bulletin Board and the State Bookstore.

7.2.5 Recommended Format

Tables 7.5 and 7.6 present recommended formats for presentation of dose-response information for threshold and nonthreshold effects, respectively.

For threshold effects, separate tables should be presented for chronic and subchronic effects. Information that should be presented in the table includes:

- Name
- Toxicity value
- Source of toxicity value (i.e IRIS, HEAST)
- Date that the toxicity value was last verified
- Study Type - how the OHM was administered
- Confidence Level - identified by USEPA
- Critical Effect - target organ and toxic effect on which the dose-response value is based
- Test Animal - animal species on which the study is based
- Uncertainty of modifying factors - factors listed by agency generating the toxicity value

For nonthreshold effects, the information that should be presented in the table includes:

- Name
- Potency Value or Unit Risk
- Source of toxicity value (i.e IRIS, HEAST)
- Date that the toxicity value was last verified
- Study Type - how the OHM was administered
- Weight of Evidence - USEPA weight of evidence classification
- Test Animal - animal species on which the study is based
- Cancer type - tumor type listed by the agency establishing the toxicity value

7.3 EXPOSURE ASSESSMENT - CONCEPTS

The exposure assessment is a critical component of the site assessment process as it describes, both qualitatively and quantitatively, the contact between the contamination and the people who are potentially affected by the contamination. The exposure assessment must be consistent with the primary questions asked in the risk characterization process:

Given the current and identified foreseeable uses of the site, would the oil or hazardous material present pose significant risk of harm to health, safety, public welfare or environment if no further remedial action were to occur?

or

If a proposed remedial alternative is implemented and meets its identified remediation goals, will a condition of no significant risk of harm to health, safety, public welfare and the environment be achieved given the current and identified foreseeable uses of the site?

Whether the risk characterization is a **baseline** assessment (which answers the first question) or an evaluation of a proposed remedial alternative, the exposure assessment must incorporate site conditions associated with both current use and identified foreseeable uses of the site and surrounding environment. In this context site *use* or site *activity* are short-hand references for the exposures to site contaminants which could occur at or near the disposal site.

There are two important results of the exposure assessment: exposure profiles and quantitative estimates of exposure. An exposure profile is a narrative description of the exposures which may occur at the disposal site, and the information is often summarized in one or more tables for easy reference. The quantification of exposure translates the narrative exposure profile into a series of exposure equations resulting in numerical estimates of exposure. These numerical estimates are subsequently used in the risk calculations.

EXAMPLES: Dose-Response Summary Tables

Table 7.2.5

Chronic Oral Reference Doses

Chemical Name	CAS Number	Chronic Oral RfD	Source	Date Last Verified	Study Type	Confidence Level	Target Organ/ Critical Effect	Test Animal	Uncertainty/ Modifying Factors
Carbon Tetrachloride	56-23-5	7E-04	IRIS	1/94	Gavage, 12 weeks	Medium	Liver/Lesions	Rat	1,000
c-1,2-Dichloroethylene	156-59-2	1E-02	HEAST	1/94	Gavage, 90 day	N/A	Blood/Decreased Hematocrit	Rat	3,000
Dichloromethane	75-09-2	6E-02	IRIS	1/94	Drinking Water, 2-year	Medium	Liver/Liver Toxicity	Rat	100

Table 7.2.6

Oral Cancer Slope Factors

Chemical Name	CAS Number	Oral CSF	Source	Date Last Verified	Study Type	Weight of Evidence	Tumor Type	Test Animal(s)
Carbon Tetrachloride	56-23-5	1.3E-01	IRIS	1/94	Gavage	B2	Hepatocellular carcinomas/hepatomas	Hamster Mouse Mouse Rat
p-Cloronitrobenzene	100-00-5	1.8E-02	HEAST	1/94	Diet	B2	Cardiovascular System Tumors	Mouse
Dichloromethane	75-09-2	7.5E-03	IRIS	1/94	Inhalation Drinking Water	B2	Hepatocellular adenomas or carcinomas Hepatocellular cancer and neoplastic nodules	Mouse Mouse

Baseline Risk Characterizations

Baseline risk characterizations evaluate the "***no action***" alternative: What risks would be posed by the contamination if no remedial action were taken? If risk reduction measures have already been completed, then the baseline risk characterization would evaluate the risks if no *further* remedial action were taken.

Anticipated or proposed remedial actions or land use restrictions should never be incorporated into a baseline risk characterization, as it would no longer be an evaluation of the "no action" alternative. By extension, completed Immediate Response Actions (IRS's), Release Abatement Measures (RAM's) or Utility-related Abatement Measures (URAM's) can be considered in a baseline risk characterization ***only if they are considered to be permanent***.

For example, temporary fencing of an area as an Immediate Response Action to eliminate direct contact with contaminated soils should not be incorporated into a baseline risk characterization. Rather, the conditions which would exist in the absence of the IRA should be evaluated to determine the need for a permanent solution: the exposure assessment would assume that no fence is in place. If, however, a completed IRA, RAM or URAM permanently changes the exposure potential at a disposal site (e.g., the complete removal and disposal of contaminated soil), that impact of that *permanent* response action would be considered in the baseline assessment.

7.3.1 Development of Exposure Profiles

Exposure profiles provide the narrative description of how exposure takes place at the disposal site. The exposure profiles assist the risk assessor in identifying appropriate values for the exposure variables (such as intake rate, frequency of exposure, etc...) by providing a context within which the variables have meaning. Exposure profiles are sometimes referred to as "*exposure scenarios*".

An exposure profile should be developed for each of the receptors identified for all current and foreseeable uses of the site. The number and content of the exposure profiles will vary from site-to-site, reflecting the nature and complexity of the exposures which may occur.

There are also several ways to streamline this process and minimize the number of exposure profiles needed. If the current use of the site is assumed to remain unchanged into the future, then separate exposure profiles need not be developed for both the current and future receptors. For example, if a residential area is being evaluated and the land is likely to remain residential, it is unnecessary to construct exposure profiles to represent other uses. For a property where the frequency and intensity of exposure is low, it is also possible to assume that the use and activities will remain the same, but this assumption requires an activity and use limitation, as detailed in Section 2.1 of this Guidance Document.

Another situation conducive to streamlining exposure profiles is when two (or more) hypothetical receptors share the same exposures but the magnitude of exposure is demonstrably greater for one. In this case, a detailed exposure profile may be developed for the highly exposed receptor, accompanied by the conclusion that lesser exposed receptors will also be protected.

The USEPA *Guidelines for Exposure Assessment* (1992) describes exposure scenarios (exposure profiles) as containing the "*facts, data, assumptions, inferences, and sometimes professional judgement*" about how the exposures take place. Since these factors determine the magnitude of exposure (and thus the magnitude of the risk posed by the disposal site) it is important that there be a clear description and summary of this information. The exposure profiles allow anyone concerned about the disposal site to read and understand what was considered in the risk characterization and what was the basis for the decision on the need for remedial action.

Risk Characterizations for Remedial Alternatives

A risk characterization for a remedial alternative is performed to determine whether that action will achieve (if the alternative is *proposed*) or has achieved (if the alternative has been *implemented*) a condition of No Significant Risk.

The conclusions of the risk characterization report must be explicit about the conditions and assumptions upon which the risk characterization is based. Sections 40.0923(4) and (5) of the MCP require that such conditions and assumptions (such as *Activity and Use Limitations*, or the implementation of a remedial measure) be clearly and concisely stated and it must be noted that the results of the risk characterization are only valid upon if and when the remedial measures (including AULs) are carried out.

Note that the information which goes into an exposure profile (the receptors, exposure points, exposure point concentrations, etc...) comes from the site investigation. Thus the investigation must be designed in such a way to provide the risk assessor with information suitable for the risk characterization. These exposure attributes are interrelated (e.g., the location of the exposure points depends on the migration of the OHM and the activities of the receptors) so the information should be collected and processed in an iterative manner. The following subsections discuss the specific information which must be gathered for the risk characterization, presented in the site assessment report or the documentation of the risk characterization and summarized in the exposure profiles.

7.3.1.1 Site Information Required to Quantify Exposures

The exposure assessment begins with a description of the physical characteristics of the disposal site. This information is typically collected as part of a Phase I (310 CMR 40.0480) or Phase II (310 CMR 40.830) site investigation, although the type of information needed and the appropriate level of detail should reflect the nature and complexity of the site as well as point in time at which the risk characterization is being performed. Relevant site information would include:

- the address and location of the disposal site;
- a detailed map of the site and surrounding area;
- a description of the land uses at and surrounding the disposal site;
- a listing and description of natural resources and vegetation at or near the disposal site (e.g., surface waters, wetlands, forests, grassy areas, etc...);
- a summary of the use of oil or hazardous material and a description of any known and relevant releases which may have occurred;
- a summary of site hydrogeological characteristics, including depth to groundwater, direction and rate of flow, soil types, etc...
- a summary of background concentrations of oil or hazardous materials

WHO ?...WHAT ?...WHEN ?...WHERE ?...HOW ?

The Exposure Profile should contain information to completely describe each receptor's exposures to oil or hazardous material at the disposal site.

- ***Who*** is exposed? The exposure profile should be developed for each receptor likely to be present at the disposal site or in the surrounding environment, and who, as a result, would likely be exposed to OHM.
- ***Where*** does the exposure occur? Is the contamination limited to the area near the original source, or has/will migration of contaminants result in potential exposures at a more distant point?
- ***What*** are the receptors exposed to? What oil or hazardous materials are present at the disposal site? What concentrations of the material have been reported?
- ***When*** does the exposure occur? Are the exposures likely under current site conditions, or will the exposure be of concern if the site use changes in the future?
- ***How*** does exposure occur, and how often? What receptor actions or activities result in contact with the oil or hazardous material? Do these events happen every day or are they rare incidents?

Some of this information may be available through the Massachusetts Geographic Information System (MASS-GIS) which provides color plots or digital data of wetland areas, sole source aquifers, endangered species habitats and other natural resource areas. Several data packages have been developed specific to c.21E site investigations. For a full listing of available data, contact MassGIS, EOEA Data Center, 20 Somerset Street, Boston, MA 02108, (617) 727-3888.

7.3.1.2 Identification of Potential Human Receptors

Section 40.0921 of the Massachusetts Contingency Plan contains regulations specific to the identification of receptors at c.21E sites.

The documentation of the risk characterization should contain a description of the potentially exposed persons who live, work, play, visit, or otherwise come to the disposal site or the surrounding environment. In identifying these receptors, the risk assessor must consider not only those people currently associated with the disposal site, but also those who may frequent the site in the future if the use of the site were to change (See the discussion on Current and Foreseeable Use, Section 2.1).

The human receptors are described as subpopulations (subsets of the more diverse overall population of Massachusetts) rather than specific individuals so that the results of the risk characterization can be generalized. For example "*children*", a specific, identifiable group within the larger general population of humans, are often identified as receptors of concern at c.21E disposal sites. (Hypothetically a risk assessor could identify a specific (real) child who lives at the site and conduct a risk assessment based upon that child's physical characteristics and behavioral patterns, but the result of such an assessment would be valid only for that child and could not be generalized to other children who may visit the site or live there in the future.) Note, though, that while the receptors are described in terms of "subpopulations" or "subgroups", the product of the risk assessment is still an estimate of the risk that applies to the protection of an *individual* within that group. The MCP focuses on individual risk, *not* population risk.

The receptor groups are described in terms that highlight their relationship to the site and the unique characteristics of the subpopulation. For example, the term ***site residents*** describes a diverse group which lives (or may in the future live) at the disposal site. For the purposes of the risk characterization the site residents should be further divided into subpopulations based upon gender and age if those factors are indicative of a higher exposure potential or greater susceptibility to environmental contamination. Young children and women of child-bearing age are often chosen as receptors of concern in residential locations because of these factors. At industrial locations, adults may be the most susceptible receptors. Identification of the most sensitive subpopulation should be done on a site by site basis.

Example 7.3

EXAMPLE RECEPTOR: Site Resident		
Exposure of Concern/ Health Endpoint	**Typical Subpopulation(s) Evaluated**	**Discussion**
Acute Exposure, Noncancer Effects	2 year old child 22 year old woman	The young child is of concern for acute exposures (typically 1 event or several exposures over a short period of time) due to the higher exposure potential while potential developmental effects could be of concern for the woman of child-bearing age.
Subchronic Exposure, Noncancer Effects	2 year old child 22 year old woman	The young child is of concern for subchronic exposures (typically 2 weeks to a year) due to the higher exposure potential while potential developmental effects could be of concern for the woman of child-bearing age.
Chronic Exposures, Noncancer Effects	1-8 year old child	A young child would typically experience the highest exposure in a residential setting. Chronic exposures to adults would not have to be specifically evaluated for noncancer health effects unless the adult is assumed to take part in activities which would result in unusually high exposures.
Chronic Exposures, Cancer Risk	Resident 1-31 years old	Since the magnitude of the cancer risk is dependent upon the total amount of material contacted, a 30 year exposure which incorporates the age groups which experience the highest rates of exposure should be evaluated.

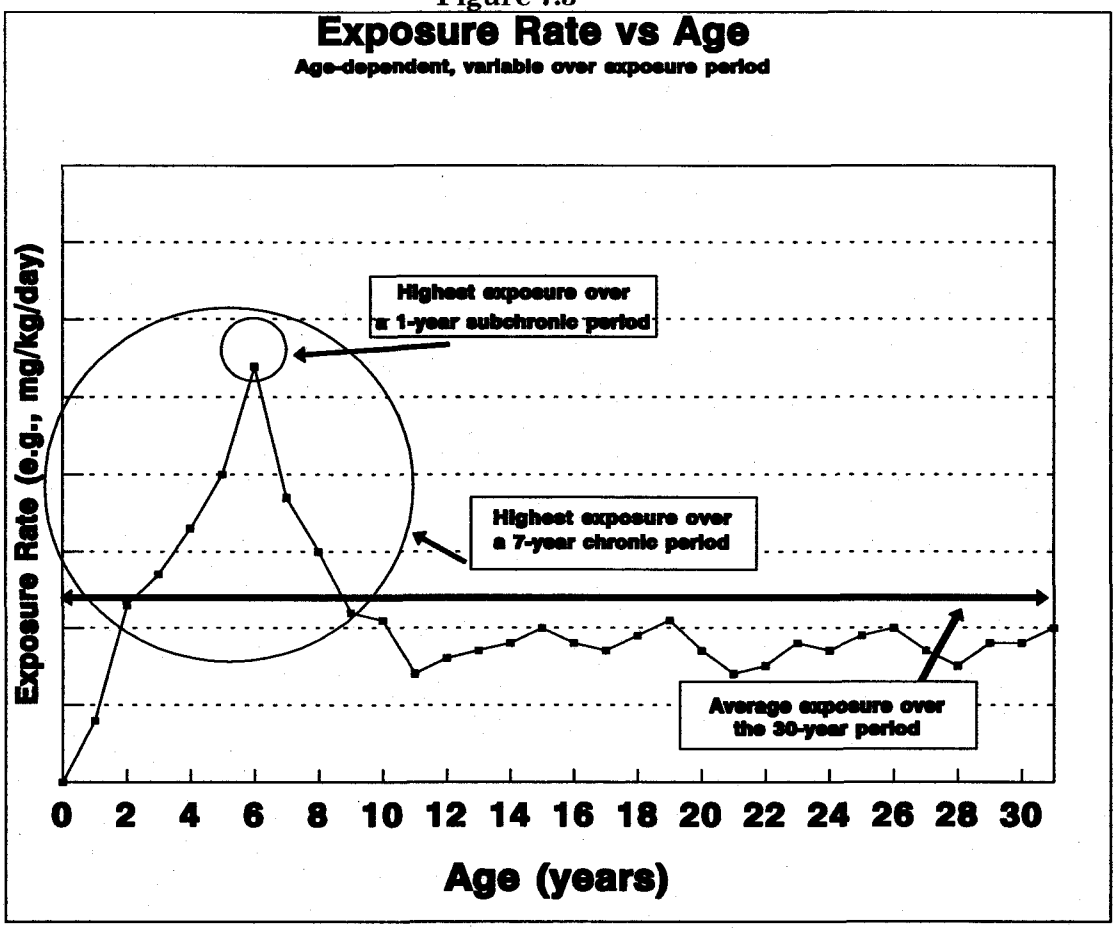
Thus to adequately evaluate the "site residents" the risk assessor may need to look at several specific receptors to insure that all sensitive subpopulations are being protected. Example 7.3 describes typical receptors who might be chosen to evaluate a residential exposure scenario.

By focusing on the subpopulations experiencing the highest rates of exposure the risk assessor may conclude that all other subpopulations at the location would be subject to lower exposures and risks than those calculated. Figure 7.3 illustrates how exposure may vary by age and highlights periods of high exposure which may need to be evaluated by the risk assessor.

7.3.1.3 Identification of Exposure Points

For receptors to be exposed to a contaminant at or from a disposal site, a realistic pathway must be established leading from the source of the oil or hazardous material to the receptor. The point at which the contact occurs is referred to as the *exposure point* (or "exposure setting"). Potential exposure points must be identified per 310 CMR 40.0924. The route by which the material travels from the source to the exposure point is called the *migration pathway*.

Figure 7.3



The migration pathway describes the movement of the material, and it is comprised of three parts: a release *source*, a release *mechanism*, and a release (or transport) *medium*. The documentation of the risk characterization must describe the source of the OHM, how the material was released to the environment and its movement through the environment. This information is routinely gathered during site investigations (see 310 CMR 40.0904), but it is restated here in terms used by risk assessors. A simple example of a migration pathway would be the volatilization of a chemical from a drum to indoor air, where the source of the OHM is the drum, the release mechanism is volatilization, and the transport medium is the air. A migration pathway may include several transport media.

Source $\xrightarrow{\text{Migration Pathway}}$ Exposure Point

Drain Pipe $\xrightarrow{\text{Discharge}}$ *Soil* $\xrightarrow{\text{Leaching}}$ *Groundwater* $\xrightarrow{\text{Migration}}$ *Water Supply Well*

Potential points of exposure may be distant from the original source material, so the risk assessor must consider the current and future migration pathways to identify all potential exposure points.

The regulations also require that *hot spots* (Section 2.2) be identified as separate and distinct exposure points for purposes of risk characterization (310 CMR 40.0924(2)). This requirement ensures that areas with high relative contamination will not simply be averaged into a wider area of lesser contamination, thus minimizing (or diluting) their potential impacts. (The MCP describes a number of risk reduction tools (IRAs, RAMs, URAMs) which can and should be used to address hot spots in a timely fashion, thus reducing overall site risks in an efficient, cost-effective manner.)

While the regulations and guidance use the term *exposure point*, the term may actually describe an area of a disposal site or surrounding environment and not necessarily a single, discrete point. The exposure point should be an area within which the receptor has an equal likelihood of exposure, such as "a backyard" or "a schoolyard". If there are areas within the site which receptors frequent at a higher rate (such as the area surrounding playground equipment within a larger schoolyard) then those areas should be evaluated as separate and distinct exposure points. Figure 7.4 depicts a site within which there are two areas that should be evaluated separately (in addition to the area of generalized contamination) as exposure points: a hot spot and a playground. Additional examples of exposure points include:

- an area where people come into contact with contaminated soil,
- a drinking water well or a potential drinking water well location
- a building into which air contaminants are migrating and accumulating in the indoor air
- an area in which ambient air contains elevated levels of site-related contaminants

In general, an exposure point for soil, sediment or surface water should be delineated by the distribution of oil or hazardous material in the environmental medium. For example, for soil, an exposure point should be a contaminated area within which the exposure of concern is likely. The area outside the boundaries of the contamination should not be included in the exposure point, and data from those areas should not be included in the concentration estimate. There are two reasons for this recommendation:

1) There is rarely enough information on current small-scale exposure patterns in the

vicinity of a contaminated area, for example a residential yard, to justify assumptions about the relative amount of time spent in the area known to be contaminated.

2) The full areal extent of contamination is not always known, unfortunately, at the time of the risk characterization. Sample collection is often focused on the areas where contamination is expected and/or obvious, and other areas are not fully characterized (although those areas may be contaminated as well). The practice of treating the contaminated area as the entire exposure provides a conservative estimate of exposure.

There may be some situations where the default approach described above is not appropriate. In cases where the extent of soil contamination is well defined and clearly constitutes only a fraction of the area over which the receptor group of concern is equally likely to be exposed, the exposure point may be an area that is somewhat larger than the contaminated area. The best example of a situation where this exception might be applied is a residential back yard. If a resident is equally likely to contact the soil at any locations within the yard, and if the contaminated area has been clearly delineated and found to comprise only a fraction of the yard, the risk assessor may opt to define the entire backyard as the exposure point.

When considering whether the exposure point should cover an area larger than that which is contaminated, the scale of the contaminated area relative to the anticipated exposure pattern is an important consideration. For example, consider a vacant lot where children are likely to play. If ¼ of a 2000 ft^2 lot were contaminated, it may be reasonable to assume that activity levels and exposures in the 500 ft^2 contaminated area are not likely to be any higher than those in the rest of the lot. However, if the ¼ of a one acre lot is contaminated, it would be more difficult to justify the assumption that activity levels in the ¼ acre that is contaminated will never be higher than in the surrounding area.

Another important consideration is whether the foreseeable activities are likely to result in more intense or more frequent exposures in some areas than in others. For example, in play parks, exposure intensity at any location depends upon the landscaping, the pattern of open space and the layout of equipment. If a small area of surface soil located within a large park were contaminated, the risk assessor may not be able to rule out the possibility that exposures to individual children will not be higher in that area than in other areas of the park. Therefore it would be more appropriate to designate the contaminated area alone as the exposure point, and not the entire park.

The burden to demonstrate that the designation of an exposure point is appropriate and conforms with this guidance rests with the risk assessor. The documentation of the risk characterization should present summary tables describing the migration pathways identified and the exposure points to be evaluated.

7.3.1.4 Identification of Exposure Routes

The mechanism by which a receptor comes into contact with the oil or hazardous material is called the *Exposure Route*. Typical exposure routes described at c.21E disposal sites include:

- **INGESTION** of contaminated soil, water or food
- **INHALATION** of contaminated air or fugitive dust
- **DERMAL ABSORPTION** from contaminated water, soil or sediments

Remember that a receptor may be exposed to oil or hazardous material at one ***or more*** exposure points, and that at each exposure point the receptor may be exposed via one **or more** routes. The exposure profile for the receptor should describe such multiple exposure scenarios in a way which makes clear to the reader that the combination of exposures to the receptor is being addressed in the risk assessment.

7.3.2.5 Identification of Exposure Pathways

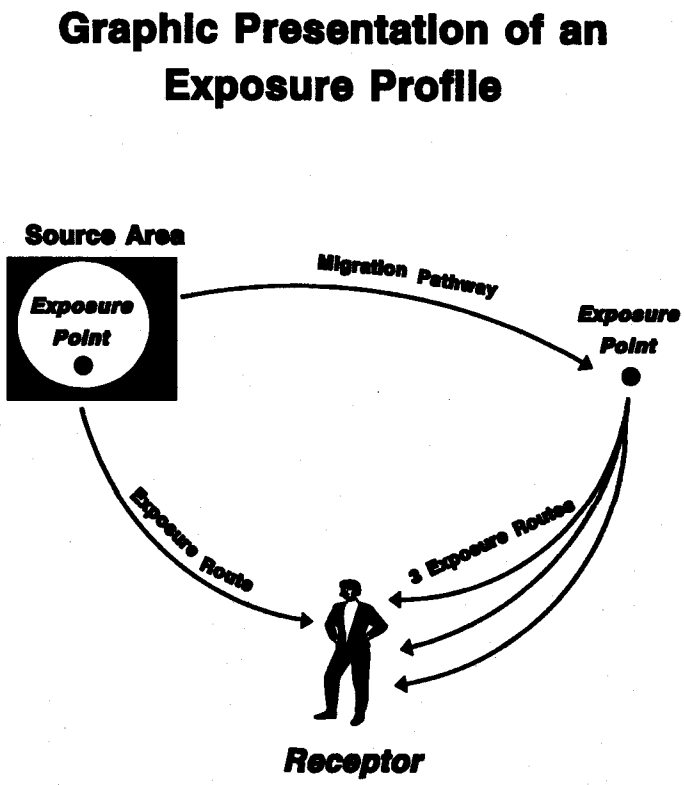
The ***Exposure Pathway*** is the term used to describe the course that the oil or hazardous material takes from the source of the material to the receptor of concern. The term encompasses the source, the migration pathway, the exposure point, the receptor and the exposure route.

Exposure Pathway:

Source — *Migration Pathway* — *Exposure Point* — *ExposureRoute* — *Receptor*

Thus the Exposure Profile (or exposure scenario) developed for each receptor would describe, in narrative and tabular form, the circumstances under which the receptor is exposed. The exposure profile may be relatively simple if a single receptor group is exposed at one location via one route of exposure. Exposures at c.21E sites are generally a bit more complex, however. A receptor group may be exposed to the oil or hazardous material through a number of exposure routes at several locations. Figure 7.5 illustrates a situation in which there is one receptor, one source of OHM, a migration pathway and four exposure routes. (There are also four exposure pathways, as there are four routes by which chemicals may move from the source to the receptor.) Example 7.4 demonstrates how a more complex example may be clearly presented in a tabular format.

7.3.2 Basic Approach/Assumptions



The basic approach which should be taken in an exposure assessment under the MCP is to produce an assessment which is realistic and health protective. The regulations (310 CMR 40.0992(2)) stipulate that the objective of a Method 3 risk characterization is to provide a conservative estimate of the impact that the oil and/or hazardous material may have on the receptors at the site and in the surrounding environment. The assessment should not be a "*worst case*" exposure assessment unless there are site-specific justifications for performing such an evaluation. (Worst case assessments are useful screening tools which may demonstrate that risks are clearly insignificant, but they are not useful in determining whether realistic risks are actually significant.) Conversely, the assessment should not represent an "*average case*" which may underestimate potential risks experienced by a large portion of the exposed subpopulation, and thus would not be considered to be health protective. This section presents guidance on identifying receptor groups that are likely to be most susceptible to contamination at the site, and on selecting exposure parameters that will result in an appropriately conservative estimate of risk to that receptor group.

Numerous attempts have been made to define a combination of exposure assumptions which would result in a reasonable yet health-protective exposure assessment. USEPA (1989) defined a **Reasonable Maximum Exposure** (RME) as "*the maximum exposure that is reasonably expected to occur at a site*" and recommended specific exposure factors (USEPA, 1991) to be used to evaluate the RME. More recently (USEPA, 1992) the concept of "*high-end*" exposure, dose and risk estimates has been introduced:

The high-end risk is taken to be a plausible estimate of the risk for persons at the upper end of the risk distribution. The intent of the high-end descriptor is to convey an estimate of risk in the upper range of the distribution, but to avoid estimates that are beyond the true distribution. Conceptually, high-end risk means risks beyond the 90th percentile of the population distribution, but not higher than the individual in the population who has the highest risk. The discriptor is intended to estimate the risks that are expected to occur in small but definable high-end segments of the subject population. The use of "above the 90th percentile" in the definition is not meant to precisely define the range of this descriptor, but rather to clarify what is meant conceptually by high-end.

Figure 7.5 graphically depicts the "high-end" exposure range (from USEPA, 1992) from a

Example 7.4

Exposure Profile Summary Table

Receptor	Age	Exposure Point	Exposure Route
Resident	Young Child, age 1-6	Residential Backyard	Soil Dermal Contact Soil Ingestion Inhalation of Volatilized Material Ingestion of Groundwater
		School Playground	Soil Dermal Contact Soil Ingestion Inhalation of Fugitive Dust
	Older Child and Adult, age 7 - 30	Residential Backyard	Soil Dermal Contact Soil Ingestion Inhalation of Volatilized Material Ingestion of Groundwater

hypothetical distribution of site exposure for a specified subpopulation.

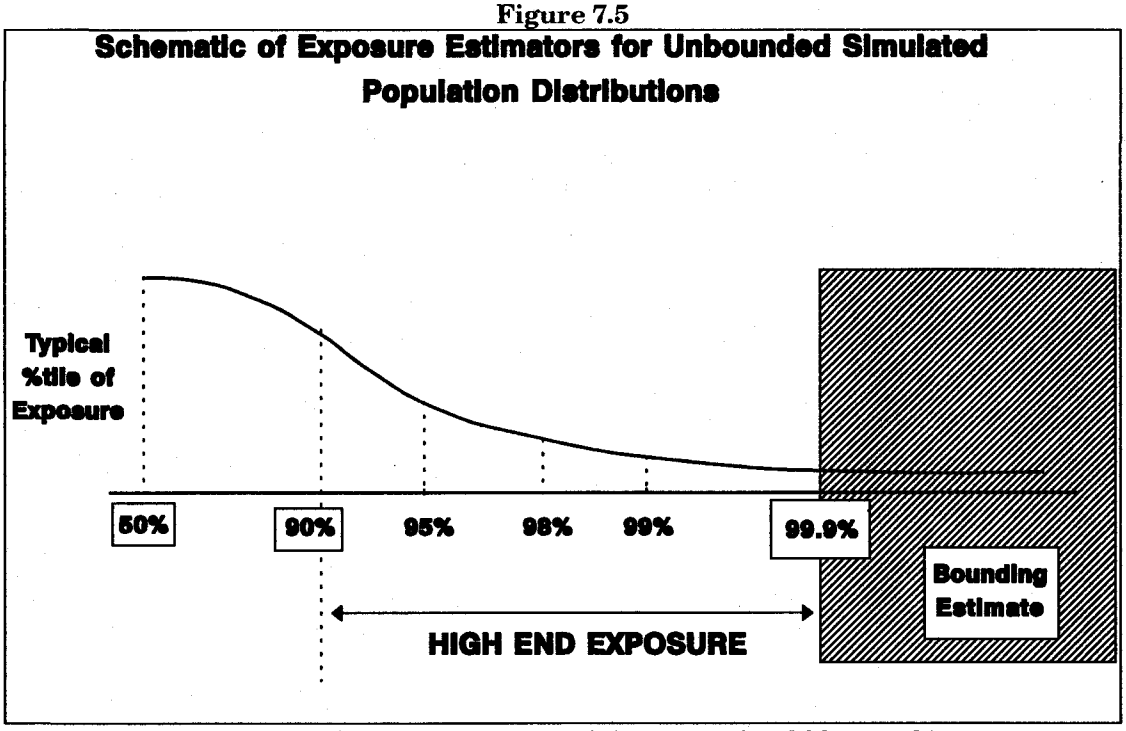
MADEP has in the past recommended (MADEP, 1992b) that the exposure assessments identify the average exposure for the Maximally Exposed Individual (MEI) of a specified receptor group. The term "*Maximally Exposed Individual*" is, therefore, a misnomer for that receptor of concern since the evaluation would focus on the <u>*average*</u> individual within this subpopulation.

For the purposes of Method 3 Risk Characterizations performed under the MCP, the receptor subpopulation of concern would be characterized by those individuals whose activities (described by the frequency and duration of the actions) represent a full and unrestricted use of the site (considering the current and foreseeable uses identified) and who

are most susceptible to the contamination at the site. The quantitative exposure assessment should describe a conservative estimate of a representative individual within

that subpopulation. (Note that the "*fullest use*" does not necessarily mean that the highest

Figure 7.5



possible values for exposure frequency and duration should be used.)

The subpopulations or receptor groups evaluated in the quantitative risk assessment should represent the most susceptible individuals and groups of all of those who are exposed to contamination at the site in question. Higher susceptibility is used here to mean a higher probability of experiencing adverse impacts as a result of exposure. Susceptibility is determined by the combination of the intensity of exposure and the sensitivity to toxic effects combined. Examples of receptor groups that are often identified as the most susceptible subpopulations include those described below:

- In typical residential areas, children are usually considered among the most susceptible receptors because (1) their activities are likely to result in more intense exposures than those of adults, (2) they are believed to intake higher amounts of soil by incidental ingestion, and (3) all other things being equal, their lower body weights result in higher normalized doses. Note that the first two factors relate to higher exposure intensity, while the third translates to higher sensitivity, all of which combine to make children generally more susceptible than adults to the contamination.

- In typical industrial areas, adults who work at the site are often considered as one of the most susceptible subgroups because their exposure frequency is higher than

for others who may be exposed on occasion.

- Occasionally, pregnant and/or nursing women may be identified as a highly susceptible subgroup. The effects of concern in these cases may be developmental effects on fetuses and babies, not necessarily effects on the mother herself. Fetuses are considered more sensitive than adults to some contaminants because a one-day exposure may be sufficient to cause adverse developmental effects. Babies are more susceptible because they may be exposed to significant levels of fat-soluble contaminants which may become concentrated in mother's milk. Because of their low body weight, a baby's exposure can lead to a relatively high normalized dose. Babies and young children are also more sensitive than adults to the toxic effects of some substances, metals in particular.

It is worth noting that, although we have often spoken in terms of the "most sensitive receptors", most of the factors that lead to a higher susceptibility are in fact related to exposure intensity, and not necessarily a greater sensitivity to the toxin. While higher sensitivity to a toxin may be an important consideration, it is seldom addressed quantitatively in health risk assessments, because the same toxicity values are generally (perhaps unfortunately) applied to all subgroups.

Exposure assessments should use mid-range estimates of exposure parameters, such as such as intake rates, contact rates and bodyweights, which are known to vary among individuals within the specified receptor group. The arithmetic mean of concentrations at exposure points are recommended (See Section 7.3.3.5) for use in the exposure calculations. Again, note that the values used for frequency and duration of exposure should reflect realistic values for receptors making the fullest use of the site or resource (given the current and future uses determined for the location) while considering climatic conditions in Massachusetts.

This mix of mid-range and conservative values is intended to produce realistic upper-end exposure estimates which will be protective of public health and produce risk estimates which will be valid for comparison to the MCP Cumulative Risk Limits. For exposure assessments performed using probabilistic techniques (such as Monte Carlo analysis) the MCP stipulates that the 95th percentile value of the resulting exposure distribution *for the specified receptor subpopulation* be used to calculate risk estimates.

For risk assessors attempting to meet the regulatory requirements of both the MADEP and the USEPA, the risk estimates calculated using the USEPA "high end" exposures would likely be equal to or higher than those estimates using the MADEP approach. Thus, cleanup decisions based upon such "high end" estimates (used with the MCP risk management criteria) are likely to meet the requirements of the MCP, even though the specific mix of exposure parameters used in the calculations will be different in the different programs.

Exposure estimates calculated as described herein are considered to be protective of public

health in that they are not likely to be underestimates of the "true risk" for individuals in the specified receptor subpopulation.

7.3.3 Quantitative Estimations of Exposure

Once exposure profiles have been developed describing the contaminants of concern, exposure points, exposure point concentrations and the receptors of concern, the potential exposures experienced by the receptors are quantified. This information will then be used to estimate risk, as described in Section 7.4.

This section of the guidance describes (a) the differences between exposure and dose, (b) the different types of doses which may be employed in the risk assessment, (c) the common factors used to estimate exposure, and (d) the pathway-specific equations employed to quantify exposure.

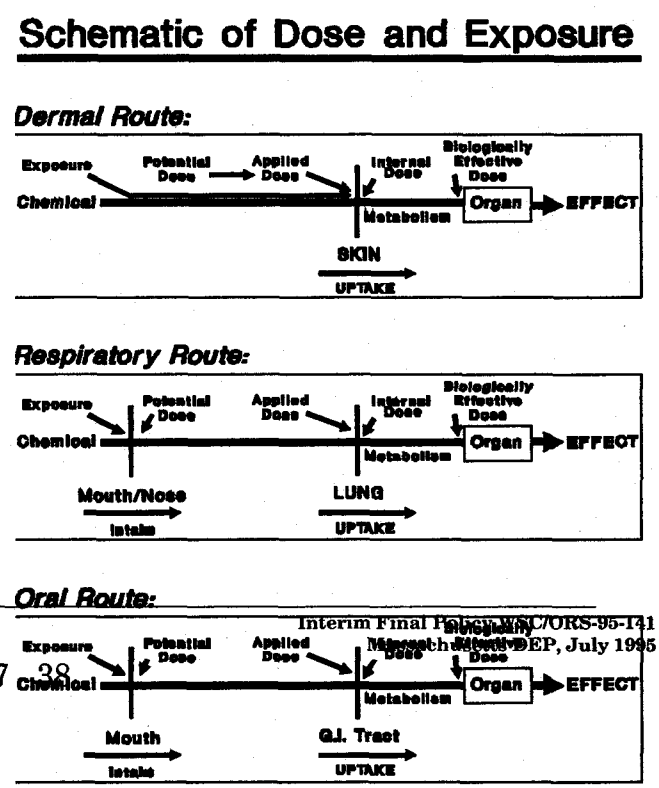
7.3.3.1 Concepts and Terminology

The concept of exposure is complex, and the numerical value calculated by the risk assessor will depend upon the nature of the exposure pathway under investigation, the duration of the exposure, and the health effects associated with the chemicals of concern.

The US EPA Exposure Assessment Group defines *exposure* as the amount of material in contact with an organism and available for absorption. The material which reaches the organism's absorption barrier (such as the skin, lung or gastrointestinal tract) is referred to as the *applied dose*, while the *absorbed* (or *internal*) *dose* is defined as the amount of material which actually crosses the organism's exchange boundary. [Note that exposure is often thought of as the "*potential dose*" and taken as an approximation of the applied dose, as it represents the amount which could be absorbed if it were 100% bioavailable. Figure 7.6 (adopted from USEPA, 1992) illustrates the differences in these terms for the dermal, respiratory, and oral routes of exposure.

The type of exposure or dose used to characterize risk will depend upon the exposure pathway under evaluation and the nature of the toxicity information available for each chemical:

- Typically *respiratory* exposures are evaluated using the exposure point concentration in combination with a



published Reference Concentration or Unit Risk value.

- Oral and dermal exposures are typically evaluated by modifying the applied dose with a *Relative Absorption Factor* (RAF) to insure that the calculated exposure is comparable to the Reference Dose or Cancer Slope Factor employed. (See Section 7.2 for a discussion of RAFs.)

Where appropriate, the equations given in the following pages include a Relative Absorption Factor. Under certain conditions the quantitative estimate of exposure will in fact be an estimate of the applied dose (or exposure) rather than an absorbed dose. For simplicity, the term "average daily dose" is used to describe the product of an "average daily exposure" and a Relative Absorption Factor.

7.3.3.2 Types of Average Daily Doses

The equations presented below outline the procedure for the calculation of an Average Daily Dose of an oil or hazardous material. Depending upon the duration of the exposure under evaluation and the type of health effect (cancer or noncancer) of concern, the calculations may yield one of several results:

- ***Lifetime Average Daily Dose (LADD):*** A LADD in units of milligrams per kilogram body weight per day (mg/kg/day) should be calculated to estimate carcinogenic risk. The total intake during that exposure is normalized to a lifetime, taken to be 75 years. [Note that exposure may occur for all or some fraction of the receptor's lifetime.]

- ***Chronic Average Daily Dose ($ADD_{chronic}$:*** Chronic human exposures are defined by MADEP to be those lasting seven years or more. The $ADD_{chronic}$ (in units of mg/kg/day) is calculated for the characterization of potential noncancer risk resulting from long-term exposures, and the value must be an estimate of exposure experienced by the receptor *during the period of exposure.*

- ***Subchronic Average Daily Dose ($ADD_{subchronic}$):*** Subchronic human exposures are defined by MADEP to be those lasting from several days up to seven years. The $ADD_{subchronic}$ (in units of mg/kg/day) is calculated for the characterization of potential noncancer risk associated with such mid-range exposures, and the value must be an estimate of exposure experienced by the receptor *during the period of exposure.*

- ***Acute Average Daily Dose (ADD_{acute}):*** The Acute exposure may range from the instantaneous to those lasting up to several days, and the ADD_{acute} (in units of mg/kg/day) is calculated for the evaluation of potential noncancer risks resulting from such short-term exposures.

Inhalation risks are characterized by calculating the exposure concentration rather than the dose. Therefore, the terminology used for inhalation exposures differs from that used for ingestion and dermal exposures. To estimate carcinogenic risk from an

inhalation exposure, the ***Lifetime Average Daily Exposure (LADE)*** (milligrams per cubic meter air per day) is calculated rather than the LADD. To estimate risks of non-cancer effects from inhalation exposures, the ***Average Daily Exposure (ADE)*** is calculated for chronic, subchronic and acute exposures rather than the ADD.

Note that it is often necessary to calculate several different daily doses of a chemical to a receptor in order to evaluate all relevant exposure scenarios. For chemicals which are considered carcinogenic, a lifetime average daily dose must be calculated as well as all appropriate average daily doses (*chronic, subchronic and/or acute*) for the evaluation of noncancer health risks. For noncarcinogens, all appropriate average daily doses (*chronic, subchronic and/or acute*) must be calculated.

7.3.3.3 General Form of Dose Equations

The general form of the equations to estimate average daily exposure (ADE) and average daily dose (ADD) is presented as:

$$ADE = \frac{(Total\ \ Amount\ \ of\ \ OHM\ \ Contacted)}{(Averaging\ \ Period)} \qquad \textbf{(7-3)}$$

and

$$ADD = \frac{(Total\ \ Amount\ \ of\ \ OHM\ \ Contacted)\ *\ (Relative\ \ Absorption\ \ Factor)}{(Body\ \ Weight)\ *\ (Averaging\ \ Period)} \qquad \textbf{(7-4)}$$

Note that "*dose*" is taken to be "*exposure*" normalized to the receptor's body weight and adjusted for absorption/bioavailability (as described in section 7.2.3).

At c.21E disposal sites it is common to have situations where a receptor may be exposed to a chemical through multiple exposure pathways, such as ingesting contaminated soil and absorbing the material following dermal contact with contaminated soil. In such cases, the doses of an oil or hazardous material received via different routes of exposure are assumed to be additive unless there is strong evidence otherwise.

$$\begin{matrix} Cumulative \\ Risk \end{matrix} = \sum\sum(\ Chemical_i, Exposure\ \ Pathway_j\ ) \qquad \textbf{(7-5)}$$

General equations for the calculation of Average Daily Dose are presented in this section for some frequently encountered exposure pathways. These equations are not intended to represent the universe of potential models and they must be tailored to site-specific conditions. It is expected that additional exposure pathways may be identified, and an average daily dose may be calculated, using appropriate models, for each receptor of concern.

There are a number of common exposure factors that are employed in virtually all of the exposure equations, and the discussion which follows describes some of the issues which

may arise when using these elements. Exposure factors which are specific to a particular pathway are discussed in the subsection which presents the equations for that pathway.

The daily dose(s) of each OHM calculated for each potential receptor should be summarized in the risk characterization report in a manner which is clear and concise. Summary tables presenting the equations and the exposure assumptions used to calculate the daily dose should also be presented and well referenced.

7.3.3.4 Descriptions of General Exposure Factors

There are eight exposure factors which recur throughout the equations used to estimate the dose of oil or hazardous material experienced by a potential receptor:

- Chemical Concentration
- Body Weight
- Frequency of Exposure
- Duration of the Exposure Event
- Duration of the Exposure Period
- Relative Absorption Factor
- Averaging Period
- Units Conversion Factors

These factors are generally used in the same manner regardless of the exposure pathway under investigation, so it is useful to discuss them separately.

Chemical Concentration

The concentration of the oil or hazardous material used to quantify exposure is the Exposure Point Concentration, or EPC, described in section 7.3.4.5. The exposure point concentration is expressed in terms of mass of the material per unit mass (or volume) of the exposure medium: mg_{OHM}/kg_{soil}, $\mu_{OHM}/liter_{water}$, and $\mu g_{OHM}/m^3_{air}$. When concentrations are expressed in terms of parts-per-million (ppm) or parts-per-billion (ppb), care must be taken to convert the concentrations to the appropriate units.

Soil, sediment, food: 1 mg/kg = 1 μg/g = 1 ppm
1 μg/kg = 1 ppb

Water: 1 mg/liter = 1 ppm
1 μg/liter = 1 ppb

Air:

$$1\ \frac{mg}{m^3} = \frac{1\ ppm * M.W.}{22.4 * \frac{T}{273°K} * \frac{P}{760\ Torr}} \qquad \textbf{(7-6)}$$

Where T is the air

temperature (often assumed to be 25˜ C or 298˜ K) and P is the atmospheric pressure (often assumed to be 1 atmosphere or 760 Torr), and M.W. is the molecular weight of the chemical under evaluation.

The exposure point concentration is represented in these exposure equations by the term: $[OHM]_{exposure\ medium}$. The exposure point concentration should *not* be adjusted for receptor exposure frequency, duration, etc... as those factors are generally addressed in the exposure calculations.

Body Weight

A receptor's body weight is relevant throughout the dose equations as dose is expressed in terms of mass of contaminant per unit body weight per day (mg/kg/day). When each receptor of concern is identified, the receptor is often described in terms of occupation (resident, construction worker), age (a child age 1 to 6 years) and sometimes gender. The receptor's body weight is dependent upon its age and gender. Since body weight is easily measured, there are numerous summaries of age and gender-specific body weights. A table of such values used by ORS is included in Appendix B.

The receptor body weight (**BW**, typically expressed in kilograms, kg) must be matched to the age and gender identified in the exposure profile. Since exposure is often assumed to occur over a period of several years, the changes in body weight which might occur during the period of exposure must also be considered. (See section 7.3.3.6 for the mathematical treatment of age groups.)

Even within a given age/sex combination, there is some variability of body weight for that subpopulation: some 8 year old boys weigh more/less than other 8 year old boys. This variation is well defined, and the distribution of body weights for this subpopulation of concern may be used as part of a probabilistic assessment of exposure. For evaluations requiring a point estimate of body weight, ORS recommends using the 50th percentile body weigh for that subpopulation, unless there is strong evidence that the potentially exposed subpopulation is biased in some manner. Note that for a normal distribution, the 50th percentile approximates the arithmetic mean.

Frequency of Exposure and Duration of the Exposure Event

A receptor may be exposed to oil or hazardous material continuously, at regular intervals, or in a sporadic manner. The Frequency of Exposure (**EF**) and the Duration of the Exposure Event (**ED**) in combination describe the pattern of exposure being modelled.

The frequency of exposure term describes how often the exposure event occurs over a given period of time. The term answers the questions: *How many times a day does exposure occur?, How many times per week?, per month?, per year?* Exposure Frequency may, in fact, be a string of terms which ultimately reduce to one expression:

$$\frac{1\,event}{day} * \frac{3\,days}{week} * \frac{4\,weeks}{month} * \frac{12\,months}{year} = \frac{144\,events}{year} \qquad \textbf{(7-7)}$$

The Duration of the Exposure Event, as the name implies, describes how long each individual exposure event might last. The term is somewhat more complex than it sounds, however, because it must be consistent with the scale of the contact rate for the exposure being modelled. For some exposure pathways, the information available describing the contact rate is broken down to a small scale (such as hours). The respiratory pathway is perhaps the best example of this case as ventilation (breathing) rates are often measured and expressed in terms of cubic meters per hour, and breathing occurs throughout the day. For such exposures ED may be described as some number of hours/event. More common, however, are contact rates which are on the scale of days rather than hours. The ingestion pathway is typical of this case. While estimates have been published on the amount of water ingested during a *day*, there can be no reliable estimate of average *hourly* ingestion rates as drinking water is a sporadic event depending upon thirst and habit. For such exposures (including drinking water ingestion, soil ingestion and dermal contact) **ED is by definition 1 day/event**. During that "1 event" the receptor is assumed to receive the daily intake of the contaminant.

Duration of the Exposure Period

The exposure period (EP) describes the length of time over which the receptor comes into contact with the oil or hazardous material. The exposure period depends upon the type of activities which lead a receptor to be exposed. Remember that the receptor may be exposed continuously, at regular intervals, or sporadically, depending upon the activity being modelled, so the exposure period would be the length of time between the first exposure experienced and the last. The EP term is typically expressed as some unit of time: days, months, years.

Averaging Period

The equations which follow calculate *average* daily doses or *average* daily exposures, and the averaging period (AP) is the time (in days, months or years) over which the total intake is normalized.

Remember that a Lifetime Average Daily Dose (LADD) is calculated for the evaluation of *cancer risk*. While the duration of the exposure period (EP) might range from one day to an entire lifetime, the total intake during that exposure is normalized to 75 years (a lifetime). The averaging period is thus assigned a value of 75 years, and, for exposures lasting less than a lifetime, the values for EP and AP will be different.

For the evaluation of *noncancer risk*, however, the Average Daily Dose calculated should be representative of the exposure received while exposure is on-going (i.e., during the exposure period). Thus the duration of the exposure period (EP) and the averaging period (AP) for an chronic, subchronic or acute Average Daily Dose are variable factors depending upon the exposure being modelled, *but the AP is set equal to EP by definition.*

Relative Absorption Factor

As described in the Dose-Response section of this guidance, the Relative Absorption Factor (RAF) relates the exposure and absorption estimated for the exposure pathway under evaluation to the exposure and absorption in the toxicological study on which the dose-response information is based. The RAF is dimensionless and is chemical and pathway specific.

EXPOSURE DURATION (EP) and AVERAGING PERIOD (AP)

The Averaging Period (AP) used in the equations to calculate dose will be equal to the Exposure Period (EP) for the evaluation of ***noncancer*** risks. When estimating ***cancer*** risk, AP is always equal to a lifetime (75 years) while EP may vary depending upon the exposure under investigation:

Example: The risk assessor is asked to evaluate the carcinogenic risk associated with a ten year exposure to chemical A. Estimation of carcinogenic risk requires the calculation of a Lifetime Average Daily Dose. Thus, the Averaging Period used for calculating the LADD would be 75 years while the Exposure Period would be equal to 10 years.

The risk assessor is also asked to evaluate the likelihood of non-carcinogenic health effects associated with that same ten year exposure. The assessor would calculate an Average Daily Dose Chronic ($ADD_{chronic}$) where EP = 10 years and AP = 10 yrs.

Units Conversion Factors

One of the most valuable habits a risk assessor can develop is to routinely conduct dimensional analyses on the equations used to quantify exposure. The exposure factors and analytical data used for a given calculation may come in several forms. For example, ventilation rates may be expressed as cubic meters per day or liters per hour; exposure point concentrations in drinking water may be in milligrams per liter or micrograms per liter. Dimensional analysis will reveal whether units conversion factors are necessary to insure that the result of the calculation (the dose) is expressed in the correct units (mg/kg/day).

Use of a units conversion factors (C) is equivalent to multiplication by one. The numerator and denominator of the factor must be an equivalent quantity expressed in different terms. It is not uncommon to need several conversion factors in the same equation to reconcile the dimensions of mass, volume and time.

EXAMPLES OF UNITS CONVERSION FACTORS (C)

Relationship	The numerator and denominator may be reversed depending upon the form of the equation.	
1,000,000 mg = 1 kg	$C = 10^6$ mg/kg	$C = 10^{-6}$ kg/mg
1 year = 365 days	C = 365 d/yr	C = 0.00274 yr/d
1,000 liters = 1 $meter^3$	$C = 10^3$ l/m^3	$C = 10^{-3}$ m^3/l

7.3.3.5 Estimating Exposure Point Concentrations - General Considerations

Sampling and Analysis

To assure that site sampling efforts provide adequate data for the risk assessment, the sampling and analysis plan should be developed in consultation with the risk assessor. Analytical data is collected during the site investigation to fully characterize the nature, extent, severity and horizontal and vertical distribution of the oil and hazardous materials at the disposal site. Some or all of the data obtained may be used for the risk assessment. The data obtained or selected for the risk assessment must be representative of actual and foreseeable exposures, and it must be compatible with the dose response value that will be used in the assessment.

Averaging

The exposure point concentration should represent the arithmetic mean of the concentrations to which an individual may be exposed over the exposure period at the exposure point.

As previously stated, the exposure point concentration should be compatible with the toxicity values that will be used to characterize health risks. Chronic and subchronic reference doses are generally based on time-weighted averages of exposure concentrations used in toxicological experiments, and are expressed in terms of an allowable average daily dose. Therefore, the exposure point concentrations used with those reference doses should approximate the time weighted average concentration to which the receptor may be exposed at the exposure point during the exposure period being evaluated. Cancer slope factors are also based on an average daily dose, and exposure point concentrations for evaluating cancer risks should represent the average daily dose for a 30 year exposure.

Four types of exposures are routinely evaluated in disposal site risk assessments: (1) acute (typically 24 hour exposures), (2) subchronic (several months to seven years) exposures to substances with non-carcinogenic effects, (3) chronic exposures (greater than seven years) to substances with non-carcinogenic effects and (4) lifetime exposures (typically 30 years and averaged over a lifetime of 75 years) to carcinogens. For each type of exposure, the risk assessment should focus on the time-segment during which the highest dose is likely to be received. The exposure point concentration should be a conservative estimate of the average exposure concentration over that period of time. For example, to evaluate three month subchronic drinking water exposure when the concentration in the water supply is known to fluctuate seasonally, the exposure point concentration should represent the highest average to which a person could be exposed within a three month time frame.

Acute Exposures

For acute exposure assessments, the exposure point concentration should represent a conservative estimate of the concentration to which a receptor might be exposed over the period of one day. Generally, the highest detected concentration should be employed when

one-time exposure could result in adverse health effects.

Using Qualified Data

Non-Detects

In estimating exposure point concentrations, it is not uncommon for the risk assessor to be presented with analytic data for a chemical at the site which includes a number of samples reported to be below the Method Detection Limit (MDL). Such results are referred to as "Non-Detects".

Non-Detect results may be classified into two general situations. First, if a chemical is truly not present at the disposal site (virtually all the samples are reported as Non-Detect), and there is no history of a release of that chemical, then the risk assessor may conclude that the chemical should be dropped from the quantitative risk assessment. Second, if the chemical is reported at the site at concentrations ranging from Non-Detect to some site maximum, the risk assessor may conclude that the reported Non-Detects actually represent a distribution of concentrations between zero and the MDL. These Non-Detect results contribute to the information known about the disposal site and should be incorporated into the quantitative risk assessment in a meaningful way. (There is a third possible situation, where the spatial pattern of positive and Non-Detect results indicate that contamination is localized to specific areas. This would represent a combination of the previous two examples.)

There are several options for the treatment of "Non-Detects" described in the literature (Travis, 1990; Helsel, 1990; Klassen, 1986 and Slymen et al., 1994). The methodologies described include the use of log-probit analysis, maximum likelihood estimation and probability plotting procedures. The level of effort and number of data points required to effectively employ these methods vary, and the risk assessor is encouraged to exercise professional judgement in the selection of a method to treat Non-Detect results.

For estimating exposure point concentrations at most c.21E sites, the Department believes that a more straightforward approach is often appropriate. When a contaminant is detected or likely to be present in the area under investigation and the laboratory reports the concentration of an OHM in a sample taken from the area as "Non-Detect", the concentration of the OHM in that sample should be assumed to be one-half of the Sample Quantitation Limit (SQL). The SQL is the actual quantitation limit for each analysis, and it accounts for sample dilution that may occur. If only the Method Detection Limit is reported, and if the sample is heavily contaminated with any constituent, the risk assessor should attempt to determine whether the sample was diluted. For samples that have been diluted (a factor of 10 is not unusual), the risk assessor could substantially underestimate the concentration by using the Method Detection Limit or the Practical Quantitation Limit as a basis for the estimate.

This methodology is simple and easy to use. These benefits must be weighed against

the bias which is introduced in the resulting EPC estimate. The Non-Detect method selection should also consider, the often high level of uncertainty which is often inherent in environmental sampling and analysis procedures. This uncertainty may result from failure to take an adequate number of samples, mistakes on the part of the sampler, the heterogeneity of the matrix being sampled, and intentional bias in the sample collection. For relatively small disposal sites, these inherent uncertainties may overwhelm the bias introduced by using 1/2 the MDL. A more statistically oriented ND method may not, in such cases, significantly reduce the uncertainty inherent in the resulting EPC. It is up to the risk assessor to judge the level of sophistication appropriate to the data set.
As always, there may be exceptions to this guidance, particularly when the site history and the NDs may indicate the absence of an OHM at a site (or areas within a site). In the latter case, the chemical may be dropped from the quantitative risk assessment or the NDs may be factored into the Exposure Point Concentration as a zero value with appropriate justification.

Tentatively Identified Compounds

Tentatively identified compounds (TICs) are compounds which are detected during sample analysis, but are not target compounds. TICs are often reported when gas-chromatography-mass spectrometry (GC-MS) is used to analyze organic compounds. Target compounds are those for which the instrument was calibrated, using a chemical standard, prior to analysis. The ability of the MS system to store mass spectra electronically in a "library" enables the analyst to compare the library spectra with the spectra produced by a non-target contaminant when one shows up in an environmental sample. Identification based on a "library" comparison is much more uncertain, however, than one based on calibration with a standard for the target compound.

There is no rule of thumb for whether TICs should be included in the risk assessment. Confidence in a TIC identification depends on a number of factors, including site history and the presence of similar compounds at the site. The EPA's *Guidance for Data Useability in Risk Assessment* provides the following guidance:

Confidence in the identification of a TIC can be increased in several ways. ...An analytical chemist trained in the interpretation of mass spectra and chromatograms can review TIC data and eliminate many false positive identifications. The use of retention indices or relative retention times can confirm TICs identified by the GC-MS computer (Eckel, et al. 1989). Examination of historical data, industry-specific compound lists, compound identifications from iterative sampling episodes, and analyses performed by different laboratories may also increase confidence in the identification of a TIC. The final identification step is to re-analyze the sample after calibrating the GC-MS instrument with an authentic standard of the compound that the TIC is believed to be.

Many compounds that appear as TICs during broad spectrum analyses belong to compound classes. Examples of compound classes are saturated aliphatic

hydrocarbons and polycyclic aromatic hydrocarbons (PAHs). The risk assessor may be able to make a preliminary judgement of toxicity at the compound class level without a definitive identification of each compound present.

The identification of a TIC can be confirmed definitively only by further analysis. However, depending on the analytical and historical information available, and the potential impact of the TIC on the results of the risk assessment, confirmatory analysis may not be warranted. The risk assessor should work with the project manager and an analytical chemist to make a prudent decision about the need for follow-up analysis.

Measured vs. Modeled Concentrations

Direct measurement of environmental concentrations is generally preferred, but estimation by an analytical or numerical model may be acceptable when direct measurement is impossible or extremely impractical. If a model is used, modeling methods, input parameters and assumptions, and model validation should be fully referenced and described. Modeling considerations are discussed further in subsequent sections on exposures to specific environmental media.

7.3.3.6 Soil Exposure Point Concentrations

Direct Contact

Direct contact with soil can result from such diverse activities as work, play and gardening on residential properties; recreational activities on public and private land; landscaping of commercial properties; grading or excavation of soil for construction or utility repair; agricultural work; outdoor work on industrial properties; and exploration of any area sufficiently unattractive to appeal to young people's curiosity. Exposure occurs primarily by dermal absorption of contaminants from soil and incidental ingestion of contaminated soil. To calculate an exposure point concentration for a particular exposure scenario, the selected samples should be representative of the area and depth within which the particular exposure is likely to occur.

Generally, for surface soil exposures, **the arithmetic mean soil concentration in an exposure area may be used as the exposure point concentration estimate**. The accuracy of this method depends on three underlying assumptions:

- Over time, soil concentrations remain constant;
- The detected concentrations represent a uniform or random distribution of soil samples over the exposure area; and
- Over time, exposure is equally likely at any location within the exposure area.

If these assumptions hold true, the arithmetic mean concentration in the exposure area will represent the arithmetic mean concentrations with which a person comes into contact over time. In other words, the spatial average may be used as a surrogate for the temporal average.

The first assumption stated above is consistent with current DEP practices. Laboratory derived degradation rates often are not observed in the field, and the conservative assumption that concentrations will not decrease over the time of the exposure period is encouraged.

There are cases, however, when the second and/or third assumptions do not hold true. Sampling locations are not always distributed evenly over the site, and exposure frequencies are often higher in some areas than others. In these cases, a weighted average of the detected concentrations should be used.

Figure 7.7 illustrates a situation where the sampling points are not evenly distributed over the site. In this example, an area weighted average exposure point concentration is considered to be a representative estimate of the exposures at the site over time. In this method, analytical data should be weighted in a manner which reflects the sampling frequency as follows:

> *If 6 equidistant samples were taken in a portion of a site approximately 10 meters by 60 meters each sample can be said to represent 100 m^2 (600 m^2/6 samples). If two additional equidistant samples were obtained from another portion of the site approximately 10 meters by 40 meters, each sample could be said to represent 200 m^2. The sample values should be weighted according to the relative area each represents. The area-weighted average obtained from this exercise represents the arithmetic mean concentration over the exposure area. If exposures are equally likely throughout the entire area over time, this area-weighted average also represents the time-weighted average, or the average exposure concentration over time.*

Figure 7.8 illustrates a scenario where the sampling locations are distributed evenly, but exposure occurs more frequently in one portion of the site than the other. In this example, a person is not equally likely to be exposed at all locations, and the time-weighted average could account for different exposure frequencies in different areas as follows:

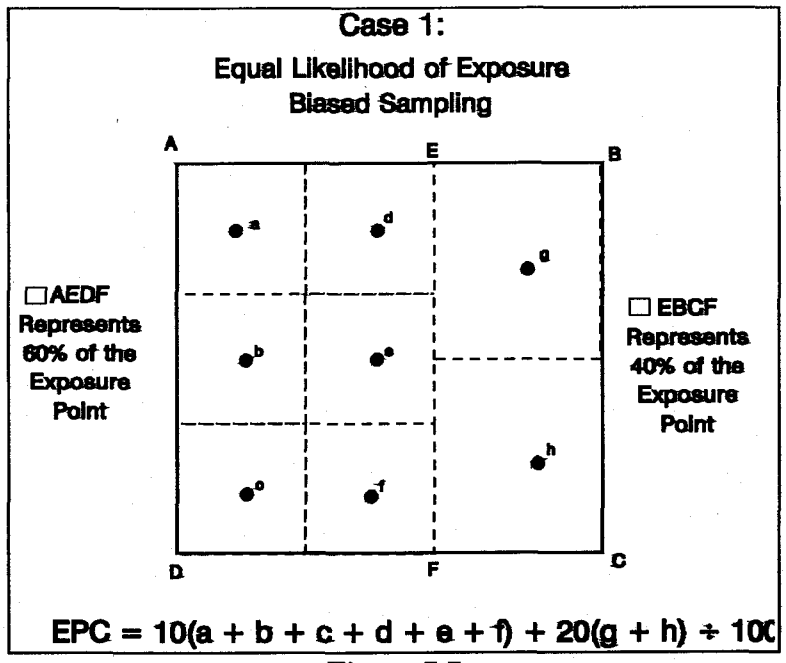


Figure 7.7

If 90% of the exposure time takes place on half of the site, and 10% of the exposure time takes place on the other half of the site. The average concentration for each half could be calculated separately, and then weighted to obtain a frequency-weighted average. Again the result represents the arithmetic mean of the concentrations to which the person is exposed over time.

Note that there may be situations in which weighting for both exposure time and area are appropriate.

These examples represent simple approaches to obtaining a weighted average. More refined techniques for weighting soil or sediment data to estimate an areal average are available. Those that appear to be best suited for exposure assessment are polygon techniques. In general, these procedures involve construction of a polygon around each data point so that each polygon contains the locations that are closer to the data point at its center than any other data point. Such methods are useful for deriving area weighted average soil concentrations which may be used as surrogates for time-weighted exposure point concentrations.

Other approaches often suggested in risk assessment literature and guidance are oriented toward estimating the most likely concentrations at locations between data points. Kriging and triangulation are examples of such methods. The problem of determining concentrations between data points is related to but different from the problem of estimating the average concentration over an exposure area. To date, DEP has found no compelling argument for the applicability and utility of these techniques for calculating exposure point concentrations, and therefore recommends against employing them at this time.

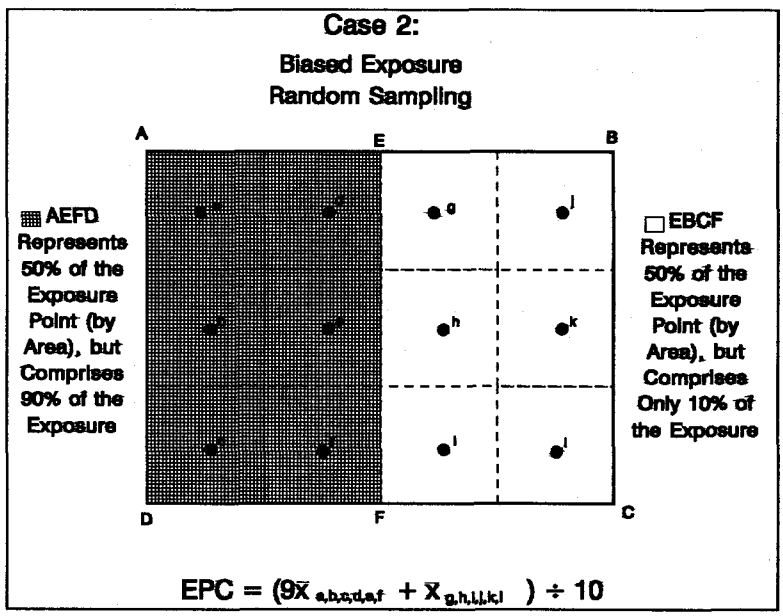


Figure 7.8

Composite Soil Samples

The concentration of a composite soil sample may be used to approximate the arithmetic average of the subsample concentrations. The use of composites can provide an arithmetic mean concentration of several locations at the same cost as analyzing an individual sample. However, the concentration detected in a composite is representative of the average concentration of subsamples only if: (1) the subsamples are representative of the exposure area (2) the composite sample is well mixed and (3) the process of compositing does not result in analyte loss. These conditions can be verified by comparing the average concentration of a set of single location samples with the concentration of a composite of sample collected from the same area. If a composite sample from one area is checked in this manner and demonstrated to be accurate for each sampling event, it is not necessary to check all composites from all areas.

Consumption of Homegrown Fruits and Vegetables

Consumption of fruits and vegetables grown in contaminated soil will result in exposure if the plant takes up a portion of contaminant from the soil. Ideally, produce concentrations should be measured directly. However, sometimes produce concentration data cannot be obtained quickly enough to be used in site management decisions, and must therefore be estimated from soil concentration data. The contaminant concentration in the produce itself is related to the soil concentration and the plant uptake factor, as follows:

$$[OHM]_{plant} = [OHM]_{soil} \ x \ Ksp_{plant/soil} \quad \textbf{(7-8)}$$

Where:

$[OHM]_{plant}$ = plant contaminant concentration (mg_{OHM}/kg_{plant})
$[OHM]_{soil}$ = soil contaminant concentration (mg_{OHM}/kg_{soil})
$Ksp_{plant/soil}$ = plant/soil uptake factor (kg_{soil}/kg_{plant})

Default plant/soil uptake factors are listed in Appendix B.

When estimating contaminant concentrations in produce, it is necessary to assure that the uptake factors and produce consumption estimates are compatible. Plant uptake factors are generally reported on a dry weight basis. Dry weight produce concentrations must be used with intake estimates that are expressed in terms of dry weight, not wet weight.

Inhalation of Particulate Matter from Contaminated Soil

Inhalation of contaminated particulate matter is of concern in cases where contaminated soil is unvegetated or is likely to be graded or excavated for site work or for development.

The exposure point concentration (mass of contaminant/volume air) should be calculated as follows:

$$EPC_{air} = [OHM]_{soil} \ x \ PM_{10} \ x \ CF \quad \textbf{(7-9)}$$

Where:

EPC_{air} = Exposure Point Concentration ($\mu g_{contaminant}/m^3_{air}$)
$[OHM]_{soil}$ = Soil concentration ($mg_{contaminant}/kg_{soil}$)
PM_{10} = Respirable particulate concentration in air ($\mu g/m^3_{air}$)
CF = Conversion factor (10^{-9} kg/μg)

When evaluating exposure to airborne particulate matter at a sparsely vegetated or unvegetated site, or at a construction site, it should be assumed that all of the PM10 is contributed by the contaminated area. This may overestimate the contribution of site soil to airborne particulate concentrations, but the data necessary to obtain a more accurate estimate for these conditions is not available. On a site-specific basis, with appropriate justification (e.g. dense vegetation), the percentage of PM10 that is soil-derived may be reduced to as low as 40% (Thurston and Spengler, 1983).

It may generally be assumed that the concentration of the contaminant in PM10 is equal to the concentration of the contaminant in soil. This assumption may underestimate the concentration of contaminant in the PM10 fraction, since smaller particulate fractions sometimes contain contaminant concentrations that are enriched relative to larger fractions. However, the data needed to derive more accurate concentration estimates is

not available.

Ideally, to assess current conditions, both the concentration of PM10 in the air and the concentrations of contaminants in the PM10 fraction should be measured directly. However, to assess future conditions, it is necessary to estimate the contaminant concentrations in air from the contaminant concentrations in soil. Default values for air concentrations of PM10 from one of two situations are usually required. The first situation is an open field condition, in which contaminated soil is sparsely vegetated or bare, and soil particulate matter readily becomes airborne. The second is a grading or excavation scenario, in which earth working activities may raise elevated levels of dust.

For open field situations, 32 $\mu g/m^3$ should be used as an estimate of the ambient PM10 concentration. This value represents the highest (from 17 sampling stations) annual arithmetic mean concentration measured in Massachusetts in 1994 by DEP's Air Quality Surveillance Branch (1994 Air Quality Report, Commonwealth of Massachusetts). A contribution factor of 100% should be used to estimate the contribution of soil to airborne particulate matter/TSP concentrations under sparsely vegetated open field conditions. If particulate exposures are being evaluated for heavily vegetated open field conditions, the contribution factor may range from 100% to 40%.

For grading and excavation scenarios, a PM10 value of 61 should be used to estimate ambient concentrations. This value is the arithmetic mean of the 24 hour maximum PM10 values from 20 samplers (at 17 locations) in the Commonwealth during 1994 (1994 Air Quality Report, Commonwealth of Massachusetts). A contribution factor of 100% should be used to estimate the portion of ambient particulate level contributed by the construction activities.

There are a number of uncertainties associated with use of the default PM10 values, including:

- The published 24 hour averages may underestimate PM10 concentrations attained during the work day.
- The sampling locations are not necessarily located near construction activities or large areas of sparsely vegetated soil.

Therefore, these PM10 values are recommended for use only in the absence of more representative data.

7.3.3.7 Groundwater Exposure Point Concentrations

Private Wells

Exposure Points

Within a GW-1 area, the risk assessment should address both the risks associated with any well in use and the foreseeable risks from the installation of a private supply well anywhere within the contaminated area. Thus, the exposure points of concern should include both existing wells and the groundwater at any location where a well could potentially be installed. In other words, the groundwater at each monitoring well should be considered a foreseeable exposure point.

Thus, regardless of the risk assessment method employed, **exposure point concentrations and risks should be evaluated separately for each well in use and for each location (monitoring well) where a well could be installed within the contaminated area.** The risk assessor should assume that any one individual would be exposed only to water from one supply well. A single exposure point concentration should include data from locations within an area likely to be influenced by one supply well.

In general, BWSC recommends against averaging concentrations detected in different monitoring wells because monitoring wells are seldom clustered closely enough to lie within an area that would affect a single well. However, in exceptional cases where the locations of monitoring wells are clustered closely enough so that several would sample from an area of groundwater from which a single private supply well could draw, concentrations may be averaged.

The monitoring wells with the highest levels of contamination should be selected to represent potential supply well locations for the risk assessment. At some sites, one monitoring well may clearly represent the highest contaminant levels. At other sites where the groundwater is contaminated by a mixture of substances of varying relative concentrations, several monitoring wells may have to be evaluated as potential supply well locations.

Averaging Periods

The exposure point concentration for a private well should represent an estimate of the average concentration to which a user is likely to be exposed over the period of concern. Lifetime exposure assessments are based on a 30 year time period, chronic exposure evaluations typically focus on a seven year period, and subchronic exposure evaluations focus on period of three months (sometimes longer, but always less than seven years). Thus, the exposure point concentration should represent an estimate of a one year, seven year or lifetime average.

A three month average for a subchronic evaluation should be based on samples

collected at a time when the concentrations can reasonably be expected to represent a maximum for the year. One sampling round is generally insufficient to obtain a reliable concentration estimate, and, confirmatory samples should always be collected.

Of course, site management decisions have to be made within time periods that are much shorter than seven years or a lifetime. Unless, as is discussed in the following paragraph, there is evidence that contaminant levels are increasing, it is reasonable to use the current annual average as an estimate of the seven year or lifetime average.

If the data suggest or show an increasing trend, the exposure point concentration estimate should reflect the predicted increase, and the assessment report should fully describe uncertainty about that estimate. However, such an estimate should only be used for preliminary site management decisions. Given the uncertainty associated with exposure estimates for wells where contamination is increasing, such estimates should not be used to support a conclusion that "no further action" is required.

If the data show a decreasing trend, it may be appropriate to use current values as an estimate of the long-term average. Including historical data in the calculation may lead to exposure estimates that are not consistent with respect to current or future conditions, and could lead to risk management decisions that are problematic. For example, it would be inappropriate to conclude that groundwater remediation is necessary in a situation where the concentrations are already below levels of concern for human health and are continuing to decrease.

Use of Mathematical Models

The use of mathematical models to estimate current exposure point concentrations for private wells is inappropriate. Existing wells should be sampled on a continuing basis to determine representative exposure point concentrations. Samples from the most highly contaminated monitoring wells (in *or* upgradient from the GW-1 area) should be used to represent potential exposures under foreseeable use and future conditions.

To Filter or Not to Filter

The nature of the samples analyzed to obtain exposure point concentrations at private water supplies should represent, as closely as possible, the nature of the water drawn from the wells in question. Often the water drawn from a private supply well is unfiltered, so, in theory, unfiltered groundwater samples from monitoring wells should be used to estimate potential exposure point concentrations. However, monitoring wells, especially newly developed monitoring wells, often produce samples that are quite turbid, and obviously are not representative of water that would be drawn from a supply well. For example, if the water from a monitoring well exceeds the turbidity standard for drinking water, it is reasonable to assume that the particulate levels are not representative of the water being drawn from the supply well. In such cases, BWSC recommends using **filtered samples** to estimate exposure point concentrations.

A promising alternative to filtering is using a peristaltic pump to purge monitoring wells and collect groundwater. In comparison to samples collected with a bailer, peristaltic pumps operated at a low flow rate (0.2 liters per minute) have reportedly produced samples that are less turbid and more representative with respect to groundwater metals concentrations (Acquisition of Representative Ground Water Quality Samples for Metals. Robert W. Puls and Robert M. Powell, *Ground Water Monitoring Review*. Summer 1992.) Although this technique has not been universally accepted or widely applied in field investigations to date, it appears to offer a reasonable alternative to the choice between filtering and not filtering, both of which have serious drawbacks. ORS would consider samples collected at low flow from monitoring wells to be reasonably representative of water drawn from a private supply well at the same location.

EPCs For Comparison to Drinking Water Standards

Massachusetts Drinking Water Quality Standards (310 CMR 22) are compared to exposure point concentrations as applicable suitably analogous standards. Each exposure point concentration, including those measured at monitoring wells, is compared with drinking water standards as a component of the Method 3 risk characterization. The drinking water quality regulations should be consulted for details concerning sampling and analysis required as part of these regulations. In general, the MMCLs are compared with average exposure point concentrations. For public water supply wells, the average of four quarterly samples is used.

Public Wells

Exposure point concentrations representing current conditions at public water supply wells are measured directly at the wellhead. Samples collected for baseline risk assessment purposes should represent pre-mixing, pre-treatment conditions. Neither mixing nor well head treatment is considered permanent, and these risk reduction activities should not be considered when estimating a baseline exposure point concentration.

Estimating exposure point concentrations under future conditions for public water supply wells is slightly more complicated than for private supplies. At supply wells located some distance away from the contamination source area, future concentrations depend on contaminant fate and transport processes such as dilution and dispersion. Even in future public supply wells that could potentially be installed in the most highly contaminated area, the exposure point concentrations are likely to be lower than current monitoring well concentrations because of dilution during pumping. As a consequence, a predictive model is needed to estimate exposure point concentrations at a public supply well under future conditions. Either a simple analytical model or a complex numerical model may be used.

BWSC generally recommends the use of a simple, conservative analytical approach to predict concentrations under future conditions. The results of a complex numerical model will not affect the conclusion of the risk assessment because of the requirement to characterize foreseeable risks by comparing standards to concentrations at each foreseeable exposure point. **The MCP requires the comparison of all current and foreseeable exposure point concentrations in GW-1 areas to applicable or suitably analogous standards** (310 CMR 40.0993(3)). Thus, current groundwater concentrations at each monitoring well in a GW-1 area must be compared with drinking water standards. If the monitoring well concentration exceeds the standard, the risk assessment will conclude that Significant Risk of harm to public health exists. This direct comparison of groundwater concentrations to standards is more likely to indicate the need for remediation than are risk estimates based on a model that incorporates dilution. Since modeled concentrations are not likely to affect the conclusions of the risk assessment, extensive mathematical modeling efforts are seldom warranted.

7.3.3.8 Indoor Air Exposure Point Concentrations

At disposal sites where soil or groundwater beneath a building is contaminated with volatile organic compounds, the potential for exposure to those substances must be considered in the human health risk assessment. Organic compounds can accumulate in indoor air by migrating from soil or groundwater, through the soil gas in the overlying unsaturated soil and into buildings through pores, cracks or openings in the foundation.

Exposure point concentrations in the air in any particular building are dependent upon a combination of conditions:

- The Henry's Law coefficients of the contaminant of concern, which provides an

indication of their tendency to partition from the groundwater to the air spaces in the overlying soil

- the concentrations of contaminant in the groundwater
- the depth of the water table below the surface of the soil
- the depth of the groundwater table below the building structure
- the physical characteristics of the soil at the location of concern
- the structure of the building
- the heating and ventilation features of the building which affect the rate at which soil gas will enter the building.

Measurement vs Modeling

The two basic approaches to estimating indoor air concentrations are direct measurement (air sampling followed by laboratory analysis) and estimation using a contaminant transport model. While each approach has advantages and disadvantages, direct measurement is preferable overall and is generally recommended for evaluating conditions in existing buildings associated with current groundwater concentrations.

It is often difficult to model indoor air concentrations with confidence from concentrations detected in groundwater, or even soil gas, for three reasons. First, the information needed to determine the validity of a model for a particular location and building is often not available. Second, the site-specific soil and building parameters needed to accurately model transport at a specific site may not be available. Third, models generally focus on water-soil gas partitioning and soil gas-indoor air diffusion, and don't account for other transport pathways, such as utility lines, that may provide the dominant migration route into a particular building.

Direct measurement also has some drawbacks. It is more resource intensive than modeling, and it is often logistically challenging. One of the most serious technical concerns is the fact that a single measurement event cannot provide an integrated estimate of the exposure point concentration over time. Indoor air concentrations in a building are heavily influenced by weather and by variations in use and activities. Thus, indoor air concentrations can vary substantially over time, and it may not be possible to predict whether concentrations at a given point in time represent a high, low or average estimate. (It should be noted that modeling does not necessarily provide an integrated estimate either, but the problem of temporal variation can be addressed to some extent by the selection of conservative modeling parameters; after that the question is generally set aside.)

The following sections discuss measurement and modeling considerations in more detail.

Indoor Air Sampling

To obtain a representative estimate of the concentration to which a person is likely to

be exposed over time in a building, sampling locations, times, and methodology must be planned carefully. Each of these considerations is discussed briefly in the following paragraphs.

Sampling Locations

Sampling locations should include areas where concentrations are likely to be highest and areas where the frequency and duration of exposure is high. Concentrations are normally expected to be highest in the basement, if there is one. However, people who live or work in the building are likely to spend more time in other areas. Results from all areas of a building should be incorporated in the exposure point concentration estimates, but data from different areas should be weighted to reflect exposure frequency. Samples from various rooms in a living area or a commercial building can vary substantially, so a number of areas should be sampled during each sampling round.

Sampling Over Time

In planning a sampling program, both **sampling time and sampling duration** are important to consider in obtaining a representative estimate.

In most buildings where volatile organic compounds migrate from groundwater into indoor air, the indoor air concentrations are likely to vary substantially over time. Seasonal changes in the depth to groundwater, temperature, and in building use can affect indoor air concentrations. Even daily changes in ambient air pressure may have a significant effect. For a long-term exposure evaluation (as opposed to an imminent hazard evaluation) sampling should be conducted several times a year. However, air sampling is time consuming and expensive, and it is not always possible to obtain samples that fully reflect temporal variations in concentration.

If sampling is only to be done once or twice because of resource constraints, the site assessment report must demonstrate that the concentrations would be highest at those times, considering depth to groundwater, heating system operating conditions, and building tightness (closed doors and windows).

The sampling duration should correspond as closely as possible to the duration of the exposure being evaluated. Since the duration of most indoor air sampling events ranges from a couple of hours to a day, and the results are often used to evaluate subchronic exposures (longer than a few months) and chronic exposures (longer than seven years), sampling durations should be as long as possible. Other factors that affect sampling duration are discussed in the following section on Sampling and Analysis Methodology.

Sampling and Analysis Methodology

Although an extensive discussion of sampling and analysis methodology is beyond the

scope of this guidance, a few words of caution may be appropriate. Air sampling should be planned and conducted by specialists in the field. Designing and executing an air sampling program requires a thorough understanding of the complexities and subtleties of air sampling theory and technology.

Method validation is crucial in enabling risk managers to make reasonable decisions based on sampling results. When available and appropriate, standard EPA methods should be employed. However, the utility of a standard method to the specific situation of concern should always be carefully evaluated.

Method sensitivity is one factor that often limits the applicability of standard methods at specific exposure situations. Because air intake rates are high relative to drinking water intake or soil intake rates, the concentration of a substance in air that is associated with a significant risk is relatively low. Therefore, it is particularly important to verify that a proposed air sampling methodology can achieve the necessary detection limits before conducting a sampling program.

Whatever the duration of an indoor air sampling event (from several hours to one day), the results are usually used to represent exposures that occur over much longer periods of time (from several months to a lifetime). In planning the duration of a sampling event, a balance must be struck between the need to collect samples that are reasonably representative of long term exposures and the technical constraints of available technologies. In many cases, the sampling duration is limited by the potential for breakthrough (desorption of contamination from the sample collection medium), which can be a serious problem if the volume of air drawn through the sampling tube is higher than that specified in the protocols. In some cases, a lower flow rate can be used to achieve a longer sampling duration. Again, it is recommended that sampling plans be developed by specialists with extensive experience in order plan flow rates and sampling durations that balance risk assessment and technical considerations.

Modeling Indoor Air Concentrations

Before a model is used, the validity of the model for conditions similar to those at the location of concern must be determined. **Precedent is not an indication of validation.** Validation must include obtaining or identifying data showing that the model can predict indoor air concentrations with a degree of accuracy that is sufficient for the risk assessment and the risk management decisions at hand.

Both groundwater and soil gas concentrations have been used as source terms for models. In principle, soil gas concentrations offer a preferable starting point, since they eliminate the need to model partitioning from groundwater into soil gas, and thus eliminate a significant source of uncertainty about the final estimate. However, soil gas measurements have a somewhat uneven track record, and in many cases, potential error associated with measuring soil gas concentrations may be a larger source of uncertainty than the partition model.

(MADEP/ORS is in the process of determining whether there are any existing models that are generally valid and conservative and could be considered default models).

7.3.3.9 Exposure Point Concentrations Related To Surface Water and Sediment Contamination

Fish Consumption

Exposure point concentrations for fish consumption should be consistent with the type of exposure being evaluated. For chronic and subchronic exposure point concentration estimates, an average of the concentration detected in tissue of individual fish fillets may be used to represent the average concentration in fish that a person might consume over time. Ideally, sufficient data would be available to calculate exposure point concentrations for each fish species present so that the risk assessment could consider exposures to populations partial to eating certain species. For substances that could have acute toxic effects, the highest concentration detected should be used as the exposure point concentration estimate when evaluating the risks from acute exposures.

In many cases, it is not possible to obtain a large enough number of fish to calculate an average concentration with a reasonable degree of certainty. The risk assessor and project manager must then decide how to deal with the uncertainty. One option would be to use an upper Confidence Limit on the mean as a conservative estimate of the average concentration. An alternative would be to describe the uncertainty in the assessment report, and compensate for it by making a very conservative risk management decision. However, a sample number smaller than three would be insufficient basis for a public health-protective decision.

Appendix D contains a detailed discussion of fish tissue sampling and analysis considerations.

Swimming

Sediment and surface water exposure point concentrations used to evaluate swimming and wading exposures should represent conservative estimates of the arithmetic mean concentration in the shoreline area used for swimming or wading. If contamination is reaching a surface water body by groundwater discharge or by surface runoff, near shore areas may be more heavily contaminated. Concentrations of samples collected over large areas of a water body will not necessarily be representative, and should not be averaged. Likewise, if a model is used to predict concentrations likely to be attained in the future, the model should focus on the near shore area, and not the entire water body.

7.3.4 Exposure Equations

The following equations, organized by exposure medium, are provided to assist the risk assessor in quantifying a receptor's potential exposure to oil or hazardous material at a c.21E disposal site. The variables specific to each equation are discussed in this section while variables common to most of the equations were presented in the previous section. Default assumptions for these variables are provided in Appendix B.

7.3.4.1 Air

The toxicity information generally used to evaluate the risk of harm to health associated with inhalation exposures, Reference Concentrations and Units Risk values, are air *concentrations*. These values are intended to be used in combination with Average Daily Exposures expressed as applied concentrations, *not* dose. In the absence of RfCs or Unit Risk values, an oral Reference Dose or Slope Factor may be used to estimate risk either by: (a) calculating an Average Daily Dose from the inhalation pathway; or (b) converting the Reference Dose to a Reference Concentration and the Slope Factor to a Unit Risk. Thus, the equation chosen to evaluate the site inhalation exposures will depend upon the availability and nature of the toxicity information.

Calculation of Average Daily Exposure$_{air}$

Gaseous oil or hazardous material (for example, OHM volatilized from contaminated soil or groundwater) may be inhaled by the receptor of concern whenever the receptor is near the disposal site. The Average Daily Exposure to the contaminated air (ADE_{air}) is dependent upon the frequency and duration of the assumed exposures. The result of this calculation should be an estimate of applied concentration, *not* dose. Note that the equation is a simple adjustment of the exposure point concentration to account for the amount of time the receptor spends in the area with contaminated air.

$$ADE_{air} = \frac{[OHM]_{air} * EF * ED * EP * C}{AP} \qquad \textbf{(7-10)}$$

Where:

[OHM]$_{air}$ = Exposure point concentration of gaseous oil or hazardous material in the air at the Exposure Point during the period of exposure (dimensions: mass/volume; typical units: $\mu g/m^3$).

EF = Number of exposure events (frequency) during the exposure period divided by the number of days in the exposure period (dimensions: events/time; typical units: events/day)

ED = Duration of each exposure event (dimensions: time/event; typical units: hours/event)

EP = Duration of the exposure period (dimensions: time; typical units: years)

AP = Averaging Period (dimension: time; typical units: years)

C = Appropriate units conversion factor(s) (e.g., 10^{-6} kg/mg, 1 week/7 days)

For receptors assumed to be exposed constantly (such as for many residential

exposures), the Average Daily Exposure would be equal to the Exposure Point Concentration:

$$ADE_{air} = \frac{[OHM]_{air} * 1\frac{event}{day} * 24\frac{hours}{event} * 6\ years * \frac{1\ day}{24\ hours}}{6\ years} \quad \textbf{(7-11)}$$

$$ADE_{air} = [OHM]_{air} \quad \textbf{(7-12)}$$

Calculation of Average Daily Dose$_{air}$

As noted above, there are circumstances under which the *dose* or hazardous material experienced by a receptor breathing contaminated air may be calculated. The equation for estimating such an Average Daily Dose (ADD_{air}) is given as:

$$ADD_{gaseousOHM} = \frac{[OHM]_{air} * VR * RAF * EF * ED * EP * C}{BW * AP} \quad \textbf{(7-13)}$$

Where:

[OHM]$_{air}$ = Exposure point concentration of gaseous oil or hazardous material in the air at the Exposure Point during the period of exposure (dimensions: mass/volume; typical units: $\mu g/m^3$)

VR = Ventilation (inhalation) rate for the receptor of concern during the period of exposure. (dimensions: volume/time; typical units: m^3/hour)

RAF = Relative Absorption Factor (unitless)

EF = Number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time; typical units: events/day)

ED = Duration of each exposure event (dimensions: time/event; typical units: hours/event)

EP = Duration of the exposure period (dimensions: time; typical units: years)

BW = Body weight of the receptor of concern during the averaging period (dimension: mass; typical units: kg)

AP = Averaging Period (dimension: time; typical units: years)

C = Appropriate units conversion factor(s) (e.g., 10^{-6} kg/mg, 1 week/7 days)

7.3.4.2 Soil

The Average Daily Dose received by a receptor via direct contact with soil containing OHM (ADD_{soil}) is the sum of the average daily doses resulting from absorption via dermal contact with the contaminated soil and the incidental ingestion of that soil.

$$ADD_{Soil} = ADD_{dermal\ absorption} + ADD_{ingestion}\ [\ + ADD_{particulate\ inhalation}\ ] \qquad \textbf{(7-14)}$$

Additional soil-related exposures may result from the inhalation of fugitive dust originating from the contaminated soil.

Note: The general procedures for assessing soil exposure described in this section have been adapted from an on-going project within the Office of Research and Standards to develop methodology for deriving soil advisory levels (MADEP, 1995b).

Dermal Contact with Contaminated Soil

Dermal absorption of oil or hazardous material is a potentially significant route of exposure whenever direct contact with soil may occur. In fact, dermal absorption from soils may be more significant than incidental ingestion for chemicals which have a percent absorption exceeding about 10% (USEPA, 1992). (Even chemicals exhibiting percentage absorption less than 10% may contribute significantly to cumulative risk estimates and thus, these chemicals must also be evaluated.) The absorption of OHM from soil depends upon chemical-specific factors as well as the characteristics of the soil (such as particle size and organic carbon content).

The Average Daily Dose due to dermal contact with OHM contaminated soil ($ADD_{dermal\ absorption}$) may be calculated:

$$ADD_{dermal\ absorption} = \frac{[OHM]_{soil} * SA * AF * RAF * EF * ED * EP * C}{BW * AP} \qquad \textbf{(7-15)}$$

Where:

$[OHM]_{soil}$ = Representative concentration of OHM in the soil at the exposure point during the period of exposure (dimensions: mass/mass)
SA = Skin surface area in contact with the soil on days exposed (dimensions: area/time)
AF = Mass of soil adhered to the unit surface area of skin exposed (dimensions: mass/area)
RAF = Relative Absorption Factor (unitless)
EF = Exposure Frequency: the number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time)
ED = Exposure Duration: the typical duration of each exposure event (dimensions: time/event)
EP = Exposure Period: the period of time over which exposure may occur (dimension: time)
BW = Body Weight of the receptor of concern during the averaging period (dimension: mass)

AP = Averaging Period (dimension: time)
C = Appropriate units conversion factor(s)

Incidental Ingestion of Contaminated Soil

The Average Daily Dose due to the incidental ingestion of OHM contaminated soil (ADD_{soi}) may be calculated:

$$ADD_{ingestion} = \frac{[OHM]_{soil} * IR * RAF * EF * ED * EP * C}{BW * AP} \quad \textbf{(7-16)}$$

Where:

ADD_{ing} = Average daily dose of oil or hazardous material received through the ingestion of soil, during the period of exposure (dimensions: mass/mass ▸ time, typical units: mg/kg ▸ day).
$[OHM]_{soil}$ = Exposure point concentration of the oil or hazardous material in soil (dimensions: mass/mass, typical units: mg/kg).
IR = Daily soil ingestion rate on days exposed during the exposure period (dimensions: mass/time, typical units: mg/day)
RAF = Relative Absorption Factor (dimensionless).
EF = Number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time, typical units: events/day).
ED = Average duration of each exposure event (dimensions: time/event, typical units: day/event).
EP = Duration of the exposure period (dimensions: time, typical units: years).
C = Appropriate units conversion factor(s)
BW = Body weight of the receptor of concern during the averaging period (dimensions: mass, typical units: kg).
AP = Averaging Period (dimension: time, typical units: years).

DERMAL EXPOSURES:
COMPARISON WITH EPA-RECOMMENDED METHOD

Equation 7-15 incorporates the USEPA recommended approach of estimating dermally absorbed doses from *any chemical* present in soil. The USEPA equation (USEPA, 1992; equation 6.18) is based upon an experimentally determined (or theoretically derived) absorption fraction (ABS) to determine the absorbed dose per event:

$$DA_{event} = C_{soil} * AF * ABS \quad \textbf{(7-17)}$$

Where:

DA_{event} = Absorbed dose per event (mg/cm^2-event)
C_{soil} = Contaminant concentration in soil (mg/kg)(10^{-6} kg/mg)
AF = Adherence factor of soil to skin (mg/cm^2-event)
ABS = Absorption Fraction

Note that C_{soil} and AF of the USEPA equation correspond to $[OHM]_{soil}$ and AF in Equation 7-15. The Absorption Fraction (ABS) of the USEPA equation is incorporated into the Relative Absorption Factor (RAF) shown in Equation 7-15 (See Section 7.2.3 for a discussion of the derivation of RAFs).

This comparison of USEPA and MADEP approaches is included here to address a common misperception that EPA guidance recommends evaluating dermal absorption for only cadmium and PCBs.

Inhalation of OHM Contaminated Particulates

Airborne particulates (fugitive dust) may carry oil or hazardous material to receptors, resulting in soil-related inhalation exposures. An Average Daily Dose due to the inhalation of OHM contaminated particulates (ADD_{inhp}) may be calculated:

$$ADD_{particulate\ inhalation} = \frac{[RP]_{air} * [OHM]_{particulate} * VR * RAF * EF * ED * EP * C}{BW * AP} \quad \textbf{(7-18)}$$

Where:

$[RP]_{air}$ = Exposure point concentration of respirable particulates (i.e., PM_{10}) in the air at the Exposure Point during the exposure event. (dimensions: mass/volume; typical units: $\mu g/m^3$)

$[OHM]_{part}$ = Representative concentration of OHM in the respirable particulates at the Exposure Point during the period of exposure. (dimensions: mass/mass; typical units: mg/kg)

VR = Ventilation (inhalation) rate for the receptor of concern during the period of exposure. (dimensions: volume/time; typical units: m^3/hour)

RAF = Relative Absorption Factor (dimensionless)

EF = Number of exposure events during the exposure period divided by the number of days in the exposure period. (dimensions: events/time; typical units: events/day)

ED = Duration of each exposure event. (dimensions: time/event; typical units: hours/event)

EP = Duration of the exposure period (dimensions: time; typical units: years)

BW = Body weight of the receptor of concern during the averaging period (dimension: mass; typical units: kg)

AP = Averaging Period (dimension: time; typical units: years)

C = Appropriate units conversion factor(s)

For airborne chemicals which act at the point of contact (e.g. the lungs) when inhaled, the Average Daily Exposure of these chemicals calculated in the manner described in Section 7.3.4.1 would be used in combination with a *Reference Concentration* or *Unit Risk* to estimate potential risks. Under such conditions, the $ADD_{particulate\ inhalation}$ would not be calculated.

In situations with high particulate concentrations, the larger (greater than 10 µm) inhaled particulates may result in significant <u>*oral*</u> exposures which should also be quantified.

7.3.4.3 Sediment

The Average Daily Dose received by a receptor via direct contact (dermal absorption and incidental ingestion) with OHM contaminated sediment will be estimated in a manner similar to the calculation of the ADD for soil exposure, including both dermal contact with the sediment and incidental ingestion of that sediment. The inhalation of fugitive dust originating from contaminated sediments would not generally be evaluated unless climatic conditions resulted in such sediments becoming dry, thus increasing the potential for dust generation.

7.3.4.4 Drinking Water

The exposure experienced by a receptor using contaminated water is not limited to exposure received when actually drinking the water. Several studies indicate that significant exposure may also result from the inhalation of material volatilized from the water and through the absorption of contaminants from water in contact with the receptor's skin (Jo et al., 1990a and 1990b). Each of these exposure pathways should be evaluated separately, as described herein. The calculated oral and dermal doses are assumed to be equitoxic and may be mathematically combined:

$$ADD_{oral,\ dermal} = ADD_{oral} + ADD_{dermal} \quad \textbf{(7-19)}$$

The assumption of equitoxicity is *not* assumed to apply to the dose received via the inhalation of volatilized material from the water, and the risk associated with this exposure must be evaluated separately using appropriate toxicity information.

Ingestion of Contaminated Drinking Water

The Average Daily Dose due to the ingestion of OHM contaminated drinking water (ADD_{dwi}) may be calculated:

$$ADD_{ingestion} = \frac{[OHM]_{water} * VI * RAF * EF * ED * EP * C}{BW * AP} \quad \textbf{(7-20)}$$

Where:

$[OHM]_{water}$ = Exposure point concentration of oil or hazardous material in the drinking water at the exposure point during the exposure period (dimensions: mass/volume; typical units: µg/liter)

VI = Volume of drinking water ingested by the receptor of concern at (or from) the exposure point during the exposure period (dimensions: volume/time; typical units: liters/day)

RAF = Relative Absorption Factor (unitless)

EF = The exposure frequency, or the number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time; typical units: events/day)

ED = Duration of each exposure event (dimensions: time/event; typical units = days/event)

EP = Duration of the exposure period (dimension: time; typical units: years)

BW = Body weight of the receptor of concern during the averaging period (dimensions: mass; typical units: kg)

AP = Averaging Period (dimension: time)

C = Appropriate units conversion factor(s)

Dermal Absorption of OHM Via Drinking Water

Dermal absorption of oil or hazardous material may occur while the receptor is in contact with the contaminated drinking water. Everyday activities such as showering, bathing, washing floors and cooking lead to direct contact with water and may result in dermal absorption of the chemicals.

DEP/ORS has assessed the magnitude of the dermal exposure received during showering (Brown et al., 1984) and has evaluated this exposure relative to that which a receptor would be expected to receive from drinking the same water. For most organic compounds, the shower/dermal absorption exposures are estimated to be

approximately 20% (or less) than the estimated drinking water ingestion exposures (MADEP, 1992a). For chemicals which penetrate the skin the fastest (i.e., those with high permeability constants of approximately 1 $cm^3/cm^2 \cdot hr$ or greater), the dermal doses received are roughly equivalent to the ingestion doses (Hutcheson, et al., in press). Based upon these observations, BWSC recommends that the following streamlined approach be adopted[1]:

- For the majority of organic compounds, the absorbed dermal dose may be approximated as 20% of the calculated dose received from drinking water ingestion:

$$ADD_{dermal} = 0.2 * ADD_{ingestion}$$

- For organic compounds which have a permeability constant greater the 0.5 $cm^3/cm^2 \cdot hr$ (including ethylbenzene and toluene), the absorbed dermal dose may be approximated as the calculated dose received from drinking water ingestion:

$$ADD_{dermal} = ADD_{ingestion}$$

- For metals and inorganic compounds, the dermal exposures experienced during showering may be assumed to be negligible when compared with the exposures received while ingesting the contaminated water.

These approximations are considered protective for most chemicals, and when applied within the stated limitations, would be generally be acceptable to the BWSC. However, the approach is generic, and will yield less accurate dose estimates for some compounds than others. Therefore, as an alternative, the risk assessor may choose to explicitly calculate the dose received when the receptor comes into dermal contact with contaminated water. The equation presented under *Surface Water Exposures* may be used with assumptions appropriate to the specific exposure being modelled.

Inhalation of OHM Volatilized from Drinking Water

As with the dermal exposures associated with the use of drinking water, numerous studies (Andelman, 1985; Foster and Chrostowski, 1987; McKone, 11987; McKone, 1991) have looked at the magnitude of the inhalation exposures associated with household water use. Based on a review of those studies, ORS has concluded that for *volatile* organic compounds (i.e. compounds with a Henry's Law Constant equal to or

---

1 These approaches assume 100% absorption via ingestion. The equation should be modified (dividing the ADD ingestion by the oral absorption efficiency) if less oral absorption is assumed to occur.
Example: **ADDdermal = 0.2 * ADDingestion ÷ Oral Absorption Efficiency**
Note that assuming lower oral absorption increases the fraction of the total dose attributable to dermal contact.

greater than 5 x 10^{-4} atm*m^3/mol*K), the shower/inhalation exposures are likely to be approximately equal to and no greater than the estimated drinking water ingestion exposures. However, exposures to compounds with lower Henry's Law Constants are likely to be lower.

Based upon these observations, BWSC recommends that the following streamlined approach be adopted for the evaluation of shower/inhalation exposures:

- For chemicals with a Henry's Law constant equal to or greater than 5 x 10^{-4} atm ▸ m^3/mol ▸ ˜K (at 20→25˜C), the applied dose (in mg/kg/day) received via inhalation may be approximated as the calculated *applied* dose received from drinking water ingestion (This value would correspond to the result of Equation 20 *if the RAF factor were removed*.)

- For chemicals with a Henry's Law constant less than 5 x 10^{-4} but greater than or equal to 1 x 10^{-5} atm ▸ m^3/mol ▸ ˜K (at 20→25˜C), the applied dose (in mg/kg/day) received via inhalation may be approximated as one half the calculated *applied* dose received from drinking water ingestion (or ½ The value which would result from Equation 20 *if the RAF factor were removed*.)

- For chemicals with a Henry's Law constant less than 1 x 10^{-5} atm ▸ m^3/mol ▸ ˜K (at 20→25˜C), the inhalation exposures experienced during showering are assumed to be negligible relative to the ingestion exposures and would not need to be evaluated unless the chemical under investigation is significantly more toxic when inhaled than when ingested.

Unlike the dermal exposures, however, it cannot be assumed that the chemicals have equal toxicity by inhalation and oral exposures. In order to estimate risk using the Reference Concentration or Unit Risk toxicity values, the doses approximated as above must be converted to an applied inhalation exposure (in concentration units such as μg/m^3) using the following equation:

$$ADE_{inhalation} = \frac{ADD_{inhalation} * BW * C}{VR} \qquad \textbf{(7-21)}$$

Where:

ADE_{inh} = The average daily exposure to the contaminant in air resulting from one shower exposure per day (dimensions: mass/volume; typical units: μg/m^3).
ADD_{inh} = Average daily dose of OHM (ia inhalation) approximated from the water ingestion pathway (dimensions: mass/mass ▸ time; typical units: mg/kg ▸ day).
BW = Body weight of the receptor of concern during the averaging period (dimension: mass; typical units: kg).
C = Appropriate units conversion factor(s).
VR = Ventilation (inhalation) rate for the receptor of concern during the exposure event (dimensions: volume/time; typical units: m^3/hr.)

NOTE: Equation 21 provides the calculation of an Average Daily Exposure. If the goal is to calculate the exposure point concentration during the shower event, Exposure Frequency and Exposure Duration terms should be inserted in the denominator of Equation 21:

EF = Exposure frequency. The number of shower events during the exposure period divided by the number of days in the exposure period. (Dimensions: events/time; typical units: event/day).

ED = Duration of shower exposure event (dimensions: time/event; typical units: minutes/event).

Alternatively, shower models available in the literature (Foster and Chrostowski, 1987) may be used to estimate chemical-specific air exposures.

7.3.4.6 Surface Water

Contamination in surface water can result in receptor exposures from the incidental ingestion of the water, through dermal contact with the water, and through the inhalation of material volatilized from the water. As with the drinking water evaluation, the ingestion and dermal doses are assumed to be equitoxic and the estimated values may be mathematically combined:

$$ADD_{oral,\ dermal} = ADD_{oral} + ADD_{dermal} \qquad \textbf{(7-22)}$$

The assumption of equitoxicity is *not* assumed to apply to the dose received via the inhalation of volatilized material from the water, and the risk associated with this exposure must be evaluated separately using appropriate toxicity information.

Surface Water Ingestion

The equation used to estimate the Average Daily Dose received by a receptor via the ingestion of contaminated surface water ($ADD_{surface\ water\ ingestion}$) is identical to that used to evaluate drinking water ingestion exposures, which is described earlier in this section. The assumptions chosen to describe the exposure (the volume of water ingested, the duration of the exposure event, etc...) should be representative of the exposure scenario being modelled.

Surface Water, Dermal Contact

The Average Daily Dose of a chemical received via dermal absorption from surface water ($ADD_{dermal,\ water}$) may be calculated using the following equation. This approach is recommended by BWSC for all chemicals when the dermal exposure is explicitly calculated.

$$ADD_{dermal,water} = \frac{[OHM]_{water} * SA * K_p * RAF * EF * ED * EP * C}{BW * AP} \quad \textbf{(7-23)}$$

Where:

ADD_{dermal} = Average daily dose of oil or hazardous material associated with dermal contact exposure to contaminated water. In units: mg/kg/day.

$[OHM]_{water}$ = The concentration of contaminant in water which is contacting the skin during the exposure event. (Dimensions: mass/volume; typical units: µg/liter).

SA = Body surface area exposed to contaminated water during the exposure event. (dimensions: area; typical units: cm^2).

K_p = Permeability Constant. (dimensions: volume/(time * area); typical units: cm^3/(hr * cm^2), which is often simplified to cm/hr).

RAF = Relative Absorption Factor for dermal contact with water. **Note:** when the permeability constant (K_p) is used to determine the flux of contaminant through the skin, it results in an *absorbed* dose of OHM. The RAF is used here to adjust this absorbed dose to make it comparable to the toxicity value employed to estimate risk. The numerator of the RAF must be assigned a value of 1, and the denominator depends upon the absorption in the study which is the basis of the toxicity value (See Section 7.2.3). If the toxicity value itself is based on an *absorbed* dose, then the RAF_{dermal} is 1 by definition. Dimensionless.

EF = The exposure frequency, or the number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time; typical units: **events/day**).

ED = The duration of each exposure event (dimensions: time/event; typical units: hours/event).

EP = Duration of exposure period (dimension: time; typical units: years).

C = Appropriate units conversion factor(s).

BW = Body weight of the receptor of concern during the averaging period (dimensions: mass; typical units: kg).

AP = Averaging Period (dimension: time; typical units: years).

Alternatively, another model, specific to organic compounds and assuming some exposure period before a steady-state condition is established, is described in a USEPA Interim Report (USEPA, 1992). The USEPA cautions in that document that this procedure is still under review by the scientific community and that further refinement of the approach is expected.

Inhalation Exposures Associated With Contaminated Surface Water

Under some circumstances the volatilization of oil or hazardous material from surface water may contribute to exposure experienced by the receptor of concern. Such exposures are more likely to be of concern if the material is volatilizing into a confined space or if the concentrations in the surface water are relatively high. The exposures associated with this scenario may be evaluated following the equation presented in Section 7.3.4.1, with the $[OHM]_{air}$ term being either measured or modelled air concentrations of the contaminant.

7.3.4.7 Food

The average daily dose (ADD_{food}) experienced by the receptor as a result of consuming food (e.g. garden produce) containing oil or hazardous material may be estimated using the following equation. The general form of this equation may be applied to the ingestion of contaminated fish, meat, or vegetables. The evaluation of exposure to infants from ingesting mother's milk or other fluids may be estimated using the general equation for drinking water exposures in combination with the appropriate exposure factors.

$$ADD_{food} = \frac{[OHM]_{food} * FI * RAF * EF * ED * EP * C}{BW * AP} \qquad \textbf{(7-24)}$$

Where:

[OHM]$_{food}$ = Representative concentration of OHM in the food of concern during the period of exposure (dimensions: mass/mass, typical units: mg/kg)
FI = Daily intake of the food of concern on days exposed during the exposure period (dimensions: mass/event; typical units: mg/meal)
RAF = Bioavailability Adjustment Factor
EF = Number of exposure events during the exposure period divided by the number of days in the exposure period (dimensions: events/time. typical units: meals/day)
ED = Duration of the exposure period (dimension: time, typical units: years)
BW = Body weight of the receptor of concern during the averaging period (dimension: mass, typical units: kg)
AP = Averaging Period (dimensions: time, typical units: years)
C = Appropriate units conversion factor(s)

7.3.4.8 Calculation of Lifetime Average Daily Dose (For All Media)

The lifetime average daily dose should be calculated to reflect age-related differences in exposure rates that are experienced by a receptor throughout his or her lifetime of exposure. Because of their low body weight and behavioral characteristics, young children receive greater exposure per unit body weight than older children and adults. Furthermore, young children typically have more dermal contact with soil and more hand-to mouth activity. Therefore, the LADD should be calculated in a way that does not "dilute" the higher exposure rates experienced by young children with lower exposure rates experienced by older children and adults.

For example, a LADD (based on a 30-year exposure period) which uses an average body weight and skin surface area value for all ages of receptor (1<31) will not be protective of the high exposure rates in young children and is <u>not</u> a recommended procedure.

There are a number of averaging methods that can be used to calculate a LADD that reflects the higher exposure rates experienced by young children. One method is to calculate average annual dose rates, normalized to body weight, for each year of exposure.

The sum of the dose rates is then averaged over a lifetime (75 years). The equation below shows this averaging approach. However, this type of calculation can be tedious, even when performed by computer.

$$LADD = \frac{\sum_{i=0}^{30\ years} \frac{IR_i \times EP_i}{BW_i}}{AP} \qquad \textbf{(7-25)}$$

Where:

IR_i = Average Intake rate for the exposure period (mg/day)
EP_i = Exposure period, one year
BW_i = Age-dependent body weight, ages 0 to 30
AP = Averaging Period, lifetime (75 years)

As an alternative, there is a simpler averaging approach which can be used to calculate the lifetime average daily dose. This simpler approach gives essentially the same results as the year-by-year averaging method. The simpler averaging approach uses a weighted average for younger children aged 1 to 6. Children aged 1 to 6 is a logical choice for the weighted group because the default soil ingestion rate for children aged 1 to 6 is 100 mg per day (double the rate used for older children and adults). Thus, children aged 1 to 6 have a much higher rate of exposure because of the higher rate of soil ingestion assumed.

As the equation below shows, only two Average Daily Doses need to be calculated instead of 30. This greatly simplifies the calculations. The Average Daily Dose for children aged 1 to 6 is calculated using average exposure parameters for children in this age group. Similarly, the Average Daily Dose for the receptors aged 6 to 31 is calculated using average values for receptors in this group. The LADD is then calculated as the sum of the two doses averaged over a lifetime. The equation below shows this weighted calculation.

$$LADD = \frac{\frac{IR_{1<6}}{BW_{1<6}} \times EP_1 + \frac{IR_{6<31}}{BW_{6<31}} \times EP_2}{AP} \qquad \textbf{(7-26)}$$

Where:

$IR_{1<6}$ = Average Intake rate for receptors aged 1<6 (mg/day)
EP_1 = Exposure period, 5 years
$BW_{1<6}$ = Average body weight for children ages 1 to 6
$IR_{6<31}$ = Average Intake rate for receptors aged 6 to 31 (mg/day)
EP_2 = Exposure period, 25 years
$BW_{6<31}$ = Average body weight for receptors aged 6 to 31
AP = Averaging Period, lifetime (75 years)

As stated above, this weighted average approach can be used to calculate the LADD and will result in essentially the same results as the more complicated year-by-year averaging approach.

7.4 RISK CHARACTERIZATION

Risk Characterization is the final step in the risk assessment process. In this step, the results of the Hazard Identification, Dose-Response Assessment and Exposure Assessment are integrated to yield quantitative measures of cancer and noncancer risk. The Risk Characterization can be thought of as providing a link between risk assessment and risk management because it presents the numerical estimates of risk posed by the site in a context that can be used easily by risk managers to make decisions about remediation.
In accordance with the MCP (310 CMR 40.0993(6)), the Risk Characterization step must also must include a comparison of Exposure Point Concentrations (EPCs) with applicable or suitably analogous public health standards.

A critical component in the presentation of risk estimates is the discussion of major assumptions, scientific judgements and uncertainties inherent in the numerical risk estimates. The importance of this component cannot be overstated. The discussion of uncertainties should place the numerical estimates of risk and hazard in the overall context of what is known about the site and what is uncertain. The numerical risk estimates should never be interpreted as a characterization of absolute risk but should always be interpreted in the context of the uncertainties.

The regulations provide clear direction regarding the way numerical estimates of risk are to be presented in the Risk Characterization (310 CMR 40.0933). The MCP requires that chemical-specific and medium-specific estimates of risk be combined to yield Cumulative Cancer and Noncancer Risks for each Receptor. These Cumulative Risks are then compared with specific risk management criteria which include public health standards and Cumulative Receptor Risk Limits (310 CMR 40.0933(6)). The result of this comparison determines whether a condition of No Significant Risk of harm to human health exists or has been achieved at the site.

This Section of the *Guidance* describes methods for characterizing cancer and noncancer risks and discusses the interpretation of Risk Characterization results within the context of the MCP. This Section also addresses the identification of Applicable or Suitably Analogous Public Health Standards and the comparison of such standards with EPCs. Lastly, this Section addresses how uncertainties in the Risk Assessment should be addressed.

7.4.1 Noncancer Risk

The measure used to describe the potential for noncarcinogenic health effects is the Hazard Index (HI). For a given chemical, the HI is the ratio of a receptor's exposure level (or dose) to the "*acceptable*" (or allowable) exposure level. A Hazard Index of 1.0 or less indicates that the receptor's exposure is equal to or less than the allowable exposure level, and it is considered unlikely that adverse health effects will occur. When the HI is less than or equal to 1.0, a conclusion of "No Significant Risk of harm to human health" based on non-cancer effects, is appropriate.

A HI of greater than 1.0 indicates that noncancer health effects could occur, and cannot be ruled out. It does not mean that noncancer effects *will* occur. Uncertainty inherent in most Reference Doses precludes identifying a specific dose above which adverse effects are likely *and* below which effects are unlikely. Accordingly, the probability of an effect cannot be quantified from a HI. *For any one chemical*, it is always true that the likelihood of an effect increases as the exposure level (and therefore the HI) increases.

The uncertainty inherent in RfDs for different chemicals differs both qualitatively and quantitatively. Therefore, for different substances, the probability of an effect increases at different rates. For example, a HI of 20 for one substance may indicate a very high probability of an effect, but may represent only a moderate probability of an effect for another chemical.

In interpreting the HI, one must consider the appropriateness of the exposure assumptions and the basis of the toxicity information used to develop the RfD. As a general rule, the greater the HI is above 1.0, the greater the level of concern.

In its most general form, the Hazard Index associated with a chemical via a given route of exposure is calculated as:

$$HI = \frac{ADD}{RfD} \tag{7-27}$$

or, for inhalation exposures,

$$HI = \frac{[OHM\ ]_{air}}{RfC} \tag{7-28}$$

Where:

HI =	The Hazard Index associated with exposure to the chemical via the specified route of exposure.
ADD =	The estimated Average Daily Dose of the chemical via the specified exposure route. In **mg/kg/day**.
RfD =	The oral Reference Dose or appropriate substitute toxicity value identified for the chemical of concern. In **mg/kg/day**.
$[OHM]_{air}$ =	The Exposure Point Concentration of the Oil or Hazardous Material in air. In **µg/m³**.
RfC =	The Reference Concentration or substitute toxicity value identified for the chemical of concern. In **µg/m³**.

The Average Daily Dose (ADD) in equation 7-27 is calculated from the Exposure Point Concentration using exposure assumptions consistent with the Exposure Profiles developed for each receptor being evaluated. Section 7.3 of this Guidance describes the process for calculating a receptor's ADD.

The allowable dose or exposure (denominators in equations 7-27 and 7-28) will typically be the EPA Reference Dose (RfD) for most exposure routes or the EPA Reference Concentration (RfC) for air exposures. Selection of an appropriate "acceptable" dose is discussed in Section 7.2.

It is important to calculate separate HIs for acute, subchronic or chronic exposures if these have been identified as exposure periods of concern in the development of exposure profiles.

As mentioned previously, the MCP requires that *cumulative* noncancer risks be calculated. A cumulative HI represents the cumulative noncarcinogenic impact that the site has on a particular receptor group. The cumulative HI accounts for exposures that a receptor may receive from multiple chemicals and multiple exposure routes.

Again, remember that separate cumulative HIs are calculated for acute, subchronic or chronic exposures that have been identified as exposure period of concern for the site.

As shown by the following two equations, the cumulative HI can be calculated by summing the exposure route-specific HI. Route specific HI are calculated as the sum of all chemical-specific HIs.

$$Total\ HI_{route\text{-}specific} = \sum HI_{chemical\text{-}specific} \quad \textbf{(7-29)}$$

$$Cumulative\ HI = \sum HI_{route\text{-}specific} \quad \textbf{(7-30)}$$

If the risk calculations are being performed using a probabilistic analysis, the risk assessor must identify the dose or concentration associated with the 95th percentile estimate of exposure (310 CMR 0993(5)). This dose or concentration should be compared with the toxicity value identified following the dose/response section of this Guidance. This HI is then compared with the HI Limit of 1.0 in order to determine whether the site poses a significant risk of harm to human health based on the risk of noncancer health effects.

The documentation of the Risk Characterization must clearly present all mathematical equations used to calculate Cumulative Noncancer Risks (310 CMR 40.0993(9).

7.4.1.1 Screening Hazard Index

Initially, the risk assessor should use equation 7-30 above to calculate a *Screening Hazard Index* for a given receptor group based on all chemicals of concern at the site in all exposure routes at all exposure points. A HI calculated in this way will provide a conservative estimate of the true HI because it treats as additive, different toxic effects from multiple chemicals acting on different organ systems by different mechanisms of action. In fact, in a true HI, the only endpoints which should be treated as additive are those which produce adverse effects on the same organ system by the same mechanism. Thus, the Screening HI will provide a conservative estimate of the actual HI because it reflects the sum of toxicities for multiple chemicals, regardless of the chemical's health endpoint, target organ or mechanism of action.

Recall that there may be multiple adverse health effects associated with exposure to a given chemical and it is the most sensitive adverse health effect observed in the scientific data which drives estimation of the Reference Dose. Thus, for a given group of chemicals, Reference Doses may be based on a different toxic effects on different organ systems by different mechanisms of action.

The screening HI should be compared with the MCP Cumulative Receptor Noncancer Risk Limit which is a HI equal to 1.0 (310 CMR 40.0933(6)). If the screening HI is less than 1.0, then no additional effort is needed to characterize noncancer risks. However, if the screening HI exceeds 1.0, the risk assessor should then calculate separate HIs for chemicals with similar toxic effects and mechanisms of action.

Remember that separate screening HIs should be calculated for different exposure periods (i.e., chronic, subchronic, acute).

7.4.1.2 Health Endpoint-Specific Hazard Index

The procedure for segregating HIs by effect and mechanism of action is not simple and should be performed by a toxicologist. If the segregation is done improperly, an underestimate of the true hazard could result. Segregation of HIs requires identification of the major health endpoints of each chemical, including effects observed at higher doses than the critical effect on which the toxicity value is based. This is because the critical effect for one chemical may not be relevant for other chemicals and doses of other chemicals may not be additive for that effect. On the other hand, additive impacts could be important for other health endpoints that are only expected at higher doses.

Major effect categories that should be considered in segregating chemicals include neurotoxicity, developmental toxicity, reproductive toxicity and immunotoxicity. Adverse effects also should be categorized by target organ (i.e., hepatic, renal, respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal and dermal/ocular). The effects and mechanism of action should be discussed in the toxicological profile.

Once chemicals have been categorized, the Cumulative Hazard Index for chemicals with similar health endpoints and mechanisms of toxicity should be calculated. Each HI should be compared with the MCP Cumulative Receptor Noncancer Risk Limit which is a HI equal to 1.0. If any of the HIs exceeds one, then the Risk Characterization must conclude that the site poses Significant Risk of harm to human health based on the risk of noncancer health effects.

7.4.2 Cancer Risk

The potential for carcinogenic (i.e., nonthreshold) health effects is characterized as the Excess Lifetime Cancer Risk (ELCR). The ELCR represents the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. For a given chemical, the estimated ELCR is the product of the receptor's quantified exposure and a measure of carcinogenic potency. The typical measures of carcinogenic potency are the EPA Cancer Slope Factor (SF) for most exposure routes and the Unit Risk (UR) for inhalation.

In its basic form, the ELCR associated with exposure to a given chemical via a particular exposure pathway is estimated as follows:

$$ELCR = LADD \times SF \quad \textbf{(7-31)}$$

or, for inhalation exposures,

$$ELCR = [OHM]_{air} \times UR \quad \textbf{(7-32)}$$

Where:

ELCR = The Excess Lifetime Cancer Risk associated with exposure to the chemical via the specified route of exposure.

LADD = The estimated Lifetime Average Daily Dose of the chemical via the specified exposure route. In **mg/kg/day**.

SF = The Cancer Slope Factor identified for the chemical, appropriate to the specific exposure pathway. In **(mg/kg/day)$^{-1}$**. The selection of this toxicity value is discussed in Section 7.2.2 of this Guidance.

$[OHM]_{air}$ = The Exposure Point Concentration of the Oil or Hazardous Material in air. In **µg/m^3**.

UR = The Unit Risk for the particular chemical of concern. In **µg/m^3**. The identification and selection of UR values is described in Section 7.2.2.

The Lifetime Average Daily Dose (LADD) in equation 7-31 is calculated from the Exposure Point Concentration using exposure assumptions consistent with the Exposure Profiles developed for each receptor being evaluated. Section 7.3 of this Guidance describes the process for calculating a receptor's LADD. The selection of Cancer Slope Factors and Unit Risk values is discussed in greater detail in Section 7.2.2.

As mentioned previously, the MCP requires that *cumulative* cancer risks be calculated. The cumulative cancer risk must be estimated for all Class A and B carcinogens (i.e., chemicals classified by EPA as being known human carcinogens and probable human carcinogens). For most Class C Carcinogens (i.e., those classified by EPA as being possible human carcinogens), the available toxicity data is insufficient to quantify cancer risks. In general, potential carcinogenic effects of these substances should be discussed qualitatively in the Uncertainty Section of the Risk Assessment. However, the Department may in the future identify some Class C carcinogens for which there is sufficient data to include these substances in the quantitative assessment of carcinogenic risk.

The cumulative ELCR represents the cumulative carcinogenic impact that the site has on a particular receptor group. The cumulative ELCR accounts for exposures that a receptor may receive from multiple chemicals and multiple exposure routes.

As shown by the following two equations, the cumulative ELCR can be calculated by summing all of the exposure route-specific ELCRs. Route-specific ELCRs are calculated as the sum all the chemical-specific ELCRs.

This is represented by the following equations:

$$Total\ ELCR_{route\text{-}specific} = \sum ELCR_{chemical\text{-}specific} \quad \textbf{(7-33)}$$

$$Cumulative\ ELCR = \sum ELCR_{route\text{-}specific} \quad \textbf{(7-34)}$$

The Cumulative ELCR should be compared with the MCP Cumulative Receptor Cancer Risk Limit which is an ELCR equal to one-in-one hundred thousand (1×10^{-5}). If the Cumulative Cancer Risk exceeds the ELCR Limit then the Risk Characterization must conclude that the site poses significant risk of harm to human health based on the risk of cancer health effects.

If the risk calculations are being performed using a probabilistic analysis, the risk assessor must identify the dose or concentration associated with the 95th percentile estimate of exposure (310 CMR 0993(5)). This dose or concentration should be compared with the toxicity value identified following the dose/response section of this Guidance. This ELCR is then compared with the Cancer Risk Limit of 1×10^{-5} in order to determine whether the site poses a significant risk of harm to human health based on the risk of cancer health effects.

The documentation of the Risk Characterization must clearly present all mathematical equations used to calculate Cumulative Cancer Risks (310 CMR 40.0993(9).

7.4.3 Comparison to Applicable or Suitably Analogous Public Health Standards

The MCP requires that the characterization of risk of harm to human health include a comparison of EPCs to applicable or suitably analogous public health standards. The list of such standards, as provided in the MCP includes, but is not limited to:

- Massachusetts Drinking Water Quality Standards, promulgated in 310 CMR 22.00 *(these standards are considered applicable only to category GW-1 groundwater)*.
- Massachusetts Air Quality Standards promulgated in 310 CMR 6.00; and
- Massachusetts Surface Water Quality Standards promulgated in 314 CMR 4.00.

It should be noted that the MCP Method 1 Soil and Groundwater Standards listed in 310 CMR 40.0970 are <u>not</u> considered applicable or suitably analogous, as those standards represent an alternative risk characterization approach to Method 3. MADEP staff have noted a tendency to include a list of the Method 1 standards in Method 3 risk characterizations, but including those standards only confuses the reader and brings into question how the risks were actually characterized.

As provided in the MCP, if any EPC exceeds an applicable or suitably analogous standard, the Risk Characterization must conclude that a condition of Significant Risk exists at the site.

7.4.4 Risk Characterization Conclusions

The documentation of the Method 3 Human Health Risk Characterization must contain a clear statement of whether or not a condition of No Significant Risk of harm to human health exists or has been achieved, based upon the criteria contained at 310 CMR 40.0993(7).

As provided in the MCP, a condition of No Significant Risk of harm to human health exists or has been achieved at the site if:

- no Exposure Point Concentration of oil or hazardous material is greater than an applicable or suitably analogous public health standard; *AND*
- no Cumulative Receptor Cancer Risk calculated is greater than the Cumulative Cancer Risk Limit; *AND*
- no Cumulative Receptor Noncancer risk is greater than the Cumulative Receptor Noncancer Risk Limit.

Note that all three criteria must be met in order for a conclusion to be reached that the site poses No Significant Risk of harm to human health.

7.5 UNCERTAINTY ANALYSIS

The Uncertainty Analysis is a critical component of the Risk Characterization. The Uncertainty Analysis should contain a narrative section which places the numerical risk estimates in the overall context of what is known and what is not known about the site and in the context of decisions that the site manager will make about remediation. The Uncertainty Analysis does not modify the risk characterization conclusions themselves. However, a Risk Characterization is not considered complete unless the numerical risk estimates are accompanied by an explanation which interprets and qualifies the risk results.

Inherent in all risk assessments are many assumptions, scientific judgements and a wide variety of uncertainties, which can be introduced at each step in the risk assessment process. In addition, dose response and exposure assessment guidance presented in this document are intended to produce conservative, consistent estimates of the potential for adverse impacts. For all of these reasons, the numerical risk estimates calculated in the Risk Characterization should never be interpreted as absolute, purely scientific estimates of the risk of harm to health.

General sources of uncertainty in the risk assessment which should be discussed in the Uncertainty Analysis include, but are not limited to:

- Identification of all site-related contaminants in sampling of the environmental media at the site.

- Modeling used to develop Exposure Point Concentrations.
- Quantitative toxicological data used to develop cancer and noncancer toxicity values.
- Development of Exposure Profiles and selection of exposure assumptions used in dose calculations.

Although the Uncertainty Analysis may be a qualitative evaluation of uncertainties affecting the risk estimates, the risk assessor should attempt to describe the magnitude and direction of effect that a particular area of uncertainty is likely to have on the numerical risk estimates.

Monte Carlo Analysis can be a powerful tool for expressing the uncertainties in risk assessments. The reader should refer to Appendix C for a discussion about the use of Monte Carlo Analysis.

7.6 SHORTCUTS

Under certain circumstances, it may be possible to substantially reduce the level of effort necessary to conduct a Method 3 risk assessment. Two possible shortcuts, the "Screening" Risk Characterization and the *DEP Risk Assessment ShortForm - Residential Scenario* are specifically discussed.

Other shortcuts, if they are logical, clearly identified and defensible (usually with a quantitative demonstration) may be used as well and are encouraged. Using a shortcut *without* adequate justification is inappropriate.

7.6.1 Screening Risk Characterization

One shortcut option that may be considered is to conduct a "*Screening*" Human Health Risk Characterization using worst-case exposure assumptions (310 CMR 40.0902(5)). The objective of a screening evaluation is to quickly demonstrate that a condition of No Significant Risk exists or has been achieved at a disposal site. To do this, the risk assessor should use worst-case exposure assumptions and conservative toxicity values. For example, the risk assessor might assign the toxicity value for the most toxic substance at a site to all substances at the site and use the maximum reported concentration for each chemical as the EPC. Assuming residential exposures at an industrial site is another possible overly-conservative assumption that may be used in a screening risk characterization.

The objective of the screening risk characterization is to save time and money by using readily available data and information that will result in risk estimates that will not underestimate the risks posed by the disposal site. Thus, if the resulting risks are below the MCP Risk Limits, clearly, remediation would not be required based on risk of harm to human health. It is important to note that remediation may still be required based on risk of harm to the environment, public welfare or safety.

A screening risk characterization may also be used to demonstrate that certain exposure pathways result in risks which are trivial, compared with the MCP Cumulative Risk Limits. Such a demonstration would justify the elimination of that exposure pathway from consideration in the risk characterization. In general, "trivial" is considered as being a level of risk that is at least one order of magnitude smaller than the MCP Risk Limit, based on a conservative risk characterization as described in the preceding paragraphs.

A screening risk characterization is intended as an option to reduce the cost and level of effort involved in conducting a risk characterization, *not site characterization*. The results of a "Screening" risk characterization should never be used to justify inadequate site characterization.

7.6.2 DEP Risk Assessment ShortForm - Residential Scenario

The *Residential ShortForm* is an optional tool which has been developed by the Department to provide a streamlined method of evaluating potential human health risks at 21e sites. The *ShortForm* streamlines the process by providing a rapid, low cost procedure for assessing health risks. The *ShortForm* is a *LOTUS 1-2-3* (or *Quattro Pro*) spreadsheet incorporating standard assumptions for assessing residential exposures and equations which are used to estimate human health cancer and noncancer risks. The *ShortForm* is intended for use at "residential" sites which are to be evaluated via a Method 3 risk assessment. The output of the *Residential ShortForm* is a series of summary tables which describe the EPCs, toxicity information and potential chemical-specific, medium-specific and cumulative health risks. These output tables can be submitted as the Risk Assessment portion of a Phase II Report.

REFERENCES FOR CHAPTER 7

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Selected PCBs (Update).

Barnes, D.G. and Dourson, M.L. 1988. Reference Dose (RfD): Description and Use in Health Risk Assessments. Regulatory Toxicology and Pharmacology.8:471-486.

Chu, M.M.L. and Chen, C.W. 1984. Evaluation and Estimation of Potential Carcinogenic Risks of Polynuclear Aromatic Hydrocarbons. Paper presented at the Symposium on Polycyclic Aromatic Hydrocarbons in the Workplace, Pacific Rim Risk Conference, Honolulu HI.

ICF-Clement Associates, Inc. 1988. Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons (Interim Final Report). Prepared for USEPA under contract 68-024403. ICF-Clement Associates. Fairfax, VA.

Dankovic, D.A., Wright, C.W., Zangar, R.C., and D.L. Springer. 1989. Complex Mixture Effects on the Dermal Absorption of Benzo(a)pyrene and Other Polycyclic Aromatic Hydrocarbons From Mouse Skin. Journal of Applied Toxicology 9:39-44.

Farland, W. and M. Dourson. M.L. 1992. Noncancer Health Endpoints: Approaches to Quantitative Risk Assessment. Pages 87-106 in Comparative Environmental Risk Assessment. C.R. Cothern (ed.). Lewis Publishers.

Hecht, S.S., Grabowski, W., and Groth, K. 1979. Analysis of Feces for B[a]P After Consumption of Charcoal-Broiled Beef by Rats and Humans. Food and Cosmetics Toxicology 17:223-227.

Jo, W.K., Weisel, C.P., and Lioy, P.J. 1990a. Chloroform Exposure and the Health Risk Associated with Multiple Uses of Chlorinated Tap Water. Risk Analysis 10:581-585.

Jo, W.K., Wiesel, C.P, and Lioy, P.J. (1990b). Routes of Chloroform Exposure and Body Burden from Showering With Chlorinated Tap Water. Risk Analysis 10:575-580.

Kao, J., Hall, J., and Helman, G. 1988. In Vitro Percutaneous Absorption in Mouse Skin: Influence of Skin Appendages. Toxicology and Applied Pharmacology 94: 93-103.

Kao, J.K., Patterson, F.K., and Hall, J. 1985. Skin Penetration and Metabolism of Topically Applied Chemicals in Six Mammalian Species, Including Man: An In Vitro Study With Benzo(a)pyrene and Testosterone. Toxicology and Applied Pharmacology 81:502-518.

Massachusetts Department of Environmental Protection (MADEP). 1990. The Chemical

Health Effects Assessment Methodology (CHEM) and The Method to Derive Allowable Ambient Limits (AALs) Volumes I and II. MADEP Office of Research and Standards Publication No. 90-1.

Massachusetts Department of Environmental Protection (MADEP). 1992a. DRAFT Risk Assessment Shortform Residential Exposure Scenario, Version 1.5. Office of Research and Standards and the Bureau of Waste Site Cleanup. (January, 1992).

Massachusetts Department of Environmental Protection (MADEP). 1992b. Risk Assessment Shortform Residential Exposure Scenario, Version 1.6. Policy WSC/ORS-142-92. Office of Research and Standards and the Bureau of Waste Site Cleanup. (October, 1992).

Massachusetts Department of Environmental Protection (MADEP). 1993. Chronic Allowable Daily Intake for Aroclors. Memorandum from Marion C. Harnois, Sc.D., D.A.B.T. to Carol Rowan West, Director MADEP Office of Research and Standards. (May 10, 1993).

Massachusetts Department of Environmental Protection (MADEP). 1994. Interim Final Petroleum Report: Development of a Health Based Alternative to the TPH Parameter. Office of Research and Standards and Bureau of Waste Site Cleanup. (August 1994)

Massachusetts Department of Environmental Protection (MADEP). 1995b. DRAFT Methodology for Relating Soil Contaminant Levels and Risk to Human Health. MADEP Office of Research and Standards. (March 1995).

Nisbet, I.C.T. and LaGoy, P.K. 1992. Toxic Equivalency Factors (TEFs) for Polycyclic Aromatic Hydrocarbons (PAHs). Regulatory Toxicology and Pharamcology. 16:290-300.

Sanders, C.L., Skinner, C., and Gelman, R.H. 1986. Percutaneous Absorption of 7,10 ^{14}C-Benzo[a]pyrene and 7,12 ^{14}C Dimethylbenz[a]anthracene in Mice. Journal of Environmental Pathology, Toxicology and Oncology (JEPTO) 2:25-34.

Silverman, D.M. and Hutcheson, M.S. 1991. Re-evaluation of the Toxicity Equivalency Factors for Dioxins and Dibenzofurans. MADEP Office of Research and Standards.

Wester, R.C., Maibach, H.I., Bucks, D.A.W., Sedik, L., Melendres, J., Liao, C., and DiZio, S. 1990. Percutaneous Absorption of [^{14}C]DDT and [^{14}C]Benzo[a]pyrene from Soil. Fundamental and Applied Toxicology 15:510-516.

United States Environmental Protection Agency (USEPA). 1986. Guidelines for Carcinogen Risk Assessment. 51 Federal Register 33992 (September 24, 1986).

United States Environmental Protection Agency (USEPA). 1989a. Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). USEPA Office of Emergency and Remedial Response. EPA 540/1-89/002.

United States Environmental Protection Agengy (USEPA). 1989b. Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) and 1989 update. EPA/625/3-89.

United States Environmental Protection Agency (USEPA). 1990. Interim Methods for Development of Inhalation Reference Doses. USEPA Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-90/066A.

United States Environmental Protection Agency (USEPA) 1991. Guidelines for Developmental Toxicity Risk Assessment. 56 Federal Register 63798. (December 5, 1991).

United States Environmental Protection Agency (USEPA). 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. USEPA Office of Research and Development. EPA/600/R-93/089.

Yang, J.J., Roy, T.A., and Mackerer, C.R. 1986. Percutaneous Absorption of Benzo[a]pyrene in the Rat: Comparison of In Vivo and In Vitro Results. Toxicology and Industrial Health 2:409-416.

Yang, J.J., Roy, T.A., Krueger, A.J., Neil, W., and Mackerer, C.R. 1989. In Vitro and In Vivo Percutaneous Absorption of Benzo[a]pyrene From Petroleum Crude-Fortified Soil in the Rat. Bulletin of Environmental Contamination and Toxicology 43:207-214.

Human and Ecological Risk Assessment: Vol. 2, No. 4, pp. 841-873, 1996

Absorption Adjustment Factor (AAF) Distributions for Polycyclic Aromatic Hydrocarbons (PAHs)

Brian Magee,[1] Paul Anderson,[1] and David Burmaster[2]
[1] Ogden Environmental and Energy Services, Westford, MA*
[2] Alceon Corporation, Cambridge, MA**

ABSTRACT

In human health risk assessment, a correction factor is needed to account for differences between absorption in the dose-response study and absorption likely to occur upon human exposure. This correction factor is defined as the absorption adjustment factor, or AAF. The AAF is used to adjust the human exposure (potential) dose to account for differences in bioavailability between laboratory vehicles and environmental matrices. AAFs are defined for oral and dermal risk assessment of polycyclic aromatic hydrocarbons (PAHs) in soils. AAF distributions and point estimates are defined. Because there are very few studies that measure oral and dermal absorption of PAHs from soils in any species under any conditions, all available data from the principal studies were given equal weight in AAF derivation. The oral-soil AAF distribution for all PAHs is a Beta4 distribution with the following characteristics: Beta4 (a=1, b=3, c=0.944964, d=0.0699) over the range of 0.07 to 1.00. The point estimate for the oral-soil AAF is 0.29. The dermal-soil AAF distribution for potentially carcinogenic PAHs is defined as two distributions. The numerator is a Beta4 distribution with the following characteristics: Beta4 (a=1, b=5, c=0.146908, d=0) over the range 0 to 0.12. The denominator is a Beta4 distribution with the following characteristics: Beta4 (a=4, b=1, c=0.397, d=0.602697) over the range 0.63 to 1.00. The point estimate for the dermal-soil AAF for potentially carcinogenic PAH is 0.02. For noncarcinogenic PAHs, an uncertainty factor distribution is applied to the dermal-soil AAF for potentially carcinogenic PAH. The uncertainty factor is defined as a uniform distribution from 1 to 10. Defining the point estimate of the uncertainty factor as 5, the point estimate for the dermal-soil AAF for noncarcinogenic PAHs is 0.10.

Key Words: bioavailability, absorption, soil, PAHs

* 239 Littleton Road, Suite 7C, Westford, MA 01886; Tel: (508) 692-9090; Fax: (508) 692-6633
** P.O. Box 382669, Harvard Square Station, Cambridge, MA 02238; Tel: (617) 864-4300; Fax: (617) 864-9954

INTRODUCTION

To estimate the potential risk to human health that may be posed by the presence of chemical compounds in soil or other environmental media, it is first necessary to estimate the human exposure dose of each compound. The exposure dose is similar to the administered dose or applied dose of a laboratory experiment. The exposure dose is then combined with an estimate of the toxicity of the compound to produce an estimate of risk posed to human health.

The estimate of toxicity of a compound, often termed the dose-response value or the toxicity criterion, can be derived from human epidemiological data, but it is most often derived from experiments with laboratory animals. The dose-response value or toxicity criterion can be based on the administered dose of the compound (similar to the human exposure dose) or, when data are available, based on the absorbed dose, or internal dose, of the compound. In most cases dose-response values or toxicity criteria are based on animal studies in which the chemical was given orally in vegetable oil or as a mixture with the diet.

In animals, as in humans, the administered dose of a compound is not necessarily completely absorbed. Moreover, differences in absorption may exist between laboratory animals and humans, as well as between different media and routes of exposure. Therefore, it is not always appropriate to directly apply a dose-response value to the human exposure dose. In many cases, a correction factor in the calculation of risk is needed to account for differences between absorption in the study from which the dose-response value or toxicity criterion was derived and absorption likely to occur upon human exposure to a compound. Without such a correction, the estimate of human health risk could be over- or underestimated.

This correction factor is defined here as the absorption adjustment factor, or AAF. The AAF is used to adjust the human exposure dose so that it is expressed in the same terms as the doses used in the dose-response study, such as the study from which a cancer slope factor was derived. The AAF is the ratio between the estimated absorption factor for the specific medium and route of exposure, and the known or estimated absorption factor for the laboratory study from which the dose-response value was derived.

In the ideal situation, AAFs can be derived from data within a single experiment if an appropriate measure of absorption is compared between different routes of administration and/or sample matrices. In other cases, a single experiment may quantitate total fractional absorption for only one matrix and route of exposure. AAFs can be derived from such experiments if coupled with data from other experiments that quantitate the absorption from the route and matrix used in the dose-response study. In this case, the AAF is derived using the following equation:

$$\text{AAF} = (\text{fraction absorbed from the environmental exposure})/(\text{fraction absorbed in the dose-response study}).$$

The use of an AAF allows the risk assessor to make appropriate adjustments if the efficiency of absorption between environmental exposures and experimental exposures is known or expected to differ because of physiological effects and/or matrix or vehicle effects. Absorption adjustment factors can be less than one or

greater than one. If the absorption from the site-specific exposure is the same as absorption in the laboratory study, then the AAF is 1.0. An AAF of 1.0 does not indicate that absorption is 100%. It indicates that absorption is known or estimated to be the same as that in the dose-response study.

The Environmental Protection Agency (EPA) explicitly discusses the appropriateness of using absorption/bioavailability factors in the Guidelines for Exposure Assessment (USEPA, 1992a). For instance, the EPA states:

> The applied dose, or the amount that reaches exchange boundaries of the skin, lung, or gastrointestinal tract, may often be less than the potential dose if the material is only partly bioavailable. Where data on bioavailability are known, adjustments to the potential dose to convert it to applied dose and internal dose may be made.
>
> This may be done by adding a bioavailability factor (range: 0 to 1) to the dose equation. The bioavailability factor would then take into account the ability of the chemical to be extracted from the matrix, absorption through the exchange boundary, and any other losses between ingestion and contact with lung or gastrointestinal tract.

The Guidelines for Exposure Assessment discuss the issues of absorption and bioavailability throughout the document, indicating the EPA's current understanding that the inclusion of properly documented absorption adjustment factors is a scientifically appropriate and important aspect of the risk assessment process. The Absorption Adjustment Factors derived here take into account matrix-specific bioavailability as well as knowledge of PAH pharmacokinetics. These AAFs should be used in the calculation of the Average Daily Doses (ADD) that are necessary to quantitatively estimate potential risk to human health.

In this paper, the route of exposure and the experimental matrix (diet, drinking water, corn oil gavage, etc.) used in the experimental studies from which the relevant dose-response values were derived are summarized for the polycyclic aromatic hydrocarbons (PAHs). In addition, the scientific literature on the absorption and bioavailability of PAHs has been reviewed for the relevant routes of exposure and matrices. Based on these data, oral-soil and dermal-soil AAFs have been derived. The information and methods used to derive these AAFs are described below.

Although it is possible in theory, absorption experiments in humans that are suitable for AAF derivation have not been executed. Thus, AAFs are derived from animal studies. Because AAFs can be derived from multiple scientific studies using different animal species and strains and different experimental conditions, there is scientific uncertainty concerning the true AAF for the human exposure situation. In addition, absorption is expected to vary depending on soil type, organic content, soil aging, and other factors as noted by Brainard and Beck (1992). This uncertainty and variability can be incorporated into the risk assessment process by deriving distributions for the relevant AAFs. Accordingly, oral-soil and dermal-soil AAFs for PAHs are derived here both as point estimates for deterministic risk assessments and as distributions for probabilistic risk assessments.

ABSORPTION FROM THE DOSE-RESPONSE STUDIES

Potentially carcinogenic PAH are routinely evaluated using the comparative potency approach described in USEPA (1993). With this approach, all potentially carcinogenic PAH are assessed in terms of their benzo(a)pyrene toxic equivalent concentrations. In addition, risk assessment of noncarcinogenic PAHs is routinely performed using Reference Doses (RfDs) for several PAHs, including acenaphthene, anthracene, fluoranthene, fluorene, and pyrene.

Derivation of Cancer Slope Factor for Benzo(a)pyrene

The risk assessment of potentially carcinogenic PAHs is performed using the oral cancer slope factor (CSF) for benzo(a)pyrene (B(a)P). The oral CSF for B(a)P (7.3 $(mg/kg\text{-}day)^{-1}$) is the geometric mean of four slope factors derived from two rodent feeding studies: Neal and Rigdon (1967) and Brune *et al.* (1981). In the first study, CFW mice were dosed with B(a)P in their laboratory chow (diet). The diet was prepared by dissolving benzo(a)pyrene in benzene, mixing with wheat flour, evaporating the benzene, and mixing the flour-benzo(a)pyrene mixture with laboratory chow pellets. In the second, Sprague Dawley rats were also dosed with B(a)P in their laboratory chow (diet).

Derivation of the Oral Reference Doses for PAHs

The oral RfD for acenaphthene was derived from a 90-day corn oil gavage study in the mouse. The mice were given 175 to 350 mg/kg-day for the period of the experiment. The RfD is reported as 0.06 mg/kg-day (USEPA, 1996).

The oral RfD for anthracene was derived from a 90-day corn oil gavage study in male and female CD-1 (ICR) BR mice. The mice were given 250 to 1000 mg/kg-day for at least 90 days. The RfD is reported as 0.3 mg/kg-day (USEPA, 1996).

The oral RfD for fluoranthene was derived from a 13-week corn oil gavage study in male and female CD-1 mice. The mice were given 125 to 500 mg/kg-day. The RfD is reported as 0.04 mg/kg-day (USEPA, 1996).

The oral RfD for fluorene was derived from a 13-week corn oil gavage study in mice. The mice were given 125 to 250 mg/kg-day. The RfD is reported as 0.04 mg/kg-day (USEPA, 1996).

The oral RfD for fluorene was derived from a 13-week corn oil gavage study in male and female CD-1 mice. The mice were given 75 to 250 mg/kg-day. The RfD is reported as 0.03 mg/kg-day (USEPA, 1996).

Gastrointestinal Absorption in Dose-Response Studies

Absorption of B(a)P from food has been shown to be high in both humans and rodents by several researchers. Many articles on absorption were reviewed. However, studies that used inappropriate scientific methods were rejected. For instance, studies that measured total radiolabel in the feces do not yield useful absorption information, because B(a)P metabolites are known to be excreted into bile (see, for instance, Chipman *et al.*, 1981a, 1981b; Bowes and Renwick, 1986).

As an example, data are presented in a paper by Chang (1943) on fecal excretion of benzo(a)pyrene and other PAH. This paper cannot be used to estimate gastrointestinal absorption of PAH, because the gravimetric method used is nonspecific and does not distinguish between unchanged PAH and PAH metabolites. A paper by Flescher and Syndor (1960) is also deficient for AAF derivation, because total tritium is measured in feces after oral dosing of rats with ^{3}H-3-methylcholanthrene. This method also does not distinguish between unabsorbed PAH and absorbed and metabolized PAH excreted into the bile and feces.

Other studies are not useful because they only define a small fraction of a PAH's total disposition. For instance, in a study by Rees *et al.* (1971), benzo(a)pyrene was given to rats by stomach tube, and the PAH was measured in the lymphatic duct. While the presence of B(a)P in the lymph indicates that absorption occurred, the experiment is not quantitative. Similarly, Foth, Kahl, and Hahl (1988) measured benzo(a)pyrene absorption in the rat after a continuous infusion into the duodenum by measuring B(a)P in the atrial blood and bile. In this case, the conditions of the experiment are unnatural, and the experiment does not account for a total mass balance of B(a)P. Other studies were rejected for similar reasons. The following principal studies are those in which useful absorption information can be gleaned. All are given equal weight in deriving AAFs.

Hecht, Grabowski, and Groth (1979)

Hecht and coworkers (Hecht *et al.*, 1979) fed B(a)P to both humans and F-344 rats and measured the unchanged B(a)P in the feces to obtain an estimate of the amount of the compound absorbed. Because unchanged B(a)P in the feces can be due to absorbed material that is excreted unchanged in the bile, these studies reveal the minimum amount of B(a)P that was absorbed. It is known, however, that B(a)P is extensively metabolized. Thus, these estimates of absorption are valid for AAF derivation.

For rats, at least 87% of the B(a)P was absorbed from a low single dose in peanut oil (0.037 mg/kg). Minimum absorption from medium and high doses (0.37 mg/kg and 3.7 mg/kg) were 92.2% and 94.4%. The mean absorption of B(a)P in peanut oil in rats was 91.2% (n=30). This value was used in AAF derivation.

When rats were fed charcoal-broiled hamburger containing B(a)P (0.002 mg/kg body weight), at least 89% was absorbed (n=10). In humans, a high percentage of B(a)P present in charcoal-broiled meat was also absorbed (0.0001 mg/kg body weight, assuming 70 kg), because no unchanged B(a)P was detected in the feces. Assuming that B(a)P was present in feces at one-half the detection limit, the minimal absorption is 98.8% (n=8). This study indicates that there is no significant difference in absorption between two dietary vehicles in rats. That is, absorption of B(a)P from peanut oil and meat was essentially the same. The results with rats and humans also indicate that there is no major difference in the gastrointestinal absorption of B(a)P between rats and humans. Both of the above values were used in AAF derivation.

Mirvish et al. (1981)

Mirvish and coworkers (Mirvish *et al.*, 1981) fed B(a)P to Syrian golden hamsters in their diets, and measured the amount of unmetabolized B(a)P in their feces to determine the efficiency of absorption from the gastrointestinal tract. B(a)P was dissolved in corn oil, and the corn oil was added to a commercial rodent chow by two different methods. Animals were treated with B(a)P in the diet for 7 to 10 days before samples were collected to give adequate time to reach steady-state PAH concentrations in the feces and gastrointestinal tract contents.

The percentage of fecal excretion of unchanged B(a)P remained relatively constant (94.3% to 98.0%) as its concentration in commercial diet was varied over a wide range (0.16 mg/kg to 5.5 mg/kg). Absorption efficiency was not dose-dependent. The minimal gastrointestinal absorption of B(a)P was found to be 96.7% for the commercial chow using preparation method I (average of results from seven experiments at different dose levels; eleven animal groups, each containing 3-5 hamsters), or 98% for the commercial chow using preparation method II (one experiment; four animal groups, each containing 3-5 hamsters, 1.6 mg/kg). These two values (96.7% and 98%) were used in AAF derivation.

3-Methyl cholanthrene (3-MC) absorption was also studied in hamsters. 3-MC (1.7 mg/kg) was dissolved in corn oil and added to a semisynthetic diet consisting of corn oil, corn starch, vitamin-free casein, and alphacel. Minimum gastrointestinal absorption was found to be 93.8% in four animal groups containing 3-5 hamsters each. This value is also used in AAF derivation.

Other experiments demonstrated that B(a)P was absorbed slightly more efficiently from semisynthetic diets than from commercial rodent diets. Addition of corn oil to the hamsters' semisynthetic diets had little effect on the fecal excretion of unchanged B(a)P, and thus its gastrointestinal absorption. Addition of bran to the semisynthetic diets caused a slight lowering of gastrointestinal absorption.

Rabache, Billaud, and Adrian (1985)

Rabache and coworkers (Rabache *et al.*, 1985) fed B(a)P to male Wistar rats in their diets and measured the amount of unmetabolized B(a)P in their feces to determine the efficiency of absorption from the gastrointestinal tract. B(a)P was dissolved in soy oil and mixed with the synthetic ration, which was comprised of 10% soy oil. Young rats were given 1 g B(a)P/kg body weight, and adult rats were given 5 g/kg. The minimal gastrointestinal absorption of B(a)P was found to be 88.7% for young rats (n=8) and 99.6% for adult rats (n=12). Both of these values are used in AAF derivation.

Withey, Law, and Endrenyi (1991)

Withey and coworkers (Withey *et al.*, 1991) administered pyrene by stomach tube to male Wistar rats in an aqueous emulsion and measured the amount of C-14 radiolabel in the blood over time to make an estimate of "bioavailability." A single dose of pyrene was given to four groups of six animals at a concentration ranging from 4-15 mg/kg as a solution in 20% Emulphor/80% physiological saline. Radiolabeled pyrene was also given intravenously for comparison. "Bioavailability"

was defined as the area of the blood level-time curve of radiolabel over a specified time period after oral dosing (0-8 hours), divided by the corresponding area of the curve for intravenous dosing.

"Bioavailability" was found to vary from 64% to 84%, depending on dose level. This pharmacokinetic parameter has its basis in classical drug studies where the circulating blood level of the parent (unmetabolized) drug is of primary interest. However, this parameter does not provide an optimal estimate of a chemical's gastrointestinal absorption, because the fraction of the chemical or its metabolites that is bound to tissues is not properly counted.

For this reason, the urinary excretion data over six days were also used to derive an estimate of absorption for each group. Absorption was estimated as the fraction of total radiolabel excreted in the urine after oral dosing, divided by the fraction excreted after intravenous dosing. Because the fraction excreted in the urine at Day 6 post-dosing was slightly higher at every dose level for oral dosing compared to intravenous dosing, the estimates of gastrointestinal absorption are 100% for all four dose groups.

For each dose group, the blood level estimate of "bioavailability" was averaged with the urinary estimate of gastrointestinal absorption to derive an estimate of gastrointestinal absorption. These estimates are: 92%, 82.5%, 86.5%, and 87% for doses ranging from 4 to 15 mg/kg. The average of these four estimates (87%) is used in AAF derivation.

Grimmer et al. (1988)

Grimmer and coworkers (Grimmer *et al.*, 1988) administered chrysene by stomach tube to male Wistar rats in a solution of 33% dimethylsulfoxide and 66% corn oil. Eight rats weighing 200-250 grams received a single dose of 50 ug chrysene. Assuming an average weight of 225 g, the dose was 0.22 mg/kg. Feces and urine were collected for four days. Unchanged chrysene and specific metabolites were analyzed. The fraction of the unchanged chrysene in the feces was determined. This serves as an estimate of minimal gastrointestinal absorption. Average absorption for the eight rats was 86.9%. This value was used in AAF derivation.

Bartosek et al. (1984)

Bartosek and coworkers (Bartosek *et al.*, 1984) administered benz(a)anthracene, chrysene, or triphenylene to female CD-COBS rats by stomach tube in an aqueous emulsion of 10% Pluronic F68 emulsifier and 90% olive oil. Animals were fasted for 24 hours prior to being given a single oral dose of the PAH. Each group consisted of 3-5 rats weighing 150-170 g. PAHs were given at single doses of 11.4 and 22.8 mg/ animal, which corresponds to 71.3 mg/kg and 142.5 mg/kg, assuming an average weight of 160 g. The fraction of administered dose of the unchanged PAH recovered in the feces after 72 hours was taken as an estimate of the minimal absorption. Results were 94% for benz(a)anthracene, 75% for chrysene, and 97% for triphenylene. These three values were used in AAF derivation.

Summary of Absorption Data for Dose-Response Studies

The 13 data points shown in Table 1 are given equal weight and averaged to derive a point estimate of the gastrointestinal absorption of B(a)P and other PAHs in the dose-response studies from which the cancer slope factor for B(a)P and the RfDs for various noncarcinogenic PAH were derived. This value is 92%.

Table 1 demonstrates that gastrointestinal absorption of PAHs given in oil vehicles or in the diet is generally high. While there is some variability in the data, no consistent trend is apparent that would lead one to conclude that absorption of one PAH differs significantly from another. Accordingly, all of the data are merged here to represent the absorption of all PAHs of interest. However, each data point in a study was not given equal weight in deriving the final estimate of oral absorption in the dose-response studies. For instance, in the Mirvish *et al.* study, the 96.7% value represents the average of results from seven experiments at different dose levels. There were 11 animal groups, each containing 3-5 hamsters. Thus, this value represents experiments with 33-55 animals. The 98% value represents one experiment at one dose group. There were four animal groups, each containing 3-5 hamsters. Thus, this data point represents 12-20 animals.

There are many ways to summarize such a large and diverse set of experimental results. Table 2, however, demonstrates that the resulting estimate of absorption in the PAH dose-response studies is not particularly sensitive to the manner of summarizing the available data.

DERIVATION OF ORAL-SOIL AAFS FOR POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

Three studies were identified in which the gastrointestinal absorption of PAHs was measured from a soil matrix. These include Goon *et al.* (1991), Rozett *et al.* (1996), and Weyand *et al.* (1996). Each of these studies is discussed below.

Rozett *et al.* (1996) studied the bioavailability of pyrene from manufactured gas plant (MGP) residue (coal tar) by comparing the urinary pyrene metabolite levels in animals receiving pyrene as pure MGP residue in their diet to animals receiving pyrene as MGP contaminated soil in their diet. The contaminated soil was aged composite soil from MGP sites. It was fractionated into seven particle size ranges from 1 mm to < 0.150 mm. Soil was added to powder diets from PMI Feeds, Inc. (rodent laboratory diet #5001) (20% soil / 80% powder diet). Pure MGP residue was added to gel diets from Bio-Serv (rodent basal gel diet) (0.003%, 0.03%, 0.1%, and 0.3% coal tar). Groups of female CD1 mice were fed soil or pure MGP residue for 15 days. Urine was collected on Day 15. The level of pyrene metabolites (1-hydroxypyrene, 1-hydroxypyrene glucuronide conjugates, and 1-hydroxypyrene sulfate conjugates) was determined by HPLC using fluorescence detection (Singh *et al.*, 1995).

"Bioavailability" is defined by the authors as the amount of pyrene and metabolites excreted in the urine over 24 hours on Day 15, divided by the amount of pyrene ingested on Day 15 x 100. The amount of pyrene and metabolites excreted into the urine as a fraction of the amount ingested in the last 24 hours is not, itself, a direct measure of bioavailability. It is also not a quantitative measure of total

Table 1. Summary of Absorption Data for PAH Dose-Response Studies

Value	Citation	Animal	PAH	Vehicle
91.2%	Hecht	male F344 rats	B(a)P	peanut oil
89%	Hecht	male F344 rats	B(a)P	char-broiled hamburger
98.8%	Hecht	Humans	B(a)P	char-broiled hamburger
88.7%	Rabache	young male Wistar rats	B(a)P	synthetic diet
99.6%	Rabache	adult male Wistar rats	B(a)P	synthetic diet
96.7%	Mirvish	male Syrian golden hamsters	B(a)P	corn oil + commercial diet Method I
98.0%	Mirvish	male Syrian golden hamsters	B(a)P	corn oil + commercial diet Method II
87%	Withey	male Wistar rats	pyrene	20% Emulphor/ 80% saline
86.9%	Grimmer	male Wistar rats	chrysene	33% DMSO/ 66% corn oil
94%	Bartosek	female CD-COBS rats	B(a)A	10% emulsifier/ 90% olive oil
75%	Bartosek	female CD-COBS rats	chrysene	10% emulsifier/ 90% olive oil
97%	Bartosek	female CD-COBS rats	triphenylene	10% emulsifier/ 90% olive oil
93.8%	Mirvish	male Syrian golden hamsters	3-methyl cholanthrene	corn oil + semisynthetic diet

Table 2. Methods of Summarizing PAH Gastrointestinal Absorption Data

Method Used	# Data Points	Average Absorption
Each experiment within a study used as a single data point[a]	13	92.0%
Each result presented in each study used as a single data point	24	92.1%
Each result presented in each B(a)P study used as a single data point	15	95.0%
Each study represented as a single data point	7	90.9%
Each B(a)P study represented as a single data point	3	94.4%

[a] Method used in this AAF derivation.

absorption of pyrene from the diet, because PAH and PAH metabolites are efficiently excreted into the feces via the biliary system. However, the level of pyrene and its metabolites in urine on Day 15 gives a measure of the steady-state level of pyrene excretion. Any pyrene or pyrene metabolite found in the urine necessarily derived from pyrene that was absorbed in the gastrointestinal tract. Because the term bioavailability has a very specific meaning in the fields of toxicology and risk assessment, the metric used by the authors is here renamed "fractional urinary excretion." However, the ratio of "fractional urinary excretion" between study groups is a good measure of relative bioavailability, as will be shown below.

As shown in Table 3, "fractional urinary excretion" of pyrene from MGP residue (coal tar) added to the diet varied from 12.8% to 24.1%, depending on the dose level. As shown in Table 4, "fractional urinary excretion" of pyrene from MGP residue-containing soil varied from 1.7% to 14.8%, depending on the size fraction of the soil sample. In addition, "fractional urinary excretion" of pyrene from unfractionated soil (< 1 mm particle size) was reported to be 6%.

The ratio of "fractional urinary excretion" from MGP contaminated soil to "fractional urinary excretion" from pure MGP residue as a dietary additive is a direct estimate of the oral-soil AAF (which is a measure of relative bioavailability between pyrene in soil and pyrene in food). It is a measure of the degree to which the soil matrix increases or decreases the absorption of pyrene compared to pyrene in the diet. The AAF estimates presented in Table 8 were derived by taking the ratios of "fractional urinary excretion" in Table 4 to the appropriate value from Table 3, based on the dose of pyrene.

Weyand *et al.* (1996) studied the bioavailability of pyrene from MGP residue (coal tar) by comparing the urinary pyrene metabolite levels in animals receiving pyrene as methylene chloride extracts of MGP contaminated soil in their diet to animals receiving pyrene as MGP contaminated soil in their diet. The two

Table 3. Pyrene Metabolites in Mouse Urine Following "Neat" MGP Ingestion (Rozett *et al.*, 1996)

Amount of MGP residue in diet	Sum of Metabolites µg/mouse[a]	Pyrene consumed µg/mouse[b]	Fractional Urinary Excretion[c]
0.003%	0.10	0.79	12.8
0.030%	1.39	11.39	12.2
0.100%	7.58	31.46	24.1
0.300%	12.13	62.27	19.5
Control	-	-	-

[a] The sum of 1-OH P-GlcUA, 1-OH P-Sul, and 1-OH P levels is expressed in terms of equivalents of pyrene.
[b] The amount of pyrene consumed by animals in metabolism cages on Day 15 over a period of 24 hours.
[c] Fractional Urinary Excretion = (amount of pyrene excreted/amount of pyrene consumed) x 100. (The authors termed this "bioavailability." Because this is a nonstandard use of the term, it is renamed here.)

Note: The pyrene level in "neat" MGP was 6.89 mg/kg.

Table 4. Pyrene Metabolites in Mouse Urine Following Soil Ingestion (Rozett *et al.*, 1996)

Soil Fraction	Sum of Metabolites µg/mouse[a]	Soil consumed g/mouse[b]	Pyrene in soil µg/g	Pyrene consumed µg/mouse[b]	Fractional Urinary Excretion[c]
>0.850 mm	0.37	0.65	14.3	9.4	3.9
>0.710 mm	0.69	0.64	61.8	39.7	1.7
>0.600 mm	0.70	0.68	63.4	43.1	1.6
>0.500 mm	0.95	0.63	74.6	47.2	2.0
>0.300 mm	1.72	0.66	26.8	17.7	9.7
>0.150 mm	1.77	0.58	177.9	102.4	1.7
≤0.150 mm	9.86	0.36	185.6	66.7	14.8
Control	-	-	-	-	-

[a] The sum of 1-OH P-GlcUA, 1-OH P-Sul, and 1-OH P levels is expressed in terms of equivalents of pyrene.
[b] The amount of soil and pyrene consumed in metabolism cages on Day 15 over a period of 24 hours.
[c] Fractional Urinary Excretion = (amount of pyrene excreted/amount of pyrene consumed) x 100. (The authors termed this "bioavailability." Because this is a nonstandard use of the term, it is renamed here.)

contaminated soil samples were aged soils from MGP sites. They were sieved to a particle size range of less than or equal to 0.150 mm. Soil was added to powder diets from PMI Feeds, Inc. (rodent laboratory diet #5001) (20% soil/80% powder diet). MGP contaminated soil extracts were added to gel diets from Bio-Serv (rodent basal gel diet) so that the same amount of pyrene was present as in the soil/diet groups. Groups of female $B_6C_3F_1$ mice were fed soil or organic extract for 14 days. Urine was collected on Day 14. The level of pyrene metabolites (1-hydroxypyrene, 1-hydroxypyrene glucuronide conjugates, and 1-hydroxypyrene sulfate conjugates) was determined by HPLC using fluorescence detection (Singh *et al.*, 1995).

As above, "fractional urinary excretion" is defined as the amount of pyrene and metabolites excreted in the urine over 24 hours on Day 15, divided by the amount of pyrene ingested on Day 15 x 100.

As shown in Table 5, the "fractional urinary excretion" of pyrene from Soil #1 was 6.2%, and from Soil #2 was 1.7%. The "fractional urinary excretion" of pyrene from the organic extract of Soil #1 was 17.2%, and from Soil #2 was 16.1%.

The ratio of "fractional urinary excretion" from MGP contaminated soil to "fractional urinary excretion" from an extract of MGP contaminated soil added to the diet is a direct estimate of the oral-soil AAF. It is a measure of the degree to which the presence of soil increases or decreases the absorption of pyrene from the diet. The AAF from Soil #1 was 36% (6.2%/17.2% x 100). The AAF from Soil #2 was 11% (1.7%/16.1% x 100). This study shows that pyrene in aged soil is absorbed in the gastrointestinal tract to a lesser degree than is pyrene added to rodent food as an organic extract.

Goon *et al.* (1991) studied the bioavailability of benzo(a)pyrene administered orally as the pure chemical, or as B(a)P adsorbed onto soil particles. Additional information about the study was obtained directly from the authors (Goon and Burnette, 1996). Male Sprague-Dawley rats were gavaged with B(a)P mixed with ^{14}C-B(a)P in solution [0.5% Tween 80 (v/v in saline)] (1.0 μmol B(a)P/kg, 25 μCi/kg) or the equivalent dose adsorbed onto a clay-based soil or a sand-based soil. The soils consisted of 2.5 g solid/kg containing 100 mg/kg B(a)P. All animals received 7.5 mL of 0.5% Tween 80 (v/v in saline).

Venous blood samples were collected from the retro-orbital plexus at predetermined times (0.5, 1, 2, 4, 8, 12, 24, 48, 72, 96, 120, 144, and 168 hours), and excreta were collected continuously over 24-hour intervals. After 168 hours, animals were euthanized, and tissues collected for analysis. Total radioactivity was measured by liquid scintillation in blood, urine, feces, and tissues.

The sandy soil was classified as a loam which was very low in organic content, 0.04%. It contained 47% sand, 41% silt, and 12% clay. The pH was 6.5, and the cation exchange content was 0.6 meq/100 g. The clay-based soil was classified as a clay with low organic content, 1.35%. It contained 6% sand, 18% silt, and 76% clay. The pH was 7.0, and the cation exchange content was 45.65 meq/100 g. The sandy soil was ground and sonic- sifted. The clay-based soil was dried and passed through a Brickman ultra-centrifugal mill. In both cases, the particles size was small, <100 μm. Both soils were washed twice with methylene chloride and dried before use. This destroyed any microbial activity that may have existed in the soils.

Table 5. Pyrene Urinary Metabolites, Soil vs Organic Extract of Soil (Weyand *et al.*, 1996)

Diet	Pyrene Ingested (μg/mouse)[a]	Pyrene Excreted (μg/mouse)[b]	Fractional Urinary Excretion[c]
Extracted Soil #1	0	0	ND
Extracted Soil #2	0	0	ND
Soil #1	0.60	0.039	6.2
Soil #2	30.42	0.527	1.7
Organic Extract #1	0.56	0.097	17.2
Organic Extract #2	25.91	4.16	16.1

[a] The sum of 1-OH P-GlcUA, 1-OH P-Sul, and 1-OH P levels is expressed in terms of equivalents of pyrene.

[b] The amount of soil and pyrene consumed in metabolism cages on Day 15 over a period of 24 hours.

[c] Fractional Urinary Excretion = (amount of pyrene excreted/amount of pyrene consumed on day 15) x 100. (The authors termed this "bioavailability." Because this is a nonstandard use of the term, it is renamed here.)

Note: Soil #1: 9 ppm total PAHs; Soil #2: 377 ppm total PAHs.

B(a)P and ^{14}C-B(a)P were added in acetone to soils. The acetone was evaporated, leaving soils that were 100 ppm in B(a)P and 1.0 μCi/g in radiolabel. Animals were administered the soil-adsorbed B(a)P at various time intervals after the soil and the B(a)P were mixed: 1 day, 7 days, 30 days, 6 months, and one year. Animals were fasted for 12 hours prior to dosing. Two hours after dosing, Purina Rodent Chow 5001 and water were available *ad libitum*.

Relative bioavailability was measured by comparing the area under the blood curve (AUC) for total radiolabel over the entire 168 hour experimental period during which blood B(a)P levels were measured. Radiolabel in the blood represents a fraction of the B(a)P that was absorbed in the gastrointestinal tract, including parent B(a)P and metabolites.

The use of AUC measurements is a classic approach in drug pharmacology where systemic bioavailability is defined as the blood AUC after an intravenous dose, divided by the AUC after an oral dose. In the case of drugs, the amount of parent drug circulating in the blood over a long period of time is of primary interest, because, in most cases, first pass metabolism of the drug in the liver reduces the drug efficacy. Metabolites are inactive and are excreted. Thus, total blood level of parent drug is of greater interest than is drug plus metabolites.

This same concern is not relevant for the risk assessment of PAHs, such as B(a)P, because B(a)P is not direct-acting. No toxic effects are manifested by the parent, unmetabolized B(a)P. Instead, metabolism is required for toxicity. It is the

metabolites of B(a)P and other PAHs that bind to cellular macromolecules, such as DNA, and cause adverse effects in various tissues. Metabolism of PAHs occurs in many, if not all, tissues, and orally administered B(a)P has caused tumors in laboratory animals in various tissues, including stomach, lung, esophagus, larynx, and others. B(a)P metabolism is also multistepped. In order for the B(a)P diol epoxide, the putative mutagenic metabolite, to be formed, several metabolic conversions involving several enzymes must occur.

Thus, in some cases the toxic metabolite in a distant tissue, such as the lung, is caused by a B(a)P molecule that was absorbed through the gastrointestinal tract, was *not* metabolized in the liver, circulated through the blood, and was metabolized in several steps in the lung. In other cases, the toxic lung metabolite was formed by a molecule that was absorbed though the gastrointestinal tract, was metabolized to an intermediate metabolite in the liver, and circulated through the blood as a B(a)P metabolite, and was metabolized several more times in the lung to a toxic metabolite.

In addition, B(a)P and B(a)P metabolites excreted in the bile are known to be reabsorbed in the gastrointestinal tract by a process known as enterohepatic recirculation (Chipman et al., 1981a,b). Thus, some B(a)P metabolites are known to be excreted into the bile and the gastrointestinal tract. When present in the gastrointestinal tract, parent B(a)P can be reabsorbed. In addition, conjugated metabolites, such as glucuronide, sulfate, and glutathione metabolites can be deconjugated by enzymes residing in bacteria present naturally in the gastrointestinal tract. After deconjugation, the primary metabolite can and is reabsorbed. After reabsorption, it can travel to a distant tissue via the systemic circulation and cause damage.

Thus, for B(a)P and other PAHs, the circulating blood level of just the parent compound is not a relevant dose metric. Instead, the total B(a)P dose, including parent B(a)P and metabolites, is the critical parameter to measure. This is because some metabolites are directly toxic to distant tissues, some metabolites are metabolic precursors of secondary metabolites that are toxic to distant tissues and can be formed therein, and some metabolites can be excreted and reabsorbed and can later cause damage in distant tissues, including the gastrointestinal tract itself.

While the total blood radiolabel AUC from 0-168 hours does not define the fraction of the administered B(a)P that was absorbed in an animal or a treatment group, the ratio of AUC measurements for two treatment groups administered the B(a)P by the same route of exposure is an excellent measure of *relative* bioavailability between the two treatment groups.

For the clay-based soil, relative bioavailability was 49-59% for the soils that were aged from 1-30 days. For clay-based soils aged 6 months and one year, the relative bioavailability was 39% (see Table 6). For the sand-based soil, relative bioavailability was 67-70% for the soils that were aged from 1-30 days. For clay-based soils aged 6 months and one year, the relative bioavailability was 54% and 62%, respectively (see Table 6).

The above data show that reduction in PAH bioavailability due to soil adsorption is a time-dependent phenomenon. This result is consistent with other studies on chemical adsorption to soil. Because the PAH compounds of interest in

Table 6. Benzo(a)pyrene Bioavailability from Soils[a] (Goon *et al.*, 1991)

Soil Aging	Sandy Soil	Clay-Based Soil
1 day	66.9%	48.8%
1 week	70.4%	52.1%
1 month	67.7%	58.5%
6 months	54.3%	38.5%
1 year	62.2%	38.6%
Average- 6 mo. & 1 year	58.3%	38.6%

[a] (Area under the blood radioactivity curve)$_{soil}$ / (Area under blood radioactivity curve)$_{solution}$

most soil risk assessments were released to the soil environment many years ago, the results for the 6 month and one year aged soils are used for AAF derivation. These results are 38.6% for clay-based soil and 58.3% for sand-based soil.

These values represent "relative bioavailability" compared to the control animals in which the B(a)P was administered as a solution. They are not direct estimates of gastrointestinal absorption in the soil-treated animals, and they are not direct estimates of AAFs. Accordingly, the values must be modified before they can be used to derive AAFs. As shown below, the relative bioavailability value must be multiplied by the absorption in the control animals:

Absorption from soil = Relative Bioavailability x Absorption from solution

The Goon *et al.* (1991) study did not measure total B(a)P absorption in the control animals which received B(a)P in solution. However, four of the absorption estimates presented in Table 1 were from experiments in which the PAH was administered in solution. The results of the five values were averaged to yield 88.5%. Thus, the absorption from sandy soil is estimated as 52% (58.3% x 88.7%). The absorption from clay-based soil is estimated as 34% (38.6% x 88.5%). The AAFs are defined as the absorption from soil divided by the absorption from diet x 100. They are as follows:

AAF oral-soil (sandy) = 52%/92% = 0.57

AAF oral-soil (clay-based) = 34%/92% = 0.37

The two soils studied were very low in organic content (0.04% and 1.35%). Certainly, the value for sandy soil is much lower than a typical soil. For instance, in its Risk Based Corrective Action guidance, the ASTM assumes 1% organic content as a default value for typical soils. Accordingly, the AAF for clay-based soil is probably more typical of average soils than the AAF for sandy soil.

In an earlier experiment, Goon *et al.* (1990) studied the bioavailability of B(a)P in aqueous solution, in laboratory chow, in unaged sandy soil, and in unaged clay-based soil. Additional information was obtained directly from the authors (Goon and Burnette, 1996). The study was performed in the same manner as the one described above, with the exception that 4 male rats and 4 female rats were placed in each of four study groups, including rodent chow.

In that study, the bioavailability from rodent food was shown to be less than from solution. When the area under the curve for total radioactivity in blood over 168 hours was compared, the solution group was 5944 pmol-hour/mol and the rodent chow group was 3179 pmol-hour/mol. Thus, bioavailability from food was 54%, compared to aqueous solution. Bioavailability of B(a)P administered in slurries adsorbed onto small particles from sand and clay-based soils were also decreased relative to B(a)P in solution (47% for sandy soil and 28% for clay-based soil).

The data from the Goon *et al.* (1990) study were rejected for AAF derivation for several reasons. First, the results for B(a)P adsorbed to rodent chow and dissolved in a solution with an aqueous emulsifier are at variance from the results presented in the large literature on B(a)P absorption discussed above. Table 1 shows that in all other studies of B(a)P and other PAHs, absorption is high and similar for PAHs adsorbed to food (either meat or rodent chow), dissolved in vegetable oils, or dissolved in emulsifier solutions.

Second, the results for each treatment group were averaged over data for both males and females, which had very different starting and ending body weights (see Table 7). The starting body weight for female rats was 75% to 81% of the body weight of the male rats. Goon *et al.* in the 1990 experiment averaged the blood radioactivity levels for 3-5 male and 4-5 female rats in each treatment group, and then calculated a group-wide area under the curve (AUC). They did not calculate the AUC for the total 168 hour experiment for each animal and then average the animal-specific AUCs. Thus, a sex-specific reduction in bioavailability or any source of animal-specific variability could lead to artifacts in the group average AUCs.

Such variability is apparent by evaluating the data for body weights and the weight gain over the experimental period. Table 7 shows the weights of the animals in each group before the 12-hour fast period, after the fast period and before dosing, and after the 7-day experiment. The variability in the weights of the male animals in the solution group and in the sandy soil group is much higher than the variability in any of the other groups. In particular, the variabilities in the post-experiment weights for animals in the food groups (male and female) were much smaller than the variability in the male solution group.

Regardless of the reasons for the inadequacies of the 1990 study, the 1991 experiment does not suffer from these sorts of variabilities and differences in weight gains. In addition, the experiment used only male animals, so the uncertainties and confounding effects of averaging the results over animal groups with widely differing body weights and food consumption rates are not seen. Accordingly, the data from Goon *et al.* (1991) were used in AAF derivation, and the Goon *et al.* (1990) data were rejected.

Table 7. Animal Weights During Goon *et al.* (1990)

Treatment Group	Sex	Nonfasted Weight (g)	Fasted Weight (g)	Weight at Day 7 (g)
Solution	Males	221 +/- 9	218 +/- 12	237 +/- 24
	Females	175 +/- 3	165 +/- 4	179 +/- 3
Rodent Chow	Males	226 +/- 7	222 +/- 2	255 +/- 5
	Females	173 +/- 6	165 +/- 2	193 +/- 4
Sandy Soil	Males	222 +/- 6	216 +/- 6	228 +/- 19
	Females	180 +/- 4	167 +/- 4	190 +/- 4
Clay-Based Soil	Males	230 +/- 5	221 +/- 8	251 +/- 10
	Females	172 +/- 6	162 +/- 6	188 +/- 4

Summary of Oral-Soil AAFs

Twelve estimates of the oral-soil AAF for PAHs were derived from three studies, as shown in Table 8. Because of the paucity of experimental data, each estimate was given equal weight in AAF derivation. For probabilistic risk assessments, a distribution of AAF values is required. Curve-fitting exercises using Mathematica™ software and using the methods shown in Burmaster (1996) determined that the 12 data points best fit a Beta4 distribution with the following characteristics: Beta4 (a=1, b=3, c=0.944964, d=0.0699) over the range of 0.07 to 1.00. (Note that to employ this distribution in a Crystal Ball™ simulation, one needs to represent the Beta4 (a,b,c,d) distribution using Crystal Ball™'s Beta distribution as follows; beta (a,b) x c + d). Then, Monte Carlo simulations were run using Crystal Ball™ software. The mean oral-soil AAF for PAHs after 20,000 trials was 0.31, with a standard deviation of 0.18. The 50th percentile oral-soil AAF was 0.27, and the upper 90th percentile oral-soil AAF was 0.57. For deterministic risk assessments, a point estimate is needed for the AAF. The average of the twelve values is 0.29. This average value is similar to the mean and 50th percentile values from the AAF distribution. Accordingly, 0.29 is an appropriate point estimate of the oral-soil AAF.

Applicability of Oral-Soil AAFs

These estimates of oral-soil AAFs were derived from studies with B(a)P, a five-ring potentially carcinogenic PAH, and pyrene, a four-ring noncarcinogenic PAH. Because the AAF estimates for the two PAHs were similar, and because the gastrointestinal absorption of various potentially carcinogenic and noncarcinogenic PAHs is similar (see Table 1), it is appropriate to derive a single oral-soil AAF for the potentially carcinogenic and noncarcinogenic risk assessment of all PAHs.

DERIVATION OF DERMAL-SOIL AAFS FOR POTENTIALLY CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Two studies were identified in which the dermal absorption of PAHs was measured from a soil matrix. These include Yang *et al.* (1989) and Wester *et al.* (1990). These studies are discussed below. Estimates of dermal-soil AAFs can be derived from the results of these studies and data on absorption from the dose-response studies.

Dermal Absorption Studies

Yang, *et al.* (1989) measured the percutaneous absorption of benzo(a)pyrene (B(a)P) from petroleum crude-fortified soil and from pure petroleum crude oil, both in live rats and in *in vitro* studies using excised rat skin (see Table 9). The soil was a loam containing 1.64% organic matter, 46% sand, 36% silt, and 18% clay. The B(a)P-soil mixture was prepared by adding the radiolabeled crude oil in dichloromethane to the soil. The solvent was removed by rotary evaporator. All soils were used within 72 hours of preparation.

Table 8. Oral-Soil AAFS for PAHS

Oral-Soil AAF	Notes	Source
0.07	CD-1 mice, MGP soil, 0.71-0.85 mm	Rozett *et al.* (1996)
0.07	CD-1 mice, MGP soil, 0.6-0.71 mm	Rozett *et al.* (1996)
0.08	CD-1 mice, MGP soil, 0.5-0.6 mm	Rozett *et al.* (1996)
0.09	CD-1 mice, MGP soil, 0.15-0.3 mm	Rozett *et al.* (1996)
0.11	$B_6C_3F_1$ mice, MGP soil	Weyand *et al.* (1996)
0.28	CD-1 mice, MGP soil, <1 mm	Rozett *et al.* (1996)
0.32	CD-1 mice, MGP soil, 0.85-1 mm	Rozett *et al.* (1996)
0.36	$B_6C_3F_1$ mice, MGP soil	Weyand *et al.* (1996)
0.37	rats, clay-based soil	Goon *et al.* (1991)
0.40	CD-1 mice, MGP soil, 0.3-0.5 mm	Rozett *et al.* (1996)
0.57	rats, sandy soil	Goon *et al.* (1991)
0.76	CD-1 mice, MGP soil, <0.15 mm	Rozett *et al.* (1996)

Radiolabeled B(a)P (^{3}H-B(a)P) was added at a known concentration for quantification. In the *in vivo* experiments, soil containing B(a)P in crude petroleum or pure crude petroleum containing B(a)P was applied to the dorsal skin of the female Sprague-Dawley rats. In both cases, the dose of B(a)P was 0.01 μg/cm^2. For the crude oil, 90 μg/cm^2 of oil containing 100 ppm B(a)P was applied. For soil, 9 mg/cm^2 of soil containing 1 ppm of B(a)P was applied. The dorsal area was covered with a nonocclusive glass cell to prevent ingestion of the B(a)P by grooming behavior.

Absorption was determined by measuring the radioactivity in the urine and feces once daily and the urine, feces, and tissues at 96 hours. Data from five animals were averaged. After 96 hours, cumulative absorption of B(a)P from crude-soaked soil (9.2%) was less than that from the crude alone (35.3%).

In the *in vitro* experiments, dorsal skin was excised from female Sprague-Dawley rats after sacrifice. 350-μm skin sections were placed in consoles containing 15 mm diameter Franz diffusion cells. The receptor fluid was an aqueous solution of 6% Volpo-20, a nonionic surfactant. The absorption was measured by analyzing the surfactant containing receptor fluid that bathed the receiving reservoir of the absorption chamber for radiolabeled B(a)P. The receptor fluid was sampled once every 24 hours for four days. Data from five trials were averaged. Again, 96-hour cumulative absorption was greater for B(a)P in oil (38.1%) versus B(a)P in oil-soaked soil (8.4%).

Table 9. Dermal Absorption of Benzo(a)pyrene from Soil in the Rat (Yang, *et al.*, 1989)

Time Point	*In Vivo* Results	*In Vitro* Results
24 Hours[a]	1.1% (0.3)[a,b]	1.5%[d]
48 Hours[a]	3.7% (0.8)[a,b]	3.5%[d]
72 Hours[a]	5.8% (1.0)[a,b]	5.5%[d]
96 Hours[c]	9.2% (1.2)[a,c]	8.4%[d]

[a] Values shown for 48-96 hours are cumulative. Results are the mean for five rats (standard error).
[b] Urine plus feces.
[c] Urine plus feces plus tissues.
[d] See Figure 1 of Yang *et al.* (1989)

Wester *et al.* (1990) measured the absorption of B(a)P *in vivo* over 24 hours in the monkey using acetone as vehicle, or using soil containing B(a)P at the 10 ppm level (see Table 10). The soil used contained 26% sand, 26% clay, and 48% silt. The organic content was not specified. The B(a)P-containing soil was prepared by adding the B(a)P in (7:3, v/v) hexane:methylene chloride. The soil was mixed by hand and left open to the air to allow dissipation of the solvent. The B(a)P-soil mixture was not aged before use.

Four female Rhesus monkeys were tested with 40 mg soil/cm^2 applied to the abdominal skin. The skin area was covered with a nonocculusive cover to prevent loss of soil or ingestion of soil by grooming behavior. Percutaneous absorption was measured by comparing the quantity of radiolabel [^{14}C-B(a)P] in the urine following topical application to that, following intravenous application. Urine was collected for 24 hours. After 24 hours, all visible soil was collected from the application site. The skin surface was washed with soap and water, and the monkeys were returned to metabolic cages for urine collection for an additional six days. *In vivo*, the absorption was 51.0% for acetone vehicle and 13.2% for soil.

In vitro studies were also carried out with viable human cadaver skin in cells of the flow-through design. Human serum was used as the receptor fluid. Radiolabel was determined in the receptor fluid after 24 hours, as well as in the skin after a surface wash with soap and water. The amount of B(a)P that cannot be removed from the skin with a soap and water wash is designated here as "absorbed" for the purposes of AAF derivation. In six experiments with skin from two donors, 23.8% of the B(a)P was absorbed with acetone vehicle. From soil (10 ppm), 1.45% was absorbed in 24 hours.

Dermal-Soil AAF Derivation

The fraction absorbed in a 24-hour or 96-hour experiment has little relevance to human risk assessment. People who might touch, walk on, or otherwise contact PAH-containing soil would only be exposed for a period of 6-12 hours at maximum

Table 10. Dermal Absorption of Benzo(a)pyrene from Soil (Wester *et al.*, 1990)

Sample	Monkey Skin	Human Skin
1	13.1%[a]	1.01%[c]
2	10.8%[a]	1.52%[c]
3	18.0%[a]	0.61%[c]
4	11.0%[a]	2.21%[c]
5	NA	0.31%[c]
6	NA	3.01%[c]
Mean +/- SD	13.2% +/- 3.4%[b]	1.45% +/- 1.02%[b]

[a] Percentage of applied dose absorbed = (^{14}C urinary excretion for seven days following 24 hour topical application) /(^{14}C urinary excretion following intravenous administration) x 100.
[b] Mean +/- Standard Deviation.
[c] Fraction of applied dose in the skin plus fraction in receptor fluid.

before washing themselves or before the soil would drop off or be rubbed off the skin. The Wester, *et al.* (1990) paper demonstrates that soap and water wash can remove a large amount of the administered dose (53-91%), even after 24 hours. Even more would be removed after only 6-12 hours exposure.

EPA guidance for dermal risk assessment recognizes that the time period of a dermal experiment is an important factor to consider when evaluating experimental data. The EPA (1992b) has noted: "The experiment should provide absorption estimates over a time corresponding to the time that soil is likely to remain on skin during actual human exposures."

Accordingly, the data from the Yang *et al.* (1989) and Wester *et al.* (1990) experiments should be prorated for a reasonable exposure period, such as 6-12 hours. A health-protective way to do this is to simply assume that absorption is linear over time. The Yang *et al.* (1989) *in vitro* study showed a linear absorption into rat skin from 24-96 hours, but no data are available for the 0-24 hour period.

In fact, Kao, Patterson, and Hall (1985) have shown that the appearance of radiolabel from topically applied benzo(a)pyrene and other chemicals in human, rodent, and other species' skin in the culture medium of their *in vitro* system was exponential, not linear. A distinct time lag is apparent before any absorption occurs. A time lag has also been shown for various chlorophenols in human skin (Roberts, Anderson, and Swarbrick, 1977; Huq *et al.*, 1986). The EPA (1992b) also recognizes that a time lag may exist: "time is required after initial contact with the skin for such a steady-state to be achieved." Also: "Linear adjustments may not be accurate, since it is unknown how soon steady-state is established and since steady-state conditions may not be maintained throughout the experiment due to mass balance constraints."

Thus, linear adjustments of 24-hour absorption data to estimate absorption over 6-12 hours may overestimate the true absorption, but are not likely to underestimate absorption. A health-protective approach would be to assume that a relevant absorption period is as high as 12 hours. With this assumption, the Yang *et al.* 1989 data from the *in vitro* experiment can be adjusted to 0.66% absorption over 12 hours using a linear regression of all four time points. The data from the *in vivo* experiment can be adjusted to 1.15% absorption over 12 hours. The 96-hour data is used in this case, because tissue-bound B(a)P was measured only for this time point. The 12-hour estimated absorption using a linear regression is only 0.50%, and it was thus rejected for AAF derivation.

The Wester *et al.* (1990) data can be adjusted to 6.6% absorption in the *in vivo* monkey experiment over a 12-hour exposure period. Similarly, the 12-hour estimated exposure for the *in vitro* human skin experiment is 0.73%.

For probabilistic risk assessments, a distribution of AAF values is required. The numerator and the denominator of the AAF ratio are defined as separate distributions which are sampled independently during the probabilistic risk assessment.

Curve-fitting exercises for the numerator (dermal absorption of potentially carcinogenic PAHs from soil) using Mathematica™ software and the methods described in Burmaster (1996) indicated that the four data points best fit a Beta4 distribution with the following characteristics: Beta4 (a=1, b=5, c=0.146908, d=0) over the range 0 to 0.12. Monte Carlo simulations were then run using Crystal Ball™ software. The mean fractional dermal absorption of potentially carcinogenic PAHs after 20,000 trials was 0.02, with a standard deviation of 0.02.

Curve-fitting exercises for the denominator (gastrointestinal absorption of PAHs from dose-response studies) using Mathematica™ indicated that the 13 data points for absorption in the PAH dose-response studies best fit a Beta distribution with the following characteristics: Beta4 (a=4, b=1, c=0.397, d=0.602697) over the range 0.63 to 1.00. Monte Carlo simulations were then run using Crystal Ball™. The mean fractional gastrointestinal absorption of PAHs in the dose-response studies after 20,000 trials was 0.92, with a standard deviation of 0.06.

Monte Carlo simulations of the dermal-soil AAF were then run using these assumptions. The mean dermal-soil AAF for potentially carcinogenic PAHs after 20,000 trials is 0.03, with a standard deviation of 0.02. The 50th percentile AAF was 0.02, and the 90th percentile AAF is 0.06.

For deterministic risk assessments, a single estimate of the dermal-soil AAF is needed. In this case, four estimates of the dermal absorption of PAHs from soil were presented: 0.66%, 0.73%, 1.15%, and 6.6%. In addition, 12 estimates of the absorption of PAHs from the dose-response study were presented in Table 1. The average value is 92%. Four AAF estimates are 0.007, 0.008, 0.01, and 0.07. The deterministic estimate of the dermal-soil AAF is simply the average of the four AAFs, 0.02. This value is similar to the mean and 50th percentile estimates for the AAF distribution, and is thus appropriate for use in deterministic risk assessments.

APPLICABILITY OF DERMAL-SOIL AAFS TO OTHER PAHS

Dermal-soil AAFs have been derived for B(a)P based on four experimental data points with B(a)P. However, risk assessment of PAHs involves the calculation of benzo(a)pyrene-toxic equivalents, which includes the seven PAHs designated as potentially carcinogenic, as well as the separate evaluation of various noncarcinogenic PAHs. The following section addresses the applicability of the B(a)P AAF to other PAHs.

Various researchers have investigated the dermal absorption of different PAHs from pure mixtures, such as coal tar, or from solvent vehicles, such as acetone. From these studies, data on the comparative dermal absorption of various pure PAHs are available, but no studies are available on the dermal absorption of various PAHs from a soil matrix.

For instance, Sanders, Skinner, and Gelman (1984) studied the dermal absorption of B(a)P and dimethylbenz(a)anthracene (DMBA) in Swiss-Webster mice from an acetone vehicle. The dermal absorption was similar for the two PAHs. For example, at similar dose levels, the amount found in the tissues and excreta 24 hours after dosing was 84% for B(a)P and 82% for DMBA.

Yang, Roy, and Mackerer (Yang *et al.* 1986a; 1986b) studied dermal absorption of B(a)P and anthracene at similar doses from solvent vehicles in the female Sprague-Dawley rat in both *in vivo* and *in vitro* systems. Absorption was similar for the two PAHs. *In vivo*, absorption after 144 hours was 46.2% for B(a)P and 52.3% for anthracene. *In vitro*, absorption after 144 hours was 49.9% for B(a)P and 55.9% for anthracene.

Ng and coworkers (Ng *et al.*, 1992) studied dermal absorption of B(a)P and pyrene at similar doses from an acetone vehicle in the hairless guinea pig. Absorption after 24 hours was 73.3% for B(a)P and 93.9% for pyrene. In an *in vitro* experiment, absorption of B(a)P was 67.4% versus 89.9% for pyrene. In another *in vitro* experiment, absorption of B(a)P was 39.8% versus 40.8% for pyrene.

Dankovic and colleagues (Dankovic *et al.*, 1989) studied the comparative dermal absorption in female CD-1 mice of 12 high molecular weight PAHs isolated from the 800-850° F complex organic mixture (COM) derived from a coal liquefaction process. Absorption was measured as the half-life of disappearance of the PAH from the mouse skin. The half-life was 5.0 hours for pyrene. For B(a)P, the half-life was 6.7 hours. All other PAH had half-lives similar to B(a)P, including benz(a)anthracene (6.5 hr), chrysene (7.3 hr), and benzo(j/k)fluoranthene (8.1 hr).

VanRooij *et al.* (1995) studied the dermal absorption in the blood-perfused pig ear of 10 PAHs present in coal tar. The blood-perfused pig ear was chosen as a test system because pig skin resembles human skin morphologically and functionally, and because percutaneous absorption rates of various chemicals in pig skin are comparable to the rates seen in human skin.

The absorption after 3.3 hours varied among PAHs. Absorption was greatest for phenanthrene and fluorene. Anthracene, fluoranthene, and pyrene showed similar absorption rates that were roughly 10 times less than those for phenanthrene and fluorene. The 4-6 ring PAHs showed substantially lower dermal absorption, which

was 100-1000 times less than that seen with phenanthrene and fluorene. It should be noted, however, that the maximum fractional absorption seen, which was with fluorene, was only 0.004% of the applied dose.

Of the potentially carcinogenic PAHs studied in the above dermal absorption experiments, B(a)P showed equal or greater dermal absorption. None of these experiments were performed with soil matrices. They all involved applying the PAHs as solutions in organic solvents.

As noted above, dimethylbenz(a)anthracene, benz(a)anthracene, and benzo(b)fluoranthene were absorbed to a degree similar to B(a)P. Chrysene, benzo(k)fluoranthene, indeno[1,2,3-cd]pyrene, and dibenzo(a,h)anthracene were absorbed to a lesser degree than was B(a)P. Accordingly, it is health-protective to use dermal-soil AAFs derived for B(a)P for performing risk assessment of all potentially carcinogenic PAH.

Derivation of Dermal-Soil AAF for Noncarcinogenic PAHs

Noncarcinogenic PAH with smaller molecular weights, however, were absorbed to a greater degree than was B(a)P in several experiments. Fluorene, phenanthrene, anthracene, fluoranthene, and pyrene were absorbed at rates varying from 1.03 times the B(a)P rate to 92 times the B(a)P rate. Accordingly it may be appropriate to modify upward the dermal-soil AAF derived from studies with B(a)P by the use of an uncertainty factor so that it can be used in the risk assessment of noncarcinogenic PAHs.

However, all of the available experiments used coal tar or PAHs in solutions. No information is available on the comparative absorption of different PAHs from soil matrices. It is possible that small molecular weight PAHs in pure form are absorbed through skin to a greater degree than are large molecular weight PAHs, but that these smaller PAHs are also *less* bioavailable in soil matrices than are large PAHs. This could occur if the smaller PAHs more efficiently enter the small pore spaces of the soil matrices than do larger PAHs.

In the absence of appropriately designed experiments for noncarcinogenic PAH AAF derivation, it is difficult to determine a reasonable uncertainty factor. The dermal-soil AAF for noncarcinogenic PAHs may be higher, or lower, or the same, as the dermal-soil AAF for potentially carcinogenic PAHs.

An uncertainty factor is defined here as a uniform distribution between 1 and 10, with a mean of 5. Thus, it is not assumed that the dermal-soil AAF for noncarcinogenic PAHs could be less than the dermal-soil AAF for potentially carcinogenic PAHs. Instead, it is assumed that it could be the same or higher by a factor of as high as 10.

For probabilistic risk assessments, a distribution of AAF values is required. The numerator is defined as two distributions that are multiplied together: the distribution of absorption of potentially carcinogenic PAHs from soil and the distribution of uncertainty factors for noncarcinogenic PAHs. The denominator of the AAF ratio is the distribution of the gastrointestinal absorption estimates from the dose-response studies. All three are defined as separate distributions which are sampled independently during the probabilistic risk assessment.

Curve-fitting exercises for the numerator (dermal absorption of potentially carcinogenic PAHs from soil) using Mathematica™ software and the methods described in Burmaster (1996) indicated that the four data points best fit a Beta4 distribution with the following characteristics: Beta4 (a=1, b=5, c=0.146908, d=0) over the range 0 to 0.12. Monte Carlo simulations were then run using Crystal Ball™ software. The mean fractional dermal absorption of potentially carcinogenic PAHs after 20,000 trials was 0.02 with a standard deviation of 0.02.

The uncertainty factor was defined as a uniform distribution with a minimum of 1.0 and a maximum of 10.0. The selected range is from 1 to 10. Monte Carlo simulations were then run using Crystal Ball™. The mean uncertainty factor after 10,000 trials was 5.5, with a standard deviation of 2.6.

Curve-fitting exercises for the denominator (gastrointestinal absorption of PAHs from dose-response studies) using Mathematica™ indicated that the 13 data points for absorption in the PAH dose-response studies best fit a Beta4 distribution with the following characteristics: Beta4 (a=4, b=1, c=0.397, d=0.602697) over the range 0.63 to 1.00. Monte Carlo simulations were then run using Crystal Ball™. The mean fractional gastrointestinal absorption of PAHs in the dose-response studies after 20,000 trials was 0.92 with a standard deviation of 0.06.

Monte Carlo simulations of the dermal-soil AAF were run with Crystal Ball™ using these assumptions. The mean dermal-soil AAF for potentially carcinogenic PAHs after 10,000 trials is 0.15 with a standard deviation of 0.5. The upper 50th percentile AAF was 0.09, and the 90th percentile AAF is 0.36.

For deterministic risk assessments, the uncertainty factor is defined as 5. Thus, the point estimate of the dermal-soil AAF for noncarcinogenic PAHs is defined as 0.10 (0.02 x 5). Because the mean of the AAF distribution is 0.15 and the 50th percentile of the AAF distribution is 0.09, 0.10 is a reasonable point estimate for the dermal-soil AAF for noncarcinogenic PAHs.

RELEVANCE TO HUMAN ABSORPTION

Limited quantitative data are available on PAH absorption in humans. By the oral route, absorption of pure B(a)P was shown in one study to be similar in humans compared to that seen in rats and hamsters. However, no data are available on the human gastrointestinal absorption of PAHs in a soil matrix. The literature presents no basis for presuming that gastrointestinal absorption of PAHs from soils would be significantly different in humans and experimental animals. Thus, it is reasonable to assume that the use of the above oral-soil AAFs for human health risk assessment does not introduce significant uncertainty because of interspecies differences.

By the dermal route, several studies are available that document absorption of PAHs from pure mixtures, such as coal tar, in human subjects. For instance, Clonfero *et al.* (1986) measured PAH metabolites in the urine of humans dermally exposed to coal tar. Storer *et al.* (1984) measured PAH levels in the blood of humans exposed to coal tar. Finally, Schoket *et al.* (1990) measured aromatic DNA adducts in the skin of humans exposed to coal tar. These and other studies clearly demonstrate that absorption of PAHs from pure mixtures or from PAHs dissolved in solvents can occur in human skin.

Only three, however, are available that have quantitated the absorption of pure PAHs or PAHs in soil matrices in human skin. As discussed above, Wester *et al.* (1990) studied the absorption of B(a)P in an acetone vehicle and in soil, in both monkeys and in human skin *in vitro*. The absorption from acetone was 2.1 times higher over 24 hours in the monkey compared to the human skin. From the soil matrix, absorption was 9.1 times higher in the monkey compared to the human skin.

Kao *et al.* (1985) studied the absorption of B(a)P from acetone in an *in vitro* system with skin from six species, including humans. Absorption over 24 hours was highest in the mouse. Absorption in the marmoset, rat, and rabbit was similar to that in human skin. Absorption in the guinea pig was the lowest.

Storm *et al.* (1990) studied the absorption of B(a)P *in vitro* in flow through diffusion cells with skin from humans, two rat strains, guinea pig, and two mouse strains. Absorption over 24 hours was similar in the mice, rats, and guinea pig. Absorption in human skin, however, was significantly lower by 1.5- to 2-fold.

Available studies indicate that human skin is less permeable to PAHs in pure form than is rodent or monkey skin. Thus, the dermal-soil AAF may overestimate the true AAF for human skin. Because the dermal-soil AAFs are derived from data on rats, monkeys, and humans, however, they are reasonable, health-protective estimates for use in human health risk assessment.

SUPPORTING EVIDENCE THAT SOIL ADSORPTION REDUCES GASTROINTESTINAL AND DERMAL ABSORPTION OF PAH

There are several bodies of experimental data that support the concept that soil adsorption over time binds and sequesters PAH molecules so that they are unavailable for absorption in the skin and gastrointestinal tracts of humans and animals that might contact the affected soils. The results of these experiments cannot easily be used to derive a quantitative estimate of the lowering in absorption, but they are presented here as scientific justification of the phenomenon.

Studies on Soil Bioavailability of Other Chemicals

Several studies were identified that compared tetrachlorodibenzodioxin (TCDD) absorption from soil to either diet, oil vehicle, or alcohol vehicle. These studies demonstrate that gastrointestinal absorption of TCDD is reduced when present as a component of soil or other matrix that can adsorb the TCDD. Dioxins and PAHs are two classes of lipophilic chemicals that would be expected to behave similarly with regard to soil adsorption.

For instance, Van den Berg, Olie, and Hutzinger (1983) administered PCDDs and PCDFs from fly ash and fly-ash extract to male Wistar rats as a dietary constituent. The absorption from fly ash was only 22% of the absorption from extracts.

Other studies are available in which absorption of TCDD from soil was compared to oil or alcohol vehicles. McConnell *et al.* (1984) investigated absorption in guinea pigs using soil from Missouri that contained TCDD. Gastrointestinal absorption from soil was 15-24% of the absorption from corn oil.

In a similar experiment, Poiger and Schlatter (1980) studied the effects of soil adsorption on the oral bioavailability of TCDD in Sprague-Dawley rats. When TCDD was administered as an aqueous suspension of soil particles that had been in contact with the TCDD for 8 days, the fraction of the administered dose that was found in the liver 24 hours later was 43% of that found with an aqueous ethanol vehicle.

Similar studies have also been performed in rabbits by Bonaccorsi *et al.* (1984). Levels of TCDD in the liver 7 days after an oral dose of TCDD, either in alcohol or in soil from Seveso, Italy were compared. The ratio of TCDD absorption from soil relative to alcohol vehicle was 32% in this study.

Umbreit, Hesse, and Gallo (1986) also studied the effect of soil adsorption on 2,3,7,8-TCDD-induced toxicity in guinea pigs. Dioxin as a suspension of corn oil and acetone (9:1) (6 ug/kg) given to guinea pigs by stomach tube caused death in 5 of 8 animals within 5-31 days, and autopsy showed signs typical of the TCDD-induced toxicity that is observed in the guinea pig. When the same amount of 2,3,7,8-TCDD was placed on soil for only one hour and then administered to the animals, similar results were seen. However, contaminated soil from a site in New Jersey containing the same or double the amount of 2,3,7,8-TCDD failed to cause any deaths, and also failed to induce any recognizable signs of TCDD-induced toxicity. Thus, aging of the soil causes decreased bioavailability.

Studies on Effects of Dietary Components on PAH Absorption

Several studies have been evaluated on the effects of dietary fiber and other food items on PAH absorption in the gastrointestinal tract. In general, it has been shown that dietary fiber of various types can bind or adsorb PAH and reduce their absorption in the gut of experimental animals. For instance, Gulliver *et al.* (1983) showed that dietary fiber binds dimethylbenz(a)anthracene *in vitro* and decreases solubilization by bile salt solutions by 61-98%. Mirvish *et al.* (1981) showed that B(a)P absorption in rats was reduced from 99.8% in semisynthetic diets having no fiber to 95% when wheat bran was added. Kawamura *et al.* (1988) studied B(a)P absorption from various food items in the rat. Absorption was highest when B(a)P was administered in triolein oil. When B(a)P was given in different food items that included cellulose, bread, lignin, ovalbumin, spinach, and others, absorption was reduced to as low as 40% of that seen with triolein. Similar results were seen with the release of B(a)P from food items *in vitro* in artificial intestinal fluid.

Studies on the Effects of Soil Components on PAH Mutagenicity

Sato *et al.* (1987) studied the effects of organic chemicals found in soil on the mutagenicity of B(a)P to *Salmonella typhimurium*. Humic acid and lignin totally inhibited the ability of B(a)P to mutate the bacteria in culture. Fulvic acid and water-soluble humic substances inhibited B(a)P-induced mutagenicity to a lesser degree. It was found that the humic acid inhibited mutagenicity by binding the B(a)P and making it unavailable to the bacteria in culture. This was shown by mixing B(a)P and humic acid and then extracting the B(a)P by ethyl acetate. In the presence of humic acid, only 25% of the B(a)P could be extracted compared

to controls containing no humic acid. All of the added B(a)P could, however, be released after ultrasonication, indicating that the humic acid was reducing B(a)P's bioavailability.

Studies on Solvent Extractability of PAH from Soils

Karickhoff (1980) showed that PAHs became increasingly more difficult to extract from sediments with increasing contact time. For instance, after 4 minutes pyrene was 94% recoverable with solvent extraction, but after 122 hours, only 36% could be recovered. Quantitative recovery after a 72-hour Soxhlet extraction confirmed that the PAH had not degraded, but rather was adsorbed tightly to sediment particles.

Hatzinger and Alexander (1995) showed that butanol extractability of phenanthrene decreased from 95% recovery to 61% recovery from a high organic content soil when the mixture was aged 84 days. The soil was sterilized to prevent bacterial degradation. Greater recoveries after Soxhlet extraction confirmed that soil adsorption was the reason for reduced solvent extraction efficiency.

Studies on Bacterial Degradation of PAH in Soils

Hatzinger and Alexander (1995) introduced phenanthrene into high organic content soils that had been sterilized to remove organisms that might degrade the PAH. After aging the phenanthrene in the soil for varying periods of time (29 weeks, 45 weeks), a phenanthrene-degrading organism was introduced. After a month, 60% of the phenanthrene was degraded in the unaged control. Bacterial degradation was diminished in the aged soils. Degradation plateaued at 45% for the 29-week soil and at 40% for the 45-week soil. Adsorption of the PAH to the soil was responsible for the reduction in its bioavailability to microorganisms.

Weissenfels, Klewer, and Langhoff (1992) studied the biodegradation of PAHs in soils from a closed coking plant. PAHs were not degraded by autochthonous organisms or after inoculation with bacteria known to degrade PAHs. However, rapid degradation of PAHs was observed when PAHs were extracted from the soil by an organic solvent and then reintroduced into the extracted soil material. Sorption of the extracted PAHs onto the extracted soil followed a two-phase process. The authors described the slow phase of sorption as migration into less accessible sites within the soil matrix. The authors concluded that the PAHs so sorbed within the soil matrix are nonbioavailable and nonbiodegradable. The initial soil was extracted with water and assayed for toxicity with bioluminescent bacteria. No toxicity was observed in the aqueous phase.

Studies on Reduction in Chemical Toxicity After Aging in Soil Matrices

Edwards, Beck, and Lichtenstein (1957) showed that the lethal dose of lindane and aldrin in *Drosophila melanogaster* increased as soil organic content increased. The LD_{50} for lindane varied from 0.25 mg/kg in soils containing 0.5% organic matter to 8.6 mg/kg in soils containing 40% organic matter. For aldrin, the results were similar. Peterson, Adams, and Cutkomp (1971) reported a similar result for DDT in *Drosophila melanogaster*. The LD_{50} increased from 43 to 790 mg/kg as the fraction of organic matter in the soil increased.

SUMMARY

Oral-Soil and Dermal-Soil AAFs were derived for deterministic and probabilistic risk assessment of PAH. Values are given for both potentially carcinogenic PAH and noncarcinogenic PAH. For deterministic risk assessment, point estimates are defined. For probabilistic risk assessment, AAF distributions are defined.

The point estimate Oral-Soil AAF derived for deterministic risk assessment of potentially carcinogenic PAH is 0.29. For probabilistic risk assessments, the Oral-Soil AAF distribution is defined as a Beta4 distribution, with the following characteristics: Beta4 (a=1, b=3, c=0.944964, d=0.0699) over the range of 0.07 to 1.00.

The point estimate Dermal-Soil AAF derived for deterministic risk assessment of potentially carcinogenic PAH is 0.02. For probabilistic risk assessments, a distribution of Dermal-Soil AAF values is required. The numerator and the denominator of the AAF ratio are defined as separate distributions which are sampled independently during the probabilistic risk assessment. The numerator (dermal absorption from soil) is defined as a Beta4 distribution, with the following characteristics: Beta4 (a=1, b=5, c=0.146908, d=0) over the range 0 to 0.12. The denominator (gastrointestinal absorption of PAHs from dose-response studies) is defined as a Beta4 distribution, with the following characteristics: Beta4 (a=4, b=1, c=0.397, d=0.602697) over the range 0.63 to 1.00.

Recent experiments suggest that dermal absorption of noncarcinogenic PAH may be higher than absorption of potentially carcinogenic PAH. To derive an AAF for noncarcinogenic PAH, an uncertainty factor is applied to the dermal-soil AAF for potentially carcinogenic PAH. The uncertainty factor distribution was defined as a uniform distribution with a minimum of 1.0 and a maximum of 10.0. For deterministic risk assessments, the uncertainty factor is defined as 5. Thus, the point estimate of the dermal-soil AAF for noncarcinogenic PAHs was defined as 0.10 (0.02 x 5).

References

Bartosek, I., Guitani, A., Modica, R., Fiume, M., and Urso, R. 1984. Comparative kinetics of oral benz(a)anthracene, chrysene, and triphenylene in rats: A study with hydrocarbon mixtures. *Toxicol. Lett.* **23**, 333-339.

Bonaccorsi, A., di Domenico, A., Fanelli, R., Merli, F., Motta, R., Vanzati, R., and Zapponi, G.A. 1984. The influence of soil particle adsorption on 2,3,7,8-tetrachlorodibenzo-p-dioxin biological uptake in the rabbit. *Arch. Toxicol. Suppl.* **7**, 431-434.

Bowes, S.G. and Renwick, A.G. 1986. The hepatic metabolism and biliary excretion of benzo[a]pyrene in guinea-pigs fed normal, high-fat or high-cholesterol diets. *Xenobiotica* **16**, 531-542.

Brainard, J. and Beck, B.D. 1992. A Review of Bioavailability of Petroleum Constituents. *Journal of Soil Contamination*, **1**, 273-307.

Brune, H., Deutsch-Wenzel, R.P., Habs, M., Ivankovic, S., and Schmahl, D. 1981. Investigation of the tumorigenic response to benzo(a)pyrene in aqueous caffeine solution applied orally to Sprague-Dawley rats. *J. Cancer Res. Clin. Oncol.* **102**, 2, 153-157.

Burmaster, D.E. 1996. Using Beta Distributions Efficiently in a Probabilistic Exposure Assessment. *Risk Analysis.* (In review).

Chang, L.H. 1943. The fecal excretion of polycyclic hydrocarbons following their administration to the rat. *J. Biol. Chem.* **151**, 93-99.

Chipman, J.K., Hirom, P.C., Frost, G.S., and Millburn, P. 1981a. The biliary excretion and enterohepatic circulation of benzo(a)pyrene and its metabolites in the rat. *Biochemical Pharmacol.* **30**, 937-944.

Chipman, J.K., Frost, G.S., Hirom, P.C., and Millburn, P. 1981b. Biliary excretion, systemic availability, and reactivity of metabolites following intraportal infusion of [3H]benzo[a]pyrene in the rat. *Carcinogenesis* **2**, 741-745.

Clonfero, E., Zordan, M., Cottica, D., Venier, P., Pozzoli, L., Cardin, E.L., Sarto, F., and Levis, A.G. 1986. Mutagenic activity and polycyclic aromatic hydrocarbon levels in urine of humans exposed to therapeutical coal tar. *Carcinogenesis* **7**, 5, 819-823.

Dankovic, D.A., Wright, C.W., Zangar, R.C., and Springer, D.L. 1989. Complex mixture effects on the dermal absorption of benzo[a]pyrene and other polycyclic aromatic hydrocarbons from mouse skin. *J. Appl. Toxicol.* **9**, 4, 239-244.

Edwards, C.A., Beck, S.D., and Lichtenstein, E.P. 1957. Bioassay of aldrin and lindane in soil. *J. Econ. Entomol.* **50**, 622-626 (cited in GRI, 1995).

Flescher, J.W. and Syndor, K.L. 1960. Distribution and excretion of radioactivity in rats after oral administration of H3-3-methylcholanthrene. *Proc. Soc. Expl. Biol. Med.* **104**, 776-779.

Foth, H., Kahl, R. and Hahl, G.F. 1988. Pharmacokinetics of low doses of benzo[a]pyrene in the rat. *Fd. Chem. Toxic.* **26**, 45-51.

Gas Research Institute. 1990. Manufactured Gas Plant Update: A Publication of the Gas Research Institute (GRI) Environment & Safety Research Department.

Gas Research Institute. 1995. Environmentally Acceptable Endpoints in Soil: Risk-Based Approach to Contaminated Site Management Based on Availability of Chemicals in Soil. April, 1995. Draft Report.

Goon, D., Hatoum, N.S., Klan, M.J., Jerniganm, J.D., and Farmer, R.G. 1991. Oral bioavailability of "aged" soil-adsorbed benzo[a]pyrene (BaP) in rats. *Toxicologist* **11**, 1356.

Goon, D. and Burnette, D. 1996. Personal communication.

Goon, D., Hatoum, N.S., Jernigan, J.D., Schmidt, S.L. and Garvin, P.J. 1990. Pharmacokinetics and Oral Bioavailability of Soil-Adsorbed Benzo(a)pyrene (B(a)P in Rats. *Toxicologist* **10**, 218.

Grimmer, G., Brune, H., Dettbarn, G., Heinrich, U., Jacob, J., Mohtashamipur, E., Orpoth, K., Pott, F., and Wenzel-Hartung, R. 1988. Urinary and faecal excretion of chrysene and chrysene metabolites by rats after oral, intraperitoneal, intratracheal or intrapulmonary application. *Arch. Toxicol.* **62**, 401-405.

Gulliver, W.P., Kutty, K.P., Laher, J.M., and Barrowman, J.A. 1983. In vitro interaction of 7,12-dimethylbenz[a]anthracene and its biliary metabolites with dietary fibers. *J. Nat. Cancer Inst.* **71**, 207-210.

Hatzinger, P.B. and Alexander, M. 1995. Effect of aging of chemicals in soil on their biodegradability and extractability. *Environ. Sci. Technol.* **29**, 537-545.

Hecht, S.S., Grabowski, W., and Groth, K. 1979. Analysis of feces for benzo(a)pyrene after consumption of charcoal-broiled beef by rats and humans. *Cosmet. Toxicol.* **17**, 223-227.

Huq, A.S., Ho, N.F.H., Husari, N., Flynn, G.L., Jetzer, W.E., and Condie, L. 1986. Permeation of water contaminative phenols through hairless mouse skin. *Arch. Environ. Contam. Toxicol.* **15**, 557-566.

Kao, J., Patterson, F.K., and Hall, J. 1985. Skin penetration and metabolism of topically applied chemicals in six mammalian species, including man: An *in vitro* study with benzo(a)pyrene and testosterone. *Toxicol. Appl. Pharmacol.* **81**, 502-516.

Karickhoff, S.W. 1980. Sorption kinetics of hydrophobic pollutants in natural sediments. In: R. A. Baker, ed., Contaminant and Sediments, Volume 2 (Ann Arbor Science: Ann Arbor, MI). pp. 193-206 (cited in GRI, 1995).

Kawamura, J., Kamata, E., Ogawa, Y., Kaneko, T., Uchiyama, S., and Saito, Y. 1988. The effect of various foods on the intestinal absorption of benzo(a)pyrene in rats. *J. Food Hyg. Soc. Japan* **29**, 21-25.

McConnell, E., Lucier, G., Rumbaugh, R., Albro, P., Harvan, D., Hass, J., and Harris, M. 1984. Dioxin in soil: bioavailability after ingestion by rats and guinea pigs. *Science* **223**, 1077-1079.

Mirvish, S.S., Ghadirian, P., Wallcave, L., Raha, C., Bronczyk, S., and Sams, J.P. 1981. Effect of diet on fecal excretion and gastrointestinal tract distribution of unmetabolized benzo(a)pyrene and 3-methylcholanthrene when these compounds are administered orally to hamsters. *Cancer Res.* **41**, 2289-2293.

Neal, J. and Rigdon, R.H. 1967. Gastric tumors in mice fed benzo(a)pyrene: A quantitative study. *Texas Rep. Biol. Med.* **25**, 553.

Ng, K.M.E., Chu, I., Bronaugh, R.L., Franklin, C.A., and Somers, D.A. 1992. Percutaneous absorption and metabolism of pyrene, benzo[a]pyrene, and di(2-ethylhexyl) phthalate: Comparison of *in vitro* and *in vivo* results in the hairless guinea pig. *Toxicol. Appl. Pharmacol.* **115**, 216-223.

Peterson, J.R., Adams, R.S. and Cutkomp, L.K. 1971. Soil properties influencing DDT bioactivity. *Soil Sci. Soc. Am. Proc.* **35**, 72-78 (cited in GRI, 1995).

Poiger, H. and Schlatter, C. 1980. Influence of solvents and adsorbents on dermal and intestinal absorption of TCDD. *Food Cosmet. Toxicol.* **18**, 477-481.

Rabache, M., Billaud, C., and Adrian, J. 1985. Evolution du benzo(a)pyrene dans le tube digestif. 1. Sa disparition. Internat. *J. Vit. Nutr. Res.* **55**, 113-117.

Rees, E.D., Mandelstam, P., Lowry, J.Q., and Lipscomb, H. 1971. A study of the mechanism of intestinal absorption of benzo(a)pyrene. *Biochemica et Biophysica Acta* **225**, 96-107.

Roberts, M.S., Anderson, R.A., and Swarbrick, J. 1977. Permeability of human epidermis to phenolic compounds. *Pharm. Pharmacol.* **29**, 677-683.

Rozett, K., Singh, R., Roy, T., Neal, W., and Weyand, E.H. 1996. Bioavailability of chemical components of soil contaminated with manufactured gas plant residue. *Fundam. Appl. Toxicol.* **30**, 1, Part 2.

Sanders, C.L., Skinner, C., Gelman, R.A. 1984. Percutaneous absorption of [7, 10^{-14} C] benzo[a]pyrene and [7,12-14C] dimethylbenz[a]anthracene in mice. *Environ. Res.* **33**, 353-360.

Sato, T., Ose, Y., Nagase, H., and Hayase, K. 1987. Mechanism of the desmutagenic effect of humic acid. *Mutation Res.* **176**, 199-204.

Schoket, B., Horkay, I., Kosa, A., Paldeak, L., Hewer, A., Grover, P.L., and Philips, D.H. 1990. Formation of DNA adducts in the skin of psoriasis patients, in human skin in organ culture, and in mouse skin and lung following topical application of coal-tar and juniper tar. *J. Investigative Dermatol.*, 241-246.

Singh, R., Tucek, M., Maxa, K., Tenglerova, T., and Weyand, E.H. 1995. A rapid and simple method for the analysis of 1-hydroxypyrene glucuronide: A potential biomarker for polycyclic aromatic hydrocarbon exposure. *Carcinogenesis* **16**, 2909-2915.

Storer, J.S., DeLeon, I., Millikan, L.E., Laseter, J.L., and Griffing, C. 1984. Human absorption of crude coal tar products. *Arch. Dermatol.* **120**, 874-877.

Storm, J.E., Collier, S.W., Stewart, R.F., and Bronaugh, R.L. 1990. Metabolism of xenobiotics during percutaneous penetration: Role of absorption rate and cutaneous enzyme activity. *Fundam. Appl. Toxicol.* **15**, 132-141.

Umbreit, T.H., Hesse, E.J., and Gallo, M.A. 1986. Bioavailability of dioxin in soil from a 2,4,5-T manufacturing site. *Science* **232**, 497-499.

USEPA. (U.S. Environmental Protection Agency). 1992a. *Guidelines for Exposure Assessment.* (Final). 57 *Federal Register* 22888-22938.

USEPA. (U.S. Environmental Protection Agency). 1992b. *Dermal Exposure Assessment Principles and Applications.* Office of Research and Development, Washington, DC. EPA 600/8-91/011B.

USEPA. (U.S. Environmental Protection Agency). 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons.* Office of Research and Development, Washington, DC. EPA/600/R-93/089

USEPA. (U.S. Environmental Protection Agency). 1996. Integrated Risk Information System. On-line Database.

Van den Berg, M., Olie, K., Hutzinger, O. 1983. Uptake and selective retention in rats of orally administered chlorinated dioxins and dibenzo-furans from fly-ash and fly-ash extract. *Chemosphere* **12**, 4/5, 537-544.

VanRooij, J.G.M., Vinke, E., De Lange, J., Bruijnzeel, P.L.B., Bodelier-Bade, M.M., Noordhoek, J., and Jongeneelen, F.J. 1995. Dermal absorption of polycyclic aromatic hydrocarbons in the blood-perfused pig ear. *J. Appl. Toxicol.* **15**, 3, 193-200.

Weissenfels, W.D., Klewer, H.J., and Langhoff, J. 1992. Adsorption of polycyclic aromatic hydrocarbons (PAHs) by soil particles; Influence on biodegradability and biotoxicity. *Appl. Microbiol. Biotechnol.* **36**, 689-696.

Wester, R.D., Maibach, H.I., Bucks, D.A., Sedik, L., Melendres, J., Liao, C., and DiZio, S. 1990. Percutaneous absorption of [^{14}C]DDT and [^{14}C] benzo(a)pyrene from soil. *Fundam. Appl. Toxicol.* **15**, 510-516.

Weyand, E.H., Rozett, K., Koganit, A., and Singh, R. 1996. Effect of soil on the genotoxicity of manufactured gas plant residue. *Fundam. Appl. Toxicol.* **30**, 1, Part 2.

Withey, J.R., Law, F.C.P., and Endrenyi, L. 1991. Pharmacokinetics and bioavailability of pyrene in the rat. *J. Toxicol. Environ. Health* **32**, 429-447.

Yang, J.L., Roy, T.A., and Mackerer, C.R. 1986a. Percutaneous absorption of anthracene in the rat: Comparison of *in vivo* and *in vitro* results. *Toxicol. Industrial Health* **2**, 1, 79-84.

Yang, J.L., Roy, T.A., and Mackerer, C.R. 1986b. Percutaneous absorption of benzo[a]pyrene in the rat: Comparison of *in vivo* and *in vitro* results. *Toxicol. Industrial Health*, **2**, 4.

Yang, J.J., Roy, T.A., Krueger, A.J., Neil, W., and Mackerer, D.R. 1989. *In vitro* and *In vivo* percutaneous absorption of benzo(a)pyrene from petroleum crude-fortified soil in the rat. *Bull. Environ. Contam. Toxicol.* **43**, 207-214.