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November 24, 1998

U. S. Environmental Protection Agency
Region II Headquarters
Chief RCRA Caribbean Section
290 Broadway - 22nd Floor
New York, New York 10007-1866

Attn: Ms. Nicoletta DiForte

Re: Contract N62470-89-D-4814
Navy CLEAN, District III
Contract Task Order (CTO) 0277
RCRA/HSWA Permit Number PR2170027203, U. S. Naval Station Roosevelt Roads
Response to EPA Comment Letter Dated September 15, 1998

Dear Ms. DiForte:

Baker Environmental, Inc. is pleased to provide this letter on behalf of the Navy. The letter is in response to the United States Environmental Protection Agency's (EPA) Region II letter dated September 15, 1998, addressed to Mr. Paul Rakowski, P. E., Head, Environmental Program Branch, Atlantic Division (LANTDIV) Naval Facilities Engineering Command. EPA's comments pertain to the following subjects as indicated in the letter:

- EPA Comments on Report on Additional RFI Investigations for Operable Units (OUs) #1,6, and 7, dated May 6, 1998
- Corrective Measures Study (CMS) Notification for SWMU #46/AOC C, SWMU #13, and former "uncontrolled storage area" associated with SWMU #31/#32 area.

This letter and attachments serves to provide a response to each of EPA's comments on the above referenced topics. The EPA comments precede our responses for ease of review.

EPA Comments

Comment

EPA approves the Navy's recommendation, as given in Section 4.0 of the Report, that a Corrective Measure Study (CMS) be performed for the ditch sediments associated with SWMU #13 and the combined SWMU #46/AOC C area. This letter shall constitute EPA's notification that CMSs are required for the ditch sediments associated with SWMU # 13 and the combined SWMU #46/AOC C area. Pursuant to Conditions E.5.(c) and E.5.(d) of Module III of the 1994 RCRA Permit (the Permit) for the facility, the Navy is required to submit CMS workplans and Task I reports (refer to

bcc: PAShucet/CF, JWMentz/PRGM F; TCFuller/PJT F;
MEKimes; Daily File
S.O.# 62470-277-SRN
Subfile #
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Appendix B "Scope of Work for a Corrective Measure Study" [CMS Scope of Work] of the 1994 Permit) for the ditch sediments associated with SWMU # 13 and the combined SWMU #46/AOC C area, within 60 calender days after written notification that the CMS is required.

As discussed in the Advanced Notice of Proposed Rulemaking (ANPR) on "Corrective Action for Releases From Solid Waste Management Units at Hazardous Waste Management Facilities", published on May 1, 1996 The Federal Register, Vol. 61, No. 85, pp 19431-19464, the CMS does not have to address all potential remedies, and the CMS may incorporate usage of "presumptive remedies". If the Navy wishes to utilize such a "streamlined" CMS, omitting certain portions/requirements described in Appendix B of the Permit (CMS Scope of Work), and/or incorporating a "presumptive remedy" for either the ditch sediments associated with SWMU # 13 and/or the combined SWMU #46/AOC C area, please submit, within 60 days of your receipt of this letter, either the actual "streamlined" CMS report(s), or an outline for each, with the actual CMS report(s) to be submitted within 60 days of EPA's approval of the outline(s).

The focus of the "streamlined" CMSs for the ditch sediments associated with SWMU # 13 and the combined SWMU #46/AOC C area should be to describe fully (including appropriate figures/maps, etc.) the proposed remedies and to confirm that they are protective of human health and the environment, based on facility-specific conditions.

Response

Outlines for the Corrective Measures study at these sites are attached to this document as Attachments 1 and 2. The Navy has proposed a "presumptive" remedy approach. In addition, the Navy proposes to do the designs for AOC C/SWMU 46, SWMU 13 and SWMU 31/32 together. This will allow the work to be performed by a single contractor mobilizing once resulting in schedule compression and cost savings.

Comment

In addition, since unacceptable potential human health risks are indicated for current on-site workers from possible dioxin exposure at the former "uncontrolled storage area" investigated as part of the SWMU # 31/# 32 area, EPA cannot approve the no further action recommendation for the SWMU # 31/# 32 area. That recommendation was based on an "industrial usage" restriction being placed on the area, coupled with the contention in the Report that "The risk to current onsite workers is mitigated by the fact that significant portions of the site are paved and where unpaved, the material is hard packed and does not generally produce dust when windblown or transited". However, the "industrial usage" restriction would not eliminate unacceptable health risks to current or future on-site workers. In addition, the "mitigating factors" (covered by pavement and "hard packed"soils) cited in the Report are a) undocumented, and b) the mitigation of the human health risks due to the "hard packed" nature of unpaved areas is questionable, as discussed in the enclosed TechLaw Evaluation. Also, if the dioxin contaminated soils are not cleaned-up, restrictions on soil excavation and management for those dioxin contaminated soils appear warranted. Accordingly, this letter shall constitute EPA's notification that a CMS is required for the dioxin contaminated soils in the former "uncontrolled storage area" associated with the SWMU # 31/# 32 area. As discussed above, a "streamlined" CMS and/or CMS based on a presumptive remedy may be submitted for the dioxin contaminated soils in the SWMU # 31/# 32 area. Please submit either a CMS *workplan, or an outline for a "streamlined" CMS, for the dioxin contaminated soils in the SWMU #31/#32 area, as described above, within 60 days of your receipt of this letter.*

Response

An outline for a streamlined CMS at SWMU 31/32 is included in this document as Attachment 3.

Comment

In addition, EPA is not yet prepared to fully approve the no further action recommendations made in the Report for the following: SWMU #6/AOC B area, SWMU #26, and AOC D. This due to deficiencies and/or data gaps in the Navy's evaluations of possible risk scenarios, and questions about the representativeness of certain background data used in support of no-farther action determinations. These deficiencies and/or data gaps, and concerns about certain background data are discussed in the enclosed June 30, 1998 Evaluation of the Report prepared by EPA's contractor TechLaw, Inc (the TechLaw Evaluation).

Response

The TechLaw comments are addressed in detail in this document.

Comment

In order to facilitate conclusion of the RFI Final report and the action/no-action determination process for all of the above discussed SWMUs and AOCs, EPA requests the Navy to submit, within 60 days of your receipt of this letter, a written response addressing all comments in the enclosed TechLaw Evaluation (in addition to your submission of the CMS workplans or outlines for "streamlined" CMSs, as discussed above). EPA will then evaluate and respond to the Navy's comments, prior to you having to submit any revisions to the Report.

Response

This document comprises the requested submission.

Comment

Also, as indicated in previous correspondence, for any SWMU or AOC where the no further action recommendation is based on restricted future site usage, i.e., "institutional control", EPA will require documentation of such "institutional control" (such as certification by the base's commanding officer, or some other enforceable document, of restricted future usage). Such documentation is required for the SWMUs #6/AOC B area. However, as previously discussed with Mr. Christopher Penny, of your staff, and at several Joint Interest Group meetings held between EPA, the Navy, and the Puerto Rico Environmental Quality Board (PREQB), such documentation may be submitted as part of a comprehensive CMS/CMI (Corrective Measures Study/Corrective Measures Implementation) document, once all other issues regarding the final decision for all SWMUs and AOCs have been resolved.

Response

It is the intent of the Navy to comply by providing the requested information at the appropriate time.

TechLaw Comments

Comment

3.0 GENERAL COMMENTS

1. Site features illustrated in figures presented in Section 2.0 appear to have been significantly modified since the July 1996 Draft Phase I Report. The text should explain the modifications to the site features. Building, 112 depicted in Figure 5-1 of the July 1996 report is not illustrated in Figure 2-2 of the May 1998 report. In addition, several figures have dark dashed lines, which are not identified in the legends. The figures must be revised to clarify meaning of the dark dashed lines.

Response

The mapping used in the most recent submittal is new and was made from fresh aerial photography. Minor changes in what is included on the figures have been noted. In all cases, features important to understanding conditions at a given SWMU have been included. Where structures or other features are outside the limits of the SWMU or AOC they have only been included as "landmarks" if deemed important to the site. Building 112, referenced specifically in the comment, has not been razed or moved. It was simply not placed on the figure since it is unimportant to site context.

There are "dark dashed lines" on many of the drawings. No specific occurrence was cited. The lines represent numerous things. In the case of Figure 2-2, the dashed lines in the SWMU area represent cleared areas which appear to be bare and trafficked by vehicles (the equipment storage area which comprises a large portion of the present SWMU use).

In future submissions, any "dark dashed lines" will be labeled.

Comment

2. The human health risk assessment performed as part of the Draft Additional Investigations Report for OUs 1, 6, and 7 (SWMUs 6, 10, 13, 26, 3 1, and 46 and AOCs B, C, and D) complied with EPA guidance with several minor exceptions which are discussed below in page-specific comments. However, many of the Navy's conclusions' and recommendations presented in Section 4.0 are not supported by the information provided in the risk assessment. The no further action recommendations for SWMUs 6, 26, and 31 and AOC D are not adequately justified. In addition, the Navy does not adequately respond to comments #1 and #2 in EPA's April 25, 1997 letter. The comments presented concerns regarding the derivation of background concentrations and additional exposure scenarios to be evaluated for SWMU 6, SWMU 26, SWMU 31, and AOC D. These issues are summarized below in items A through E and page-specific comments.

Response

Comment No. 2 is one that is summary in nature. The specific points raised are responded to under the applicable detailed comments which followed.

Comment

A. Derivation of Background Constituent Concentrations

The Navy's response to comment #1 in EPA's April 25, 1997 letter, does not address the concern regarding the derivation of site background constituent concentrations. As noted previously by EPA, *the site background data and the SWMU 26 background data both include samples in which organics were detected. Xylene, PAHs, total HxCDD and 2,4,5-T were detected in the site background samples. Ten SVOCs were detected in the SWMU 26 background samples. The detection of organic constituents suggests that the background samples are impacted by human activity. Therefore, the inorganic constituents detected may not represent naturally occurring conditions. The Navy must evaluate the adequacy of the background data and present corrective actions to develop an adequate background data set.*

Response

The purpose of background is to establish a baseline of ambient environmental conditions in environmental media of concern. Background is not some arbitrary standard from some pristine setting totally unaffected by man but is based on site-specific conditions.

All sites, whether they are SWMUs or not, are equally affected by anthropomorphic contamination from multiple sources. Specifically, runoff from parking lots and roadways often contain volatile and semi-volatile organics arising from petroleum based paving materials and emissions from vehicles. These chemicals commonly occur in soils and drainage ditch sediments near these features. The historic and long-term use of pesticides and herbicides, especially in a tropical environment, will often produce low levels of residual chemicals in the soil and sometimes groundwater. Finally, airborne contaminants (dioxin being a prime example) can migrate onto a facility from offsite sources and eventually show up randomly in site soils.

In all the cases discussed above, the important consideration is establishing ambient site conditions. All the factors which may affect the site must be taken into consideration. This is the key to constructing a background database that is representative of ambient conditions, unaffected by waste management activities.

Based on the forgoing information, the Navy contends that it is perfectly reasonable and technically supportable to use background data for organics.

The presence of antimony, beryllium, cadmium, mercury, selenium, silver and thallium are not in the background as a result of "man's impact". These are naturally occurring elements whose presence in site media is of no surprise especially considering the igneous nature of the parent rock.
Attachment 4 to this letter provides some brief information concerning the occurrence of the "trace elements" in soil and groundwater. As can be seen, all the elements attributed to "man's impact" in the comments are commonly occurring. Of special interest is the quote from the McGraw Hill volume regarding the occurrence of selenium in Puerto Rico soils.

Based on the above, the Navy still contends that the background data is of particular importance in considering inorganics constituents and to what extent they may be site related.

Recent discussions with the EPA (primarily during the November 4, 1998 JIG conference call) allowed the Navy to express some of its concern regarding the whole question of background and how it is to be utilized at the site. It is the opinion of the EPA that a "risk-based" approach is the one of choice for most of the sites. While this is apparently applicable in many cases, there still are the occasions where the risk is being imparted by soil and groundwater constituents that the Navy contends are the naturally occurring. It was generally agreed that the review presently being completed by EPA for the OU 3/5 RFI report will address the issue of background in detail since it appears that it will be of critical importance for those units. A final disposition of the comments contained herein regarding background will be deferred until such time as the OU 3/5 situation is resolved.

Comment

B. SWMU 6/AOC B

The Navy must revise the risk assessment to address concerns identified in Comment #2, e and f of EPA's April 25, 1997 letter. Concerns were presented regarding the potential exposure of future residents and current workers to accumulated/standing water in Building 145 (where mercury was measured at a concentration of 22 ug/l). The Navy must quantitatively assess risks to on-site workers and future residents through ***accidental ingestion and dermal contact, to standing water in*** *Building 145 and add the risks calculated for these exposures to the other exposure risks at AOC B. If unacceptable potential risk is indicated, a remedial work plan for cleanup operations must be submitted prior to initiating on-site work. This issue must be addressed before the recommendation of no further action at this site can be evaluated.*

Response

Attachment 5 to this response document contains the results of the requested risk assessment. The conclusions reached indicate that the risk posed by the "standing water" in Building 145 does not change significantly the conclusions of the original assessment. There are unacceptable risks to future residents when the various risks are summed. There is a slight risk to on-site workers posed primarily by the surface soil (of which 26% comes from beryllium which is attributed to natural occurrence). The HI for on-site workers remains below 1.

Based on the results of the newly performed risk assessments, it appears that the recommendation of "Institutional controls" in the form of a property use restriction is still applicable.

Comment

C. SWMU 26

The Navy must clearly demonstrate that the beryllium is due to native sources or the Navy must revise the risk assumptions for beryllium and/or the basis of closure for SWMU 26. The Navy has asserted that the concentrations of beryllium (and other elements) are likely the result of background conditions. Beryllium is present in SWMU 26 surface soils at concentrations that would pose an unacceptable increased risk to future residents. This SWMU is located in an area which, according to text on page 2-14, may be used for base housing at some future point. If the Navy cannot demonstrate the beryllium is naturally occurring, then, assuming otherwise valid risk assumptions for beryllium and other identified contaminants, the no action alternative for SWMU 26 will be unacceptable.

The no action approach to SWMU 26 is based in part on the assumption of background conditions. This assumption appears to be inappropriate for two primary reasons. First, the background data set developed for arsenic and beryllium for SWMU 26 may not be valid. Ten different SVOCs were detected in both surface and subsurface background soil samples at SWMU 26, which suggests that *soil in this area was impacted by anthropogenic activity and may not be representative of naturally occurring conditions for SVOCs. By extension, the concentrations of other constituents may have been impacted by anthropogenic activity. Second, the maximum detected concentration of beryllium detected in both surface and subsurface background soil samples for SWMU 26 is 1,200 ug/kg. This is over 3 times greater than the concentration of beryllium in the site-wide surface soil background database (360 ug/kg) and over 1.5 times greater than the sitewide subsurface soil background concentration (740 ug/kg). This data suggests that the SWMU 26 "background" levels are elevated and are not representative of native, mineralogically derived beryllium.*

__Response__

The site-wide background referred to in the comment was developed at a location three or four miles from SWMU 26. SWMU 26 is the only SWMU in the "Bundy Area". The most recent investigations at this site included the development of site-specific background to address the difference in background across the base especially in what is a potentially rapidly changing area of soil conditions given their varying volcanic source rocks. The comment would appear to imply that the presence of even one non-naturally occurring organic in the background database is sufficient to nullify the entire database. Organics, particularly semi-volatiles are ubiquitous in the environment especially one that has an urban setting as does Roosevelt Roads. Their presence should not be a surprise at low levels and should not negate the entire background database.

Recent discussions with the EPA (primarily during the November 4, 1998 JIG conference call) allowed the Navy to express some of its concern regarding the whole question of background and how it is to be utilized at the site. It is the opinion of the EPA that a "risk-based" approach is the one of choice for most of the sites. While this is apparently applicable in many cases, there still are the occasions where the risk is being imparted by soil and groundwater constituents that the Navy contends are the naturally occurring. It was generally agreed that the review presently being completed by EPA for the OU 3/5 RFI report will address the issue of background in detail since it appears that it will be of critical importance for those units. A final disposition of the comments contained herein regarding background will be deferred until such time as the OU 3/5 situation is resolved.

__Comment__

The second element of the Navy's no action approach is the assumption that the area will not be used for residential housing. However, text concerning SWMU 26 on page 2-14, paragraph 2 contradicts this assumption by indicating this area could be used for a base housing expansion in the future.

__Response__

The Navy, at this time, would like to reuse the site with no conditions. This could include its use as residential property in the future. Therefore, the Navy desires that no property use restriction be placed on the SWMU. While this is the case, the Navy reserves its right to reverse this decision in the future should it become in the best interest of the Navy.

Comment

D. SWMU 31

Dioxin was detected at concentrations in soil samples collected from SWMU 31 which exceeded EPA's risk-based acceptable concentration range for on-site workers. Although the Navy recommends an industrial land-use restriction on the SWMU to protect future residents from exposure, this land-use restriction does not protect current workers. According to the health and safety plan for this site, SWMU 31 is an area of "intense vehicular activity" and easily accessed by base personnel. Vehicular activity may disturb "hard packed" areas generating significant amounts of dust potentially containing elevated levels of dioxin. Therefore current workers may be exposed to unacceptable levels of dioxin. The Navy must justify the no further action recommendation in the context of present use exposure scenarios. If the no action approach is not protective of current site workers, then 1) the no action assumptions must be revised, or 2) Health and Safety precautions including exposure monitoring, must be implemented to protect current site workers.

Response

A Corrective Measures Study for this site has been mandated by the EPA the outline for which is attached to this response document.

Comment

E. AOC D

The Navy's no further action recommendation for AOC D is not acceptable since Phase I sediment sampling results indicate that sediments present a potentially unacceptable risk to recreational users and future residents. The Navy must summarize these risks in Section 4.8 and indicate that conclusions regarding these risks are valid and are not modified by the Phase II sample results. The Navy must also provide recommendations for mitigating recreational user and future resident exposure to AOC D sediments.

Response

A review of the original risk assessment for AOC D indicated that the primary risks were coming from two areas: the three sediment samples taken in Puerca Bay (SWMU 11/45) at the end of the cooling water tunnel, and the sediment samples associated with SWMU 2.

The SWMU 11/45 samples should not have been included in the database since they are not a part of the Ensenada Honda sediments. Also, the area of Puerca Bay near the tunnel has been investigated through sediment sampling since the original investigations that the risk assessment addressed. The results of this sampling, and subsequent risk assessment performed for Puerca Bay, indicated that a problem with the sediments was present and that finding triggered the recommendation that a CMS be performed for the sediments. Based on this, the three samples from Puerca Bay were deleted from the AOC D database.

The sediments at SWMU 2 also contributed significantly to risk at AOC D. These near shore sediments are likely to have been impacted by erosion of the SWMU 2 soil. This being the case, it is the Navy's technical opinion that the SWMU 2 sediments should be addressed along with the SWMU and that any CMS for SWMU 2 (should one be required at some time in the future) will include the sediments. On this basis, the sediment sampling results from SWMU 2 were also deleted from the AOC D database.

A new risk assessment was performed for AOC D using all the original data with the exception of that from SWMU 11/45 and SWMU 2. The results of the new assessment are provided in Attachment 6 to this document. The findings indicate that there are no unacceptable risks posed by the AOC D sediments.

Comment

3. *Unacceptable risk based levels of dioxin compounds have been identified at various sites at NSRR during the RFI. The identification of dioxin compounds at certain sites (i.e. SWMU 1, 2, and 31, and AOC D) does not inherently correspond to the site specific uses. A separate source of dioxins appears to have entrained dioxin contaminants into the air pathway, depositing contaminants at various locations at the site. Two possibilities should be considered:*

   1). *Dioxin compounds may be present on-site at areas not yet discovered or sampled for dioxins (i.e. areas of air borne deposition or secondary deposition from runoff such as AOC D). This may have resulted in a more widespread and as of yet uncharacterized areas of dioxin contamination at NSRR.*

   2). *If a dioxin source is identified on-site as causing air borne contamination, the impact area could be addressed as a separate segregated site. Certain sites within the dioxin site could potentially be "closed", if a level of no significant risk was demonstrated for the remaining site specific contaminants of concern and the site use history did not support dioxin contamination.*

The Navy must complete a study to investigate dioxin contamination detected across NSRR. All dioxin data for NSRR should be correlated to identify a potential source for dioxins and the potential migration pathways. A workplan should be prepared to address any data gaps identified by EPA prior to implementation.

Response

Attachment 7 to this document contains tables showing all the dioxin detections and a base map indicating where all the dioxin hits occurred.

A review of the base map indicates that there is certainly no clear, point source for the dioxins which have been found on the base. Its presence in one of the background samples would appear to give some indication that at least some of the dioxins are imported from off-site. The occurrence of dioxins appears to be concentrated in the "industrial horseshoe" that comprises the area around the harbor. This is quite possibly misleading though since that area also correlates to the area of most intensive sampling and analysis for dioxin.

Dioxins are found commonly at low levels in most industrialized areas. Attachment 8 contains some information from NIOSH regarding the derivation of dioxin. A review of this document indicates that the likely source of the dioxin found at Roosevelt Roads is from the historic use of herbicides to control growth along roads, fence lines, and areas of intensive use. It is also quite possible that herbicides were extensively used off the base in surrounding farms, municipalities, and industries. This likely potential source for the dioxin would appear to fit well with the occurrence pattern of the sampling results, namely, dioxins are found in the utilized portion of the base at the low levels that would be expected to be seen given the fact that dioxins are a contaminant in certain herbicides.

The Navy strongly opposes the idea of a base-wide dioxin sampling program based on the following three reasons:

1. <u>The ubiquitous nature of dioxins in industrialized settings.</u> Dioxins are ubiquitous in industrial areas, especially those where past use of herbicides has been made, such as that found near the harbor at Roosevelt Roads. The extremely low risk values for these compounds cause there to be a calculated unacceptable risk for practically any detection without the need for any additional contaminants to be associated with the dioxin.

2. <u>The ability to remediate dioxins is limited and problematic.</u> The only effective means of dioxin destruction is incineration. There are some other remedial approaches that have shown promise but these are not proven technologies and, for the most part, are designed to reduce dioxin concentrations leaving behind residual dioxins that are above the levels that have been detected at Roosevelt Roads. To remove large amounts of soil from the base and send it off-island for incineration would entail astronomical costs and damage to the ecology.

3. <u>The cost of any meaningful dioxin investigation would be extreme and would not provide a benefit commensurate with the expenditure.</u> There are 33,500 acres which comprise the contiguous Roosevelt Roads Naval Station. Assuming a sampling density of one sample per 50 acres (which is not in any way a sufficient number of samples to provide a representative database for the Station) and a cost of approximately $500 per sample in only analytical and validation costs, the total would be $335,000. To this cost must be added the costs for sampling , data evaluation, risk assessment, and reporting which will easily drive the total cost to $500,000 - and this if for an insufficient sampling program.

   Assuming for a moment that the investigation were performed, a CMS would be required since there will undoubtedly be risks associated with the lows levels of dioxin expected to be found. The expected result of the CMS is that no remediation will be required based on the cost benefit analysis of risk reduction to remediation costs. This is especially true when the damage to the environment and possible releases during transport are factored into the equation.

Based on the information discussed above, the Navy respectfully requests that the EPA reconsider their request for a base-wide dioxin sampling program.

Comment

4.0 PAGE SPECIFIC COMMENTS

Page 2-2, Section 2.1.2.1 Paragraph 3 and 5 and Page 2-3, Section 2.1.2.3, Paragraph 3

The Navy states that "... three semivolatile organic compounds ... were detected in [background surface soil] sample BGMW01-00" (see Table 2-3) and "Trace concentrations of organic compounds... were detected in the background subsurface soil sample set as shown in Table 24". The presence of xylene, PAHs, total HxCDD and 2,4,5-T in the site-wide background data set is a strong indication that the results are not representative of natural conditions. All samples with detected organics must be eliminated from the organic compound background data set. This will result in an organic background data set of three surface soil samples and three subsurface soil samples. Average background levels must be recalculated and conclusions regarding risk must be revised.

Response

See responses to previous comments related to background.

Comment

Page 2-14, Section 2.5.1, Paragraph 5

The Navy has not demonstrated that "...the concentrations (of arsenic and beryllium) are likely the result of background conditions..." at SWMU 26. First, the background data set developed for arsenic and beryllium for SWMU 26 may not be valid. Ten different SVOCs were detected in both surface and subsurface background soil samples at SWMU 26, which suggests that soil in this area was impacted by anthropogenic activity and may not be representative of naturally occurring conditions for SVOCs. By extension, the concentrations of other constituents may have been impacted by anthropogenic activity. Second, the maximum detected concentration of beryllium detected in both surface and subsurface background soil samples for SWMU 26 is 1,200 ug/kg. This is over 3 times greater than the concentration of beryllium in the site-wide surface soil background database (360 ug/kg) and over 1.5 times greater than the site-wide subsurface soil background concentration (740 ug/kg). This data suggests that the SWMU 26 "background" levels are elevated and are not representative of native, mineralogically derived beryllium. If the Navy cannot demonstrate that the beryllium is naturally occurring, then, assuming otherwise valid risk assumptions for beryllium and other identified contaminants, the no action alternative for SWMU 26 will be unacceptable.

Response

See responses to previous comments related to background.

Comment

In addition, with regard to the no further action approach advanced by the Navy for SWMU 26, beryllium is present in surface soils at concentrations posing potentially unacceptable increased risk to future residents. The no action approach relied on the assumption that no residents would be present in the future. However, this SWMU is located at an area which, according to text on page 2-14, may be used for base housing at some future point.

The Navy must clearly demonstrate that the beryllium is due to native sources and must revise the risk assumptions for beryllium and/or the basis of closure for SWMU 26.

<u>Response</u>

See responses to previous comments related to background.

<u>Comment</u>

<u>Page 2-20, Section 2.7.2, Paragraph 1</u>

The text states that samples ACSS39 through ACSS41 were inadvertently labeled SWMU AOC C instead of SWMU 46. No analytical data for these samples are presented in Table 2-31, Table 2-36, or Appendix D. The analytical data from these samples should be included.

<u>Response</u>

The analytical data for samples ACSS39 through ACSS41 can be found on Table 2-31 at the bottom of the first page. Table 2-36 is in reference to AOC C and the sample results therefore do not belong in Table 2-36 as the text in Section 2.7.2 described. These three samples (ACSS39 through ACSS41) are from SWMU 46. Appendix D does present the data for the three samples in question. They can be found on the table labeled Appendix D.20.

<u>Comment</u>

<u>Page 2-21, Section 2.7.3.1 and Figure 2-13</u>

The extent of PCB contamination at SWMU 46 and AOC C has not been adequately delineated and must be delineated via further surface and subsurface soil sampling. Figure 2-0 illustrates an increase in PCB levels in soil at the location of soil sample AC-SS27. This increase in PCB levels reflects an increase in contaminant levels at the perimeter of the site. Additional samples should be collected to delineate the extent of PCB contamination.

<u>Response</u>

It is the intent to provide for additional site characterization during the remediation of the site soils. Attached to this comment response document is an outline for the CMS which will be performed for the site. The outline contains provisions for pre-soil removal sampling in those areas where the extent of soil requiring removal is not definitively known.

<u>Comment</u>

<u>Page 2-23, Section 2.8.2, Paragraph 1 & 2</u>

The text should report on the wipe sampling, conducted at SWMU AOC C. Analytical results presented in Appendix D indicate that Aroclor 1260 was detected in several samples at a maximum concentration of 130,000,000 mg/wipe. The significance of the results must be discussed.

<u>Response</u>

The results of the wipe samples were discussed in the July 1996 RFI report. No additional wipe sampling was performed. The pads will be addressed by the CMS which will be performed for this site. An outline for this program is attached to this comment response document.

Comment

Page 3-2, Section 3.1.1, Paragraph 2

The identification and selection of chemicals of potential concern (COPCs) must consider chemicals for which there are no toxicity criteria or EPA Region III screening values. The detected concentrations of such chemicals must be carried through the risk assessment and addressed qualitatively in the risk characterization and uncertainty sections of the risk assessment text. For example, methapynilene was detected in a SWMU 6 subsurface soil sample at a concentration of 930 ug/kg. Although no Risk Based Concentrations (RBCs) are established for this constituent, the chemical must be carried through the risk assessment.

Response

Those chemicals detected for which no toxicity criteria exist will be identified and will be qualitatively carried throughout the risk assessment. The resulting uncertainties as to whether quantitative risks are over- or underestimated as a result of the presence of such constituents will also be addressed. This will be included in the final document.

Comment

Page 3-6, Paragraph 3 & 4

Total, rather than dissolved, inorganic results must be quantitatively evaluated in the human risk assessment. It is not appropriate to assume concentrations from dissolved samples more closely approximate exposure conditions at the tap, when the actual characteristics of a possible future water supply are unknown. The Navy must revise the quantitative risk assessment to include total inorganic results.

Response

It has been an accepted practice, by Region II, on all past NSRR risk assessments to evaluate and retain both total and dissolved inorganics as groundwater COPCs; however, in the Exposure Assessment, the tap water pathways for total inorganics are logically eliminated since the amount of sedimentation from turbidity observed in the samples is never representative of conditions at the tap. It is more logical to evaluate exposures to total inorganics in groundwater under, e.g., construction worker scenarios, where shallow groundwater may be encountered during excavation.

Comment

Page 3-6, SWMU 06/AOC B

For clarity, the text should summarize subsurface soil analysis results and indicate that all detections were below applicable residential RBC's. The detection of methapyrilene should be presented and the potential increased risk, if any, posed by this chemical should be qualitatively addressed in the uncertainty and risk characterizations sections. Methapyrilene should not be eliminated from consideration simply because a toxicity value does not exist.

Response

A subsection discussing the organics (2-sec-butyl-4,6-dinitrophenol and methapyrilene) and inorganics detections in subsurface soil and the non-exceedence of existing RBCs will be provided for SWMU 6/AOC B in the final report. See response to comment made on Page 3-2, Section 3.1.1, Paragraph 2 regarding methapyrilene issue.

Comment

Page 3-13, Paragraphs 3 and 4

In Phase II, additional sediment samples were collected from two locations at AOC D that were not sampled during Phase I. The results of these two new samples indicate the presence of chemicals at concentrations less than or equal to that detected in Phase I samples. The text should clarify that Phase II results were collected at new locations and should not be considered duplicate results of samples collected during Phase I. The comparison of the Phase I data to the Phase II data "in lieu of a risk assessment" is potentially misleading, and may cause the reader to infer that the Phase II data supersedes the Phase I data. The text must clearly indicate that the risks estimated during the Phase I HEA are still valid.

Response

Additional clarification will be added to the text when the report is eventually finalized. The content of the comment indicates that the reviewer has a correct understanding of the additional sampling.

Comment

Page 3-23, Paragraph 3 and Page 3-53, Paragraph 2

The statement "The area will not be developed for personnel housing, in the future.." is inconsistent with page 2-14, paragraph 2, the text of which states, "The Building 544 Area is located within the "Bundy" portion of the station. Bundy is a primary location for bachelor's quarters and, therefore, it is possible that the Building 544 Area could be used for base housing expansion at some point in the future." The text must be revised since residential development is possible.

Response

The cited portion of the text is correct at this time. The Navy's intent is to have the site available for all possible uses. Depending on the final disposition of the site, this language may have to be revised (or that of the other referenced text) in the final document.

Comment

Page 3-31, Paragraph 2

The Navy's derivation of the particulate emission factor (PEF) should be provided since it differs from EPA's Human Health Evaluation Manual, Development of Risk-Based Preliminary Remediation Goals (Part B), dated December 1991 (6.79 x 10^9 m^3/kg vs. 4.63 x 10^3 mg/kg.

Response

The PEF value of 1.32 x 10^9 m^3/kg used in this risk assessment is an updated USEPA default value that was obtained from USEPA's Soil Screening Guidance (1996).

Comment

Page 3-48, Section 3.6.3, Paragraph 3

The reference to the 1989 Exposure Factors Handbook should be updated to EPA's Exposure Factors Handbook (EPA/600/P-95/002Fa), dated August 1997.

<u>Response</u>

The cited reference for the Exposure Factors Handbook will be modified in the final report to reflect the updated document number and publication date of EPA/600/P-95/002Fa and August 1997, respectively.

<u>Comment</u>

<u>Tables 3-16, 3-17 and Appendix O</u>

The guidance referenced by the Navy for the exposure input parameters for inhalation of contaminated air states that "... 20 m^3 per 8-hour workday represents a reasonable upper-bound inhalation rate for the occupational setting". The Navy, however, is using input parameters for respiration rate and exposure time which result in an inhalation rate of 10m^3 per 8-hour workday. The input parameters for respiration rate and exposure time must be changed to reflect an inhalation rate of 20 m^3 per 8-hour workday for current on-site workers and future construction workers.

<u>Response</u>

The inhalation rate will be changed as noted in the final edition of the report. It should be noted that this modification is not significant enough to change the outcome of the risk assessment results.

<u>Comment</u>

<u>Page 4-3, Section 4.3. Paragraph 1</u>

The streamlined CMS proposed for SWMU 13 will be considered incomplete until an ecological assessment demonstrates that a condition of no unacceptable risk to the environment has been achieved.

<u>Response</u>

It is the purpose of the CMS to address the contamination that represents a complete risk pathway (the sediments in the drainage ditch). Once the Corrective Measure is completed, the risk will be reduced below unacceptable levels.

<u>Comment</u>

<u>Page 4-4, Paragraph 6 and Page 4-5, Paragraph 4</u>

In order to support a no further action at SWMU 46 and AOC C a reliable background data set must be used. Based on the detection of organics, the CMS for SWMU 46 and AOC C must address elevated levels of arsenic and beryllium. The current background data set does not appear to adequately represent natural soil conditions.

<u>Response</u>

See responses to previous comments related to risk.

<u>Comment</u>

<u>Page 4-5, Section 4.6 and 4.7</u>

The additional proposed investigation activities must be documented in a work plan addendum and submitted for review.

Response

An outline for the conduct of a CMS at the combined sites AOC C/SWMU 46 is attached to this document. The outline contains provisions for additional sampling during the corrective measure to address those areas requiring further delineation of contamination.

Comment

Page 4-6, Section 4.8

The no further action recommendation for AOC D sediments is not consistent with the Phase I HEA which stated that AOC D sediments pose potentially unacceptable risks to recreational users and future residents. The Navy must summarize these risks in Section 4.8 and state that conclusions regarding these risks are still valid and must re-evaluate the no further action recommendation. Recommendations for mitigating recreational user and future resident exposure to AOC D sediments must be provided.

Response

See comment response to "General Comment-2.E

Comment

5.0 EDITORIAL COMMENTS

Table 2-43

Results presented in Table 2-43 need to be cross-checked with analytical results in Appendix D and revised as appropriate. The data presented in Table 2-43 are not consistent with corresponding data contained in Appendix D.

Response

The tables will be cross-checked with the appendix for the final document to be prepared once all issues are resolved.

Comment

Figure 2-3

Sample identifiers BGW02-03 and BGW02-04 should be labeled BMW-02-03 and BMW-02-04 for consistency with sample identifiers in Table 2-10 and Section 2.

Response

The designations on the figure will be altered as needed during final report preparation.

Comment

Page 3-5, Paragraph 3

Although TPH concentrations do not exceed Puerto Rico Environmental Quality Board (PREQB) criteria, the Navy's statement "... due to a lack of toxicity criteria, TPH was not evaluated in the selection of COPCs, nor was it evaluated in the risk assessment" must be revised to avoid future misunderstanding. Any detected levels of TPH must be evaluated and concentrations which exceed PREQB criteria must be addressed in the risk characterization section.

Response

The text will be altered in accordance with the comment for the final report.

Comment

Table 2-43

The summary columns on page 4 of 4 must be revised. The summary columns indicate that 33 sample results were included in the data evaluation; however, results from only 27 samples are presented on pages 1 through 3 of Table 2-43.

Response

The table will be revised as needed for the final report.

Comment

Page 3-9, Paragraph 1 (SWMU 46) and Table 3-5

The number of soil samples presented in the text and Table 3-5 is inconsistent with the number of soil samples presented in Section 2.0 and Table 2- 5 and must be revised as appropriate.

Response

Appropriate revisions will be made for the final report.

Comment

Page 3-10, Paragraph 5

The number of soil samples presented in the text and Table 3-27 is inconsistent with the number of samples presented in Section 2.0 and Tables 2-36 and 2-37 and should be revised as appropriate. The text and Table 3-7 indicate that 29 surface soil samples were collected; however, Section 2.0 text and corresponding Tables 2-36 and 2-37 list 26 soil samples.

Response

Appropriate revisions will be made for the final report.

Comment

Table 3-4

The RBC's listed for total TCDF on this table are incorrect and must be revised.

Response

The values were correct when the report was submitted; however, they have been updated since that time. Correct values will be used in the final report.

Comment

Table 3-11

Table 3-11 indicates that no dioxin data was generated in Phase II. Since this is incorrect, the table must be revised.

Response

The table will be revised for the final report.

Comment

Page 4-1, Section 4.0, Paragraph 1

The text should summarize estimated risks and subsequent conclusions and recommendations generated during the Phase I HEA.

Response

The final report will contain the summary requested in the comment.

Should you have any questions or desire further clarification of any of the points discussed, please do not hesitate to call me at (412) 269-2065 or Mr. Christopher T. Penny, the Navy Technical Representative at (757) 322-4815.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Thomas C. Fuller
Activity Coordinator

TCF/lq

cc: Mr. Christopher T. Penny, Code 1823 - LANTDIV
Ms. Madeline Rivera, NSRR
Mr. Isreal Torres - EQB
Ms. Luz A. Muriel Diaz - EQB
Mr. Tim Gordon - US EPA Region II

ATTACHMENT 1
SWMU 13 CMS OUTLINE

Corrective Measures Study
for a
Presumptive Remedy
Solid Waste Management Unit 13
Naval Station Roosevelt Roads
Annotated Outline

The purpose of this annotated outline is to provide the framework for a streamlined Corrective Measures Study (CMS) at SWMU 13 which is a former pesticide management area.

1.0 Introduction

Section designed to introduce the reader to the site and the intent of the CMS.

1.1 Regulatory framework

This section will provide a synopsis of how the project has proceeded from initial identification through investigation and now to corrective action. A brief explanation of the overall RCRA process will be included. It is the intent of this section to provide a person who is unfamiliar with the site a reasonable understanding of the process and at what stage SWMU 13 is.

1.2 Intent of the Presumptive Remedy CMS

The "normal" CMS process will be briefly described. It will be explained that, based on the results of the investigation, only one environmental media at the site (the drainage ditch sediments) has been significantly impacted based on an analysis of risks. Since the scope of corrective measures required is limited and there are very few technologies that are appropriate, a remedy has been selected without the formal CMS process that will allow site clean-up to proceed with the greatest amount of speed.

1.3 Goals of the Corrective Measure Process

Very brief section which will establish the objective of the program (to effect clean-up of the ditch sediments at SWMU 13) and the goals of the remedy (to reduce contaminant levels to a point at or below the clean-up levels established in this document).

1.4 Organization of the Report

Will provide a description of the report's organization which will make navigating through the report easier.

2.0 Description of Current Conditions

This section will provide information related to the results of the RFI activities at the site.

2.1 General Site Description

SWMU 13 will be described in this section. Included will be a site location map and a SWMU map. The history of site usage will be briefly discussed.

2.2 Summary of Site Conditions

2.2.1 Investigation History

The various stages of site investigation will be detailed. This will include work done before the permit and all the RFI activities. Pertinent reports will be referenced.

2.2.2 Site Conditions

The results of the investigations will be discussed here. Each individual sampling program will not be detailed rather, a summary of current conditions will be provided. Maximum use will be made of tables and figures to provide the summary. It is expected that the tables and figures will be available from previous reports.

3.0 Establishment of Corrective Action Objectives

This section will evaluate the results of the baseline human health risk assessment and determine the remediation goals for the drainage ditch sediments at SWMU 13.

3.1 Identification of Media of Concern/Contaminants of Concern (COCs) as Determined by the Human Health Risk Assessment

This section will identify the media of concern and COCs for SWMU 13 with respect to the human health risk assessment developed in the RCRA Facility Investigation.

3.2 Exposure Routes and Receptors

This section will identify the potential exposure pathways and human receptors that are applicable in determining risk-based preliminary remediation goals.

3.3 Remediation Goal Options and Remediation Levels

3.3.1 Pertinent Regulatory Criteria

This section will present remediation goal options in the form of applicable Puerto Rico and federal criteria.

3.3.2 Human Health Risk-Based Preliminary Remediation Goals

This section will provide details on the process whereby risk-based preliminary remediation goals for the COCs are developed.

3.3.2.1 Risk Assessment Evaluation

This section will present a brief summary of the risk assessment methodology employed in determining preliminary remediation goals.

3.3.2.2 Summary of Site-Specific Risk-Based Remediation Goals

This section will summarize the risk-based remediation goals developed for the COCs.

3.3.2.3 Comparison of Risk-Based Remediation Goals to Maximum Contaminant Concentrations

This section will compare the risk-based remediation goals to the maximum detected concentrations of the COCs.

3.3.3 Summary of Final Remediation Goals and COCs

This section will present the final remediation goals for the COCs at SWMU 13.

4.0 Recommendation and Justification of the Presumptive Remedy

The presumptive remedy will be recommended and justified in this section of the report.

4.1 Description of the Remedy

The remedy selected will be removal of the drainage ditch sediments with disposal off-site. This approach will be briefly described - a more detailed conceptual design is provided for later in the report.

4.2 Justification of the Presumptive Remedy

The presumptive remedy will be justified based on technical, human health and environmental considerations.

4.2.1 Technical Considerations

The removal remedy selected will be technically justified in terms of its performance (removal is a permanent remedy), reliability (the reliability of removal actions can be demonstrated trough confirmatory testing), implementability (the selected method is implementable at the site based on the expected limited volume of material and easy site access), and safety (there are minimal safety concerns with removal of the sediments).

4.2.2 Human Health Considerations

The clean-up goals established in the previous section will be based on human health risks. It will be indicated in this section that reaching the goals will assure that human health are reduced to acceptable levels.

4.2.3 Environmental Considerations

This section will discuss how removal of the sediments will provide the greatest improvement to the environment over the shortest possible time.

5.0 Technical Approach to the Presumptive Remedy

This section of the report will describe the elements that need to go into the presumptive remedy. Included will be a description of the various plans required, a conceptual design for the corrective measure, a description of the confirmatory sampling program which will be implemented following the initial clean-up, and a listing of the various reporting requirements.

5.1 Conceptual Design

The various parts of the conceptual design will be discussed in this section.

5.1.1 Design Considerations

Certain site conditions affect remedial approaches and their design. The various factors that are present at SWMU 13 will be discussed. These include site access, availability of off-site disposal, staging areas, minimization of site disturbance, etc.

5.1.2 Description of the Approach

The removal action proposed for SWMU 13 will be described in this section.

5.1.2.1 Technical Approach

This section will contain a narrative of the technical approach proposed for use at SWMU 13. Included will be a description of the equipment expected to be employed, containerization procedures for the removed sediments, the sampling program to be used to characterize the excavated sediments, decontamination of the equipment, and final site closure.

5.1.2.2 Required Planning Documents

Also included in this section will be a brief description of the work plans which will be required as a part of the remediation. These include the contractor's "Work Plan", the Environmental Protection Plan, the Accident and Analysis Plan, the Stormwater Pollution Prevention Plan, and the Health and Safety Plan.

5.1.3 Confirmatory Sampling Plan

The confirmatory sampling program to be employed to demonstrate that the removal action was effective in meeting the clean-up goals will be described in this section.

5.1.3.1 Sampling Approach

The sampling strategy to be employed will be described in this section. Included will be an estimated number of samples to be taken, the approximate location of sampling, and the parameters which will be analized.

5.1.3.2 Sampling and Analysis Procedures

The sampling methods will be described in this section. It is expected that the methods employed in the RFI will be incorporated by reference as has been done in the past.

The analytical methods to be used will be listed. The methods will be the same as those used during the various RFI field programs.

5.1.3.3 Quality Control/Quality Assurance Program

The Quality Assurance Project Plan employed in the RFI phase will be incorporated by reference as has been done in the past. Any points requiring updating will be detailed in this section.

5.1.3.4 Data Validation

The final confirmatory sampling data will be validated by a third party, independent, data validation firm. The Region II specfic data validation procedures will be used as has been done in the past.

5.2 Reporting

The various reports required for the presumptive remedy will be detailed in this section.

5.2.1 Corrective Measures Study

The report, for which this is the outline, will be prepared in draft and final form. It is expected that the final will be subjected to a public comment period before the EPA will approve the selected remedy.

5.2.2 Presumptive Remedy Design

Since the approach is straightforward, of relativly low technology, and is to be provided in conceptual form in the report referenced in Section 5.2.2, it is anticipated that only a draft and final design will be required. This wiil provide the details of how the remediation will be undertaken.

5.2.3 Project Close-out Report

The project close-out report will contain a description of the remedial activities performed, an estimate of the quantity of sediments removed, a discuusion of the disposition of the sediments removed and all the results of the confirmatory sampling.

Interim reporting of remediation activities will be provided in the RCRA quqrterly progress reports already being programmatically being prepared on a regular basis.

ATTACHMENT 2
SWMU 46/AOC C CMS OUTLINE

Corrective Measures Study
for a
Presumptive Remedy
Solid Waste Management Unit 46/Area of Concern C
Naval Station Roosevelt Roads
Annotated Outline

The purpose of this annotated outline is to provide the framework for a streamlined Corrective Measures Study (CMS) at SWMU 46/AOC C which is the area where the Base transformers were stored and where now the Base Operating Support contractor has his "under 90-day" storage area.

1.0 Introduction

Section designed to introduce the reader to the site and the intent of the CMS.

1.1 Regulatory framework

This section will provide a synopsis of how the project has proceeded from initial identification through investigation and now to corrective action. A brief explanation of the overall RCRA process will be included. It is the intent of this section to provide a person who is unfamiliar with the site a reasonable understanding of the process and at what stage SWMU 46/AOC C is.

1.2 Intent of the Presumptive Remedy CMS

The "normal" CMS process will be briefly described. It will be explained that, based on the results of the investigation, only one environmental media at the site (the surface and subsurface soils) has been significantly impacted based on an analysis of risks. Since the scope of corrective measures required is limited and there are very few technologies that are appropriate, a remedy has been selected without the formal CMS process that will allow site clean-up to proceed with the greatest amount of speed.

1.3 Goals of the Corrective Measure Process

Very brief section which will establish the objective of the program (to effect clean-up of the surface and subsurface soils SWMU 46/AOC C) and the goals of the remedy (to reduce contaminant levels to a point at or below the clean-up levels established in this document).

1.4 Organization of the Report

Will provide a description of the report's organization which will make navigating through the report easier.

2.0 Description of Current Conditions

This section will provide information related to the results of the RFI activities at the site.

2.1 General Site Description

SWMU 46/AOC C will be described in this section. Included will be a site location map and a SWMU map. The history of site usage will be briefly discussed.

2.2 Summary of Site Conditions

2.2.1 Investigation History

The various stages of site investigation will be detailed. This will include work done before the permit and all the RFI activities. Pertinent reports will be referenced.

2.2.2 Site Conditions

The results of the investigations will be discussed here. Each individual sampling program will not be detailed rather, a summary of current conditions will be provided. Maximum use will be made of tables and figures to provide the summary. It is expected that the tables and figures will be available from previous reports.

3.0 Establishment of Corrective Action Objectives

Two previous clean-ups of PCB contaminated surface and subsurface soils have been performed at Roosevelt Roads. The close-out reports for these projects have been approved. As a part of this work, acceptable clean-up levels for PCBs have been established. It is the intent that the previously established values will be used for this site. Based on this, the "normal" steps undertaken to derive clean-up goals are not necessary.

4.0 Recommendation and Justification of the Presumptive Remedy

The presumptive remedy will be recommended and justified in this section of the report.

4.1 Description of the Remedy

The remedy selected will be removal of the surface and subsurface soils with disposal off-site. This approach will be briefly described - a more detailed conceptual design is provided for later in the report.

4.2 Justification of the Presumptive Remedy

The presumptive remedy will be justified based on technical, human health and environmental considerations.

4.2.1 Technical Considerations

The removal remedy selected will be technically justified in terms of its performance (removal is a permanent remedy), reliability (the reliability of removal actions can be demonstrated trough confirmatory testing), implementability (the selected method is implementable at the site based on the expected limited volume of material and easy site access), and safety (there are minimal safety concerns with removal of the surface and subsurface soils).

4.2.2 Human Health Considerations

The clean-up goals established in the previous work have taken into account human health risks. It will be indicated in this section that reaching the goals will assure that human health are reduced to acceptable levels.

4.2.3 Environmental Considerations

This section will discuss how removal of the surface and subsurface soils will provide the greatest improvement to the environment over the shortest possible time.

5.0 Technical Approach to the Presumptive Remedy

This section of the report will describe the elements that need to go into the presumptive remedy. Included will be a description of the various plans required, a conceptual design for the corrective measure, a description of the confirmatory sampling program which will be implemented following the initial clean-up, and a listing of the various reporting requirements.

5.1 Conceptual Design

The various parts of the conceptual design will be discussed in this section.

5.1.1 Design Considerations

Certain site conditions affect remedial approaches and their design. The various factors that are present at SWMU 46/AOC C will be discussed. These include site access, availability of off-site disposal, staging areas, minimization of site disturbance, etc.

5.1.2 Description of the Approach

The removal action proposed for SWMU 46/AOC C will be described in this section.

5.1.2.1 Additional Site Sampling

The additional site sampling required to fully define the extent of contamination present at levels exceeding the clean-up goals will be described in this section. Reliance will be placed on the approved RFI work plan for sampling and analytical methodologies.

5.1.2.2 Technical Approach

This section will contain a narrative of the technical approach proposed for use at SWMU 46/AOC C. Included will be a description of the equipment expected to be employed, containerization procedures for the removed surface and subsurface soils, the sampling program to be used to characterize the excavated surface and subsurface soils, decontamination of the equipment, and final site closure.

5.1.2.3 Required Planning Documents

Also included in this section will be a brief description of the work plans which will be required as a part of the remediation. These include the contractor's "Work Plan", the Environmental Protection Plan, the Accident and Analysis Plan, the Stormwater Pollution Prevention Plan, and the Health and Safety Plan.

5.1.3 Confirmatory Sampling Plan

The confirmatory sampling program to be employed to demonstrate that the removal action was effective in meeting the clean-up goals will be described in this section.

5.1.3.1 Sampling Approach

The sampling strategy to be employed will be described in this section. Included will be an estimated number of samples to be taken, the approximate location of sampling, and the parameters which will be analized.

5.1.3.2 Sampling and Analysis Procedures

The sampling methods will be described in this section. It is expected that the methods employed in the RFI will be incorporated by reference as has been done in the past.

The analytical methods to be used will be listed. The methods will be the same as those used during the various RFI field programs.

5.1.3.3 Quality Control/Quality Assurance Program

The Quality Assurance Project Plan employed in the RFI phase will be incorporated by reference as has been done in the past. Any points requiring updating will be detailed in this section.

5.1.3.4 Data Validation

The final confirmatory sampling data will be validated by a third party, independent, data validation firm. The Region II specfic data validation procedures will be used as has been done in the past.

5.2 Reporting

The various reports required for the presumptive remedy will be detailed in this section.

5.2.1 Corrective Measures Study

The report, for which this is the outline, will be prepared in draft and final form. It is expected that the final will be subjected to a public comment period before the EPA will approve the selected remedy.

5.2.2 Presumptive Remedy Design

Since the approach is straightforward, of relativly low technology, and is to be provided in conceptual form in the report referenced in Section 5.2.1, it is anticipated that only a draft and final design will be required. This will provide the details of how the remediation will be undertaken.

5.2.3 Report on Additional Site Sampling

This report will contain the results of the additional site sampling that is required to delineate the extent of soil contamination present at levels above the clean-up goals.

5.2.4 Project Close-out Report

The project close-out report will contain a description of the remedial activities performed, an estimate of the quantity of surface and subsurface soil removed, a discussion of the disposition of the surface and subsurface soils removed and all the results of the confirmatory sampling.

Interim reporting of remediation activities will be provided in the RCRA quqrterly progress reports already being programmatically being prepared on a regular basis.

ATTACHMENT 3
SWMU 31/32 CMS OUTLINE

Corrective Measures Study
for a
Presumptive Remedy
Solid Waste Management Unit 31/32
Naval Station Roosevelt Roads
Annotated Outline

The purpose of this annotated outline is to provide the framework for a streamlined Corrective Measures Study (CMS) at SWMU 31/32 which is the area adjacent to Building 31 (Public Works) where various wastes were previously stored.

1.0 Introduction

Section designed to introduce the reader to the site and the intent of the CMS.

1.1 Regulatory framework

This section will provide a synopsis of how the project has proceeded from initial identification through investigation and now to corrective action. A brief explanation of the overall RCRA process will be included. It is the intent of this section to provide a person who is unfamiliar with the site a reasonable understanding of the process and at what stage SWMU 31/32 is.

1.2 Intent of the Presumptive Remedy CMS

The "normal" CMS process will be briefly described. It will be explained that, based on the results of the investigation, only one environmental media at the site (the surface soils) has been significantly impacted based on an analysis of risks. Since the scope of corrective measures required is limited and there are very few technologies that are appropriate, a remedy has been selected without the formal CMS process that will allow site clean-up to proceed with the greatest amount of speed.

1.3 Goals of the Corrective Measure Process

Very brief section which will establish the objective of the program (to effect clean-up of the surface soils SWMU 31/32) and the goals of the remedy (to reduce contaminant levels to a point at or below the clean-up levels established in this document).

1.4 Organization of the Report

Will provide a description of the report's organization which will make navigating through the report easier.

2.0 Description of Current Conditions

This section will provide information related to the results of the RFI activities at the site.

2.1 General Site Description

SWMU 31/32 will be described in this section. Included will be a site location map and a SWMU map. The history of site usage will be briefly discussed.

2.2 Summary of Site Conditions

2.2.1 Investigation History

The various stages of site investigation will be detailed. This will include work done before the permit and all the RFI activities. Pertinent reports will be referenced.

2.2.2 Site Conditions

The results of the investigations will be discussed here. Each individual sampling program will not be detailed rather, a summary of current conditions will be provided. Maximum use will be made of tables and figures to provide the summary. It is expected that the tables and figures will be available from previous reports.

3.0 Establishment of Corrective Action Objectives

This section will evaluate the results of the baseline human health risk assessment and determine the remediation goals for the surface soils at SWMU 31/32.

3.1 Identification of Media of Concern/Contaminants of Concern (COCs) as Determined by the Human Health Risk Assessment

This section will identify the media of concern and COCs for SWMU 31/32 with respect to the human health risk assessment developed in the RCRA Facility Investigation.

3.2 Exposure Routes and Receptors

This section will identify the potential exposure pathways and human receptors that are applicable in determining risk-based preliminary remediation goals.

3.3 Remediation Goal Options and Remediation Levels

3.3.1 Pertinent Regulatory Criteria

This section will present remediation goal options in the form of applicable Puerto Rico and federal criteria.

3.3.2 Human Health Risk-Based Preliminary Remediation Goals

This section will provide details on the process whereby risk-based preliminary remediation goals for the COCs are developed.

3.3.2.1 Risk Assessment Evaluation

This section will present a brief summary of the risk assessment methodology used in determining preliminary remediation goals.

3.3.2.2 **Summary of Site-Specific Risk-Based Remediation Goals**

This section will summarize the risk-based remediation goals developed for the COCs.

3.3.2.3 **Comparison of Risk-Based Remediation Goals to Maximum Contaminant Concentrations**

This section will compare the risk-based remediation goals to the maximum detected concentrations of the COCs.

3.3.3 Summary of Final Remediation Goals and COCs

This section will present the final remediation goals for the COCs at SWMU 31/32.

4.0 Recommendation and Justification of the Presumptive Remedy

The presumptive remedy will be recommended and justified in this section of the report.

4.1 Description of the Remedy

The remedy selected will be removal of the surface soils with disposal off-site. This approach will be briefly described - a more detailed conceptual design is provided for later in the report.

4.2 Justification of the Presumptive Remedy

The presumptive remedy will be justified based on technical, human health and environmental considerations.

4.2.1 Technical Considerations

The removal remedy selected will be technically justified in terms of its performance (removal is a permanent remedy), reliability (the reliability of removal actions can be demonstrated trough confirmatory testing), implementability (the selected method is implementable at the site based on the expected limited volume of material and easy site access), and safety (there are minimal safety concerns with removal of the surface soils).

4.2.2 Human Health Considerations

The clean-up goals established in the previous section will be based on human health risks. It will be indicated in this section that reaching the goals will assure that human health are reduced to acceptable levels.

4.2.3 Environmental Considerations

This section will discuss how removal of the surface soils will provide the greatest improvement to the environment over the shortest possible time.

5.0 Technical Approach of the Presumptive Remedy

This section of the report will describe the elements that need to go into the presumptive remedy. Included will be a description of the various plans required, a conceptual design for the corrective measure, a description of the confirmatory sampling program which will be implemented following the initial clean-up, and a listing of the various reporting requirements.

5.1 Conceptual Design

The various parts of the conceptual design will be discussed in this section.

5.1.1 Design Considerations

Certain site conditions affect remedial approaches and their design. The various factors that are present at SWMU 31/32 will be discussed. These include site access, availability of off-site disposal, staging areas, minimization of site disturbance, etc.

5.1.2 Description of the Approach

The removal action proposed for SWMU 31/32 will be described in this section.

5.1.2.1 Technical Approach

This section will contain a narrative of the technical approach proposed for use at SWMU 31/32. Included will be a description of the equipment expected to be employed, containerization procedures for the removed surface soils, the sampling program to be used to characterize the excavated surface soils, decontamination of the equipment, and final site closure.

5.1.2.2 Required Planning Documents

Also included in this section will be a brief description of the work plans which will be required as a part of the remediation. These include the contractor's "Work Plan", the Environmental Protection Plan, the Accident and Analysis Plan, the Stormwater Pollution Prevention Plan, and the Health and Safety Plan.

5.1.3 Confirmatory Sampling Plan

The confirmatory sampling program to be employed to demonstrate that the removal action was effective in meeting the clean-up goals will be described in this section.

5.1.3.1 Sampling Approach

The sampling strategy to be employed will be described in this section. Included will be an estimated number of samples to be taken, the approximate location of sampling, and the parameters which will be analized.

5.1.3.2 Sampling and Analysis Procedures

The sampling methods will be described in this section. It is expected that the methods employed in the RFI will be incorporated by reference as has been done in the past.

The analytical methods to be used will be listed. The methods will be the same as those used during the various RFI field programs.

5.1.3.3 Quality Control/Quality Assurance Program

The Quality Assurance Project Plan employed in the RFI phase will be incorporated by reference as has been done in the past. Any points requiring updating will be detailed in this section.

5.1.3.4 Data Validation

The final confirmatory sampling data will be validated by a third party, independent, data validation firm. The Region II specfic data validation procedures will be used as has been done in the past.

5.2 Reporting

The various reports required for the presumptive remedy will be detailed in this section.

5.2.1 Corrective Measures Study

The report, for which this is the outline, will be prepared in draft and final form. It is expected that the final will be subjected to a public comment period before the EPA will approve the selected remedy.

5.2.2 Presumptive Remedy Design

Since the approach is straightforward, of relativly low technology, and is to be provided in conceptual form in the report referenced in Section 5.2.1, it is anticipated that only a draft and final design will be required. This wiil provide the details of how the remediation will be undertaken.

5.2.3 Project Close-out Report

The project close-out report will contain a description of the remedial activities performed, an estimate of the quantity of surface soil removed, a discuusion of the disposition of the surface soils removed and all the results of the confirmatory sampling.

Interim reporting of remediation activities will be provided in the RCRA quqrterly progress reports already being programmatically being prepared on a regular basis.

ATTACHMENT 4
BACKGROUND SOILS INFORMATION

Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States

By HANSFORD T. SHACKLETTE *and* JOSEPHINE G. BOERNGEN

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1270

An account of the concentrations of 50 chemical elements in samples of soils and other regoliths

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1984

TABLE 1.—*Average or median contents, and range in contents, reported for elements in soils and other surficial materials*

[Data are in parts per million; each average represents arithmetic mean; leaders (—) in figure columns indicate no data available. A, average; M, median. <, less than; >, greater than]

Element	This report: Average	This report: Range	Rose, and others (1979) (elements useful in geochemical prospecting)	Vinogradov (1959) (presumably, averages from worldwide sampling)	Jackson (1964): "Typical",[1] average, or range in values	Mitchell (1964): Range in contents in Scottish surface soils	Brooks (1972): Average or range
Al	72,000	700 - <10,000	—	71,300	10,000 - 60,000	—	—
As	7.2	<0.1 - 97	7.5 (M)	5	—	—	5
B	33	<20 - 300	29 (M)	10	30	—	10
Ba	580	10 - 5,000	300 (M)	—	—	400 - 3,000	500
Be	.92	<1 - 15	0.5 - 4	6	—	<5 - 5	6
Br	.85	<0.5 - 11	—	5	—	—	—
C, total	25,000	600 - 370,000	—	20,000	—	—	—
Ca	24,000	100 - 320,000	—	13,700	7,000	—	—
Ce	75	<150 - 300	—	—	—	—	—
Co	9.1	<3 - 70	10 (M)	8	—	<2 - 80	10
Cr	54	1 - 2,000	6.3 (M)	200	—	5 - 3,000	200
Cu	25	<1 - 700	15 (M)	20	20	<10 - 100	20
F	430	<10 - 3,700	300 (M)	200	—	—	—
Fe	26,000	100 - >100,000	21,000 (M)	38,000	7,000 - 42,000		10,000 - 50,000
Ga	17	<5 - 70	—	30	—	15 - 70	20
Ge	1.2	<0.1 - 2.5	—	1	—	—	5
Hg	.09	<0.01 - 4.6	0.056 (M)	—	—	—	.01
I	1.2	<0.5 - 9.6	—	—	—	—	—
K	15,000	50 - 63,000	11,000 (M)	13,600	400 - 28,000	—	—
La	37	<30 - 200	—	—	—	<30 - 200	—
Li	24	<5 - 140	6.2 (M)	30	—	—	30
Mg	9,000	50 - >100,000	—	6,300	<6,000	—	—
Mn	550	<2 - 7,000	320 (M)	850	—	200 - 5,000	850
Mo	.97	<3 - 15	2.5 (A)	2	—	<1 - 5	2.5
Na	12,000	<500 - 100,000	—	6,300	—	—	—
Nb	11	<10 - 100	15 (A)	—	—	—	15
Nd	46	<70 - 300	—	—	—	—	—
Ni	19	<5 - 700	17 (M)	40	—	10 - 800	40
P	430	<20 - 6,800	300 (M)	800	500	—	—
Pb	19	<10 - 700	17 (M)	—	—	<20 - 80	10
Rb	67	<20 - 210	35 (M)	100	—	—	—
S, total	1,600	<800 - 48,000	100 - 2,000	850	—	—	—
Sb	.66	<1 - 8.8	2 (A)	—	—	—	.5
Sc	8.9	<5 - 50	—	7	—	<3 - 15	—
Se	.39	<0.1 - 4.3	0.31 (M)	.001	—	—	.5
Si	310,000	16,000 - 450,000	—	330,000	—	—	—
Sn	1.3	<0.1 - 10	10 (A)	—	—	—	10
Sr	240	<5 - 3,000	67 (M)	300	—	60 - 700	300
Ti	2,900	70 - 20,000	—	4,600	1,200 - 6,000	—	—
Th	9.4	2.2 - 31	—	—	—	—	13
U	2.7	0.29 - 11	1 (A)	—	—	—	1
V	80	<7 - 500	57 (M)	100	—	20 - 250	100
Y	25	<10 - 200	—	50	—	25 - 100	—
Yb	3.1	<1 - 50	—	—	—	—	—
Zn	60	<5 - 2,900	36 (M)	50	—	—	50
Zr	230	<20 - 2,000	270 (M)	300	—	200 - >1,000	—

[1]Author's usage; generally used to indicate the most commonly occurring value.

collected by U.S. Geological Survey personnel along their routes of travel to areas of other types of field studies or within their project areas.

The locations of the routes that were sampled depended on both the network of roads that existed and the destinations of the samplers. Sampling intensity was kept at a minimum by selecting only one sampling site every 80 km (about 50 miles; selected for convenience because vehicle odometers were calibrated in miles) along the routes. The specific sampling sites were selected, insofar as possible, that had surficial materials that were very little altered from their natural condition and that supported native plants suitable for sampling. In practice, this site selection necessitated sampling away from roadcuts and fills. In some areas, only cultivated fields and plants were available for sampling.

Contamination of the sampling sites by vehicular emissions was seemingly insignificant, even though many sites were within 100 m or less of the roads. Col-

1, unlike the geometric means shown in table 2, are estimates of geochemical abundance (Miesch, 1967). Arithmetic means are always larger than corresponding geometric means (Miesch, 1967, p. B1) and are estimates of the fractional part of a single specimen that consists of the element of concern rather than of the typical concentration of the element in a suite of samples.

Concentrations of 46 elements in samples of this study are presented in table 2, which gives the determination ratios, geometric-mean concentrations and deviations, and observed ranges in concentrations. The analytical data for most elements as received from the laboratories were transformed into logarithms because of the tendency for elements in natural materials, particularly the trace elements, to have positively skewed

TABLE 2.—*Mean concentrations, deviations, and ranges of elements in samples of soils and other surficial materials in the conterminous United States*

[Means and ranges are reported in parts per million (µg/g), and means and deviations are geometric except as indicated. Ratio, number of samples in which the element was found in measurable concentrations to number of samples analyzed. <, less than; >, greater than]

Element	Conterminous United States			Western United States (west of 96th meridian)					Eastern United States (east of 96th meridian)				
	Mean	Deviation	Estimated arithmetic mean	Ratio	Mean	Deviation	Observed range	Estimated arithmetic mean	Ratio	Mean	Deviation	Observed range	Estimated arithmetic mean
Al, percent	4.7	2.48	7.2	661:770	5.8	2.00	0.5 - >10	7.4	450:477	3.3	2.87	0.7 - >10	5.7
As	5.2	2.23	7.2	728:730	5.5	1.98	<0.10 - 97	7.0	521:527	4.8	2.56	<0.1 - 73	[illegible]
B	26	1.97	33	506:778	23	1.99	<20 - 300	29	425:541	31	1.88	<20 - 150	38
Ba	440	2.14	580	778:778	580	1.72	70 - 5,000	670	541:541	290	2.35	10 - 1,500	420
Be	.63	2.38	.92	310:778	.68	2.30	<1 - 15	.97	169:525	.55	2.53	<1 - 7	.85
Br	.56	2.50	.85	113:220	.52	2.74	<0.5 - 11	.86	78:128	.62	2.18	<0.5 - 5.3	.85
C, percent	1.6	2.57	2.5	250:250	1.7	2.37	0.16 - 10	2.5	162:162	1.5	2.88	0.06 - 37	2.6
Ca, percent	.92	4.00	2.4	777:777	1.8	3.05	0.06 - 32	3.3	514:514	.34	3.08	0.01 - 28	.63
Ce	63	1.78	75	81:683	65	1.71	<150 - 300	75	70:489	63	1.85	<150 - 300	76
Co	6.7	2.19	9.1	698:778	7.1	1.97	<3 - 50	9.0	403:533	5.9	2.57	<0.3 - 70	9.2
Cr	37	2.37	54	778:778	41	2.19	3 - 2,000	56	541:541	33	2.60	1 - 1,000	52
Cu	17	2.44	25	778:778	21	2.07	2 - 300	27	523:533	13	2.80	<1 - 700	22
F	210	3.34	430	598:610	280	2.52	<10 - 1,900	440	390:435	130	4.19	<10 - 3,700	360
Fe, percent	1.8	2.38	2.6	776:777	2.1	1.95	0.1 - >10	2.6	539:540	1.4	2.87	0.01 - >10	2.5
Ga	13	2.03	17	767:776	16	1.68	<5 - 70	19	431:540	9.3	2.38	<5 - 70	14
Ge	1.2	1.37	1.2	224:224	1.2	1.32	0.58 - 2.5	1.2	130:131	1.1	1.45	<0.1 - 2.0	1.2
Hg	.058	2.52	.089	729:733	.046	2.33	<0.01 - 4.6	.065	534:534	.081	2.52	0.01 - 3.4	.12
I	.75	2.63	1.2	169:246	.79	2.55	<0.5 - 9.6	1.2	90:153	.68	2.81	<0.5 - 7.0	1.2
K, percent[1]	1.5	.79	None	777:777	1.8	.71	0.19 - 6.3	None	537:537	1.2	.75	0.005 - 3.7	--
La	30	1.92	37	462:777	30	1.89	<30 - 200	37	294:516	29	1.98	<30 - 200	37
Li	20	1.85	24	731:731	22	1.58	5 - 130	25	479:527	17	2.16	<5 - 140	22
Mg, percent	.44	3.28	.90	777:778	.74	2.21	0.03 - >10	1.0	528:528	.21	3.55	0.005 - 5	.46
Mn	330	2.77	550	777:777	380	1.98	30 - 5,000	480	537:540	260	3.82	<2 - 7,000	640
Mo	.59	2.72	.97	57:774	.85	2.17	<3 - 7	1.1	32:524	.32	3.93	<3 - 15	.79
Na, percent	.59	3.27	1.2	744:744	.97	1.95	0.05 - 10	1.2	363:449	.25	4.55	<0.05 - 5	.78
Nb	9.3	1.75	11	418:771	8.7	1.82	<10 - 100	10	322:498	10	1.65	<10 - 50	12
Nd	40	1.68	46	120:538	36	1.76	<70 - 300	43	109:332	46	1.58	<70 - 300	51
Ni	13	2.31	19	747:778	15	2.10	<5 - 700	19	443:540	11	2.64	<5 - 700	18
P	260	2.67	430	524:524	320	2.33	40 - 4,500	460	380:382	200	2.95	<20 - 6,800	360
Pb	16	1.86	19	712:778	17	1.80	<10 - 700	20	422:541	14	1.95	<10 - 300	17
Rb	58	1.72	67	221:224	69	1.50	<20 - 210	74	107:131	43	1.94	<20 - 160	53
S, percent	.12	2.04	.16	34:224	.13	2.37	<0.08 - 4.8	.19	20:131	.10	1.34	<0.08 - 0.31	.11
Sb	.48	2.27	.67	35:223	.47	2.15	<1 - 2.6	.62	31:131	.52	2.38	<1 - 8.8	.76
Sc	7.5	1.82	8.9	685:778	8.2	1.74	<5 - 50	9.6	389:526	6.5	1.90	<5 - 30	8.0
Se	.26	2.46	.39	590:733	.23	2.43	<0.1 - 4.3	.34	449:534	.30	2.44	<0.1 - 3.9	.45
Si, percent[1]	31	6.48	None	250:250	30	5.70	15 - 44	None	156:156	34	6.64	1.7 - 45	--
Sn	.89	2.36	1.3	218:224	.90	2.11	<0.1 - 7.4	1.2	123:131	.86	2.81	<0.1 - 10	1.5
Sr	120	3.30	240	778:778	200	2.16	10 - 3,000	270	501:540	53	3.61	<5 - 700	120
Ti, percent	.24	1.89	.29	777:777	.22	1.78	0.05 - 2.0	.26	540:540	.28	2.00	0.007 - 1.5	.35
Th	8.6	1.53	9.4	195:195	9.1	1.49	2.4 - 31	9.8	102:102	7.7	1.58	2.2 - 23	8.6
U	2.3	1.73	2.7	224:224	2.5	1.45	0.68 - 7.9	2.7	130:130	2.1	2.12	0.29 - 11	2.7
V	58	2.25	80	778:778	70	1.95	7 - 500	88	516:541	43	2.51	<7 - 300	66
Y	21	1.78	25	759:778	22	1.66	<10 - 150	25	477:541	20	1.97	<10 - 200	25
Yb	2.6	1.79	3.1	754:764	2.6	1.63	<1 - 20	3.0	452:486	2.6	2.06	<1 - 50	3.3
Zn	48	1.95	60	766:766	55	1.79	10 - 2,100	65	473:482	40	2.11	<5 - 2,900	52
Zr	180	1.91	230	777:778	160	1.77	<20 - 1,500	190	539:541	220	2.01	<20 - 2,000	290

[1]Means are arithmetic, deviations are standard.

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For this reason, container soils are often supplied with nutrient sources that break down slowly to release nutrients over a relatively longer time.

John H. Madison

Bibliography. M. Baldwin, C. E. Kellogg, and J. Thorp, Soil classification, in *Soils and Men*, USDA Yearb. Agr., 1938; L. J. Bartelli et al. (eds.), *Soil Surveys and Land Use Planning*, 1966; P. W. Birkeland, *Pedology, Weathering, and Geomorphological Research*, 1974; C. E. Black (ed.), *Methods of Soil Analysis*, 1965; N. C. Brady, *The Nature and Properties of Soils*, 1974; A. C. Bunt, *Modern Potting Composts*, 1976; E. T. Cleaves, A. E. Godfrey, and J. K. Coulter, Soil management systems, in *Soils of the Humid Tropics*, 1972; J. Doorenbos and W. O. Pruitt, *Crop Water Requirements*, FAO Irrig. Drain Pap. 24 (rev.), 1977; R. Dudal (ed.), *Dark Clay Soils of Tropical and Subtropical Regions*, FAO Agr. Dev. Pap. 83, 1965; Food and Agricultural Organization–UNESCO, *Soil Map of the World*, 1971–1976; H. D. Foth, *Fundamentals of Soil Science*, 6th ed., 1978; R. M. Hagan, H. R. Naise, and T. W. Edminster (eds.), *Irrigation of Agriculture Lands*, Agr. Monogr. 11, American Society of Agronomy, 1967; N. Hudson, *Soil Conservation*, 2d ed., 1981; H. Jenny, *The Soil Resource: Origin and Behavior*, Ecological Studies, vol. 37, 1980; A. A. Klinebiel and P. H. Montgomery, *Land Capability Classification*, Agr. Handb. 210, 1966; L. Lyles, L. J. Hagan, and E. L. Skidmore, *Soil Conservation: Principles of Erosion by Wind*, Agron. Monogr. 23, American Society of Agronomy, 1983; J. H. Madison, *Principles of Turfgrass Culture*, 1982; J. V. Mannering and C. R. Fenster, Vegetative water erosion control for agricultural areas, in *Soil Erosion and Sedimentation*, American Society of Agricultural Engineers, 1977; National Academy of Sciences, *Soils of the Humid Tropics*, 1972; K. G. Renard and G. R. Foster, *Soil Conservation: Principles of Erosion by Water*, Agron. Monogr. 23, American Society of Agronomy, 1983; E. W. Russell, *Soil Conditions and Plant Growth*, 1973; R. W. Simonson, Loss of nutrient elements in soil formation, in O. P. Englestad (ed.), *Nutrient Mobility in Soils: Accumulation and Losses*, Soil Sci. Soc. Amer. Spec. Publ. 4, 1970; Soil Survey Staff, *Soil Taxonomy: Basic System of Soil Classification for Making and Interpreting Soil Surveys*, USDA Handb. 436, 1975; J. H. Turner (ed.), *Fundamentals of No-Till Farming*, American Association for Vocational Instructional Materials, 1983; U.S. Department of Agriculture, *Soil*, Yearb. Agr., 1957; W. H. Wischmeier, Conservation tillage of control water erosion, in *Proceedings of a National Tillage Conference*, Soil Conservation Society of America, 1973; H. M. Young, Jr., and W. A. Hayes, *No-Tillage Farming and Minimum Tillage Farming*, 1982.

Soil chemistry

The study of the composition and chemical properties of soil. Soil chemistry involves the detailed investigation of the nature of the solid matter from which soil is constituted and of the chemical processes that occur as a result of the action of hydrological, geological, and biological agents on the solid matter. Because of the broad diversity among soil components and the complexity of soil chemical processes, the application of a wide variety of concepts and methods employed in the chemistry of aqueous solutions, of amorphous and crystalline solids, and of solid surfaces is required. For a general discussion of the origin and classification of soils SEE SOIL.

Elemental composition. The elemental composition of soil varies over a wide range, permitting only a few general statements to be made. Those soils that contain less than 12–20% organic carbon are termed mineral. (The exact percentage to consider in a specific case depends on drainage characteristics and clay content of the soil.) All other soils are termed organic. Carbon, oxygen, hydrogen, nitrogen, phosphorus, and sulfur are the most important constituents of organic soils and of soil organic matter in general. Carbon, oxygen, and hydrogen are most abundant; the content of nitrogen is often about one-tenth that of carbon, while the content of phosphorus or sulfur is usually less than one-fifth that of nitrogen. The number of organic compounds into which these elements are incorporated in soil is very large, and the elucidation of the chemistry of soil organic matter remains a challenging problem. SEE HUMUS.

Besides oxygen, the most abundant elements found in mineral soils are silicon, aluminum, and iron (**Table 1**). The distribution of chemical elements will vary considerably from soil to soil and, in general, will be different in a specific soil from the distribution of elements in the crustal rocks of the Earth. Often this difference may be understood in terms of pedogenic weathering processes and the chemical reactions that accompany them. Some examples evident in Table 1 are the accumulation of aluminum and iron oxides in the Oxisols and of calcium carbonate in the Mollisols. The most important micro or trace elements in soil are boron, copper, manganese, molybdenum, and zinc, since these elements are essential in the nutrition of green plants. Also important are cobalt, which is essential in animal nutrition, and selenium, cadmium, and nickel, which may accumulate to toxic levels in soil. The average distribution of trace elements in soil is not greatly different from that in crustal rocks (**Table 2**). This indicates that the total content of a trace element in soil usually reflects the content of that element in the soil parent material and, generally, that the trace element content of soil often is not affected substantially by pedochemical processes.

The elemental composition of soil varies with depth below the surface because of pedochemical weathering. The principal processes of this type that result in the removal of chemical elements from a given soil horizon are: (1) soluviation (ordinary dissolution in water), (2) cheluviation (complexation by organic or inorganic ligands), (3) reduction (lowering of the oxidation state), and (4) suspension. Soluviation, cheluviation, and reduction include leaching by water into lower horizons; suspension involves removal by erosion or by translocation downward along soil pores. The principal effect of these four processes is the appearance of illuvial horizons in which compounds such as aluminum and iron hydrous oxides, aluminosilicates, or calcium carbonate have been precipitated from solution or deposited from suspension. SEE WEATHERING PROCESSES.

Minerals. The minerals in soils are the products of physical, geochemical, and pedochemical weathering. Soil minerals may be either amorphous or crystalline. They may be classified further, approximately, as primary or secondary minerals, depending on whether

Table 1. Average percentages of the major and some micro elements in subsurface soil clays and crustal rocks

Soil order:	Alfisol	Inceptisol	Mollisol	Oxisol	Spodosol	Ultisol	Crustal rocks
Silicon (Si)	19.20	24.69	23.01	12.43	5.79	16.02	27.72
Aluminum (Al)	12.38	19.61	10.29	19.33	15.86	17.49	8.13
Iron (Fe)	8.04	3.81	6.83	10.83	3.29	11.96	5.00
Calcium (Ca)	0.69	0.00	3.59	0.10	0.29	0.15	3.63
Magnesium (Mg)	1.26	0.40	1.62	0.46	0.15	0.08	2.09
Sodium (Na)	0.18	2.52	0.04	0.00	0.27	0.06	2.83
Potassium (K)	3.63	n.d.	1.20	0.07	0.40	0.22	2.59
Titanium (Ti)	0.40	0.28	0.44	1.32	0.16	0.50	0.44
Manganese (Mn)	0.06	n.d.	0.06	0.08	0.06	0.05	0.10
Phosphorus (P)	0.14	n.d.	0.14	0.27	0.17	0.12	0.11

they are inherited from parent rock or are produced by chemical weathering, respectively.

Primary minerals in soil. The bulk of the primary minerals that occur in soil are found in the silicate minerals, such as the olivines, garnets, pyroxenes, amphiboles, micas, feldspars, and quartz. The feldspars, micas, amphiboles, and pyroxenes commonly are hosts for trace elements that may be released slowly into the soil solution as weathering of these minerals continues. Chemical weathering of the silicate minerals is responsible for producing the most important secondary minerals in soil. The general scheme of the weathering sequence is shown in **Fig. 1**. *See Silicate minerals*.

Secondary minerals in soil. The important secondary minerals that occur in soil are found in the clay fraction. These include aluminum and iron hydrous oxides (sometimes in the form of coatings on other minerals), carbonates, and aluminosilicates. The term allophane is applied to x-ray amorphous, hydrous aluminosilicates that are characterized by variable composition and a defect-riddled kaolinite structure containing Al in both tetrahedral and octahedral coordination. The significant crystalline aluminosilicates possess a layer structure; they are chlorite, halloysite, kaolinite, montmorillonite (smectite), and vermiculite. These clay minerals are identified in soil by means of the characteristic x-ray diffraction patterns they produce after certain pretreatments, although their positive identification may be difficult if two or more of the minerals are present at once. *See Clay minerals*.

The distribution of secondary minerals varies among different soils and changes with depth below the surface of a given soil. However, under a leaching, well-oxidized environment, soil minerals do possess a differential susceptibility to decomposition, transformation, and disappearance from a soil profile. This has made possible the arrangement of the clay-sized soil minerals in the order of increasing resistance to chemical weathering. Those minerals ranked near the top of the following list are present, therefore, in the clay fractions of slightly weathered soils; those minerals near the bottom of the list predominate in extensively weathered soils.

Weathering index	*Clay-sized minerals*
1	Gypsum, halite
2	Calcite, apatite
3	Olivine, pyroxene
4	Biotite, mafic chlorite
5	Albite, microcline
6	Quartz
7	Muscovite, illite, sericite
8	Vermiculite
9	Montmorillonite, Al-chlorite
10	Kaolinite, allophane
11	Gibbsite, boehmite
12	Hematite, goethite
13	Anatase, rutile, zircon

In zonal soils of humid-cool to subhumid-temperate regions, illite is the predominant clay mineral. Mixtures of kaolinite, vermiculite, and interstratified clay minerals are found in humid-temperate regions. In humid-warm regions, kaolinite, halloysite, allophane, gibbsite, and goethite are found. The mineralogical composition of the highly weathered and leached soils of the humid tropics is a subject of active investigation, in part because these soils (the Oxisols and Ultisols) constitute approximately one-third of the world's potentially arable land. The soil minerals are dominated by iron and aluminum hydrous oxides, kaolinite, halloysite, and quartz. Weathering residues also are found in thin coatings on clay particle surfaces. Vermiculite and montmorillonite with interlayer Al hydroxy polymers are common.

The chemical conditions favoring the genesis of kaolinite are the removal of the basic cations and Fe^{2+} by leaching, the addition of H^+ in fresh water, and a high Al-Si molar ratio. Smectite (montmorillonite) is favored by the retention of basic cations (arid conditions or poor drainage) and of silica. *See Gibbsite; Goethite; Halloysite; Illite; Kaolinite; Montmorillonite; Vermiculite*.

Table 2. Average amounts of trace elements commonly found in soils and crustal rocks

Trace element	Soil, mg/kg	Crustal rocks, mg/kg
Arsenic (As)	6	1.8
Boron (B)	10	10
Cadmium (Cd)	0.06	0.2
Columbium (Co)	8	25
Chromium (Cr)	100	100
Copper (Cu)	20	55
Molybdenum (Mo)	2	1.5
Nickel (Ni)	40	75
Lead (Pb)	10	13
Selenium (Se)	0.2	0.05
Vanadium (V)	100	135
Zinc (Zn)	50	70

Powder River is derived from many stream sources, and excess molybdenum that any one stream may contribute is largely diluted.

Magnesium. Studies of magnesium concentration in grasses reveal how glaciers, overriding bedrock, influence glacial drift and the soils formed on it. There is appreciably more magnesium in grasses from the glacial drift plains in Wisconsin than in similar grasses from the drift plains in Michigan. The soils in the two states are morphologically and genetically the same, and differ principally in the underlying limestone bedrock that the glaciers overrode. Dolomite is a magnesium-rich limestone that underlies areas in Wisconsin but not Michigan. The southerly movement of the glaciers has expanded the influence of the dolomitic rock into parts of Illinois and Iowa.

Grass tetany is a nutritional deficiency disease due to low magnesium in forage plants. Grasses with 0.2% magnesium or more protect cattle from grass tetany. The disease is virtually absent in Wisconsin but quite prevalent in Michigan.

Pregnant cows and cows with nursing calves are most susceptible to grass tetany. Older cows in the fourth or fifth pregnancy are more susceptible than younger ones. Knowing the geographic areas where cows may graze low-magnesium forage is important so that animal losses can be minimized, especially in springtime when the incidence of grass tetany is highest. Cool-season grasses are often the first fresh forage available to cattle in spring. If the growing temperature during this period is warm, grasses tend to have more magnesium. However, soils formed in dolomitic till tend to overcome effects of cool temperature and grow grasses with magnesium adequate for animals. In the West, grasses growing on soils formed in or influenced by volcanic ash generally have small amounts of magnesium and respond only weakly to warm growing temperatures. In these soils, the grasses have 0.15% or less of magnesium.

Selenium. Other mineral elements are associated with soil-related nutritional problems in animals as a result of soil parent material interacting with soils. The best-known disease is selenium toxicity, or selenosis. In parts of the Rocky Mountain and the Great Plains states where calcareous soils are formed in seleniferous rocks, or in materials derived from them, the incidence of selenosis in grazing animals is high. Acute cases occur where selenium accumulator plants such as *Astragalus bisulcatus* or *Stanlyea pinnata* grow. These plants may have a selenium level of 1000 ppm or more, often greatly exceeding the level in the soil. Selenium-rich rocks occur in Hawaii and Puerto Rico, but selenosis is not a nutritional problem there. Selenium is appreciably less available to plants growing on acid soils, and the plants do not accumulate levels toxic to animals. Because of the differences in plant response, the selenium-rich soil areas in Hawaii and Puerto Rico are identified as nontoxic seleniferous soils.

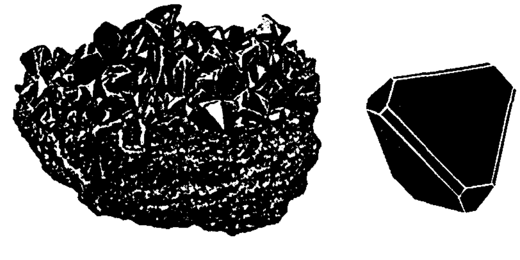
Cobalt. Areas of cobalt deficiency in cattle in the eastern United States also result from the combined effect of soil parent materials and the soils themselves. The area between the Merrimac River in New Hampshire and the Saco River in Maine is low in cobalt, because only small amounts were contributed to the glacial drift by the White Mountain granites. The Lower Atlantic Coastal Plain is the other broad area of low-cobalt soils. The coastal plain deposits in which soils formed are materials that already had undergone a cycle of weathering in the uplands. In both the Northeast and the Southeast, leaching losses of cobalt below rooting depths of common plants occur with the development of Spodosols that form in the sandy deposits. Forage plants and native grasses grown on soils in both areas have 0.04 to 0.07 ppm or less of cobalt, well in the deficiency range recognized for animals.

Joe Kubota

Bibliography. H. Bohn et al., *Soil Chemistry*, 1979; E. Bresler et al., *Saline and Sodic Soils*, 1982; W. R. Chappell and K. Kellogg (eds.), *Molybdenum in the Environment*, 1977; B. E. Davies (ed.), *Applied Soil Trace Elements*, 1980; D. J. Greenland and M. H. B. Hayes (eds.), *The Chemistry of Soil Constituents*, 1978; D. H. Greenland and M. H. B. Hayes (eds.), *The Chemistry of Soil Processes*, 1981; W. L. Lindsay, *Chemical Equilibria in Soils*, 1979; G. Sposito, *The Surface Chemistry of Soils*, 1984; G. Sposito, *The Thermodynamics of Soil Solutions*, 1981; F. J. Stevensen, *Humus Chemistry*, 1982; W. Stumm and J. J. Morgan, *Aquatic Chemistry*, 1981; B. K. G. Theng (ed.), *Soils with Variable Charge*, 1980; I. Thornton (ed.), *Applied Environmental Geochemistry*, 1983.

Sphalerite

A mineral, β-ZnS, also called blende. It is the low-temperature form and more common polymorph of ZnS. Pure β-ZnS on heating inverts to wurtzite, α-ZnS, at 1020°C (1868°F), but this temperature can be lowered substantially by impurity-atom solid solution (especially Cd^{2+} and Fe^{2+}) and sulfur fugacity. Sphalerite crystallizes in the hextetrahedral class of the isometric system with a structure similar to that of diamond. The space group is $F\bar{4}3m$, and the cubic unit cell has an edge a = 0.543 nanometer, which contains four ZnS molecules. Zinc atoms occupy the positions of half the carbon atoms of diamond, and sulfur atoms occupy the other half. Each zinc atom is bonded to four sulfur atoms, and each sulfur atom is bonded to four zinc atoms. The common crystal forms of sphalerite are the tetrahedron, dodecahedron, and cube, but crystals are frequently complex and twinned (see **illus.**). The mineral is most commonly in coarse to fine, granular, cleavable masses. The luster is resinous to submetallic; the color is white when pure, but is commonly yellow, brown, or black, darkening with increased percentage of iron. It has been shown that excess sulfur can also contribute to the darkening of the color. There is perfect dodecahedral



(a) (b)

Sphalerite. (*a*) Crystals in limestone from Joplin, Missouri (*specimen from Department of Geology, Bryn Mawr College*). (*b*) Crystal habit (*after C. S. Hurlbut, Jr., Dana's Manual of Mineralogy, 17th ed., John Wiley and Sons, 1959*)

The Soil Chemistry of Hazardous Materials

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TABLE 3.1 Native Soil Concentrations of Various Elements

Element	Concentration (ppm) Typical Range	Concentration (ppm) Extreme Limits
Ag	0.1 - 5.0	0.1 - 50
Al	10,000 - 300,000	—
As	1.0 - 40	0.1 - 500
B	2.0 - 130	0.1 - 3000
Ba	100 - 3500	10 - 10,000
Be	0.1 - 40	0.1 - 100
Br	1.0 - 10	—
Ca	100 - 400,000	—
Cd	0.01 - 7.0	0.01 - 45
Ce	30 - 50	—
Cl	10 - 100	—
Co	1.0 - 40	0.01 - 500
Cr	5.0 - 3000	0.5 - 10,000
Cs	0.3 - 25	—
Cu	2.0 - 100	0.1 - 14,000
F	30 - 300	—
Fe	7,000 - 550,000	—
Ga	0.4 - 300	—
Ge	1.0 - 50	—
Hg	0.01 - 0.08	—
I	0.1 - 40	—
K	400 - 30,000	—
La	1.0 - 5000	—
Li	7.0 - 200	1.0 - 3000
Mg	600 - 6000	—
Mn	100 - 4000	1.0 - 70,000
Mo	0.2 - 5.0	0.1 - 400
Na	750 - 7500	400 - 30,000
Ni	5.0 - 1000	0.8 - 6200
P	50 - 5000	—
Pb	2.0 - 200	0.1 - 3000
Ra	$10^{-6.5}$ - $10^{-5.7}$	—
Rb	20 - 600	3.0 - 3000
S	30 - 10,000	—
Sb	0.6 - 10	—
Sc	10 - 25	—
Se	0.1 - 2.0	0.01 - 400
Si	230,000 - 350,000	—
Sn	2.0 - 200	0.1 - 700
Sr	50 - 1000	10 - 5000
Th	0.1 - 12	—
Ti	1000 - 10,000	400 - >10,000
U	0.9 - 9.0	< 250
V	20 - 500	1.0 - 1000
Y	10 - 500	—
Zn	10 - 300	3.0 - 10,000
Zr	60 - 2000	10 - 8000

[a] Based on an Analysis of Data Presented in References 1,2,3,4,5, and 6.

TABLE 3.2 Natural Concentrations of Various Elements in Groundwater.[a]

Element	Concentration: Typical Value	Concentration: Extreme Value
	Major Elements (ppm)	
Ca	1.0 - 150[b] < 500[d]	95,000[c]
Cl	1.0 - 70[b] < 1000[d]	200,000[c]
F	0.1 - 5.0	70 1600[c]
Fe	0.01 - 10	> 1000[c,e]
K	1.0 - 10	25,000[c]
Mg	1.0 - 50[b] < 400[d]	52,000[c]
Na	0.5 - 120[b] < 1000[d]	120,000[c]
NO_3	0.2 - 20	70
SiO_2	5.0 - 100	4,000[c]
SO_4	3.0 - 150[b] < 2000[d]	200,000[c]
Sr	0.1 - 4.0	50
	Trace Elements (ppb)	
Ag	< 5.0	
Al	< 5.0 - 1000	
As	< 1.0 - 30	4,000
B	20 - 1000	5,000
Ba	10 - 500	
Br	< 100 - 2000	
Be	< 10	
Bi	< 20	
Cd	< 1.0	
Co	< 10	
Cr	< 1.0 - 5.0	
Cu	< 1.0 - 30	
Ga	< 2.0	
Ge	< 20 - 50	
Hg	< 1.0	
I	< 1.0 - 1000	48,000[c]
Li	1.0 - 150	
Mn	< 1.0 - 1000	10,000[c]
Mo	< 1.0 - 30	10,000
Ni	< 10 - 50	
PO_4	< 100 - 1000	
Pb	< 15	
Ra	< 0.1 - 4.0[f]	720[c, f]
Rb	< 1.0	
Se	< 1.0 - 10	
Sn	< 200	
Ti	< 1.0 - 150	
U	0.1 - 40	
V	< 1.0 - 10	70
Zn	< 10 - 2000	
Zr	< 25	

[a] based on an analysis of data presented in references 7,8, and 9.
[b] in relatively humid regions.
[c] in brine.
[d] in relatively dry regions.
[e] in thermal springs and mine areas.
[f] picocuries/liter (i.e. 0.037 disintegrations/sec).

ATTACHMENT 5
SWMU 6/AOC B REVISED RISK ASSESSMENT

REVISED HUMAN HEALTH RISK ASSESSMENT

SWMU 6/AOCB

The objective of this effort is to re-evaluate potential human health risks associated with SWMU 6/AOC B based on cumulative exposures to COPCs identified in surface soil, the standing water on the floor in Building 145 and groundwater. Potential health risks to surface soil were previously calculated as part of the Draft RFI Report for OU 1, 6 and 7 prepared by Baker in July 1996, and the risks to groundwater were previously estimated as part of the Draft Additional Investigations Report for OU 1, 6 and 7 prepared by Baker in May 1998. Although a standing water sample was collected from Building 145 and analyzed as part of the 1996 RFI, potential health risks were never estimated using those data. This effort was conducted to estimate total site risks overall of these media. Current on-site workers and future residents were evaluated as potential receptors, with the former being the most likely and realistic of the two exposure scenarios. The following pathways were evaluated these receptors:

Current On-Site Workers
- Incidental ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of fugitive dusts emanating from surface soil
- Incidental ingestion of standing water in Building 145
- Accidental dermal contact with standing water in Building 145

Future Adult and Child (Ages 1 - 6 Years Old) Residents
- Incidental ingestion of surface soil
- Dermal contact with surface soil
- Inhalation of fugitive dusts emanating from surface soil
- Incidental ingestion of standing water in Building 145 (during potable use)
- Dermal contact with standing water in Building 145 (during potable use)
- Ingestion of groundwater during potable use
- Dermal contact with groundwater (whole body exposure, i.e., during bathing)

The COPCs identified and evaluated in each medium, the assumptions regarding the aforementioned exposures, and the applied toxicity criteria are all presented in the attached risk calculation spreadsheets (spreadsheets 1 through 12). Since previously assessing risks to surface soil and groundwater some changes have occurred in the toxicity criteria for some the of COPCs. The oral cancer slope factor for beryllium, the oral reference dose for mercury, and the inhalation cancer slope factors for the carcinogenic PAHs have been withdrawn from USEPA's IRIS database, pending further review. However, for the purpose of health conservatism, as well as consistency with the previous risk assessments, these withdrawn toxicity criteria have been used in this re-evaluation of SWMU 6/AOC B. Also, it is acknowledged that USEPA has recently changed the oral reference dose for beryllium from 0.005 mg/kg/day to 0.002 mg/kg/day. Again for consistency with previous risk assessments, the former value was applied to this evaluation, with virtually no significant impact to the outcome of the systemic risk evaluations had the new value been applied.

Prior to discussing the risks estimated for these receptors, it should be noted that the evaluated exposure assumptions are associated with a high degree of conservatism and uncertainty. First, the estimation of risks from exposures to the standing water observed in Building 145 represents an almost unrealistic scenario for both receptor groups. This is because access into the building 145 is highly restricted due to the presence of fencing that is welded onto entry ways of the building. In addition, data acquired for the sample collected from the standing water area are over two years old and do not reflect physical and chemical changes that have occurred to the water over that period of time as a result of natural processes acting on the water (e.g., evaporation and recharge from numerous precipitation events). It is also likely that due to the small volume of water observed on the floor in the building, there may be periods during which no standing water is present. Therefore, the standing water data used in this risk evaluation are associated with a high degree of uncertainty because those data are considered to only be representative of that "snapshot in time" during which the sample was collected.

In addition, the assumption of residential receptors living within the boundaries of SWMU 6/AOC B, while being exposed to the standing water in Building 145 and shallow groundwater during potable use, represents an unrealistic extreme for estimating and characterizing potential risks associated with the SWMU. This is because residential development of the SWMU and the use of the shallow aquifer as a potable source (of poor quality and yield) are highly unlikely to occur. In addition, the notion of residential use of the standing water on the floor of Building 145, potable or non-potable, is even more unrealistic than the assumption of domestic groundwater use.

The following text, as well as Tables 1 and 2, characterize the potential health risks estimated for future residents and current on-site workers at SWMU 6/AOC B. Carcinogenic and noncarcinogenic risks were compared to USEPA's target cancer risk (excess incremental lifetime cancer risk - ICR) range of 1×10^{-4} to 1×10^{-6} and a target hazard index value of 1.0, respectively.

Future On-Site Residents

Table 1 shows that unacceptable total carcinogenic risks were estimated for future adult and young child residents (6.2×10^{-4} and 3.8×10^{-4}, respectively) at SWMU 6/AOC B. Dermal contact exposures to to benzo(a)pyrene and beryllium in surface soil (29% and 26% risk contributions to surface soil, respectively), and ingestion exposures to dissolved beryllium in groundwater used as drinking water (attributed nearly 100% of the risk to groundwater exposures) predominantly contributed to the total ICRs.

The total HIs estimated for both the adult and young child (3.1 and 7.6, respectively) exceeded USEPA's acceptable target value of 1.0 due primarily to ingestion exposures to mercury detected in the standing water on the floor of Building 145 (approximately an 82% risk contribution to the ingestion pathway).

Current On-Site Workers

Table 2 shows that an unacceptable total carcinogenic risk was estimated for on-site workers (2.0×10^{-4}) at SWMU 6/AOC B. As was the case for future residents, dermal contact exposures to to benzo(a)pyrene and beryllium in surface soil (29% and 26% risk contributions to surface soil, respectively) predominantly contributed to the total ICR.

The total HI estimated for this receptor (0.82) is less than USEPA's acceptable target value of 1.0, indicating that no adverse systemic effects are expected to result subsequent to exposures to SWMU 6/AOC B surface soil and the standing water in Building 145.

TABLE 1
INCREMENTAL CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
FOR FUTURE ADULT AND YOUNG CHILD RESIDENTS
SWMU 6/AOC B
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

	Residents			
	Adult		Young Child	
Pathway	ICR	HI	ICR	HI
Surface Soil				
Incidental Ingestion	3.2×10^{-5}	0.08	7.5×10^{-5}	0.79
Dermal Contact	2.3×10^{-4}	0.32	1.0×10^{-4}	0.56
Inhalation [1]	1.3×10^{-8}	<0.01	1.5×10^{-8}	<0.01
Subtotal	2.6×10^{-4}	0.40	1.8×10^{-4}	1.4
Standing Water				
Incidental Ingestion	7.2×10^{-5}	2.5	4.2×10^{-5}	5.8
Dermal Contact	1.0×10^{-6}	0.03	4.8×10^{-7}	0.05
Subtotal	7.3×10^{-5}	2.5	4.2×10^{-5}	5.8
Groundwater				
Ingestion	2.4×10^{-4}	0.18	1.4×10^{-4}	0.42
Dermal Contact	4.8×10^{-5}	<0.01	2.2×10^{-5}	<0.01
Subtotal	2.9×10^{-4}	0.18	1.6×10^{-4}	0.42
TOTAL	6.2×10^{-4} [2]	3.1 [3]	3.8×10^{-4} [2]	7.6 [3]

Notes:

(1) Inhalation of fugitive dusts.

(2) Total ICR exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene and beryllium (29% and 26% risk contributions, respectively) in surface soil. In addition, ingestion of dissolved beryllium contributed nearly 100% of the risk to groundwater exposures.

(3) Total HIs estimated for both adult and child exceeded USEPA's acceptable target value of 1.0 due primarily to to ingestion exposures to mercury in the standing water (approximately an 82% risk contribution to the ingestion pathway).

Shading indicates exceedence of USEPA acceptable target risk criteria by total risk value.

TABLE 2
INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
ADULT ON-SITE WORKERS
SWMU 6/AOC B
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Medium/Pathway	Adult On-site Worker	
	ICR	HI
Surface Soil		
Incidental Ingestion	1.2×10^{-5}	0.03
Dermal Contact	1.7×10^{-4}	0.23
Inhalation (1)	3.3×10^{-9}	<0.01
Subtotal	1.8×10^{-4}	0.26
Standing Water		
Incidental Ingestion	1.1×10^{-5}	0.35
Dermal Contact	8.2×10^{-6}	0.21
Subtotal	1.9×10^{-5}	0.56
TOTAL	2.0×10^{-4} (2)	0.82

Notes:
(1) Inhalation of fugitive dusts.

(2) Total ICR exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene and beryllium (29% and 26% risk contributions, respectively) in surface soil.

Shading indicates exceedence of USEPA acceptable target risk criteria by total risk value.

SPREADSHEET 1
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
INGESTION OF POOLED SURFACE WATER AS DRINKING WATER AT SWMU 6/AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cw*IR*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult	Young Child	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cw	Concentration of chemical in water (mg/L)	CS	CS	
IR	Ingestion Rate (L/d)	2	1	changed to 0.05 liter/hr and added exposure time of 2 hr/day
EF	Exposure Frequency (d/yr)	350	350	
ED	Exposure Duration (yrs)	24	6	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	

				Adult						Young Child					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
4,4'-DDE	0.00052	3.40E-01	NA	4.9E-06	1.7E-06	2.3%	1.4E-05	--	--	2.8E-06	9.7E-07	2.3%	3.3E-05	--	--
Total Arsenic	0.0050	1.50E+00	3.00E-04	4.7E-05	7.0E-05	97.7%	1.4E-04	4.6E-01	18.5%	2.7E-05	4.1E-05	97.7%	3.2E-04	1.1E+00	18.5%
Total Mercury	0.0220	NA	3.00E-04	2,1E-04	--	--	6.0E-04	2.0E+00	81.5%	1.2E-04	--	--	1.4E-03	4.7E+00	81.5%
				Total ILCR:	7.2E-05	100.0%	HI:	2.5E+00	100.0%	Total ILCR:	4.2E-05	100.0%	HI:	5.8E+00	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

ok 3.4x10^-1

SPREADSHEET 2
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
DERMAL CONTACT WITH POOLED SURFACE WATER AT SWMU 6/AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cw*CF*Kp*SA*EF*ED*ET)/(BW*AT)

ILCR = CDI*CSFo Adj   CSF Adj = CSF/AD
HQ = CDI/RfDo Adj   RfD Adj = RfD*AD

Parameter	Description	Adult	Young Child	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
SA	Skin surface area available for contact (cm2)	20000	8023	
ET	Exposure frequency (d/yr)	350	350	
ED	Exposure duration (yrs)	24	6	
ET	Exposure time (hrs/day)	0.2	0.2	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	
Cw	Concentration of chemical in water (mg/L)	CS	CS	
CF	Conversion factor (L/cm3)	0.001	0.001	
Kp	Dermal permeability coefficient (cm/hour)	CS	CS	
AD	Adjustment for Absorbed Dose	CS	CS	

								Adult						Young Child					
								Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	Kp (cm/hour)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	AD (unitless)	Adj CSFo 1/(mg/kg/d)	Adj RfDo (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
4,4'-DDE	0.00052	2.40E-01	3.40E-01	NA	0.90	3.78E-01	NA	2.3E-06	8.9E-07	85.7%	6.8E-06	--	--	1.1E-06	4.1E-07	85.7%	1.3E-05	--	--
Total Arsenic	0.0050	1.00E-03	1.50E+00	3.00E-04	0.95	1.58E+00	2.85E-04	9.4E-08	1.5E-07	14.3%	2.7E-07	9.6E-04	3.5%	4.4E-08	6.9E-08	14.3%	5.1E-07	1.8E-03	3.5%
Total Mercury	0.0220	1.00E-03	NA	3.00E-04	0.15	NA	4.50E-05	4.1E-07	--	--	1.2E-06	2.7E-02	96.5%	1.9E-07	--	--	2.3E-06	5.0E-02	96.5%
								Total ILCR:	1.0E-06	100.0%	HI:	2.8E-02	100.0%	Total ILCR:	4.8E-07	100.0%	HI:	5.2E-02	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 3
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
ACCIDENTAL INGESTION OF SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult	Young Child	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	200	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	1	1	
EF	Exposure Frequency (d/yr)	350	350	
ED	Exposure Duration (yrs)	24	6	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	

				Adult						Young Child					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	0.73	NA	1.1E-06	8.2E-07	2.6%	3.3E-06	--	--	2.6E-06	1.9E-06	2.6%	3.1E-05	--	--
Benzo(a)pyrene	1.8	7.3	NA	8.5E-07	6.2E-06	19.2%	2.5E-06	--	--	2.0E-06	1.4E-05	19.2%	2.3E-05	--	--
Benzo(b)fluoranthene	4.3	0.73	NA	2.0E-06	1.5E-06	4.6%	5.9E-06	--	--	4.7E-06	3.4E-06	4.6%	5.5E-05	--	--
Dibenzo(a,h)anthracene	0.18	7.3	NA	8.5E-08	6.2E-07	1.9%	2.5E-07	--	--	2.0E-07	1.4E-06	1.9%	2.3E-06	--	--
4,4'-DDE	22	0.34	NA	1.0E-05	3.5E-06	10.9%	3.0E-05	--	--	2.4E-05	8.2E-06	10.9%	2.8E-04	--	--
4,4'-DDD	18	0.24 ✓	NA	8.5E-06	2.0E-06	6.3%	2.5E-05	--	--	2.0E-05	4.7E-06	6.3%	2.3E-04	--	--
4,4'-DDT	14	0.34	0.0005	6.6E-06	2.2E-06	6.9%	1.9E-05	3.8E-02	45.6%	1.5E-05	5.2E-06	6.9%	1.8E-04	3.6E-01	45.6%
Total HxCDD (2378-TCDD TEC	0.000076	150,000	NA	3.6E-11	5.4E-06	16.6%	1.0E-10	--	--	8.3E-11	1.2E-05	16.6%	9.7E-10	--	--
Total HxCDF (2378-TCDD TEC	0.000026	150,000	NA	1.2E-11	1.8E-06	5.7%	3.6E-11	--	--	2.8E-11	4.3E-06	5.7%	3.3E-10	--	--
Arsenic	10.0	1.5	0.0003	4.7E-06	7.0E-06	21.9%	1.4E-05	4.6E-02	54.3%	1.1E-05	1.6E-05	21.9%	1.3E-04	4.3E-01	54.3%
Beryllium	0.55	4.3	0.005	2.6E-07	1.1E-06	3.4%	7.5E-07	1.5E-04	0.2%	6.0E-07	2.6E-06	3.4%	7.0E-06	1.4E-03	0.2%
				Total ILCR:	3.2E-05	100.0%	Total HI:	8.4E-02	100.0%	Total ILCR:	7.5E-05	100.0%	Total HI:	7.9E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

Beryllium toxicity values wrong

SPREADSHEET 4
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
DERMAL CONTACT WITH SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult	Young Child	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	5300	2006	
EF	Exposure Frequency (d/yr)	350	350	
ED	Exposure Duration (yrs)	24	6	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	

					Adult						Young Child					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	0.1	1.46	NA	6.0E-06	8.7E-06	3.8%	1.7E-05	--	--	2.6E-06	3.9E-06	3.8%	3.1E-05	--	--
Benzo(a)pyrene	1.8	0.1	14.6	NA	4.5E-06	6.5E-05	28.9%	1.3E-05	--	--	2.0E-06	2.9E-05	28.9%	2.3E-05	--	--
Benzo(b)fluoranthene	4.3	0.1	1.46	NA	1.1E-05	1.6E-05	6.9%	3.1E-05	--	--	4.7E-06	6.9E-06	6.9%	5.5E-05	--	--
Dibenzo(a,h)anthracene	0.18	0.1	14.6	NA	4.5E-07	6.5E-06	2.9%	1.3E-06	--	--	2.0E-07	2.9E-06	2.9%	2.3E-06	--	--
4,4'-DDE	22	0.1	0.38	NA	5.5E-05	2.1E-05	9.2%	1.6E-04	--	--	2.4E-05	9.2E-06	9.2%	2.8E-04	--	--
4,4'-DDD	18	0.1	0.27	NA	4.5E-05	1.2E-05	5.3%	1.3E-04	--	--	2.0E-05	5.3E-06	5.3%	2.3E-04	--	--
4,4'-DDT	14	0.1	0.38	0.00045	3.5E-05	1.3E-05	5.8%	1.0E-04	2.3E-01	71.6%	1.5E-05	5.8E-06	5.8%	1.8E-04	4.0E-01	71.6%
Total HxCDD (2378-TCDD TE	0.000076	0.03	167,000	NA	5.7E-11	9.5E-06	4.2%	1.7E-10	--	--	2.5E-11	4.2E-06	4.2%	2.9E-10	--	--
Total HxCDF (2378-TCDD TEC	0.000026	0.03	167,000	NA	1.9E-11	3.2E-06	1.4%	5.7E-11	--	--	8.6E-12	1.4E-06	1.4%	1.0E-10	--	--
Arsenic	10.0	0.032	1.58	0.000285	8.0E-06	1.3E-05	5.6%	2.3E-05	8.2E-02	25.8%	3.5E-06	5.6E-06	5.6%	4.1E-05	1.4E-01	25.8%
Beryllium	0.55	0.01	430	0.00005	1.4E-07	5.9E-05	26.0%	4.0E-07	8.0E-03	2.5%	6.0E-08	2.6E-05	26.0%	7.1E-07	1.4E-02	2.5%
					Total ILCR:	2.3E-04	100.0%	Total HI:	3.2E-01	100.0%	Total ILCR:	1.0E-04	100.0%	Total HI:	5.6E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

.01
change

HxCDD TEF = 0.1
HxCDF TEF = 0.1
HxCDD Hexachlorodibenzodioxin $CSF_o = 6.2 \times 10^3$ $CSF_i = 4.5 \times 10^3$
HxCDF Hexachlorodibenzofuran CSF_o } CSF_i } not available use TEF

wrong? listed as 0.76 ug/kg in appendix or 0.00076 mg/kg & 0.26 ug/kg ~ 0.00026 mg/kg

RES6.WB1

SPREADSHEET 5
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
INHALATION OF FUGITIVE DUSTS EMANATING FROM SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Ca*RR*ET*EF*ED)/(BW*AT)
Where: Ca = Cs * (1/PEF)

ILCR = CDI*CSFi
HQ = CDI/RfDi

Parameter	Description	Adult	Young Child	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFi	Inhalation cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDi	Inhalation reference dose (mg/kg/d)	CS	CS	
Ca	Concentration of chemical in air as fugitive dusts (mg/m3)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
PEF	Particulate emission factor (m3/kg)	1.32E+09	1.32E+09	
RR	Respiration rate (m3/hr)	0.83	0.83	
ET	Exposure time (hrs/d)	24	24	
EF	Exposure Frequency (d/yr)	350	350	
ED	Exposure Duration (yrs)	24	6	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	

change

					Adult						Young Child					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	Ca (mg/m3)	CSFi 1/(mg/kg/d)	RfDi (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	1.82E-09	0.61	NA	1.7E-10	1.0E-10	0.8%	5.0E-10	--	--	2.0E-10	1.2E-10	0.8%	2.3E-09	--	--
Benzo(a)pyrene	1.8	1.36E-09	6.1	NA	1.3E-10	7.8E-10	5.9%	3.7E-10	--	--	1.5E-10	9.1E-10	5.9%	1.7E-09	--	--
Benzo(b)fluoranthene	4.3	3.26E-09	0.61	NA	3.0E-10	1.9E-10	1.4%	8.9E-10	--	--	3.6E-10	2.2E-10	1.4%	4.1E-09	--	--
Dibenzo(a,h)anthracene	0.18	1.36E-10	6.1	NA	1.3E-11	7.8E-11	0.6%	3.7E-11	--	--	1.5E-11	9.1E-11	0.6%	1.7E-10	--	--
4,4'-DDE	22	1.67E-08	NA	NA	1.6E-09	--	--	4.5E-09	--	--	1.8E-09	--	--	2.1E-08	--	--
4,4'-DDD	18	1.36E-08	NA	NA	1.3E-09	--	--	3.7E-09	--	--	1.5E-09	--	--	1.7E-08	--	--
4,4'-DDT	14	1.06E-08	0.34	NA	9.9E-10	3.4E-10	2.5%	2.9E-09	--	--	1.2E-09	3.9E-10	2.5%	1.4E-08	--	--
Total HxCDD (2378-TCDD TEC)	0.000076	5.76E-14	150,000	NA	5.4E-15	8.1E-10	6.1%	1.6E-14	--	--	6.3E-15	9.4E-10	6.1%	7.3E-14	--	--
Total HxCDF (2378-TCDD TEC)	0.000026	1.97E-14	150,000	NA	1.8E-15	2.8E-10	2.1%	5.4E-15	--	--	2.1E-15	3.2E-10	2.1%	2.5E-14	--	--
Arsenic	10.0	7.58E-09	15.1	NA	7.1E-10	1.1E-08	80.7%	2.1E-09	--	--	8.3E-10	1.2E-08	80.7%	9.6E-09	--	--
Beryllium	0.55	4.17E-10	NA	8.4	3.9E-11	--	--	1.1E-10	1.4E-11	100.0%	4.5E-11	--	--	5.3E-10	6.3E-11	100.0%
					Total ILCR:	1.3E-08	100.0%	Total HI:	1.4E-11	100.0%	Total ILCR:	1.5E-08	100.0%	Total HI:	6.3E-11	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

CsFi + RfDi for Beryllium incorrect

RfDi is 5.7×10^{-6}
CsFi is 8.4

CsFi for PAHs wrong

RES6.WB1

SPREADSHEET 6
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
INGESTION OF GROUNDWATER AS DRINKING WATER AT SWMU 06 / AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cw*IR*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult	Young Child	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cw	Concentration of chemical in water (mg/L)	CS	CS	
IR	Ingestion Rate (L/d)	2	1	
EF	Exposure Frequency (d/yr)	350	350	
ED	Exposure Duration (yrs)	24	6	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	

				Adult						Young Child					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
~~Dissolved~~ Barium	0.45	NA	0.07	0.004227	--	--	0.012329	0.176125	0.987059	0.0024658	--	--	0.028767	0.410959	0.987059
~~Dissolved~~ Beryllium	0.0059	4.3	7.00E-02	5.542E-05	2.4E-04	100.0%	0.000162	0.002309	0.012941	3.233E-05	1.4E-04	100.0%	0.000377	0.005388	0.012941
~~Dissolved~~ Lead	0.0191	NA	NA	0.0001794	--	--	0.000523	--	--	0.0001047	--	--	0.001221	--	--
				Total ILCR:	2.4E-04	100.0%	HI:	0.178434	100.0%	Total ILCR:	1.4E-04	100.0%	HI:	0.416347	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

ok
max total

Res_06b.xls

B-GW-Ing

SPREADSHEET 7
ADULT AND YOUNG CHILD RESIDENTS (AGES 1 TO 6 YEARS) - FUTURE SCENARIO
DERMAL CONTACT WITH GROUNDWATER DURING BATHING AT SWMU 06 / AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cw*CF*Kp*SA*EF*ED*ET)/(BW*AT)

ILCR = CDI*CSFo Adj   CSF Adj = CSF/AD
HQ = CDI/RfDo Adj   RfD Adj = RfD*AD

Parameter	Description	Adult	Young Child	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
SA	Skin surface area available for contact (cm2)	20000	8023	
ET	Exposure frequency (d/yr)	350	350	
ED	Exposure duration (yrs)	24	6	
ET	Exposure time (hrs/day)	0.2	0.2	
BW	Body weight (kg)	70	15	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	8760	2190	
Cw	Concentration of chemical in water (mg/L)	CS	CS	
CF	Conversion factor (L/cm3)	0.001	0.001	
Kp	Dermal permeability coefficient (cm/hour)	CS	CS	
AD	*Adjustment for Absorbed Dose*	CS	CS	

								Adult						Young Child					
								Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	Kp (cm/hour)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	AD (unitless)	Adj CSFo 1/(mg/kg/d)	Adj RfDo (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Dissolved Barium	0.45	0.001	NA	0.07	1	NA	0.07	8.454E-06	--	--	2.47E-05	0.000352	0.432692	3.957E-06	--	--	4.62E-05	0.000659	0.432692
Dissolved Beryllium	0.0059	0.001	4.3	7.00E-02	0.01	430	0.0007	1.108E-07	4.8E-05	100.0%	3.23E-07	0.000462	0.567308	5.187E-08	2.2E-05	100.0%	6.05E-07	0.000865	0.567308
Dissolved Lead	0.0191	0.001	NA	NA	NA	NA	NA	3.588E-07	--	--	1.0E-06	--	--	1.7E-07	--	--	2.0E-06	--	--
								Total ILCR:	4.8E-05	100.0%	HI:	0.000814	100.0%	Total ILCR:	2.2E-05	100.0%	HI:	0.001524	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

October 1999

	RfDo	RfDi
Barium	7.0×10^{-2}	1.4×10^{-4}
Beryllium	2.0×10^{-3}	5.7×10^{-6}
Lead - NO RfD		

Barium - not carcinogen
Beryllium - 5.7×10^{-4} CsFi
no oral
Lead - not carcinogen

SPREADSHEET 8
ADULT ON-SITE WORKER
INGESTION OF POOLED SURFACE WATER AS DRINKING WATER AT SWMU 6/AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cw*IR*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult	
CDI	Chronic daily intake (mg/kg/d)	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	
Cw	Concentration of chemical in water (mg/L)	CS	
IR	Ingestion Rate (L/hour)	0.05	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	25	
ET	Exposure Time (hours)	8	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	

				Adult Worker					
				Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
4,4'-DDE	0.00052	3.40E-01	NA	7.3E-07	2.5E-07	2.3%	2.0E-06	--	--
Total Arsenic	0.0050	1.50E+00	3.00E-04	7.0E-06	1.0E-05	97.7%	2.0E-05	6.5E-02	18.5%
Total Mercury	0.0220	NA	3.00E-04	3.1E-05	--	--	8.6E-05	2.9E-01	81.5%
				Total ILCR:	1.1E-05	100.0%	HI:	3.5E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 9
ADULT ON-SITE WORKER
DERMAL CONTACT WITH POOLED SURFACE WATER AT SWMU 6/AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cw*CF*Kp*SA*EF*ED*ET)/(BW*AT)

ILCR = CDI*CSFo Adj   CSF Adj = CSF/AD
HQ = CDI/RfDo Adj   RfD Adj = RfD*AD

Parameter	Description	Adult	
DAD	Dermally absorbed dose (mg/kg/d)	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	
SA	Skin surface area available for contact (cm2)	5300	
ET	Exposure frequency (d/yr)	250	
ED	Exposure duration (yrs)	25	
ET	Exposure time (hrs/day)	8	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	
Cw	Concentration of chemical in water (mg/L)	CS	
CF	Conversion factor (L/cm3)	0.001	
Kp	Dermal permeability coefficient (cm/hour)	CS	
AD	Adjustment for Absorbed Dose	CS	

								Adult Worker					
								Carcinogens			Noncarcinogens		
Parameter	Cw (mg/L)	Kp (cm/hour)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	AD (unitless)	Adj CSFo 1/(mg/kg/d)	Adj RfDo (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
4,4'-DDE	0.00052	2.40E-01	3.40E-01	NA	0.90	3.78E-01	NA	1.8E-05	7.0E-06	85.7%	5.2E-05	--	--
Total Arsenic	0.0050	1.00E-03	1.50E+00	3.00E-04	0.95	1.58E+00	2.85E-04	7.4E-07	1.2E-06	14.3%	2.1E-06	7.3E-03	3.5%
Total Mercury	0.0220	1.00E-03	NA	3.00E-04	0.15	NA	4.50E-05	3.3E-06	--	--	9.1E-06	2.0E-01	96.5%
								Total ILCR:	8.2E-06	100.0%	HI:	2.1E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 10
ADULT ON-SITE WORKER
ACCIDENTAL INGESTION OF SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult	
CDI	Chronic daily intake (mg/kg/d)	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	
IR	Ingestion Rate (mg/d)	100	
CF	Conversion factor (kg/mg)	1E-06	
FI	Fraction of soil ingested from site	0.5	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	25	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	

				Adult Worker					
				Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	0.73	NA	4.2E-07	3.1E-07	2.6%	1.2E-06	--	--
Benzo(a)pyrene	1.8	7.3	NA	3.1E-07	2.3E-06	19.2%	8.8E-07	--	--
Benzo(b)fluoranthene	4.3	0.73	NA	7.5E-07	5.5E-07	4.6%	2.1E-06	--	--
Dibenzo(a,h)anthracene	0.18	7.3	NA	3.1E-08	2.3E-07	1.9%	8.8E-08	--	--
4,4'-DDE	22	0.34	NA	3.8E-06	1.3E-06	10.9%	1.1E-05	--	--
4,4'-DDD	18	0.24	NA	3.1E-06	7.5E-07	6.3%	8.8E-06	--	--
4,4'-DDT	14	0.34	0.0005	2.4E-06	8.3E-07	6.9%	6.8E-06	1.4E-02	45.6%
Total HxCDD (2378-TCDD TEC)	0.000076	150,000	NA	1.3E-11	2.0E-06	16.6%	3.7E-11	--	--
Total HxCDF (2378-TCDD TEC)	0.000026	150,000	NA	4.5E-12	6.8E-07	5.7%	1.3E-11	--	--
Arsenic	10.0	1.5	0.0003	1.7E-06	2.6E-06	21.9%	4.9E-06	1.6E-02	54.3%
Beryllium	0.55	4.3	0.005	9.6E-08	4.1E-07	3.4%	2.7E-07	5.4E-05	0.2%
				Total ILCR:	1.2E-05	100.0%	Total HI:	3.0E-02	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

Be
① No CsFo
② RfDo = .002

SPREADSHEET 11
ADULT ON-SITE WORKER
DERMAL CONTACT WITH SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult	
DAD	Dermally absorbed dose (mg/kg/d)	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	
CF	Conversion factor (kg/mg)	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	
ABS	Absorption fraction	CS	
A	Skin surface area available for contact (cm2)	5300	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	25	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	

					Adult Worker					
					Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	0.1	1.46	NA	4.4E-06	6.5E-06	3.8%	1.2E-05	--	--
Benzo(a)pyrene	1.8	0.1	14.6	NA	3.3E-06	4.9E-05	28.9%	9.3E-06	--	--
Benzo(b)fluoranthene	4.3	0.1	1.46	NA	8.0E-06	1.2E-05	6.9%	2.2E-05	--	--
Dibenzo(a,h)anthracene	0.18	0.1	14.6	NA	3.3E-07	4.9E-06	2.9%	9.3E-07	--	--
4,4'-DDE	22	0.1	0.38	NA	4.1E-05	1.5E-05	9.2%	1.1E-04	--	--
4,4'-DDD	18	0.1	0.27	NA	3.3E-05	9.0E-06	5.3%	9.3E-05	--	--
4,4'-DDT	14	0.1	0.38	0.00045	2.6E-05	9.9E-06	5.8%	7.3E-05	1.6E-01	71.6%
Total HxCDD (2378-TCDD TEC)	0.000076	0.03	167,000	NA	4.2E-11	7.1E-06	4.2%	1.2E-10	--	--
Total HxCDF (2378-TCDD TEC)	0.000026	0.03	167,000	NA	1.4E-11	2.4E-06	1.4%	4.0E-11	--	--
Arsenic	10.0	0.032	1.58	0.000285	5.9E-06	9.4E-06	5.6%	1.7E-05	5.8E-02	25.8%
Beryllium	0.55	0.01	430	0.00005	1.0E-07	4.4E-05	26.0%	2.9E-07	5.7E-03	2.5%
					Total ILCR:	1.7E-04	100.0%	Total HI:	2.3E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

or

change in accordance with Region III adjustment factors

adjustment of 0.5 used for PAH where's ref

Beryllium

SPREADSHEET 12
ADULT ON-SITE WORKER
INHALATION OF FUGITIVE DUSTS EMANATING FROM SURFACE SOIL IN AOC B
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Ca*RR*ET*EF*ED)/(BW*AT)
Where: Ca = Cs * (1/PEF)

ILCR = CDI*CSFi
HQ = CDI/RfDi

Parameter	Description	Adult	
CDI	Chronic daily intake (mg/kg/d)	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	
CSFi	Inhalation cancer slope factor (1/(mg/kg/d))	CS	
HQ	Hazard quotient	CS	
RfDi	Inhalation reference dose (mg/kg/d)	CS	
Ca	Concentration of chemical in air as fugitive dusts (mg/m3)	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	
PEF	Particulate emission factor (m3/kg)	1.32E+09	
RR	Respiration rate (m3/hr)	0.83	
ET	Exposure time (hrs/d)	8	
EF	Exposure Frequency (d/yr)	250	
ED	Exposure Duration (yrs)	25	
BW	Body weight (kg)	70	
ATc	Averaging time, carcinogens (d)	25550	
ATn	Averaging time, noncarcinogens (d)	9125	

					Adult Worker					
					Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	Ca (mg/m3)	CSFi 1/(mg/kg/d)	RfDi (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)anthracene	2.4	1.82E-09	~~0.01~~	NA	4.2E-11	2.6E-11	0.8%	1.2E-10	--	--
Benzo(a)pyrene	1.8	1.36E-09	~~0.1~~	NA	3.2E-11	1.9E-10	5.9%	8.9E-11	--	--
Benzo(b)fluoranthene	4.3	3.26E-09	~~0.01~~	NA	7.6E-11	4.6E-11	1.4%	2.1E-10	--	--
Dibenzo(a,h)anthracene	0.18	1.36E-10	~~0.1~~	NA	3.2E-12	1.9E-11	0.6%	8.9E-12	--	--
4,4'-DDE	22	1.67E-08	NA	NA	3.9E-10	--	--	1.1E-09	--	--
4,4'-DDD	18	1.36E-08	NA	NA	3.2E-10	--	--	8.9E-10	--	--
4,4'-DDT	14	1.06E-08	0.34	NA	2.5E-10	8.4E-11	2.5%	6.9E-10	--	--
Total HxCDD (2378-TCDD TEC)	0.000076	5.76E-14	150,000	NA	1.3E-15	2.0E-10	6.1%	3.7E-15	--	--
Total HxCDF (2378-TCDD TEC)	0.000026	1.97E-14	150,000	NA	4.6E-16	6.9E-11	2.1%	1.3E-15	--	--
Arsenic	10.0	7.58E-09	15.1	NA	1.8E-10	2.7E-09	80.7%	4.9E-10	--	--
Beryllium	0.55	4.17E-10	~~NA~~	~~8.4~~	9.7E-12	--	--	2.7E-11	3.2E-12	100.0%
					Total ILCR:	3.3E-09	100.0%	Total HI:	3.2E-12	100.0%

3.10

5.7 x 10^{-6}

8.4

? source

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

ATTACHMENT 6
AOC D REVISED RISK ASSESSMENT

REVISED HUMAN HEALTH RISK ASSESSMENT

AOC D

During the Draft RFI Report for OU 1, 6 and 7 prepared by Baker in July 1996, a risk assessment was conducted which evaluated sediments in SWMUs 1, 2, 3, 7, and 11, both individually, and as being inclusive of AOC D (Ensenada Honda). Current recreational users (adult and adolescent ages 7 - 15 years old), current on-site workers and future residents were evaluated for ingestion and dermal exposures to sediments in each of these SWMUs. That evaluation indicated that recreational users were most the most sensitive of the receptor groups, being that unacceptable carcinogenic risks were estimated for exposures to SWMUs 2 and 11. Table 3 presents all pathway and total risks previously estimated for recreational users exposed to sediments in each of the SWMUs that were evaluated as being part of AOC D.

Table 3 shows that the total ICRs estimated for adult and adolescent recreational users in SWMU 2 (2.5×10^{-4} and 1.2×10^{-4}, respectively) exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene, total HxCDD and total PeCDD (41%, 25% and 10% risk contributions, respectively). In addition, the total ICRs estimated for adult and adolescent recreational users in SWMU 11 (1.6×10^{-3} and 7.3×10^{-4}, respectively) exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene and dibenzo(a,h)anthracene (73% and 13% risk contributions, respectively).

As a result of the aforementioned risks, the total carcinogenic risks summed over AOC D for the adult and adolescent recreational users (1.9×10^{-3} and 8.9×10^{-4}, respectively) exceeded USEPA's target risk range. In addition, the total HI value estimated for adolescent recreational users (1.3) slightly exceeded USEPA's acceptable target value of 1.0. However, it should be noted that since the SWMU 11 sampling locations are actually not in the Enseneda Honda, but rather, are in an arm of Puerca Bay, SWMU 11 should be removed from AOC D. In addition, with the presence of elevated risks associated with the SWMU 2 sediments, it has been determined that the sediments should be excluded from AOC D to be combined with the rest of the SWMU 2 media and addressed as part of that unit. Therefore, as Table 3 shows, removal of SWMUs 2 and 11 from AOC D, as indicated by the last row of the table, results in all total site risks, both carcinogenic and noncarcinogenic, are within the corresponding, acceptable target risk criteria.

TABLE 3

**INCREMENTAL CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
FOR CURRENT ADULT AND ADOLESCENT RECREATIONAL USERS
AOC D SEDIMENTS
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO**

Pathway	Recreational Users			
	Adult		Adolescent	
	ICR	HI	ICR	HI
SWMU 1				
Ingestion	--	<0.01	--	<0.01
Dermal Contact	--	<0.01	--	<0.01
SWMU 1 Subtotal	--	<0.01	--	<0.01
SWMU 2				
Ingestion	9.1×10^{-6}	<0.01	5.2×10^{-6}	0.01
Dermal Contact	2.4×10^{-4}	0.60	1.1×10^{-4}	0.90
SWMU 2 Subtotal	2.5×10^{-4} (1)	0.60	1.2×10^{-4} (1)	0.91
SWMU 3				
Ingestion	1.4×10^{-6}	<0.01	8.0×10^{-7}	<0.01
Dermal Contact	5.6×10^{-5}	<0.01	2.5×10^{-5}	<0.01
SWMU 3 Subtotal	5.7×10^{-5}	<0.01	2.6×10^{-5}	<0.01
SWMU 7				
Ingestion	1.4×10^{-6}	<0.01	7.8×10^{-7}	0.01
Dermal Contact	2.5×10^{-5}	0.09	1.1×10^{-5}	0.14
SWMU 7 Subtotal	2.6×10^{-5}	0.09	1.2×10^{-5}	0.15
SWMU 11				
Ingestion	2.2×10^{-5}	<0.01	1.2×10^{-5}	0.02
Dermal Contact	1.6×10^{-3}	0.13	7.2×10^{-4}	0.19
SWMU 11 Subtotal	1.6×10^{-3} (2)	0.13	7.3×10^{-4} (2)	0.21
TOTAL (AOC D)	1.9×10^{-3}	0.82	8.9×10^{-4}	1.3
TOTAL [AOC D - (SWMUs 2 + 11)]	5.0×10^{-5}	0.09	4.0×10^{-5}	0.18

TABLE 3
(Continued)

**INCREMENTAL CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
FOR CURRENT ADULT AND ADOLESCENT RECREATIONAL USERS
AOC D
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO**

Notes:

(1) The total ICR exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene, total HxCDD and total PeCDD (41%, 25% and 10% risk contributions, respectively).

(2) The total ICR exceeded USEPA's target risk range due to dermal exposures to benzo(a)pyrene and dibenzo(a,h)anthracene (73% and 13% risk contributions, respectively).

-- Not ICRs were estimated since no carcinogenic COPCs were identified for SWMU 1.

Shading indicates exceedence of USEPA acceptable target risk criteria by subtotal or total risk value.

SPREADSHEET 13
RECREATIONAL USERS - CURRENT SCENARIO
ACCIDENTAL INGESTION OF SEDIMENT IN SWMU 1
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult Recreationa User	Adolescent Recreational User	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	100	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	0.5	0.5	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

				Adult Recreational User						Adolescent Recreational User					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Copper	110.0	NA	0.04	9.6E-06	--	--	2.2E-05	5.6E-04	100.0%	5.4E-06	--	--	4.2E-05	1.1E-03	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 14
RECREATIONAL USERS - CURRENT SCENARIO
DERMAL CONTACT WITH SEDIMENT IN SWMU 1
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	20000	15700	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

					Adult Recreational User						Adolescent Recreational User					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Copper	110	0.01	NA	0.024	3.8E-05	--	--	9.0E-05	3.7E-03	100.0%	1.7E-05	--	--	1.3E-04	5.5E-03	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 15
RECREATIONAL USERS - CURRENT SCENARIO
ACCIDENTAL INGESTION OF SEDIMENT IN SWMU 2
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	100	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	0.5	0.5	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

				Adult Recreational User						Adolescent Recreational User					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Anthracene	0.3	NA	0.3	2.6E-08	--	--	6.1E-08	2.0E-07	0.0%	1.5E-08	--	--	1.2E-07	3.9E-07	0.0%
Benzo(a)anthracene	2.2	0.73	NA	1.9E-07	1.4E-07	1.5%	4.5E-07	--	--	1.1E-07	8.0E-08	1.5%	8.5E-07	--	--
Benzo(a)pyrene	1.9	7.3	NA	1.7E-07	1.2E-06	13.3%	3.9E-07	--	--	9.4E-08	6.9E-07	13.3%	7.3E-07	--	--
Benzo(b)fluoranthene	2.7	0.73	NA	2.4E-07	1.7E-07	1.9%	5.5E-07	--	--	1.3E-07	9.8E-08	1.9%	1.0E-06	--	--
Chrysene	2.6	0.0073	NA	2.3E-07	1.7E-09	0.0%	5.3E-07	--	--	1.3E-07	9.4E-10	0.0%	1.0E-06	--	--
Dibenzo(a,h)anthracene	0.26	7.3	NA	2.3E-08	1.7E-07	1.8%	5.3E-08	--	--	1.3E-08	9.4E-08	1.8%	1.0E-07	--	--
Fluoranthene	3.5	NA	0.04	3.1E-07	--	--	7.1E-07	1.8E-05	0.3%	1.7E-07	--	--	1.3E-06	3.4E-05	0.3%
Fluorene	0.062	NA	0.04	5.4E-09	--	--	1.3E-08	3.2E-07	0.0%	3.1E-09	--	--	2.4E-08	6.0E-07	0.0%
Indeno(1,2,3-cd)pyrene	1	0.73	NA	8.7E-08	6.4E-08	0.7%	2.0E-07	--	--	5.0E-08	3.6E-08	0.7%	3.9E-07	--	--
Phenanthrene	1.9	NA	0.04	1.7E-07	--	--	3.9E-07	9.7E-06	0.1%	9.4E-08	--	--	7.3E-07	1.8E-05	0.1%
Pyrene	5.5	NA	0.03	4.8E-07	--	--	1.1E-06	3.7E-05	0.5%	2.7E-07	--	--	2.1E-06	7.1E-05	0.5%
4,4'-DDE	0.033	0.34	NA	2.9E-09	9.8E-10	0.0%	6.7E-09	--	--	1.6E-09	5.6E-10	0.0%	1.3E-08	--	--
Total PeCDD (2378-TCDD TEC	0.00013	150,000	NA	1.1E-11	1.7E-06	18.7%	2.6E-11	--	--	6.4E-12	9.7E-07	18.7%	5.0E-11	--	--
Total HxCDD (2378-TCDD TEC	0.00033	150,000	NA	2.9E-11	4.3E-06	47.5%	6.7E-11	--	--	1.6E-11	2.5E-06	47.5%	1.3E-10	--	--
Total HxCDF (2378-TCDD TEC)	0.0001	150,000	NA	8.7E-12	1.3E-06	14.4%	2.0E-11	--	--	5.0E-12	7.4E-07	14.4%	3.9E-11	--	--
Cadmium	1.2	NA	0.0005	1.0E-07	--	--	2.4E-07	4.9E-04	7.1%	5.9E-08	--	--	4.6E-07	9.2E-04	7.1%
Copper	830.0	NA	0.04	7.2E-05	--	--	1.7E-04	4.2E-03	61.2%	4.1E-05	--	--	3.2E-04	8.0E-03	61.2%
Lead	339	NA	NA	3.0E-05	--	--	6.9E-05	--	--	1.7E-05	--	--	1.3E-04	--	--
Mercury	2.7	NA	0.0003	2.4E-07	--	--	5.5E-07	1.8E-03	26.5%	1.3E-07	--	--	1.0E-06	3.5E-03	26.5%
Zinc	432	NA	0.3	3.8E-05	--	--	8.8E-05	2.9E-04	4.2%	2.1E-05	--	--	1.7E-04	5.5E-04	4.2%
				Total ILCR:	9.1E-06	100.0%	Total HI:	6.9E-03	100.0%	Total ILCR:	5.2E-06	100.0%	Total HI:	1.3E-02	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 16
RECREATIONAL USERS - CURRENT SCENARIO
DERMAL CONTACT WITH SEDIMENT IN SWMU2
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	20000	15700	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

					Adult Recreational User						Adolescent Recreational User					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Anthracene	0.3	0.1	NA	0.6	1.0E-06	--	--	2.4E-06	4.1E-06	0.0%	4.7E-07	--	--	3.6E-06	6.0E-06	0.0%
Benzo(a)anthracene	2.2	0.1	1.46	NA	7.7E-06	1.1E-05	4.7%	1.8E-05	--	--	3.4E-06	5.0E-06	4.7%	2.7E-05	--	--
Benzo(a)pyrene	1.9	0.1	14.6	NA	6.6E-06	9.7E-05	40.6%	1.5E-05	--	--	3.0E-06	4.3E-05	40.6%	2.3E-05	--	--
Benzo(b)fluoranthene	2.7	0.1	1.46	NA	9.4E-06	1.4E-05	5.8%	2.2E-05	--	--	4.2E-06	6.1E-06	5.8%	3.3E-05	--	--
Chrysene	2.6	0.1	0.0146	NA	9.1E-06	1.3E-07	0.1%	2.1E-05	--	--	4.0E-06	5.9E-08	0.1%	3.1E-05	--	--
Dibenzo(a,h)anthracene	0.26	0.1	14.6	NA	9.1E-07	1.3E-05	5.6%	2.1E-06	--	--	4.0E-07	5.9E-06	5.6%	3.1E-06	--	--
Fluoranthene	3.5	0.1	NA	0.02	1.2E-05	--	--	2.8E-05	1.4E-03	0.2%	5.4E-06	--	--	4.2E-05	2.1E-03	0.2%
Fluorene	0.062	0.1	NA	0.02	2.2E-07	--	--	5.0E-07	2.5E-05	0.0%	9.6E-08	--	--	7.5E-07	3.7E-05	0.0%
Indeno(1,2,3-cd)pyrene	1	0.1	1.46	NA	3.5E-06	5.1E-06	2.1%	8.1E-06	--	--	1.6E-06	2.3E-06	2.1%	1.2E-05	--	--
Phenanthrene	1.9	0.1	NA	0.02	6.6E-06	--	--	1.5E-05	7.7E-04	0.1%	3.0E-06	--	--	2.3E-05	1.1E-03	0.1%
Pyrene	5.5	0.1	NA	0.015	1.9E-05	--	--	4.5E-05	3.0E-03	0.5%	8.5E-06	--	--	6.6E-05	4.4E-03	0.5%
4,4'-DDE	0.033	0.1	0.38	NA	1.2E-07	4.4E-08	0.0%	2.7E-07	--	--	5.1E-08	1.9E-08	0.0%	4.0E-07	--	--
Total PeCDD (2378-TCDD TEC	0.00013	0.03	167,000	NA	1.4E-10	2.3E-05	9.5%	3.2E-10	--	--	6.1E-11	1.0E-05	9.5%	4.7E-10	--	--
Total HxCDD (2378-TCDD TEC	0.00033	0.03	167,000	NA	3.5E-10	5.8E-05	24.2%	8.1E-10	--	--	1.5E-10	2.6E-05	24.2%	1.2E-09	--	--
Total HxCDF (2378-TCDD TEC	0.0001	0.03	167,000	NA	1.0E-10	1.7E-05	7.3%	2.4E-10	--	--	4.7E-11	7.8E-06	7.3%	3.6E-10	--	--
Cadmium	1.2	0.01	NA	0.0000125	4.2E-07	--	--	9.8E-07	7.8E-02	12.9%	1.9E-07	--	--	1.5E-06	1.2E-01	12.9%
Copper	830.0	0.01	NA	0.024	2.9E-04	--	--	6.8E-04	2.8E-02	4.7%	1.3E-04	--	--	1.0E-03	4.2E-02	4.7%
Lead	339	0.01	NA	NA	1.2E-04	--	--	2.8E-04	--	--	5.3E-05	--	--	4.1E-04	--	--
Mercury	2.7	0.01	NA	0.0000045	9.4E-07	--	--	2.2E-06	4.9E-01	80.8%	4.2E-07	--	--	3.3E-06	7.3E-01	80.8%
Zinc	432	0.01	NA	0.075	1.5E-04	--	--	3.5E-04	4.7E-03	0.8%	6.7E-05	--	--	5.2E-04	7.0E-03	0.8%
					Total ILCR:	2.4E-04	100.0%	Total HI:	6.0E-01	100.0%	Total ILCR:	1.1E-04	100.0%	Total HI:	9.0E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 17
RECREATIONAL USERS - CURRENT SCENARIO
ACCIDENTAL INGESTION OF SEDIMENT IN SWMU 3
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	100	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	0.5	0.5	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

				Adult Recreational User						Adolescent Recreational User					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Total HxCDD (2378-TCDD TEC)	0.0001	150,000	NA	8.7E-12	1.3E-06	93.1%	2.0E-11	--	--	5.0E-12	7.4E-07	93.1%	3.9E-11	--	--
Beryllium	0.26	4.3	0.005	2.3E-08	9.8E-08	6.9%	5.3E-08	1.1E-05	5.1%	1.3E-08	5.5E-08	6.9%	1.0E-07	2.0E-05	5.1%
Copper	38.4	NA	0.04	3.3E-06	--	--	7.8E-06	2.0E-04	94.9%	1.9E-06	--	--	1.5E-05	3.7E-04	94.9%
Lead	194	NA	NA	1.7E-05	--	--	3.9E-05	--	--	9.6E-06	--	--	7.5E-05	--	--
				Total ILCR	1.4E-06	100.0%	Total HI:	2.1E-04	100.0%	Total ILCR:	8.0E-07	100.0%	Total HI:	3.9E-04	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 18
RECREATIONAL USERS - CURRENT SCENARIO
DERMAL CONTACT WITH SEDIMENT IN SWMU 3
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult Recreationa User	Adolescent Recreational User	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	20000	15700	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

					Adult Recreational User						Adolescent Recreational User					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Total HxCDD (2378-TCDD TEC	0.0001	0.03	167,000	NA	1.0E-10	1.7E-05	30.9%	2.4E-10	--	--	4.7E-11	7.8E-06	30.9%	3.6E-10	--	--
Beryllium	0.26	0.01	430	0.00005	9.1E-08	3.9E-05	69.1%	2.1E-07	4.2E-03	76.5%	4.0E-08	1.7E-05	69.1%	3.1E-07	6.3E-03	76.5%
Copper	38.4	0.01	NA	0.024	1.3E-05	--	--	3.1E-05	1.3E-03	23.5%	6.0E-06	--	--	4.6E-05	1.9E-03	23.5%
Lead	194	0.01	NA	NA	6.8E-05	--	--	1.6E-04	--	--	3.0E-05	--	--	2.3E-04	--	--
					Total ILCR:	5.6E-05	100.0%	Total HI:	5.5E-03	100.0%	Total ILCR:	2.5E-05	100.0%	Total HI:	8.2E-03	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 19
RECREATIONAL USERS - CURRENT SCENARIO
ACCIDENTAL INGESTION OF SEDIMENT IN SWMU 7
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	100	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	0.5	0.5	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

				Adult Recreational User						Adolescent Recreational User					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib HI
Benzo(a)pyrene	0.15	7.3	NA	1.3E-08	9.6E-08	6.9%	3.1E-08	--	--	7.4E-09	5.4E-08	6.9%	5.8E-08	--	--
Chrysene	0.47	0.0073	NA	4.1E-08	3.0E-10	0.0%	9.6E-08	--	--	2.3E-08	1.7E-10	0.0%	1.8E-07	--	--
Arsenic	9.8	1.5	0.0003	8.5E-07	1.3E-06	93.0%	2.0E-06	6.6E-03	100.0%	4.9E-07	7.3E-07	93.0%	3.8E-06	1.3E-02	100.0%
				Total ILCR:	1.4E-06	100.0%	Total HI:	6.6E-03	100.0%	Total ILCR:	7.8E-07	100.0%	Total HI:	1.3E-02	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 20
RECREATIONAL USERS - CURRENT SCENARIO
DERMAL CONTACT WITH SEDIMENT IN SWMU 7
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult Recreationa User	Adolescent Recreational User	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	20000	15700	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

					Adult Recreational User						Adolescent Recreational User					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Benzo(a)pyrene	0.15	0.1	14.6	NA	5.2E-07	7.6E-06	30.6%	1.2E-06	--	--	2.3E-07	3.4E-06	30.6%	1.8E-06	--	--
Chrysene	0.47	0.1	0.0146	NA	1.6E-06	2.4E-08	0.1%	3.8E-06	--	--	7.3E-07	1.1E-08	0.1%	5.7E-06	--	--
Arsenic	9.8	0.032	1.58	0.00028	1.1E-05	1.7E-05	69.3%	2.6E-05	9.1E-02	100.0%	4.9E-06	7.7E-06	69.3%	3.8E-05	1.4E-01	100.0%
					Total ILCR:	2.5E-05	100.0%	Total HI:	9.1E-02	100.0%	Total ILCR:	1.1E-05	100.0%	Total HI:	1.4E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 21
RECREATIONAL USERS - CURRENT SCENARIO
ACCIDENTAL INGESTION OF SEDIMENT IN SWMU 11
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

CDI (mg/kg/d)= (Cs*IR*CF*FI*EF*ED)/(BW*AT)
ILCR = CDI*CSFo
HQ = CDI/RfDo

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
CDI	Chronic daily intake (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
IR	Ingestion Rate (mg/d)	100	100	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
FI	Fraction of soil ingested from site	0.5	0.5	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

				Adult Recreational User						Adolescent Recreational User					
				Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	CSFo 1/(mg/kg/d)	RfDo (mg/kg/d)	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI	CDI (mg/kg/d)	ILCR	% Contrib. Total ILCR	CDI (mg/kg/d)	HQ	% Contrib. HI
Acenaphthylene	1.8	NA	0.04	1.6E-07	--	--	3.7E-07	9.2E-06	0.1%	8.9E-08	--	--	6.9E-07	1.7E-05	0.1%
Anthracene	2.2	NA	0.3	1.9E-07	--	--	4.5E-07	1.5E-06	0.0%	1.1E-07	--	--	8.5E-07	2.8E-06	0.0%
Benzo(a)anthracene	3.7	0.73	NA	3.2E-07	2.4E-07	1.1%	7.5E-07	--	--	1.8E-07	1.3E-07	1.1%	1.4E-06	--	--
Benzo(a)pyrene	23	7.3	NA	2.0E-06	1.5E-05	67.8%	4.7E-06	--	--	1.1E-06	8.3E-06	67.8%	8.9E-06	--	--
Benzo(b)fluoranthene	24	0.73	NA	2.1E-06	1.5E-06	7.1%	4.9E-06	--	--	1.2E-06	8.7E-07	7.1%	9.2E-06	--	--
Benzo(k)fluoranthene	21	0.073	NA	1.8E-06	1.3E-07	0.6%	4.3E-06	--	--	1.0E-06	7.6E-08	0.6%	8.1E-06	--	--
Chrysene	10	0.0073	NA	8.7E-07	6.4E-09	0.0%	2.0E-06	--	--	5.0E-07	3.6E-09	0.0%	3.9E-06	--	--
Dibenzo(a,h)anthracene	4.2	7.3	NA	3.7E-07	2.7E-06	12.4%	8.5E-07	--	--	2.1E-07	1.5E-06	12.4%	1.6E-06	--	--
Fluoranthene	0.66	NA	0.04	5.8E-08	--	--	1.3E-07	3.4E-06	0.0%	3.3E-08	--	--	2.5E-07	6.4E-06	0.0%
Indeno(1,2,3-cd)pyrene	10	0.73	NA	8.7E-07	6.4E-07	2.9%	2.0E-06	--	--	5.0E-07	3.6E-07	2.9%	3.9E-06	--	--
Pyrene	6	NA	0.03	5.2E-07	--	--	1.2E-06	4.1E-05	0.5%	3.0E-07	--	--	2.3E-06	7.7E-05	0.5%
Arsenic	13.2	1.5	0.0003	1.2E-06	1.7E-06	8.0%	2.7E-06	9.0E-03	99.4%	6.5E-07	9.8E-07	8.0%	5.1E-06	1.7E-02	99.4%
Lead	194	NA	NA	1.7E-05	--	--	3.9E-05	--	--	9.6E-06	--	--	7.5E-05	--	--
				Total ILCR:	2.2E-05	100.0%	Total HI:	9.0E-03	100.0%	Total ILCR:	1.2E-05	100.0%	Total HI:	1.7E-02	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

SPREADSHEET 22
RECREATIONAL USERS - CURRENT SCENARIO
DERMAL CONTACT WITH SEDIMENT IN SWMU 11
REASONABLE MAXIMUM EXPOSURE
POTENTIAL CARCINOGENIC AND NONCARCINOGENIC RISKS
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

DAD (mg/kg/d)= (Cs*CF*AF*ABS*A*EF*ED)/(BW*AT)
ILCR = CDI*CSFd
HQ = CDI/RfDd

Parameter	Description	Adult Recreational User	Adolescent Recreational User	
DAD	Dermally absorbed dose (mg/kg/d)	CS	CS	(Chemical Specific)
ILCR	Incremental lifetime cancer risk	CS	CS	
CSFo	Oral cancer slope factor (1/(mg/kg/d))	CS	CS	
HQ	Hazard quotient	CS	CS	
RfDo	Oral reference dose (mg/kg/d)	CS	CS	
Cs	Concentration of chemical in soil (mg/kg)	CS	CS	
CF	Conversion factor (kg/mg)	1E-06	1E-06	
AF	Soil to skin adherence factor (mg/cm2-event)	1	1	
ABS	Absorption fraction	CS	CS	
A	Skin surface area available for contact (cm2)	20000	15700	
EF	Exposure Frequency (d/yr)	104	104	
ED	Exposure Duration (yrs)	30	9	
BW	Body weight (kg)	70	37	
ATc	Averaging time, carcinogens (d)	25550	25550	
ATn	Averaging time, noncarcinogens (d)	10950	3285	

					Adult Recreational User						Adolescent Recreational User					
					Carcinogens			Noncarcinogens			Carcinogens			Noncarcinogens		
Parameter	Cs (mg/kg)	ABS	CSFd 1/(mg/kg/d)	RfDd (mg/kg/d)	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI	DAD (mg/kg/d)	ILCR	% Contrib. Total ILCR	DAD (mg/kg/d)	HQ	% Contrib. HI
Acenaphthylene	1.8	0.1	NA	0.02	6.3E-06	--	--	1.5E-05	7.3E-04	0.6%	2.8E-06	--	--	2.2E-05	1.1E-03	0.6%
Anthracene	2.2	0.1	NA	0.6	7.7E-06	--	--	1.8E-05	3.0E-05	0.0%	3.4E-06	--	--	2.7E-05	4.4E-05	0.0%
Benzo(a)anthracene	3.7	0.1	1.46	NA	1.3E-05	1.9E-05	1.2%	3.0E-05	--	--	5.8E-06	8.4E-06	1.2%	4.5E-05	--	--
Benzo(a)pyrene	23	0.1	14.6	NA	8.0E-05	1.2E-03	72.7%	1.9E-04	--	--	3.6E-05	5.2E-04	72.7%	2.8E-04	--	--
Benzo(b)fluoranthene	24	0.1	1.46	NA	8.4E-05	1.2E-04	7.6%	2.0E-04	--	--	3.7E-05	5.4E-05	7.6%	2.9E-04	--	--
Benzo(k)fluoranthene	21	0.1	0.146	NA	7.3E-05	1.1E-05	0.7%	1.7E-04	--	--	3.3E-05	4.8E-06	0.7%	2.5E-04	--	--
Chrysene	10	0.1	0.0146	NA	3.5E-05	5.1E-07	0.0%	8.1E-05	--	--	1.6E-05	2.3E-07	0.0%	1.2E-04	--	--
Dibenzo(a,h)anthracene	4.2	0.1	14.6	NA	1.5E-05	2.1E-04	13.3%	3.4E-05	--	--	6.5E-06	9.5E-05	13.3%	5.1E-05	--	--
Fluoranthene	0.66	0.1	NA	0.02	2.3E-06	--	--	5.4E-06	2.7E-04	0.2%	1.0E-06	--	--	8.0E-06	4.0E-04	0.2%
Indeno(1,2,3-cd)pyrene	10	0.1	1.46	NA	3.5E-05	5.1E-05	3.2%	8.1E-05	--	--	1.6E-05	2.3E-05	3.2%	1.2E-04	--	--
Pyrene	6	0.1	NA	0.015	2.1E-05	--	--	4.9E-05	3.3E-03	2.6%	9.3E-06	--	--	7.3E-05	4.8E-03	2.6%
Arsenic	13.2	0.032	1.58	0.00028	1.5E-05	2.3E-05	1.4%	3.4E-05	1.2E-01	96.6%	6.6E-06	1.0E-05	1.4%	5.1E-05	1.8E-01	96.6%
Lead	194	0.01	NA	NA	6.8E-05	--	--	1.6E-04	--	--	3.0E-05	--	--	2.3E-04	--	--
					Total ILCR:	1.6E-03	100.0%	Total HI:	1.3E-01	100.0%	Total ILCR:	7.2E-04	100.0%	Total HI:	1.9E-01	100.0%

NOTES:
NA - Toxicity criterion not available.
-- Not applicable.

ATTACHMENT 7
DIOXIN OCCURRENCE AT NSRR

U.S.NAVAL STATION ROOSEVELT ROADS
DIOXIN DETECTIONS IN SOIL

Site ID	Sample Date	Depth (ft)	Analyte	Conc.	Units	Qualifier
13SS05	10/24/95	0.5	Total HxCDD	0.18	ug/kg	J
13SS05	10/24/95	0.5	Total HxCDF	0.8	ug/kg	J
13SS06	10/24/95	0.5	Total HxCDF	0.09	ug/kg	J
13SS06	10/24/95	0.5	Total PeCDF	0.22	ug/kg	J
13SS06D	10/24/95	0	Total HxCDF	0.15	ug/kg	J
13SS06D	10/24/95	0	Total PeCDF	0.11	ug/kg	J
13SS07D	10/24/95	0.5	Total HxCDD	0.007	ug/kg	J
13SS08D	10/24/95	0	Total HxCDD	0.17	ug/kg	J
13SS08D	10/24/95	0	Total HxCDF	0.41	ug/kg	J
1MW01	10/29/96	5	Total PeCDF	0.09	ug/kg	J
1MW05	9/18/97	11	Total HxCDF	0.14	ug/kg	J
1SB03	10/24/96	7	Total HxCDF	0.17	ug/kg	J
1SB03	10/24/96	7	Total HxCDD	0.3	ug/kg	J
1SD01	10/22/96	0	Total HxCDF	0.31	ug/kg	J
1SD01	10/22/96	0	Total HxCDD	0.64	ug/kg	J
1SD02	10/22/96	0	Total HxCDF	2.2	ug/kg	J
1SD02	10/22/96	0	Total PeCDF	0.34	ug/kg	J
1SD02	10/22/96	0	Total PeCDF	0.13	ug/kg	J
1SD02	10/22/96	0	Total HxCDD	2.4	ug/kg	J
1SS06	10/10/96	0	Total HxCDF	0.13	ug/kg	JS
2SB03	10/8/96	0	Total HxCDF	0.17	ug/kg	J
2SB03	10/8/96	0	Total HxCDD	0.37	ug/kg	J
2SB04	11/10/96	5	Total PeCDF	0.28	ug/kg	JS
2SB04	11/10/96	5	Total HxCDD	0.21	ug/kg	JS
2SB05	11/10/96	4	Total PeCDF	0.07	ug/kg	JS
2SD03	10/31/95	0.5	Total HxCDD	2.5	ug/kg	
2SD03	10/31/95	0.5	Total HxCDF	0.91	ug/kg	J
31SS02	10/31/95	0.5	Total HxCDF	0.06	ug/kg	J
31SS04	10/31/95	0.5	Total HxCDD	12	ug/kg	
31SS04	10/31/95	0.5	Total HxCDF	43	ug/kg	
31SS04	10/31/95	0.5	Total PeCDD	0.74	ug/kg	J
31SS04	10/31/95	0.5	Total PeCDF	3.1	ug/kg	
31SS04	10/31/95	0.5	Total TCDF	0.17	ug/kg	J
31SS05	9/24/97	0.5	Total HxCDD	1.5	ug/kg	J
31SS05	9/24/97	0.5	Total HxCDF	3.3	ug/kg	
31SS05	9/24/97	0.5	Total PeCDF	0.52	ug/kg	J
31SS06	9/24/97	0.5	Total HxCDD	0.58	ug/kg	J
31SS06	9/24/97	0.5	Total HxCDF	1.7	ug/kg	
31SS06	9/24/97	0.5	Total PeCDF	0.69	ug/kg	J
31SS06	9/24/97	0.5	Total TCDF	0.15	ug/kg	J
31SS07	9/24/97	0.5	Total HxCDD	1.4	ug/kg	J
31SS07	9/24/97	0.5	Total HxCDF	1.8	ug/kg	
31SS07	9/24/97	0.5	Total PeCDF	1.1	ug/kg	
31SS08	9/24/97	0.5	Total HxCDD	0.16	ug/kg	J

U.S.NAVAL STATION ROOSEVELT ROADS
DIOXIN DETECTIONS IN SOIL

Site ID	Sample Date	Depth (ft)	Analyte	Conc.	Units	Qualifier
31SS08	9/24/97	0.5	Total HxCDF	0.4	ug/kg	J
31SS08	9/24/97	0.5	Total PeCDF	0.29	ug/kg	J
31SS08	9/24/97	0.5	Total TCDF	0.04	ug/kg	J
31SS11	9/24/97	0.5	Total PeCDF	0.07	ug/kg	J
31SS12	9/24/97	0.5	Total HxCDF	0.1	ug/kg	J
31SS12D	9/24/97	0.5	Total HxCDD	0.3	ug/kg	J
31SS12D	9/24/97	0.5	Total HxCDF	0.67	ug/kg	J
3SD15	10/28/95	0.5	Total HxCDD	1	ug/kg	J
6SB01	3/19/96	0.5	Total HxCDD	0.25	ug/kg	J
6SB01D	3/19/96	0	Total HxCDF	0.26	ug/kg	J
6SS01	3/19/96	0.5	Total HxCDD	0.76	ug/kg	J
6SS01	3/19/96	0.5	Total HxCDF	0.23	ug/kg	J
6SS01D	3/19/96	0.5	Total HxCDD	0.74	ug/kg	J
6SS01D	3/19/96	0.5	Total HxCDF	0.17	ug/kg	J
ACSS02	10/25/95	0.5	Total HxCDF	2	ug/kg	
ACSS02	10/25/95	0.5	Total PeCDF	2.4	ug/kg	
ACSS02	10/25/95	0.5	Total TCDF	1	ug/kg	J
ACSS03	10/25/95	0.5	Total HxCDF	0.14	ug/kg	J
BGMW03	4/12/96	7	Total HxCDD	0.31	ug/kg	J

U.S.NAVAL STATION ROOSEVELT ROADS
DIOXIN DETECTIONS IN SEDIMENTS

Site ID	Sample Date	Depth (ft)	Analyte	Conc.	Units	Qualifier
1SD01	10/22/96	0	Total HxCDF	0.31	ug/kg	J
1SD01	10/22/96	0	Total HxCDD	0.64	ug/kg	J
1SD02	10/22/96	0	Total HxCDF	2.2	ug/kg	J
1SD02	10/22/96	0	Total PeCDF	0.34	ug/kg	J
1SD02	10/22/96	0	Total PeCDF	0.13	ug/kg	J
1SD02	10/22/96	0	Total HxCDD	2.4	ug/kg	J
2SD03	10/31/95	0.5	Total HxCDD	2.5	ug/kg	
2SD03	10/31/95	0.5	Total HxCDF	0.91	ug/kg	J
3SD15	10/28/95	0.5	Total HxCDD	1	ug/kg	J

REVISIONS		NORTH		
	DRAWN WJH REVIEWED TCF S.O.# 62470-277-0000-07000 CADD# 277917WP			

CTO – 0277
U.S. NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DIOXIN DETECTIONS IN SOIL LOCATION MAP

SCALE 1" = 1000'

DATE NOVEMBER 1998

SHEET NO. 1 OF 1

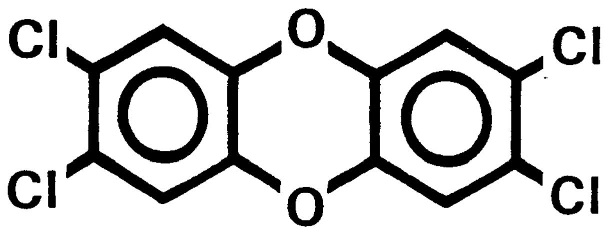
ATTACHMENT 8
SOURCE OF DIOXIN REFERENCE

NIOSH

Current Intelligence Bulletin 40

January 23, 1984

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD, "dioxin")



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

DISCLAIMER

Mention of the name of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

DHHS (NIOSH) Publication No. 84-104

FOREWORD

Current Intelligence Bulletins are reports issued by the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control, Atlanta, Georgia, for the purpose of disseminating new scientific information about occupational hazards. A Current Intelligence Bulletin may draw attention to a hazard previously unrecognized or may report new data suggesting that a known hazard is either more or less dangerous than was previously thought.

Current Intelligence Bulletins are prepared by the staff of the Division of Standards Development and Technology Transfer, NIOSH, (Robert A. Taft Laboratories, 4676 Columbia Parkway, Cincinnati, Ohio, 45226) and are distributed to representatives of organized labor, industry, public health agencies, academic institutions, and public interest groups as well as to those federal agencies, such as the Department of Labor, which have responsibilities for protecting the health of workers. It is our intention that anyone with the need to know should have ready access to the information contained in these documents; we welcome suggestions concerning their content, style, and distribution.

Because of the recent attention given to human exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD, "dioxin") contaminated materials and published reports on the toxicity of TCDD, NIOSH staff consider it necessary to present a review of the pertinent data and a summary of findings related to the human hazard potential of TCDD. Because of the compression in this bulletin of the voluminous literature on TCDD, it is suggested that readers wanting to know more of the details of the reported studies consult the appended references.

J. Donald Millar, M.D., D.T.P.H. (Lond.)
Assistant Surgeon General
Director, National Institute for
Occupational Safety and Health
Centers for Disease Control

CURRENT INTELLIGENCE BULLETIN #40

2,3,7,8-Tetrachlorodibenzo-p-dioxin
(TCDD, "DIOXIN")

January 23, 1984

ABSTRACT

In animals, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD, "dioxin") causes various systemic effects at a wide range of exposure concentrations, including tumorigenesis, immunological dysfunction, and teratogenesis. Studies of humans exposed to TCDD-contaminated materials suggest that TCDD is the cause of observed chloracne, metabolic disorders (porphyria), and other systemic problems and are suggestive of TCDD's ability to cause cancer.

TCDD occurs as a contaminant of materials such as 2,4,5-trichlorophenol (TCP), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and 2-(2,4,5-trichlorophenoxy)propionic acid (silvex). Occupational exposure may occur through contact with these materials during use or from the past contamination of worksites.

The National Institute for Occupational Safety and Health (NIOSH) recommends that TCDD be regarded as a potential occupational carcinogen, that occupational exposure to TCDD be controlled to the fullest extent feasible, and that decontamination measures be used for TCDD-contaminated work environments. This recommendation is based on a number of reliable studies demonstrating TCDD carcinogenicity in rats and mice.

BACKGROUND

Physical and Chemical Properties of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)

TCDD is one of a family of isomers known chemically as dibenzo-p-dioxins. The chemical and physical properties are summarized in Table I. TCDD is a colorless crystalline solid at room temperature. It is sparingly soluble in most organic solvents and essentially insoluble in water. TCDD is stable to heat, acids, and alkali and will decompose when exposed to ultraviolet light, including sunlight [1].

TABLE I

CHEMICAL AND PHYSICAL PROPERTIES OF TCDD [2,3]

CAS Registry No.: 1746-01-6		
Empirical formula		$C_{12}H_4Cl_4O_2$
Percent by weight	C	44.7
	O	9.95
	H	1.25
	Cl	44.1
Molecular weight		322
Vapor Pressure mm Hg at 25°C		1.7×10^{-6}
Melting point, °C		305
Decomposition temperature, °C		>700
Solubilities, g/liter		
o-Dichlorobenzene		1.4
Chlorobenzene		0.72
Benzene		0.57
Chloroform		0.37
n-Octanol		0.05
Methanol		0.01
Acetone		0.11
Water		2×10^{-7}

Formation and Use of TCDD

TCDD forms as a stable by-product or contaminant during the production of TCP. Run-away reactions at high temperature, in which excess TCDD was produced, have occurred at TCP production sites in the United States and elsewhere [4]. Normally, TCDD persists as a contaminant in TCP in relatively small, variable amounts (0.07-6.2 mg/kg) [5]. TCP has been utilized primarily as a feedstock for production of the phenoxy herbicides 2,4,5-T and silvex, resulting in the contamination of these products with TCDD. Production of 2,4,5-T and silvex ceased in the United States in 1979. However, stockpiles of both products are still being distributed and used. TCP also is used in the production of hexachlorophene, a bactericide and fungicide.

The combustion of 2,4,5-T can result in its conversion to small amounts (0.6 ppt TCDD/1 ppm 2,4,5-T burned) of TCDD. Also, the burning or heating of commercial and purified chlorophenates and pyrolysis of polychlorinated biphenyls (PCBs) contaminated with trichlorobenzenes have resulted in the production of TCDD [6,7]. The formation of TCDD from trace chemical reactions in fires has been postulated but has not been verified [8,9].

Existing Regulations and Guides

No occupational exposure standard exists for TCDD. The United States Environmental Protection Agency (U.S. EPA) temporarily suspended or banned most uses of 2,4,5-T and silvex in 1979, although their use was allowed on sugarcane, orchards and for miscellaneous non-crop uses [10]. On October 18, 1983 EPA published its intent to cancel registration of pesticide products containing 2,4,5-T and silvex and to prohibit the transfer, distribution, sale or importation of any unregistered pesticide product containing 2,4,5-T or silvex or their derivatives [11].

Nature of Occupational Exposure to TCDD

It is not possible to estimate accurately the number of U.S. workers currently at risk of exposure to TCDD. Occupational exposure to TCDD may occur during production of TCP; in decontamination of worksites from prior production or use of TCP, 2,4,5-T, or silvex; from waste materials (such as reclaimed oil) contaminated with TCDD; or from cleanup after fires in transformers containing polychlorinated aromatics.

Dust or soil particles contaminated with TCDD can remain airborne or accumulate on indoor or outdoor work surfaces and may present a potential exposure hazard. Exposure to TCDD as a vapor will normally be negligible because of its low vapor pressure. Contact with TCDD-contaminated liquids is possible through the handling of drums or tanks containing the liquid or through dispersion of the liquid.

TOXICITY

Results of Studies of TCDD in Animals

Acute and Chronic Toxicity

There is wide variation in the dosage of TCDD required to cause death among animal species (oral LD_{50} 0.6-5,000 µg TCDD/kg body weight (bw)) [12,13]. Progressive weight loss with death several weeks later is reported to characterize the response in experimental animals after administration of a lethal dosage of TCDD [12,14,15]. Animals given single or repeated oral dosages of TCDD of 0.1 to 25 µg/kg bw demonstrated increased liver weights and lipid accumulation, thymic atrophy, and histopathological changes in liver and thymus [12,16-18].

TCDD is reported to be at least three times more potent than any other known compound in stimulating production of aminolevulinic acid synthetase (ALA), the rate-limiting enzyme in porphyrin and heme synthesis [19,20]. Varied effects on hematological functions have been reported in rats and mice dosed with TCDD: increased numbers of erythrocytes and leucocytes, increased hemoglobin concentration, decreased blood platelets in rats [21,22], and decreased hemoglobin concentration in mice [23].

Effects on Reproductive Function

TCDD administered at dosages of 0.125-3.0 µg TCDD/g bw to mice and rats induced fetotoxicity that included cleft palates and kidney anomalies [24-26], intestinal hemorrhages and excessive tissue/organ fluid (edema), and prenatal mortality [27,28].

Impairment of reproduction has been reported for rats ingesting 0.01 µg TCDD/kg bw/day. Significant decreased fertility, litter size, number of pups alive at birth, postnatal survival, and postnatal body weight of pups were evident in two successive generations delivered from male and female rats that ingested TCDD 90 days prior to first mating, during pregnancies, and for the durations of time between pregnancies [29]. No significant dose-related reproductive effects were observed in male mice treated with up to 2.4 µg TCDD/kg bw/day and mated with untreated female mice [30,31].

Immunological Effects

TCDD induced immunological function alterations, expressed by decreased thymus-to-body weight ratios, in nursing newborn rats exposed through dosing of the lactating mother [32]. Other reports have shown that pre- and post-natal maternal dosing of rats and mice with TCDD caused thymic atrophy and suppression of cellular immunity in the offspring [33]. TCDD administered intraperitoneally or orally to mice induced a strong immunosuppressive effect on antibody production and cell-acquired immune responses [34].

Mutagenic Effects

Results of mutagenicity tests are inconclusive. In two studies TCDD was mutagenic in Salmonella typhimurium TA 1532 without activation [35,36]. In another study, which used a more sensitive mutant strain, Salmonella typhimurium TA 1537, TCDD was not a mutagen [37]. There is weak evidence of chromosomal aberrations in bone marrow of rats given dosages of 0.25 to 4 μg TCDD/kg bw [38,39].

Carcinogenic Effects

Male rats fed dosages of 0.001 μg TCDD/kg bw/week for 78 weeks and sacrificed at week 95 of the study showed a variety of neoplastic tumors (ear duct carcinoma; lymphocytic leukemia; kidney adenocarcinoma; malignant peritoneal histiocytoma; skin angiosarcoma; hard palate, tongue and nasal turbinate carcinoma) [40]. Female rats that had ingested TCDD for two years at a dosage of 0.1 μg/kg bw/day developed carcinomas of the liver and squamous cell carcinomas of the lung, hard palate, nasal turbinates, or tongue [41]. Male and female rats orally dosed with 0.5 μg TCDD/kg bw/week for two years demonstrated neoplastic nodules of the liver and thyroid adenomas [42].

Male mice fed dosages of TCDD of 0.05 or 0.5 μg/kg/week for two years developed liver cancer; female mice fed 0.2 or 2.0 μg/kg/week for the same duration developed liver cancer and thyroid follicular cell adenomas [42]. TCDD applied to the skin of female mice for two years (0.005 μg/kg bw/application; 3 days/week) resulted in a significantly higher incidence ($p=0.007$) of skin cancers (fibrosarcomas) when compared to untreated controls. An increase in the same tumor type, although not statistically significant ($p=0.084$), was also observed in the male mice that received a maximum dosage of 0.001 μg TCDD per application [43].

Human Health Effects

The only information on the health effects in humans from exposure to TCDD is from clinical or epidemiological studies of populations who were occupationally and non-occupationally exposed to 2,4,5-T and TCP contaminated with TCDD. Because of the coincidental exposure to 2,4,5-T and TCP and to other herbicides as well as to TCDD, it is not possible to attribute the observed health effects solely to TCDD exposure. To date, no studies of humans include a quantitation of exposure to TCDD.

Chloracne and Other Systemic Effects

Chloracne is a chronic and sometimes disfiguring skin eruption caused by exposure to halogenated aromatic compounds including TCDD. Chloracne is possibly a result of systemic effects of these compounds, although it also may occur as a contact dermatitis [44,45].

There are numerous cases of chloracne reported following accidental exposure to chlorinated aromatic chemicals which were probably contaminated with TCDD [46-48]. The most notable recent exposure occurred in Seveso, Italy in 1976 [49]. In most incidences of chloracne, there are a variety of signs and symptoms (ranging from gastrointestinal disturbances to metabolic disorders) which accompany the appearance of the skin eruptions and persist for varying lengths of time [50-54].

Reproductive Effects In Humans

Reproductive effects resulting from possible human exposure to TCDD are inconclusive. Data on male workers who applied agricultural sprays of 2,4,5-T or who produced TCDD-contaminated materials are consistent with the animal data which suggest no reproductive effects in males from TCDD exposure [55-57]. To date, no study of reproductive effects in women or in offspring of males or females with defined exposure to TCDD has been reported.

Studies of birth defects in populations that may have been exposed non-occupationally to TCDD have been conducted in Australia where a correlation was observed between 2,4,5-T use and seasonal variation in the rate of spinal cord and spine formation defects; no causal association could be drawn [58]. In a similar study in Hungary, an increased incidence of congenital malformations including spine formation defects could not be correlated with increased use of 2,4,5-T [59]. A study based on incomplete fetal tissue samples from the Seveso, Italy population found no mutagenic, teratogenic, or fetotoxic effects in 30 interrupted pregnancies and four spontaneous abortions in women believed to have been exposed to TCDD [60]. A U.S. EPA study found a positive relationship between spontaneous abortions and 2,4,5-T use in the Alsea, Oregon area [61]. The study, however, has been severely criticized because of its numerous limitations: inaccurate comparisons of the study and control areas; inaccuracies in the collection of data on spontaneous abortions; incomplete and inaccurate data on 2,4,5-T usage; and failure to recognize that the rate of spontaneous abortions was not greater than would be expected [62].

Studies of Mortality and Carcinogenesis in Humans

Findings have been inconclusive in many mortality studies of workers with occupational exposure to TCDD-contaminated materials because of the small size of the study population and concomitant exposures to other substances.

No excess mortality or tumor incidence was observed among Swedish railroad workers exposed to unknown amounts of 2,4-D, 2,4,5-T, and other herbicides but believed to have been exposed primarily to phenoxy acid herbicides for at least 45 days [63]. In a subsequent analysis of mortality in this group of workers, 45 deaths (49 expected) were observed in the total population. A significant excess of tumors also was observed among those believed to be exposed primarily to Amitrol® (3-amino-1,2,4-triazole), a suspect carcinogen, as well as to phenoxy herbicides. Two cases of stomach cancer (0.33 expected) were observed among those exposed primarily to phenoxy herbicides [64].

Among Swedish forestry workers exposed to phenoxy herbicide preparations, supervisors, who had more extensive exposure to herbicides than the other forest workers, had a nonsignificant excess of deaths from all cancers. Mortality associated with the presence of tumors was, however, lower than expected for the total group of exposed workers [65].

In a group of 74 workers involved in an accident during TCP production in Germany, 21 deaths occurred during the following 27 years. Seven (7) malignant neoplasms vs. 4.2 expected and a significant excess of stomach cancer (3 observed vs. 0.61 expected) were observed [66].

Several case control studies of cancer patients have yielded data on the carcinogenicity of phenoxyacetic herbicides. Two studies were conducted in Sweden following a clinical observation of patients with soft tissue sarcoma who had previous occupational exposure to the herbicides [67]. The first study of 52 cases of soft tissue sarcoma concluded that the sarcoma cases were 5.3 times more likely than the 206 controls to have had occupational exposure to phenoxyacetic acids (primarily 2,4,5-T and 2,4-D) [68]. The second study of 110 cases of soft tissue sarcomas indicated that this population was 6.8 times more likely to have had exposure to phenoxyacetic acids than the 219 controls [69]. In neither study was it possible to demonstrate the relative risk related to exposure to TCDD-contaminated 2,4,5-T because of the presence of impurities such as chlorinated dibenzodioxins and dibenzofurans which were part of the phenoxyacetic herbicides.

In other reports from Sweden, 11 of 17 patients with malignant lymphoma reported occupational exposures to phenoxyacetic acids or chlorophenols

[70]; a case control study with 169 malignant lymphoma cases found a significantly higher occupational exposure to phenoxyacetic acids (primarily 2,4,5-T, and 2,4-D) associated with the sarcoma cases than did the 338 controls. Analysis by individual herbicide exposure was not possible [71].

Two additional studies conducted in Sweden for colon cancer and nasal and nasopharyngeal cancer did not demonstrate an elevated risk for occupational exposure to phenoxyacetic acids [72,73].

Among four small groups of U.S. production workers exposed to TCP and 2,4,5-T a total of 105 deaths were observed [74-76]. In these, three deaths were attributed to soft tissue sarcoma (43 times the number expected for this age group of U.S. white males) [77]. Later, four additional cases were reported to have soft tissue sarcomas [78-81]. However, a detailed review of work records and expert review of pathological tissue specimens have shown only two of the seven cases with both confirmed exposure to TCP or 2,4,5-T and diagnosis of soft tissue sarcoma [82].

Summary of Toxicity in Animals and Humans

TCDD causes a variety of systemic and immunological effects in animals with wide variation among species in the dosage required to cause death. Studies using rats and mice have demonstrated that TCDD is an animal teratogen and carcinogen. Results of tests for mutagenicity are inconclusive.

Humans exposed to materials reported to be contaminated with TCDD have developed chloracne and other signs of systemic poisoning. Soft tissue sarcoma has been observed in excess among workers exposed to phenoxy herbicides. These data are inconclusive regarding TCDD toxicity in humans because the populations studied had mixed exposures making causal relationships between exposure and effect unclear. The data are, however, suggestive of an association between exposure to phenoxyacetic herbicides contaminated with TCDD and excess lymphoma and stomach cancer. Attempts to associate reproductive effects with TCDD exposure are inconclusive because of the inadequately defined populations studied and the difficulties of defining exposure.

RECOMMENDATIONS

There are several classifications for identifying a substance as a carcinogen. Such classifications have been developed by the U.S. National Institute of Environmental Health Sciences, National Toxicology Program [83], the International Agency for Research on Cancer [84], and OSHA [85]. NIOSH considers the OSHA classification the most appropriate for use in identifying carcinogens in the workplace. This classification is outlined in 29 CFR 1990.103.* Since TCDD has been shown to carcinogenic in experimental studies with rats and mice, and studies are suggestive of an association between human exposure to TCDD-contaminated materials and carcinogenicity, NIOSH recommends that TCDD be considered as a potential occupational carcinogen and exposure to TCDD in all occupational settings should be controlled to the fullest extent feasible. While observations to date do not confirm a causal relationship between TCDD exposure and soft tissue sarcoma, they suggest a need for continued investigations.

Because of the variety of situations likely to be encountered in TCDD-contaminated worksites, it is not possible to offer in this bulletin detailed procedures for assessing exposures or decontamination. Based on NIOSH hazard evaluations of TCDD-contaminated sites, the following general guidelines are recommended until more specific procedures can be developed [86,87].

Assessment of Exposure

Workers may be exposed to TCDD derived from a variety of sources: the production of TCP, residues from prior production or use of 2,4,5-T or silvex, waste materials contaminated by TCDD, or contamination resulting from transformer fires. The first step in assessing workplace contamination should be environmental sampling to determine the presence of TCDD contamination, keeping in mind the possible routes of exposure, with later sampling conducted to define the quantity of TCDD in the environment. The assessment may include sampling of soil and settled dust for TCDD, air sampling for TCDD-contaminated particles, and wipe sampling of surfaces [86,87].

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*"'Potential occupational carcinogen' means any substance, or combination or mixture of substances, which causes an increased incidence of benign and/or malignant neoplasms, or a substantial decrease in the latency period between exposure and onset of neoplasms in humans or in one or more experimental mammalian species as the result of any oral, respiratory or dermal exposure, or any other exposure which results in the induction of tumors at a site other than the site of administration. This definition also includes any substance which is metabolized into one or more potential occupational carcinogens by mammals."

Decontamination and Worker Protection Programs

In general, decontamination procedures must provide an organized process in which levels of contamination are reduced. This requires containment, collection, and disposal of contaminated solutions and residues generated during the cleanup. Separate facilities should be provided for decontamination of large equipment.

Each stage of decontamination, such as gross decontamination and repetitive wash/rinse cycles, should be conducted separately, either by using different locations or by spacing in time. Personnel decontamination locations used should be physically separated to prevent cross-contact and should be arranged in order of decreasing level of contamination. Separate entry/exit routes and locations should be provided for workers when it is necessary to isolate them from different contamination areas containing incompatible waste. Entry and exit points to these areas should be well marked and controlled. Access to the decontamination area should be separate from the path between the contaminated and clean areas. Dressing stations for entry should be separate from re-dressing areas for exit.

Protective Clothing and Equipment

All workers who may be exposed to TCDD should be equipped with adequate chemical protective clothing and equipment to ensure their protection. In the selection of protective clothing, consideration should be given to the utilization of disposable apparel due to the uncertainty of decontamination of clothing.

The protective apparel should consist of both outer and inner garments. The outer garments should consist of a zippered coverall with attached hood and draw string or elastic sleeves, gloves and closure boots. If exposure is to particulate or dust, the coveralls should be made of a non-woven fabric such as spunbonded polyethylene, Tyvek®. In cases of exposure to liquids, the coveralls, gloves and boots should be made of chemically resistant materials such as disposable laminates, e.g., Saranax® coated Tyvek®, or synthetic elastomers such as butyl, nitrile or neoprene rubber. The inner garments should consist of cotton coveralls, undershirts, undershorts, gloves, and socks and should be disposed of after use. The effectiveness of the protective clothing should be evaluated under simulated use conditions, regardless of the type of clothing used. All disposable clothing should be placed in marked and approved containers and disposed of appropriately. All reusable clothing and equipment should be thoroughly cleaned and checked for residual contamination before reuse or storage.

Respiratory Protection

The use of respiratory protection requires that a respiratory protection program be instituted according to the requirements of 29 CFR 1910.134 [88] and that the respirators have been approved by the Mine Safety and Health Administration (MSHA) and by NIOSH. This program should include training on proper fit testing and use and procedures for respirator maintenance, inspection, cleaning and evaluation.

For situations where TCDD contamination is low (e.g., exposure to dust contaminated with low levels of TCDD), air purifying respirators should provide sufficient protection until the extent and characterization of the exposure can be determined. Where quantities of materials highly contaminated with TCDD have been released and have contaminated an area (e.g., production accidents), all workers who may be exposed to TCDD should wear respirators that consist of a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. An alternate method utilizes a combination Type C supplied air respirator, with full facepiece, operated in pressure-demand mode and equipped with auxiliary positive pressure self-contained air supply.

Post-Decontamination Testing

The adequacy of the decontamination effort should be determined by conducting follow-up sampling and analysis of the contaminated areas and protective equipment. This testing should be conducted as each area is decontaminated and after the entire facility has been cleaned.

REFERENCES

1. Crosby DG, Moilanen KW, Wong AS: Environmental generation and degradation of dibenzodioxins and dibenzofurans. Environ Health Perspect 5:259-266 (1973).

2. Crummett WB, Stehl RH: Determination of chlorinated dibenzo-p-dioxins and dibenzofurans in various materials. Environ Health Perspect 5:17-25 (1973).

3. National Research Council of Canada: Polychlorinated Dibenzo-p-dioxins: Criteria for Their Effects on Man and His Environment. Pub. No. NRCC 18574: NRCC/CNRC Assoc. Comm. on Scientific Criteria for Environmental Quality, Ottawa, Canada (1981).

4. Hay A: Accidents in trichlorophenol plants: A need for realistic surveys to ascertain risks to health. Ann NY Acad Sci 320:321-324 (1979).

5. Firestone D, Ress J, Brown NL, et al.: Determination of polychlorodibenzo-p-dioxins and related compounds in commercial chlorophenols. J Assn Off Anal Chem 55(1):85-92 (1972).

6. Stehl RH, Lamparski LL: Combustion of several 2,5,5-trichlorophenoxy compounds: Formation of 2,3,7,8-tetrachlorodibenzo-p-dioxin. Science 197:1008-1009 (1977).

7. Rappe C, Marklund S: Formation of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) by burning or heating chlorophenates. Chemosphere 3:269-281 (1978).

8. Bumb RR, Crummett WB, Cutie SS, et al.: Trace chemistries of fire: A source of chlorinated dioxins. Science 210(4468):385-389 (1980).

9. Kimble BJ, Gross ML: Tetrachlorodibenzo-p-dioxin quantitation in stack-collected coal fly ash. Science 207:59-61 (1980).

10. Federal Register, Environmental Protection Agency, Part III, 44(52):15874-15920 (March 15, 1979).

11. Federal Register, Environmental Protection Agency, Part X, 48(202):48434-48437 (October 18, 1983).

12. McConnell EE, Moore JA, Haseman JK, et al.: The comparative toxicity of chlorinated dibenzo-p-dioxins in mice and guinea pigs. Toxicol Appl Pharmacol 44:335-356 (1978).

13. Henck JM, New MA, Kociba RJ, et al.: 2,3,7,8-tetrachlorodibenzo-p-dioxin: Acute oral toxicity in hamsters. Toxicol Appl Pharmacol 59:405-407 (1981).

14. McConnell EE, Moore JA, Dalgard DW: Toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin in Rhesus monkeys (Macaca mulatta) following a single oral dose. Toxicol Appl Pharmacol 43:175-187 (1978).

15. Kociba RJ, Keiler PA, Park CN, et al.: 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD): Results of a 13-week oral toxicity study in rats. Toxicol Appl Pharmacol 35:553-574 (1976).

16. Gupta GN, Vos JG, Moore JA, et al.: Pathologic effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin in laboratory animals. Environ Health Perspect 5:125-140 (1973).

17. Kimbrough RD: Morphology of lesions produced by the dioxins and related compounds. In: Tucker RE, ed.: Human and Environmental Risks of Chlorinated Dioxins and Related Compounds. Proceedings of an international symposium on chlorinated dioxins and related compounds, held October 25-29, 1981, in Arlington, Virginia. pp. 527-538 (1983).

18. Matthiaschk G: Survey about toxicological data of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). In: Paoletti R, ed.: Monographs of the Giovanni Lorenzini Foundation, Volume 1, Dioxin: Toxicological and Chemical Aspects. pp. 123-136 (1978).

19. Poland A, Glover E: 2,3,7,8-tetrachlorodibenzo-p-dioxin: A potent inducer of delta-aminolevulinic acid synthetase. Science 179:476-477 (1973).

20. Poland A, Glover E: Studies on the mechanism of toxicity of the chlorinated dibenzo-para-dioxins. Environ Health Perspect 5:245-251 (1973).

21. Weissberg JB, Zinkl JG: Effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin upon hemostasis and hematologic function in the rat. Environ Health Perspect 5:119-123 (1973).

22. Zinkl JG, Vos JG, Moore JA, et al.: Hematologic and clinical chemistry effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin in laboratory animals. Environ Health Perspect 5:111-118 (1973).

23. Vos JG, Moore JA, Zinkl JG: Toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in C57Bl/6 mice. Toxicol Appl Pharmacol 29:229-241 (1974).

24. Courtney KD, Moore JA: Teratology studies with 2,4,5-trichlorophenoxyacetic acid and 2,3,7,8-tetrachlorodibenzo-p-dioxin. Toxicol Appl Pharmacol 20:396-403 (1971).

25. Smith FA, Schwetz BA, Nitschke KD: Teratogenicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin in CF-1 mice. Toxicol Appl Pharmacol 38:517-523 (1976).

26. Moore JA, Gupta BN, Zinkl JN, et al.: Postnatal effects of maternal exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Environ Health Perspect 5:81-85 (1973).

27. Sparschu GL, Dunn FL, Rowe VK: Study of the teratogenicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin in the rat. Fd Cosmet Toxicol 9:405-412 (1971).

28. Khera KS, Ruddick JA: Polychlorodibenzo-p-dioxins: Perinatal effects and the dominant lethal test in Wistar rats. Toxicology 120:70-84 (1973).

29. Murray FJ, Smith FA, Nitschke KO, et al.: Three generation reproduction study of rats given 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the diet. Toxicol Appl Pharmacol 50(2):241-252 (1979).

30. Lamb JC IV, Moore JA, Marks TA, et al.: Development and viability of offspring of male mice treated with chlorinated phenoxy acids and 2,3,7,8-tetrachlorodibenzo-p-dioxin. J Toxicol Environ Health 8:835-844 (1981).

31. Lamb JC IV, Marks TA, Gladen BC, et al.: Male fertility, sister chromatid exchange, and germ cell toxicity following exposure to mixtures of chlorinated phenoxy acids containing 2,3,7,8-tetrachlorodibenzo-p-dioxin. J Toxicol Environ Health 8:825-834 (1981).

32. Luster MI, Faith RE, Clark G: Laboratory studies on the immune effects of halogenated aromatics. Ann NY Acad Sci 320:473-486 (1979).

33. Vos JG, Moore JA: Suppression of cellular immunity in rats and mice by maternal treatment with 2,3,7,8-tetrachlorodibenzo-p-dioxin. Int Arch Allergy Appl Immunol 47:777-794 (1974).

34. Garattini S, Vecchi A, Sironi M, et al.: Immunosuppressant activity of TCDD in mice. In: Hutzinger O, ed.: Chlorinated Dioxins and Related Compounds: Impact on the Environment. Proceedings of a workshop, Institute Superiore di Sanita, Rome, Italy, held 22-24 October 1980. pp. 403-409 (1982).

35. Hussain S, Ehrenberg L, Lofroth G, et al.: Mutagenic effects of TCDD on bacterial systems. Ambio 1:32-33 (1972).

36. Seiler JP: A survey on the mutagenicity on various pesticides. Experimenta 15(5):622-623 (1973).

37. Geiger LE, Neal RA: Mutagenicity testing of 2,3,7,8-tetrachlorodibenzo-p-dioxin in histidine auxotrophs of Salmonella typhimurium. Toxicol Appl Pharmacol 59:125-129 (1981).

38. Green S, Moreland F, Sheu C: Cytogenic effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin on rat bone marrow cells. FDA By-Lines 6:242-294 (1977).

39. Loprieno N, Sbrana I, Rusciano D, et al.: In vivo cytogenic studies on mice and rats exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). In: Hutzinger O, ed.: Chlorinated Dioxins and Related Compounds: Impact on the Environment. Proceedings of a workshop, Institute Superiore di Sanita, Rome, Italy, held 22-24 October 1980. pp. 419-428 (1982).

40. Van Miller JP, Lalich JJ, Allen JR: Increased incidence of neoplasms in rats exposed to low levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin. Chemosphere 9:537-544 (1977).

41. Kociba RJ, et al.: Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. Toxicol Appl Pharmacol 46:279-303 (1978).

42. National Toxicology Program: Technical Report Series No. 209. Carcinogenesis Bioassay of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (CAS No. 1746-01-6) in Osborn-Mendel Rats and $B6C3F_1$ Mice (Gavage Study). U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health Publication No. 82-1765, (February 1982).

43. National Toxicology Program: Technical Report Series No. 201. Carcinogenesis Bioassay of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (CAS No. 1746-01-6) in Swiss-Webster Mice (Dermal Study). U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health Publication No. 82-1757, (February 1982).

44. Crow KD: Chloracne. Semin Dermatol 1(4):305-313 (1982).

45. Jones EL, Krizek H: A technic for testing acnegenic potency in rabbits, applied to the potent acnegen, 2,3,7,8-tetrachlorodibenzo-p-dioxin. J Invest Dermatol 39:511-517 (1962).

46. May G: Chloracne from the accidental production of tetrachlorodibenzodioxin. Br J Ind Med 30:276-283 (1973).

47. Goldmann PJ: [Severe acute chloracne. A mass intoxication by 2,3,6,7-tetrachlorobenzodioxin]. Hautarzt 24:149-152 (1973) (Ger.).

48. Reggiani G: Acute human exposure to TCDD in Seveso, Italy. Toxicol Environ Health 6:27-43 (1980).

49. Pocchiari F, Silano V, Zampieri A: Human health effects from accidental release of tetrachlorodibenzo-p-dioxin (TCDD) at Seveso, Italy. Ann NY Acad Sci 320:311-320 (1979).

50. Pazderova-Vejlupkova J, Nemcova M, Pickova J, et al.: The development and prognosis of chronic intoxication by tetrachlorodibenzo-p-dioxin in men. Arch Environ Health 36(1):5-11 (1981).

51. Singer R, Moses M, Valciukas J, et al.: Nerve conduction velocity studies of workers employed in the manufacture of phenoxy herbicides. Environ Res 29:297-311 (1982).

52. Oliver RM: Toxic effects of 2,3,7,8 tetrachlorodibenzo 1,4 dioxin in laboratory workers. Br J Ind Med 32:49-53 (1975).

53. Caramashi F, Del Corono G, Favaretti C, et al.: Chloracne following environmental contamination by TCDD in Seveso, Italy. Int J Epidemiol 10(2):135-143 (1981).

54. Kimbrough RD, Carter CD, Liddle JA, et al.: Epidemiology and pathology of a tetrachlorodibenzodioxin poisoning episode. Arch Environ Health 32(2):77-85 (1977).

55. Smith AH, Matheson DP, Fisher DO: Preliminary report of reproductive outcomes among pesticide applicators using 2,4,5-T. NZ Med J 93(680):177-179 (1981).

56. Smith AH, Fisher DO, Pearce N, et al.: Congenital defects and miscarriages among New Zealand 2,4,5-T sprayers. Arch Environ Health 37(4):197-200 (1982).

57. Townsend JC, Bodner KM, Van Peenen PFD, et al.: Survey of reproductive events of wives of employees exposed to chlorinated dioxins. Amer J Epidemiol 115(5):695-713 (1982).

58. Field B, Kerr C: Herbicide use and incidence of neural tube defects. Lancet I (June 23):1341-1342 (1979).

59. Thomas HF: 2,4,5-T use and congenital malformation rates in Hungary. Lancet I (July 26):214-215 (1980).

60. Rehder H, Sanchoni L, Cefis F, et al.: [Pathologic-Embryologic studies in cases of abortion connected with the accident at Seveso]. Schweiz Med Wochenschr 108(42):1617-1625 (1978) (Ger.).

61. Report of Assessment of a Field Investigation of Six-Year Spontaneous Abortion Rates in Three Oregon Areas in Relation to Forest 2,4,5-T Spray Practices. Environmental Protection Agency. Prepared by the Epidemiologic Studies Program, Human Effects Monitoring Branch, Benefits and Field Studies Division, OPP, OTS, EPA, (1979).

62. Wagner S, Witt JM, Norris LA, et al.: A Scientific Critique of the EPA ALSEA II Study and Report. Environmental Health Sciences Center, Oregon State University, Corvallis, (October 25, 1979).

63. Axelson O, Sundell L: Herbicide exposure, mortality, and tumor incidence: An epidemiological investigation on Swedish railroad workers. Work Environ Health 11:21-28 (1974).

64. Axelson O, Sundell L, Andersson K, et al.: Herbicide exposure and tumor mortality: An updated epidemiologic investigation on Swedish railroad workers. Scand J Work Environ Health 6:73-79 (1980).

65. Hogstedt C, Westerlund B: [Mortality of forest workers exposed and not exposed to phenoxy acid preparations.] Lakartidningen 77(19):1828-1831 (1980) (Swe.).

66. Thiess AM, Frentzel-Beyme R, Link R: Mortality study of persons exposed to dioxin in a trichlorophenol-process accident that occurred in the BASF AG on November 17, 1953. Am J Ind Med 3:179-189 (1982).

67. Hardell L: [Malignant mesenchymal tumors and exposure to phenoxy acids: A clinical observation.] Lakartidningen 74:2753-2754 (1977) (Swe.).

68. Hardell L, Sandstrom A: Case control study: Soft tissue sarcomas and exposure to phenoxyacetic acids or chlorophenols. Br J Cancer 39:711-717 (1979).

69. Eriksson M, Hardell L, Berg NO, et al.: [Case-control study on malignant mesenchymal tumors of the soft parts and exposure to chemical substances.] Lakartidningen 76:3872-3875 (1979) (Swe.).

70. Hardell L: Malignant lymphoma of histiocytic type and exposure to phenoxyacetic acids or chlorophenols. Lancet I (January 6):55-56 (1979).

71. Hardell L, Eriksson M, Lenner P, et al.: Malignant lymphoma and exposure to chemicals, especially organic solvents, chlorophenols and phenoxy acids: A case-control study. Br J Cancer 43:169-176 (1981).

72. Hardell L: Relation of soft-tissue sarcoma, malignant lymphoma and colon cancer to phenoxy acids, chlorophenols and other agents. Scand J Work Environ Health 7:119-130 (1981).

73. Hardell L, Johansson B, Axelson O: Epidemiological study of nasal and nasopharyngeal cancer and their relation to phenoxy acid of chlorophenol exposure. Am J Ind Med 3:247-257 (1982).

74. Zack JA, Suskind RR: The mortality experience of workers exposed to tetrachlorodibenzodioxin in a trichlorophenol process accident. J Occup Med 22(1):11-14 (1980).

75. Ott MG, Holder BB, Olson RD: A mortality analysis of employees engaged in the manufacture of 2,4,5-trichlorophenoxyacetic acid. J Occup Med 22(1):47-50 (1980).

76. Cook RR, Townsend JC, Ott MG, et al.: Mortality experience of employees exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). J Occup Med 22(8):530-532 (1980).

77. Honchar PA, Halperin WE: 2,4,5-trichlorophenol and soft tissue sarcoma. Lancet I (January 31):268-269 (1981).

78. Cook RR: Dioxin, chloracne, and soft tissue sarcoma. Lancet I (March 1):618-619 (1981).

79. Moses M, Selikoff IJ: Soft tissue sarcomas, phenoxy herbicides, and chlorinated phenols. Lancet I (June 20):1370 (1981).

80. Johnson FE, Kugler MA, Brown SM: Soft tissue sarcomas and chlorinated phenols. Lancet II (July 4):40 (1981).

81. Fingerhut MA, Halperin WE: Dioxin exposure and sarcomas. JAMA 249(23):3176 (1983).

82. Statement by J. Donald Millar, M.D., Assistant Surgeon General, Director, National Institute for Occupational Safety and Health, Centers for Disease Control, Public Health Service, Department of Health and Human Services, Before the United States House of Representatives Committee on Public Works and Transportation Subcommittee on Investigations and Oversight. (November 9, 1983).

83. Matthews HB: NTP Technical Report on the Toxicity and Carcinogenicity of Tris(2-ethylhexyl)phosphate (Cas. No. 78-42-2) in F344/N rats and B6C3F_1 mice (gavage study), National Toxicology Program, Research Triangle Park, North Carolina, p. 4, (unpublished report, September 8, 1983).

84. World Health Organization: IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. IARC Monographs, Supplement 1 (1979).

85. Code of Federal Regulations, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1990.103 (1982).

86. Health Hazard Evaluation - Determination Report No. 83-395, Overnight Transportation Company, St. Louis, Missouri. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio (1983).

87. Health Hazard Evaluation - Determination Report No. 83-394, P.J. Hamil Transfer Company, St. Louis, Missouri. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio (1983).

88. Code of Federal Regulations, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.134 (1982).

CUMULATIVE LIST OF NIOSH CURRENT INTELLIGENCE BULLETINS

1.	Chloroprene	- January 20, 1975
2.	Trichloroethylene (TCE)	- June 6, 1975
3.	Ethylene Dibromide (EDB)	- July 7, 1975
4.	Chrome Pigment	- June 24, 1975
		- October 7, 1975
		- October 8, 1976
5.	Asbestos - Asbestos Exposure during Servicing of Motor Vehicle Brake and Clutch Assemblies	- August 8, 1975
6.	Hexamethylphosphoric Triamide (HMPA)	- October 24, 1975
7.	Polychlorinated Biphenyls (PCB's)	- November 3, 1975
		- August 20, 1976
8.	4,4'-Diaminodiphenylmethane (DDM)	- January 30, 1976
9.	Chloroform	- March 15, 1976
10.	Radon Daughters	- May 11, 1976
11.	Dimethylcarbamoyl Chloride (DMCC) Revised	- July 7, 1976
12.	Diethylcarbamoyl Chloride (DECC)	- July 7, 1976
13.	Explosive Azide Hazard	- August 16, 1976
14.	Inorganic Arsenic - Respiratory Protection	- September 27, 1976
15.	Nitrosamines in Cutting Fluids	- October 6, 1976
16.	Metabolic Precursors of a Known Human Carcinogen, Beta-Naphthylamine	- December 17, 1976
17.	2-Nitropropane	- April 25, 1977
18.	Acrylonitrile	- July 1, 1977
19.	2,4-Diaminoanisole in Hair and Fur Dyes	- January 13, 1978
20.	Tetrachloroethylene (Perchloroethylene)	- January 20, 1978
21.	Trimellitic Anhydride (TMA)	- February 3, 1978
22.	Ethylene Thiourea (ETU)	- April 11, 1978
23.	Ethylene Dibromide and Disulfiram Toxic Interaction	- April 11, 1978
24.	Direct Black 38, Direct Blue 6, and Direct Brown 95 Benzidine Derived Dyes	- April 17, 1978
25.	Ethylene Dichloride (1,2-Dichloroethane)	- April 19, 1978
26.	NIAX Catalyst ESN	- May 22, 1978
27.	Chloroethanes - Review of Toxicity	- August 21, 1978
28.	Vinyl Halides - Carcinogenicity	- September 21, 1978
29.	Glycidyl Ethers	- October 12, 1978
30.	Epichlorohydrin	- October 12, 1978
31.	Adverse Health Effects of Smoking and the Occupational Environment	- February 5, 1979
32.	Arsine (Arsenic Hydride) Poisoning in the Workplace	- August 3, 1979
33.	Radiofrequency (RF) Sealers and Heaters: Potential Health Hazards and Their Prevention	- December 4, 1979
34.	Formaldehyde: Evidence of Carcinogenicity	- April 15, 1981

CUMULATIVE LIST OF NIOSH CURRENT INTELLIGENCE BULLETINS (CONTINUED)

35.	Ethylene Oxide (EtO): Evidence of Carcinogenicity	- May 22, 1981
36.	Silica Flour: Silicosis	- June 30, 1981
37.	Ethylene Dibromide (EDB) Revised	- October 26, 1981
38.	Vibration Syndrome	- March 29, 1983
39.	The Glycol Ethers, with Particular Reference to 2-Methoxyethanol and 2-Ethoxyethanol: Evidence of Adverse Reproductive Effects	- May 2, 1983
40.	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD, "Dioxin")	- January 23, 1984

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