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THE MEMPHIS DEPOT TENNESSEE

ADMINISTRATIVE RECORD COVER SHEET



55 (**CH2MHILL**

Results of a Soil Investigation at the Former PCP Dip Vat and Underground PCP Storage Tank Sites, Main Installation, Memphis Depot (Rev. 1)

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Introduction

This Technical Memorandum (TM) presents the results from the September 2003 soil investigation conducted at the former pentachlorophenol (PCP) Dip Vat [Screening Site (SS) 42] on the Main Installation (MI) within the Defense Distribution Center (Memphis), referred to as the Memphis Depot (see Figure 1) This TM has been prepared for the U.S. Army Corps of Engineers (USACE), Huntsville Center, in support of site activities led by the Defense Logistics Agency (DLA) The supporting regulatory agencies include the U.S. Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC). Together, DLA, EPA, and TDEC constitute the Base Realignment and Closure (BRAC) Base Cleanup Team (BCT).

Based on the results of the 2001 Long Term Operational Area (LTOA) assessment for the MI, TDEC indicated that additional studies, including soil sampling, were required to effect closure of SS42. This TM summarizes previous investigations, the September 2003 soil testing results, and results of fate and transport modeling for SS42. This TM (Revision 1) also addresses comments for the TM (Revision 0), which were received during the January 15, 2004 BCT meeting and formal comments received from TDEC and USACE consultants A summary of comments and responses are included as Attachment A.

Purpose and Scope

The overall objective of the latest investigation of SS42 was to evaluate the presence or absence of PCP and PCP degradation products in soil. The testing focused on PCP degradation products that are listed either on EPA's October 2002 Region 9 Preliminary Remediation Goals (PRGs) table, or in the Integrated Risk Information system (IRIS) database (http://www.epa.gov/iriswebp/iris), or in the Health Effects Summary Tables (HEAST) (http://www.epa.gov/radiation/heast). The PCP degradation products of concern are 2,3,4,6-tetrachlorophenol (TetraCP), 2,4,5-trichlorophenol (TCP), 2,4,6-TCP, 2,4-dichlorophenol (DCP), 2-chlorophenol (CP), and phenol. Soil samples were analyzed for

these compounds. The presence of these degradation products could be used to help evaluate the occurrence of PCP biodegradation at the site.

The scope of the September 2003 soil investigation included the following tasks:

- Advance seven soil borings within the site, and collect composite soil samples for laboratory analysis.
- Evaluate whether concentrations of PCP or PCP degradation compounds in soil pose a threat to groundwater using soil screening calculations and fate and transport modeling.
- Analyze four soil samples for dioxins and furans, per TDEC's request.

Site History and Background

SS42 is located in BRAC Parcel 33 in Functional Unit (FU) 4 on the MI. The site is adjacent to SS43, the former Underground PCP Tank area, and to the southwest of SS46, the former Pallet Drying area. Figure 1 presents a site location map and Figure 2 presents the site layout Sites SS42 and SS43 are located near Building 737, the Entomology Shop. SS46 is located south of Building 720, as shown on Figure 3.

Beginning in 1952, Depot personnel treated wood products, particularly pallets, in a metal shed, known as the Dip Vat Building. The wood was treated in a 5,000-gallon dip vat with a product called POL-NU, consisting of approximately 11 percent PCP. After the wood was treated, it was dried in open storage areas (SS46). A 12,000-gallon underground storage tank (UST), south of Building 737, was used to store additional PCP liquid. In 1971, when it became more economical to purchase pre-treated pallets, use of the dip vat was discontinued.

In August 1985, a sample of the liquid PCP was collected from the dip vat; results indicated the sample contained 15.5 percent PCP [O. H. Materials (OHM), February 1986]. Consequently, OHM conducted soil sampling to delineate site contamination. A longitudinal sampling grid was constructed around the Building 737 area. Soil samples were taken at 5-foot intervals to a depth of 35 feet (ft). Soil contamination, to a depth of 25 feet, was identified as being the greatest in a 20-foot long area to the north of the dip vat and drain pan (in the area of the former rollers [Figure 2]). Based on the results of the soil investigation in 1985, OHM removed the PCP dip vat, the PCP UST, the associated pump house and sump, and approximately 602 cubic yards (cy) of soil that contained total dioxin and furan concentrations exceeding 200 ppb. The Dip Vat Building was also disassembled and removed. During the UST removal, the structural integrity of the tank was determined to be sound. However, leaking was discovered at six joints in the subsurface piping (OHM, February 1986).

Soil in the Dip Vat and UST areas was excavated to depths between 2 and 14 feet below land surface (bls). The soil excavation was stopped at a depth of 10 feet in the immediate Dip Vat area, although soil contamination was detected below the limits of the excavation (OHM, February 1986). The excavation pit was backfilled with native soil and crushed stone. Three inches of surface soil also were removed in an area to the east of the former dip vat. This area and the surface of the former PCP Dip Vat and the PCP UST are currently covered by concrete. The former Pallet Drying area was covered by 8 to 10 inches of gravel.

In 1989 and 1990, Law Environmental conducted a RI for the Memphis Depot (Law, August 1990). One surface soil sample (SS-47) was collected in the vicinity of SS42 (Figure 4). Three subsurface soil samples (19 ft bls, 26 ft bls, and 102 ft bls) were collected from boring STB-4, located at SS46 (Figure 3). Neither PCP nor its degradation products were detected in these samples. CH2M HILL (1998, 2000) reported results from its sampling events conducted between 1996 and 1998. CH2M HILL collected five surface soil samples, and advanced three soil borings two at SS42 and one at SS46 PCP was analyzed in two surface samples (SS-43C, SS-46E) and one subsurface soil sample (SB-46A) at SS46 (Figure 3), no PCP was detected PCP was analyzed in two subsurface samples (SB-42A and SB-43A) at SS42; PCP was detected at 8-10 feet bgs in SB-42A (Figure 4).

In 2001, CH2M HILL conducted soil and groundwater sampling to evaluate potential contamination downgradient of Long Term Operational Areas (LTOAs). Three deep soil samples collected from boring SB-105 at SS42 were analyzed for PCP (Figure 4). PCP was not detected in any of the soil samples. Five composite soil samples also were collected and analyzed for leachable PCP via the synthetic precipitation leaching procedure (SPLP). The leachate from the sample from 10 to 30 feet bls had an estimated concentration of 0.003J milligram per liter (mg/L). No other samples contained PCP or any other chlorophenols above laboratory detection limits (CH2M HILL, July 2002).

Geology and Hydrogeology

The uppermost geologic unit on the MI is Quaternary loess. The loess deposits consist of silty clay, clayey silt, and fine sandy clayey silt. This unit is described as a continuous, brown to yellowish, low-plasticity clayey silt (ML) or low-plasticity silty clay (CL). The loess ranges in thickness from 6 to 44 feet, with an average thickness of 28 feet. At SS42, the loess is about 38 feet thick.

The loess deposits overlie the fluvial deposits consisting of fine to coarse sand with some gravel and fines (clay and silt). The thickness of the fluvial deposits ranges from approximately 30 feet to greater than 120 feet at the MI. At SS42, the fluvial deposits average about 60 feet thick at SB-105. This formation holds the fluvial aquifer that occurs under unconfined (water table) conditions The average depth to the fluvial aquifer on the MI is 87 feet bls (CH2M HILL, January 2000). Thickness of the fluvial aquifer ranges from less than 1 foot at the northwest corner of the MI to 57 feet in the west central portion of the MI. The fluvial aquifer is typically underlain by clay-rich units (clay or clayey sand) of the Jackson Formation/Upper Claiborne Group that occurs beneath most of the MI. The Jackson Formation/Upper Claiborne Group separates the fluvial aquifer from the underlying Memphis aquifer, that is the source of water supply for the City of Memphis.

Groundwater in the fluvial aquifer flows toward the northeast in the southwest corner of the MI but toward the southwest from the northeast corner of the MI. Groundwater converges near the central, southern portion of the MI (Figure 5) Soil boring logs and depth-to-water measurements in the northwest corner of the MI show a 'no flow to limited flow' boundary around an area where the confining clay underlying the fluvial deposits is discontinuous. In the "no-flow" area northwest of MW-63A and MW-63B, the fluvial deposits are in direct contact with the lower intermediate aquifer, and there is no fluvial aquifer (due to lower water levels in the intermediate aquifer). Beneath SS42 the fluvial deposits are in a transition zone between being separated and connected with the

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underlying intermediate aquifer. In addition, directly beneath SS42 the confining clay rises above the local water-table elevation and there is no fluvial aquifer.

During the LTOA investigation, CH2M HILL drilled a boring for a monitoring well near boring SB-105 (Figure 4), however, the fluvial aquifer was not detected in the boring. Since there was no water table aquifer detected at the SB-105 location, and based on the potentiometric surface at the time, monitoring well MW-108 was installed 325-feet southsoutheast of SB-105 (see Figure 5). Within MW-108, the saturated thickness of the water table aquifer was measured at approximately 57-feet. MW-108 was screened in the lower 10foot section of the aquifer. No PCP or resultant degradation products were detected in the groundwater sample (CH2M HILL, July 2002).

Groundwater samples were collected from monitoring wells MW–89 and –90 in March 2002 as part of a follow-up action to the LTOA effort. The samples were analyzed for semi-volatile organic compounds (SVOCs), including PCP. These wells were sampled because of potential leaching of contaminants from soil to groundwater at the Site SS-42/43. None of the four groundwater samples collected from these two monitoring wells contained PCP above the reporting limit of 2.66 μ g/L. Within MW-89, bis(2-ethylhexl)phthalate was detected at 152 feet BTOC (4.23J μ g/L) and 162 feet BTOC (6.59 μ g/L). No other SVOCs were detected.

Soil Investigation Activities

Soil Boring Installation and Soil Sampling

The soil investigation was conducted on September 22 and 23, 2003 at SS42 and SS43. Seven soil borings (SB-109 through SB-115) were advanced using direct push technology (DPT) methods (Figure 6). Soil borings SB-109 through SB-112 were located within the limits of the 1985 soil excavation, and were completed to 40 feet bls (bottom of the loess). Borings SB-113 through SB-115 were completed from land surface (just beneath the concrete slab) to 20 feet bls. No groundwater was encountered in the borings. The log for boring SB-105 (CH2M HILL, 2000) provides detailed lithology to a depth of over 100 feet beneath SS42.

Continuous soil samples were retrieved using the DPT Macro-Core[®] sampling system. Soil samples were collected from 10 to 40 feet bls in SB-109 through SB-112. Since the average depth of the 1985 pit excavation was 10 feet (OHM, February 1986), no soil samples were collected in the zero to 10-foot interval from SB-109 through SB-112. In borings SB-113 through SB-115, continuous soil samples were obtained from zero to 20 feet bls. Since the objective of the soil investigation did not include geologic characterization, all soil borings were shallow and completed within the loess layer, and the soil borings SB-112 and SB-114 are presented in Attachment B. The soil is a silty clay to clayey silt from zero to 35 feet bls. At a depth of 35 feet, the lithology changes to a silty sand (fluvial deposits). During the investigation, an undefined odor was noted in the field logs for borings SB-109 and SB-111.

Composite soil samples were collected for laboratory analysis at each boring. All sampling was conducted in accordance with procedures described within the EPA Region 4 Science and Ecosystems Services Division *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EISOPQAM), dated November 2001. For borings SB-109

through SB-112, a sample from each foot of the soil core was collected and used to form a composite sample on a 6-foot basis, for a total of five composite samples from each boring. For borings SB-113, SB-114, and SB-115, a sample from each foot of the soil core was collected and used to form a composite sample on a 6 to 7-foot basis, for a total of three composite samples from each boring. Additionally, four shallow soil samples from borings SB-113, SB-114, and SB-115 were collected by CH2M HILL for TDEC for analysis of dioxins and furans. Composite samples are appropriate when collecting samples for leachate analysis that will be used for soil screening calculations (EPA, July 1996). Therefore, samples collected for soil leachate analysis were composited over vertical intervals of 10 to 20 feet. Table 1 summarizes the location and sample interval for each soil sample.

Upon completion of soil sampling, all seven boreholes were plugged and abandoned using procedures presented in Section 6.9 of the EISOPQAM. Soil cuttings not used for laboratory analysis were placed back in their respective boreholes. Borings were then filled to land surface with clean sand and bentonite. Other investigation derived waste (IDW) was placed into a 55-gallon drum and staged on-site for later disposal.

Allen & Hoshall, Inc , a registered surveyor, completed the horizontal control surveying (X-, Y-coordinates) of the borings on October 3, 2003. Soil borings were located in Tennessee state plane coordinates (NAD 27). Vertical ground surface elevations were located to the nearest tenth of a foot The survey data are provided in Table 2

Laboratory Analysis

Soil samples were shipped to Columbia Analytical Services (CAS) in Kelso, Washington. CAS Kelso is certified by USACE and the National Environmental Laboratory Accreditation Program (NELAP) All soil samples were packaged and shipped under standard chain of custody procedures. The samples were delivered to the laboratory within the appropriate holding period. As indicated in Table 1, the following analyses were conducted:

- PCP and applicable degradation products by EPA SW-846 Method 8270C
- PCP and applicable degradation products by EPA SW-846 Method 8151
- Leachable PCP and applicable degradation products by SPLP Method 1312 and EPA SW-846 Method 8270C with selected ion monitoring (SIM)
- pH by EPA SW-846 Method 9045
- Total organic carbon (TOC) by ASTM Method D4129

Since PCP has a very low soil screening level (SSL) in the EPA Region 9 PRG table, some samples were analyzed using two methods. Samples were initially analyzed by Method 8270 Samples that tested below laboratory detection limits were subsequently analyzed using Method 8151. PCP reporting limits are much lower using the latter method. However, Method 8151 does not analyze all of the PCP degradation products important to this study Therefore, results from both methods had to be used.

Soil samples collected from boring SB-113 (zero to 6 ft bls), SB-114 (zero to 6 ft bls), SB-115 (zero to 6 ft bls), and SB-115 (6 to 13 ft bls) were collected for TDEC. These samples were sent to Severn Trent Laboratories, Inc. (STL) in Knoxville, Tennessee and analyzed for

dioxins and furans by EPA SW-846 Method 8290. The USACE and NELAP also certify this lab.

Analytical results were provided by CAS Kelso and STL Knoxville in both hard copy and in an electronic data deliverable (EDD) format (comma-delimited ASCII file format) that is compliant with CH2M HILL's EDD 4 0 specification

Data Quality Evaluation

A CH2M HILL chemist validated the data for compliance with the method requirements. This process included a review of the data to assure proper shipping and handling, and to assess the accuracy, precision, and completeness The review was made following procedures described in the U.S. Army Corps of Engineers EM-200-1-6, *Chemical Quality Assurance for Hazardous, Toxic and Radioactive (HTRW) Projects* (USACE, October 1997) and procedures modeled on EPA Contract Laboratory Program, *National Functional Guidelines for Organic Data Review* (EPA, October 1999), *National Functional Guidelines for Inorganic Data Review* (EPA, July 2002) and *National Functional Guidelines for Dioxin/Furan Data Review* (EPA, August 2002). The chemist reviewed chain of custody forms, quality assurance/quality control (QA/QC) summary forms, and laboratory data reports to complete his assessment. The data validation noted the following:

- Soil samples were collected, shipped, and analyzed with appropriate quality control (QC) samples. QC samples included three field duplicates, two matrix spikes, two matrix spike duplicates and one equipment rinsate blank. Samples were received in good condition and were extracted/analyzed within holding times.
- Nine SPLP samples were analyzed in secondary dilutions due to target compounds exceeding the instrument calibration range. In order to have only one valid result for each parameter in each sample, results exceeding the calibration range were excluded and the dilutions within range were retained.
- For the chlorinated phenolic acids analyzed by 8270C_SIM, 11 samples were analyzed in secondary dilutions due to target compounds exceeding the instrument calibration range. In order to have only one valid result for each parameter in each sample, results exceeding the calibration range were excluded and the dilutions within range were retained.
- Octachlorodibenzo-p-dioxin (OCDD) exceeded the instrument calibration range in two samples (SB-114 and SB-115). As the samples were not reanalyzed, the OCDD results were qualified as estimated ("J").
- One field sample and both field duplicates were re-extracted beyond method holding time for the chlorinated herbicides (SW8151) due to low surrogate recoveries As surrogate recoveries were much improved, the re-extracted data were retained and qualified as estimated due to the holding time exception. The original results were excluded

No data were rejected during the data validation process. The precision, accuracy, representativeness, comparability and completeness (PARCCs) meet the project objectives.

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The data are 100% complete and can be used in the project decision-making process as qualified by the data quality evaluation process

Variations from the Defined Scope

In general, the September 2003 soil investigation was conducted as outlined in the *PCP Dip Vat Soil Investigation Work Plan* [Work Plan] (CH2M HILL, August 2003). However, the following variances are noted.

- The Work Plan stated that all soil samples would be analyzed by both Methods 8151 and 8270C. PCP and all of the target degradation products are analyzed by Method 8270C, but 8151 method was to be used to achieve low reporting limits for PCP All soil samples were run initially using Method 8270C. If PCP was not detected by this analysis, then the sample was re-analyzed using Method 8151. This reduced the total number of 8151 analyses required.
- The Work Plan stated that SPLP soil samples would be analyzed using Methods 8151 and 8270C. However, upon further investigation, it was discovered that Method 8270C SIM included the desired list of analytes and would meet the desired reporting limits. Therefore, Method 8270 SIM was used exclusively.
- The Work Plan stated that soil would be analyzed for TOC by SW-846 Method 9060. However, CAS Kelso analyzed the samples using ASTM Method D4129. This is an alternative method for TOC analysis, with the results reported in units of percent.
- The sample depths for SPLP samples were modified to include a larger composite sample interval The *Soil Screening Guidance: User's Guide* (EPA, July 1996) states, "For the leach test option, collect discrete samples along a soil boring from within the zone of contamination and composite them to produce a sample representative of the average soil boring concentration." Therefore, the sample interval for SPLP analysis was increased to 10-feet and 20-feet, depending on the soil boring.
- The Work Plan stated that soil samples from SB-115 would be split with TDEC for analysis of dioxins and furans. After further clarification, one sample each from soil borings SB-113 and SB-114, and two samples from SB-115 were collected by CH2M HILL on behalf of TDEC for this analysis.
- The Work Plan stated that an ambient blank would be collected for analysis of TOC and pH. This was not performed. However, both parameters were analyzed in the equipment blank sample. Since these were not the primary analytes of concern, this did not impact the study conclusions.
- The Work Plan stated that three equipment blanks would be collected during the investigation. Because all sampling was completed in two days, only one equipment blank was collected This is considered adequate for such a short sampling period.

Analytical Results

PCP and Degradation Products

Table 3 presents the analytical results for the investigation. Analytical results were compared against the 2002 Region 9 PRGs for Industrial Direct Contact of 90 mg/Kg [assuming a target cancer risk of 10⁻⁵ and a hazard index (HI) of 1.0]. PCP exceeded this PRG in five samples. SB-109 (10 to 16 ft bls), SB-109 (16 to 22 ft bls), SB-110 (10 to 16 ft bls), SB-110 (16 to 22 ft bls), and SB-111 (16 to 22 ft bls).

Of the PCP degradation products with health-based criteria, only 2,3,4,6-TetraCP was detected in soil. 2,3,4,6-TetraCP was detected in samples from borings SB-109, SB-110, and SB-111; concentrations were below the 2002 Region 9 PRGs for industrial soil exposures All other parameters were reported as not detected in all samples, and the reporting limits for these parameters were below the Region 9 PRGs.

Leachable PCP and Degradation Products

As described in the Soil Screening Guidance (EPA, July 1996), a leach test may be used in lieu of the linear soil/water partition equation for evaluating the soil to groundwater migration pathway Both the partition equation and the leach test estimate the contaminant release to soil leachate. The partition equation estimates leachate concentrations using mathematical calculations. The leach test estimates the concentrations using laboratory analyses. Table 4 presents the September 2003 analytical results for leachable concentrations of PCP and target degradation products. PCP; 2,3,4,6-TetraCP; 2,4,6-TCP; and 2,4-DCP were detected or estimated above laboratory detection limits in several samples. Concentrations were highest in the 10 to 22-foot depth.

The leachate results were compared to site-specific soil leachate target concentrations. The site-specific target leachate concentrations, or leachate SSLs, were calculated for each compound by multiplying a dilution attenuation factor (DAF) by the applicable groundwater risk-based criteria [either the maximum contaminant level (MCL) or the Region 9 tap water PRG]; these are presented in Table 4. A site-specific DAF of 39.3 was calculated to account for the effect of dilution on the soil leachate concentration once it reaches the water table aquifer. Input parameters for the DAF include the infiltration rate, hydraulic conductivity and gradient, and mixing zone depth. DAF calculations are included in Attachment C.

Leachable PCP concentrations exceeded the leachate SSL of 39 μ g/L in samples from SB-109 through SB-112, and SB-114 Leachable concentrations for PCP degradation products were all below their respective leachate SSL. Since PCP leachate concentrations exceeded the leachate SSL, fate and transport modeling was conducted to determine the potential for development of a PCP plume within the fluvial or the transition zone to the intermediate aquifer. This modeling is discussed below.

Dioxins and Furans

Dioxins and furans are typically associated with PCP operations. Table 5 presents analytical concentrations of dioxins and furans for the four soil samples analyzed during the September 2003 soil investigation. Of the detected dioxins and furans, the higher

chlorinated, more persistent isomers were the most commonly detected. Only 2,3,7,8-TCDD has an EPA Region 9 PRG of 0.016 mg/Kg for industrial direct contact. The concentration of 2,3,7,8-TCDD in all samples was below this value.

Concentrations of dioxins and furans for each sample were transformed into a total TCDD toxicity equivalent (TEQ) concentration To calculate the TEQ for each sample, each individual compound was multiplied by the toxic equivalency factor (TEF), which relates the compound to the toxicity of 2,3,7,8-TCDD TEFs were obtained from the 1998 World Health Organization values (Van de Berg, et al , December 1998). The individual TEQ values were then summed to determine the total TEQ

The TCDD TEQ background values at the MI are 0.01 μ g/Kg in surface soil and 0.006 μ g/Kg in subsurface soil (CH2M HILL, January 2000). TEQ values slightly exceeded these background values at sample points SB-114 (zero to 6 ft bls) and SB-115 (6 to 13 ft bls). The EPA action level for the TCDD TEQ is 1 μ g/Kg, or 1 ppb, for residential soils and 5 μ g/Kg to 20 μ g/Kg for industrial soils (EPA, April 1998). TEQs for all samples were below the 1 μ g/Kg level.

Fate and Transport Analysis

PCP Fate in Soil and Groundwater

PCP and its degradation products are subject to several processes that attenuate concentrations in soil and groundwater. Principal processes are adsorption (to soil and organic matter), dilution, biodegradation, chemical reaction (photolysis and hydrolysis), and volatilization. Adsorption and dilution may lower the measured concentrations, but do not transform the contaminants, while the latter processes are relatively insignificant in soil and groundwater. During this study, two soil borings were advanced adjacent to historical soil borings with relatively high PCP concentrations. Soil Boring SB-109 was placed adjacent to Boring 25 (2400 mg/Kg at 20 ft bls) and soil boring SB-111 was placed adjacent to Boring 3 (2400 mg/Kg at 10 ft bls), as shown on Figure 6 PCP concentrations in soil samples from SB-109 (maximum of 990 mg/Kg) and SB-111 (maximum of 440 mg/Kg) were well below the historical concentrations of 2400 mg/Kg. This suggests that PCP concentrations in soil have attenuated since 1985.

Factors Impacting PCP Attenuation

Several factors impact the attenuation of PCP in soil Based on the EXTOXNET information profile (June 1996), PCP biodegradation is fastest under higher temperatures and in the presence of organic matter. Organic carbon serves as an electron donor source for the reductive dechlorination mechanism TOC was analyzed in seven soil samples from SS42. The average organic carbon content in soil was 3,000 mg/Kg, thus calculating a fraction organic carbon (foc) content of 0.003 The presence of organic carbon indicates that PCP and its degradation products are less likely to leach, and preferentially sorbing to the loess matrix.

Soil pH also has a significant impact on the leaching and biodegradation of PCP in soil As stated in the EPA's technical factsheet for PCP (EPA, November 2002), the adsorption of PCP to soil is greater under low pH or acidic conditions. Chlorophenols were documented

by Okeke et al. (1996) to biodegrade more readily under initial low-pH soil conditions. Soil pH was analyzed at varying depths in seven soil samples during the September 2003 investigation, the average value reported was 7.3. This neutral pH is above the favorable pH range for PCP biodegradation; however, it is most likely not a limiting factor.

Biodegradation

Biodegradation is believed to be the predominant transformation mechanism for PCP in soil and groundwater at SS42. PCP has been reported to degrade more rapidly in anaerobic environments than in aerobic ones (ATSDR, September 2001; Montgomery, 1996). Anaerobic degradation of PCP in soil occurs primarily via reductive dechlorination. During this process, the chlorinated compound is used as an electron acceptor by microorganisms and a chlorine is replaced by hydrogen. The phenol ring is broken relatively late in the degradation process. PCP is reductively broken down in the following general sequence:

 $PCP \rightarrow TetraCP \rightarrow TCP \rightarrow DCP \rightarrow CP \rightarrow Phenol$

The pathway (or specific isomers created during the anaerobic degradation process) that is followed at a specific site is dependent on the type of microorganism present in the system (Mahaffey, 1997). Possible intermediate breakdown products include three isomers of TetraCP, five isomers of TCP, six isomers of DCP, and three isomers of CP. The isomers of CP may dechlorinate to phenol or may mineralize to carbon dioxide and water; however, this is not prevalent. A possible pathway for reductive dechlorination of PCP is presented as Figure 7.

In aerobic degradation, PCP is broken down by a series of pathways. The aerobic byproducts are considered to be short-lived and do not generally accumulate in the environment (Mahaffey, 1997). The degradation process begins with oxidative dechlorination reactions, forming intermediate degradation products, which may include tetrachloroatechol, tetrachlorohydroquinone (TeCHQ), tetrachlorobenzoquinone (TeCBQ), trichlorohydroxylbenzoquinone (TCBHQ), trichlorohydroquinone (TCHQ), dichlorohydroquinone (DCHQ), and chlorohydroquinone (CHQ) These aerobic degradation products have fewer chloride atoms than does PCP, and they degrade quickly by cleavage of the phenol ring. Therefore, PCP does not fully break down to hydroquinone. The final degradation products by mineralization are water, carbon dioxide, and chloride ions The aerobic degradation pathway for PCP is presented in Figure 8.

Evidence of Biodegradation

Since there are no aerobic degradation products with listed health-based criteria, these compounds were not included in the September 2003 soil investigation. During the September 2003 soil investigation, selected anaerobic degradation products were analyzed, including 2,3,4,6-TetraCP; 2,3,4,5-TetraCP, 2,3,5,6-TetraCP; 2,4,5-TCP; 2,4,6-TCP; 2,4-DCP; 2-CP, and phenol. Three TetraCP isomers were either detected or estimated above laboratory detection limits in at least one soil sample. None of the other anaerobic degradation products were detected This indicates that some degradation of PCP may be occurring. However, the TetraCPs are either not being reduced to TCPs or are being reduced to isomers of TCP that were not analyzed. As indicated above, it is very difficult to predict the degradation pathway for PCP and which isomers of the chlorophenols will be formed. It is

possible that other isomers, that were not analyzed, were produced by reductive dechlorination

PCP Transport Modeling

Since the PCP leachate concentration exceeded the leachate SSL, transport modeling was performed to evaluate the potential for a PCP plume in the fluvial aquifer or intermediate aquifer to migrate to a downgradient receptor. Model results were used to determine if the current PCP soil concentrations pose a risk to potential human receptors. The model was not used to estimate possible PCP concentrations which might have leached into groundwater from historical PCP soil concentrations, which were higher than those reported in 2003. The model simulated contaminant transport vertically to groundwater and then horizontally to a point (potential receptor) downgradient. Since PCP soil contamination already extends completely through the loess deposits (to a depth of 40 feet bls), vertical transport modeling was only performed in the fluvial deposits.

The selected model for the assessment was the EPA's Multimedia Exposure Assessment Model (MUTIMED). MULTIMED is a one-dimensional (1-D) screening model created to simulate the movement of contaminants leaching from a waste disposal facility. The model is documented in *Multimedia Exposure Assessment Model (MULTIMED) for Evaluating the Land Disposal of Wastes – Model Theory* (Salhotra et al., 1990). MULTIMED simulates vertical flow of soil contaminants in the unsaturated zone and horizontal transport in the saturated zone, while incorporating processes of dispersion, adsorption, biodegradation, and volatilization. This screening model was selected for SS42 over a three-dimensional (3-D) model, since a 3-D model could not be developed with the available data. Furthermore, a 1-D model is often preferable to a 2-D or 3-D model for numerous reasons, including lack of data. The model results are useful for understanding PCP transport; however, they cannot replace soil and groundwater analyses from SS42 to determine human health risk.

Conceptual Model

Approximately 40 feet of loess overlies approximately 125 feet of sand at SS42. SS42 appears to be located either within or on the very edge of the "*no flow to limited flow*" boundary (Figure 5) discussed above. Since a confining clay layer rises above the local water table elevation, the fluvial aquifer does not appear to be present at this location. The fluvial deposits are in direct contact with the intermediate aquifer. The lithology at MW-107 (as presented in Figure 7 of the *Evaluation of Soil and Groundwater Data Collected from Long-Term Operational Areas (LTOAs)* (CH2M HILL, July 2002)] was used to estimate thickness of the vadose zone and intermediate aquifer for MULTIMED calculations. MW-107 is located cross-gradient to SS42 and also within the transition zone of the fluvial aquifer and the intermediate aquifer The depth to groundwater is approximately 112.5 feet bgs. Furthermore, since the conceptual model presented in the LTOA TM (CH2M HILL, July 2002) indicates that water table aquifer might be in direct contact with underlying confined aquifers, the Allen Well Field was used as the potential downgradient receptor.

The MULTIMED model was run under steady state conditions. The initial (source) concentration of PCP was based on the SPLP analyses, and PCP was assumed to contaminate the entire thickness of the loess. [Transport of PCP was **only** modeled in the unsaturated and saturated zones of the fluvial deposits and underlying sands.] A constant

concentration was assumed (no source decay) to occur at the top of the fluvial deposits. This is a very conservative assumption since there are no longer any PCP-handling activities at SS42, and the "source" areas with highly-contaminated soil were excavated. These assumptions all were considered to be "conservative", in that their use in subsequent calculations tends to produce overestimates of the highest PCP concentrations that might occur at a potential exposure point.

For comparison purposes, the model was run under five scenarios, which are listed as follows

- Scenario 1: Average PCP leachate concentration, no biodegradation,
- Scenario 2: Maximum PCP leachate concentration, no biodegradation,
- Scenario 3. Average PCP leachate concentration, conservative biodegradation, and
- Scenario 4 Maximum PCP leachate concentration, conservative biodegradation.
- Scenario 5. No Runoff, maximum PCP leachate concentration, conservative biodegradation.

Hydrologic Evaluation of Landfill Performance (HELP) Model

Prior to running MULTIMED, the HELP model, Version 3.07 (Schroeder et al., September 1994), was used to estimate the infiltration rate between the loess and the fluvial deposits. This is an essential input parameter to simulate PCP transport using MULTIMED. HELP is a quasi-two-dimensional (2-D) model that simulates water movement through landfills. The model is described in detail in *The Hydrologic Evaluation of Landfill Performance (HELP) Model Engineering Documentation for Version 3* (Schroeder et al., September 1994).

The HELP model for SS42 was setup as a 2-layer model (loess and fluvial deposits). Precipitation enters the loess (top layer) and either evaporates or migrates downward to infiltrate into the fluvial deposits Input parameters are divided into weather, soil, and design data. The weather data include evapotranspiration, precipitation, temperature, and solar radiation data. The soil and design input includes area of site, percent of area where runoff is possible, soil layer data, and runoff curve data. The HELP model input data are summarized in Table 6.

The model was run under two situations. The first situation was based on current conditions, in which a concrete slab covers a majority of the site. Therefore, infiltration into the subsurface is restricted. The HELP model was also run under a conservative conditions, which assumed no runoff at the site. This latter situation is meant to simulate the maximum recharge at the site if the concrete slab is removed in the future. Each scenario was run for a 10-year period Under current site conditions, the average annual percolation rate between the loess and fluvial deposits is 0.01 m/yr. Under a conservative, no runoff scenario, the average annual percolation rate is 0.27 m/yr. These values were used as the infiltration (recharge) rate for the fluvial deposits in the MULTIMED model. The HELP model output files are presented in Attachment D

MULTIMED Model Model Input The MULTIMED model code contains several modules: Landfill, Air, Surface Water, Unsaturated Zone, and Saturated Zone. For this evaluation, the Unsaturated and Saturated Zone Modules were selected. Model input parameters are summarized in Table 7. Input parameters which were model-derived were also hand calculated; these calculations are included as Attachment E.

The maximum (31,000 μ g/L) and average (5,920 μ g/L) PCP soil leachate concentrations from the September 2003 investigation were used in the simulations. In reality, the concentration of soil leachate migrating through the subsurface is expected to be near the average concentration. However, the maximum value was used for comparison purposes.

Scenarios 3 and 4 were prepared because it is likely that biodegradation of PCP is occurring beneath SS42. There was limited evidence for anaerobic biodegradation in the loess based on the analytical results. The fluvial sands are known to be an aerobic environment (CH2M HILL, July 2002), facilitating aerobic biodegradation and oxidation. PCP has been shown to degrade in aerobic soil, with reported half-lives of 45 days, (Extoxnet, 1996), 2 to 4 weeks [Agency for Toxic Substances and Disease Registry (ASTDR), September 2001], and weeks to months (EPA, November 2002). Aqueous aerobic half-lives for PCP have been reported between 23 and 178 days (Mackay, et al., 2000). For Scenarios 3 and 4, the longest PCP half-life [36,480 hours or 1,520 days] reported by Mackay and others (2000) was used. Also, note that no abiotic decay of PCP was assumed in the model.

Scenario 5 was added to the list of model runs to address comments received at the January 15, 2003 BCT meeting from TDEC. This scenario addresses the potential that the concrete slab at the site may be removed in the future, thus increasing infiltration into the subsurface. For this scenario, the current maximum PCP leachate concentration and a conservative biodegradation rate were assumed.

Model Results

The MULTIMED model output for all five scenarios is included as Attachment F. Assuming no biodegradation, the concentration of PCP reaching the water table was 5,920 μ g/L using the average source concentration and 31,000 μ g/L using the maximum source concentration. These results indicate there was no attenuation during the vertical transport through the fluvial deposits. This lack of attenuation is due to the assumption of steady state, no source decay, no biodegradation or abiotic decay, and the low organic carbon content of the fluvial deposits. The model calculated PCP concentrations in groundwater at the Allen Well Field of 0.010 μ g/L (average source concentration), and 0.052 μ g/L (maximum source concentration). Both values are below the MCL of 1 μ g/L for PCP.

By allowing some aerobic biodegradation, the estimated PCP concentration leaching into groundwater was less than $0\ 001\ \mu\text{g/L}$ using either average or maximum source concentration. The estimated PCP concentration in groundwater at the Allen Well Field was zero under both scenarios. These scenarios are considered more realistic of the environment beneath SS42 These model results indicate PCP contamination slowly leaches down to the fluvial deposits, due to the low vertical percolation rate. Within the fluvial deposits, aerobic conditions are conducive to biodegradation of the PCP so that contaminant levels within the fluvial aquifer are low to non-detect. Analyses of groundwater from monitoring wells most near SS42 have not detected PCP, thus partially validating the Scenario 3 and 4 calculations

If the concrete slab were to be removed in the future, the estimated PCP concentration leaching into groundwater is less than 0 001 μ g/L. This is based on a maximum source concentration and a conservative biodegradation rate. Additionally, the model calculated PCP concentration in groundwater at the Allen Well Field was also less than 0 001 μ g/L

Risk Evaluation

Direct Contact with Soil

Of 29 soil samples analyzed, PCP concentrations in five deep samples were reported as exceeding the 2002 Region 9 PRG of 90 mg/Kg (cancer risk of 10⁻⁵) for industrial direct soil contact. However, PCP concentrations were well below the industrial PRG in all shallow soil samples (zero to 6 ft bls) 2,3,4,6-TetraCP; 2,3,4,5-TetraCP; and 2,3,5,6-TetraCP were the only daughter products of PCP that were detected in any soil samples. All reported concentrations of 2,3,4,6-TetraCP were below the PRG of 18,000 mg/Kg (HI of 1.0) for industrial direct soil contact 2,3,4,5-TetraCP and 2,3,5,6-TetraCP do not have any listed health-based criteria. All other PCP degradation products that were analyzed were not detected at reporting limits that were below their industrial contact PRGs.

Potential Migration to Groundwater

Site-specific screening levels for soil leachate were calculated using a site-specific DAF of 39.3 (Attachment C) and protective groundwater criteria Most of the 11 loess samples had leachate concentrations reported above the target leachate concentration of 39 μ g/L. Because the loess is well above the water-table aquifer, transport modeling was performed to estimate PCP concentrations that might migrate toward a potential downgradient receptor.

As discussed above, five scenarios were run: Scenario 1 (average PCP leachate concentration, no biodegradation), Scenario 2 (maximum PCP leachate concentration, no biodegradation), Scenario 3 (average PCP leachate concentration, with biodegradation), Scenario 4 (maximum PCP leachate concentration, with biodegradation), and Scenario 5 (no runoff, maximum PCP leachate concentration, with biodegradation). Assuming no biodegradation, the model estimated the PCP leachate concentration reaching the water table exceeded the site-specific target concentration using either average or maximum source concentration reaching the water table is essentially zero under current site conditions. If the concrete slab was to be removed at the site in the future, model results indicated that the PCP leachate concentration reaching the water table would still be less than 0.001 μ g/L. The model calculates that the concentration of PCP at the potential receptor point (Allen Well Field) was below the MCL for PCP of 1 μ g/L under all five scenarios. Therefore, PCP in soil is not considered a threat to potential downgradient receptors

Conclusions and Recommendations

Conclusions

A soil investigation was conducted at SS42, SS43 and SS46 - the former PCP dip vat, UST, and wood treatment drying areas at the MI - in September 2003. The objective of the investigation was to identify the presence or absence of PCP and its degradation products, and to determine if the contamination posed a risk to human receptors. Seven soil borings were advanced at SS42 to depths ranging from 20 to 40 feet bls. Composite soil samples were collected at each boring for chemical analysis. Chemical analysis showed that PCP and several degradation products occur in deep samples of the loess. Concentrations of PCP ranged from 0.004 to 990 mg/Kg. The PCP levels in five samples exceeded the 2002 Region 9 PRGs for industrial Direct soil contact of 90 mg/Kg. None of the samples were from depths less than 10 feet bgs. None of the PCP degradation products that were detected exceeded a PRG. Seven of the 11 soil samples submitted for analysis of leachate using synthetic precipitation developed a leachate that exceeded site-specific target concentrations of 39 μ g/L. The laboratory leachate results were used in a transport model to estimate potential PCP concentrations in groundwater beneath SS42 and at a potential downgradient receptor.

Analysis of four samples for dioxins and furans showed detections of some highly chlorinated persistent dioxin isomers. The only isomer with a Region 9 PRG is 2,3,7,8-TCDD and its level did not exceed the PRG. The concentrations of the dioxins and furans were transformed to a total TCDD toxicity equivalent but the calculated level in all samples was below EPA's action level of $1 \mu g/Kg$

The soil analyses provide limited evidence that PCP at SS42 is biodegrading. TetraCP isomers were the only degradation isomers detected, possibly because other isomers were not analyzed. Additionally, the aerobic biodegradation pathway was not evaluated since the intermediate byproducts are short-lived and difficult to analyze. Comparison of 2003 PCP levels in the two borings completed near borings made in 1985 suggest attenuation may be occurring. However, this is could be due to leaching and other attenuation processes.

Based on TOC analyses, there is an abundant supply of organic carbon in the loess deposits. This is conducive to adsorption and to promoting reductive dechlorination of PCP Soil pH values were in the neutral range. Since PCP has been shown to degrade more rapidly under low pH or acidic conditions, this may indicate that anaerobic biodegradation can occur, but at a slow rate.

Transport modeling through the unsaturated zone of the fluvial deposits and then in groundwater to the Allen Well field was completed using very conservative assumptions including no degradation. The model results indicate that PCP concentrations at the well field might be detectable but would not exceed the MCL. Available data show the fluvial deposits are aerobic and PCP is reported to biodegrade readily under aerobic conditions. Modeling using a minimal rate of aerobic biodegradation suggest PCP may not be detectable in groundwater beneath SS42, and should be zero at the well field

Recommendations

PCP is not considered a direct contact risk under the industrial land use scenario. Although PCP was detected in some soil samples above the industrial PRG, all samples with exceedances were located at depths of 10 feet or deeper. No shallow samples (between zero and 10 ft) had PCP concentrations above the industrial PRG. Furthermore, PCP concentrations in the shallow borings were all below 1 mg/Kg. Since there is some evidence that biodegradation is occurring, PCP concentrations in soil are expected to decrease. Neither is PCP considered a threat to human health via groundwater migration. Assuming no degradation, the MULTIMED model predicted that the PCP groundwater concentration at Allen Well Field would be below the MCL

Residual PCP in soil does not appear to be a threat to the groundwater underlying SS42 and SS43. PCP has not been detected in any of the monitoring wells located most near SS42 and SS43, although there are no wells immediately downgradient of the site. Based on the MULTIMED results, with limited biodegradation, PCP concentrations in soil leachate should attenuate below the MCL of $1 \mu g/L$ before reaching the water table. However, it is recommended that one or two monitoring wells (or nested wells) be installed immediately downgradient of SS42 and SS43 in order to confirm that PCP leachate is not affecting groundwater. Additional monitoring wells will be installed as part of the remedial design/remedial action (RD/RA) for the MI as follows:

"Based on the location of monitoring well MW-108 and the concentrations of CVOCs detected, the RD may consider this well as part of the LTM program during the RA. Upon review of the hydrogeologic data derived from this investigation, MW-108 does not appear to be downgradient of Sites SS-42/43. Therefore, the primary objective of installing a monitoring well downgradient of the LTOA sites was not met. To satisfy this objective, the BCT decided that sentry wells completed in the intermediate aquifer west of LTOA Site SS-42/43 will be addressed as part of the LTM program during the RA. Additional monitoring well installation activity descriptions in the RD will be accompanied with a decision tree that provides direction as to which way to proceed based on the stratigraphic data from these wells (i.e., Does the clay confining unit dip downward to MW-108 from MW-62 or are there two separate units? Also, is groundwater flowing beneath the clay at MW-62 similar to what is seen at monitoring wells MW-27, -89, and -90?)."

A decision tree that incorporates new stratigraphic data from these planned wells, particularly refinement in knowledge of the dip of the clay confining unit and local groundwater flow direction, has been developed and is included as Figure 5-3 of the Rev. 0 Long-Term Groundwater Monitoring Plan for the MI (CH2M HILL, October 2003). PCP will be included in the analyte list for these wells. Installation of additional sentinel wells will require knowledge of the chemical, hydrogeological, and geological characteristics of the area surrounding the window into the intermediate aquifer within the northwest corner of the MI.

The results of this study indicate that no further action (NFA) is required for soil at Site SS42 and SS43 at this time. Based on formal comments received in January 2004, TDEC agrees that environmental data supports the conclusion that neither PCP nor Dioxin poses a risk to industrial workers above the 10 feet horizon bls. As stated in the Record of Decision (ROD) for the MI (CH2M HILL, February 2001) and the Land Use Controls Implementation Plan

(LUCIP) (CH2M HILL, October 2003 2001), the future land use for FU4 is industrial (residential land use is restricted). A digging restriction will need to be included on the deed for this parcel to protect future industrial workers from elevated PCP soil concentrations 10 feet bls The ROD and LUCIP have established groundwater use restrictions for the MI. If the results of future groundwater monitoring at newly installed wells indicate that PCP and daughter products originating at Site SS42 have not adversely affected groundwater, then NFA will be formally proposed as the final response action for Site SS42.

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Acronyms

1-D	one-dimensional
2-D	two-dimensional
3-D	three-dimensional
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BCT	Base Cleanup Team
bls	below land surface
BRAC	Base Realignment and Closure
CAS	Columbia Analytical Services
CHQ	chlorohydroquinone
COC	chemical of concern
COPC	chemical of potential concern
СР	2-chlorophenol
су	cubic yard
DAF	dilution attenuation factor
DCHQ	Dichlorohydroquinone
DCP	2,4,6-TCP; 2,4-dichlorophenol
DLA	Defense Logistics Agency
DPT	direct push technology
DQO	data quality objective
EDD	electronic data deliverable
EPA	U S. Environmental Protection Agency
EXTOXNET	Extension Toxicology Network
foc	fraction organic carbon
FS	Soil Feasibility Study
ft	feet
FU	Functional Unit
HEAST	Health Effects Summary Tables
HELP	Hydrologic Evaluation of Landfill Performance
HI	hazard index
HTRW	Hazardous, Toxic and Radioactive
IRIS	Integrated Risk Information system
LTOA	Long Term Operational Area

LUCIP	Land Use Control Implementation Plan
m/yr	meters per year
MCL	maximum contaminant level
mg/L	milligram per liter
MI	Main Installation
MUTIMED	Multimedia Exposure Assessment Model
NELAP	National Environmental Laboratory Accreditation Program
OCDD	Octachlorođibenzo-p-dioxin
OHM	O H. Materials Corporation
PARCC	precision, accuracy, representativeness, comparability and completeness
РСР	pentachlorophenol
ppb	part per billion
PRG	Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
RI	remedial investigation
ROD	Record of Decision
SIM	selected ion monitoring
SPLP	synthetic precipitation leaching procedure
SSL	soil screening level
STL	Severn Trent Laboratories, Inc.
SVOC	semi-volatile organic compounds
SW	solıd waste
TCBHQ	Trichlorohydroxylbenzoquinone
TCDD	2,3,7,8-tetrachlorodibenzo-p-dıoxin
TCDF	tetrachlorodibenzofurans
TCHQ	Trichlorohydroquinone
ТСР	2,4,5-trichlorophenol
TDEC	Tennessee Department of Environment and Conservation
TeCBQ	Tetrachlorobenzoquinone
TeCHQ	tetrachlorohydroquinone
TEF	toxic equivalency factor
TEQ	total TCDD toxicity equivalent
TetraCP	2,3,4,6-tetrachlorophenol
ТМ	Technical Memorandum
TOC	Total organic carbon
USACE	U.S. Army Corps of Engineers

TECHNICAL MEMORANDUM TM 01 22

UST underground storage tank

WES Waterways Experiment Station

551 23

Tables

Summary of Soil Samples Collected for Laboratory Analysis at Former PCP Dip Vat Site (September 2003) *Main Installation, Memphis Depot*

		Sample		
Sample iD	Sample Type	Depth (ft bls)	Soil Boring	Analysis
SB10910	Composite	10-16	SB-109	SVOCs by SW-846 Methods 8270C and 8151
SB10916	Composite	16-22	SB-109	SVOCs by SW-846 Method 8270C
SB10922	Composite	22-28	SB-109	SVOCs by SW-846 Method 8270C
SB10928	Composite	28-34	SB-109	SVOCs by SW-846 Method 8270C
SB10934	Composite	34-40	SB-109	SVOCs by SW-846 Method 8270C, pH by SW-846 Method 9045, TOC by ASTM Method D4129
SB11010	Composite	10-16	SB-110	SVOCs by SW-846 Method 8270C
SB11016	Composite	16-22	SB-110	SVOCs by SW-846 Method 8270C, pH by SW-846 Method 9045, TOC by ASTM Method D4129
SB11022	Composite	22-28	SB-110	SVOCs by SW-846 Method 8270C
SB11028	Composite	28-34	SB-110	SVOCs by SW-846 Methods 8270C and 8151
SB11034	Composite	34-40	SB-110	SVOCs by SW-846 Method 8270C
SB11110	Composite	10-16	SB-111	SVOCs by SW-846 Method 8270C
SB11116	Composite	16-22	SB-111	SVOCs by SW-846 Method 8270C
SB11122	Composite	22-28	SB-111	SVOCs by SW-846 Method 8270C, pH by SW-846 Method 9045, TOC by ASTM Method D4129
SB11128	Composite	28-34	SB-111	SVOCs by SW-846 Methods 8270C and 8151
SB11134	Composite	34-40	SB-111	SVOCs by SW-846 Method 8270C
SB11210	Composite	10-16	SB-112	SVOCs by SW-846 Methods 8270C and 8151
SB11216	Composite	16-22	SB-112	SVOCs by SW-846 Methods 8270C and 8151
SB11222	Composite	22-28	SB-112	SVOCs by SW-846 Methods 8270C and 8151
SB11228	Composite	28-34	SB-112	SVOCs by SW-846 Methods 8270C and 8151, pH by SW-846 Method 9045, TOC by ASTM Method D4129
SB11234	Composite	34-40	SB-112	SVOCs by SW-846 Methods 8270C and 8151
SB1130	Composite	0-6	SB-113	SVOCs by SW-846 Methods 8270C and 8151, pH by SW-846 Method 9045, TOC by ASTM Method D4129, Dioxins and Furans by SW-846 Method 8290
SB1136	Composite	6-13	SB-113	SVOCs by SW-846 Methods 8270C and 8151
SB11313	Composite	13-20	SB-113	SVOCs by SW-846 Methods 8270C and 8151
SB1140	Composite	0-6	SB-114	SVOCs by SW-846 Method 8270C, Dioxins and Furans by SW-846 Method 8290
SB1146	Composite	6-13	SB-114	SVOCs by SW-846 Methods 8270C and 8151, pH by SW-846 Method 9045, TOC by ASTM Method D4129

Summary of Soil Samples Collected for Laboratory Analysis at Former PCP Dip Vat Site (September 2003) *Main Installation, Memphis Depot*

	Sample	Sample Depth		
Sample ID	Туре	(ft bls)	Soil Boring	Analysis
SB11413	Composite	13-20	SB-114	SVOCs by SW-846 Methods 8270C and 8151
SB1150	Composite	0-6	SB-115	SVOCs by SW-846 Methods 8270C and 8151, Dioxins and Furans by SW-846 Method 8290
SB1156	Composite	6-13	SB-115	SVOCs by SW-846 Method 8270C, Dioxins and Furans by SW-846 Method 8290
SB11513	Composite	13-20	SB-115	SVOCs by SW-846 Methods 8270C and 8151, pH by SW-846 Method 9045, TOC by ASTM Method D4129
SB10910SPLP	Composite	10-22	SB-109	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB10922SPLP	Composite	22-40	SB-109	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11010SPLP	Composite	10-22	SB-110	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11022SPLP	Composite	22-40	SB-110	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11110SPLP	Composite	10-22	SB-111	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11122SPLP	Composite	22-40	SB-111	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11210SPLP	Composite	10-22	SB-112	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB11222SPLP	Composite	22-40	SB-112	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB113SPLP	Composite	0-20	SB-113	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB114SPLP	Composite	0-20	SB-114	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM
SB115SPLP	Composite	0-20	SB-115	Leach by SW-846 Method 1312 SVOCs by SW-846 Method 8270C SIM

Note⁻ Only pentachiorophenol and degradation products were included in the following analyses SW-846 Method 8270C, Method 8151, and Method 8270 SIM

ASTM American Society of Testing and Materials

- ft bls feet below land surface
- SVOC semi-volatile organic compound

SW solid waste

TOC total organic carbon

Survey Data for Soil Borings at the Former PCP Dip Vat Site Main Installation, Memphis Depot

Survey ID	Soil Boring	Northing (ft)	Easting (ft)	Elevation (ft)
6002	SB109	278049 8	802936 8	303 557
6003	SB110	278030	802934 5	303 825
6007	SB111	278002 5	802922 6	304 119
6009	SB112	277980 1	802896 8	304 058
6004	SB113	278038 6	802923 2	303 957
6006	SB114	278019	802915 7	341 968
6008	SB115	277991	802904 3	304 263

<u>Notes</u>

1 Horizontal Datum is Tennessee State Plane Coordinates North American Datum 1927 (NAD 27)

2 Vertical datum for Memphis Depot is National Geodetic Vertical Datum 1929 (NGVD 29)

ft

feet

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TABLE 3 Summary of Results for Phenols and Inorganc Analyses at the Former PCP Dip Vat Site (September 2003) Main Installation, Memphils Depol

Soll	Sample						Soll Concentration					
Boring	Depth	РСР	2,3,4,5-TetraCP	2,3,4,6-TetraCP	2,3,5,6-TetraCP	2,4,5-TCP	2,4,6-TCP	2,4-DCP	2-CP	Phenol	TOC	Hd
	(ft bis)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(mg/Kg)	(percent)	
Indus	strial PRG	ନ୍ତ	NL	18,000	N	62,000	62	1,800	240	100,000	NL	۶
SB-109	10-16	= 066	73 U	58 c	490 J	0 35 U	0 29 U	033 U	0 Z U	0.39.0	Ą	AN
SB-109	16-22	160 =	NA	49=	NA	0 021 U	0 018 U	0 021 U	0 013 U	0 024 U	NA	AN
SB-109	22-28	= 09	MA	14=	AN	0 021 U	0 018 U	0 02 U	0 013 U	0 024 U	NA	NA
SB-109	28-34	7 =	AN	022 J	NA	0 02 U	0 017 U	0 02 U	0 012 U	0 023 U	NA	NA
SB-109	34-40	17J	AA	0 01 U	NA	0 02 U	0 017 U	0 019 U	0 012 U	0 023 U	0 22 =	684=
SB-110	10-16	100 =	NA	64 =	NA	0 021 U	0 018 U	0 02 U	0 013 U	0 024 U	NA	AN
SB-110	16-22	340 =	AN	21 =	NA	0 21 U	018 U	020	0 13 U	0 24 U	0 67 =	7 67 =
SB-110	22-28	= 11	AN	24 =	AA	0 021 U	0 018 U	0 02 U	0 013 U	0 024 U	NA	AN
SB-110	28-34	11 =	0 710 U	054 =	0 440 U	0 021 U	0 018 U	0 02 U	0 013 U	0 024 U	NA	AN
SB-110	34-40	15.5	NA	r 60 0	NA	0 02 U	0 017 U	0 019 U	0 012 U	0 023 U	NA	AN
SB-111	10-16	03.5	AA	0 074 U	NA	0 021 U	0 018 U	0 02 U	0 012 U	0 024 U	AN	AN
SB-111	16-22	440 =	NA	37 =	M	0 22 U	0 18 U	021 U	0 13 U	0 25 U	NA	AN
SB-111	22 28	35 =	AA	19 =	AN	0 021 U	0 018 U	0.021 U	0 013 U	0 024 U	05=	6 55 =
SB-111	28-34	0 061 =	0 00072 U	0 075 U	U 00003 U	0 022 U	0 00045 U	0 021 U	0 013 U	0 025 U	A	NA
SB-111	34-40	35 =	AA	13=	NA	0 021 U	0 018 U	0 021 U	0 013 U	0 024 U	NA	NA
SB-112	10-16	0 044 =	0 00073 U	0 077 U	0 010 U	0 D22 U	0 00046 U	0 021 U	D 013 U	0 025 U	AN	AN
SB-112	16-22	c 0069 =	0 00072 U	0 076 U	0 00045 U	0 022 U	0 00045 U	0 021 U	0 013 U	0 025 U	AN	AN
SB-112	22-28	0 0065 =	0 00073 U	0 076 U	0 00045 U	0 022 U	0 00045 U	0 021 U	0 013 U	0 025 U	NA	AN
SB-112	28-34	L 9500 0	0 0007 U	0 073 U	0 00044 U	0 021 U	0 00044 U	0 02 U	0 012 U	0 024 U	0 12 =	- 17 -
SB-112	34-40	0 007 1 =	0 00069 U	0 072 U	0 00043 U	0 021 U	0 00043 U	0 02 U	0 012 U	0 023 U	NA	NA
SB-113	0-6	0 190 =	0 00073 U	0 076 U	N 6600 0	0 022 U	0 00045 U	0 021 U	0 013 U	0 025 U	0 29 =	8 75 =
SB-113	6-13	0 017 =	0 00074 U	0 077 U	0 00046 U	0 022 U	0 00046 U	0 021 U	0 013 U	0 025 U	NA	AN
SB-113	13-20	0 043 J	0 00073 UJ	0 077 U	0 0012 UJ	0 022 U	0 00046 UJ	0 021 U	0 013 U	0 025 U	NA	AN
SB-114	0-6	0 95 J	AA	0 074 U	NA	0 021 U	0 018 U	0.02 U	0 012 U	0 024 U	NA	AN
SB-114	6-13	0 930 J	0 0073 UJ	0 077 U	0 015 UJ	0 022 V	0 0046 UJ	0 021 U	0 013 U	0 025 U	0 08 =	588=
SB-114	13-20	0 170 =	0 0036 U	0 075 U	0 0041 J	0 022 U	0 0023 U	0 021 U	0 013 U	0 025 U	NA	AN
SB-115	0-6	0 150 =	0 00072 U	0 075 U	0 011 =	0 022 U	0 00045 U	0 021 U	0 013 U	0 024 U	NA	AN
SB-115	6-13	0 26 J	AN	0 076 U	NA	0 022 U	0 018 U	0 021 U	0 013 U	0 025 U	NA	NA
SB-115	13-20	0 180 =	0 0021 J	0 075 U	0013.J	0 021 U	0 00045 U	0 021 U	0 013 U	0 024 U	0 24 =	7 63 =
Notes				1								
1 Direct co	ntact PRG from E	PA Region 9 200.	02 PRG Table, Industria	el criteria Assumes :	a Cancer Risk of 10 ⁻² and i	a Hazard Index (HI)	of 1					
2 Site-sper	afic SSLs calculati	ions presented in	h Attachment C									
ft bis feet	below land surfac	еРСР	pentachlorophenol	100	total organic carbon							
DCP dich	orophenol	PRG	preliminary remedia	tton goal =	detected value							
mg/Kg mili	grams per kilograr.	n SSL	soil screening level	-	estimated value							
NA not ?	naiyzed	TCP	trichlorophenof	5	undetected							
NL not I.	isted	TetraC	CP tetrachlorol	phenol								

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TABLE 4

Summary of Analytical Results for Synthetic Precipitation Leaching Procedure (SPLP) Samples from the Former PCP Dip Vat Site (September 2003) Main Installation, Memphis Depot

	Sample Depth			Soil Leac	chate Concentratic	n (µg/L)		
	(ft bls)	РСР	2,3,4,6-TetraCP	2,4,5-TCP	2,4,6-TCP	2,4-DCP	2-CP	Phenol
Grou	Indwater Criteria:	10	1,100	3,600	40	110	30	22,000
Target Leachat	e Concentration:	39	43,200	142,000	142	4,320	1,180	865,000
SB-109	10-22	31,000 =	1,500 =	0 77 U	0 77 U	1.4 J	16 U	0 77 U
SB-109	22-40	2,100 =	63 =	0.79 U	0 79 U	0 79 U	16 U	0.79 U
SB-110	10-22	11,000 =	370 =	080	0.88 J	0.8 U	16 U	0.8 U
SB-110	22-40	= 066	72 =	0 87 U	0 87 U	0 87 U	18 U	0 87 U
SB-111	10-22	19,000 =	2,300 =	0 8 U	11J	080	16 U	080
SB-111	22-40	= 066	54 =	0 84 U	0.84 U	0.84 U	17 U	0 84 U
SB-112	10-22	2.6 =	0 69 J	0 04 U	0.04 U	0 19 J	080	0 04 U
SB-112	22-40	11 =	0.96 J	0 044 U	0 044 U	0 31 J	0 88 U	0 044 U
SB-113	0-20	2.4 J	0.08 J	0 039 UJ	0.039 UJ	018J	0 77 UJ	0 039 UJ
SB-114	0-20	63 J	11 J	0 041 UJ	0 041 UJ	0 55 J	0 82 UJ	0 041 UJ
SB-115	0-20	2.6 J	0 12 J	0 041 UJ	0.041 UJ	0 48 J	0 82 UJ	0 041 UJ
Notes						=		

1 Groundwater protective criteria are the 2002 EPA Region 9 Tap Water Preliminary Remediation Goals (PRGs) for all compounds except PCP The maximum contaminant level was used for PCP.

2 The target leachate concentrations were calculated by multiplying the groundwater protective criteria by a DAF of 39.3 DAF calculations are included in Attachment C

ft bls	feet below land	РСР	pentachlorophenol	Ħ	detected value
surface		TCP	trichlorophenol	ت.	estimated value
рсР	dichlorophenol	TetraCP	^b tetrachlorophenol	⊃	undetected
hg/l	micrograms per liter				

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Summary of Results for Dioxins and Furans Analyses at the Former PCP Dip Vat Site (September 2003) Main Installation, Memphis Depot

Parameter	Units	SB-113	SB-114	SB-115	SB-115	TEF
Sample Dept	h (ft bls)	(0-6)	(0-6)	(0-6)	(6-13)	
Octachlorodibenzo-p-Dioxin	pg/g	1,700 =	49,000 J	2,300 =	35,000 J	0 0001
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	pg/g	95 =	4,500 =	190 =	3,600 =	0 01
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	pg/g	0 35 U	15 =	1 J	20 =	05
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	pg/g	3 2 J	130 =	76=	150 =	0 1
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	pg/g	1.3 J	28 =	2 5 J	50 =	0 1
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	pg/g	0 3 U	51J	0 56 J	8 =	1
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	pg/g	0 55 U	0 59 U	0 37 U	1 J	1
Octachlorodibenzofuran	pg/g	190 =	7,100 =	310 =	5,900 =	0 0001
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	29 =	1,500 =	79 =	1,500 =	0 01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2 4 J	100 =	57J	110 =	0 01
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	0 78 J	35 =	36J	70 =	0 1
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	35 J	190 =	11 =	53 =	01
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	0 43 U	2 J	0 22 U	21J	01
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	0 45 J	21 =	19J	30 =	0 1
1,2,3,7,8-Pentachlorodibenzofuran	pg/g	0 26 U	4 3 J	0 32 J	81=	0 05
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	0 23 U	3 2 J	0 48 J	78=	05
2,3,7,8-Tetrachlorodibenzofuran	pg/g	0 78 J	13=	04 U	24 =	0 05
Total TCDD Equivalent (TEQ)	μg/kg	0.004	0.122	0.007	0.115	

<u>Notes</u>

1 TEF values based on the 1998 World Health Organization values (Berg, etc al , December 1998)

2 A TEQ value is calculated by multiplying the compound concentration by its respective TEF. The total TEQ is the sum of the individual TEQs.

3 The EPA action levels for the TCDD TEQ are 1 μg/Kg for residential soil and 5 to 20 μg/Kg for industrial soil (EPA, April 1998)

4 The background values for the Total TCDD TEQ at the Main Installation are 0 01 μg/Kg for surface soil and 0 06 μg/Kg for subsurface soil (CH2M HILL, January 2000)

- ft bls feet below land surface
- μg/Kg micrograms per kilogram
- pg/g picogram per gram = 10^{-6} milligram per kilogram = $10^{-3} \mu g/Kg$
- TEF toxicity equivalency factor
- TEQ toxicity equivalents
- = detected value
- J estimated value
- U undetected

Parameter	Value	Reference
Weather Data		
Evapotranspiration	Memphis, TN	Model Default Data
Evaporative Zone Depth	45 72 cm	Silt lithology, HELP User's Guide (Schroeder et al , September 1994)
Maximum Leaf Area Index	Scenarios 1 to 4 10	Poor stand of grass
	Scenario 5 0 0	Bare Ground
		HELP User's Guide (Schroeder et al , September 1994)
Precipitation	Memphis, TN, normal mean monthly values	Model Synthetic Data
Temperature	Memphis, TN, normal mean monthly values	Model Synthetic Data
Solar Radiation	Memphis, TN	Model Synthetic Data
Soil and Design Data		
Landfill Area (assume source area)	0 039 hectare	Estimate using Figure 1-4 of the PCP Dip Vat Soil Investigation Work Plan (CH2M HILL, August 2003)
Percent of Area Where Runoff is	Scenarios 1 to 4, 95 percent	Most of site currently covered by concrete
Possible	Scenario 5 0 percent	Conservative scenario Assume no concrete slab and no runoff
Initial Moisture Storage	Model-Derived	
Layer 1 Type	1 (vertical percolation layer)	
Layer 1 Thickness	1219 2 cm	Assume 40 feet, maximum depth of investigation
Layer 1 Texture	8 (ML = low plasticity clayey silt)	Section 2 of the RI Report (CH2M HILL, January 2000)
Layer 1 Total Porosity	0 46	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Layer 1 Saturated Vertical Hydraulic Conductivity	1 0E-05 cm/s	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Layer 2 Type	1 (vertical percolation layer)	
Layer 2 Thickness	2209 8 cm	Unsaturated zone of fluvial sand layer, estimated from Figure 7 of the LTOA Technical Memorandum (CH2M HILL, July 2002)
Layer 2 Texture	1 (SP = poorly sorted sand and gravel)	Section 2 of the RI Report (CH2M HILL, January 2000)
Layer 2 Total Porosity	0 48	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Layer 2 Saturated Vertical Hydraulic Conductivity	1 4E-03 cm/s	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Runoff Curve Number	Scenarios 1 to 4 93	Concrete Surface, Soil Group D, Industrial Use
	Scenario 5 80	Worst Case for Soil Group D Soil, Industrial Use
		Table 2-2a of Technical Release 55 (USDA, June 1986)

Note Values for weather data are included in HELP Model output (Attachment C)

- cm/s centimeters per second
- LTOA long term operational area
- RI remedial investigation

TN Tennessee

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Parameter	Value	Reference
Chemical-Specific Parameters (for PCP)		
Solid Phase Decay Coefficient	Model-Derived	
Dissolved Phase Decay Coefficient	Model-Derived	
Overall Chemical Decay Coefficient	Model-Derived	
Acid Catalyzed Hydrolysis Rate	0 0 1/M-yr	Assume no hydrolysis
Neutral Hydrolysis Rate Constant	0 0 1/yr	Assume no hydrolysis
Base Catalyzed Hydrolysis Rate	0 0 1/M-yr	Assume no hydrolysis
Reference Temperature for Hydrolysis	25°C	Default
Normalized Distribution Coefficient (Koc)	1560 mL/g	Table C-2, Attachment C, Soil Screening Guide User's Guide (EPA, July 1996) Assumes pH = 6 0
Distribution Coefficient (Kd)	Model-Derived	
Biodegradation Coefficient (saturated zone)	Scenarios 1 and 2 0 0/yr	Assume no biodegradation
	Scenarios 3 to 5 0 167/yr	Mackay et al, 2000
Source-Specific Parameters		
Infiltration Rate (at Source)	Scenarios 1 to 4 0.01 m/yr	HELP model output,
	Scenario 5 0 27 m/yr	percolation rate from loess deposits to fluvial sands
Area of Waste Disposal Unit	390 m²	Estimate using Figure 1-4 of the PCP Dip Vat Soil Investigation Work Plan (CH2M HILL, August 2003)
Spread of Contaminant Source	Model-Derived	
Recharge Rate (Downgradient of Source)	Scenarios 1 to 4 0 01 m/yr	HELP model output,
	Scenario 5 0 27 m/yr	percolation rate from loess deposits to fluvial sands
Source Decay Constant	0 0	Assume no source decay
Initial Concentration	Maximum 31 mg/L	September 2003 Soil
	Average 5 92 mg/L	Investigation Results
Length Scale of Facility	19 5 m	Estimate using Figure 1-4 of the PCP Dip Vat Soil Investigation Work Plan (CH2M HILL, August 2003)
Width Scale of Facility	20 0 m	Estimate using Figure 1-4 of the PCP Dip Vat Soil Investigation Work Plan (CH2M HILL, August 2003)
Unsaturated Source Parameters		
Number of Different Porous Materials (NMAT)	1	Fluvial Sands (Contamination extends through Loess)
Van Genuchten or Brooks/Corey Parameters (KPROP)	Van Genuchten	Model Default

Parameter	Value	Reference
Number of Physical Flow Layers (NVFLAY)	1	Fluvial Sands (Contamination extends through Loess)
Depth of the Unsaturated Zone	22 10 m	Figure 7 Lithologic Cross- Section D-D', LTOA Technical Memorandum (CH2M HILL, July 2002)
Saturated (Vertical) Hydraulic Conductivity	5 15 cm/hr	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
(Effective) Porosity of Unsaturated Zone	0 30	Main Installation RI (CH2M HILL, January 2000)
Air Entry Pressure Head	0 0 m	Assume no entry pressure for sand
Residual Water Content	0 07	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Alpha coefficient for Van Genuchten method	0 145	Table 6-5, MULTIMED Application Manual (Salhotra et al , 1990)
Beta coefficient for Van Genuchten method	2 68	Table 6-5, MULTIMED Application Manual (Salhotra et al , 1990)
Unsaturated Transport Parameters		
Number of different layers (NLAY)	1	Model Default
Scheme for evaluation (ISOL)	Stehfest Scheme	Model Default
Number of terms for scheme (N)	18	Model Default
Number of Lagrangian Points (NTEL)	3	Model Default
Number of Gauss Points (NGPTS)	104	Model Default
Convolution Integral Segments (NIT)	2	Model Default
Thickness of Layer in the unsaturated zone	22.10 m	Figure 7 Lithologic Cross- Section D-D', LTOA Technical Memorandum (CH2M HILL, July 2002)
Longitudinal Dispersivity	Model-Derived	
Percent Organic Matter	0 138	Attachment B, Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Bulk Density of Soil Material	1 41 g/cm3	Attachment B, Appendix C, Dunn Field Feasibility Study

Parameter	Value	Reference
		Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Biological Decay Coefficient	Scenarios 1 and 2 0 0/yr	Assume no biodegradation
	Scenarios 3 to 5 0 167/yr	Mackay et al, 2000
Aquifer-Specific Parameters		
Porosity of Aquifer	0 30	Main Installation RI (CH2M HILL, January 2000)
Bulk Density	1 41 g/cm3	Attachment B; Appendix C, Dunn Field Feasibility Study Report, Rev 2 (CH2M HILL, May 2003) Geotechnical analyses – Fluvial Sands
Depth of Aquifer (Aquifer Thickness)	16 0 m	Figure 7 Lithologic Cross- Section D-D', LTOA Technical Memorandum (CH2M HILL, July 2002)
Mixing Zone Depth	Model-Derived	······································
Type of Source for Saturated Zone Module	Gaussian	Model Default
Hydraulic conductivity	2,460 m/yr	Main Installation RI (CH2M HILL, January 2000)
Hydraulic Gradient	0 0258 m/m	Figure 3A, Memphis Depot LTOA Technical Memorandum (CH2M HILL, July 2002)
Seepage Velocity	Model-Derived	
Retardation Coefficient	Model-Derived	
Longitudinal Dispersivity	Model-Derived	
Transverse Dispersivity	Model-Derived	
Vertical Dispersivity	Model-Derived	
Temperature of Aquifer	20 5°C	Average from available Field data from – LTOA Study (CH2M HILL, July 2002) and EBT Pilot Study (CH2M HILL, October 2003)
pH of Aquifer	60	Average from available Field data from – LTOA Study (CH2M HILL, July 2002) and EBT Pilot Study (CH2M HILL, October 2003)
Organic Carbon Content	0 001	LTOA Technical Memorandum, based on TOC analyses in Fluvial Sands (CH2M HILL, July 2002)
Radial Distance from Site to Receptor (X-dist)	3,660 m	Figure 2-14, Main Installation Rt – Allen Well Field (CH2M HILL, January 2000)

	Paramet	er		Value	Reference
Angle	off Center (from Grou	ndwater C	enterline)	0	Measured along GW Flowpath
Well V	ertical Distance from	Water tabl	e (Z-dist)	00m	Assume Receptor at Water Table
°C	degrees Celsius	М	mole	RI	remedial investigation
cm g	centimeter gram	mg/L mL/g	milligrams per liter milliliter per gram	yr	year
ĥr m	hour meter	LTOA	long term operational	area	
Figures



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excavation in 1985. The sump associated with Building 737 was filled and abandoned in the early 1990's The purpose of the Building 737 sump was to hold wash water prior to treatment at a water treatment system during the 1985 excavation, and to collect spilled material into the building for recoupment, however, no spills occurred.

> Figure 2 Site Layout PCP Dip Vat Investigation Memphis Depot Main Installation

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CH2MHILL E122003008ATL \ Memphis 108 av

Memphis Depot Main Installation



Note: Soil boring locations are approximate

Source: On-Site Remedial Activities at the Defense Depot Memphis, OHM, 1986

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E122003008ATL \ Memphis 107 ar

Figure 4 PCP Levels in Soil at SS42 and 43 PCP Dip Vat Investigation Memphis Depot Main Installation



SB-47 SB-113 ft bls PCP 0 190 0-6 FORMER 0.017 6-13 SUMP 33 13-20 0 043 SB-109 PCP ft bls 10-16 990 16-22 160 22-28 PESTICIDE STORAGE BUILDING 50 28-34 7 34-40 17J Buliding 737 SB-42A Ø 25 OFFICE ERS \odot FORMER METAL SHED SUMP SB-43A 1 O SB-110 r 1 SB-114 1 ft bls PCP STORAGE 1 PCP ł 10-16 100 ft bls FORMER 16-22 340 0-6 0 95J 6 22-28 77 6-13 0 930J 28-34 13-20 0 170J 11 34-40 15J N SB-115 ft bis PCP , 126 0-6 0 150 0 SB-111 PUMP 7 6-13 0 26J HOUSE ft bls PCP 1 FORMER 13-20 0 180 10-16 0 3 J UNDERGROUND 11 STOR TANK į 127 ю 10 16-22 440 SB-105 1 22-28 35 FEET x - 128 1 28-34 1 0 061 1 1 34-40 35 SB-112 ft bls PCP 10-16 0 0 4 4 LEGEND 16-22 0 0069 22-28 0 0065 Former Soil Boring Location 28-34 0 0039J 34-40 0 0071 0 2003 Soil Boring Location Estimated Value J ft bis feet below land surface PCP

PCP Pentachlorophenol, milligrams per kilogram

Note: Survey data for 2003 borings is listed on Table 2 of this TM

Source: On-Site Remedial Activities at the Defense Depot Memphis, OHM, 1986

> Figure 6 September 2003 Soil Boring Locations PCP Dip Vat Investigation Memphis Depot Main Installation

CH2MHILL E122003008ATL \ Memphis 104 ai FIGURE 7 Potential Reductive Dechlorination Pathway for PCP Main Installation, Memphis Depot



Fig. 5 Proposed a pathway for anaerobic dechlorination and degradation by the PCP-degrading granules. Part of the PCP was dechlorinated through 2.4,6-trichlorophenol (TCP), 2,4-dichlorophenol (DCP), and 2-chlorophenol (CP) or 4-CP to phenol and phenol was further degraded to methane and CO₂ (*o ortho* dechlorination; *m meta* dechlorination, *p para* dechlorination)

Source: Kennes, C, W.M Wu, L. Bhatnager, and J.G. Zeikus. 1996. *Anaerobic dechlorination and mineralization of pentachlorophenol and 2,4,6-trichlorophenol by methanogenic pentachlorophenol-degrading granules*. Applied Microbiology and Biotechnology, Volume 44, p. 805.







Attachment A

Comment Responses to Revision 0 Technical Memorandum

Summary of Comments and Responses for the PCP Dip Vat Tech Memo., Rev. 0 Main Installation, Memphis Depot

ltem	Reference	Comment	Response
Comm	ents from James Mori	rison/TDEC	
-	General	Overall a this Technical Memorandum is very good	This comment is appreciated
5	General	TDEC agrees that environmental data supports the conclusion that neither PCP nor Dioxin poses a risk to industrial workers above the 10 feet horizon below land surface	We are in agreement
η	General	TDEC notes that since PCP was detected at ~1000 ppm below the 10 horizon, remedial actions may be required if soil is disturbed during excavation or construction activities With this understood, TDEC agrees that a digging restriction will need to be noted on the deed for this parcel. There are two reasons for this restriction. 1 The potential for exposure of onsite workers to levels that far exceed industrial worker scenarios as noted in this document, and 2. Contaminant levels that greatly exceed remedial action requirements if this site is excavated.	This information has been forwarded to the Defense Logistics Agency for their consideration A digging restriction for the site deed will be added to the TM recommendations
4	General	TDEC does not agree with the assumptions used to model the attenuation of PCP before reaching groundwater. This model is based on the assumptions that a low permeability concrete liner has and will always be in place at this site, and that the current levels of PCP (~1,000 ppm) detected in soil is the maximum amount of contamination ever detected at this site. This model does not take into account that past contaminant levels detected at this site, prior to and after the removal in 1986, far exceeded the current ~1000 ppm detected at the site. This not take is not permeable concrete pad, translates into actual past and future conditions with a low permeable concrete pad, translates into actual past and future conditions.	The model was re-run assuming a conservative, bare cover, no runoff recharge rate. With this assumption, the model estimated that the concentration of PCP leaching into groundwater beneath the site and reaching the Allen Well Field are below 0 001 ug/L. Therefore, there is still no risk to groundwater even if the concrete slab is removed. Model results will also be presented in Rev. 1 of the TM Historical PCP concentrations at SS42 were much lower than values detected in September 2003. Since PCP concentrations appear to be decreasing at the site, September 2003 concentrations were used to estimate current and future threat to groundwater. However, this does not estimate the maximum possible threat to groundwater which occurred at the site in the past
5	General	Based on comment #4, TDEC notes and agrees that additional, appropriately placed, down gradient / down-dip wells will need to be installed to monitor this site	Concur Additional monitoring wells will be installed downgradient of Sites SS42 and SS43 as part of the RA for the MI.
Comm	ents from MACTEC		

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ltem	Reference	Comment	Response
e	Page 14	Concentrations of PCP ranged from 0 004 to 31,000 mg/Kg Comment: This does not correspond to the data in Table 3, which indicates that the highest PCP concentration in the soil samples collected was 990 mg/kg	The statement wil be revised to say, "ranged from 0 004 to 990 mg/Kg"
2	Page 15	Due to the depth and concentrations of PCP in soil and the uncertainty regarding groundwater flow direction in the area beneath SS42, SS43, and SS46, MACTEC recommends adding PCP to the LTM analyte list for wells nearest these areas	PCP will be included in the analyte list for the LTM wells to be nstalled downgradient of Sites SS42 and SS43 as part of the RA for the MI
Comn	nents from John W. Ar	thony/Miretek Systems	
ω	Page 1	Please point out that the possible presence of PCP degradation products could be of use in evaluating the occurrence of PCP degradation in the subsurface	A sentence has been added to the test stating. "The presence of these degradation products could be used to nelp evaluate the ocurrance of PCP biodegradation at the site "
တ	Page 4	Although the borings drilled during this investigation are in relatively close proximity to each other, couldn't subsurface heterogeneities cause differences in the soil column at each location sufficient to warrant description of each boring?	The loess geologic layer is well documented for the MI and has been included in previous reports. This includes a deep poring (SB-105) which was installed over 100 feet at the site Since the objective of the investigation did not include characterization of lithology and borings installed at the site were shallow, only two borings were logged. This will be urther emphasized in the text of the TM
10	Page 5	Aithough use of cuttings as backfill material may be allowed by the EISOPQAM, should more appropriate procedures not require that cuttings generated during investigation activities in areas of known contamination be collected in a container and managed as investigation-derived waste (IDW)?	The soil at this site has been characterized during previous nvestigations for disposal requirements, including the LTOA study Therefore, soil cuttings were placed back in boreholes, as allowed in the EISOPQAM

Response	Please see the Technical Memorandum, <i>Additional</i> <i>Discussion on Comment Responses to PCP Dip Vat TM</i> , <i>Rev 0,</i> for the response to this comment	Please see the Technical Memorandum, <i>Additional</i> Discussion on Comment Responses to PCP Dip Vat TM, Rev 0, for the response to this comment	A statement will be added to the text to futher emphasize this point
Comment	Neither MCL concentrations nor tap-water PRGs are appropriate risk-based criteria for groundwater at this site. Rather, the results of a site-specific risk assessment, based on exposure scenarios that track to the Land Use Control Implementation Plan (LUCIP) for the MI, should be used to establish site-specific risk-based concentrations A site-specific risk analysis would identify site-related hazards, assess potential exposure, and apply a toxicity assessment to characterize site-related risk During the site-specific risk assessment to characterize site-related risk During the site-specific risk assessment, the four necessary elements (a source and mechanism of chemical release to the environment, an environmental transport medium for the released chemicals, a point of potential contact) of a site-specific exposure pathway would be identified. The site-specific risk assessment would conclude that, because the fluvial aquifer is not used as a drinking-water source, and because county regulations prohibit its development as a drinking-water source, inhalation, or dermal routes, hence, no site-related risk to potential receptors.	A stated objective of the investigation was to evaluate the occurrence of PCP and its degradation products (page 1) if byproducts generated during the aerobic degradation of PCP were not analyzed, then the possibility that degradation is occurring via the aerobic pathway was not evaluated, and the occurrence of aerobic degradation is uncertain or speculative Would it not have been worthwhile to analyze for aerobic degradation products of PCP, even though no health-based criteria are associated with them, in order to evaluate the aerobic degradation pathway? Moreover, an understanding of the occurrence and significance of the aerobic degradation pathway could be factored into the overall efficiency of degradation pathways at reducing contaminant mass and toxicity	Actually, in most instances application of a 1-D formulation is preferable to a 2- D or 3-D model of unsaturated-zone migration for a number of reasons, including availability of data This point could be further emphasized
Reference	Bage 8	Page 10	Page 11
Item	रू	3	13

Summary of Comments and Responses for the PCP Dip Vat Tech Memo., Rev. 0 Main Installation, Memphis Depot

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ltem	Reference	Comment	Response
14	Page 11	Please re-word this final sentence to state that "These assumptions all were considered to be "conservative", in that their use in subsequent calculations tends to produce overestimates of the highest PCP concentrations that might occur at a potential exposure point "	The sentence will be re-worded, as suggested
15	Page 12	This is a reasonable result for local soil and climatic conditions	Noted
16	Page 12	If the subsurface environment is known to be aerobic, and it is necessary to evaluate the potential for PCP degradation (via all possible mechanisms) for the purpose of assessing contaminant fate, why would you not analyze samples for aerobic PCP degradation byproducts, as originally recommended in Mitretek's comments to the Rev 0 Draft Work Plan (comments issued on 29 July 2003)?	Please see the Technical Memorandum, <i>Additional</i> Discussion on Comment Responses to PCP Dip Vat TM, Rev 0, for the response to this comment
11	Page 14	, particularly those compounds that are daughter products of aerobic PCP degradation,	This statement is not applicable to this sentence Isomers of chlorophenols are not included in the aerobic biodegradation pathway. However, a sentence will be added to the text to state that the aerobic pathway was not evaluated
18	Page 15	Under the circumstances, it is not possible to evaluate the rate of PCP degradation with the available information. Consequently, the statement regarding the "slow" rate of degradation is speculative, and should be removed	The statement will be removed
<u>5</u>	Page 15	Concur that one or more additional groundwater monitoring wells should be installed downgradient from the SS42 area Please ensure that the boreholes from these wells are logged in detail, as additional geologic information could be used to address some of the outstanding questions regarding the stratigraphy and hydrostratigraphy of the immediate area	Boreholes for new monitoring wells in be logged in detail and will be used to help determine the dip direction of the clay and local groundwater flow conditions
50	Page 16	Rather than requiring possible future remedial action, simply ensure that the LUCIP for the FU4 area limits intrusive activities in the subsurface, and that if some intrusive activities are necessary (e g , repair of subsurface utilities), appropriate health and safety measures will be established and followed	The reference to remedial action will be removed A digging restriction for this site will be added to the Recommendations section of the TM
21	Page 16	Also indicate that if the results of future groundwater monitoring at newly- installed wells indicate that PCP and daughter products originating at Site SS42 have not adversely affected groundwater, then NFA will be formally proposed as the final response action for Site SS42	This recommendation has been added to the TM.

Summary of Comments and Responses for the PCP Dip Vat Tech Memo., Rev. 0 Main Installation, Memphis Depot

ltem	Reference	Comment	Response
22	Page 29	The area of potential infiltration that was established for modeling purposes apparently was approximately 20 m by 20 m (Figure 2 and Table 7 of the TM) Inspection of Figure 2 suggests that the footprints of 2 buildings cover approximately 1/2 of this area Although the buildings have been demolished, confirm that the concrete slabs also have been removed. If the slabs remain, this would greatly reduce the area over which infiltration potentially could occur.	The concrete slab at the site remains Thus, runoff was assumed to ocurr at 95% percent of the site. However, an additional conservative scenario will be run, with a no-cover reacharge rate to estimate if slab is removed during future activities
23	Page 30	The area of potential infiltration that was established for modeling purposes apparently was approximately 20 m by 20 m (Figure 2 of the TM). Inspection of Figure 2 suggests that the footprints of 2 buildings cover approximately 1/2 of this area Although the buildings have been demolished, it is possible that the concrete slads remain. If so, this would greatly reduce the area over which infitration potentially could occur	See response to comment above
24	Page 31	HELP model simulations, used to estimate infiltration through the unsaturated zone, used a value of 0 00143 cm/sec (equivalent to 5 cm/hr) for the vertical hydraulic conductivity of the fluvial sands Please rectify this apparent discrepancy	The vertical hydraulic conductivity for the fluvial sand are 0.00143 cm/sec. This value will be corrected in the MUTLIMED model runs
25	Page 31	Please report the value of the model-derived longitudinal dispersivity, as a check on the reasonableness of the calculations	Model-derived values were hand-calculated using equations presented in the MULTIMED User's Guide These are now presented as Attachment E
26	Page 32	Please report the value of the model-derived mixing-zone depth, as a check on the reasonableness of the calculations	See response to comment above
27	Page 32	Please report the values of the model-derived seepage velocity, retardation, and the longitudinal, transverse, and vertical dispersivities, as a check on the reasonableness of the calculations	See response to comment above
28	Page 32	The Main Installation Ri actually reports (Section 2 74) a value of 11 79 ft/day (equivalent to about 1,310 m/yr) for the hydraulic conductivity of the fluvial unit Please resolve this apparent discrepancy	The RI reports that the groundwater velocity at the MI is approximately 11.79 ft/day It states that the hydraulic conductivity is approximately 22 11 ft/day Therefore, the model input parameter is correct

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CH2MHILL

Additional Discussion on Comment Responses to PCP Dip Vat TM, Rev0.

PREPARED FOR	U.S. Army Engineering and Support Center, Huntsville
PREPARED BY:	CH2M HILL
COPIES	Memphis Depot BRAC Cleanup Team
DATE.	February 4, 2004

Introduction

This Technical Memorandum (TM) provides additional discussion in response to three comments received from Mitretek Systems in January 2004 on the *Results of a Soil Investigation at the Former PCP Dip Vat and Underground PCP Storage Tank Sites, Main Installation, Memphis Depot (Rev. 0) Technical Memorandum* (CH2M HILL, December 2003). Comments for the TM were received from the Tennessee Department of Environment and Conservation (TDEC), MACTEC, and Miretek Systems.

A summary of responses for all comments has been prepared and will be included as an attachment to Revision 1 of the former PCP dip vat and underground storage tanks (SS42/SS43) TM Three of the comments require a more detailed response than is provided in the summary table These responses are presented in this document.

Comment Response 1

Comment from Miretek Systems (Page 8):

Neither MCL concentrations nor tap-water PRGs are appropriate risk-based criteria for groundwater at this site. Rather, the results of a site-specific risk assessment, based on exposure scenarios that track to the Land Use Control Implementation Plan (LUCIP) for the MI, should be used to establish sitespecific risk-based concentrations A site-specific risk analysis would identify site-related hazards, assess potential exposure, and apply a toxicity assessment to characterize site-related risk. During the site-specific risk assessment, the four necessary elements (a source and mechanism of chemical release to the environment, an environmental transport medium for the released chemicals, a point of potential contact for receptors, and a receptor exposure route at the point of contact) of a site-specific exposure pathway would be identified. The site-specific risk assessment would conclude that, because the fluvial aquifer is not used as a drinking-water source, and because county regulations prohibit its development as a drinking-water source, there is no completed exposure pathway via the ingestion, inhalation, or dermal routes, hence, no site-related risk to potential receptors.

Response:

CH2M HILL conducted a human health risk assessment (HHRA) for all functional units (FUs) at the Main Installation (MI), including groundwater, as part of the remedial investigation (RI). As part of the HHRA, an exposure and toxicity assessment were performed The exposure assessment identified potentially complete exposure pathways at the MI. The toxicity assessment determined the relationship between the magnitude of exposure to a chemical at the MI and the likelihood of adverse health effects to potentially exposed populations. A full discussion and site- and chemical-specific risk estimates with the acceptable health risks and hazard index (HI) levels are presented in the *Memphus Depot Main Installation Remedial Investigation Report* (CH2M HILL, January 2000).

Based on the site conceptual model, SS42 appears to be located either within or on the very edge of the "*no flow to limited flow*" boundary. The fluvial deposits are in direct contact with the intermediate aquifer, therefore, the fluvial aquifer is not present at this location. The RI concluded that a thick clay unit typically occurs between the intermediate aquifer (confined sand aquifer in the Jackson Formation/Upper Claiborne Group) and the Memphis Sand aquifer. However, soil boring logs from multiple monitoring well locations have shown that there gaps or windows within this confining clay layer. Studies by Parks (1990) and Kingsbury and Parks (1993) have shown interaction through interaquifer leakage between the Memphis Sand and overlying formations. Therefore, due to the potential interconnection between the fluvial aquifer and the Memphis Sand aquifer in the site conceptual model, the Allen Well Field, was selected as the downgradient receptor for fate and transport modeling to alleviate possible concerns. The Allen Well Field, which draws from the Memphis Sand Aquifer, supplies the City of Memphis with a portion of its drinking water.

The applicability of the MCLs and tap-water PRGs is a risk management decision. In the absence of measured data for exposures, risk calculations include conservative assumptions. Thus, when the actual situation is not known (uncertain), bias toward conservatism was used.

Based on current and future land use, MCLs and tap-water RBCs are overly conservative remedial goals for onsite groundwater. However, there is no need to develop additional risk-based goals for SS42 and SS43. Leachable concentrations of PCP degradation products were all below their respective site-specific leachate SSL. The results of the fate and transport analysis indicated there was no risk to human health from the migration of PCP soil contamination to groundwater

Comment Response 2

Comment from Miretek Systems (Page 10): A stated objective of the investigation was to evaluate the occurrence of PCP and its degradation products (page 1). If byproducts generated during the aerobic degradation of PCP were not analyzed, then the possibility that degradation is occurring via the aerobic pathway was not evaluated, and the occurrence of aerobic degradation is uncertain or speculative. Would it not have been worthwhile to analyze for aerobic degradation products of PCP, even though no health-based criteria are associated with them, in order to evaluate the aerobic degradation pathway? Moreover, an understanding of the occurrence and significance of the aerobic degradation pathway could be factored into the overall efficiency of degradation pathways at reducing contaminant mass and toxicity.

Response:

PCP is biodegraded in soil under both aerobic and anaerobic conditions. PCP has been shown to degrade in soil, with reported half-lives of 45 days, (Extoxnet, 1996) and weeks to months (EPA, November 2002). In aerobic degradation, PCP is broken down by a series of pathways. The degradation process begins with oxidative dechlorination reactions, forming intermediate degradation products, which may include tetrachloroatechol, tetrachlorohydroquinone (TeCHQ), tetrachlorobenzoquinone (TeCBQ), trichlorohydroxylbenzoquinone (TCBHQ), trichlorohydroquinone (TCHQ), dichlorohydroquinone (DCHQ), and chlorohydroquinone (CHQ). These aerobic degradation products have fewer chloride atoms than does PCP and they degrade quickly by cleavage of the phenol ring Therefore, PCP does not fully break down to hydroquinone. The final degradation products by mineralization are water, carbon dioxide, and chloride ions. The aerobic biodegradation pathway for PCP is presented as **Figure 1**.

The aerobic byproducts are considered to be short-lived and do not generally accumulate in the environment (Mahaffey, 1997). They are not listed on EPA's October 2002 Region 9 Preliminary Remediation Goals (PRGs) table, or in the Integrated Risk Information system (IRIS) database (<u>http://www.epa.gov/iriswebp/iris</u>), or in the Health Effects Summary Tables (HEAST) (<u>http://www.epa.gov/radiation/heast</u>). Therefore, there are no health-based values for these compounds.

Laboratories performing work for the Memphis Depot must be U.S. Army Corps of Engineers (USACE)-certified and perform work in accordance with the USACE's requirements under EM 200-1-3 (February 2001). Several laboratories were contacted about their USACE-certification and their ability to analyze for the PCP aerobic byproducts, particularly the chlorinated quinones, chloromaleylacetate, and maleylacetate. All laboratories which responded, stated they do not analyze for these compounds, these laboratories are listed below:

- Acurra Analytical Laboratory, Inc., Norcross, Georgia
- Columbia Analytical Services (CAS), Kelso, Washington
- Environmental Testing & Consulting, Inc (ETC), Memphis, Tennessee
- General Engineering Laboratories, LLC (GEL), Cincinnati, Ohio
- PEL Laboratory, Tampa, Florida
- Severn Trent Laboratories (STL), Knoxville, Tennessee
- STL, Tallahassee, Florida

STL Knoxville indicated they could look for these compounds as tentatively identified compounds (TICs) While the estimated additional cost for this procedure is low, any reported values could not be validated and would only be available as screening data. Another option, would be to perform a method determination study, which would involve buying standards, evaluating the compounds to see how they behave, doing an method detection limits study, and performing an initial demonstration. The estimated cost of this study would be approximately \$2,500 plus the cost for the individual samples

(approximately \$175). Since we submitted 32 soil samples, this would have increased the laboratory cost approximately \$8000 The risk associated with this approach is that the compounds may not really be amenable to analysis. Therefore, there is no guarantee that either of these methods would be able to detect the aerobic degradation products

Although the ability of aerobic biodegradation at reducing the contaminant mass and toxicity is beneficial, it is not necessary for risk management decisions at the site. The soil investigation concluded that there was no risk from PCP in soil under industrial land use and the site-specific land use controls. The fate and transport modeling concluded that PCP in soil is not considered a threat to human health via groundwater migration either Additionally, not enough data is available to perform mass calculations of PCP in soil at Sites SS42 and SS43. Therefore, additional investigation would be required to evaluate the aerobic biodegradation pathway and it's impact on PCP mass. Since no toxicity information for aerobic biodegradation products could be identified, it is difficult to quantify the reduction of toxicity which could be observed, although it is expected to be lower.

Comment Response 3

Comment from Miretek Systems (Page 12): If the subsurface environment is known to be aerobic, and it is necessary to evaluate the potential for PCP degradation (via all possible mechanisms) for the purpose of assessing contaminant fate, why would you not analyze samples for aerobic PCP degradation byproducts, as originally recommended in Mitretek's comments to the Rev 0 Draft Work Plan (comments issued on 29 July 2003)?

As discussed in the section above, there are several reasons why aerobic degradation products were not included in the soil investigation. These are summarized below.

- There are no health-based criteria for aerobic degradation products.
- These compounds are short-lived in the environment.
- No USACE-certified laboratories were identified with the capability to analyze for these compounds.
- A method determination study may not be effective in analyzing for these compounds.

References

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U.S. Environmental Protection Agency. October 2002. Region 9 Preliminary Remediation Goals (PRGs) Table.

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Zeng, Yuemo. 2003. *Pentachlorophenol Family Pathway Map*. University of Minnesota. <u>http://umbbd.ahc.umn.edu/pcp/pcp_map.html</u>

FIGURE 1 Aerobic Degradation Pathway for PCP Main Installation, Memphis Depot



Source: Zeng, Yuemo 2003. University of Minnesota. <u>http://umbbd.ahc.umn_edu/pcp/pcp_map_html</u>

Attachment B

Soil Boring Logs



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SB-12

SOIL BORING LOG

PROJE	СТ	PCP Dip	Vat Soil Inve	stigation	· · · · · · · · · · · · · · · · · · ·	LOCATION	Memphis, TN	
ELEVA	TION ,	304 058	ft NGVD		DRILLING (CONTRACTOR	Prosonic	······
DRILLIN	IG METI	HOD AND	EQUIPMEN	T USED	Direct Push Technology (DPT)			
WATER	LEVEL	5	N/A	START	09/23/2003 END	09/23/2003	LOGGER	J Phelan
DEPTH	BELOW S	URFACE (FT)	STANDARD	SOIL	DESCRIPTION		COMMENTS
1	INTERV/	<u>AL (FT)</u>		PENETRATION				
		RECOVE	RY (IN)	TEST	SOIL NAME, USCS GROUP SYMBO	L, COLOR,		DEPTH OF CASING, DRILLING RATE,
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SOIL BORING LOG

PROJECT	PCP Dip Vat Soil Inve	stigation	LOCATION Memphis, TN	
ELEVATION	304 058 ft NGVD		DRILLING CONTRACTOR Prosonic	
DRILLING MET	HOD AND EQUIPMEN	T USED	Direct Push Technology (DPT)	
VVATER LEVEL	S N/A	START	09/23/2003 END 09/23/2003 LOGGEF	J Phelan
DEPTH BELOW :		DEVETDATION	SOIL DESCRIPTION	COMMENTS
INTERV		PENEIRATION		
		RESULTS	MOISTURE CONTENT RELATIVE DENSITY	DEPTR OF CASING DRILLING RATE,
		6*_6*_6*_6*	OP CONSISTENCY SOIL STRUCTURE	TESTS AND INSTRUMENTATION
		(N)	MINERALOGY	
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PROJECT NUMBER 181018.FE 01

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SOIL BORING LOG

PROJE	ст	PCP Dip	Vat Soil Inve	stigation	LOCATION Memphis TN	
		341 968	ft NGVD		DRILLING CONTRACTOR Prosonic	
WATER			N/A	START	09/22/2003 END 09/22/2003 LOGGER	J Phelan
DEPTH	BELOW S	JRFACE (FT)	STANDARD	SOIL DESCRIPTION	COMMENTS
	INTERVA	L (FT)		PENETRATION		
1		RECOVE	RY (IN)	TÉST	SOIL NAME, USCS GROUP SYMBOL, COLOR	DEPTH OF CASING DRILLING RATE
			#/TYPE	RESULTS	OD CONSISTENCY, COLLECTIVE DENSITY,	DRILLING FLUID LOSS,
	1			0-0-0-0 (N)	MINERALOGY	TESTS, AND INSTRUMENTATION
	İ				CLAYEY SILT, light brown, dry to moist, firm	
-	;			Used DP1		
-	!			no penetration test		-
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	1					
5-	i				SANDY, CLAYEY, SILT hoht brown, moist firm	
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	!	!	1		SAME AS ABOVE with trace gravel	
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Attachment C

DAF Calculations

ATTACHMENT C

Dilution Attenuation Factor (DAF) Parameters for Former PCP Dip Vat Site Main Installation, Memphis Depot

Parameter	Units	Value	Reference
Hydraulic Conductivity	(m/yr)	2460	Fluvial aquifer, Final Groundwater Characterization Data Report (CH2M HILL, 1997a)
Hydraulic Gradient	(m/m)	0 0258	Figure 3A; Memphis Depot LTOA Technical Memorandum (CH2M HILL, July 2002)
Aquifer Thickness	(m)	16 00	Figure 7; Memphis Depot LTOA Technical Memorandum (CH2M HILL, July 2002)
Source Length	(ш)	15.64	Figure 1-4, PCP Dip Vat Soil Investigation Work Plan (CH2M HILL, August 2003)
Infiltration Rate	(m/yr)	0 18	HELP model output
Mixing Zone Thickness	(m)	17	Calculated using Equation 12 from SSL Guidance (EPA, 1996)
DAF		39.3	Calculated using Equation 11 from SSL Guidance (EPA, 1996)

Equation 11: DAF = 1 + (KidllL)

Where, K = hydraulic conductivity,

i = hydraulic gradient,

d = mixing zone thickness,

l = infiltration rate, and

L = source length parallel to groundwater flow direction

Equation 12: d = (0.0112L2)0.5 + da{1 - exp[(-LIIKida)]} Where, da = aquifer thickness

Attachment D

Hydrologic Evaluation of Landfill Performance (HELP) Model

HELP Output.txt

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****	***************************************	******
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**		* *
* *		**
* *	HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE	* *
* *	HELP MODEL VERSION 3.07 (1 NOVEMBER 1997)	**
**	DEVELOPED BY ENVIRONMENTAL LABORATORY	* *
* *	USAE WATERWAYS EXPERIMENT STATION	**
* *	FOR USEPA RISK REDUCTION ENGINEERING LABORATORY	**
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C:\PROGRA~1\HELP3\USER\PCPP.D4
C:\PROGRA~1\HELP3\USER\PCPT.D7
C:\PROGRA~1\HELP3\USER\PCPS.D13
C:\PROGRA~1\HELP3\USER\PCPE.D11
C:\PROGRA~1\HELP3\USER\pcpd2.D10
C:\PROGRA~1\HELP3\USER\pcpout2.OUT

TIME: 13:18 DATE: 12/ 9/2003

TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0THICKNESS=1219.20CMPOROSITY=0.4600VOL/VOLFIELD CAPACITY=0.2320VOL/VOLWILTING POINT=0.1160VOL/VOLINITIAL SOIL WATER CONTENT=0.2408VOL/VOLEFFECTIVE SAT. HYD. COND.=0.999999975000E-05CM/SEC

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER Page 1

HELP Output.txt

MATERIAL TEX	XTURE	NUMBER 0		
THICKNESS	=	2209.80	CM	
POROSITY	=	0.4800	VOL/VOL	
FIELD CAPACITY	=	0.0450	VOL/VOL	
WILTING POINT	=	0.0180	VOL/VOL	
INITIAL SOIL WATER CONTEN	T =	0.0450	VOL/VOL	
EFFECTIVE SAT, HYD. COND.	=	0.13999999	5000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM MEMPHIS TENNESSEE

STATION LATITUDE	=	35.03 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	79
END OF GROWING SEASON (JULIAN DATE)	=	315
EVAPORATIVE ZONE DEPTH	=	45.7 CM
AVERAGE ANNUAL WIND SPEED	=	14.00 КРН
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
					
117.1	110.0	138.2	146.6	128.5	90.9
102.4	95.0	91.9	60.2	105.9	123.2

HELP Output.txt NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.2	6.4	11.0	17.0	21.7	26.0
27.9	27.0	23.5	17.2	10.7	6.3

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE AND STATION LATITUDE = 35.03 DEGREES

	MM	CU. METERS	PERCENT	
PRECIPITATION	1196.70	466.713	100.00	
RUNOFF	313.848	122.401	26.23	
EVAPOTRANSPIRATION	779.452	303.986	65.13	
PERC./LEAKAGE THROUGH LAYER 2	0.004081	0.002	0.00	
CHANGE IN WATER STORAGE	103.396	40.324	8.64	
SOIL WATER AT START OF YEAR	3930.289	1532.813		
SOIL WATER AT END OF YEAR	4033.685	1573.137		
SNOW WATER AT START OF YEAR	0.000	0.000	0.00	
SNOW WATER AT END OF YEAR	0.000	0.000	0.00	
ANNUAL WATER BUDGET BALANCE	-0.0005	0.000	0.00	
*****	******	*****	******	

ANNUAL	TOTALS	FOR	YEAR	2
				_

	MM	CU. METERS	PERCENT
PRECIPITATION	1564.20	610.038	100.00
RUNOFF	649.869	253.449	41.55
EVAPOTRANSPIRATION	748.531	291.927	47.85
PERC./LEAKAGE THROUGH LAYER 2	0.005078 Page 3	0.002	0.00

ł	HELP Output.txt		
CHANGE IN WATER STORAGE	165.795	64.660	10.60
SOIL WATER AT START OF YEAR	4033.685	1573.137	
SOIL WATER AT END OF YEAR	4199.479	1637.797	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0004	0.000	0.00
****	*****	****	*****

ANNUAL TOTALS FOR YEAR 3

	 MM	CU. METERS	PERCENT
PRECIPITATION	1538.10	599.859	100.00
RUNOFF	543.643	212.021	35.35
EVAPOTRANSPIRATION	830.260	323.801	53.98
PERC./LEAKAGE THROUGH LAYER 2	0.006081	0.002	0.00
CHANGE IN WATER STORAGE	164.192	64.035	10.67
SOIL WATER AT START OF YEAR	4199.479	1637.797	
SOIL WATER AT END OF YEAR	4363.671	1701.832	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0008	0.000	0.00
******	****	******	*******

ANNUAL TOTALS FOR YEAR 4	ł
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		ММ	CU. METERS	PERCENT
PRECIPITATION		1172.80	457.392	100.00
RUNOFF		293.324	114.396	25.01
EVAPOTRANSPIRATION		801.995	312.778	68.38
PERC./LEAKAGE THROUGH LAYER	2	0.006272	0.002	0.00

CHANGE IN WATER STORAGE	HELP Output.txt 77.475	30.215	6.61
SOIL WATER AT START OF YEAR	4363.671	1701.832	
SOIL WATER AT END OF YEAR	4441.146	1732.047	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0003	0.000	0.00
*****	******	*****	*****

ANNUAL TOT	ALS FOR YEAR 5		
	 MM	CU. METERS	PERCENT
PRECIPITATION	1452.10	566.319	100.00
RUNOFF	507.065	197.755	34.92
EVAPOTRANSPIRATION	790.824	308.421	54.46
PERC./LEAKAGE THROUGH LAYER 2	0.006064	0.002	0.00
CHANGE IN WATER STORAGE	154.206	60.140	10.62
SOIL WATER AT START OF YEAR	4441.146	1732.047	
SOIL WATER AT END OF YEAR	4595.352	1792.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0003	0.000	0.00
******	******	*****	*****

ANNUAL TOTALS FOR YEAR 6

	•		
	MM	CU. METERS	PERCENT
PRECIPITATION	1477.10	576.069	100.00
RUNOFF	449.191	175.184	30.41
EVAPOTRANSPIRATION	870.155	339.361	58.91
PERC./LEAKAGE THROUGH LAYER 2	0.005644	0.002	0.00
CHANGE IN WATER STORAGE	157.748 Page 5	61.522	10.68

н	ELP Output.txt		
SOIL WATER AT START OF YEAR	4595.352	1792.187	
SOIL WATER AT END OF YEAR	4753.100	1853.709	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00
*****	*********	******	*****

ANNUAL IO	TALS FOR YEAR /		
	MM	CU. METERS	PERCENT
PRECIPITATION	1183.60	461.604	100.00
RUNOFF	434.478	169.446	36.71
EVAPOTRANSPIRATION	609.824	237.831	51.52
PERC./LEAKAGE THROUGH LAYER 2	0.005757	0.002	0.00
CHANGE IN WATER STORAGE	139.292	54.324	11.77
SOIL WATER AT START OF YEAR	4753.100	1853.709	
SOIL WATER AT END OF YEAR	4892.392	1908.033	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0003	0.000	0.00

ANNUAL TOTALS FOR YEAR 8

	MM	CU. METERS	PERCENT
PRECIPITATION	1436.70	560.313	100.00
RUNOFF	562.484	219.369	39.15
EVAPOTRANSPIRATION	754.774	294.362	52.54
PERC./LEAKAGE THROUGH LAYER 2	0.010280	0.004	0.00
CHANGE IN WATER STORAGE	119.431	46.578	8.31

Page 6

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SOIL WATER AT START OF YEAR	HELP Output.txt 4892.392	1908.033	
SOIL WATER AT END OF YEAR	5011.823	1954.611	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0003	0.000	0.00
*****	*******	******	*****

******	*******	*******	
ANNUAL TOTALS FOR YEAR 9			
MM	CU. METERS	PERCENT	
1321.70	515.463	100.00	
437.987	170.815	33.14	
757.679	295.495	57.33	
8.618426	3.361	0.65	
117.416	45.792	8.88	
5011.823	1954.611		
5129.239	2000.403		
0.000	0.000	0.00	
0.000	0.000	0.00	
-0.0006	0.000	0.00	
	<pre>************************************</pre>	LS FOR YEAR 9 MM CU. METERS 1321.70 515.463 437.987 170.815 757.679 295.495 8.618426 3.361 117.416 45.792 5011.823 1954.611 5129.239 2000.403 0.000 0.000 0.000 0.000 -0.0006 0.000	

ANNUAL TOTALS FOR YEAR 10								
	MM	CU. METERS	PERCENT					
PRECIPITATION	1407.60	548.964	100.00					
RUNOFF	502.373	195.925	35.69					
EVAPOTRANSPIRATION	756.676	295.104	53.76					
PERC./LEAKAGE THROUGH LAYER 2	73.402893	28.627	5.21					
CHANGE IN WATER STORAGE	75.148	29.308	5.34					
SOIL WATER AT START OF YEAR	5129.239 Page 7	2000.403						

HELP Output.txt						
SOIL WATER AT END OF YEAR	5204.387	2029.711				
SNOW WATER AT START OF YEAR	0.000	0.000	0.00			
SNOW WATER AT END OF YEAR	0.000	0.000	0.00			
ANNUAL WATER BUDGET BALANCE	0.0007	0.000	0.00			
******	******	*****	*******			

AVERAGE MO	NTHLY VALUE	5 (MM) FO	R YEARS	1 THROUG	GH 10	
	JAN/JUL	FE8/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
RECIPITATION						
TOTALS	123.08 96.81	125.62 92.02	127.66 93.77	147.58 92.82	162.62 88.12	101.96 123.00
STD. DEVIATIONS	77.37 65.30	40.27 63.19	64.70 39.88	96.30 35.06	76.43 27.59	51.14 81.38
UNOFF						
TOTALS	52.327 18.978	48.938 15.718	53.877 19.811	57.921 26.630	71.010 28.392	19.64 56.17
STD. DEVIATIONS	51.311 30.581	28.617 14.680	38.149 15.755	59.416 16.295	52.384 18.789	17.06 56.26
VAPOTRANSPIRATION						
TOTALS	35.243 119.910	47.472 75.997	63.231 52.129	80.303 42.860	91.030 31.539	100.78 29.52
STD. DEVIATIONS	5.245 27.501	6.357 41.760	11.335 22.753	20.962 2.787	18.794 6.996	30.42 3.82
ERCOLATION/LEAKAGE	THROUGH LAY	er 2				
TOTALS	0.5731 0.2977	0.7841 0.3835	0.9391 0.7804	0.6748 0.9207	0.5967 0.8274	0.40 1.02
STD. DEVIATIONS	1.8101 0.6914	2.4761 0.9068	2.9632 2.0582	2.1048 2.5177	1.7951 2.2134	1.14 2.54
******	*******	******	*******	******	*******	******
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AVERAGE ANNUAL TO	TALS & (STD	. DEVIATI	ONS) FOR	YFARS	1 тироцен	10

Page 8
	HELP OU MN	tput.txt 1	CU. METERS	PERCENT
PRECIPITATION	1375.06	(147.493)	536.3	100.00
RUNOFF	469.426	(109.0695)	183.08	34.139
EVAPOTRANSPIRATION	770.017	(68.2215)	300.31	55.999
PERCOLATION/LEAKAGE THROUGH LAYER 2	8.20706	(23.06682)	3.201	0.59685
CHANGE IN WATER STORAGE	127.410	(1.3493)	49.69	9.266
*******	*****	*****	******	******

OUGH 10
M) (CU. METERS)
0 46.800
32 32.9675
73020 0.18448
9 24.9570
0.4315
0.1160
*

FINAL WATER STORAGE AT END OF YEAR 10 ----------LAYER (CM) (VOL/VOL) ____ 1 414.3371 0.3398 106.1016 2 0.0480 0.000 SNOW WATER *****

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Hel	p_R	.OUT

<pre>HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) DEVELOPED BY ENVIRONMENTAL LABORATORY USAE WATERWAYS EXPERIMENT STATION FOR USEPA RISK REDUCTION ENGINEERING LABORATORY PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 SOLAND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOLAND SOLAND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOLAND SOLAND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOLAND SOLAND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOLAND SOLAND pre>	
<pre>HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) DEVELOPED BY ENVIRONMENTAL LASORATORY FOR USEPA RISK REDUCTION ENGINEERING LABORATORY FOR USEPA RISK REDUCTION ENGINEERING LABORATORY PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D7 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D1 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP0.U3.OUT TIME: 14:34 DATE: 1/16/2004 MITCH: PCP DIP VAT SITE, MEMPHIS DEPOT MITCH: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 MICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL FIELD CAPACITY = 0.4530 VOL/VOL FIELD CAPACITY = 0.4530 VOL/VOL INITIAL SOIL WATER CONTENT = 0.1160 VOL/VOL INITIAL SOIL WATER CONTENT = 0.1264 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC</pre>	***************************************
HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) DEVELOPED BY ENVIRONMENTAL LABORATORY USAE WATERWAYS EXPERIMENT STATION FOR USEPA RISK REDUCTION ENGINEERING LABORATORY FOR USEPA RISK REDUCTION ENGINEERING LABORATORY SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP5.D13 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP5.D13 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D11 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOL SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP3.SOL AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. ILAYER 1 LAYER 1	א א א א א א א א א א א א א א א א א א א
<pre>** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE ** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) ** USAE WATERWAYS EXPERIMENT STATION ** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY ** ** ** ** ** ** ** ** ** ** ** ** **</pre>	** **
<pre>** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) ** ** USAE WATERNAYS EXPERIMENT STATION USAE WATERNAYS EXPERIMENT STATION ** ** OUSAE WATERNAYS EXPERIMENT STATION ** ** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY ** ** PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D4 TEMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCPS.D13 EVAPOTRANSPIRATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPS.D13 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPS.D13 SOL AND DESIGN DATA FIL</pre>	** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
<pre>** DEVELOPED BY ENVIRONMENTAL LABORATORY ** ** USAE WATERWAYS EXPERIMENT STATION ** ** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY ** ** ** PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D4 TEMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCPT.D7 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE.D3 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE.D3 SOLAR RADISENDATA FILE: C:\PROGRA-1\HELP3\USER\PCPE.D3 SOLAR RADISER\PCPE.D3 SOLAR RADISENDATA FILE: C:\PROGRA-1\HELP3\USER\PCPE.D3 SOLAR RADISER\PCPE.D3 SOLAR RADI</pre>	** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) **
** USAE WATERWAYS EXPERIMENT STATION ** ** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY ** ** ** ** ** ** ** ** ** ** ** ** **	** DEVELOPED BY ENVIRONMENTAL LABORATORY **
<pre>** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY ** ** ** PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D4 TEMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCPT.D7 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOLAR RADISTION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOLAR RADISTION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE2.D13 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPE3.D10 OUTPUT DATA FILE: DITA FILE: C:\PROGRA-1\HELP3\USER\PCPE3.D10 OUTPUT DATA FILE: D'THE I_1/16/2004 ***********************************</pre>	** USAE WATERWAYS EXPERIMENT STATION **
<pre>** ** ** ** ** ** ** ** ** ** ** ** **</pre>	** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
<pre>** ** *** *** *** *** ***************</pre>	**
<pre>PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP1.DT EMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D1 SOLAR ADDATAION DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D11 SOL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCCP2.D10 TIME: 14:34 DATE: 1/16/2004</pre>	**
PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D4 FEMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCPT.D7 SOLAR RADIATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCP2.D11 SOLAND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCP03.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP03.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCP043.D10 TIME: 14:34 DATE: 1/16/2004 TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT MOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 PROGSTY = 1.219.20 CM POROSTY = 0.4630 VOL/VOL FIED CAPACITY = 0.430 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC	***************************************
PRECIPITATION DATA FILE: C:\PROGRA-1\HELP3\USER\PCPP.D4 TEMPERATURE DATA FILE: C:\PROGRA-1\HELP3\USER\PCPS.D13 EVAPOTRANSPIRATION DATA; C:\PROGRA-1\HELP3\USER\PCPS.D13 EVAPOTRANSPIRATION DATA; C:\PROGRA-1\HELP3\USER\PCP2.D11 SOIL AND DESIGN DATA FILE: C:\PROGRA-1\HELP3\USER\PCPd3.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCPd3.D10 OUTPUT DATA FILE: C:\PROGRA-1\HELP3\USER\PCPd3.D10 TIME: 14:34 DATE: 1/16/2004 TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT MOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 MICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL MITITAL SOIL WATER CONTENT = 0.2364 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2364 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC	***************************************
TIME: 14:34 DATE: 1/16/2004 TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 	PRECIPITATION DATA FILE: C:\PROGRA~1\HELP3\USER\PCPP.D4 TEMPERATURE DATA FILE: C:\PROGRA~1\HELP3\USER\PCPT.D7 SOLAR RADIATION DATA FILE: C:\PROGRA~1\HELP3\USER\PCPS.D13 EVAPOTRANSPIRATION DATA: C:\PROGRA~1\HELP3\USER\PCPE2.D11 SOIL AND DESIGN DATA FILE: C:\PROGRA~1\HELP3\USER\pcpd3.D10 OUTPUT DATA FILE: C:\PROGRA~1\HELP3\USER\pcpout3.OUT
TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT MOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 	TIME: 14:34 DATE: 1/16/2004
TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT MOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8 THICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2564 VOL/VOL INITIAL SOIL WATER COND. = 0.369999994000E-03 CM/SEC LAYER 2	********************************
NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 	TITLE: PCP DIP VAT SITE, MEMPHIS DEPOT
NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8 THICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL WILTING POINT = 0.1160 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2564 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC	
NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM. LAYER 1 TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8 THICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL WILTING POINT = 0.1160 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2564 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC LAYER 2	***************************************
LAYER 1 TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8 THICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL WILTING POINT = 0.1160 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2564 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC LAYER 2	NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.
TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8 THICKNESS = 1219.20 CM POROSITY = 0.4630 VOL/VOL FIELD CAPACITY = 0.2320 VOL/VOL WILTING POINT = 0.1160 VOL/VOL INITIAL SOIL WATER CONTENT = 0.2564 VOL/VOL EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC LAYER 2	LAYER 1
TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8THICKNESS= 1219.20 CMPOROSITY= 0.4630 VOL/VOLFIELD CAPACITY= 0.2320 VOL/VOLWILTING POINT= 0.1160 VOL/VOLINITIAL SOIL WATER CONTENT= 0.2564 VOL/VOLEFFECTIVE SAT. HYD. COND.= 0.369999994000E-03 CM/SEC	
LAYER 2	TYPE 1 - VERTICAL PERCOLATION LAYER MATERIAL TEXTURE NUMBER 8THICKNESS= 1219.20POROSITY= 0.4630VOL/VOLFIELD CAPACITY= 0.2320WILTING POINT= 0.1160VOL/VOLINITIAL SOIL WATER CONTENT= 0.2564EFFECTIVE SAT. HYD. COND.= 0.36999994000E-03CM/SEC
	LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER Page 1

Help_R.OUT

		, —			
M	ATERIAL	TEXTURE	NUMBER	1	
THICKNESS		=	2209.80	CM	
POROSITY		=	0.417	70 VOL/VOL	
FIELD CAPACITY		=	0.04	50 VOL/VOL	
WILTING POINT		=	0.018	30 VOL/VOL	
INITIAL SOIL WA	TER CONT	ΓENT ≕	0.04	55 VOL/VOL	
EFFECTIVE SAT.	HYD. CON	ND. =	0.9999999	978000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER		80.00	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.0390	HECTARES
EVAPORATIVE ZONE DEPTH	=	45.7	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	12.006	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	21.168	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	5.304	CM
INITIAL SNOW WATER	=	0.000	CM
INITIAL WATER IN LAYER MATERIALS	=	413.269	CM
TOTAL INITIAL WATER	=	413.269	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM MEMPHIS TENNESSEE

STATION LATITUDE	=	35.03 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	79
END OF GROWING SEASON (JULIAN DATE)	=	315
EVAPORATIVE ZONE DEPTH	=	45.7 CM
AVERAGE ANNUAL WIND SPEED	=	14.00 КРН
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	68.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
117.1	110.0	138.2	146.6	128.5	90.9
102.4	95.0	91.9	60.2	105.9	123.2

Help_R.OUT NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.2	6.4	11.0	17.0	21.7	26.0
27.9	27.0	23.5	17.2	10.7	6.3

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR MEMPHIS TENNESSEE AND STATION LATITUDE = 35.03 DEGREES

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ANNUAL TOTALS FOR YEAR

	 ММ	CU. METERS	PERCENT				
PRECIPITATION	1196.70	466.713	100.00				
RUNOFF	0.000	0.000	0.00				
EVAPOTRANSPIRATION	881.538	343.800	73.66				
PERC./LEAKAGE THROUGH LAYER 2	0.044419	0.017	0.00				
CHANGE IN WATER STORAGE	315.117	122.896	26.33				
SOIL WATER AT START OF YEAR	4132.686	1611.748					
SOIL WATER AT END OF YEAR	4447.803	1734.643					
SNOW WATER AT START OF YEAR	0.000	0.000	0.00				
SNOW WATER AT END OF YEAR	0.000	0.000	0.00				
ANNUAL WATER BUDGET BALANCE	-0.0002	0.000	0.00				

ANNUAL TO	TALS FOR YEAR	2			
	 ММ	CU. METERS	PERCENT		
PRECIPITATION	1564.20	610.038	100.00		
RUNOFF	0.000	0.000	0.00		
EVAPOTRANSPIRATION	829.521	323.513	53.03		
PERC./LEAKAGE THROUGH LAYER 2	0.056774 Page 3	0.022	0.00		

		Help_R.OUT			
	CHANGE IN WATER STORAGE	734.623	286.503	46.96	
	SOIL WATER AT START OF YEAR	4447.803	1734.643		
	SOIL WATER AT END OF YEAR	5182.426	2021.146		
	SNOW WATER AT START OF YEAR	0.000	0.000	0.00	
	SNOW WATER AT END OF YEAR	0.000	0.000	0.00	
	ANNUAL WATER BUDGET BALANCE	-0.0006	0.000	0.00	
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ANNUAL TOTALS FOR YEAR 3					
	ММ	CU. METERS	PERCENT		
PRECIPITATION	1538.10	599.859	100.00		
RUNOFF	0.000	0.000	0.00		
EVAPOTRANSPIRATION	935.040	364.666	60.79		
PERC./LEAKAGE THROUGH LAYER 2	0.202767	0.079	0.01		
CHANGE IN WATER STORAGE	602.857	235.114	39.19		
SOIL WATER AT START OF YEAR	5182.426	2021.146			
SOIL WATER AT END OF YEAR	5785.282	2256.260			
SNOW WATER AT START OF YEAR	0.000	0.000	0.00		
SNOW WATER AT END OF YEAR	0.000	0.000	0.00		
ANNUAL WATER BUDGET BALANCE	0.0004	0.000	0.00		
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		MM	CU. METERS	PERCENT
PRECIPITATION		1172.80	457.392	100.00
RUNOFF		0.000	0.000	0.00
EVAPOTRANSPIRATION		912.660	355.937	77.82
PERC./LEAKAGE THROUGH LAYER	2	73.728394	28.754	6.29

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CHANGE IN WATER STORAGE	Help_R.OUT 186.413	72.701	15.89
SOIL WATER AT START OF YEAR	5785.282	2256.260	
SOIL WATER AT END OF YEAR	5971.695	2328.961	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0002	0.000	0.00
*****	*****	******	*****

ANNUAL TOTALS FOR YEAR 5				
	MM	CU. METERS	PERCENT	
PRECIPITATION	1452.10	566.319	100.00	
RUNOFF	0.000	0.000	0.00	
EVAPOTRANSPIRATION	917.675	357.893	63.20	
PERC./LEAKAGE THROUGH LAYER 2	296.833191	115.765	20.44	
CHANGE IN WATER STORAGE	237.593	92.661	16.36	
SOIL WATER AT START OF YEAR	5971.695	2328.961		
SOIL WATER AT END OF YEAR	6209.288	2421.622		
SNOW WATER AT START OF YEAR	0.000	0.000	0.00	
SNOW WATER AT END OF YEAR	0.000	0.000	0.00	
ANNUAL WATER BUDGET BALANCE	-0.0004	0.000	0.00	

ANNUAL TOTALS FOR YEAR 6

ANNUAL TOTALS FOR TEAK O				
	ММ	CU. METERS	PERCENT	
PRECIPITATION	1477.10	576.069	100.00	
RUNOFF	0.000	0.000	0.00	
EVAPOTRANSPIRATION	1019.291	397.523	69.01	
PERC./LEAKAGE THROUGH LAYER 2	383.960297	149.745	25.99	
CHANGE IN WATER STORAGE	73.849 Page 5	28.801	5.00	

	Help_R.OUT		
SOIL WATER AT START OF YEAR	6209.288	2421.622	
SOIL WATER AT END OF YEAR	6283.137	2450.423	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	0.000	0.00
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ANNUAL TOTALS FOR YEAR 7					
	MM	CU. METERS	PERCENT		
PRECIPITATION	1183.60	461.604	100.00		
RUNOFF	0.000	0.000	0.00		
EVAPOTRANSPIRATION	708.390	276.272	59.85		
PERC./LEAKAGE THROUGH LAYER 2	493.224579	192.358	41.67		
CHANGE IN WATER STORAGE	-18.014	-7.026	-1.52		
SOIL WATER AT START OF YEAR	6283.137	2450.423			
SOIL WATER AT END OF YEAR	6265.122	2443.398			
SNOW WATER AT START OF YEAR	0.000	0.000	0.00		
SNOW WATER AT END OF YEAR	0.000	0.000	0.00		
ANNUAL WATER BUDGET BALANCE	-0.0002	0.000	0.00		
*******	*****	******	****		

ANNUAL TOTALS FOR YEAR 8

	 ММ	CU. METERS	PERCENT
PRECIPITATION	1436.70	560.313	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	887.863	346.266	61.80
PERC./LEAKAGE THROUGH LAYER 2	501.515686	195.591	34.91
CHANGE IN WATER STORAGE	47.322	18.455	3.29

6265.122	2443.398	
6312.444	2461.853	
0.000	0.000	0.00
0.000	0.000	0.00
0.0000	0.000	0.00
	6265.122 6312.444 0.000 0.000 0.000	6265.122 2443.398 6312.444 2461.853 0.000 0.000 0.000 0.000 0.000 0.000

ANNUAL TOTALS FOR YEAR 9				
	 ММ	CU. METERS	PERCENT	
PRECIPITATION	1321.70	515.463	100.00	
RUNOFF	0.000	0.000	0.00	
EVAPOTRANSPIRATION	860.620	335.642	65.11	
PERC./LEAKAGE THROUGH LAYER 2	514.384277	200.610	38.92	
CHANGE IN WATER STORAGE	-53.304	-20.788	-4.03	
SOIL WATER AT START OF YEAR	6312.444	2461.853		
SOIL WATER AT END OF YEAR	6259.140	2441.065		
SNOW WATER AT START OF YEAR	0.000	0.000	0.00	
SNOW WATER AT END OF YEAR	0.000	0.000	0.00	
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00	

ANNUAL	TOTALS	FOR YEAR	10

	MM	CU. METERS	PERCENT
PRECIPITATION	1407.60	548.964	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	876.721	341.921	62.28
PERC./LEAKAGE THROUGH LAYER 2	468.066437	182.546	33.25
CHANGE IN WATER STORAGE	62.813	24.497	4.46
SOIL WATER AT START OF YEAR	6259.140 Page 7	2441.065	

	Help_R.OUT		
SOIL WATER AT END OF YEAR	6321.953	2465.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0004	0.000	0.00
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AVERAGE MON	THLY VALUES	5 (MM) FOI	R YEARS	1 THROUG	GH 10	
	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	123.08 96.81	125.62 92.02	127.66 93.77	147.58 92.82	162.62 88.12	101.96 123.00
STD. DEVIATIONS	77.37 65.30	40.27 63.19	64.70 39.88	96.30 35.06	76.43 27.59	51.14 81.38
RUNOFF						
TOTALS	$0.000 \\ 0.000$	0.000	0.000 0.000	$0.000 \\ 0.000$	0.000 0.000	0.000 0.000
STD. DEVIATIONS	$0.000 \\ 0.000$	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION						
TOTALS	44.119 84.296	56.135 84.245	83.175 65.824	102.649 71.676	110.150 47.356	91.926 41.381
STD. DEVIATIONS	6.188 38.470	7.906 44.572	10.913 30.766	21.069 7.008	28.799 15.142	34.869 4.794
PERCOLATION/LEAKAGE	THROUGH LAYE	ER 2				
TOTALS	27.9840 18.1688	22.0812 23.7108	18.2873 27.8137	8.7679 35.7831	12.8716 29.0319	15.9983 32.7031
STD. DEVIATIONS	25.7098 18.8725	20.0440 22.7454	17.5829 25.4158	12.6956 30.5612	12.5336 23.6998	16.5884 26.2319
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*****	* * * * * * * * * * * * * * *	*****	******	*******	*****	****
AVERAGE ANNUAL TO	TALS & (STD	. DEVIATI	ONS) FOR	YEARS	1 THROUGH	10

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	Heip_ MM	_R.OUT M	CU. METERS	PERCENT
PRECIPITATION	1375.06	(147.493)	536.3	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	882.932	(79.7775)	344.34	64.210
PERCOLATION/LEAKAGE THROUGH LAYER 2	273.20169	(229.26105)	106.549	19.86835
CHANGE IN WATER STORAGE	218.927	(10.4091)	85.38	15.921
*****	*****	*****	*****	*******

PEAK DAILY VALUES FOR YEARS	1 THROUGH	10
	(MM)	(CU. METERS)
PRECIPITATION	120.00	46.800
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.905333	1.13308
SNOW WATER	63.99	24.9570
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.	4458
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.	1491
*****	*****	*****

| | |

FINAL WATER	STORAGE AT	END OF YEAR 10	
LAYER	(СМ)	(VOL/VOL)	
1	358.7920	0.2943	
2	273.4033	0.1237	
SNOW WATER	0.000		
*****	******	******	**********
******	*****	******	******

Attachment E

MULTIMED Model-Derived Parameters

ATTACHMENT E

Calculations for MULTIMED Model-Derived Input Parameters *Main Installation, Memphis Depot*

1. Longitudinal Dispersivity of Each Layer

$\alpha_{\nu} =$	0.02 + 0.022 L	(Equation 6 4)
α _v	=Longitudinal Dispersivity (unsaturated zone) =	0.51 m
L	=Depth of the unsaturated zone =	22.1 m

2. Longitudinal Dispersivity of Aquifer

$\alpha_{L} =$	$= 0.1 x_r$	(Equation 6 12)
α_{L}	=Longitudinal Dispersivity (aquifer) =	366 m
× _r	=Distance to the receptor well =	3660 m

3. Transverse Dispersivity of Aquifer

$$\alpha_T = \frac{\alpha_L}{3.0}$$
 (Equation 6 13)

 α_{T} =Longitudinal Dispersivity (aquifer) = 122 m

4. Vertical Dispersivity of Aquifer

$$\alpha_{\nu} = 0.056 \alpha_{L}$$
 (Equation 6.14)

 α_v =Vertical Dispersivity (aquifer) = 20.50 m

5. Seepage Velocity

V_{s}	=	KS / Θ

 Vs
 =Seepage rate =
 211.56 m/yr

 K
 =Hydraulic conductivity =
 2460 m/yr

 S
 =Hydraulic gradient =
 0 0258 m/m

(Equation 6 10)

0.3

 Θ =Porosity =

6. Distribution Coefficient

K _d =	$K_{oc} f_{oc}$	(Equation 6 1)
K _d	=Contaminant distribution coefficient =	1.56 mL/g
K_{oc}	=Normalized organic carbon distribution coefficient =	1560 mL/g
f _{oc}	= Organic carbon content =	0 001

ATTACHMENT E

Calculations for MULTIMED Model-Derived Input Parameters Main Installation, Memphis Depot

6. Retardation Coefficient

$$R_s = 1 + \frac{\rho_b K_d}{\Theta}$$

(Equation 6 11)

Rs =Retardation coefficient =

 ρ_b =Bulk density =

8.33 1.41 g/cc

7. Mixing Zone Depth

$$H = (2\alpha_{\nu}L)^{\frac{V_{2}}{2}} + B\left(1 - \exp\left(-\frac{LQ_{f}}{V_{S}\Theta B}\right)\right)$$
(Equation 6.8)

$$H = \text{Mixing Zone Thickness (Scenarios 1-4)} = 28.28 \text{ m}$$

$$= \text{Mixing Zone Thickness (Scenario 5)} = 28.36 \text{ m}$$

$$L = \text{Length scale of the facility} = 19.5 \text{ m}$$

B =Thickness of saturated zone =

Q_f =Percolation rate (Scenarios 1-4) = =Percolation rate (Scenario 5) =

10 0	
16	m
0 01	m/yr

0 27 m/yr

Note: Equations from MULTIMED Application Manual (EPA, August 1990).

Attachment F

MULTIMED Model Output for Average and Maximum Soil Leachate Conditions

AGENCY

U.S. ENVIRONMENTAL PROTECTION

АЧЕНСТ

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1 Run options

Former PCP Dip Vat

Main Installation, Memphis Depot Chemical simulated is PENTACHLOROPHENOL

Option Chosen Saturated and unsaturated zone models Run was DETERMIN Infiltration input by user Run was steady-state Reject runs if Y coordinate outside plume Do not reject runs if Z coordinate outside plume Gaussian source used in saturated zone model 1 UNSATURATED ZONE FLOW MODEL PARAMETERS (input parameter description and value) NP - Total number of nodal points 240

Page 1

SCE1.OUT - Number of different porous materials NMAT 1 KPROP - Van Genuchten or Brooks and Corey 1 IMSHGN - Spatial discretization option 1 NVFLAYR - Number of layers in flow model 1 OPTIONS CHOSEN ---- ---Van Genuchten functional coefficients User defined coordinate system 1 Layer information LAYER NO. LAYER THICKNESS MATERIAL PROPERTY 1 22.10 1 DATA FOR MATERIAL 1 VADOSE ZONE MATERIAL VARIABLES VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX _____ Saturated hydraulic conductivity cm/hr CONSTANT -999. 0.100E-10 0.100E+05 5.15 Unsaturated zone porosity -999. 0.100E-08 0.990 ---CONSTANT 0.300 Air entry pressure head 0.000E+00 -999. 0.000E+00 -999. Depth of the unsaturated zone 22.1 -999. 0.100E-08 -999. m CONSTANT CONSTANT m DATA FOR MATERIAL 1 - --- ----VADOSE ZONE FUNCTION VARIABLES VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX Residual water content 0.700E-01 -999. 0.100E-08 1.00 --CONSTANT , Brook and Corey exponent,EN - -CONSTANT Page 2

			SCEL OUT		
0.000E+00) -999. ALEA coeff	0.000E+00	10.0	1/cm	CONSTANT
0.145	-999.	0.000E+00	1.00	±/ Cill	CONSTANT
2.68 1	-999.	1.00	5.00		CONSTANT
UNSATUR	ATED ZONE TRA	ANSPORT MODEL	PARAMETERS		
NLAY NTSTPS DUMMY ISOL N NTEL NGPTS NIT IBOUND ITSGEN TMAX WTFUN	- Number of a - Number of t - Not present - Type of sch - Stehfest ta - Points in L - Number of a - Convolution - Type of bou - Time values - Max simulat - Weighting f	different lay time values of tly used neme used in erms or numbe agrangian in Gauss points nuntegral se undary condit s generated of tion time factor	vers used concentration calc unsaturated zone er of increments iterpolation egments tion or input 	$ \begin{array}{r}1\\40\\1\\1\\18\\3\\104\\2\\1\\1\\0.0\\1.2\end{array} $	
OPTIONS Stehfest Nondecay Computer	CHOSEN The continue Chosen of the continue Ch	inversion algous source times for com	gorithm mputing concentratio	ons	
T					
1				DATA FOR LA	VFR 1
T				DATA FOR LA	AYER 1
				DATA FOR LA	AYER 1 NSPORT VARIABLES
L 		VARIABLE N	 JAME	DATA FOR LA VADOSE TRAN	AYER 1 SPORT VARIABLES
PARAMETER		VARIABLE M LIMITS	 NAME	DATA FOR LA VADOSE TRAN	AYER 1 ISPORT VARIABLES
L PARAMETER MEAN	RS STD DEV	VARIABLE M LIMITS MIN	AME MAX	DATA FOR LA VADOSE TRAN	AYER 1 ISPORT VARIABLES
L PARAMETER MEAN	RS STD DEV	VARIABLE N LIMITS MIN	IAME MAX	DATA FOR LA VADOSE TRAN	AYER 1 ISPORT VARIABLES
 РАКАМЕТЕР МЕАN 22.1	RS STD DEV Thickness -999.	VARIABLE N LIMITS MIN of layer 0.100E-08	MAX	DATA FOR LA VADOSE TRAN UNITS DI	AYER 1 ISPORT VARIABLES
L PARAMETER MEAN 	RS STD DEV Thickness -999. Longitudir -999.	VARIABLE N LIMITS MIN of layer 0.100E-08 1al dispersiv 0.100F-02	MAX MAX -999. /ity of layer 0.100F+05	DATA FOR LA VADOSE TRAM UNITS DI m m	AYER 1 ISPORT VARIABLES ISTRIBUTION CONSTANT DERIVED
L PARAMETER MEAN 22.1 ~999. 0.138	Thickness -999. Longitudir -999. Percent or -999.	VARIABLE N LIMITS MIN of layer 0.100E-08 ial dispersiv 0.100E-02 'ganic matter 0.000F+00	MAX MAX 999. vity of layer 0.100E+05 100.	DATA FOR LA VADOSE TRAM UNITS DI m m	AYER 1 ISPORT VARIABLES STRIBUTION CONSTANT DERIVED CONSTANT
L PARAMETER MEAN 22.1 ~999. 0.138 1.41	RS STD DEV Thickness -999. Longitudir -999. Percent or -999. Bulk densi -999.	VARIABLE N LIMITS MIN of layer 0.100E-08 1al dispersiv 0.100E-02 ganic matter 0.000E+00 ity of soil f 0.100E-01	MAX MAX MAX 999. Vity of layer 0.100E+05 100. for layer 5.00	DATA FOR LA VADOSE TRAM UNITS DI m m m g/cc	AYER 1 INSPORT VARIABLES CONSTANT DERIVED CONSTANT CONSTANT CONSTANT
L PARAMETER MEAN 22.1 ~999. 0.138 1.41 0.000E+00	RS STD DEV Thickness -999. Longitudir -999. Percent or -999. Bulk densi -999. Biological 2 -999.	VARIABLE N LIMITS MIN of layer 0.100E-08 dispersiv 0.100E-02 ganic matter 0.000E+00 ity of soil f 0.100E-01 decay coeff 0.000E+00	MAX MAX MAX MAX MAX MAX MAX MAX MAX MAX	DATA FOR LA VADOSE TRAN UNITS DI m m g/cc 1/yr	AYER 1 INSPORT VARIABLES CONSTANT CONSTANT CONSTANT CONSTANT CONSTANT

Page 3

- -

			SCE1.OUT		
PARAMETER	S	VARIABLE LIMITS	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
	Solid pha	se decav coe	 fficient	 1/vr	
-999.	-999.	0.000E+00	0.100E+11	1/yr	DERIVED
-999.	-999.	0.000E+00	0.100E+11	1/yi	
-999.	-999.	0.000E+00	0.100E+11	1/yr	DERIVED
0.000E+00	AC10 Cata) -999.	0.000E+00	9999.	I/M-yr	CONSTANT
0.000E+00	Neutral h)-999.	ydrolysis ra 0.000E+00	te constant -999.	1/yr	CONSTANT
0.000F+00	Base cata	lyzed hydrol	ysis rate _999	1∕M-yr	CONSTANT
25 0	Reference	temperature	100	С	CONSTANT
0 1565.04	Normalize	d distributi	on coefficient	ml/g	CONSTANT
0.150E+04	Distribut	ion coeffici	-999. ent		DERIVED
~999.	-999. Biodegrad	0.000E+00 ation coeffi	0.100E+11 cient (sat. zone)) 1/yr	CONSTANT
0.000E+00) -999. Air diffu	0.000E+00 sion coeffic	-999. ient	cm2/s	CONSTANT
0.560E-01	L -999. Reference	0.000E+00 temperature	10.0 for air diffusio	on C	CONSTANT
25.0	-999. Molecular	0.000E+00	100.	a/M	CONSTANT
0.000E+00) -999.	0.000E+00	-999.	9/ H	CONSTANT
0.000E+00) -999.	0.100E-08	1.00		CONSTANT
0.000E+00	vapor pre) -999.	ssure of sol 0.000E+00	ute 100.	mm Hg	CONSTANT
0.000E+00	Henry's 1)-999.	aw constant 0.100E-09	1.00	atm-m^3/M	CONSTANT
0.000E+00	Overall 1	st order dec	ay sat. zone	1/yr	DERIVED
-999	Not curre	ntly used	1.00		CONSTANT
000	Not curre	ntly used	1.00		CONSTANT
-999. 1	-999.	0.000E+00	1.00		
				SOURCE	SPECIFIC VARIABLES
					
PARAMETER	RS	VARIABLE LIMITS	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
					
0 1005 01	Infiltrat	ion rate		m/yr	CONSTANT
0.100E-01	Area of w	u.100E-09 aste disposa	0.100E+11 l unit	m^2	CONSTANT
390.	-999.	0.100E-01	-999. Page 4		

			SCE1.OUT		
-999.	Duration o	f pulse 0.100F-08	-999	yr	CONSTANT
-999	Spread of	contaminant	Source 0 1005+11	m	DERIVED
0 1005-01	Recharge r	ate	0.1005,11	m/yr	CONSTANT
0.1002-01	Source dec	ay constant	0.1002+11	1/yr	CONSTANT
0.000E+00	Initial co	ncentration	at landfill	mg/l	CONSTANT
5.92	Length sca	le of facili	-999. ity	m	CONSTANT
19.5	-999. Width scal	e of facilit	J.100E+11	m	CONSTANT
20.0	-999. Near field	0.100E-08 (dilution).100E+11		DERIVED
1.00 1	0.000E+00	0.000E+00	1.00		
				AQUIFER	SPECIFIC VARIABLES
					
PARAMETER	s	VARIABLE N	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MTN	мах		
0.125	Particle c -999.	liameter 0.100E-08	100.	Cm	CONSTANT
0.300	Aquifer po	orosity 0.100F-08	0.990		CONSTANT
1 41	Bulk densi	ty 0 100E-01	5 00	g/cc	CONSTANT
16.0	Aquifer th	ickness		m	CONSTANT
10.0	Source thi	ckness (mix	ing zone depth)	m	DERIVED
-999.	Conductivi	ty (hydraul	ic)	m/yr	CONSTANT
0.2462+04	Gradient ((hydraulic)	0.100E+09		CONSTANT
0.258E-01	Groundwate	0.100E-07 er seepage ve	-999. elocity	m/yr	DERIVED
-999.	-999. Retardatio	0.100E-09 on coefficier	0.100E+09 nt		DERIVED
-999.	-999. Longitudir	1.00 Nal dispersiv	0.100E+09 vity	m	FUNCTION OF X
-999.	-999. Transverse	-999. e dispersivit	-999. tv	m	FUNCTION OF X
-999.	-999. Vertical d	-999. lispersivity	-999.	m	FUNCTION OF X
-999.	-999. Temperatur	-999. Te of aquife	-999. r	 C	
20.5	-999,	0.000E+00	100.	C	CONSTANT
6.00	-999.	0.300	14.0		CONSTANT
0.100E-02	-999.	0.100E-05	1.00		CUNSTANT
0.366E+04	well dista	ince from sit	се -999.	m	CONSTANT
	Angle off	center	Page 5	degree	CONSTANT

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SCE1.OUT 0.000E+00 -999. 0.000E+00 360. Well vertical distance m CONSTANT 0.000E+00 -999. 0.000E+00 1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.9948E-05

S1-VTRNSPT.OUT

CONCENTRATION AT BOTTOM OF VADOSE ZONE RUN NO. 1 STEADY-STATE CONC 0.5920E+01

1

NORMALIZED

CONCENTRATION

DEPTH CONCENTRATION

AGENCY

U.S. ENVIRONMENTAL PROTECTION

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1 Run options

Former PCP Dip Vat

Main Installation, Memphis Depot Chemical simulated is PENTACHLOROPHENOL

Option Chosen Saturated and unsaturated zone models Run was DETERMIN Infiltration input by user Run was steady-state Reject runs if Y coordinate outside plume Do not reject runs if Z coordinate outside plume Gaussian source used in saturated zone model 1 UNSATURATED ZONE FLOW MODEL PARAMETERS (input parameter description and value) NP - Total number of nodal points 240

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Page 1
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SCE2.OUT - Number of different porous materials NMAT 1 1 KPROP - Van Genuchten or Brooks and Corey IMSHGN - Spatial discretization option 1 NVFLAYR - Number of layers in flow model 1 **OPTIONS CHOSEN** Van Genuchten functional coefficients User defined coordinate system 1 Layer information ---------------LAYER NO. LAYER THICKNESS MATERIAL PROPERTY 1 22.10 1 DATA FOR MATERIAL 1 ---- --- ------VADOSE ZONE MATERIAL VARIABLES VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX ____ Saturated hydraulic conductivity -999. 0.100E-10 0.100E+05 cm/hr CONSTANT 5.15 Unsaturated zone porosity -999. 0.100E-08 0.990 --CONSTANT 0.300 Air entry pressure head 0.000E+00 -999. 0.000E+00 -999. Depth of the unsaturated zone 22.1 -999. 0.100E-08 -999. m CONSTANT CONSTANT m DATA FOR MATERIAL 1 ----VADOSE ZONE FUNCTION VARIABLES VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX Residual water content 0.700E-01 -999. 0.100E-08 1.00 CONSTANT _ _ Brook and Corey exponent, EN --CONSTANT Page 2

0.145 2.68 1 UNSATUR) -999. ALFA coef -999. Van Genuc -999. ATED ZONE TR	0.000E+00 ficient 0.000E+00 hten exponent 1.00 ANSPORT MODEL	10.0 1.00 2. ENN 5.00 2. PARAMETERS	1/cm 	CONSTANT CONSTANT
NLAY NTSTPS DUMMY ISOL N NTEL NGPTS NIT IBOUND ITSGEN TMAX WTFUN	- Number of - Number of - Not presen - Type of sc - Stehfest t - Points in - Number of - Convolutio - Type of bo - Time value - Max simula - Weighting	different lay time values of tly used heme used in erms or numbe Lagrangian ir Gauss points n integral se undary condit s generated of tion time factor	vers used concentration calc unsaturated zone er of increments iterpolation gments ion or input 	1 40 1 1 18 3 104 2 1 1 0.0 1.2	
OPTIONS Stehfes Nondecay Compute	CHOSEN t numerical ying continu r generated	inversion alg ous source times for com	orithm puting concentrat	cions DATA FOR	R LAYER 1
				VADOSE T	RANSPORT VARIABLES
PARAMETE	 RS	VARIABLE N LIMITS	IAME	UNITS	DISTRIBUTION
PARAMETE MEAN	RS STD DEV	VARIABLE N LIMITS MIN	IAME MAX	UNITS	DISTRIBUTION

Page 3

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PARAMETER	रऽ	VARIABLE N LIMITS	IAME	SCE2.OUT	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX			
	Solid phas	se decay coef	ficie	nt F+11	1/yr	DERIVED
-000	Dissolved	phase decay	coeff	icient	1/yr	DERIVED
000	Overall cl	nemical decay	/ coef	ficient	1/yr	DERIVED
- 9999. 0 000F+00	Acid cata	lyzed hydroly	0.100 /sis r _999	ate	l∕M-yr	CONSTANT
	Neutral hy	drolysis rat	e con	stant	1/yr	CONSTANT
	Base cata	lyzed hydroly	-999. /sis r	ate	l∕M-yr	CONSTANT
	Reference	temperature	-999.		с	CONSTANT
23.0	Normalized	distributio	n coe	fficient	ml/g	CONSTANT
0.1565+04	Distribut	ion coefficie	-999. ent	_ 11		DERIVED
-999.	Biodegrada	tion coeffic	0.100	(sat. zone)	1/yr	CONSTANT
0.000E+00	Air diffu	0.000E+00 sion_coeffici	-999. ent		cm2/s	CONSTANT
0.560E-0.	Reference	0.000E+00 temperature	10.0 for a	ir diffusion	n C	CONSTANT
25.0	-999. Molecular	0.000E+00 weight	100.		g/M	CONSTANT
0.000E+00	0 -999. Mole fract	0.000E+00 tion of solut	-999. :e			CONSTANT
0.000E+00	0 -999. Vapor pres	0.100E-08 ssure of solu	1.00 ute		mm Hg	CONSTANT
0.000E+0(0 -999. Henry`s la	0.000E+00 aw constant	100.		atm-m^3/M	CONSTANT
0.000E+00	0 -999. Overall 1:	0.100E-09 st order deca	1.00 v sat	. zone	1/vr	DERIVED
0.000E+00	0 0.000E+00 Not currer	0.000E+00 htlv used	1.00		-,,,	
-999.	-999. Not currer	0.000E+00	1.00			CONSTANT
-999. 1	-999.	0.000E+00	1.00			CONSTANT
Ĩ					SOURCE	SPECIFIC VARIABLES
PARAMETER	RS	VARIABLE N LIMITS	IAME		UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX			
			-		·····	
0.100E-0	1 -999.	0.100E-09	0.100	E+11	m/yr	CONSTANT
390.	-999.	0.100E-01 -	999.		m^2	CONSTANT
				Page 4		

			SCE2.OUT		
-999	Duration of -999.	of pulse	-999	yr	CONSTANT
_000	Spread of	contaminant	source	m	DERIVED
- JJJJ.	Recharge	rate	0.1002+11	m/yr	CONSTANT
0.1002-01	Source de	cay constant	0.1002+11	1/yr	CONSTANT
0.000E+00	Initial co	oncentration	at landfill	mg/l	CONSTANT
31.0	Length sca	0.000E+00 ale of facil	-999. ity	m	CONSTANT
19.5	-999. Width sca	0.100E-08 le of facili	0.100E+11 ty	m	CONSTANT
20.0	-999. Near field	0.100E-08 dilution	0.100E+11		DERIVED
1.00 1	0.000E+00	0.000E+00	1.00		
				AQUIFER	SPECIFIC VARIABLES
PARAMETER	s	VARIABLE	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
0.125	Particle (-999.	0.100E-08	100.	CM	CONSTANT
0.300	Aquifer po -999.	orosity 0.100E-08	0.990		CONSTANT
1.41	Bulk dens: -999.	ity 0.100E-01	5.00	g/cc	CONSTANT
16.0	Aquifer the -999.	hickness 0.100E-08	0.100E+06	m	CONSTANT
-999	Source th	ickness (mix	ing zone depth)	m	DERIVED
0 2465-04	Conductiv	ity (hydrau)	ic)	m/yr	CONSTANT
0.2402+04	Gradient	(hydraulic)	0.1002+09		CONSTANT
0.258E-01	Groundwat	er seepage v	elocity	m/yr	DERIVED
-999.	-999. Retardati	0.100E-09 on coefficie	0.100E+09 nt		DERIVED
-999.	-999. Longitudi	1.00 nal dispersi	0.100E+09 vity	m	FUNCTION OF X
-999.	-999. Transversi	-999. e dispersivi	-999. tv	m	FUNCTION OF X
-999.	-999.	-999. dispersivity	-999.	m	
-999.	-999.	-999.	999.	iii C	FUNCTION OF X
20.5	-999.	0.000E+00	100.	C	CONSTANT
6.00	рн -999.	0.300	14.0		CONSTANT
0.100E-02	Organic c 2 -999.	arbon conten 0.100E-05	t (fraction) 1.00		CONSTANT
0.366E+04	Well dist -999.	ance from si 1.00	te -999.	m	CONSTANT
	Angle off	center		degree	CONSTANT

Page 5

SCE2.OUT 0.000E+00 -999. 0.000E+00 360. Well vertical distance m CONSTANT 0.000E+00 -999. 0.000E+00 1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.5209E-04

S2-VTRNSPT.OUT

CONCENTRATION AT BOTTOM OF VADOSE ZONE RUN NO. 1 STEADY-STATE CONC 0.3100E+02

1 NORMALIZED

CONCENTRATION

DEPTH CONCENTRATION

SCE3.OUT

1

1

1 1

U. S. ENVIRONMENTAL PROTECTION AGENCY EXPOSURE ASSESSMENT MULTIMEDIA MODEL MULTIMED (Version 1.01, June 1991) Run options --- ------Former PCP Dip Vat Main Installation, Memphis Depot Chemical simulated is PENTACHLOROPHENOL Option Chosen Saturated and unsaturated zone models Run was DETERMIN Infiltration input by user Run was steady-state Reject runs if Y coordinate outside plume Do not reject runs if Z coordinate outside plume Gaussian source used in saturated zone model UNSATURATED ZONE FLOW MODEL PARAMETERS (input parameter description and value) NP - Total number of nodal points 240 Page 1

SCE3.OUT - Number of different porous materials NMAT 1 KPROP - Van Genuchten or Brooks and Corey IMSHGN - Spatial discretization option 1 1 NVFLAYR - Number of layers in flow model 1 **OPTIONS CHOSEN** Van Genuchten functional coefficients User defined coordinate system 1 Layer information LAYER NO. LAYER THICKNESS MATERIAL PROPERTY 22.10 1 1 DATA FOR MATERIAL 1 VADOSE ZONE MATERIAL VARIABLES _____ VARIABLE NAME UNITS DISTRIBUTION LIMITS PARAMETERS MAX MEAN STD DEV MIN Saturated hydraulic conductivity cm/hr -999. 0.100E-10 0.100E+05 CONSTANT 5.15 Unsaturated zone porosity -999. 0.100E-08 0.990 ---CONSTANT 0.300 Air entry pressure head 0.000E+00 -999. 0.000E+00 -999. Depth of the unsaturated zone 22.1 -999. 0.100E-08 -999. m CONSTANT CONSTANT m DATA FOR MATERIAL 1 --- --- -----VADOSE ZONE FUNCTION VARIABLES _____ VARIABLÉ NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX ------Residual water content 0.700E-01 -999. 0.100E-08 1.00 CONSTANT --Brook and Corey exponent, EN ___ CONSTANT Page 2

0.000E+00 0.145 2.68 1) -999. ALFA coeff -999. Van Genuch -999.	0.000E+00 icient 0.000E+00 ten exponent 1.00	SCE3.OUT 10.0 1.00 5.00	1/cm 	CONSTANT
UNSATURA NLAY NTSTPS DUMMY ISOL N NTEL NGPTS NIT IBOUND ITSGEN TMAX WTFUN	ATED ZONE TRA - Number of d - Number of t - Not present - Type of sch - Stehfest te - Points in L - Number of G - Convolution - Type of bou - Time values - Max simulat - Weighting f	NSPORT MODEL ifferent lay ime values of ly used eme used in rms or numbe agrangian ir auss points integral se ndary condit generated of ion time actor	PARAMETERS vers used concentration calc unsaturated zone er of increments iterpolation egments tion or input	1 40 1 1 18 3 104 2 1 1 0.0 1.2	
OPTIONS Stehfes Nondecay Compute	CHOSEN t numerical i ying continuo r generated t	nversion alg us source imes for con	gorithm nputing concentrati	ons DATA FOR FOR VADOSE TR	LAYER 1 ANSPORT VARIABLES
PARAMETEI MEAN	RS STD DEV	VARIABLE M LIMITS MIN	IAME MAX	UNITS	DISTRIBUTION
22.1 -999. 0.138 1.41 0.167	Thickness -999. Longitudin -999. Percent or -999. Bulk densi -999. Biological -999.	of layer 0.100E-08 - al dispersiv 0.100E-02 ganic matter 0.000E+00 ty of soil f 0.100E-01 decay coeff 0.000E+00	-999. vity of layer 0.100E+05 100. for layer 5.00 ficient -999.	m m g/cc 1/yr CHEMICAL S	CONSTANT DERIVED CONSTANT CONSTANT CONSTANT PECIFIC VARIABLES

		VARTARIE	SCE3.OU	JT DTTAIL	DISTRIBUTION
PARAMETER	S	LIMITS		UNT 12	DISECTOR
MEAN	STD DEV	MIN	MAX		
-999.	Solid pha -999.	se decay coe 0.000E+00	fficient 0.100E+11	1/yr	DERIVED
-999.	Dissolved	phase decay	<pre>coefficient 0.100F+11</pre>	1/yr	DERIVED
-999	Overall c	hemical deca	y coefficient	t 1/yr	DERIVED
0.000=.00	Acid cata	lyzed hydrol	ysis rate	l/M-yr	CONSTANT
	Neutral h	ydrolysis ra	te constant	1/yr	CONSTANT
0.000E+00	Base cata	lyzed hydrol	ysis rate	l/M-yr	CONSTANT
0.000E+00	Reference	temperature	-999.	C	CONSTANT
25.0	-999. Normalize	0.000E+00 d distributi	100. on coefficie	nt ml/g	CONSTANT
0.156E+04	I -999. Distribut	0.000E+00 ion coeffici	-999. ent		DERIVED
-999.	-999. Biodegrad	0.000E+00 ation coeffi	0.100E+11 cient (sat. ;	zone) 1/vr	CONSTANT
0.167	-999. Air diffu	0.000E+00 sion coeffic	-999. ient	cm2/s	CONSTANT
0.560E-01	-999. Reference	0.000E+00	10.0	fusion C	CONSTANT
25.0	-999.	0.000E+00	100.		CONSTANT
0.000E+00) -999.	0.000E+00	-999.	97 M	CONSTANT
0.000E+00) -999.	0.100E-08	1.00	~ ~	CONSTANT
0.000E+00	Vapor pre)-999.	ssure of sol 0.000E+00	ute 100.	mm Hg	CONSTANT
0.000E+00	Henry's 1)-999.	aw constant 0.100E-09	1.00	atm-m^3/M	CONSTANT
0.000E+00	Overall 1 0.000E+00	st order dec 0.000E+00	ay sat. zone 1.00	1/yr	DERIVED
-999.	Not curre	ntly used 0.000F+00	1.00		CONSTANT
-999	Not curre	ntly used	1 00		CONSTANT
1	- , , , , , , , , , , , , , , , , , , ,	0.0002+00	1.00	SOURCE	CRECTETC MARTARIES
				SUURCE	SPECIFIC VARIABLES
					
PARAMETER	۹S	VARIABLE LIMITS	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
	 				
0.100E-01	L -999.	0.100E-09	0.100E+11	m/yr	CONSTANT
390.	-999.	0.100E-01	-999.	m^2	CONSTANT
			Page 4	4	

		SCE3.OUT		
Duratio	on of pulse	_999	yr	CONSTANT
Spread	of contaminan	t source	m	DERIVED
Rechary	ge rate	0.100E+11	m/yr	CONSTANT
0.100E-01 -999. Source	decay constan	t	1/yr	CONSTANT
0.000E+00 -999. Initia	l concentratio	n at landfill	mg/l	CONSTANT
5.92 -999. Length	0.000E+00 scale of faci	-999. lity	m	CONSTANT
19.5 -999. Width	0.100E-08 scale of facil	0.100E+11 ity	m	CONSTANT
20.0 -999. Nearf	0.100E-08 ield dilution	0.100E+11		DERIVED
1.00 0.000E+0 1	0 0.000E+00	1.00		
			AQUIFER	SPECIFIC VARIABLES
			--	
PARAMETERS	VARIABLE LIMITS	NAME	UNITS	DISTRIBUTION
MEAN STD DEV	MIN	MAX		
Partic	 le diameter		Cm	CONSTANT
0.125 -999. Aquife	0.100E-08 r porosity	100.		CONSTANT
0.300 -999. Bulk d	0.10ÓE-08 ensity	0.990	a/cc	CONSTANT
1.41 -999.	0.100E-01	5.00	g, cc m	CONSTANT
16.0 -999.	0.100E-08	0.100E+06	m	DERTVED
-999999.	0.100E-08	0.100E+06	III 111	DERIVED
0.246E+04 -999.	0.100E-06	0.100E+09	m/yr	CONSTANT
Gradie 0.258E-01 -999.	nt (hydraulic) 0.100E-07	′ <u>-999</u> .		CONSTANT
Ground -999999.	water seepage 0.100E-09	velocity 0.100E+09	m/yr	DERIVED
Retard -999999.	ation coeffici 1.00	ent 0.100E+09		DERIVED
Longit	udinal dispers -999.	ivity _999	m	FUNCTION OF X
-999 -999	erse dispersiv	vity _999	m	FUNCTION OF X
	al dispersivit	-999. :y	m	FUNCTION OF X
20 5 000	ature of aquif	-999. er 100	с	CONSTANT
20.3 -999. pH	0.000E+00	14.0		CONSTANT
6.00 -999. Organi	c carbon conte	14.0 ent (fraction)		CONSTANT
0.100E-02 -999. Well d	0.100E-05	1.00		
	istance from s	nte	m	CONSTANT

· ··· --- -- --

SCE3.OUT 0.000E+00 -999. 0.000E+00 360. Well vertical distance m CONSTANT 0.000E+00 -999. 0.000E+00 1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.0000E+00

S3-VTRNSPT.OUT

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CONCENTRATION AT BOTTOM OF VADOSE ZONE RUN NO. 1 STEADY-STATE CONC 0.4690E-65

1 NORMALIZED

CONCENTRATION

DEPTH CONCENTRATION

SCE4.OUT

AGENCY

U.S. ENVIRONMENTAL PROTECTION

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1 Run options

Former PCP Dip Vat

Main Installation, Memphis Depot Chemical simulated is PENTACHLOROPHENOL

Option Chosen Saturated and unsaturated zone models Run was DETERMIN Infiltration input by user Run was steady-state Reject runs if Y coordinate outside plume Do not reject runs if Z coordinate outside plume Gaussian source used in saturated zone model 1 UNSATURATED ZONE FLOW MODEL PARAMETERS (input parameter description and value) NP - Total number of nodal points 240

, Page 1
SCE4.OUT - Number of different porous materials NMAT 1 KPROP - Van Genuchten or Brooks and Corey 1 IMSHGN - Spatial discretization option 1 NVFLAYR - Number of layers in flow model 1 **OPTIONS CHOSEN** Van Genuchten functional coefficients User defined coordinate system 1 Layer information LAYER NO. LAYER THICKNESS MATERIAL PROPERTY ----------22.10 1 1 DATA FOR MATERIAL 1 ---- --- -----VADOSE ZONE MATERIAL VARIABLES _____ VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX _____ Saturated hydraulic conductivity -999. 0.100E-10 0.100E+05 cm/hr CONSTANT 5.15 Unsaturated zone porosity -999. 0.100E-08 0.990 --CONSTANT 0.300 Air entry pressure head 0.000E+00 -999. 0.000E+00 -999. Depth of the unsaturated zone 22.1 -999. 0.100E-08 -999. m CONSTANT CONSTANT m DATA FOR MATERIAL 1 VADOSE ZONE FUNCTION VARIABLES ------VARIABLE NAME UNITS DISTRIBUTION PARAMETERS LIMITS MEAN STD DEV MIN MAX _____ Residual water content 0.700E-01 -999. 0.100E-08 1.00 ---CONSTANT Brook and Corey exponent, EN --CONSTANT Page 2

0.000E+00 0.145 2.68 1) -999. ALFA coeff -999. Van Genuch -999.	0.000E+00 Ticient 0.000E+00 Iten exponent 1.00	SCE4.OUT 10.0 1.00 5.00	1/cm 	CONSTANT
UNSATURA NLAY NTSTPS DUMMY ISOL N NTEL NGPTS NIT IBOUND ITSGEN TMAX WTFUN	ATED ZONE TRA - Number of t - Number of t - Not present - Type of sch - Stehfest te - Points in L - Number of c - Convolution - Type of bou - Time values - Max simulat - Weighting t	ANSPORT MODEL different lay time values of teme used in terms or numbe agrangian in Gauss points n integral se undary condit s generated of tion time factor	PARAMETERS ers used concentration calc unsaturated zone of increments terpolation egments ion or input 	1 40 1 1 18 3 104 2 1 1 0.0 1.2	
OPTIONS Stehfes Nondeca Compute	CHOSEN t numerical f ying continuo r generated f	inversion al <u>c</u> ous source cimes for con	porithm nputing concentrati	ons DATA FOR VADOSE T	LAYER 1 RANSPORT VARIABLES
PARAMETE	RS STD DEV	VARIABLE M LIMITS MIN	IAME MAX	UNITS	DISTRIBUTION
22.1 -999. 0.138 1.41 0.167	Thickness -999. Longitudiu -999. Percent ou -999. Bulk dens -999. Biologica -999.	of layer 0.100E-08 1al dispersiv 0.100E-02 rganic matter 0.000E+00 ity of soil 1 0.100E-01 l decay coeff 0.000E+00	-999. vity of layer 0.100E+05 100. for layer 5.00 ficient -999.	m m g/cc 1/yr CHEMICAL	CONSTANT DERIVED CONSTANT CONSTANT CONSTANT SPECIFIC VARIABLES

			SCE4.OUT		
PARAMETER	S	VARIABLE N LIMITS	IAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
			· •		
-999.	Solid phas	e decay coef	ficient 0 100F+11	1/yr	DERIVED
-999.	Dissolved	phase decay	coefficient 0 100F+11	1/yr	DERIVED
-999.	Overall ch	emical decay	coefficient	1/yr	DERIVED
0.000F+00	Acid catal	yzed hydroly	sis rate	l/м-yr	CONSTANT
0 000E+00	Neutral hy	drolysis rat	constant	1/yr	CONSTANT
0.00000000	Base catal	yzed hydroly	vsis rate	l/M-yr	CONSTANT
25 0	Reference	temperature	100	C	CONSTANT
0 1565+04	Normalized	distributio	n coefficient	ml/g	CONSTANT
_000	Distributi	on coefficie	-999. ent 0 1005.11		DERIVED
- 555. 0 167	Biodegrada	tion coeffic	cient (sat. zone)	1/yr	CONSTANT
0.107	Air diffus	ion coeffici	-999. ent	cm2/s	CONSTANT
25 0	Reference	temperature	for air diffusion	C	CONSTANT
23.0 0.000 <u>-</u> .00	Molecular	weight	100.	g/M	CONSTANT
0.000E+00	Mole fract	ion of solut	-999. e		CONSTANT
0.000E+00	Vapor pres	sure of solu	ite	mm Hg	CONSTANT
0.000E+00	Henry`s la	w constant	100.	atm-m^3/M	CONSTANT
0.000E+00	Overall 1s	t order deca	I.UU Ny sat. zone	1/yr	DERIVED
0.000E+00	Not curren	tly used	1.00		CONSTANT
-999.	Not curren	tly used	1.00		CONSTANT
-999. 1	-999.	0.000E+00	1.00		
				SOURCE S	SPECIFIC VARIABLES
PARAMETER	S	LIMITS	IAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
0 100= 01	Infiltrati	on rate	0 1005.11	m/yr	CONSTANT
300	Area of wa	ste disposal	Unit	m^2	CONSTANT
550.		0.1005-01 -	Page 4		

SCE4.OUT		
Duration of pulse -999999. 0.100E-08 -999.	yr	CONSTANT
Spread of contaminant source	m	DERIVED
Recharge rate	m/yr	CONSTANT
Source decay constant	1/yr	CONSTANT
Initial concentration at landfill	mg/l	CONSTANT
Length scale of facility	m	CONSTANT
19.5 -999. 0.100E-08 0.100E+11 width scale of facility	m	CONSTANT
20.0 -999. 0.100E-08 0.100E+11 Near field dilution		DERIVED
1.00 0.000E+00 0.000E+00 1.00 1		
	AQUIFER	SPECIFIC VARIABLES
VARIABLE NAME	UNITS	DISTRIBUTION
PARAMETERS LIMITS		
MEAN STD DEV MIN MAX		
Particle diameter 0.125 -999. 0.100E-08 100.	Cm	CONSTANT
Aquifer porosity 0.300 -999. 0.1005-08 0.990		CONSTANT
Bulk density	g/cc	CONSTANT
Aquifer thickness	m	CONSTANT
Source thickness (mixing zone depth)	m	DERIVED
-999999. 0.100E-08 0.100E+06 Conductivity (hydraulic)	m/yr	CONSTANT
0.246E+04 -999. 0.100E-06 0.100E+09 Gradient (hydraulic)		CONSTANT
0.258E-01 -999. 0.100E-07 -999. Groundwater seepage velocity	m/yr	DERIVED
-999999. 0.100E-09 0.100E+09 Retardation coefficient		DERIVED
-999999. 1.00 0.100E+09	m	FUNCTION OF X
-999999999999. Transverse dispersivity	m	
-999999999999.		
-999999999999.	m	FUNCTION OF X
Temperature of aquifer 20.5 -999. 0.000E+00 100.	C	CONSTANT
рн 6.00 -999. 0.300 14.0		CONSTANT
Organic carbon content (fraction) 0.100E-02 -999. 0.100E-05 1.00		CONSTANT
Well distance from site 0.366E+04 -999. 1 00 -999.	m	CONSTANT
Angle off center	degree	CONSTANT

SCE4.OUT 0.000E+00 -999. 0.000E+00 360. Well vertical distance m CONSTANT 0.000E+00 -999. 0.000E+00 1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.0000E+00

S4-VTRNSPT.OUT

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CONCENTRATION AT BOTTOM OF VADOSE ZONE RUN NO. 1 STEADY-STATE CONC 0.2456E-64

1 NORMALIZED

CONCENTRATION

DEPTH CONCENTRATION

SCE5.OUT

EXPOSURE ASSESSMENT MULTIMEDIA MODEL MULTIMED (Version 1.01, June 1991) Run options --- -----Former PCP Dip Vat Main Installation, Memphis Depot Chemical simulated is PENTACHLOROPHENOL Option Chosen Saturated and unsaturated zone models Run was DETERMIN Infiltration input by user Run was steady-state Reject runs if Y coordinate outside plume Do not reject runs if Z coordinate outside plume Gaussian source used in saturated zone model UNSATURATED ZONE FLOW MODEL PARAMETERS (input parameter description and value) - Total number of nodal points NP 240

ENVIRONMENTAL PROTECTION

U. S.

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AGENCY

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NMAT - Number KPROP - Van Ge IMSHGN - Spatia NVFLAYR - Number	r of different p enuchten or Broc al discretization r of layers in f	5.OUT erials rey	1 1 1 1						
OPTIONS CHOSEN									
Van Genuchten fo User defined coo 1	unctional coeff ordinate system	icients							
Layer information	on								
LAYER NO. LA	YER THICKNESS	MATERIA	PROPERTY						
1	22.10		1						
				DATA FO	R MATERIAL 1				
			VADO	DSE ZONE	MATERIAL VARIABLES				
	VARIABLE	NAME		•••••	DISTRIBUTION				
MEAN STD DEV	MIN	MAX							
Satur 5.15 -999. Unsat 0.300 -999. Air e 0.000E+00 -999. Depth 22.1 -999.	ated hydraulic 0.100E-10 urated zone por 0.100E-08 ntry pressure h 0.000E+00 of the unsatur 0.100E-08	conductivi 0.100E+05 osity 0.990 ead -999. ated zone -999.	ty (- - n r	 -m/hr n	CONSTANT CONSTANT CONSTANT CONSTANT				
			VADO	DATA FO	FUNCTION VARIABLES				
PARAMETERS	VARIABLE LIMITS	NAME	 1U		DISTRIBUTION				
MEAN STD DEV	MIN	MAX							
Resid 0.700E-01 -999. Brook	ual water conte 0.100E-08 and Corey expo	nt 1.00 nent,EN Pag			CONSTANT CONSTANT				

0.000E+00 0.145 2.68 1) -999. ALFA coef -999. Van Genuch -999.	0.000E+00 ficient 0.000E+00 nten exponent 1.00	SCE5.OUT 10.0 1.00 , ENN 5.00	1/cm 	CONSTANT
UNSATURA NLAY - NTSTPS - DUMMY - ISOL - N - NTEL - NGPTS - NIT - IBOUND - ITSGEN - TMAX - WTFUN -	ATED ZONE TRA - Number of a - Number of a - Type of scl - Type of scl - Stehfest to - Stehfest to - Number of a - Number of a - Convolution - Type of boa - Time values - Max simula - Weighting	ANSPORT MODEL different lay time values c tly used neme used in erms or numbe Lagrangian in Gauss points n integral se undary condit s generated o tion time factor	PARAMETERS ers used oncentration calc unsaturated zone r of increments terpolation gments ion r input 	$ \begin{array}{c} 1\\ 40\\ 1\\ 1\\ 18\\ 3\\ 104\\ 2\\ 1\\ 0.0\\ 1.2 \end{array} $	
OPTIONS Stehfes Nondecay Computer	CHOSEN t numerical ying continue generated	inversion alg ous source times for com	orithm puting concentrati	ONS DATA FOR VADOSE T	LAYER 1 RANSPORT VARIABLES
PARAMETEI MEAN	RS STD DEV	VARIABLE N LIMITS MIN	 AME MAX	UNITS	DISTRIBUTION
	Thicknoss				

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	25	VARIABLE	SCE5.OUT NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	MAX		
					
-999.	Solıd pha -999.	se decay coe 0.000E+00	fficient 0.100E+11	1/yr	DERIVED
-999.	Dissolved	phase decay	coefficient	1/yr	DERIVED
-999.	Overall c -999.	hemical decay 0.000F+00	y coefficient 0.100F+11	1/yr	DERIVED
0.000E+00	Acid cata) -999.	lyzed hydrol 0.000E+00	ysis rate -999.	l/M-yr	CONSTANT
0.000E+00	Neutral h)-999.	ydrolysis ra 0.000E+00	te constant -999.	1/yr	CONSTANT
0.000E+00	Base cata) -999.	lyzed hydrol 0.000E+00	ysis rate -999.	l/M-yr	CONSTANT
25.0	Reference	temperature 0.000F+00	100.	С	CONSTANT
0.156F+04	Normalize	d distribution	on coefficient	ml/g	CONSTANT
-999	Distribut	ion coeffici	ent 0 100F+11		DERIVED
0.167	Biodegrad	ation coeffi	cient (sat. zone) 1/yr	CONSTANT
0 560F-01	Air diffu 1 -999	sion coeffic	ient 10 0	cm2/s	CONSTANT
25.0	Reference	temperature	for air diffusi	on C	CONSTANT
0 0005+00	Molecular	weight	_999	g/M	CONSTANT
	Mole frac	tion of solu	te 1 00		CONSTANT
	Vapor pre	ssure of sol	ute 100	mm Hg	CONSTANT
0.0000000000	Henry`s]	aw constant	1.00	atm-m^3/M	CONSTANT
	Overall 1	st order dec	ay sat. zone	1/yr	DERIVED
0.0002+00	Not curre	ntly used	1.00		CONSTANT
-999.	Not curre	ntly used	1.00		CONSTANT
-999. 1	-999.	0.0002+00	1.00	6000000	
				SOURCE	SPECIFIC VARIABLES
					
PARAMETER	RS	VARIABLE LIMITS	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MIN	МАХ		
					
0.270	Infiltrat -999	ion rate 0.100F-09	0.100F+11	m/yr	CONSTANT
390.	Area of w	aste disposa	1 unit -999	m^2	CONSTANT
		0.100C 01	Page 4		

			SCE5.OUT		
-999	Duration	of pulse 0 100F-08	-999	yr	CONSTANT
_000	Spread of	contaminan	t source	m	DERIVED
	Recharge	rate	0.1005.11	m/yr	CONSTANT
0.270	Source de	cay constan	t	1/yr	CONSTANT
0.000E+0	Initial o	0.000E+00 concentratio	-999. n at landfill	mg∕l	CONSTANT
31.0	-999. Length so	0.000E+00 ale of faci	-999. lity	m	CONSTANT
19.5	-999. Width sca	0.100E-08 ale of facil	0.100E+11 ity	m	CONSTANT
20.0	-999. Near fiel	0.100E-08 d dilution	0.100E+11		DERIVED
1.00 1	0.000E+00	0.000E+00	1.00		
				AQUIF	FER SPECIFIC VARIABLES
PARAMETE	RS	VARIABLE	NAME	UNITS	DISTRIBUTION
MEAN	STD DEV	MTN	ΜΔΧ		
0.125	Particle -999.	diameter 0.100E-08	100.	CM	CONSTANT
0.300	Aquifer p -999.	orosity 0.100E-08	0.990		CONSTANT
1.41	Bulk dens -999.	sity 0.100E-01	5.00	g/cc	CONSTANT
16.0	Aquifer 1	thickness 0.100F-08	0.100F+06	m	CONSTANT
-999	Source th	nickness (mi	xing zone depth) m	DERIVED
0 2465+0	Conductiv	ity (hydrau	11c)	m/yr	CONSTANT
	Gradient	(hydraulic)	0.1002+09		CONSTANT
0.2365-0	Groundwat	ter seepage	velocity	m/yr	DERIVED
-999.	-999. Retardat	ion coeffici	0.100E+09 ent		DERIVED
-999.	-999. Longitud	1.00 inal_dispers	0.100E+09 ivity	m	FUNCTION OF X
-999.	-999. Transvers	-999. se dispersiv	-999. ity	m	FUNCTION OF X
-999.	-999. Vertical	-999. dispersivit	-999. V	m	FUNCTION OF X
-999.	-999. Temperati	-999. are of aquif	´ -999. er	с	CONSTANT
20.5	-999. pH	0.000E+00	100.		CONSTANT
6.00	-999. Organic (0.300 Carbon conte	14.0 nt (fraction)		CONSTANT
0.100E-0	2 -999. Well die	0.100E-05	1.00		
0.366E+0	4 -999.	1.00	-999.	doaroo	
				ueuree	CUNSTANT

SCE5.OUT 0.000E+00 -999. 0.000E+00 360. Well vertical distance m CONSTANT 0.000E+00 -999. 0.000E+00 1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.3188E-15

S5-VTRNSPT.OUT

CONCENTRATION AT BOTTOM OF VADOSE ZONE RUN NO. 1 STEADY-STATE CONC 0.4253E-06

1

NORMALIZED

CONCENTRATION

DEPTH CONCENTRATION

