APPLICATION OF THE MEPAS MODEL - INVESTIGATION OF LEAD MIGRATION AT THE CAMP EDWARDS MILITARY RANGE

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INTRODUCTION

One of the primary goals of the United States Military is to maintain troop readiness. Training ranges have been established in numerous locations across the country to assist the Army in accomplishing this mission. These training areas encompass large areas of land, and activities at these sites have the potential to have a negative impact on the environment. Environmental impacts at these sites can include those resulting from training exercises occurring at small arms ranges, gunnery ranges, hand grenade ranges, mortar, and large impact training areas. A Military Munition Rule is currently being drafted in an effort to prevent negative impacts to these areas (USEPA 1995).

Small Arms Ranges (SAR) may include numerous facilities such as mortar and grenade ranges; however, in this study they are limited to outdoor pistol and rifle training ranges. Figure 1 represents a typical SAR configuration. In this figure, it can be seen that an impact berm serves to stop and hold the projectiles fired at the range. Weapons used at these sites are typically 50 caliber or small munitions. Smaller munitions include 9mm pistol, M16-5.56 mm machine gun, M60-7.62 mm machine gun, and 45 cal. pistol rounds. The primary environmental concern at a SAR is the fate of the spent munitions.

The projectile is fired from the weapon and travels through the range and lodges into the earthen impact berm. Munitions are comprised of a copper jacket bullet and a lead core. Approximately 75% of the weight of the projectile is lead. The total amount of lead and copper which accumulates into the berms can be massive. Bricka (1996) estimated that 12,000 lbs of lead could potentially accumulate in a single SAR berm on an annual basis. Lead represents a significant health risk to humans. Public drinking standards for lead and copper have been set at 50 ug/l and 1 ppm, respectively (USEPA 1986). While copper has been shown to have little effects on human health, lead, even at concentrations below the public drinking standard, has been shown to cause serious brain, kidney, and nervous system damage (Gale, Liu, and Bricka 1994). Lead migration occurs at the sites through two primary mechanisms. Overland flow transport can occur during runoff events resulting in surface water contamination, and groundwater contamination can occur during infiltration events resulting in contaminated aquifers.

This study investigates the potential migration of lead to groundwater resources from SARs at the Camp Edwards Military Reservation located near Cape Cod, Massachusetts. Both concentrations and time of arrival were determined for both vertical and horizontal migration of lead. Vertical migration consisted of computing the time for the lead to migrate to the surface of the groundwater aquifer. After arriving at the aquifer, horizontal transport to wells located at various distances from the source was calculated. The Multimedia Environmental Pollutant Assessment System (MEPAS) model was used to conduct this groundwater modeling study investigating the potential migration of lead from SARs at the Camp Edwards Military Range.

SITE DESCRIPTION

The Camp Edwards Military Reservation is located on western Cape Cod Figure 2 and covers an area approximately 34 square miles including portions of the towns of Bourne, Sandwich, Mashpee, and Falmouth. The site was first utilized as a training area in 1912 and was a major installation for the U.S. Air Force during 1948-73 (Masterson, Walter, and Savoie 1996). The National Guard and U.S. Coast Guard have been the primary users of the site since 1973. In an effort to gain an understanding of contaminant plumes at the site, the National Guard Bureau's Installation Restoration Program (IRP) was initiated in 1986. Organic solvents leaking from chemical spills, pipe lines, and inorganic chemical constituents from both the landfill and sewage treatment facility at the Massachusetts Military Reservation were identified as problems at the site. Nine separate plumes were identified, and contaminants at the site include 1,2-dichloroethylene (DCE), tetrachloroethylene (PCE), trichloroethylene (TCE), and ethylene dibromide (EDB). A comprehensive groundwater model has been developed to characterize the movement of these plumes. Another concern at the site is the movement of lead from the SARs. Soil cores taken from the impact berms have indicated a migration of lead into lower soil layers. While the concentrations in the lower soil layers do not currently exceed the EPA drinking water standard, a modeling effort was recommended to predict the long-term effect of the SARs on groundwater quality.

The SAR selected for this study was Range G. Range G is a 25-meter zeroing range consisting of approximately 27 firing points (Bricka 1996). Range G measures 60 meters wide by approximately 35 meters long. The impact berm was located 6 meters behind the targeting area. As previously mentioned, the berm collects the majority of the projectiles fired at the range. This range was utilized primarily for training involving M-16 rifles and 9 mm pistols. The soil at the site is classified as a Merrimac Sandy Loam (MeB). The soil is very friable, having leaf and pine litter contained in the top 3 inches. From a depth of 3 to 21 inches, the soil is described as a sandy loam, and from 21 to 26 inches, a loose coarse sand. Table 1 lists properties of the soil type.

Soil samples were taken at Range G during the time period of 06NOV95-11NOV95. These samples were collected using a drill rig and 2.5 inch diameter drive tube and/or a split spoon sampler. The drilling hole was uncased, and core samples were placed in plastic sampling vessels as withdrawn from the bore hole. Six inch samples were collected the entire depth of the core hole, except where the site conditions prevented sample collection.

MODELING APPROACH

Potential vertical migration of lead into the groundwater can occur when the soil pore water becomes saturated with dissolved lead. During infiltration events, the pore water can be flushed and transported into the groundwater. Once the contaminant passes through the vadose zone and reaches the groundwater table, it can be transported horizontally from the source. Factors affecting transport of lead include soil chemistry, water chemistry, metal speciation, atmospheric precipitation, site topography, wetting and drying cycles, freezing and thawing cycles, and groundwater depth and velocity.

The Multimedia Environmental Pollutant Assessment System (MEPAS) was used to conduct a groundwater modeling study investigating the potential migration of lead from SARs at the Camp Edwards Military Range. MEPAS is a physics based risk computation code that integrates source-term, transport, and exposure models. The model is primarily a screening level model which has been used for the evaluation and ranking of environmental problems for the Environmental Protection Agency (EPA) (Whelan et al. 1992). The mutimedia MEPAS model was developed at the Pacific Northwest Laboratory and can be used to evaluate air, groundwater, surface-water, and overland flow transport pathways. For the CEMR, the primary focus was on groundwater contamination.

Several assumptions were made in the modeling process. One assumption was the beginning date for soil loading at the site. For this modeling effort, January 1, 1973, was used as the initialization point. In viewing the output graphs from the model, year zero on the x-axis corresponds to 1JAN73. Thus, for calibration purposes, the 1996 data collected by Bricka (1996) were calibrated to the concentrations at year twenty-three. Two area source loading scenarios were investigated. The two included a fifty and a 1000 year loading from 1JAN73. The purpose was to provide insight into the difference between short and long-term continued loading at Range G on groundwater resources. Other assumptions included utilizing the Boston, Massachusetts, weather data summaries for Camp Edwards, groundwater transport was the media investigated (no overland flow or volatilization was considered), soil chemical and physical parameters were obtained from the Bricka (1996) report when available, and the MEPAS guide otherwise, and a groundwater well receptor was used to determine horizontal migration from the site. The water table aquifer was approximately 100 feet deep. The well depth in the aquifer was originally placed at one foot to obtain the highest possible concentration. This depth was varied to fifty feet to obtain more realistic concentrations for well withdrawals.

Model Calibration

The model was calibrated through use of soil data collected by Bricka (1996). Data collected included soil concentrations at various depths at Range G. Model output was compared to collected data at 1.75 and 5.5 foot vertical depths in the soil profile. To match the observed concentrations, the loading rate of lead at the site was varied until an approximate match was obtained. The observed value of lead at the 1.75 foot level was 2,380 ppm, and the simulated value was 2,802 ppm. At the 5.5 foot level, the observed was 44.8 ppm compared to the 45.5 ppm simulated value. Although it is recognized that there is a wide range of values that would enable the calibration of the model, based on yearly precipitation and best estimates of lead loading at the site and best engineering judgement, the above calibration values appear to be reasonable and prudent.

RESULTS AND CONCLUSIONS

The schematic of the soil column utilized for the model runs is shown in Figure 3. The layers consisted of a sandy loam, coarse sand, sand and fine gravel, and the aquifer. The depth to each layer was 1.75, 3.65, 77.50, and 180.00 feet, respectively. Figure 4 shows the flux of lead in g/yr through each of the soil layers and the time of arrival. The simulation was for a 50 year continuous loading of lead. It can be seen from the graph that the lead never arrived at the bottom of the third soil layer. Thus, there was no potential for the leachate to reach the groundwater for this scenario.

The next simulation was run increasing the loading of the lead for 1000 years. Figures 5 and 6 show the results of the concentration at a well receptor at a horizontal distance of 15 feet from the source and at a depth of 1 foot into the aquifer and 5 miles and 50 feet into the aquifer, respectively. From Figure 5 it can be seen that the maximum concentration is reached at approximately year 600 and peaks until year 1590. The concentration is representative of water 15 feet from the source and 1 foot into the aquifer. Since this was a worse case scenario, the model was rerun utilizing a more realistic distance and well depth. From Figure 6 it can be seen that a well located 5 miles away from the source and with an intake depth of 50 feet into the aquifer did not have concentrations which exceeded the drinking water standards. The lead concentration did not exceed the public drinking water standard 3000 years into the simulation. Thus, range G does not appear to be a threat to groundwater resources based on the MEPAS model runs.

SUMMARY

The Multimedia Environmental Pollutant Assessment System (MEPAS) was used to conduct a groundwater modeling study investigating the potential migration of lead from small arm ranges (SARs) at the Camp Edwards Military Range (CEMR). MEPAS is a physics based risk computation code that integrates source-term, transport, and exposure models. The model is primarily a screening level model which has been used for the evaluation and ranking of environmental problems for the Environmental Protection Agency (EPA). The multimedia MEPAS model was developed at the Pacific Northwest Laboratory and can be used to evaluate air, groundwater, surface-water, and overland flow transport pathways. For the CEMR, the primary focus was on groundwater contamination. The objective of this study was to investigate the potential migration of lead to groundwater resources from SARs at CEMR. Both concentrations and time of arrival were determined for both vertical and horizontal migration of the lead. Model simulations demonstrated that lead migration from the SARs into surrounding soil and groundwater wells was highly unlikely.

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Table 1. Soil Properties for Range G

Soil Property	Value
Clay Content	1-4%
Bulk Density	1.2-1.4 g/cm^3
Permeability	2.0-6.0 in/hr
Soil pH	3.6-6.0
Organic Content	1-5%
High Risk of Corrosion	

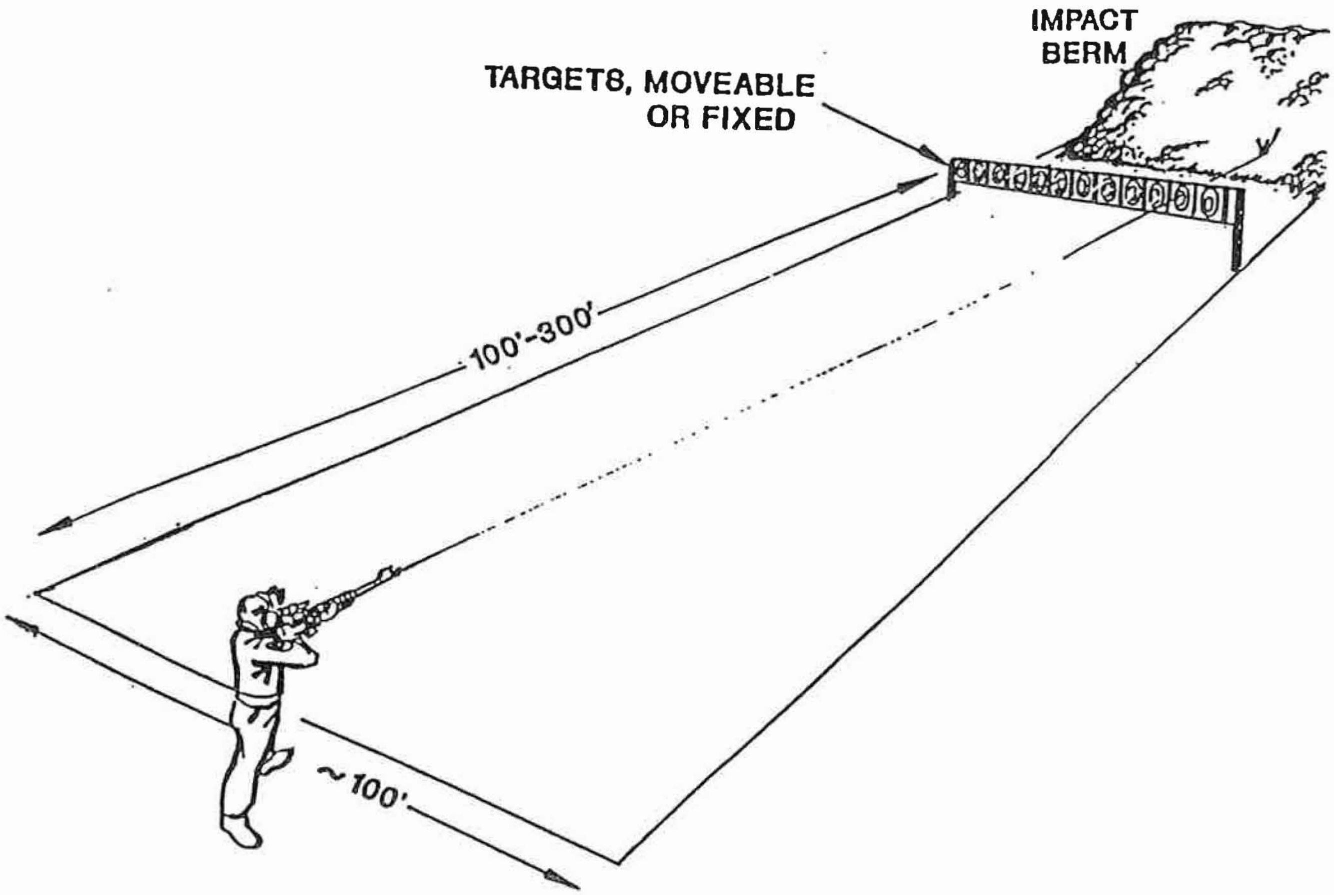

Figure 1. Typical Small Arms Range

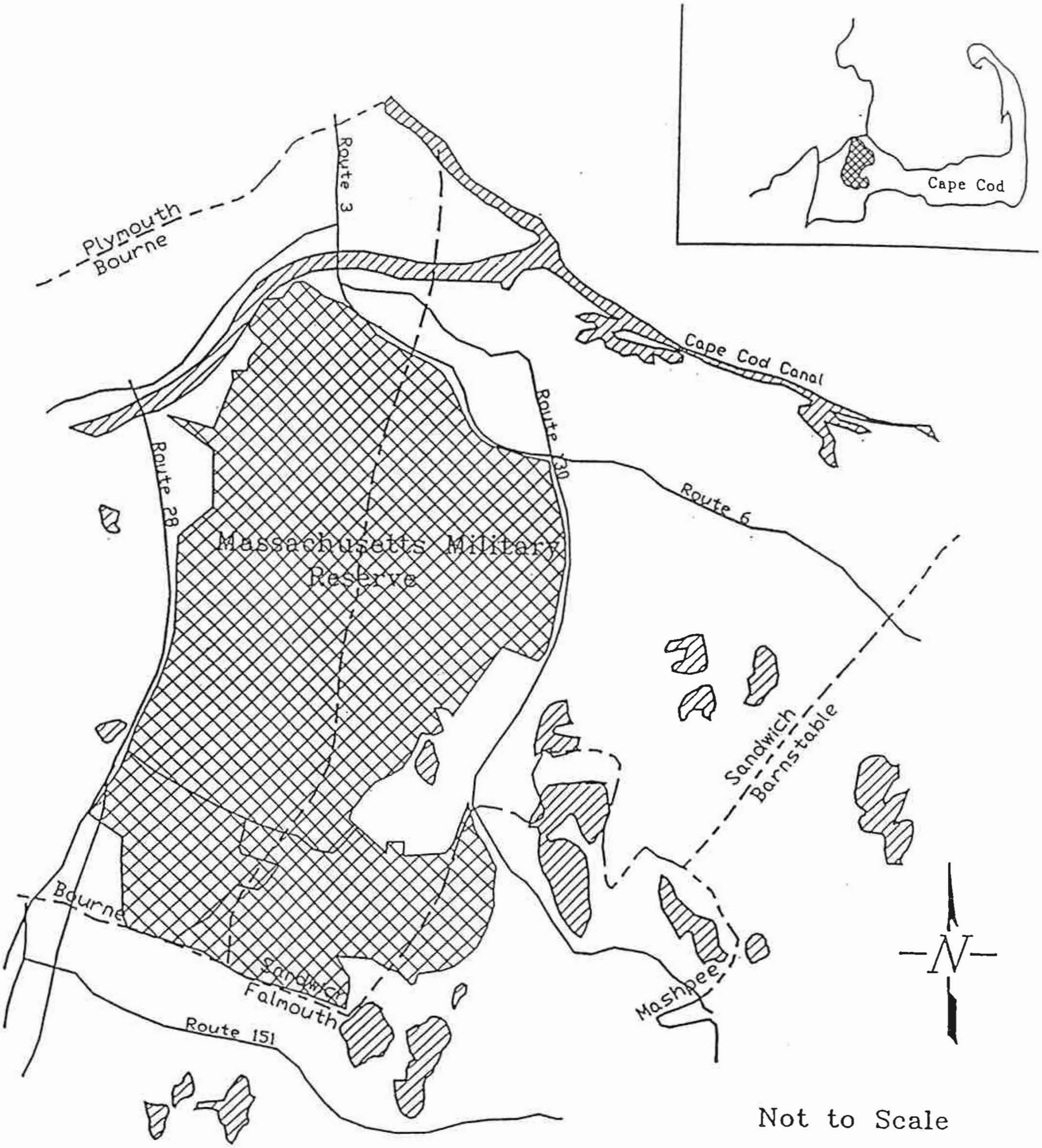

Figure 2. Location of Camp Edwards Military Reservation (CEMR)

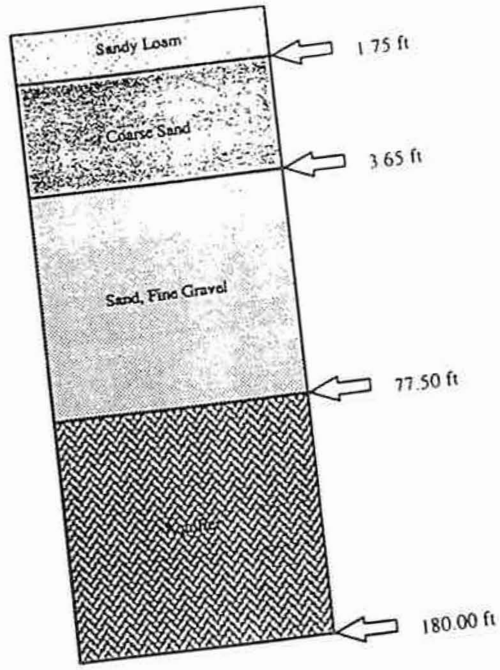

Figure 3. Schematic of Soil Column for Camp Edwards Range G

CAMP EDWARDS MILITARY RANGE
LEAD FLUX RANGE G

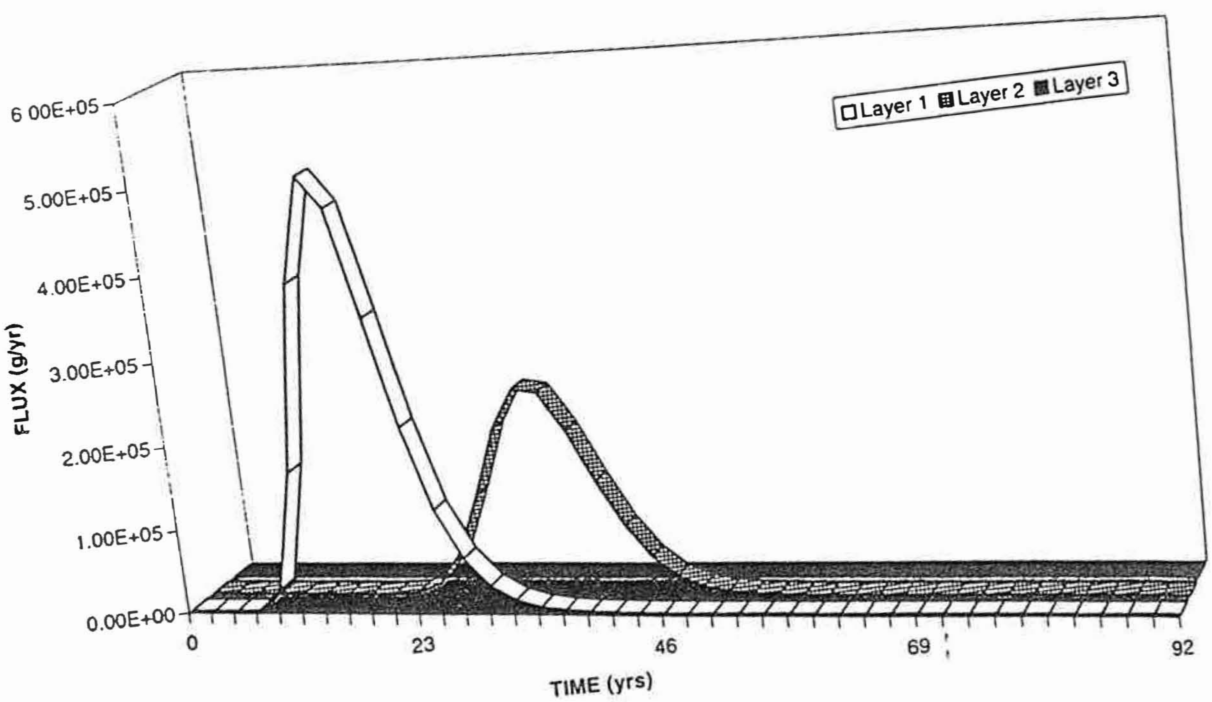

Figure 4. Soil Flux at CEMR Range G

CAMP EDWARDS MILITARY RANGE
LEAD CONCENTREATION RANGE G
WELL RECEPTOR #1

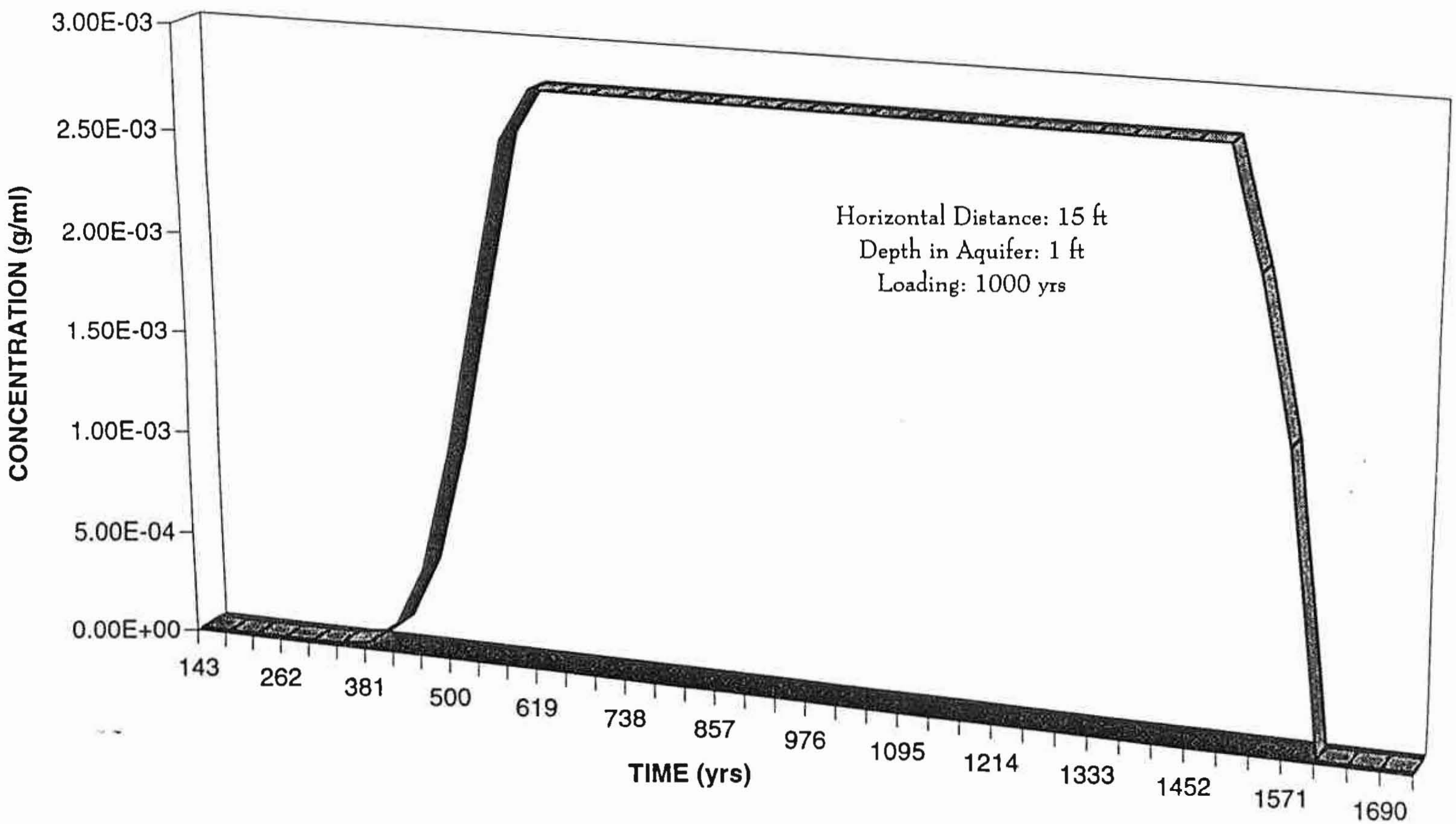

Figure 5. Groundwater Lead Concentrations Utilizing Conservative Parameters

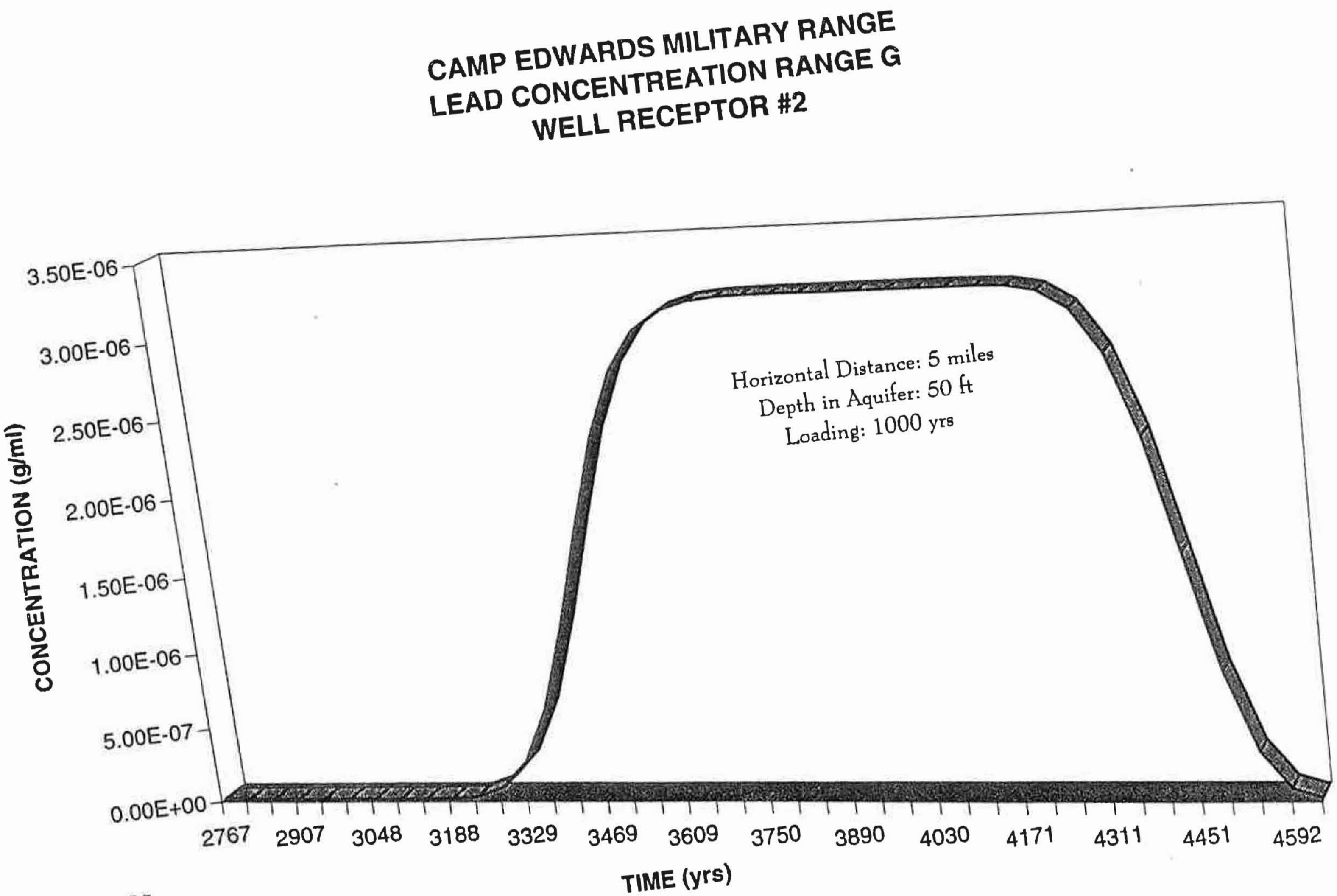

Figure 6. Groundwater Lead Concentrations Utilizing Actual Parameters