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July 11, 2002

U.S. Environmental Protection Agency – Region II
290 Broadway – 22nd Floor
New York, New York 10007-1866

Attn: Ms. Nicoletta DiForte
Chief, RCRA Caribbean Section

Re: Contract N62470-95-D-6007
Navy CLEAN, District III
Contract Task Order (CTO) 0034
U.S. Naval Station Roosevelt Roads (NSRR), Puerto Rico
RCRA/HSWA Permit No. PR2170027203
Revised Section 4.0 to the Draft Final Corrective Measures Study Task I Report
Tow Way Fuel Farm (SWMU 7/8)

Dear Ms. DiForte:

Baker Environmental, Inc. (Baker), on behalf of the Navy, is providing you with two copies of the revised Section 4.0 to the Draft Final Corrective Measures Study Task I Report, Tow Way Fuel Farm (TWFF). Please replace the text in the document that you received on July 10, 2002 with the attached text. The attached revised text is to be utilized for your review, please disregard the text mailed to you on July 9, 2002.

If you have questions regarding this submittal, please contact Mr. Kevin Cloe, P.E. at (757) 322-4736. Additional distribution has been made as indicated below.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Mark E. Kimes, P.E.
Activity Manager

MEK/lp
Attachments

cc: Mr. Kevin R. Cloe, LANTDIV - Code EV23KRC (1 copy)
Ms. Madeline Rivera, NSRR (4 copies)
Mr. Tim Gordon, US EPA Region II (2 copies)
Ms. Kathy Rogovin, Booz Allen & Hamilton (1 copy)
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4.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

4.1 Introduction

The results of the human health risk assessment (RA) portion of the Revised Draft RCRA Facility Investigation (RFI) report (Baker, 1997) indicate that corrective measures must be evaluated for the TWFF. This section of the document established the site-specific objectives and clean up goals used to identify corrective measures.

This Section is an update of the Section 3.0 of the Task 1 Corrective Measures Study (CMS) submission (Baker, 2001b), based on additional data collected at the TWFF and some minor changes in risk assessment methodology. The previous document was requested as a way of improving the CMS process and schedule in a letter from the Navy on November 8, 2000. A meeting was held at EPA Region II headquarters in New York City on December 19, 2000 to discuss the CMS process at the TWFF, including the framework for the previous revision. At the meeting, and subsequent discussions about the meeting, the revised Section 3.0 was approved and the general changes made to the Task 1 CMS Report (Baker, 2000) were agreed to by EPA Region II.

The first step in evaluating corrective measures is to develop corrective action objectives (CAOs), which consist of medium- and chemical-specific goals for protecting human health and the environment. The CAOs are used to focus the development of corrective measure alternatives on technologies that may achieve appropriate target levels, thereby limiting the number of alternatives analyzed.

CAOs can be specific and numerical (i.e., quantitative) or general and descriptive (i.e., qualitative). They are achieved by reducing exposure (e.g., installing a soil cover or limiting access) or by reducing contaminant levels (e.g., active remediation; USEPA, 1988). CAOs are used to evaluate which samples/areas within a site may require corrective measures, and which corrective measures alternative best protects human health and the environment.

The CAOs for the TWFF, developed in Section 4.6, are based on land use and potential receptor assumptions (Section 4.2), summary of the human health RA and selection of contaminants of potential concern (Section 4.3), exposure assessment and methodology (Section 4.4), and toxicity evaluation (Section 4.5). They were developed in accordance with the U.S. Environmental Protection Agency (EPA) guidance (USEPA, 1989, 1991a, and others), and the human health RA performed as part of the RFI (Baker, 1997).

4.2 Land Use and Potentially Exposed Receptors

To focus on developing practicable and cost-effective corrective measures alternatives and to streamline the environmental cleanup process, EPA guidance ("Land Use in the CERCLA Remedy Selection Process," (USEPA, 1995a)) and U.S. Department of Defense (Longuemare, 1997) direct that CAOs should reflect the reasonably anticipated land use.

The TWFF is an industrial area of NSRR where fuel is stored in underground storage tanks (USTs) to support Station activities. Future property use of the TWFF is expected to remain industrial for the duration of Naval operations of NSRR. As a result, potential human exposure is limited to industrial or commercial property use, now and in the foreseeable future

The baseline human health RA (Baker, 1997) assumed that industrial workers are potentially exposed receptors for the current land use; and that on-base residents, industrial workers, and

construction workers are potentially exposed receptors for the future land use. Although future onsite residential land use was quantitatively evaluated as an additional hypothetical exposure scenario in the human health RA, it is not considered reasonably anticipated.

Therefore, based on the RFI and EPA and Department of Defense guidance that CAOs should reflect actual anticipated land use, the assumed land use is continued military use, with industrial workers (i.e., civilians and or military personnel stationed at NSRR) the most likely receptors. Construction workers (e.g., fuel line pipe-fitters) may be exposed to soil from the surface to a depth of ten feet below ground surface. It is extremely unlikely that the TWFF would ever be developed into a residential area given the topography of the area and the fact that the TWFF is critical to the mission of the station. If land use changes in the future, the SWMUs will be reevaluated.

4.3 Summary of Human Health Risk Assessment and Selection of Contaminants of Potential Concern

The baseline RA for the TWFF identified the potential for human health risk to onsite workers and future residents exposed to soil affected by site related activities (Table 4-1). This table from the RFI (Baker, 1997), demonstrates that the worker risk exceeds the risk range of $1x10^{-4}$ to $1x10^{-6}$ that USEPA generally considers acceptable, thus causing a CMS to be recommended for the TWFF. Tables 4-2 and 4-3 from the RFI present a breakdown of unacceptable risk values by exposure pathway and identify chemicals responsible for the majority of risk by receptors. Analytical data presented in the RFI (Baker, 1997) were incorporated in the baseline RA by a chemicals of potential concern (COPC) selection process.

More data have been collected at TWFF since the RFI was completed. Therefore, the COPC selection process has been performed again for this report using all of the data and the same methodology as used in the RFI. COPCs are those contaminants retained for further evaluation at this stage of the CMS process. They are contaminants that are detected in at least one sample in a given media at concentrations that are greater than screening criteria. The screening criteria are USEPA Region III Risk-Based Concentrations (RBCs). RBCs are derived by USEPA Region III using default exposure parameter values and the most recent toxicological criteria available. The RBCs used for this report are those issued in April 2002 (USEPA, 2002a) and are based on conservative residential exposure for soil and residential tap water exposure for groundwater. (The target risk used to calculate the RBCs is $1x10^{-6}$, while the target hazard quotient (HQ) is 0.1 to account for cumulative effects.) RBCs are not available for lead due to its unique toxicological characteristics (see Section 4.5.2). EPA's residential action level of 400 mg/kg (USEPA, 1994) for soil and the promulgated maximum contaminant level (MCL) concentration of 15 mg/L (40 CFR 161) for groundwater were used for COPC screening criteria for lead.

Tables 4-4 through 4-6 summarize the data for the three media identified at TWFF (surface soil, zero to two foot depth; subsurface soil, zero to ten foot depth; and groundwater) and the COPC selection process. As in the RFI, frequency of detection was a criterion used to exclude analytes from the COPC list. Table 4-6 shows that eight analytes were excluded as groundwater COPCs based on the rationale of detection in less than five percent of the samples and that were not detected previously (1,2-dibromo-3-dichloropropane, 2-butanone, acetonitrile, acrylonitrile, carbon tetrachloride, acetophenone, indeno(1,2,3-cd)pyrene, and total antimony) In addition, all of these analytes but one (acetephenone) were detected just once and all of the concentrations were less than their detection limit (i.e., J-flagged values). Acrolein was eliminated as a COPC in groundwater based on the rationale that it is a common anthropogenic background compound (primarily as a component in exhaust from combustion of fuels), the Navy policy on

anthropogenic background compounds (CNO, 2000), and the fact that it was detected only once in groundwater at a concentration less than the detection limit.

Tables 4-4 through 4-6 indicate several additional COPCs have been identified based on the newly collected data. These are: thallium in surface and total soil; and isobutanol, methyl tert-butyl ether, 3&4-methylphenol, bis(2-ethylhexyl) phthalate, total cadmium, dissolved mercury, dissolved thallium, and dissolved vanadium in groundwater.

4.4 Exposure Assessment and Methodology for Development of CAOs

4.4.1 Qualitative CAOs

4.4.1.1 Groundwater

There is no direct current exposure to contaminated groundwater at the TWFF nor is future exposure likely based on the future land use scenarios discussed in Section 4.2. (Indirect exposure via inhalation of volatiles emitted from the contaminated groundwater through the overlying soils is possible, as discussed in detail below.) Groundwater is not currently used for potable purposes because drinking water is available from El Yunque, which supplies all of NSRR's present and projected needs.

Under nonresidential land use – particularly the continued military future land use scenario, in which the U.S. Navy determines the specific use of the property – it is reasonable to assume that no groundwater well will be installed within the limited volume of contaminated groundwater and be used for domestic purposes. Furthermore, pump test data generated during other investigations performed at NSRR, indicate that the yield of the uppermost aquifer is generally insufficient to be used as a potable source. Besides potential exposure from inhalation of volatiles emitted from groundwater, limited direct contact to contaminated groundwater is possible for construction workers. Section 4.4.2 describes the methodology and exposure pathways for developing quantitative CAOs. The qualitative CAOs for contaminated groundwater are:

- To prevent further degradation of Puerto Rico's waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To further restrict and prevent possible exposure to contaminated groundwater (e.g., by institutional controls).

- To protect public health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

- A goal to limit phase-separated hydrocarbons (free product) to a thickness of 0.01 foot based on the limits of technology to recover free product.

4.4.1.2 Soil

Under the continued military land use scenario, contact with contaminants will occur from both surface and subsurface soil at the TWFF. Section 4.4.2 describes the methodology and exposure pathways for developing quantitative CAOs based on these potential exposures. The qualitative CAOs for soil are:

- To prevent further degradation of Puerto Rico's waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To protect human health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

4.4.2 Quantitative CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. The following components of the human health RA are used to determine CAOs for soil and groundwater:

- Intake by assumed exposure pathways.

- Chemical-specific toxicity data in the form of health effects criteria (see Section 4.5).

- Assumed target cancer risk level and noncancer hazard quotient (HQ).

The target risk level and HQ are general health effects levels deemed acceptable for exposure to individual carcinogenic and noncarcinogenic contaminants, respectively. The general equation for chemical intake used in the human health RA is:

$$Intake(mg/kg\text{-}day) = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT} \qquad \text{(Eq 4-1)}$$

where:

C	=	chemical concentration
IR	=	intake rate
EF	=	exposure frequency
ED	=	exposure duration
CF	=	conversion factor (to attain proper units)
BW	=	body weight
AT	=	averaging time for cancer or noncancer effects.

This equation is algebraically combined with the general expressions for cancer risk and noncancer health effects, respectively:

$$Risk = Intake \times SF \qquad \text{(Eq 4-2)}$$

$$HQ = Intake/RfD \qquad \text{(Eq 4-3)}$$

where:

Risk	=	target risk level (1×10^{-6}, or one in 1 million excess cancer cases due to exposure to a chemical, given the assumed exposure pathway).
SF	=	slope factor, or health effects criterion for cancer effects.
HQ	=	target HQ (1.0, implying that intake should not exceed the RfD).
RfD	=	reference dose, or health effects criterion for noncancer effects.

Assumed values for risk and HQ and chemical-specific SFs or RfDs are used to solve for the concentration term, or the pathway-specific CAO.

For the continued military land use scenario at the TWFF, the industrial worker and construction worker are used to characterize potential future exposure to contaminated soil and groundwater. Industrial worker exposure is limited to surface soil (defined as zero to two feet), while construction workers may also be exposed to subsurface soil (zero to ten feet).

The exposure pathways evaluated for developing quantitative CAOs for soil are inadvertent ingestion, inhalation of contaminants in particulates; inhalation of volatiles emitted from soil, and dermal absorption of contaminants following direct contact.

Groundwater exposure for industrial workers is only via inhalation of volatiles emitted through the soil into buildings. The Johnson and Ettinger (1991) model is used to quantify this exposure. EPA placed this model into a spreadsheet format and produced a User's Guide for use at contaminated sites (USEPA, 2000). The version used is an update of the Johnson and Ettinger model used in the previous submission of this Section (Baker, 2001). This new version of the Johnson and Ettinger model is summarized and the results of the modeling efforts for the TWFF are presented in Appendix I. Exposure by indoor inhalation of contaminants is much greater than outdoor exposure due to greater dilution in outside air and enhanced volatilization indoors due to chimney and pressure effects. For these reasons, and because the model assumes full time exposure indoors (i.e., leaving no time for additional outdoor exposure), outdoor inhalation exposure to groundwater is not quantitatively evaluated.

Construction workers may be directly exposed to groundwater following excavation because groundwater at the TWFF is relatively shallow at some locations (i.e., less than 10 feet deep). The exposure pathways used to develop quantitative groundwater CAOs for the construction worker are accidental ingestion, inhalation of volatiles, and dermal absorption.

Tables 4-7 to 4-17 quantitatively summarize each of these pathways and media. The exposure pathway equations and variable values are generally directly from EPA guidance documents and the rationale for their selection is explained in the tables. Those exposure variable value assumptions based on professional judgement or that are not based on standard EPA defaults are discussed further below.

- Target risk levels. It should be noted that, in the absence of regulatory criteria, EPA recommends use of the 1×10^{-6} cancer risk level as a starting point for analysis of remedial alternatives. This reflects EPA's preference for managing risks at the more protective end of the risk range (USEPA, 1991a; NCP preamble, 55 *Federal Register* 8718-9). This same EPA guidance presents some flexibility in target risk

levels ("Preliminary and final remediation goals, i.e., target risk levels, however, may vary from the point of departure depending upon site-specific circumstances.") A $1x10^{-6}$ target risk level is assumed for all COPCs, with the exception of the carcinogenic polynuclear aromatic hydrocarbons (PAH_cs). A $1x10^{-6}$ target risk level for PAH_cs would produce CAO concentrations less than their detection limit and likely less than background concentrations, since PAHs are a common anthropogenic contaminant produced by sources such as fossil fuel combustion and asphalt (Menzie et al, 1992; Bradley et al, 1994). Furthermore, a $1x10^{-5}$ target risk level was assumed for these PAH_cs to be consistent with the Task 1 CMS Report (Baker, 2000).

- Construction Worker Exposure. The construction worker is assumed to work for six months (i.e., an exposure frequency of 180 days/year and an exposure duration of one year) performing activities such as excavation to repair underground pipes where they may come into contact with subsurface soil to a depth of ten feet. During these activities the possibility exists that they may come in contact with shallow groundwater. To quantify the groundwater exposure it is conservatively assumed that 10% of their time (i.e., exposure frequency of 18 days/year) will be spent in an open hole filled with groundwater at which time they can accidentally ingest small quantities of water, inhale volatiles emitted from the water, and be immersed from the waist down for an assumed duration of one hour (Baker 2001). Supporting calculations are provided in Appendix J.

  The ingestion rate for the construction worker is assumed to be greater than the industrial worker due to their assumed higher contact rate. The assumed value of 100 mg/day is based on the recommendation of EPA (Maddaloni and Rogovin, 2000).

  The construction worker exposure via inhalation of volatiles emitted from groundwater is based on a procedure from EPA's "Preliminary Remediation Goals Guidance" (USEPA, 1991a) that estimated total volatilization from household water. This estimate is considered a conservative measure of what would be volatized from a water-filled hole that a construction worker would be in or near. The groundwater COPCs were screened for volatility using the criteria presented in EPA (1991a) (i.e., Henry's Law constant greater than $1x10^{-5}$ atm-m^3/mole and molecular weight less than 200 g/mole). All the groundwater COPCs at the TWFF are considered volatile by these criteria and are quantitatively evaluated.

- Volatilization Factor Parameters. The inhalation of volatiles emitted from soil exposure pathway applied to industrial and construction workers uses a soil-to-air volatilization factor (VF) from EPA's "Soil Screening Guidance" (USEPA, 1996a). Table 4-10 presents the calculation for VF. Default values were used for the VF parameters with the following exceptions. The Q/C term, based on meteorological modeling performed by EPA for a variety of cities throughout the U.S., has been changed from the default value to the value for modeled Zone IX represented by Miami in accordance with EPA guidance (USEPA, 1996b). The variable for total exposure time (T) has been changed from 30 years to 25 years to reflect the difference between industrial and residential exposure. The porosity terms for water- and air-filled porosity have been changed from the default of 0.15 and 0.28, respectively, to 0.20 and 0.23, respectively to conform to the default values used in

the Johnson and Ettinger (1991) model used to model volatiles emitted from groundwater (see Appendix I).

Table 4-10 includes the equation for the soil saturated concentration or C_{sat}. The VF equation is not applicable if the soil concentration is greater than C_{sat} because the model does not include free-phase contamination. C_{sat} was calculated for all organic COPCs in soil at the TWFF and it was greater than the VF based CAOs for all COPCs. Therefore, the VF model is applicable for all organic COPCs with inhalation-based toxicity at the TWFF.

- Dermal Exposure to Contaminants in Soil. Recommended default values for workers' skin surface area (SA) and soil adherence factors (AF) have recently changed to 3,300 cm^2 and 0.2, respectively, based on new EPA guidance (USEPA, 2001). These two default values applied to industrial and construction workers are based on a reinterpretation of data presented in the "Exposure Factors Handbook" (USEPA, 1997a).

4.5 Toxicity Evaluation

For the development of quantitative CAOs based on exposure to chemicals, the following health effects criteria are of principal importance:

- RfDs for oral exposure – estimates of acceptable daily intake for chronic and subchronic exposure that will not produce deleterious noncancer effects. EPA defines subchronic exposure as periods of less than 7 years (USEPA, 1989a). Therefore, subchronic RfDs apply to construction workers, while chronic RfDs apply to industrial workers.

- Reference concentrations (RfCs) for inhalation exposure – estimates of acceptable concentrations for chronic and subchronic exposure that will not produce deleterious noncancer effects. These values are converted to inhalation RfDs by multiplying the RfC by the reference IR value of 20 m^3/day and dividing by the reference BW of 70 kilograms. RfCs are used in the Johnson and Ettinger (1991) model (Appendix I), while other inhalation pathways use the inhalation RfD. Subchronic inhalation RfDs and RfCs apply to the construction worker only, as discussed for RfDs for oral exposure.

- SFs for oral exposure – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a).

- SFs for the inhalation route – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a). Inhalation SFs are calculated from inhalation unit risk values in a similar manner as described above for inhalation RfDs. Unit risk values are used in the Johnson and Ettinger (1991) model (Appendix I), while all other inhalation pathways use the inhalation SF.

The primary source of chemical-specific health effects criteria is EPA's Integrated Risk Information System (IRIS) database (USEPA, 2002b). IRIS is a computer-housed catalog of

EPA health effects criteria and information. Data in IRIS are reviewed and updated monthly. If health effects criteria are not available in IRIS, EPA recommends use of the Office of Research and Development's Health Effects Assessment Summary Tables (HEAST; USEPA, 1997b) as a secondary data source. The Superfund Technical Support Center (STSC) is used for additional health effects criteria not provided in IRIS or HEAST. STSC develops provisional RfDs and SFs on a site-specific basis for those contaminants with adequate toxicological data, but for which no approved values exist in IRIS or HEAST.

Table 4-18 presents the toxicological criteria used to calculate CAOs for the TWFF COPCs.

4.5.1 Modification to Dermal Exposure Route

Health effects criteria are available only for the oral and inhalation routes, and most of these criteria are based on the administered rather than the absorbed dose (i.e., the amount of chemical at a human exchange boundary, such as skin, that is available for absorption – but not the amount actually absorbed into the blood). As presented in Tables 4-12 and 4-15, the equation for dermal contact exposures defines absorbed dose rather than intake. Thus, the administered dose health effects criteria must be converted to absorbed dose criteria in accordance with EPA methodology (USEPA, 1989a; 1992).

This adjustment is made using oral absorption efficiency data (i.e., data on gastrointestinal absorption) from the species on which the oral health effects criteria are based. The administered dose oral health effects criterion is multiplied (for RfDs) or divided (for SFs) by the gastrointestinal absorption factor to derive the absorbed dose criterion. New EPA guidance on the dermal exposure pathway (USEPA, 2001) recommends adjusting health effects criteria only if gastrointestinal absorption is less than 50 percent. This source summarizes the available gastrointestinal absorption data in Exhibit 4-1 and these values are used here. A gastrointestinal absorption of 100 percent is assumed as recommended for COPCs not included in Exhibit 4-1 from this source (USEPA, 2001) or compounds with greater than 50 percent absorption. Tables H-4, H-9, and H-13 in Appendix H, present dermal absorption pathways and the gastrointestinal absorption data used to develop CAOs.

4.5.2 Noncancer Effects Associated with Lead

The evaluation of the potential for noncancer effects associated with exposure to lead is different from that of other chemicals for two reasons:

- Although many studies have evaluated the effects of low-level exposure to lead, EPA study groups have not reached a consensus on a threshold level for lead exposure. It appears that some of lead's effects, particularly those associated with certain blood enzymes and neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. As a result, no RfD is established for lead, even though adverse effects are well known.

- Lead in the environment originates from a variety of sources, including air pollution, diet, water pipes, soil, and paints. Because exposure is rarely limited to one pathway, the hazards associated with lead cannot be fully evaluated without considering other environmental contributors.

To adjust for these factors, EPA developed the integrated exposure uptake/biokinetic model (IEUBK), which combines the various exposure pathways to calculate blood lead levels in a given

population of children. The results of this model, preformed by EPA using default variable values, produces an acceptable soil concentration of 400 mg/kg (USEPA, 1994) that conservatively screens out all lead in soil data from the TWFF (i.e., lead is not a COPC). The lead MCL (used as a screening criterion for COPC selection since there is no RBC for lead) is not based on toxicity, but is based on the best available treatment technology. Groundwater lead concentrations at the TWFF exceed the MCL so that lead in groundwater is a COPC. However, the IEUBK model is unsuitable for calculating a CAO at the TWFF since residential exposure will not occur. Therefore, until a method can be determined to calculate a health-based groundwater CAO for lead, or a background-based CAO can be developed (see Section 4.5.4), the MCL will be used as an interim CAO so that lead will be evaluated further in the CMS process.

4.5.3 Approach to Evaluating Carcinogenic PAHs

The human health RA performed for the TWFF RFI (Baker, 1997) and the previous draft of this document (Baker, 2000) used two approaches for evaluating carcinogenic polycyclic aromatic hydrocarbons (PAH_cs). Both appear to be acceptable based on current guidance (USEPA, 1993).

- The first approach calls for adjusting the SF of each individual PAH_c using the estimated order of potential potency compared to benzo(a)pyrene (BaP), calculating the risks separately for each PAH_c, and summing the risks.

- The second approach calls for adjusting the soil chemical data using the same estimated order of potential potency values for each PAH_c, summing the adjusted data to produce a BaP equivalency concentration, and calculating the risk using the BaP SF.

Each of these approaches produces the exact same risk given the same data. The RAs for the RFI used the individual PAH_c approach, while the previous draft of this document used the BaP equivalency approach.

However, when comparing data to CAOs, these two approaches do not necessarily produce identical results. The BaP equivalency approach is, theoretically, slightly more conservative. Rather than using an individual target risk, as is done for all other contaminants, it assumes a more restrictive risk for a *combination* of seven PAH_cs. Additivity of risk is usually accounted for within the framework of risk-based cleanup values or CAOs by using a conservative target risk estimate with the understanding that even if several carcinogenic contaminants are present, the overall standards are still protective. It is unnecessary to assume a greater level of protectiveness for PAH_cs compared to other contaminants. The equivalency approach is, theoretically, slightly more conservative – but only in unusual cases at extremely low concentrations, very near the CAOs.

The individual PAH_c approach is used herein rather than the BaP equivalency approach. The effort required to manipulate the TWFF soil data is not warranted based on the minimal differences in results and the sufficient protectiveness of the individual PAH_c approach.

Several advantages of the individual PAH_c approach are noted below:

- It allows determination of which specific PAH_cs may require cleanup at a particular site.

- It allows immediate comparison of future sampling to CAOs without performing an intermediate BaP equivalency calculation for each data point.

- It reduces the complication of evaluating exceedingly high detection levels needed for future statistical calculations of PAH_cs.

4.6 Background Concentrations as CAOs

Background concentrations may be used as quantitative CAOs when they exceed risk-based CAOs. The National Contingency Plan (NCP) preamble (55 *Federal Register*, 8717) states that preliminary remediation goals (PRGs; i.e., the CERCLA equivalent to quantitative CAOs) may be revised based on consideration of "technical factors," which may include background levels of contaminants.

Ideally, it is desirable to prevent any unacceptable risks posed by exposure to environmental conditions. Unfortunately, however, if lifetime exposure is assumed, some chemicals present estimated carcinogenic risks greater than 1×10^{-6}, or HIs greater than 1.0, even at natural concentrations. Studies of risk perception (Slovic *et al*., 1990; Plough and Krimsky, 1990) conclude that people are more willing to accept risks that they feel are beyond anyone's control (e.g., those caused by earthquakes or general air pollution) or are within their control (e.g., driving a car). Highly toxic compounds, such as arsenic and beryllium in natural concentrations in soil, fall into the former category; but site-related contamination does not.

This risk perception generality, the NCP guidance, and the practical impossibility of reducing exposure or remediating background concentrations to reduce risks to acceptable levels lead to the use of certain background concentrations as quantitative CAOs. Therefore, if a calculated CAO is less than background, the background concentration is used as the CAO. For the TWFF, arsenic in soil and groundwater and lead in groundwater are the only analytes for which background-based quantitative CAOs may be used.

4.7 Quantitative CAOs

Quantitative CAOs are calculated based on the exposure methodology, contaminants, and health effects criteria presented in Sections 4.4 and 4.5. Table 4-19 presents the quantitative soil CAOs for the military land use for comparison with site data. These values represent the concentrations at which a target risk level of 1×10^{-6} (or $1\text{x}10^{-5}$ in the case of PAH_cs) or a target HQ of 1.0 for individual COPCs is achieved by exposure via the exposure pathways presented in Section 4.4. Table 4-20 presents a similar quantitative CAO summary for groundwater.

With the exception of lead in groundwater the quantitative CAOs in Tables 3-19 and 3-20 follow this risk-based approach. The interim lead CAO for groundwater is based on the MCL as discussed in Section 3.5.2.

Tables H-1 through H-14 in Appendix H present pathway- and medium-specific CAOs based on a target risk level of 1×10^{-6} and a target HQ of 1.0. These tables also list the CAOs for target cancer risk levels of 1×10^{-5} and 1×10^{-4} for comparison.

Tables H-5, H-10, and H-14 in Appendix H summarize CAOs for individual pathways, assuming a chemical-specific target risk of 1×10^{-6} (or $1\text{x}10^{-5}$ for PAH_cs) and a target HQ of 1.0 for each pathway, and resulting CAOs assuming exposure via all pathways (i.e., the column headed

"Combination" in the summary tables). Note that the combination CAO is less than the individual pathway CAO because it is based on a total target risk or target HQ posed to a receptor via all of the pathways. Pathway-specific CAOs are algebraically combined using a relationship of the reciprocal of the sum of the reciprocal of the pathway-specific CAOs.

4.8 References

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