Public Health Assessment for

EAGLE PICHER CAREFREE BATTERY SITE
SOCORRO, SOCORRO COUNTY, NEW MEXICO
EPA FACILITY ID: NMD001829506
FEBRUARY 27, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

Foreword

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, the U.S. EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data are needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate the possible health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals, and community groups. To ensure that the report responds to the community's health concerns, an

early version is also distributed to the public for their comments. All the public comments that related to the document are addressed in the final version of the report.

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.
Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Manager, ATSDR Record Center Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E-60), Atlanta, GA 30333.

Table of Contents

Foreword ……..i

Summary ……..1

Background ……..4

Site Description and History 4

Physical Setting and Resource Uses 5

Health Issues and Community Health Concerns 8

Contaminant Sources, Concentrations, and Estimated Exposure Doses 10

Contaminant Sources and Migration 10

Contaminant Concentrations and Distribution 13

Groundwater 13

Soil 14

Exposure Doses..... 19

Public Health Implications.....22

1,1-dichloroethylene (1,1-DCE) 24

Trichloroethylene (TCE or trichloroethene)..... 26

Child Health Considerations..... 30

Adequacy of Available Data..... 30

Conclusions, Recommendations, and Public Health Action Plan 32

Conclusions..... 32

Recommendations..... 33

Public Health Action Plan..... 33

Authors, Technical Advisors and Reviewers.....34

References…….....35

ATSDR Glossary of Environmental Health Terms A-37

List of Figures

Figure 1. Location and topographic map of EP site and surrounding area ……6

Figure 2. Aerial photograph of EP site and adjacent area showing locations of the sewage impoundments, former location of lined evaporation lagoons and main EP building……7

Figure 3. Demographic map of community surrounding EP site……...…9

Figure 4. Locations of wells on or down-gradient of EP site……...12

Figure 5. TCE trends in selected wells down-gradient of EP site…….…….17

Figure 6. TCE concentration trends in selected wells…….…….…….....18

Figure 7. 1,1-DCE doses and health effects……....25

Figure 8. TCE doses and health effects……...29

List of Tables

Table 1. Groundwater contaminant concentrations in private and municipal drinking water wells……..15
Table 2. Concentrations and soil screening values for metals at the EP site……...16
Table 3. Exposure pathways on or adjacent to the Eagle Picher site, Socorro New Mexico……..…20
Table 4. TCE and 1,1-DCE doses from groundwater exposure in a residence near the EP site…..…...21
Table 5. VOC doses, health comparison values (CVs), and excess cancer risks from exposure to groundwater at Well B……..……23

Summary

As a result of groundwater and soil contamination the Eagle Picher Carefree Battery (EP) site was placed on the EPA Superfund National Priorities List in 2007. Although the EP site has only been recently added to the EPA NPL list (9/19/07), the EPA and the New Mexico Environment Department (NMED) have conducted site environmental sampling and assessments since at least 1981 (USACE, 2007). These site evaluations have resulted in regulated closures of an on-site landfill and waste lagoons, provision of City water to several offsite residences, and discontinued use of a public water well due to contamination (this well was shut down due to arsenic concentrations rather than EP site contaminants). Since 1986, the Agency for Toxic Substances and Disease Registry (ATSDR) has been required by law to conduct a public health assessment (PHA) at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. This document is the ATSDR PHA for the EP site.

The EP site occupies about 173 acres on the western portion of the Rio Grande valley where the foothills of the Sierra Ladrones Mountains merge with the flat-lying Rio Grande valley. From ~1964 until 1976, Eagle Picher developed and used the property to manufacture various products, including electrical circuit boards. From 1977 to 1980, the City of Socorro used an arroyo on the north side of the property as a municipal landfill. The landfill was used for disposal of waste from residential, commercial, institutional, and recreational facilities. Most wastes were disposed in the arroyo, but some liquid wastes including sewage and waste oil, were disposed in a bermed arroyo located west of the primary disposal area. The landfill was closed in 1980 when Eagle Picher reoccupied the site under a lease agreement with the City of Socorro. From 1980 until the late 1990's Eagle Picher manufactured lead-acid batteries on the site.

As a result of manufacturing operations and waste releases on the EP site, groundwater samples from private and public water supply wells adjacent to the EP site have consistently detected mostly low concentrations of several volatile organic compounds (VOCs). In 1987 and 1988 trichloroethylene (TCE) and other volatile organic compounds (VOCs) such as 1,1-dichloroethylene [1,1-DCE], cis-1,2-dichloroethene [cis-1,2-DCE], and tetrachloroethene [PCE], were detected in the City's Eagle Picher well and other private wells down-gradient (south) of the EP site. 1,1-DCE and TCE were the only compounds detected at concentrations above their health-based screening values in water supply wells.

Contaminant measurements at the City water distribution point (where municipal water leaves the water treatment system and enters the distribution pipes) have not detected any EP-related contaminants. Of the four residential drinking water wells (Wells A,B,C, and D) with detectable VOC concentrations, only one (Well B) had 1,1-DCE and TCE concentrations significantly above the health-based screening values (at the time this well used for drinking water supply; July 1999). The other private water supply wells had 1,1-DCE and TCE concentrations below or barely above the drinking water standards.

A survey of soil contamination found elevated concentrations of cadmium, chromium, and lead in several areas within the EP site, most notably in the vicinity of sewage impoundments, the

building parking lot, and adjacent to a small outbuilding. Analyses of off-site residential properties with flood deposits did not indicate metals concentrations above background levels.

Based on the available soil sampling data, measured soil concentrations are below levels of public health concern and site specific doses are not calculated.

1999 measurements of 1,1-DCE were 67 ppb in Well B, 9 ppb in Well C, 11 ppb in Well D and trace or non-detectable concentrations in all other residential wells (Table 1). The Well B drinking water concentrations result in estimated combined (ingestion plus inhalation plus dermal contact) 1,1-DCE doses of 0.0038 mg/kg/day for adults and 0.0084 mg/kg/day for children. *Based on the available measured 1,1-DCE concentrations and estimated doses, adverse health effects from past exposure to 1,1-DCE via contaminated drinking water wells around the EP site are unlikely to produce any adverse health effects, including cancer.*

1999 measurements of TCE were 38 ppb in Well B, 5.7 ppb in Well C, 1.4 ppb in Well D and trace or non-detectable concentrations in all other residential wells (Tables 1 and 2). The Well B drinking water concentrations result in estimated combined (ingestion plus inhalation plus dermal contact) TCE doses of 0.0022 mg/kg/day for adults and 0.0048 mg/kg/day for children. Estimated doses at other locations are more than 6 times lower than Well B doses. *Based on the available measured TCE concentrations and estimated doses, adverse health effects from past exposure to TCE via contaminated drinking from the contaminated water wells around the EP site are unlikely to produce any adverse health effects, including cancer.*

Evaluation of the contaminant distributions and estimated doses, using both children and adult body weights and intake rates for 1,1-DCE and TCE leads to the following public health determinations;

- Adverse health effects, including cancer, are unlikely for users of the contaminated private wells based on recent measured concentrations of VOCs.
- Residences with contaminated wells are currently being provided with municipal water. Current exposure to VOCs at these locations is limited to incidental use of the wells for irrigation or other outside uses. These exposures are unlikely to create adverse health effects.
- The available information on the historic use and release of VOCs at the EP site and patterns of groundwater flow is not adequate to determine how long (prior to 1999) the residential wells were contaminated.
- The current distribution of groundwater VOCs suggests that concentrations in residential wells were not higher in the past.
- Based on the above findings, *past, current and future* exposures to VOCs via contaminated groundwater are “no apparent public health hazard.” This determination means that exposures to site-related contaminants has or may be occurring, but at levels unlikely to create any adverse health effects.

Based on the above conclusions, ATSDR recommends:

- Continued monitoring of the groundwater contaminants and additional evaluation of the times and locations of VOC releases in order to more completely evaluate historic contaminant concentrations and distributions.
- Initiation of appropriate groundwater source remediation or management based on the findings of the ongoing remedial investigation. All future exposures to VOCs should be eliminated by instituting appropriate management practices to ensure that new drinking water wells are not developed within the area of the contaminant plume.
- Expand locations of surface soil sampling to include former paintball facility. Any future soil sampling should be conducted using spatially representative multi-increment analyses (with at least 30 increments per sample).

To ensure community understanding and address future public health issues related to the EP site, ATSDR will conduct the following public health actions:

- ATSDR will evaluate future site data and information as provided by the NMED and the EPA and revise the public health conclusions of this health assessment as necessary.

Background

Site Description and History

The former Eagle Picher Carefree Battery site (EP site) consists of approximately 173 acres of land located about two miles north of the City of Socorro, Socorro County, New Mexico. This history of the EP site is summarized from the "…Expanded Site Inspection and Remedial Investigation Report" prepared for the US Army Corps Engineers (April 2007). The property, which is currently owned by the City of Socorro, was formerly owned by the United States government and was used as a Civilian Conservation Corps barracks circa 1932. The property was used by the State of New Mexico as a tuberculosis sanitarium from 1936 until 1956. During this period, septic waste was discharged into unlined impoundments in the southeast portion of the property (USACE, 2007).

The City of Socorro acquired the property after closure of the sanitarium and sold it to Eagle Picher, Inc. in 1964. From ~1964 until 1976, Eagle Picher developed and used property to manufacture various products, including electrical circuit boards. Domestic sewage and industrial wastes from the manufacturing operations were released into the unlined impoundments during this time period (USACE, 2007).

In 1976, Eagle Picher, Inc. released the property back to the City of Socorro which then leased the building to RayChester of Socorro, Inc. (from 1977 to 1980) for the purpose of jewelry manufacturing (no chlorinated solvents were used or discharged during this period; USACE, 2007). Also during this time period, the City of Socorro used an arroyo on the north side of the property as a municipal landfill. The landfill was used for disposal of waste from residential, commercial, institutional, and recreational facilities. Most wastes were disposed in the arroyo, but some liquid wastes including sewage and waste oil, were disposed in a bermed arroyo located west of the primary disposal area.

The landfill was closed in 1980 when Eagle Picher reoccupied the site under a lease agreement with the City of Socorro. From 1980 until the late 1990's Eagle Picher manufactured lead-acid batteries on the site. During this time, Eagle Picher constructed two lined evaporation lagoons for disposal of industrial wastes. These waste lagoons were located south of the main building and west of the existing unlined impoundments. The unlined impoundments were used for domestic waste until the City installed a septic system in 1989. The lined lagoons were closed as part of a Resource Conservation and Recovery Act (RCRA) operation in the late 1990s.

In 2005, the City leased approximately 11 acres of the site, including the manufacturing building and surrounding property, for recreational and commercial use as a motocross track and motorcycle repair facility. The area of the former tuberculosis sanitarium was also used for recreation as an outdoor paintball facility. In July and August of 2006, flash flooding damaged the manufacturing building and motocross track. Soil erosion during the flooding exposed lead battery straps/plates and exposed two wells in the area of the former sanitarium. Recreational and commercial use of the property ceased following the floods and the site is currently vacant and unused.

As a result of groundwater and soil contamination the site was place on the EPA Superfund National Priorities List in 2007. Although the EP site has only been recently added to the EPA NPL list (9/19/07), the EPA and the New Mexico Environment Department (NMED) have

conducted site environmental sampling and assessments since at least 1981 (USACE, 2007). These site evaluations (as summarized at the EPA Superfund web site; http://cfpub.epa.gov/supercpad/cursites/csitinfo.cfm?id=0600805 and the various site reports, USACE, 2007) have resulted in regulated closure of the City landfill, the lined evaporation lagoons, provision of City water to several offsite residences, and discontinued use of a City water well due to contamination. Relevant conclusions and data from these various reports are presented and discussed in following sections of this document as they relate to this assessment of public health and potential community exposures to EP site related contaminants.

Physical Setting and Resource Uses

The physical setting of the EP site is a description of the geologic and hydrologic conditions that determine how contaminants released at the site may migrate to offsite areas or result in contaminant exposures at either on or offsite locations. Figure 1 shows the EP site boundaries in relation to the surrounding terrain. The EP site is on the western portion of the Rio Grande valley where the foothills of the Sierra Ladrones Mountains merge with the flat-lying Rio Grande valley. The resulting terrain slopes to the south and southeast with relatively steep gradients between dry washes or arroyos.

The arroyos are usually dry stream beds that serve as drainage courses for infrequent flash floods such as those that occurred in July and August of 2006. Average annual precipitation is less than 10 inches per year and the region is considered arid to semi-arid. As a result of the limited precipitation, both the EP site and the surrounding area are sparsely vegetated. Evaporation greatly exceeds precipitation such that groundwater is predominately derived by recharge from the Rio Grande River, the intermittent streams, related irrigation canals, or applied irrigation water. Several groundwater studies of the EP site (as summarized in USACE, 2007) indicate that groundwater flow from the EP site moves southward.

The depth to the water table is generally quite shallow with the topographically higher areas having depths of 80 to 120 feet (below ground level; bgl) and the water table occurring at depths of 20 to 60 feet bgl in lower or flat-lying areas (from well and water data transmitted to ATSDR; Eagle Picher Carefree Batteries Site, Expanded Site Inspection CD, April 2007). The groundwater gradient is about 5 feet per mile (or 0.0009 ft/ft; USACE, 2007).

Drinking water for the City of Socorro municipal system and private residences is obtained from wells. The locations of these wells and other features of the EP site and surrounding community are shown in Figure 2. As previously stated, three of the down-gradient residences were connected with City water (although the wells may still be used for non-potable purposes) and one of the municipal wells used by the City of Socorro (the Olsen Well) is no longer used. An additional municipal supply well, located on the EP site (the Eagle Picher Well), has contaminant detections at concentrations below applicable drinking water standards.

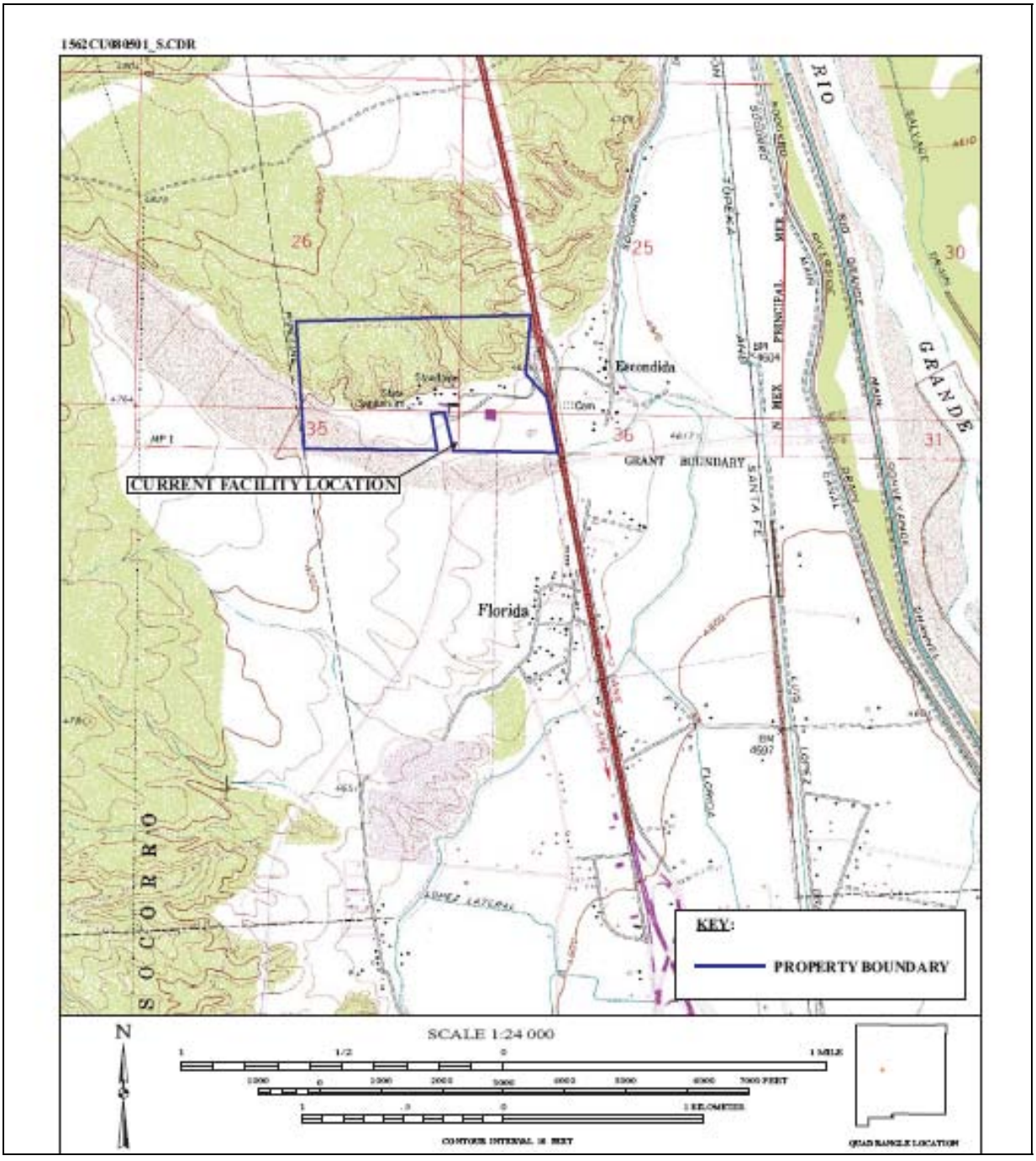

Figure 1. Location and topographic map of EP site and surrounding area (from USACE, 2007).

Figure 2. Aerial photograph of EP site and adjacent area showing locations of the sewage impoundments, former location of lined evaporation lagoons and main EP building. The former tuberculosis sanitarium and paintball course is immediately west of the property boundary. Note that the property outline of Figure 1 is much larger than the EP site boundary shown in this figure (from USACE, 2007).

Health Issues and Community Health Concerns

Discussions with representatives of the City of Socorro, the Socorro Community Health Council, the Socorro County Health Office, the New Mexico Health and Environment Departments, and a reporter for the El Defensor Chieftan (the local Socorro newspaper) have all indicated that there has been little vocal community concern about potential public health issues related to the EP site. Periodic news articles in the El Defensor Chieftan have reported on the status of the site with regard to groundwater and soil monitoring and contamination, site cleanup and assessment activities, and the effects of the 2006 floods on the site and adjacent properties.

At the request of EPA Region 6, ATSDR has conducted two reviews of soil contamination at the EP site with regard to exposures related to the former motocross facility (New Venture Racing Grand Prix Track). These reviews were based on data assessments conducted before and after the 2006 flood events (4/8/2005 and 8/17/2006). Based on the data available, the initial review found that exposures to site soil via motorcycle riding and associated activities were below levels of health concern and that soil exposures could be further reduced by implementing dust management and suppression procedures.

The second data review, conducted after the 2006 floods, observed that site conditions had changed due to erosion from the floods and that motocross operations should be suspended until a complete site characterization and possible remedial actions could be completed. Although the commercial motocross facility has suspended activities, access to the EP site is not restricted and neighbors report that motorcycle riders continue to use the track.

Groundwater contaminants have also been detected in drinking water wells at and down-gradient of the EP site. The potential doses and health implications from exposures to contaminants in drinking water and site soils due to these activities will be evaluated in this assessment. One other possible health issue has been mentioned by a representative of the Socorro Community Health Council. That issue is whether former EP site workers may have been exposed to hazardous chemicals as a result of occupational activities when the EP site was operating. Although that issue is beyond the scope of this PHA, ATSDR will present this issue to appropriate representatives of the NMDOH for their consideration.

Figure 3 is a map of the EP site and surrounding community that shows the number of people living within one mile of the site boundary (656 people based on 2000 census data). This map also shows the number of people comprising sensitive sub-populations within this area, such as young children, women of child-bearing age, and adults over age 65. These sub-populations are highlighted because they may, for a number of reasons, be especially susceptible to the toxicological effects of site-related contaminants. Those potential health effects are presented in the following section on “Public Health Implications.”

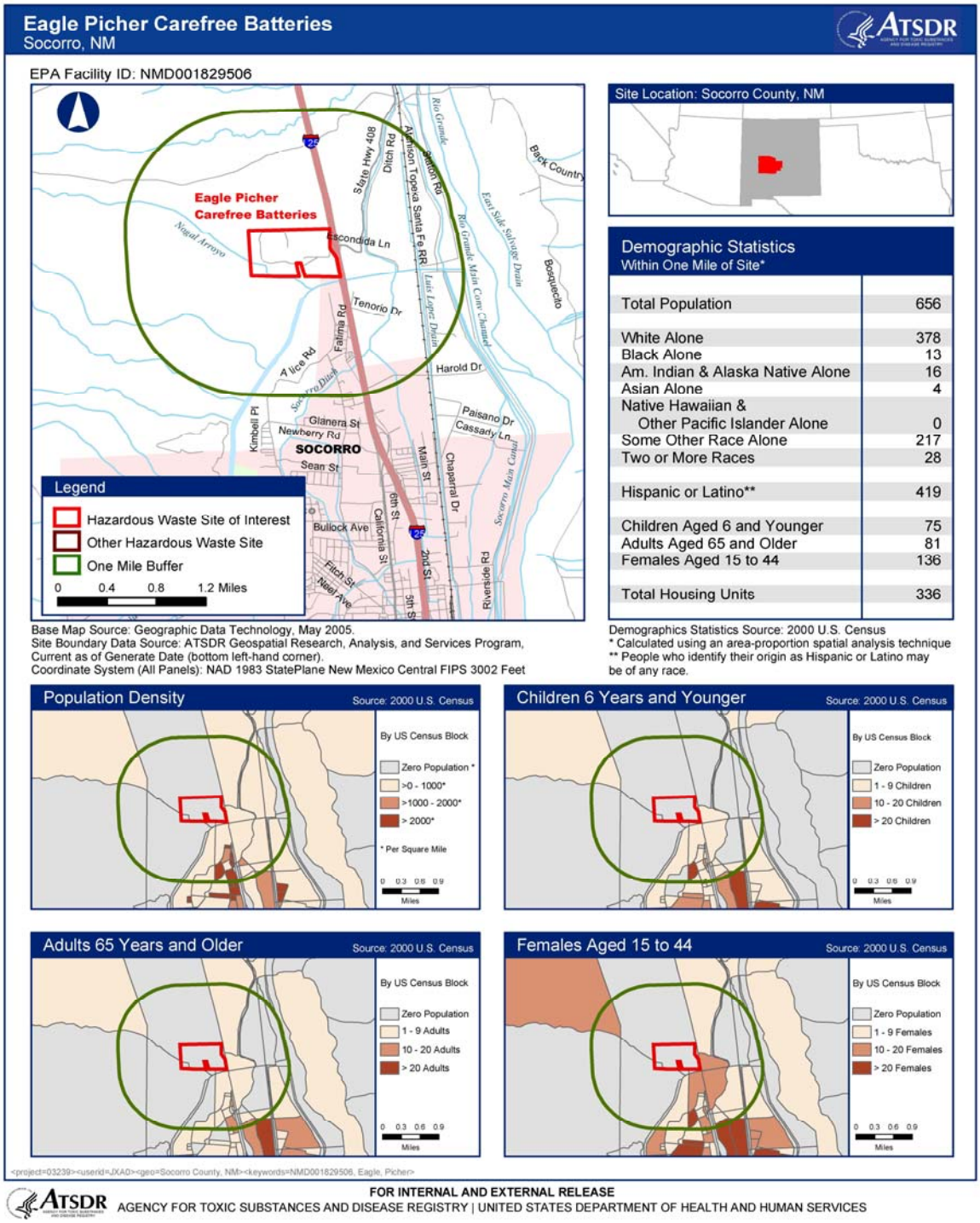

Figure 3. Demographic map of community surrounding EP site. This map shows the number of children, females aged 15 to 44, adults aged 65 or older, and total population density for people living within one mile of site boundary.

Contaminant Sources, Concentrations, and Estimated Exposure Doses

Contaminant Sources and Migration

Several investigations have been conducted to investigate sources of groundwater and soil contamination at and adjacent to the EP site. In 1977, the NM Bureau of Mines and Mineral Resources conducted a hydrogeological investigation of the City of Socorro Landfill (on the EP site; Stone and Foster, 1977). Although this investigation did not identify any specific contaminants from the landfill, it did conclude that the landfill was poorly sited with a high potential for down-gradient contamination of the City of Socorro well field and other private drinking water wells.

In 1987 and 1988 trichloroethylene (TCE) and other volatile organic compounds (VOCs) such as 1,1-dichloroethylene [1,1-DCE], cis-1,2-dichloroethene [cis-1,2-DCE], and tetrachloroethene [PCE], were detected in the City's Eagle Picher well and other private wells down-gradient (south) of the EP site (NMEID, 1989). A "Listing Site Inspection" of the Socorro Landfill determined that previous Eagle Picher operations rather than the landfill was the source of the down-gradient groundwater contamination (NMEID, 1989). Eagle Picher manufacturing operations during the 1960's and 1970's used TCE for cleaning and degreasing electronic components (USACE, 2007). Used solvents were commonly poured on the ground or emptied into the floor drains, which went to the unlined sewage impoundments (USACE, 2007).

It is important to note that Eagle Picher discontinued use of the unlined impoundments when they re-occupied the site in 1980. They constructed lined evaporation lagoons at that time which probably reduced contaminant migration to the underlying groundwater. Contaminant concentration trends in down-gradient monitor and drinking water wells over time are discussed in following sections. The locations of these sewage impoundments are shown in Figure 2 and the various monitor and drinking water well in Figure 4. Figure 4 also shows an interpretation of the distribution of the VOC plume extending from the EP site to the Olsen well (approximately two miles down-gradient; from USACE, 2007).

The NM Health and Environment Department investigated reports of improper storage and dumping of chemicals at the Energetic Materials Research and Testing Center (EMTRC, a.k.a. TERA) in 1987 (Claffy, 1987). This site is up-gradient of the Olson Well and could be a source of groundwater contaminants detected in that well. Although no groundwater testing took place, the investigation concluded that allegations of improper chemical storage and dumping were unfounded (Claffy, 1987). Other potential sources of VOC ground-water contamination down-gradient of the EP site include an old construction equipment wash pad and suspected illegal dumps or landfills. Soil boring samples from the suspected dumping area and the former construction wash pad area indicate no VOC contamination from these sources; "No evidence for the contribution of any chlorinated organic contamination was identified…." (USACE, 20007).

An extensive survey of soil contamination was conducted as part of the Expanded Site Inspection (USACE, 2007). This survey included surface and subsurface sampling of the EP site as well as selected off-site areas that may have received soil deposits from the 2006 floods or represent additional areas of contamination (as described above). The sampling plan divided most of the EP site into 100 foot grids for estimation of metals concentrations. Field analyses of cadmium, chromium, and lead were conducted using an x-ray fluoresence (XRF) instrument with

confirmation via laboratory analyses of total metals (USACE, 2007). Elevated concentrations of cadmium, chromium, and lead were measured in several areas within the EP site, most notably in the vicinity of sewage impoundments, the building parking lot, and adjacent to a small outbuilding (location K9; USACE, 2007). Analyses of off-site residential properties with flood deposits did not indicate metals concentrations above background levels (USACE, 2007).

The available environmental data indicate that EP-related contaminants are present in groundwater at and down-gradient of the EP site and in soil at the EP site. Potential exposures and estimated doses to these groundwater and soil contaminants are presented in the following section.

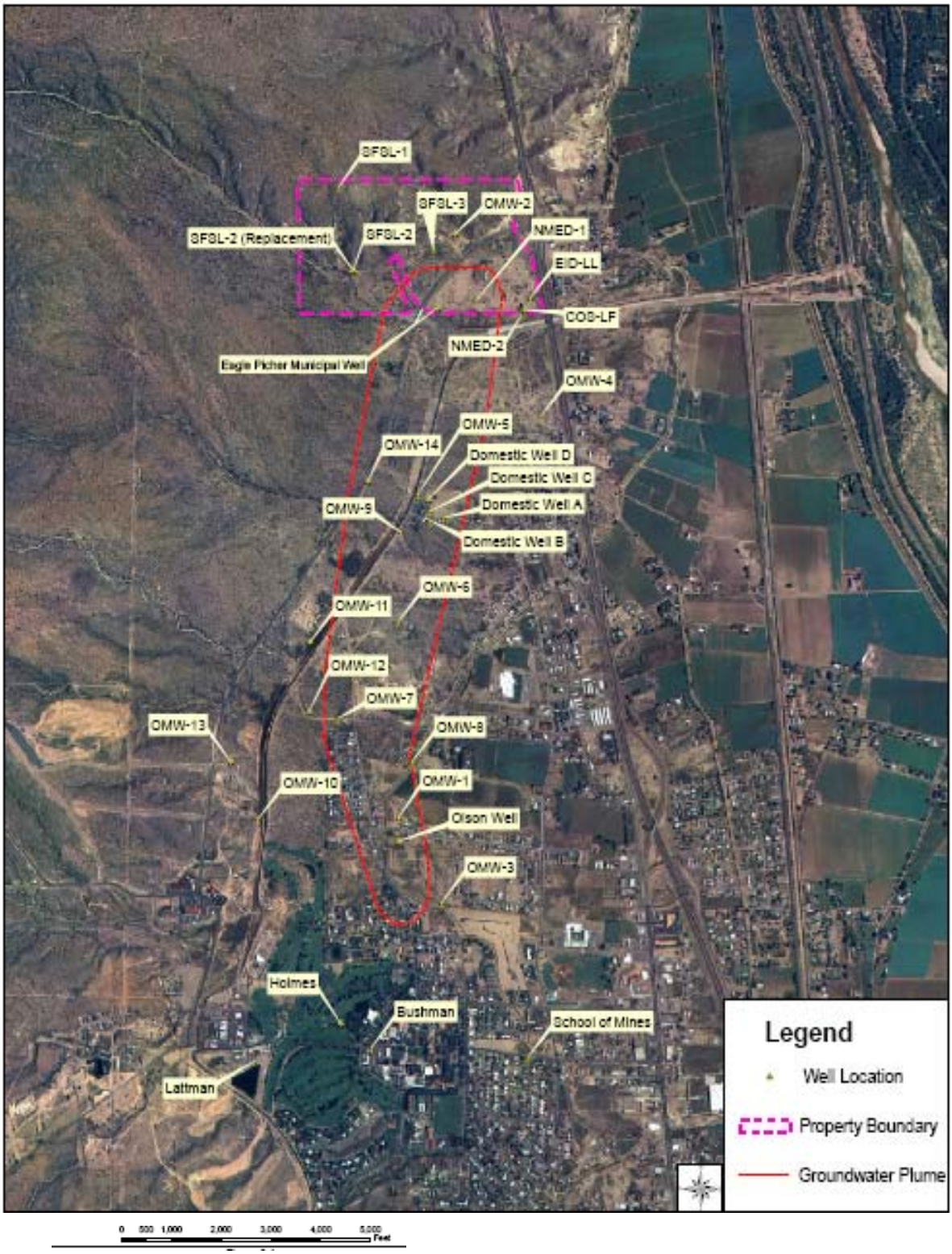

Figure 4. Locations of wells on or down-gradient of EP site. Dashed red line shows approximate outline of VOC plume as of June 2005 (from USACE, 2007). The plume outline includes any wells that have detectable VOC concentrations.

Contaminant Concentrations and Distribution

Groundwater: Figure 4 shows the approximate location of the VOC groundwater plume and affected wells (from USACE, 2007; based on sampling data through 2005). As of 2005, the plume had migrated approximately 2 miles south of the EP site. Figure 5 shows the TCE concentrations in five wells down-gradient of the EP site. The TCE concentrations illustrated in Figure 5 vary from non-detectable (< 2 ppb) to 260 ppb. The concentrations in each well vary greatly over time and the TCE concentrations appear to increase after 1999 and all except Domestic Well B appear to decrease around 2001 or 2002.

It is important to note that the contaminated private wells (Well B in Figures 5/6) were not used for drinking water sources after July 1999. Concentrations that those residents may have been exposed to were much lower before 1999. Figure 6 shows the same TCE concentration data as in Figure 5, but places each well in its respective up-gradient/down-gradient location. Figure 6 shows that TCE concentrations from Well B are increasing at the same time that both up-gradient and down-gradient wells (MW-5, MW-6, and MW-7) are decreasing. Also, Well A, which is less than 500 feet from Well B (Figure 4), has barely detectable TCE concentrations at the same time that Well B concentrations are increasing to more than 200 ppb. This spatial and temporal pattern of TCE contamination is repeated for 1,1-DCE with Well B concentrations increasing from 67 ppb to more than 500 ppb and Well A 1,1-DCE concentrations varying from ~1 to 5 ppb for the same time frame.

There are several possible explanations for this pattern of contaminant distribution. The well depths and screen openings may be different for each well (these depths are known for the monitor wells and unknown for the private wells). Additionally, the geologic substrate and hydrogeologic conditions (such as zones of alluvial channels and preferred flow) may differ from well to well. Any of the hydrogeological variables could affect the subsurface migration of VOCs from the EP site.

In addition to the hydrogeological variables for each well, the groundwater contaminants may have been released intermittently and/or groundwater flow may vary with season or rainfall/flood events. Each of these processes could lead to pulses or bubbles of contamination that migrate with varying concentrations to down-gradient wells. It is also possible that there are VOC sources other than releases on the EP site. Although several investigations have not identified other sources, they have also not confirmed the absence of any other sources (as summarized in USACE, 2007).

An important example of how these hydrogeologic variables affect contaminant concentrations is the low concentrations measured in the Eagle Picher municipal well (Figure 4). The screen openings (water intake depths) are more than 165 feet below the ground surface while the other down-gradient contaminated wells are screened at much shallower depths (~40 to 65 feet below ground level; EPCB Site Expanded Site Inspection Report and Data Tables; EPA 2007). The TCE concentrations in this well vary from non-detectable to 3.2 ppb (less than the maximum contaminant level MCL of 5 ppb). The depths to the screen openings in the EP municipal supply well at least partially explain these very low TCE concentrations.

The significance of the spatial and temporal distribution of groundwater contamination is in determining appropriate contaminant concentrations for evaluating past exposures and predicting

whether concentrations may increase in the future. Measured contaminant concentrations from the affected residential and municipal water supply wells are shown in Table 1. It should be noted that contaminant measurements at the City water distribution point (where municipal water leaves the water treatment system and enters the distribution pipes) have not detected any EP-related contaminants.

Of the four residential drinking water wells shown in Table 1, only Well B had 1,1-DCE and TCE concentrations significantly above the EPA MCL at the time this well was removed from use (as a drinking water supply; July 1999). Wells C and D had 1,1-DCE and TCE concentrations at or barely above the drinking water standards. Doses and potential health implications to exposures at the concentrations listed in Table 1 are discussed in the following sections.

It should also be noted that Figure 4 shows several additional water wells down-gradient of the existing plume. If the VOC plume continues to migrate to the south, these wells could be affected in the future. Although the latest TCE measurements from OMW-1 and the Olsen Well (USACE, 2007) show decreasing concentrations over time, these results could reflect seasonal variations and are not definitive regarding future concentration trends. Continued monitoring of the contaminant plume is necessary.

Soil: Table 2 lists the cadmium (Cd), chromium[1] (Cr), and lead (Pb) concentration ranges, averages and respective comparison or screening levels for the on-site samples measured using laboratory analyses. XRF measurements were also taken at more locations, but are largely non-detections for Cr and Cd and Pb XRF values are essentially similar to Pb lab samples. Based on the average concentrations listed in Table 2 and the soil screening values (SSVs) none of the metals listed exceed their respective screening values for chronic (365 days or greater) exposures to children or adults. Although soil concentrations for each of the metals exceeds the SSVs for isolated areas within the EP site, chronic soil exposures, and their underlying SSVs, are based on average concentrations across an exposure area (such as a residential yard, a child's outdoor play area, or the EP site motocross track). Based on the available soil sampling data, measured soil concentrations are below levels of public health concern and site specific doses are not calculated.

Note that site specific background levels of cadmium, chromium, and lead in soils were not reported for this site. Determination of naturally-occurring metals in soil may be important in cases where such background levels exceed the SSVs (Table 2). At the EP site, average site metals concentrations do not exceed their respective SSVs and it is assumed that background soil concentrations are not of public health concern.

[1] Chromium may be present as either chromium III or chromium VI. As the analytical methods used do not discriminate between these species, it is assumed that all chromium is present as the more toxic chromium VI.

Table 1. Groundwater contaminant concentrations in private and municipal drinking water wells.

Well	Sample Dates	Contaminant	MCL [1] (ppb)	Concentration Range (ppb)	Exposure Conc. (ppb) [2]
Well A	6/99 to 4/05	1,1-DCE	7	0.5 to 5.7	ND[3]
		TCE	5	ND to 1.8	ND[3]
Well B	6/99 to 4/05	1,1,2-TCA	--	1.2 to 1.5	<1.0
		1,1-DCA	--	2.4 to 9.0	2.4
		1,1-DCE	7	67 to 519	**67**
		TCE	5	38 to 204	**38**
Well C	6/99 to 5/06	**1,1-DCE**	7	9.0 to 20.8	**9.0**
		TCE	5	5.7 to 8.8	**5.7**
Well D	4/05	**1,1-DCE**	7	**11.3**	**<11.3**
		TCE	5	1.4	1.4
EP MSW [4]	12/89 to 4/05	TCE	5	ND to 3.2	ND
Olson Well [4]	12/89 to 4/05	TCE	5	ND to 6.5	ND

Notes: [1] MCL is the EPA maximum contaminant limit.

[2] The estimated exposure concentrations for the private drinking water wells are the 1999 sample results (if available) and for the municipal supply wells (MSW) contaminants have not been detected at the city distribution point.

[3] The residence at the Well A location utilized a water filtering system. No contaminants have been detected in filtered water.

[4] Sampling at the municipal supply wells has continued through present time but results are not included in EPA ESI data set (2007).

Table 2. Concentrations and soil screening values for metals at the EP site.[1]

Contaminant	Soil Screening Value (ppm)	SSV reference	Concentration Range (ppm)	Average concentration (ppm)
Cadmium	10 Child 100 Adult	EMEG $_{chronic}$	0.1 to 18	2.6
Chromium[2]	200 Child 2000 Adult	RMEG	7.4 to 1,190	110.3
Lead	400 play area 1200 yard average	RLHS (EPA)	11 to 1430	204.5

Notes: EMEG is an ***environmental media evaluation guide*** and represents "concentrations of a substance to which people may be exposed during a specified time period without experiencing adverse health effects" (ATSDR, 2005). Adult and child EMEGs are different because of differences in body weights and exposure rates. The chronic EMEG is for time periods of one or more years.

RMEG is an EMEG based on the EPA ***Reference Dose*** which is an "estimate of daily human exposure, including exposure to sensitive subpopulations that are likely to be without appreciable risk of adverse non-cancer health effects for a lifetime (70 years)."

RLHS is the EPA ***Residential Lead Hazard Standard***: "lead is considered a hazard when equal to or exceeding: …400 parts per million (ppm) of lead in bare soil in children's play areas or 1200 ppm average for bare soil in the rest of the yard." (http://www.epa.gov/lead/pubs/leadhaz.htm)

[1]Soil samples were measured using both field XRF instruments and laboratory chemical analyses. Results presented in this table use the laboratory analyses. USACE (2007) reports that agreement between the respective analytical methods is acceptable. Laboratory analyses are used in this PHA due to the high frequency of non-detects for the XRF analyses.

[2]Chromium may be present as either chromium III or chromium VI. As the analytical methods used do not discriminate between these species, it is assumed that all chromium is present as the more toxic chromium VI.

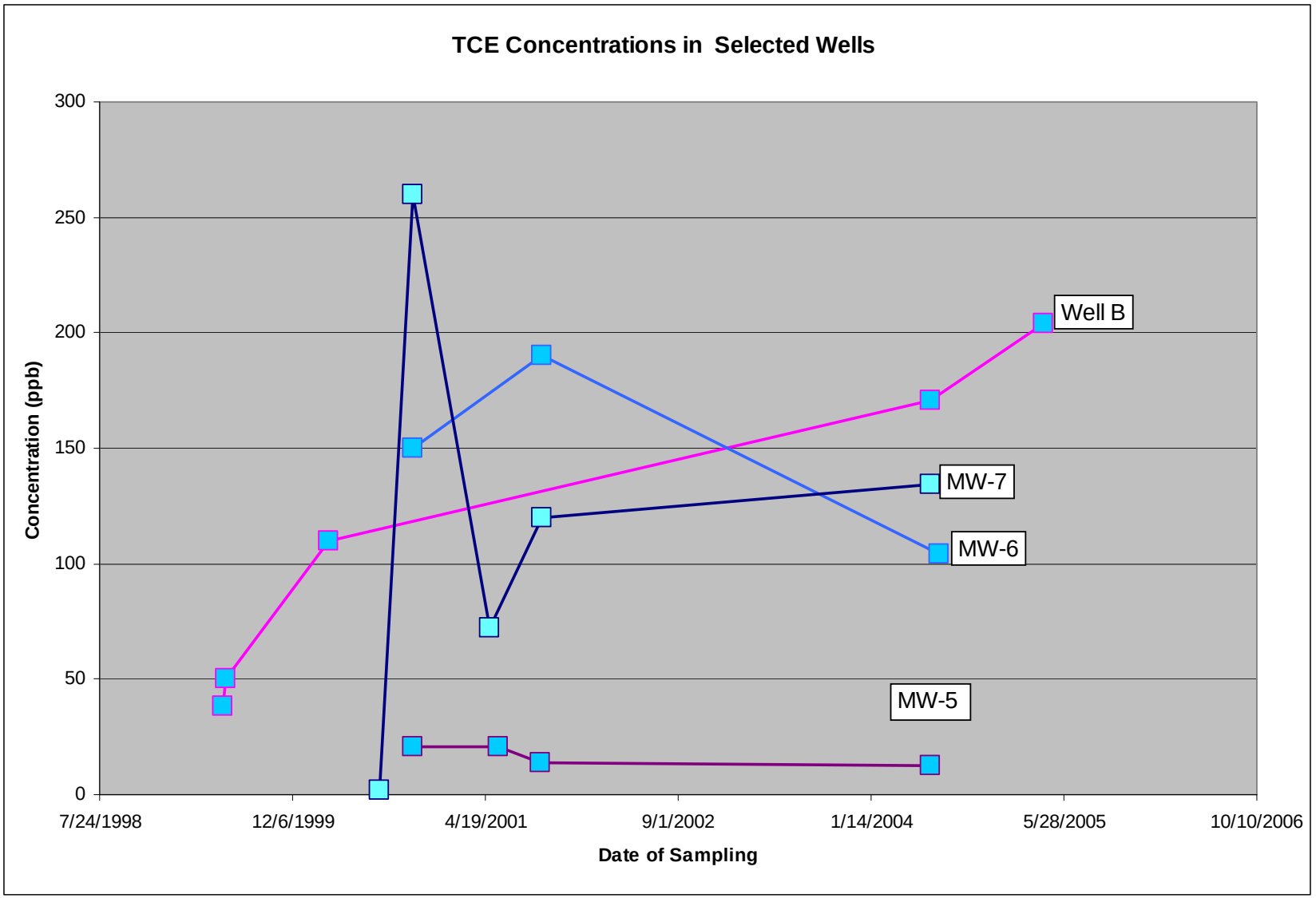

Figure 5. TCE trends in selected wells down-gradient of EP site. Note that TCE concentrations in are relatively low in 1998/99 and increase and then decrease for monitor wells 6 and 7 (MW-6, MW-7) but are continuously increasing for domestic well B (Well B).

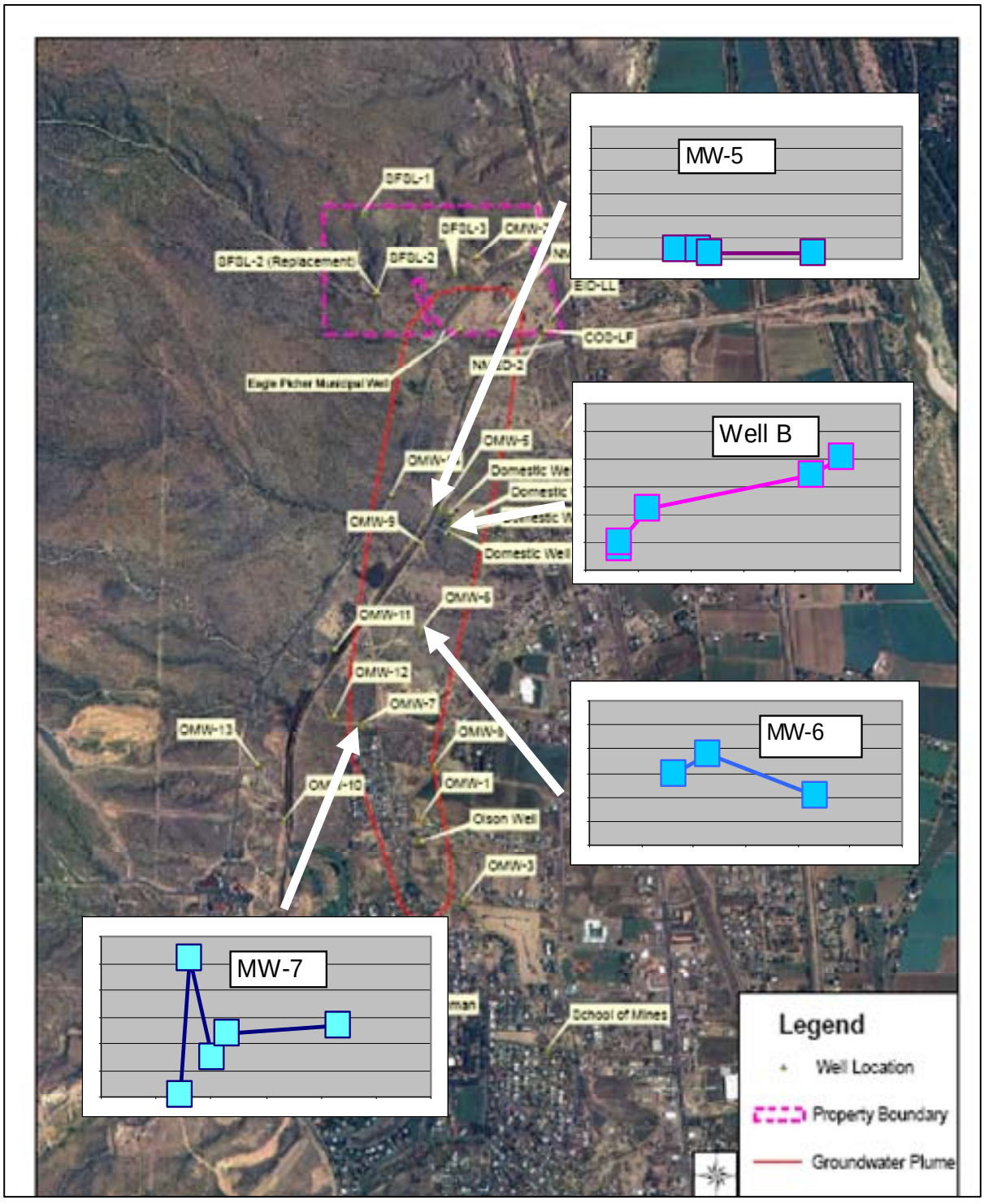

Figure 6. TCE concentration trends in selected wells. Scale of concentrations (Y axis, 0 to 300 ppb) and time (X axis, 7/98 to 10/06) are as in Figure 5. Note that TCE concentration in Well B is increasing relative to both up-gradient and down-gradient monitor wells. Also, MW-6 has initially higher TCE concentrations (relative to Well B) but then declines while Well B continues increasing.

Exposure Doses

Pathways of Exposure: A pathway of exposure describes the process and timeframe by which a person is exposed to contaminants from a site. Pathways may be "complete, incomplete, or potential" if all parts of the pathway are present, one or more parts are not present, or are unknown, respectively. Exposure pathways also have a time component, such that is they may have been completed in the past, the present, or the future.

Table 2 summarizes the exposure pathways present at the EP site, including their status and timeframe of exposures. Excluding former EP workers, there are only two significant ways that people could be or have been exposed to contaminants from the EP site. Those pathways are past exposures to VOC-contaminated groundwater via drinking water wells and past and current exposures to metals in soil and dust at the on-site motocross track and possibly at the on-site paintball venue.

Several other possible exposure pathways have been considered, but based on available information are considered incomplete or very unlikely. Those pathways include ongoing VOC exposures at the three residences with contaminated wells, off-site exposure to dust from areas of on-site soil contamination, and VOC vapor intrusion into down-gradient residences from the subsurface contaminant plume.

According to a representative of the NMED, one or more of the VOC-contaminated private wells may still be used for outdoor watering or other non-drinking water uses. Although people may occasionally come into contact with water or volatized contaminants from those wells, such incidental contact to low concentrations does not represent a significant exposure. Similarly, soil samples from properties adjacent to the EP site have not detected metals concentrations above background levels. This indicates that contaminated dust from on-site locations is not accumulating at levels of health concern on adjacent properties so there is no off-site soil/dust exposure. Under some geologic conditions, vapor from subsurface VOC plumes can accumulate in basements or underground living areas. Such zones of vapor intrusion require relatively high concentration and shallow VOC plumes directly underlying a basement with foundation cracks or drainage sumps that allow the vapor to seep into the basement. None of these conditions appear to be present at the EP site and down-gradient areas.

It is also important to note that the presence of a completed exposure pathway does not indicate that the resulting exposures represent a public health hazard. Determination of a public health hazard requires contaminant exposures at concentrations that create doses that may produce adverse health effects. The estimation of doses from the completed pathways depends on the duration and magnitude of exposure which are presented in the following section.

Table 3. Exposure pathways on or adjacent to the Eagle Picher site, Socorro New Mexico.

Source/contaminants	Media/transport	Exposure point	Exposure route	Population	Status/timeframe
TCE and other VOCs released to sewage impoundments or dumped on ground at various on-site locations	Seepage to groundwater and subsequent down-gradient flow to private drinking water wells	Private drinking water wells down-gradient of EP site.	Ingestion of well and tap water with additional exposure via inhalation and dermal uptake.	Residents of three houses down-gradient of EP site	Complete/past; the three houses were provided with city water in 1999. Note that EP contaminants have never been detected in any analyses at the City water distribution point.
Cadmium, chromium, and lead released to sewage impoundments or dumped on ground at various on-site locations	Soil and/or airborne dust	On-site soil/dust	Incidental ingestion and inhalation	Motorcycle riders, spectators, and workers at the on-site motocross track.	Complete/past and present, although commercial operation of the track has ceased, people still use the track. Although the pathway is complete, average site concentrations are below soil screening levels.

Exposure pathway: A model describing how a substance moves from its source (where it was released) to where and how people come into contact with the chemical(s). ATSDR defines an exposure pathway as having five parts; 1) source of contamination, 2) environmental media and transport process, 3) point of exposure, 4) route of exposure, and 5) receptor population. When all five parts of an exposure pathway are present, it is considered a "completed exposure pathway."

Exposure scenarios and dose calculation: Estimating an exposure dose requires identifying how much, how often, and how long a person may come in contact with some concentration of the chemical in a specific medium (air, water, soil). The equation used to estimate exposure doses from ingesting contaminants in water is below (ATSDR, 2005a).

Equation 1: Exposure Dose Equation for Ingestion

$$\text{Dose} = \frac{C \times IR \times EF \times CF}{BW}$$

Where:

D	=	exposure dose in milligrams per kilogram per day (mg/kg/day)
C	=	chemical concentration in micrograms per liter (µg/L)
IR	=	intake rate in liters per day (L/day)
EF	=	exposure factor (unitless = 2)
CF	=	conversion factor, 1×10^{-6} milligrams/microgram (mg/µg)
BW	=	body weight in kilograms (kg)

Doses from ingestion, inhalation, and dermal contact with TCE and 1,1-DCE at the Well B location are shown in Table 4. Doses from other residences are 6 to 10 times lower than the Well B location due to the overall lower levels of contamination. The doses listed in Table 4 include an exposure factor of two to account for inhalation exposure to TCE and 1,1-DCE (breathing the vapors that volatize into the air from water in showers and other uses) and for dermal exposure (direct absorption through the skin). These secondary exposures to the VOCs in drinking water essentially represent a doubling of the ingestion dose. The public health implications of the cumulative doses are discussed in the following section.

Table 4. TCE and 1,1-DCE doses from groundwater exposure in a residence near the EP site.

Well B	Dose (mg/kg/day)	Concentration (ppb)	Ingestion Rate (L/day)	Exposure Factor	Conv. Factor	Body Wt. (kg)	
TCE	4.75E-03	38	1	2	1.00E-03	16	Child
	2.17E-03	38	2	2	1.00E-03	70	Adult
1,1-DCE	8.38E-03	67	1	2	1.00E-03	16	Child
	3.83E-03	67	2	2	1.00E-03	70	Adult

Notes:
Concentrations are from Table 1.
The exposure factor of 2 is used to account for a doubling of the ingestion dose due to inhalation and dermal contact.
Intake rates and body weights of children and adults are recommended values from the EPA Exposure Factors Handbook (EPA, 1999).

Public Health Implications

Recent analyses of groundwater samples from residential wells adjacent to the EP site have consistently detected mostly low concentrations of several VOCs. The specific compounds, their measured concentrations, and health comparison values (CVs) are listed in Table 1. 1,1-DCE and TCE were the only compounds detected at concentrations above their respective screening values (MCLs). Note that only one well (listed as Well B in Table 1) had VOC concentrations significantly above the comparison values and had the highest concentrations of most of the compounds.

The CVs are calculated concentrations of a substance in air, water, food, or soil that are unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health evaluation process. Exposure to these compounds at concentrations greater than their comparison value does not necessarily mean that someone will get sick. Substances found in amounts greater than their CVs are selected for further evaluation by estimation of the doses that people may be exposed to via drinking or direct absorbtion of the contaminants from water and breathing them in air. These estimated doses are then compared with doses that have resulted in disease or sickness for people or laboratory animals. The health implications for each contaminant are presented in a discussion that relates the potential doses with the specific diseases or health effects caused by each contaminant.

Table 4 shows the two contaminants that had concentrations above their respective comparison values. These contaminants and their estimated doses, are shown in Table 4, (1,1-DCE and TCE). The estimated doses in Table 4 are based on measured concentrations of each contaminant in Well B. This location had the highest measured contaminant concentrations, with other wells having VOC concentrations at least 6 to 10 times lower than Well Bs. Other wells had only trace concentrations or non-detections of VOCs.

Table 4 includes estimated combined ingestion/inhalation/dermal contact doses for both adults and children based on measured VOCs from the drinking water wells. Adult doses are estimated assuming a person drinks 2 liters of water per day (from the household source) and weighs 70 kg (154 pounds). Doses for children assume 1 liter per day water ingestion and a weight of 16 kg (35 pounds). In addition to the oral dose from drinking water, for these VOCs a person may also absorb these compounds directly from contaminated water through the skin (dermal dose) and breathe the compound in the air (inhalation dose).

Studies have shown that exposure to volatile organic compounds (VOCs) from routes other than direct ingestion might be as large as the exposure from ingestion alone. The inhalation dose due to volatization during a shower may equal the ingestion dose from 1.3 liters of water (Wan, et.al., 1990) and that 50—90% of VOCs in water may volatize during showering, laundering, and other activities (Moya et al, 1999; Giardino and Andelman, 1996). Similarly, the dermal dose has been estimated to equal 30% of the ingested dose (Maine DEP/DHS, 1992). Based on the results of these studies, combined VOC exposure doses in Table 4 include an inhalation dose that is 70% of the ingestion dose, and a dermal contact dose that is 30% of the ingestion dose.

Table 5 shows the estimated doses and theoretical excess cancer risk for each compound. These comparison values (MRLs, RfDs, and CSFs) are as defined below:

MRL-- (minimal risk level) is an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified period of exposure (acute—minutes to 14 days; intermediate—14 to 365 days; chronic—more than 1 year);

RfD--(Reference Dose) is a daily dose that is likely to be without discernable risk of deleterious effects to human population (including sensitive subgroups) during a lifetime of exposure.

CSF--(cancer slope factor) is an estimate of age-averaged lifetime excess cancer incidence rate per unit intake.

A discussion of the estimated doses, cancer risks, and possible health effects from exposure to each to these contaminants is presented in the following sections.

Table 5. VOC doses, health comparison values (CVs), and excess cancer risks from exposure to groundwater at Well B.

Well B Contaminant	Adult Dose[1] mg/kg/day	MRL mg/kg/day	RfD mg/kg/day	CSF[2]	30 year Cancer Risk[3]
1,1-DCE	0.0038	0.009	0.009	NA[4]	NA[4]
TCE	0.0022	NA	NA	0.02 to 0.4[5]	3.7E-4 to 1.9E-5

Notes:

[1] Adult doses are used to estimate cancer risk because the risks are based on lifetime exposures. Child exposures and intakes occur over a small portion of the assumed lifetime.

[2] Cancer slope factors (CSF) are in units of risk per unit dose 1/(mg/kg/day).

[3] Cancer risk is "excess theoretical risk" for a 30 year exposure. Standard cancer risk estimates are based on a 70 year lifetime excess risk. As the EP site operations began in 1964 (and it would take several years for groundwater contaminants to migrate to down-gradient locations) and exposures ceased in 1999, the 30 year exposure duration is appropriate and health protective.

[4] 1,1-DCE is considered a "possible" human carcinogen. Available data are not adequate to calculate quantitative risk factors (http://www.epa.gov/ncea/iris/subst/0039.htm).

[5] TCE cancer risks are calculated using two different slope factors. The EPA recommends using this range of CSFs and presenting a range of estimated excess cancer risks (EPA, 2001).

1,1-dichloroethylene (1,1-DCE)

Based on the available measured 1,1-DCE concentrations and estimated doses, adverse health effects from past exposure to 1,1-DCE via contaminated drinking water wells around the EP site are unlikely to produce any adverse health effects, including cancer.

1999 measurements of 1,1-DCE were 67 ppb in Well B, 9 ppb in Well C, 11 ppb in Well D and trace or non-detectable concentrations in all other residential wells (Table 1). The Well B drinking water concentrations result in estimated combined (ingestion plus inhalation plus dermal contact) 1,1-DCE doses of 0.0038 mg/kg/day for adults and 0.0084 mg/kg/day for children (Figure 7; Table 4). Estimated doses at other locations are more than 6 times lower than Well B doses. The estimated doses at the Well B location are below the ATSDR MRL and EPA RfD, which are "estimates of daily doses that are likely to be without discernible risks of adverse health effects" for long term exposures. The estimated Well B doses are also more than 1,000 times lower than any doses that have been associated with adverse health effects in laboratory animals (Figure 7; ATSDR, 1994).

The following summary of 1,1-DCE and its potential health effects is derived from the ATSDR Toxicological Profile (ATSDR, 1994). 1,1-DCE (also known as vinylidene chloride) is a colorless, sweet-smelling liquid that evaporates rapidly at room temperature. 1,1-DCE is used in the manufacture of polyvinylidene chloride copolymers. These polymers are used extensively in the food packaging products (such as SARAN and VELON wraps). The Food and Drug Adminstration (FDA) has mandated that plastic packaging materials can contain no more than 10 ppm 1,1-DCE (FDA, 1988). Because of its use in food packaging materials, 1,1-DCE is commonly found in packaged foods. Industrial releases of 1,1-DCE have also been noted at battery and electronic component manufacturing facilities such as the EP site.

1,1-DCE spilled or released onto surface soil will tend to evaporate into the atmosphere with a smaller amount percolating into subsurface soil where it will again partition between absorption onto soil particles and solution into groundwater. Once dissolved in groundwater, 1,1-DCE will migrate with groundwater (ATSDR, 1994). In typical anaerobic groundwater conditions, 1,1-DCE is degraded to vinyl chloride by methanogenic bacteria over the course of a few weeks to several months. Vinyl chloride has not been detected in any of the available groundwater samples. A possible explanation is that the alluvial aquifer materials underlying this area do not contain sufficient organic material to sustain the methanogenic bacteria necessary to mediate the degradation of the 1,1-DCE.

The potential health effects of exposure to 1,1-DCE have been summarized by several governmental agencies including the ATSDR Toxicological Profile (ATSDR, 1994) and the EPA Integrated Risk Information System (IRIS; http://www.epa.gov/ncea/iris/subst/0039.htm). Available information indicates that prolonged inhalation of 1,1-DCE can induce adverse neurological effects and is possibly associated with liver and kidney damage in humans. Studies in animals indicate that 1,1-DCE can affect the normal function of the liver, kidneys, and lungs. However, the doses to which these animals were exposed were much higher than any doses associated with releases from the EP site.

The available studies concerning 1,1-DCE exposure and human cancer risk are inconclusive and no quantitative cancer slope factors are currently available from the EPA or the International Agency for Research on Cancer (IARC).

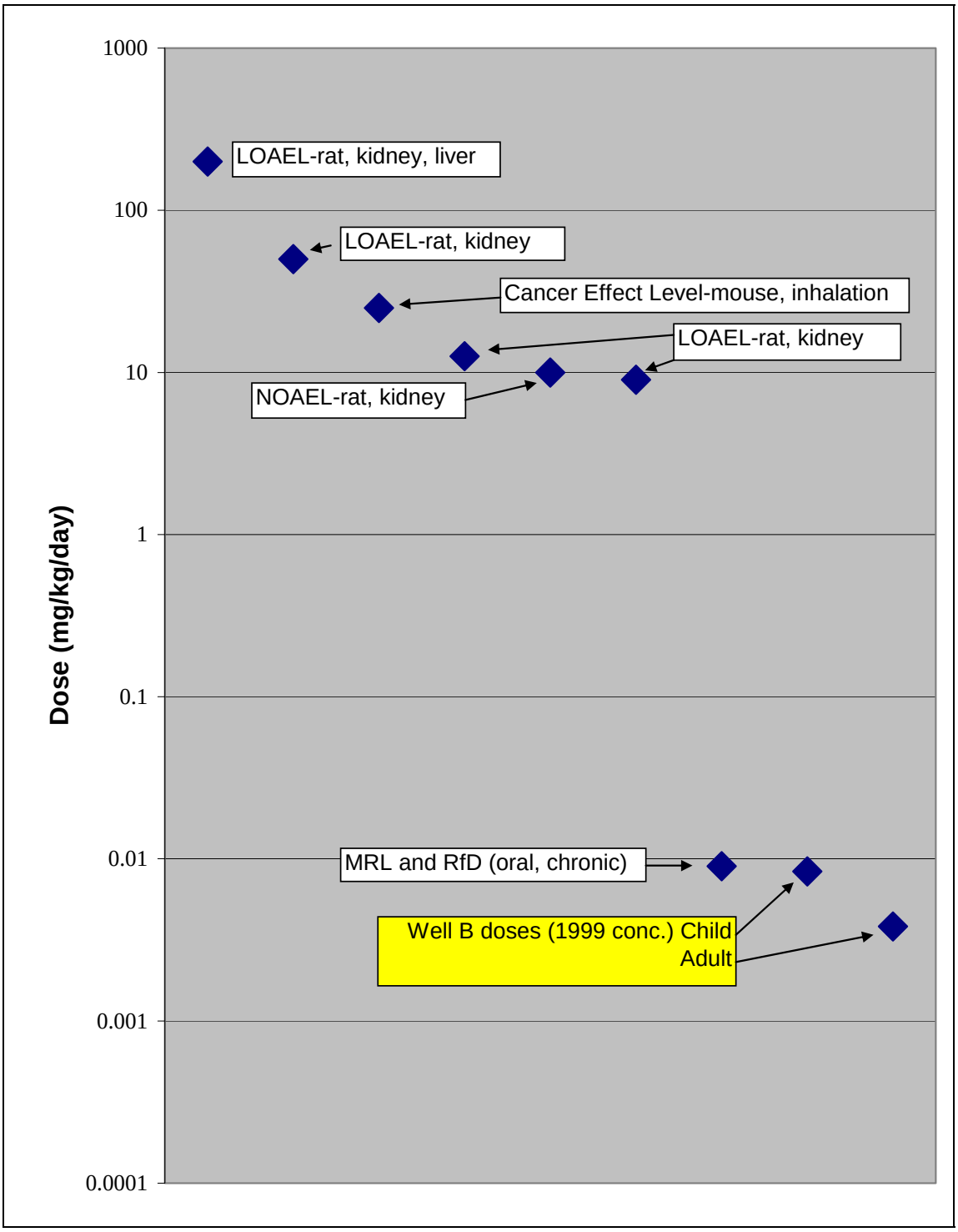

Figure 7. 1,1-DCE doses and health effects. Note that the highest estimated doses (Well B) are slightly lower than the MRL and RfD for long-term oral exposure and more than 1,000 times lower than any doses associated with adverse health effects in laboratory animals. Abbreviations are defined in Appendix A.

Trichloroethylene (TCE or trichloroethene)

Based on the available measured TCE concentrations and estimated doses, adverse health effects from past exposure to TCE via contaminated drinking from the contaminated water wells around the EP site are unlikely to produce any adverse health effects, including cancer.

Measurements of TCE (taken in 1999) were 38 ppb in Well B, 5.7 ppb in Well C, 1.4 ppb in Well D and trace or non-detectable concentrations in all other residential wells (Tables 1 and 2). The Well B drinking water concentrations result in estimated combined (ingestion plus inhalation plus dermal contact) TCE doses of 0.0022 mg/kg/day for adults and 0.0048 mg/kg/day for children (Table 4). Estimated doses at other locations are more than 6 times lower than Well B doses.

TCE is a nonflammable, oily, colorless liquid that has a sweet odor and a sweet, burning taste. Years ago, TCE was used as an anesthetic. It is now used as a solvent to remove grease from metal parts and to make other chemicals. It is heavier than water and has low solubility (up to one part TCE per thousand parts of water at room temperature; ATSDR, 1997). These qualities make TCE a troublesome contaminant at hazardous waste sites. When present in groundwater, TCE tends to settle into a layer at the bottom of the aquifer and then continuously dissolves into the groundwater. This may result in high levels of TCE in the aquifer for years after the original release of contamination has ended. This may have happened at the EP site and may be the reason why there is TCE contamination in private well water.

There are several reports of an increased occurrence of nervous system and developmental effects, and cancer, from ingestion and inhalation of TCE by animals and humans (ATSDR, 1997; 1998). Human health studies *suggest* an increased incidence of cancer of various types (e.g., bladder, lymphoma, kidney, respiratory tract, cervix, skin, liver, and stomach) from exposure to TCE; however, no studies provide clear, unequivocal evidence that exposure is linked to increased cancer risk in humans (ATSDR, 1997; 1998). The available studies suffer from inadequate characterization of exposure, small numbers of subjects, and the fact that subjects were likely exposed to other potentially carcinogenic chemicals. There is, however, sufficient evidence that TCE exposure results in cancer development in animals, although animal studies may not be relevant for evaluating health hazard to humans (ATSDR, 1997).

In 1989, EPA withdrew its cancer assessment for TCE, which was based primarily on animal studies conducted in 1990 and earlier, because more recent pharmacokinetic and mechanistic data for TCE became available (EPA, 2006; Cogliano, 1999). An updated approach to TCE cancer assessment using existing animal data and state-of-the-science papers has been proposed (Cogliano, 1999). This approach, which is supported by high-dose animal studies, does not appear entirely relevant for evaluating the health hazard of low-dose human environmental exposures for several reasons. First, cancer in animals appears to result from species-specific mechanisms that are not entirely relevant to humans (ATSDR, 1997). Second, the animals used in these studies were exposed to very high doses of TCE, several orders of magnitude *higher* than estimated for EP site neighbors, and the overall death rate in the animal studies was high. The surviving animals were not likely to have been in good health and, therefore, would have been more susceptible to adverse effects from TCE exposure (like infections and illnesses) than

healthy animals. Third, the overall findings from animal studies are inconsistent: some studies report an increased incidence of cancer, while an equal number do not report an increase at similar levels of exposure (ATSDR, 1997). Fourth, the studies used pure TCE and did not evaluate the effect of exposure to stabilizers and impurities in TCE; these things may also be carcinogenic.

ATSDR has also derived a health guideline of 0.2 mg/kg/day for ingestion of TCE based on an acute-duration (less than 14 days) study showing developmental and behavioral changes in mouse pups administered 50 mg/kg/day of TCE (Fredriksson et al., 1993). In this study, the TCE was dissolved in oil and administered by stomach tube (gavage; ATSDR, 1997). The findings of this study are not entirely relevant for evaluating health hazard for EP site neighbors exposed to TCE in well water for several reasons. First, gavage doses in the animal study were administered as one large dose per day, while EP site neighbors were likely to have been exposed to TCE in drinking water several times a day. (The body handles a single large dose much differently than it does a series of smaller doses.) Second, the total dose entering the body is higher and maintained for a longer time when TCE is dissolved in oil than when it is dissolved in water. Lastly, exposure to TCE in the animal study lasted less than 14 days, while maximum exposures to EP site neighbors may have occurred over a period of many years. Despite these limitations, the estimated TCE doses for EP site neighbors are much lower than any for which adverse health effects have been documented.

ATSDR's TCE Sub-Registry reports an excessive number of children aged 9 years old or younger with speech and hearing deficits (ATSDR, 1994). Although the exposure levels of these children were not well characterized, the findings support the types of outcome seen in animals. Several studies of workers and community residents suggest a possible association between exposure to TCE (and other chemicals) and developmental outcomes (ATSDR, 1998; Fagliano et al., 1990; Bove et al., 1995; MDPH, 1997). However, none of the studies provide conclusive evidence for a causal relationship, largely because information about TCE exposure was incomplete and exposure to other chemicals was likely (ATSDR, 1997). Collectively, the scientific data indicate that the developing nervous system in young animals and humans may be sensitive to the toxic effects of TCE (ATSDR, 1997), although the dose levels at which these effects occur has not been established. The available TCE measurements indicate that past exposures to TCE by EP site neighbors were many orders of magnitude below TCE doses that have been shown to cause neurotoxic effects in animals.

The excess cancer risks in Table 5 represent the expected increase in cancer risk due to exposure to TCE. Note that the TCE cancer risks in Table 5 include estimated excess risk calculated with two different cancer slope factors. The EPA TCE Health Risk Assessment (EPA, 2001) has identified several cancer slope factors, with most between $2x10^{-2}$ and $4x10^{-1}$ per mg/kg-d (Table 5). As there is no scientific consensus on a specific CSF, the EPA recommends using a range of CSFs and presenting a range of estimated excess cancer risks. Consequently, the highest estimated excess cancer risks due to thirty years of Well B TCE exposure range from about 4 in 10,000 (3.7E-04) to about 2 in 100,000 (1.9E-5; Table 5). Cancer risks at Well C and D locations with lower TCE concentrations are much lower.

All of the uncertainties and conservative exposure assumptions associated with the dose calculations are included in the risk estimation as well as the uncertainty in deriving the cancer slope factor (EPA, 2000). The risk estimates in Table 5 cannot be interpreted as evidence that

any of the EP site neighbors will develop cancer as a result of TCE exposure. *These estimates of excess risk fall within the range of low to no apparent increased risk* (ATSDR, 1991). Note that the highest theoretical excess cancer risk (calculated using the highest cancer slope factor and assuming 30 years of exposure) of about 4 in 10,000 (3.7E-04) is "outside the EPA acceptable risk range." These low risk estimates indicate that TCE is not likely to create excess cancers. Excess cancer risks at other locations (Wells C and D; Table 2) are much lower and also fall within the range of low to no apparent increased risk.

Also, as the estimated TCE doses are much lower than any doses that have been shown to produce other, non-cancer health effects, such as liver disease (Figure 8), past exposures to TCE, via drinking water wells are unlikely to produce any non-cancer adverse health effects. The highest estimated Well B doses are above the proposed RfD (Figure 8). However, these exposures would not be expected to cause adverse health effects because the proposed RfD has an uncertainty factor of 3,000 (this means the RfD is 3,000 times lower than doses which have caused adverse health effects in laboratory animals).

It must be noted that these dose estimates and health determinations are based on the available measured VOC concentrations. Although unlikely (based on extrapolation of available concentration trends), it is possible that pre-1999 concentrations were higher than 1999 measured concentrations. If this had occurred, the resulting doses would have been commensurately higher.

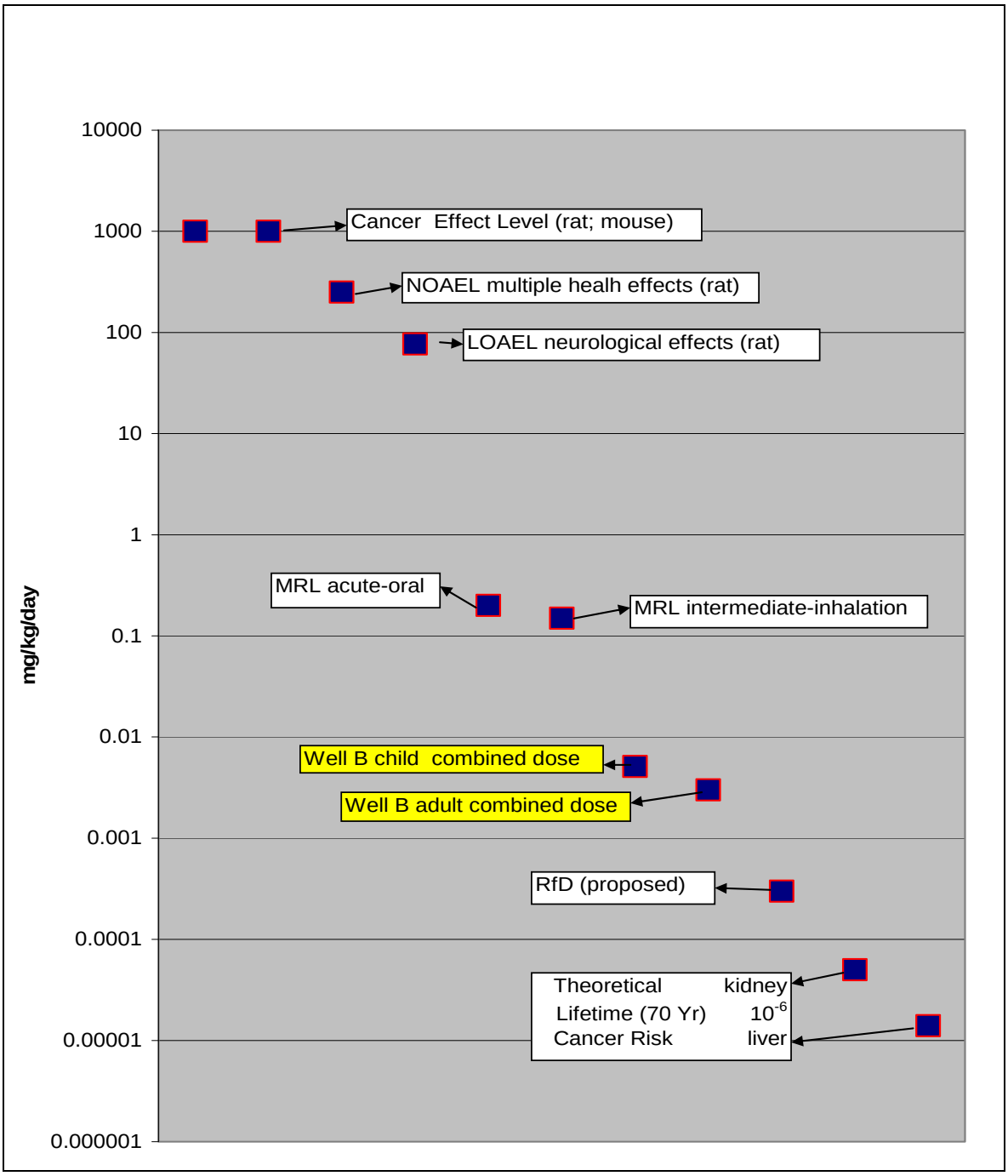

Figure 8. TCE doses and health effects. Note that the highest estimated doses (Well B) are much lower than any doses associated with adverse health effects in laboratory animals. Although estimated doses are higher than those associated with 70 year cancer risks, thirty year risk estimates range from about 4 in ten thousand to about 2 in one hundred thousand (3.7E-4 and 1.9E-5, resp.; depending on the specific cancer slope factor; Table 5). Data are from Table 5, ATSDR (1997), and EPA (2001). Abbreviations are defined in Appendix A.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

In this PHA, doses to children have been estimated using child-specific intake rates and body weights. As the estimated child-specific doses are somewhat greater than adult doses, the resulting public health determinations are based on the doses and potential adverse health effects to children.

Adequacy of Available Data

The groundwater and well monitoring data in off-site drinking water wells indicate that at least three households may have been exposed to VOCs via ingestion of water, direct skin contact with the water, and inhalation of vapors from the water. Low concentrations of the VOCs have also been detected in two municipal drinking water supply wells but not in the water distribution system (after the treatment plant). The concentrations and distributions for two different VOCs (1,1-DCE and TCE) are listed in Table 1 and Figures 5 and 6. The figures show time-variable concentrations of VOCs that decrease toward the south and are consistent with southerly groundwater flow and a contaminant plume originating at the EP site. Comparison of the estimated VOC doses at the private well locations with health comparison values and doses associated with adverse health effects in humans and laboratory animals indicates that adverse health effects are unlikely.

However, the contaminant concentrations on which these dose estimates are based reflect only current or recent groundwater trends at each location. There is no historic monitoring data available to determine the rate of subsurface VOC migration or when the private wells first became contaminated. Although the available monitoring data suggests that pre-1999 contaminant concentrations were lower than current values, it is possible that pre-1999 concentrations were higher in some wells. Ongoing data collection and evaluation by the EPA as part of its Superfund Remedial Investigation may clarify this issue.

For most of the off-site drinking water wells that only have trace concentrations of VOCs, if historic concentrations were 10 times greater than current concentrations, the resulting doses would still be below levels of public health concern. However, if concentrations were 10 times

greater at a few of the locations, the resulting VOC exposures could present a public health hazard. It is very unlikely that VOC concentrations in the municipal drinking water wells and water distribution system were ever higher. Although existing data suggest that past concentrations were not any higher than present, additional data and evaluation of the contaminant sources and distribution of contaminant concentrations and groundwater flow modeling may be required to address this issue. Groundwater sampling was conducted using EPA protocols with EPA and NMED oversight and analyses were conducted at the EPA Region 6 or other EPA-approved laboratory (USACE, 2007). Sampling protocols and quality control procedures for the groundwater samples appear adequate for use of the resulting data in public health determinations.

It should also be noted that measurement of groundwater contaminants in residential and monitoring wells has not been conducted after 2005 (municipal water supply wells are tested regularly). Southward migration of the VOC plume may have occurred after 2005 and regular testing of water wells down-gradient of the plume should be continued. Based on low and possibly decreasing VOC concentrations in OMW-1 and the Olsen Well, the plume seems to be migrating very slowly. Although it is unlikely that VOC contamination has spread to wells located down-gradient of the 2005 plume location, that assumption should be confirmed by continued monitoring. Based on available information from NMED and the City of Socorro, water wells down-gradient of the existing plume are used only for irrigation with the exception of the School of Mines well (Figure 4) which is part of the City of Socorro supply system (note that this well is regularly analyzed for VOCs and other contaminants).

Soil sampling at the EP site included a complete grid coverage of the area of the EP site used for the motocross track and associated operations. This grid was sampled using a direct reading XRF instrument with laboratory samples of selected areas. In general, there was good agreement between the instrument and laboratory samples although the XRF analyses have a higher detection limit and consequently a high proportion of non-detects for chromium and cadmium analyses (USACE, 2007). It is also likely that the laboratory analyses may overestimate site-wide average concentrations because the grid areas that were chosen for laboratory analyses were those areas likely to have significant soil contamination (such as unlined evaporation ponds). However, using a conservative estimate of the site-wide average concentrations to assess potential exposures is a health-protective measure.

The soils of the paintball course and former city landfill were not sampled as part of the expanded site investigation (USACE, 2007). Although there is little potential exposure at the former landfill area, the paintball course does represent an area of exposure for people. Although the site history does not suggest that there have been any significant contaminant releases to surface soils at the paintball course location, future soil sampling as part of the ongoing EPA remedial investigation should be conducted in this area. Soil sampling was conducted using EPA protocols with EPA and NMED oversight and analyses were conducted at the EPA Region 6 or other EPA-approved laboratory (USACE, 2007). Sampling protocols and quality control procedures for the soil samples appear adequate for use of the resulting data in public health determinations.

Conclusions, Recommendations, and Public Health Action Plan

Conclusions

Based on the above findings, past operations at the EP site have led to releases of several VOCs, including 1,1-DCE and TCE into groundwater underlying the EP site. Off-site migration of the VOCs, via groundwater flow, has caused the contamination of up to four residential drinking water wells and two public water supply wells. VOCs have never been detected in the City of Socorro water distribution system and no exposures have occurred via the municipal water system. People living in the residences with private wells have been exposed to the VOCs by drinking water from the wells, direct skin contact with the VOCs in the household water, and breathing the gaseous VOCs that have escaped into the household air.

This PHA provides an estimate of the VOC doses to residents of those houses using the measured concentrations of the VOCs in 1999 (when potable use of the wells ceased). Evaluation of the contaminant distributions and estimated doses, using both children and adult body weights and intake rates for 1,1-DCE and TCE leads to the following public health determinations;

- Adverse health effects are unlikely for users of most of the contaminated private wells based on recent measured concentrations of VOCs.
- Residences with contaminated wells are currently being provided with municipal water. Current exposure to VOCs at these locations is limited to incidental use of the wells for irrigation or other outside uses. These exposures are unlikely to create adverse health effects.
- The available information on the historic use and release of VOCs at the EP site and patterns of groundwater flow is not adequate to determine how long (prior to 1999) the residential wells were contaminated.
- The current distribution of groundwater VOCs suggests that concentrations in residential wells were not higher in the past.
- Based on the above findings, *past, current and future* exposures to VOCs via contaminated groundwater are “no apparent public health hazard.” This determination means that exposures to site-related contaminants has or may be occurring, but at levels unlikely to create any adverse health effects. *Past exposures* at all residences with contaminated wells are “no apparent public health hazard.”

In addition to groundwater contamination, past EP operations led to direct contamination of surface soils by several metals (cadmium, chromium, and lead). Although there are isolated areas of cadmium, chromium, and lead surface soil contamination on the EP site, average concentrations are below levels of public health concern. Off-site soil samples have not detected these contaminants at concentrations above soil screening guidelines.

Recommendations

Based on the above conclusions, ATSDR recommends:

- Continued monitoring of the groundwater contaminants and additional evaluation of the times and locations of VOC releases in order to more completely evaluate historic contaminant concentrations and distributions.
- Initiation of appropriate groundwater source remediation or management based on the findings of the ongoing remedial investigation. All future exposures to VOCs should be eliminated by appropriately destroying the contaminated wells.
- Expand locations of surface soil sampling to include former paintball facility. Any future soil sampling should be conducted using spatially representative multi-increment analyses (with at least 30 increments per sample).

Public Health Action Plan

To ensure community understanding and address future public health issues related to the EP site, ATSDR will conduct the following public health actions:

- ATSDR will evaluate future site data and information as provided by the NMED and the EPA and revise the public health conclusions of this health assessment as necessary.

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Appendix A. ATSDR Glossary of Environmental Health Terms

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Activity: The number of radioactive nuclear transformations occurring in a material per unit time. The term for *activity* per unit mass is specific activity.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

Antagonistic Effect: A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount or concentration range of a substance in a specific environment or, amounts that occur naturally in the environment.

Biota: Used in public health, things that humans would eat – including animals, fish and plants.

Body burden: The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP: See **C**ommunity **A**ssistance **P**anel**.**

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Community Assistance Panel (CAP): A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.

Comparison Value (CVs): Concentrations or the amount of substances in air, water, food, and soil that are, upon exposure, unlikely, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated. See Appendix 4 for the derivation of CVs.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or question about substances in the environment that might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Contaminant of (public health) concern: An environmental contaminant for which, (1) environmental concentrations exceed media-specific comparison values, or (2) has noted community health concerns, or (3) the quality and extent of sampling data with which to evaluate potential exposure and human health hazard is inadequate.

Delayed Health Effect: A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemcials of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A model describing how a substance moves from its source (where it was released) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts:

1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Hazardous Substance (Waste): Substances that have been released into the environment which could, under certain conditions, be harmful to people who come into contact with them.

Health Comparison Value: See Comparison Value.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Health Guideline: Doses such as MRLs and RfDs that are likely to be without any adverse health effects. Health guideline values are expressed in units of dose such as mg/kg/day or cancer risk values as inverse dose ($mg/kg/day^{-1}$).

Health Protective Dose: Doses calculated using health protective exposure factors and contaminant concentrations that are most likely greater than any real dose to a member of the community.

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Malignancy: See **Cancer**.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's PHA documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's PHA documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume: A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). For examples:

the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or a group of individual persons, or objects from which samples are taken for statistical measurements.

PRP: **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in ATSDR documents for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Sample: A representative individual or item from a larger group or population, or finite part of a statistical population.

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an Exposure Pathway.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic effect: A health effect from an exposure to more than one chemical where the combined effect of the chemicals together is greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.