ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

U.S. ARMY ABERDEEN PROVING GROUND,
EDGEWOOD AREA
ABERDEEN, HARFORD COUNTY, MARYLAND

EPA FACILITY ID: MD2210020036

MAY 20, 2008

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:

Site and Radiological Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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List of Abbreviations

AL	action level
APG	Aberdeen Proving Ground
APG-EA	Aberdeen Proving Ground, Edgewood Area
APG-AA	Aberdeen Proving Ground, Aberdeen Area
Army	U.S. Army
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BSAF	Biota to Sediment Accumulation Factor
BTC	Beef transfer coefficient
CHPPM	U.S. Army Center for Health Promotion and Preventative Medicine
CREG	cancer risk evaluation guide
CV	comparison value
CWM	chemical warfare material
DDTs	A sum of DDT, DDD, and DDE
DOD	Department of Defense
DU	depleted uranium
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
GIS	Geographical Information System
IEUBK	EPA's Integrated Exposure Uptake Biokinetic
IMPPA	Isopropyl Methylphosphonic acid
IUR	inhalation unit risk
kg	kilogram
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
MEC	Munitions and Explosives of Concern
mg	milligram
MPPA	Methylphosphonic acid
MRL	ATSDR's minimal risk level
ND	Non-Detect
NIOSH	National Institute of Occupational Safety and Health
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PCA	Tetrachloroethane
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PHA	public health assessment
ppb	parts per billion
ppm	parts per million
RAB	Restoration Advisory Board
REL	recommended exposure limit
RfC	EPA's reference concentration
RfD	EPA's reference dose
RMEG	reference dose media evaluation guide
ROD	Record of Decision
SSL	EPA's soil screening level
TCA	Trichloroethane
$\mu g/m^3$	Microgram per cubic meter

List of Abbreviations

UXO	unexploded ordnance
VOC	volatile organic compound

Summary

Aberdeen Proving Ground (APG) is an active U.S. Army (Army) post that encompasses approximately 72,000 acres of land and water in Harford and southeastern Baltimore Counties. APG is divided into two areas: the Aberdeen Area (APG-AA)[1] and the Edgewood Area (APG-EA). This public health assessment (PHA) addresses the APG-EA portion of APG, an area of approximately 13,000 land acres bordered by the Bush River to the east, the Chesapeake Bay to the south, the Gunpowder River and Baltimore County to the west, and Harford County to the north.

Munitions testing and training began at APG-EA in 1917. APG-EA was also used as a center for military chemical warfare material (CWM) research, development, testing, and storage. It was also a major receiving center for waste, including low-level radiological waste.

As a result of operations, contamination has been released to the groundwater, surface water, sediment, and soil at locations throughout APG-EA. These contaminants also may be released to air during range fires and may bioaccumulate in the food chain. In addition, past ordnance testing resulted in the presence of munitions and explosives of concern (MEC)[2] at several sites at APG-EA.

In preparing this PHA, the Agency for Toxic Substances and Disease Registry (ATSDR) obtained data from the Army and local water suppliers, and spoke with community members about their health concerns. Based on available data and community concerns, ATSDR evaluated contaminants in groundwater, surface water, sediment, surface soil, air, and the food chain for their potential to reach people and cause health effects. ATSDR also assessed possible harm from contact with MEC.

ATSDR has concluded that, although APG-EA is highly contaminated in some areas, the potential for people to be exposed to this contamination is decreased by access restrictions to the most contaminated portion of the post, and restrictions on contact with affected shorelines. However, there are a few ways in which people are or could be exposed to contamination or MEC:

Contact with surface water, sediment, and/or surface soil contamination. Sediment and surface water are contaminated in several areas on the post with a variety of substances. Surface soils are contaminated in areas with polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs),

1 APG-AA is listed on the US Environmental Protection Agency's National Priorities List (Superfund) as Aberdeen Proving Ground (Michaelsville LF).

2 Munitions or Explosives of Concern (MEC) include unexploded ordnance and other military munitions that have been abandoned or discarded.

pesticides, and metals. Localized contamination of sediment containing lead and surface soil containing lead and copper might cause minor, temporary health effects to workers, hunters, or trespassers who are exposed to continuously for extended periods of time. This conclusion, however, is based on data collected prior to the recent remediation activities (e.g., actions conducted since 2005), which was the data set available to ATSDR during the PHA process. The likelihood of health effects happening is small because people access these areas infrequently and soil contamination is localized. In addition, ongoing and completed remediation activities eliminate these potential exposures.

Ingestion of contaminated fish and aquatic animals. Fish were found to be contaminated with PCBs, DDTs, lead and mercury. Turtles are contaminated with PCBs, chlordane, DDE, copper, chromium, and lead. Crabs remain uncontaminated. Adverse health effects are not expected to occur as a result of the observed contamination, as long as people adhere to the fish consumption limits recommended by the Maryland Department of the Environment (MDE). The level of lead in the meat of some turtles is elevated, and could contribute to any existing lead exposure to children.

Ingestion of contaminated deer. Deer were found to have levels of lead which are of concern. However, it is not clear whether this contamination is from post activities or other sources. An elevated level of lead was observed in an off-post deer sample from Gunpowder Falls State Park. The source of elevated lead is unclear and additional sampling to assess lead levels in deer is recommended. Regardless of the source, the level of lead in the meat and liver of some deer could contribute to any existing lead exposure to children.

Contact with Munitions and Explosives of Concern (MEC). Munitions and explosives have been fired or disposed of on the post for many years. Workers and trespassers might contact unexploded munitions in restricted areas of the post. Recreational users may contact unexploded munitions if they do not follow post restrictions regarding shoreline contact.

Because the post is contaminated with hazardous substances, wastes, and MEC, it is imperative that access restrictions continue to be enforced.

Background

Site Description and History

Aberdeen Proving Ground (APG) is in southern Harford County and southeastern Baltimore County, Maryland, on the western shore of the Chesapeake Bay, and is bordered by the bay to the east and south (Figure 1). Gunpowder Falls State Park and residential areas are west of APG; the towns of Edgewood, Magnolia, Aberdeen, and Perryman are to the north.

APG is an active U.S. Army (Army) post that encompasses approximately 72,000 acres of land and water. APG is divided into two areas: the Aberdeen Area (APG-AA) and the Edgewood Area (APG-EA). APG-AA consists of approximately 17,000 land acres and is separated by the Bush River from APG-EA's approximately 13,000 land acres. Because of the complexity of environmental issues at APG, the different missions of APG-AA and APG-EA, and the physical separation of the two areas, they will be addressed in separate documents. This Public Health Assessment (PHA) addresses only the APG-EA portion. A separate PHA has been prepared for APG-AA, listed on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL) as Aberdeen Proving Ground-Michaelsville Landfill.

Military use of APG began in 1917 when the government acquired APG-AA and established the Ordnance Proving Ground. APG-EA was also acquired in 1917 and was established as the Edgewood Arsenal. These two facilities operated independently until 1971 when the Edgewood Arsenal became a part of APG. APG-EA historically was used as a center for military chemical agent research, development, and related activities. Specific activities included laboratory research, field testing of chemical warfare material (CWM) and munitions, and pilot-scale and production-scale CWM manufacturing. APG-EA has also been a center for CWM storage and a major receiving center for waste, including low-level radiological waste.

APG-EA currently supports a variety of tenants, including:

- the U.S. Army Soldier and Biological Chemical Command, which is responsible for the research, development, management, and maintenance of chemical and biological defense systems, and manages compliance with the chemical weapons treaty and provides support for worldwide disposal of CWM and weapons;
- the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), which supports the Army's preventative medicine program;
- the U.S. Army Medical Research Institute of Chemical Defense, which researches protection against chemical and biological weapons;
- the U.S. Army Edgewood Chemical Biological Center, which assists in the detection, decontamination, and management of chemical and biological defense systems;

- the U.S. Army Chemical Materials Agency, which stored and destroyed chemical agents; and
- the U.S. Army Environmental Center, which supports the Army's environmental program and focuses on environmental cleanup and compliance at APG.

Environmental Contamination and Safety Hazards

Operation of APG-EA, disposal of post wastes, and use and testing of CWM and munitions resulted in contamination of groundwater, surface water and sediment, and surface soil at various locations throughout the post. These contaminants may be released to air during range fires or bioaccumulate in the food chain. In addition, past ordnance testing resulted in the presence of unexploded munitions at several sites at APG-EA. Liquid chemical and industrial wastes were discharged directly to on-site streams until the late 1970s. Solid wastes were also discharged to surface waters if they could be thinned by heating or dilution [Lorah and Vroblesky 1989]. Most of the industrial waste discharge points were on the East and West Branches of Canal Creek with additional outfalls on Kings Creek and Bush River. Sanitary wastes were also discharged directly to surface waters until the construction of sewage treatment plants during WWII [DSHE 1999].

In 1976, APG began to identify locations at APG-EA where hazardous materials and unexploded ordnance (UXO) might have been released to the environment. Initial investigations included a review of historical documents to identify potential areas where releases may have occurred. Based on results from initial investigations EPA proposed in 1985 that APG-EA be placed on the NPL. The proposal was finalized in 1990, and APG-EA is now on the EPA's NPL.

The Army has identified many areas of known or potential contamination at APG-EA. Areas of potential contamination were grouped into ten study areas:

- Canal Creek
- O-Field
- J-Field
- Carroll Island
- Graces Quarters
- Westwood
- Bush River
- Lauderick Creek
- Nike area
- Other Edgewood areas

The relative locations of each of the study areas are shown in Figure 2.

ATSDR Involvement

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits at APG in March 1991 and April 1992. The intent of these site visits was to gain an understanding of current site conditions, learn about proposed and completed remedial actions, and identify community concerns. ATSDR reviewed site documents and toured the environmental study areas at APG. ATSDR staff spoke with the APG Environmental Management Division staff, the Directorate of Safety Health and Environment, and the EPA Remedial Project Manager for APG. Discussions also were held with members of the Army Health Clinic about

preventive medicine and industrial hygiene activities at APG. ATSDR also attended meetings of the Restoration Advisory Board (RAB) to discuss concerns among community members regarding public health effects related to environmental contamination at APG. ATSDR spoke with members of the RAB as well as with members of the general public.

In 1993, ATSDR issued a public health assessment on APG-EA for public comment. At that time, environmental contamination had not been well characterized because of the size and complexity of APG. As a result, ATSDR could not determine whether environmental contamination at APG was a public health hazard. ATSDR recommended that the Army conduct additional sampling and surveys to further characterize contamination, abandon contaminated wells according to federal and state regulations, install access controls to minimize contact with media contamination and UXO, and obtain information about fish, game, and recreational activities [ATSDR 1993a].

Because of the indeterminate findings of the 1993 draft PHA, as well as the unique nature of APG, ATSDR did not release a final version of the document. Instead, ATSDR later revisited the site while additional environmental sampling was being pursued. In October 1999 and April 2000, ATSDR visited APG and spoke with the APG Environmental Management Division staff, conducted a site tour, and attended a RAB meeting. Since then, additional sampling data has become available. This information was used to prepare this PHA. In addition, comments submitted to ATSDR on the 1993 draft PHA have been addressed in this PHA.

Demographics

ATSDR examines demographic data (i.e., population information) to determine the number of people potentially exposed to environmental chemicals and to determine the presence of sensitive populations, such as children (age 6 and younger), women of childbearing age (age 15-44), and the elderly (age 65 and older). Estimates of the numbers of people in these groups are listed in Table 1, for people who live on the APG-EA post, and the people who live within one mile of the APG-EA boundary.

Table 1: Estimated numbers of people living on or near the Aberdeen Proving Ground – Edgewood Area. [Census 1991 and Census 2001].

Population Group	On-Post Residents		Off-Post Residents (within one mile)		Total	
	1990 Census	2000 Census	1990 Census	2000 Census	1990 Census	2000 Census
Everyone	1,760	1,000	16,990	16,240	18,750	17,240
Ages 6 and Younger	170	190	2,220	1,800	2,390	1,990
Women Aged 15 to 44	360	280	4,360	3,700	4,720	3,980
Ages 65 and Older	10	10	950	1,170	960	1,180

In addition to people who live on or near the post, there are many people who are employed on the post. The Aberdeen Proving Ground (both the Aberdeen and the Edgewood Areas) have more than 5000 military personnel, more than 7500 civilian employees, and nearly 3000 contractors or employees of private businesses.

Land and Natural Resources Uses

Off-Post

The land surrounding APG-EA is occupied mostly by residential communities, which include local parks and schools. Five county parks are located near the northern boundary of APG-EA. These parks support playgrounds, pavilions and picnicking areas, boating launches and facilities, ice skating, fishing areas, and/or nature trails. In addition, the Gunpowder Falls State Park is located along the northern boundary of Graces Quarters. This park encompasses more than 11,000 acres along the Gunpowder River and supports picnicking areas, hiking trails, hunting, and horse trails. A swimming beach is on the shore of the Gunpowder River.

The majority of APG-EA lands are surrounded by the Chesapeake Bay and its tributaries. These waterways are used for boating, water skiing, trapping, and commercial and recreational fishing. The Army owns and restricts use of portions of the Chesapeake Bay, Gunpowder River, Bush River, and their tributaries near APG-EA. These restrictions are discussed as part of the on-post land uses in the following section of this PHA.

Drinking water for residences and businesses in the area is primarily drawn from surface water bodies upstream of APG, such as the Susquehanna River. Groundwater also provides a portion of the water supply for the region. In the past, Harford County operated four water supply wells in Joppatowne, approximately 1 mile north of APG-EA. Groundwater flow in this area is to the south, so that the wells are upgradient of Edgewood. The drinking water supply is treated and

regularly monitored to ensure that federal and state drinking water standards are met. Harford County and the Town of Aberdeen, which is located in Harford County, also operate water supply wells adjacent to and/or within the APG-AA boundaries. Impacts to these wells will be discussed in the PHA addressing APG-AA.

On-Post

APG-EA is an active military facility that supports three types of land use: current and former weapons testing areas, industrial areas, and on-site housing areas. Weapons testing areas currently occupy the southern half of APG-EA, which consists of Gunpowder Neck peninsula. O-Field, J-Field, and the Other Edgewood Areas are located on Gunpowder Neck. In the past, weapons testing was also conducted at Carroll Island and Graces Quarters located across the Gunpowder River from the main portion of APG-EA, at Westwood located in the northwestern corner of APG-EA, and at Lauderick Creek located in the northeastern corner of APG-EA. Access to former and current weapons testing areas from land is restricted by fences, gates, and guard check points. Access to these areas from the water is restricted by warning signs, buoys, and regular patrols by the military police and other security forces. Fences also separate APG-EA from the surrounding neighborhoods

Industrial areas are located in the Canal Creek, Westwood, and Bush River areas in the northern portion of APG-EA. Canal Creek supports most of the research laboratories, office buildings, and industrial facilities at APG-EA. Westwood and Bush River areas were used mostly as storage and waste handling and disposal areas. The Lauderick Creek area was used for training. The Nike area was used as a missile launch site.

On-site housing areas are located in the northern portion of APG-EA. Family housing for officers is located along the Gunpowder River in the Canal Creek area. Housing for Army personnel and their families is in the Bush River area. Currently, approximately 1,000 people live in on-post housing.

APG-EA was most active during World Wars I and II. During World War I, Army soldiers worked at the production facilities and firing ranges. During World War II, civilian employees worked at the production facilities and Army soldiers conducted testing and training programs at the test ranges. There is currently a mix of civilian and military workers in the offices, laboratories, and training facilities. At peak operations during World War II, approximately 50,000 people worked at APG. Currently, approximately 15,000 people work at APG. At APG-EA, most of these people work in industrial-type facilities.

The Army allows recreational use of APG-EA resources by active personnel and approximately 20,000 military retirees and their families. Playgrounds and picnic areas are located near the housing areas in Canal Creek and Bush River. A golf course is located near the Edgewood Road gate. Nature trails and a fishing spot

are found in the Bush River area. A campsite and boat docks are on Skippers Point. A boat ramp is in the Canal Creek area, on the Gunpowder River.

Much of APG-EA is covered with extensive woodlands and wetlands that provide habitat for many animals, including white tail deer, foxes, and wild turkeys. Under strict Army control, hunting and trapping is permitted in designated areas of APG-EA. Table 2 lists the game and areas where hunting is permitted. The Army issues hunting permits to people that have obtained state hunting licenses and are either associated with APG or are sponsored by an APG employee. Hunters must remain in designated areas only and follow Army regulations. Punishment for violating regulations is severe and may include revoking a persons hunting permit. Deer are the most common game sought at APG. During the fall deer hunting season, trained volunteers escort permitted hunters to assigned hunting locations. Hunters must remain within 50 yards of their assigned location. These locations are selected by the Army based on safety concerns for the hunter; areas may be closed if hazards are found in the area or testing activities are being conducted nearby. Between 700 and 900 deer permits are issued to hunters annually. Hunters are permitted to take as many as seven deer in each of three seasons, but the average hunter only takes two deer. Trespassers without permits take approximately 100 deer annually. In 1999, approximately 200 deer hunting permits were issued for hunting in APG-EA [DSHE 1992, USAG 2000].

Table 2: APG-EA Hunting Information [USAG 1998]

Game	Designated Areas
Upland Game (hunting)	Areas designated for upland game are located throughout Edgewood, excluding portions of the O-Field and all of the J-Field.
Woodchuck and Deer (bow hunting)	Bow-hunting is allowed in the same locations as for upland game.
Deer (from gun stands)	Deer stands are located throughout the same areas as for upland game.
Migratory Game Birds (from duck blinds)	Duck blinds are located along shorelines of Canal Creek (only a limited number of designated areas), Carroll Island, Graces Quarters, Westwood, Lauderick Creek, and Other Edgewood Areas
Snapping Turtle (trapping)	Trapping areas are located along shorelines and in wetlands within Canal Creek, adjacent to O-Field and J-Field, Carroll Island, Graces Quarters, Westwood, Bush River, Lauderick Creek, and the Other Edgewood Areas

APG-EA also includes water bodies as part of its property, including on-post streams and portions of the Gunpowder River, Bush River, and Chesapeake Bay. Because of concerns about recreational users contacting unexploded munitions, the Army has implemented restrictions in some areas. Several streams are always closed to public use at APG-EA. Fishing, boating, water skiing, and crabbing is permitted in navigable waters (Gunpowder River, Bush River, Chesapeake Bay, Dundee Creek, and Saltpeter Creek) in the evenings and on weekends, unless temporary restrictions are in effect because of testing. Commercial and

recreational fishers can catch a variety of fish and shellfish, such as striped bass, white perch, American shad, and blue crab. Boating and water skiing are also permitted in navigable waters provided that people do not touch any land, either along the shorelines or underwater. Swimming is prohibited in all water bodies at all times. The Army enforces these restrictions using signs, buoy markers, and patrol boats.

Crabbing, trapping, and shoreline fishing are allowed in designated areas. In the past, as much as 4,000 pounds of snapping turtles were annually harvested by trapping at APG-EA. Data from 1996 indicates that only about 800 pounds of snapping turtle were trapped for consumption that year [AEHA 1994; USAG 1996a, 1998d].

Drinking water at APG-EA is currently provided by surface water body intakes located upstream of APG. Surface water is treated and regularly monitored to ensure that federal and state drinking water standards are met. According to the EPA, no contaminants have been found in the APG water supply above the federal drinking water limits [EPA 2005a].

Groundwater has served as a secondary source of industrial and potable water. Since World War I, as many as 43 supply wells have been used at APG-EA. The few that remain active are used for non-potable water. Many others have been properly closed. The wells that have not been documented as closed are no longer visible and cannot be located.

Evaluation of Environmental Contamination and Potential Exposure Pathways

Introduction

What is Exposure?

ATSDR's PHAs are driven by exposure, or contact with contamination in the environment. If exposure occurs, chemical contaminants which have been disposed or released into the environment have the potential to cause adverse health effects. However, *a release does not always result in exposure*. People can only be exposed to a contaminant if they come in contact with that contaminant. Exposure may occur by breathing, eating, drinking, or touching a substance containing the contaminant.

How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people are exposed, were previously exposed, or might be exposed in the future to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (water, soil, air, or biota) has occurred, is

occurring, or will occur through ingestion (eating), dermal (skin) contact (touching), or inhalation (breathing).

If exposure was, is, or could be possible, ATSDR scientists then consider whether contamination is present at levels that might affect public health. ATSDR scientists select contaminants for further evaluation by comparing them against health-based comparison values (CVs). CVs are developed by ATSDR from scientific literature available on exposure and health effects. These CVs are derived for each of the different media and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., amount of water or soil consumed) and body weight.

CVs are not thresholds for adverse health effects. ATSDR's CVs establish contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above CVs, ATSDR further analyzes exposure variables (for example, duration and frequency), the toxicology of the contaminant, and other epidemiology or medical studies.

Some of the CVs used by ATSDR scientists include:

- ATSDR's Environmental Media Evaluation Guide (EMEG, iEMEG, and aEMEG)
    - is based on ATSDR's Minimal Risk Level, an exposure dose below which no adverse health effects are expected to occur.
    - uses estimates on how much and how long a person may be exposed.
    - can be different exposure timeframes:
        - chronic, or long-term exposure lasting over a year (EMEG);
        - intermediate exposure lasting from two weeks to a year (iEMEG); and
        - acute exposure lasting up to two weeks (aEMEG).
- ATSDR's Reference Dose Media Evaluation Guide (RMEG):
    - is based on EPA's Reference Dose, an exposure dose below which no adverse health effects are expected to occur;
    - uses estimates on how much and how long a person may be exposed; and
    - is developed for chronic, or long-term exposure.
- ATSDR's Cancer Risk Evaluation Guide (CREG):
    - is a concentration at which the theoretical risk of excess cancer from exposure is one in a million;
    - is based on EPA's oral cancer slope factor or inhalation unit risk;
    - uses estimates on how much and how long a person may be exposed;
    - is developed for lifetime exposures lasting as long as 70 years; and
    - in most cases, is *extremely* protective of public health.

- EPA's Maximum Contaminant Level (MCL) is an enforceable drinking water regulation.
- EPA's Soil Screening Level (SSL) is a health-based screening level.

If no CV is available, a substance will be evaluated individually based upon a review of the toxicological literature.

CVs are further described in the Appendix. More information about the ATSDR evaluation process can be found in ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html.

If someone is exposed, will they get sick?
Exposure does not always result in harmful health effects. The type and severity of health effects that occur in an individual from contact with a contaminant depend on many factors: the exposure concentration (how much); the frequency and/or duration of exposure (how often and for how long); the way in which the individual was exposed (breathing, eating, drinking, or touching); and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur as a result of exposure to a contaminant in the environment.

There is considerable uncertainty about the true level of exposure to environmental contamination. To account for the uncertainty and to be protective of public health, ATSDR scientists typically use high-end, worst-case exposure level estimates as the initial screen for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than the levels to which people are really exposed. If the exposure levels indicate that adverse health effects are possible, then a more detailed review of exposure combined with scientific information from the toxicological and epidemiologic literature about the health effects from exposure to hazardous substances is performed.

Identification of Potential and Completed Exposure Pathways at APG-EA

Summary of Known Contamination on the Post

Many investigations have been made about potential contamination at APG-EA. Results of most of those investigations since the early 1990s have been included in a single database provided to ATSDR by APG [USAG 2004]. This database was reviewed to evaluate known contamination of the post, as well to consider the extent of the sampling and analysis. Information in this database is the result of investigations into areas of suspected or known contamination. As such, the sampling is not random. Instead, it is biased, so that it is representative of contaminated areas; it is not representative of the entire post, which is comprised of both contaminated and uncontaminated areas.

A summary of the contamination in various environmental media is given in Table 3. The presence of moderate or high levels of contamination in an environmental medium does not indicate that people are experiencing adverse health effects; this depends upon whether people are exposed to the contamination. Also, most of the moderate and high levels of contamination are usually localized to a few areas. Details of any contamination to which people are exposed is discussed in more detail later in this document.

Table 3: Summary of known contamination observed on APG-EA [USAG 2004]. Note: Information in this table does not consider whether people are actually being exposed to contaminated environmental media at APG-EA. Possible exposures will be evaluated later in this document.

	Ground water	Sediment	Surface Water & Seeps	Surface Soil (to one foot deep)	Subsurface Soil	Air	Fish	Deer
Munitions-Related	Moderate*	Moderate*	Low*	Low*	Low*	Low		ND
PAHs	ND	Moderate	Low	Moderate	Moderate			
PCBs	ND	Moderate	Low	**High**	Low	Low	Moderate	ND
Pesticides	Moderate	Moderate	Low	Moderate	Low	Moderate	Moderate	ND
Metals	**High**	**High**	**High**	**High**	**High**	Moderate	Low	Moderate
Solvents	**High**	Low	**High**	Moderate	Moderate	Moderate		
Radionuclides	Low	Low	Low	Low	Low	Low		

*** -** Perchlorate was not analyzed for
ND – Substances were analyzed for, but not detected.
Blank entries – Media was not analyzed for substance.
Low – Substances were detected, but below concentrations that might cause health effects.
Moderate – At least one substance in one sample was detected at a concentration that could cause health effects if children were exposed every day for as long as 1 year.
High – At least one substance in one sample was detected at a concentration that could cause health effects if adults or children were exposed every day for as long as 1 year.

Who might be exposed?

ATSDR reviewed information about people who may be present on or near the post, and information about what controls are in place to prevent contact with contamination. At APG-EA, ATSDR considered the populations most likely to be exposed. This PHA focuses on the most relevant:

- *On-post workers.* Both military and civilian personnel work at APG-EA. Most Army personnel are stationed at APG-EA for 2 to 3 years before transferring to other locations. Military personnel may work in APG's offices, laboratories, training facilities, or firing ranges while stationed at APG. Civilian personnel, however, may be employed in APG's offices, laboratories, or productions facilities for many years. In evaluating potential exposures to workers, ATSDR considers only those exposures that occur inadvertently as a result of environmental contamination. Exposures that

occur as part of normal work practices are regulated under the Occupational Health and Safety Administration (OSHA) regulations and are not evaluated by ATSDR in this PHA.

- *On-post residents.* Military personnel and their families may reside in housing located in Canal Creek and Bush River. Military personnel usually live in on-post housing while stationed at APG for 2 to 3 years.

- *Off-post residents.* Residential neighborhoods are located along the northern boundary of APG-EA, near the study areas Westwood, Canal Creek, and Lauderick Creek, and along the eastern boundary of APG-EA, near the study areas Graces Quarters and Carroll Island.

- *Recreational users.* Playgrounds, picnic areas, nature trails, campsites, a boat club, and a golf course are available for use by active post personnel, as well as military retirees and their families. Designated water bodies (Gunpowder River, Bush River, Chesapeake Bay, Dundee Creek, and Saltpeter Creek) are also open to members of the public for fishing, boating, water skiing, and crabbing. Recreational users may include on-post workers, on-post residents, and off-post residents.

- *Hunters and trappers.* The Army permits hunting and trapping in portions of APG-EA. Hunters must receive a permit from the state and from the Army. Only personnel associated with APG or sponsored by an APG employee may obtain a permit. Hunters, trappers, and their families likely consume animals taken from APG-EA.

- *Fishers and crabbers.* Fishers may fish from boats in navigable waters (Chesapeake Bay, Bush River, Gunpowder River, Dundee Creek, and Saltpeter Creek). Crabbers may harvest crab from shores near APG-EA. Fishers and crabbers may include on-post workers, on-post residents, and off-post residents that return to the area year after year for many years. Fishers, crabbers, and their families probably consume fish and crab taken from near APG-EA.

- *Trespassers.* To limit trespassing, the Army maintains fences and signs stating access restrictions, and notifies boat owners and fishers through local boat launches and sports clubs. Regular patrols also reduce the potential frequency of trespassing. Signs clearly marking areas of UXO are posted throughout restricted access areas. A small number of people, however, may disregard access restrictions and trespass on APG-EA lands. Trespassers' exposures to site contaminants would be limited because the areas of greatest contamination are secured so that trespassing is difficult.

How Might People be Exposed?

After identifying potentially exposed populations, ATSDR reviewed how these populations use the land and resources at the post to identify possible exposure pathways (i.e., how people may contact site contaminants). ATSDR then evaluated whether or not these exposures are actually occurring, and if so, could these exposures lead to adverse health effects. At APG-EA, ATSDR considered the following possible exposure pathways:

- Ingestion of contaminated groundwater
  - Off-post residents are potentially exposed through private wells near the Edgewood site boundary.
- Incidental ingestion of contaminated surface water and sediment
  - On-post workers are potentially exposed infrequently during work in contaminated areas.
  - On-post residents are potentially exposed near the housing areas.
  - Recreational users are potentially exposed while on the post.
  - Hunters and trappers are potentially exposed while on the post.
  - Fishers and crabbers are potentially exposed to contamination in surface water and sediment while off the post. Although fishing is allowed in some areas on the post, fishers are not allowed to contact the shoreline except in limited areas, and so would not become exposed while on the post.
  - Trespassers are potentially exposed in accessible areas of the post.
- Incidental ingestion of contaminated surface soil
  - On-post workers and residents are potentially exposed in the cantonment[3] areas of the post. Their exposures in other areas of the base occur very infrequently.
  - Recreational users are potentially exposed while on the post.
  - Hunters and trappers are potentially exposed while on the post.
  - Trespassers are potentially exposed in accessible areas of the post.
- Inhalation of air emissions from range fires
  - On-post workers and residents are potentially exposed while on the post.
  - Off-post residents are potentially exposed in areas near the post.
  - Recreational users are potentially exposed while on the post.
  - Hunters and Trappers are potentially exposed while on the post.
  - Fishers and crabbers are potentially exposed while near the post.
  - Trespassers are potentially exposed while on the post.
- Ingestion of contaminants which have accumulated in the food chain
  - Hunters, trappers, and their families are potentially exposed when eating game harvested from the post.
  - Fishers, crabbers, and their families are potentially exposed when eating fish and crab harvested near the post.

3 The cantonment of a military installation consists of the developed portion.

- Contact with Munitions and Explosives of Concern
  - On-post workers are potentially exposed infrequently during work in contaminated areas.
  - Recreational users who ignore restrictions may come into contact with munitions and explosives of concern (MEC) along shorelines.
  - Trespassers may come into contact with MEC while in accessible areas of the post.

A summary of these potential exposure pathways which are considered in this PHA is given in Table 4.

Table 4: Exposure pathways considered in this PHA

Exposed Population	Groundwater Ingestion	Surface Water and/or Sediment Ingestion	Surface Soil Ingestion	Air Inhalation	Food Chain	Munitions and Explosives of Concern (MEC)
On-Post Workers		✓	✓	✓		✓
On-Post Residents		✓	✓	✓		
Off-Post Residents	✓			✓		
Recreational Users		✓	✓	✓		✓
Hunters and Trappers		✓	✓	✓	✓	
Fishers and Crabbers		✓		✓	✓	
Trespassers		✓	✓	✓		✓

For each of these exposure pathways, ATSDR conducted a detailed evaluation of how populations might contact contaminants through a given exposure pathway, and whether this exposure could potentially result in harm.

Ingestion of Contaminated Groundwater

Hydrogeology

> ***Summary***
> *Although a few private wells are near the post boundary, they are upgradient from the post. Therefore, it is unlikely that these wells are impacted by contamination from the post.*

Groundwater in the region is found in a complex structure of aquifers. In general, groundwater is found in three aquifers (surficial, upper, and lower) that are separated by two confining layers (upper and lower). The thickness and depth of the aquifers and confining layers increase from west to east. Groundwater flow is generally to the southeast; however, groundwater in the surficial aquifer generally flows from topographical highs to the nearest surface water body, such as the Gunpowder River or Bush River. Groundwater supply wells primarily obtain water from the lower aquifer. Each aquifer and confining layer is described below, in order from shallowest to deepest [ICF 1995].

- The **surficial aquifer** is unconfined or semi-confined and may be shallow in some areas and over 100 feet thick in other areas. This aquifer is composed of clay and sand found in recent alluvium (river deposits) or Talbot Formation soil. Near the Chesapeake Bay and its tributaries, groundwater in the surficial aquifer is influenced by the changing tides.

- The **upper confining layer** is present only in some areas. It is made of clay and silt that limits groundwater migration from the surficial aquifer down to the upper aquifer.

- The **upper aquifer** is confined in most areas of APG-EA, exceptions are portions of Canal Creek, J-Field, Graces Quarters, Westwood, and the Other Edgewood Areas, and ranges from 10 to 100 feet thick. The aquifer is composed of silt, sand, and gravel found in Talbot Formation or Potomac Group soils.

- The **lower confining layer** is present throughout the region. This layer is composed of 15 to 65 feet of clay in the Potomac Group soils that limits or prevents groundwater migration from the upper aquifer down to the lower aquifer.

- The **lower aquifer** is confined and has an undetermined thickness. It is composed of sand found in the Potomac Group soils. This aquifer provides water for private and municipal water supply wells.

Groundwater Use

Drinking water for off-post residences and businesses in the area is primarily drawn from surface water bodies upstream of APG, such as the Susquehanna River. Although groundwater also provides a portion of the water supply for the region, no public or post supply wells for potable water are currently on or near APG-EA.

Some homes near the APG-EA boundary might use private wells as a source of potable water. In 1994, a private well survey was conducted to identify homes and businesses located along APG's boundaries that rely on private wells for drinking water. Private well information was collected by reviewing state records and mailing surveys to nearby homes and businesses. Private wells in Baltimore County were identified west of Carroll Island and Graces Quarters; and in Harford County north of Westwood and Canal Creek [ASI 1994].

Nature and Extent of Known Contamination – On Site

As a result of environmental releases, areas of groundwater contamination are found at various locations throughout APG-EA. Chemicals found in groundwater include chlorinated solvents, petroleum and fuel components, pesticides, metals, and explosives. Radionuclides were found at low levels in the groundwater, and

include Bismuth-214, Lead-210 and 214, Molybdenum-99, Potassium-40, Radium-224 and 226, Tritium, Uranium-235, and Zirconium-89 [APG database]. However, groundwater is not used as a source of drinking water on the post.

Since there are currently no potable-water wells on the post, the only way people could be exposed to groundwater contamination from the post is from private wells near the post border. Details of the types of contamination in on-post groundwater near the APG-EA border are listed in Table 5. Perchlorate, a munitions-related compound, was not analyzed for in any of the samples. Groundwater in the Nike area is currently being extracted and treated to remove the solvent contamination.

Table 5: Contamination in on-post groundwater near the APG-EA border [USAG 2004].
Note: Information in this table does not consider whether people are actually being exposed to contaminated groundwater at APG-EA.

	Carroll Island	Graces Quarters	Canal Creek Area (near border)	Westwood Area (near border)	Nike Area
Munitions-Related	ND*	ND*	ND*	Moderate*	
PAHs	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND
Pesticides	ND	ND	ND	Low	Moderate
Metals	Low	Low	Moderate	**High**	Moderate
Solvents	ND	**High**	Moderate	Moderate	Moderate
Radionuclides		Low		Low	

*** -** Perchlorate was not analyzed for
ND – Substances were analyzed for, but not detected.
Blank entries – Media was not analyzed for substance.
Low – Substances were detected, but not at concentrations that might cause health effects.
Moderate – At least one substance in one sample was detected at a concentration that could cause health effects if children were exposed every day for as long as 1 year.
High – At least one substance in one sample was detected at a concentration that could cause health effects if adults or children were exposed every day for as long as 1 year.

Nature and Extent of Known Contamination – Off Site

Although groundwater on the post is contaminated, private wells in the area are not expected to be impacted, since they are not in areas which are likely to be downgradient of APG-EA.

Between 1992 and 1995, 14 residential wells in Baltimore County near Carroll Island and Graces Quarters were sampled for volatile organic compounds, inorganics, explosives, and/or CWM degradation products. Only lead (to 40 parts per billion [ppb]) was detected above its CV (an EPA Action Level of 15 ppb) [Dames & Moore 1998].

The Army also sampled eight residential wells in Harford County north of the Westwood and Canal Creek areas in 1995–1996. Samples were analyzed for

volatile organic compounds (VOCs), explosives, and unique military compounds. No contaminants were detected above CVs in any of the wells [Gannett Fleming 1997; Jacobs 1995a].

Evaluation of Potential Public Health Hazards

Off-post residents (adults and children) may have been exposed to lead in private wells in Baltimore County near Carroll Island and Graces Quarters at a maximum known level of 40 ppb. This level of lead, if consumed over a long period of time, might slightly increase a child's blood lead level. Under usual circumstances, this slight increase would not lead to any adverse health effects. However, should the child also be exposed to other sources of lead, the increase in blood lead levels would be cumulative, increasing the potential for adverse health effects [ATSDR 1999a].

Contact with Surface Water and/or Sediment Contamination

Nature and Extent of Known Contamination – Post-Wide

On-post workers could be exposed to contamination in sediment and surface water throughout the post. However, because of the localized nature of the contamination, and because these areas are not in usual workplaces, on-post workers are infrequently exposed to contamination.

Swimming and any activities that result in people touching land—along the shorelines or underwater—are prohibited. The Army also prohibits use of most streams at all times. During ATSDR's 1991 site visit, however, troops on a training exercise were seen jumping and wading through Canal Creek. Training within Canal Creek was not a common practice and troops were immediately notified to cease any training programs within Canal Creek.

Summary

Sediment and surface water are contaminated in several areas on the post with a variety of substances.

On-post workers and trespassers who remain for an extended period of time in the vicinity of the sediments which are most contaminated by lead might experience minor changes in blood chemistry, which end soon after exposure. Exposures, however, should be minimal because contaminated areas are localized and accessed infrequently.

Trespassers who ignore and circumvent access restrictions placed upon most water bodies within the APG-EA boundaries might be exposed to contamination in surface water and sediment across the post. Trespassers are assumed to access the base only infrequently, and so would not often be exposed to contamination in sediments and surface water.

Post-wide contamination was evaluated for exposure to adults (including teenagers) who might be on-post workers or trespassers, and who access the contaminated areas on an infrequent basis. CVs were used for adult exposure, and for a short timeframe: acute (every day for up to two weeks); or intermediate

(every day for up to one year). Table 6 summarizes the sediment and surface water contaminants which exceed these CVs or have no CVs.

Table 6: Noteworthy contaminants in sediment and surface water across APG-EA, screened using comparison values (CVs), if available, for adults with short-term exposure [USAG 2004].

Medium	Contaminant	Median and [Range] Of Detected Concentrations and (detects / samples)	Comparison Value[a]
Sediment	Metals		
	Arsenic	4.7 ppm [0.0002 to 539 ppm] (701/730)	None[b]
	Lead	28.6 ppm [0.002 to 26,300 ppm] (886/887)	None[b]
Surface Water	Munitions-Related		
	Beta-Thiodiglycol	12 ppb [4 to 219 ppb] (28/502)	None[b]
	Isopropyl methyl phosphonic acid	94 ppb [0.9 to 1,720 ppb] (33/457)	None[b]
	Methyl phosphonic acid	400 ppb [21 to 10,700 ppb] (4/424)	None[b]
	Metals		
	Arsenic	3 ppb [0.7 to 83.7 ppb] (138/586)	None[b]
	Lead	3.8 ppb [0.35 to 1,590 ppb] (368/578)	None[b]
	Solvents		
	Trichloroethylene	7 ppb [1 to 3,620 ppb] (39/597)	None[b]
	Vinyl Chloride	14 ppb [1.4 to 360 ppb] (11/531)	None[b]

a: CVs are for short-term exposure to adults, lasting no longer than two weeks.
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Nature and Extent of Known Contamination – On-Post Residential Areas

Military families living at APG-EA might contact contamination in sediment and surface water if it is present near their homes. Family housing is located in the Canal Creek and the Northern Bush River areas. Noteworthy contaminants in sediment and surface water near family housing are listed in Tables 7 and 8. Contaminants which exceed CVs or do not have CVs include metals and CWM degradation products.

Table 7: Noteworthy contaminants in sediment and surface water in the Northern Bush River area, screened using comparison values (CVs), if available, for long-term exposure [USAG 2004].

Medium	Contaminant	Median and [Range] of Detected Concentrations and (detects / samples)	Comparison Value[a]
Sediment	Metals		
	Lead	9 ppm [2 to 484 ppm] (14/14)	400 ppm (SSL)
Surface Water	Munitions-Related Substances		
	Isopropyl methyl phosphonic acid	94.2 ppb (1/22)	None[b]
	Methyl phosphonic acid	748 ppb (1/26)	None[b]
	Metals		
	Arsenic	2.8 ppb [2.2 to 6.5 ppb] (4/24)	0.02 ppb (CREG)
	Lead	2.7 ppb [0.9 to 35.4 ppb] (21/25)	15 ppb (AL)

a: CVs are for long-term exposure (> 1 year) to children and adults
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Table 8: Noteworthy contaminants in sediment and surface water near housing in the Canal Creek area, screened using comparison values (CVs), if available, for long-term exposure [USAG 2004].

Medium	Contaminant	Median and [Range] of Detected Concentrations and (detects / samples)	Comparison Value[a]
Sediment	Metals		
	Arsenic	22 ppm [0.5 to 219 ppm] (19/20)	0.5 ppm (CREG)
	Lead	110 ppm [0.07 to 646 ppm] (20/20)	400 ppm (SSL)
	Mercury	4.4 ppm [0.0005 to 32.7 ppm] (18/19)	23 ppm (SSL)
Surface Water	Metals		
	Arsenic	10 ppb [0.7 to 74.5 ppb] (28/131)	0.02 ppb (CREG)
	Lead	3.8 ppb [0.4 to 600 ppb] (13/16)	15 ppb (AL)

a: CVs are for long-term exposure (> 1 year) to children and adults

Nature and Extent of Known Contamination – Recreational Areas

People might come into contact with contaminated surface water and sediment while using recreational areas on the post. Picnic and camping areas are located at Skippers Point, on Lauderick Creek. A golf course is near the main gate. Boat docks and ramps are at Skippers Point, Gunpowder River, and at the mouth of Lauderick Creek. Facilities at the latter boat dock include the Gunpowder Neck Boating Activity.

Surface water and sediment at the golf course flow onto the post from off-site. The only potentially-contaminated site near the golf course is the Old Hospital and Administrative area, which included a photographic laboratory and a patient decontamination ward. Two sediment samples and one surface water sample were collected from this area. Low levels of two CWM degradation products were found in surface water; however, no contaminants were found at levels of concern [Jacobs 1995a]. More recent sampling found no CWM degradation products. A Record of Decision (ROD) concluded that no further action is warranted at this site [USAG 2008]. People using the golf course are not expected to be exposed to contamination in sediment or surface water.

No contamination is expected near the Skippers Point recreational area or the Gunpowder Neck boat docks. No major contaminants were observed to exceed CVs in the few samples of sediment and surface water taken from these areas.

Therefore, people using these facilities are not expected to be exposed to contamination in sediment or surface water.

The single contaminant of concern in sediment and surface water near the Gunpowder River boat ramp is lead. Out of 8 sediment samples and 12 surface water samples taken from area, only one sample of each medium contained elevated levels of lead—549 ppm in sediment and 619 ppb in surface water. However, these samples were found in the skeet range, which is across the road from the boat ramp. It is unlikely that children would access the skeet range while their families were using the boat ramp.

Nature and Extent of Known Contamination - Hunting & Trapping Areas

Hunters and trappers can access several water bodies, streams, and creeks on the APG-EA. Sampling of the sediment from water bodies and streams in hunting and trapping areas indicates contamination with arsenic and lead. Surface water is contaminated with arsenic, lead, and munition-related compounds. Noteworthy contaminants which exceed CVs, if available, are detailed in Table 9.

Table 9: Noteworthy contaminants in sediment and surface water in hunting and trapping areas of APG-EA, screened using comparison values (CVs) for adults with short-term exposure [USAG 2004].

Medium	Contaminant	Median Concentration and (detects / samples)	Comparison Value[a]
Sediment	Metals		
	Arsenic	3.4 ppm [0.001 to 539 ppm] (280/293)	None[b]
	Lead	16 ppm [0.07 to 2,610 ppm] (290/291)	None[b]
Surface Water	Munitions-Related		
	Beta-Thiodiglycol	8.5 ppb [4 to 213 ppb] (7/227)	None[b]
	Isopropyl methyl phosphonic acid	83 ppb [0.9 to 1,720 ppb] (11/224)	None[b]
	Methyl phosphonic acid	385 ppb [21 to 748 ppb] (2/226)	None[b]
	Metals		
	Arsenic	2.8 ppb [0.7 to 74.5 ppb] (59/292)	None[b]
	Lead	4 ppb [0.4 to 619 ppb] (189/286)	None[b]

a: CVs are for short-term exposure to adults
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Nature and Extent of Known Contamination - Fishing & Crabbing Areas

Fishing from boats is permitted in Bush River, Chesapeake Bay, Gunpowder River, and Dundee Creek. Recreational use of these water bodies is allowed in the evenings, on weekends, and on most national holidays, unless temporary restrictions are in effect because of testing. Swimming and any activities that result in people touching land—along the shorelines or underwater—are prohibited. The Army also prohibits use of most other streams at all times.

Because of the restrictions on contact with the shoreline, fishers, and crabbers are not expected to be exposed to contamination in either surface water or sediment on the post.

Evaluation of Potential Public Health Hazards

To assess exposures to contaminants found above CVs in sediment and surface water, ATSDR calculated exposure doses based on conservative assumptions about how a person may contact these environmental media. ATSDR assumed

that a person, either adult or child, would use the recreational areas 5 days a week for 26 weeks a year (130 days) over a period of 30 years for an adult and 6 years for a child.[4] Adult or child hunters and trappers were assumed to hunt or trap two days a week for a month each year. Adult workers and trespassers were assumed to access contaminated areas every day for up to two weeks. Based on studies of how much soil a person may accidentally ingest when outside, ATSDR assumed that an adult may accidentally ingest 100 milligrams (mg) of sediment and a child may accidentally ingest 200 mg of sediment every day.[5] In addition, both adults and children were assumed to accidentally swallow 10 milliliters of surface water every day. An additional, conservative assumption was made that people were exposed to the maximum level of contamination observed during sampling; this assumption overestimates actual exposures. Exposures of children to lead in sediment and surface water were estimated by using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) for Lead in Children [EPA 2005b].

Exposure doses were estimated for each contaminant in the sediment and surface water for adult workers, hunters and trappers, and trespassers, and for children residents on-post, and who use the Gunpowder River boat ramp. These doses were then compared to those found in ATSDR Toxicological Profiles, and in the toxicological literature to determine whether they could cause adverse health effects. With the exception of lead, none of the contaminants in sediment or surface water are expected to cause adverse health effects. The exposure dose for lead was elevated, and will be discussed in more detail.

Lead in Sediment

Lead was highly elevated in sediment in the northeastern portion of the Canal Creek area. The highest two levels measured were 26,300 and 16,300 ppm. The amount of lead that workers, trespassers, and hunters might be exposed to in these areas is similar to levels which caused small, reversible changes in blood chemistry in people who voluntarily took lead acetate in laboratory experiments. However, lead acetate is much more soluble in water than the forms of lead found in sediment. The less soluble forms of lead are absorbed into the bloodstream at a slower rate, and some may pass completely through the digestive tract without being absorbed. For this reason, these effects are less likely to occur to people accessing these areas.

A few of the several samples of sediment from areas near on-post housing were elevated. Lead was elevated in a single sample in the Northern Bush River area, and in two samples near the Canal Creek housing area. The patchy nature of the

4 An exposure duration of 30 years for adults represents an upper estimate of how often people live in a single residence. An exposure duration of 6 years is considered to represent childhood exposures from birth to 6 years, when exposures are highest [EPA 1997].

5 The amount of soil ingested daily drops during the winter when the ground is frozen or covered in snow.

sediment contamination makes it unlikely that children would be exposed to sufficient amounts of lead from sediments to cause adverse health effects.

Contact with Surface Soil Contamination

ATSDR defines surface soil as the top 3 inches of soil. It is the top 3 inches that people are most likely to be exposed to, through activities such as digging and playing, or because it may become wind-borne, and then inhaled and subsequently ingested by people nearby.

Surface soils at APG-EA have been sampled to one foot depth. These samples were used to approximate the composition of the top 3 inches of soil. Contaminant concentrations presented in Tables 10 through 12 only represent conditions at APG-EA for a single point in time. ATSDR reviewed data collected through 2005, which was the data set available to ATSDR during the PHA process. However, the Army has conducted remediation activities since 2005 and continues to investigate and remediate soil contamination found at the post.

Summary

Surface soils are contaminated with PAHs, PCBs, pesticides, and metals in some areas of the post. The Army, however, continues to conduct remediation activities throughout the post to eliminate possible exposures.

An evaluation of post-wide soil contamination data collected prior to remediation activities conducted since 2005 identified copper and lead as possible concerns. On-post workers, hunters, and trespassers might accidentally ingest enough contaminated soil to experience gastric distress (copper) or small, reversible changes in blood chemistry (lead) if they remain in the areas of highest contamination all day. The localized nature of the contamination and the infrequent access to contaminated areas minimize these potential exposures. Ongoing and completed remediation activities eliminate these potential exposures.

Nature and Extent of Known Contamination – Post-Wide

On-post workers may come in contact with contaminated surface soil throughout the post. However, because of completed and ongoing remediation activities, the localized nature of the contamination, and because these areas are not in usual workplaces, on-post workers are infrequently exposed to contamination.

Trespassers who ignore and circumvent access restrictions within the APG-EA boundaries might be exposed to contamination in surface soil across the post. Trespassers are assumed to access the base only infrequently, and so would not often be exposed to contamination in surface soil.

Post-wide contamination was evaluated for exposure to adults (including teenagers) who might be on-post workers or trespassers, and who access the contaminated areas on an infrequent basis. CVs were used for adult exposure, and for a short timeframe: acute (up to two weeks); or intermediate (up to one year).

Table 10: Noteworthy contaminants in surface soil to one foot depth across APG-EA, screened using comparison values (CVs), if available, for adults with short-term exposure [USAG 2004].

Contaminant	Median and [Range] of Detected Concentrations (ppm) and (detects / samples)	Comparison Value[a] (ppm)
PAHs		
Benzo(a)anthracene	0.2 [0.0008 to 126] (353/1171)	None[b]
Benzo(a)pyrene	0.2 [0.006 to 107] (336/1163)	None[b]
Benzo(b)fluoranthene	0.2 [0.015 to 151] (403/1159)	None[b]
Benzo(ghi)fluoranthene	0.14 [0.01 to 56.6] (247/1007)	None[b]
Benzo(k)fluoranthene	0.2 [0.014 to 100] (338/1159)	None[b]
Benzo(ghi)perylene	0.2 [0.04 to 23] (11/156)	None[b]
Chrysene	0.2 [0.0003 to 129] (410/1171)	None[b]
Dibenzo(a,h)anthracene	0.12 [0.003 to 26.1] (130/1162)	None[b]
Dibenzofuran	0.2 [0.02 to 34] (62/1156)	None[b]
Indeno(1,2,3-cd)pyrene	0.14 [0.01 to 54.8] (263/1162)	None[b]
PCBs		
Aroclor 1248	0.4 [0.04 to 9,370] (84/1100)	None[b]
Aroclor 1254	0.4 [0.01 to 325] (49/1101)	20 (intermediate EMEG)
Aroclor 1260	0.2 [0.003 to 75] (160/1101)	None[b]
Metals		
Copper	14 [0.9 to 40,900] (1352/1384)	10,000 (acute EMEG)
Lead	34 [1.1 to 94,200] (1382/1396)	None[b]

a: CVs are for short-term exposure to adults
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Table 10 lists noteworthy contaminants found in surface soil throughout APG-EA. High levels of polyaromatic hydrocarbons (PAHs) were found in only a few samples of surface soil, mainly in the central portion of the Canal Creek area. High levels of polychlorinated biphenyls (PCBs) were found near Building E3640, in the western portion of the Canal Creek area. High levels of copper were found in surface soils near the WWI Chlorine Plant/Gas Mask Factory in the eastern portion of the Westwood area, and also in the new O-Field site. Elevated levels of lead in surface soil were found in J-Field, near Gun Club Creek, and in the eastern portion of the Westwood area. Contaminated soils in the Westwood area, however, have been removed as part of ongoing remediation activities. Remediation activities, including installation of soil cover over toxic burn pits at J-Field and reforestation of the area, are completed or ongoing as part of the ROD for J-Field [EPA-Region III 2008].

Nature and Extent of Known Contamination – On-Post Residential Areas

Military families living at APG-EA might contact contamination in surface soil if contamination is present near their homes.

No contaminants were found to exceed CVs in a few samples of surface soil taken from the area near the Canal Creek housing.

No potentially-contaminated sites are in the immediate vicinity of the family housing in the Bush River area; subsequently, no surface soil sampling has been made in family housing. However, nearby surface soil samples from the Northern Bush River area indicate moderate levels of pesticides and metals, and a few high levels of lead. Details of the contaminants that exceed CVs, if available, are given in Table 11. Moderately high levels of lead were observed in two samples in the 'Lead Delineation Area' near the Old Bush River Road Dump. This area is not immediately near the family housing, so that younger children would not likely access it.

Table 11: Noteworthy contaminants in surface soil to one foot depth in the Northern Bush River area at APG-EA, screened using comparison values (CVs), if available, for long-term exposure [USAG 2004].

Contaminant	Median and [Range] of Detected Concentrations (ppm) and (detects / samples)	Comparison Value[a] (ppm)
Pesticides		
DDE	0.06 [0.004 to 3.8] (44/44)	2 (CREG)
DDT	0.04 [0.001 to 4] (43/44)	2 (CREG)
Metals		
Arsenic	3.3 [0.75 to 34.9] (43/44)	0.5 (CREG)
Cadmium	0.77 [0.28 to 15] (25/44)	10 (EMEG)
Lead	23 [8.7 to 2,470] (44/44)	400 (SSL)

a: CVs are for long-term exposure (> 1 year) to children and adults

Nature and Extent of Known Contamination – Recreational Areas

People might come into contact with contaminated surface soil while using recreational areas on the post. Picnic and camping areas are located at Skippers Point, on Lauderick Creek. A golf course is near the main gate. Boat docks and ramps are at Skippers Point, Gunpowder River, and at the mouth of Lauderick Creek. Facilities at the latter boat dock include the Gunpowder Neck Boating Activity.

The only potentially-contaminated site near the golf course is the Old Hospital and Administrative area, which included a photographic laboratory and a patient decontamination ward. A single soil sample was collected from this area. No contaminants were found at levels of concern in this sample [Jacobs 1995a]. Since little contamination is expected in this area and the ROD concluded that no further action is warranted at this site [USAG 2008], people using the golf course are not expected to be exposed to contamination in surface soil.

Little contamination is expected near the Skippers Point recreational area or the Gunpowder Neck boat docks. In addition, no major contaminants were observed to

exceed CVs in the few samples of surface soil taken from these areas. Therefore, people using these facilities are not expected to be exposed to contamination in surface soil.

Arsenic and lead were observed at levels of concern in surface soil collected near the Gunpowder River boat ramp. Four out of 14 samples had elevated levels of lead, to a maximum of 59,500 ppm. One of the 14 samples had an elevated level of arsenic, 846 ppm. However, these samples were found in the skeet range, which is across the road from the boat ramp. It is unlikely that children would access the skeet range while their families were using the boat ramp.

Nature and Extent of Known Contamination – Hunting & Trapping Areas

Hunters and trappers may be exposed to contamination in surface soil while on the post. Contamination in surface soil of hunting and trapping areas was compared to CVs for short-term exposure to adults. Noteworthy contaminants which exceed CVs, if available, in these soils are PAHs, PCBs, and metals. Details are listed in Table 12.

Table 12: Noteworthy contaminants in surface soil to one foot depth in hunting and trapping areas at APG-EA, screened using comparison values (CVs), if available, for adults with short-term exposure [USAG 2004].

Contaminant	Median and [Range] of Detected Concentrations (ppm) and (detects / samples)	Comparison Value[a] (ppm)
PAHs		
Benzo(a)anthracene	0.2 [0.01 to 60] (92/527)	None[b]
Benzo(a)pyrene	0.2 [0.01 to 45] (90/526)	None[b]
Benzo(b)fluoranthene	0.2 [0.015 to 70] (120/526)	None[b]
Benzo(k)fluoranthene	0.2 [0.01 to 39] (93/526)	None[b]
Benzo(ghi)perylene	0.6 [0.6 to 23] (11/156)	None[b]
Chrysene	0.2 [0.015 to 62] (110/527)	None[b]
Indeno(1,2,3-cd)pyrene	0.2 [0.01 to 33] (69/526)	None[b]
PCBs		
Aroclor 1248	2.1 [0.05 to 32] (7/534)	None[b]
Aroclor 1254	0.3 [0.04 to 7.2] (8/534)	20 (intermediate EMEG)
Aroclor 1260	0.3 [0.006 to 5.98] (54/534)	None[b]
Metals		
Copper	9.3 [0.9 to 40,900] (558/567)	10,000 (acute EMEG)
Lead	24 [1.1 to 59,500] (559/564)	None[b]

a: CVs are for short-term exposure to adults
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Evaluation of Potential Public Health Hazards

To assess exposures to contaminants found above CVs in surface soil, ATSDR calculated exposures doses based on conservative assumptions about how a

person may contact this environmental medium. ATSDR assumed that a person, either adult or child, would use the recreational areas 5 days a week for 26 weeks a year (130 days) over a period of 30 years for an adult and 6 years for a child. Adult or child hunters and trappers were assumed to hunt or trap two days a week for a month each year. Adult workers and trespassers were assumed to access contaminated areas every day for up to two weeks. Based on studies of how much soil a person may accidentally ingest when outside, ATSDR assumed that an adult may accidentally ingest 100 mg of soil, and a child may accidentally ingest 200 mg of soil every day. An additional, conservative assumption was made that people were exposed to the maximum level of contamination observed during sampling; this assumption overestimates actual exposures. Furthermore, the Army continues to conduct remediation activities throughout the post. As such, contaminated soils have been removed from some areas (e.g., the Westwood Area), which eliminates possible exposures in these areas. Exposures of children to lead in surface soils were estimated by using EPA's IEUBK for Lead in Children [EPA 2005b].

Exposure doses were estimated for each contaminant in the surface soil for adult workers, hunters and trappers, and trespassers, and for child residents on-post. These doses were then compared to those found in ATSDR Toxicological Profiles, and in the toxicological literature to determine whether they could cause adverse health effects. With the exception of copper and lead, none of the contaminants in surface soil are expected to cause adverse health effects. The exposure doses for copper and lead will be discussed in more detail.

Copper in Surface Soil

Copper was elevated in two surface soil samples in the eastern portion of the Westwood area prior to soil removal and remediation activities, and in one of several samples taken from the new O-Field in the southern portion of Edgewood. If someone were exposed to these isolated levels all day, they might ingest sufficient amounts of copper to experience nausea, vomiting, and other symptoms of gastro-intestinal discomfort. These symptoms are temporary and reversible [ATSDR 2004]. Infrequent access to these areas minimizes the likelihood of these effects occurring. Completed and ongoing remediation activities at APG-EA are expected to eliminate exposures to elevated copper in surface soil.

Lead in Surface Soil

Lead was elevated in surface soil near Gun Club Creek, in the J-Field prior to installation of a soil cover, and in the eastern portion of the Westwood area prior to soil removal and remediation activities. Adult workers, trespassers, and hunters who might be exposed to these elevated levels all day might experience small, reversible changes in blood chemistry. These changes are not expected to cause adverse health effects [ATSDR 1999a]. As with copper exposures, infrequent access to these areas minimizes the likelihood of these changes. Dense vegetation (*Phragmites sp.*, which is a tall, dense invasive grass) covers soil near Gun Club Creek and limits access to the area. Other areas are within restricted

portions of the post. In addition, completed and ongoing remediation activities at APG-EA are expected to eliminate exposures to elevated lead in soil.

Although possible, the changes in blood chemistry from exposure to lead are unlikely to occur at APG-EA. These effects were observed in laboratory studies in which people ingested known amounts of lead acetate. Lead acetate is highly soluble in water, and is much more soluble than the forms of lead found in surface soil. The less soluble forms of lead are absorbed into the bloodstream at a slower rate, and some may pass completely through the digestive tract without being absorbed [ATSDR 1999a].

Inhalation of Air Emissions from Range Fires

Ordnance testing occasionally sparks fires within the testing ranges at APG-EA. When these fires occur, they are managed by the post fire department as controlled burns within an established perimeter. The perimeter provides distance between the firefighters and possible explosions from unexploded munitions within the burn area. Range fires are most common in the late summer and early fall months.

Nature and Extent of Contamination

In 1998, a study using computer models and information about site contamination was completed to assess the potential off-post impacts of these range fires. The study modeled lead, arsenic, trichloroethylene, depleted uranium, DDT, vinyl acetate, 2-furaldehyde, mustard gas, and phosgene releases during range fires and predicted that none of these chemicals would be released in concentrations high enough to impact human health [ANL 1998].

Summary

People might be exposed to contaminated air while on or near the post during a brush fire on a firing range. Sampling during brush fires found contamination with explosive-related substances, PCBs, a pesticide, metals, and solvents. However, the concentrations were low enough that adverse health effects are not expected to occur from short-term exposure to smoke from range fires.

In 1999, the Army proposed a program of testing air during controlled burns at APG. Three locations, representing possible worst-case releases, were selected for controlled burns: J-Field and New O-Field on APG-EA, and one area in APG-AA where depleted uranium (DU) was tested. Controlled burns were conducted in April 1999 in APG-AA, and in December 1999 and April 2000 in APG-EA. The Army collected downwind air samples during each of the controlled burns. Samples collected during the controlled burns were analyzed for volatile organic compounds, pesticides, explosives, metals, radionuclides, and CWM. Air sampling found explosive-related substances, PCBs, a pesticide, metals, and solvents at concentrations above CVs for long-term exposures, but below CVs for short-term exposures; the short-term CVs are more appropriate for this exposure [GP 2001;

USAG 1999]. Because few of the substances have short-term CVs, occupational standards were also used. Table 13 summarizes the sampling results.

Table 13: Summary of air sampling data from controlled burns that exceed comparison values (CVs), if available [GP 2001]

Contaminant	Median and [Range] of Detected Concentrations (ug/m^3) And (No. of Detects / No. of Samples)		Comparison Value[a] (ug/m^3)	
	Downwind	Upwind	Long-Term Exposure	Short-Term Exposure[a]
Explosives and Explosive-Related Substances				
2-Amino-4,6-Dinitrotoluene	0.457 (1/7)	ND (0/3)	None[b]	None[b]
4-Amino-2,6-Dinitrotoluene	0.1266 (1/7)	ND (0/3)	None[b]	None[b]
PCBs				
Total PCBs	0.001 [0.0005 to 0.012] (4/7)	0.0007 [0.0002 to 0.0012] (2/3)	0.01 (CREG)	500 (OSHA PEL)
Pesticides				
Dieldrin	0.0005 [0.0005 to 0.003] (3/7)	ND (0/7)	0.0002 (CREG)	250 (OSHA PEL)
Metals				
Arsenic	0.013 [0.0025 to 0.015] (4/7)	ND (0/3)	0.0002 (CREG)	10 (OSHA PEL)
Beryllium	0.00045 [0.0004 to 0.0005] (2/7)	ND (0/7)	0.0004 (CREG)	2 (OSHA PEL)
Cadmium	0.002 [0.0005 to 0.0036] (2/7)	0.05 (1/3)	0.0006 (CREG)	5 (OSHA PEL)
Chromium	0.008 [0.0035 to 0.04] (6/7)	0.005 (2/3)	0.00008 (CREG)	500 (NIOSH REL)
Lead	0.0325 [0.0061 to 0.07] (7/7)	0.0077 (3/3)	None[b]	50 (OSHA PEL)
Manganese	0.02 [0.006 to 0.55] (7/7)	0.015 (3/3)	0.04 (EMEG)	1,000 (NIOSH REL)
Uranium (total)[c]	0.0068 (2/3) – DU site ND (0/3) – non-DU site	ND (0/2)	0.3 (EMEG)	250 (OSHA PEL)
Solvents				
Acetaldehyde	4 (1/7)	ND (0/3)	0.5 (CREG)	360,000 (OSHA PEL)
Benzene	11.3 [2.3 to 20.5] (4/7)	3.65 [2.4 to 4.9] (2/3)	0.1 (CREG)	160 (aEMEG)
Methylene chloride	15.5 [5.9 to 25] (2/7)	6.4 (1/3)	3 (CREG)	2,000 (aEMEG)

a: Occupational standards are used when an acute EMEG is not available
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

c: The concentration of total uranium never exceeded a CV. It is included here for later discussion.

Evaluation of Potential Public Health Hazards

Once emitted by fires, chemicals gradually disperse as smoke plumes blow downwind. ATSDR assumed that all of the populations identified at APG-AA (on-post workers and residents, off-post residents, recreational users, hunters, fishers, and trespassers) may be exposed to air emissions from range fires because contaminant migration within the smoke plume cannot be contained and may extend to on- and off-post locations. However, because none of the contaminants exceed CVs for short-term exposure, exposures to contaminants released during range fires is not expected to cause adverse health effects.

Ingestion of Contaminated Fish and Aquatic Animals

Fishing, crabbing and trapping occur on or near APG-EA. Some contaminants on the post can be taken up by fish, crabs, and turtles. These contaminated animals can then pass this contamination on to people who eat them.

Potential for Contamination of Aquatic Species

Many of the contaminants found in the environment at APG-EA can accumulate in fish and other aquatic animals. Those contaminants which are known to accumulate well in fish and animals are PCBs, pesticides, and some metals. Other contaminants with less potential for accumulation are solvents and munitions-related substances. The potential for perchlorate to accumulate in fish and animals is currently unknown.

Summary

Fish were found to be contaminated with PCBs, DDTs, and lead. Turtles are contaminated with PCBs, chlordane, DDE, copper, chromium, and lead. Crabs remain uncontaminated.

Adverse health effects are not expected to occur as a result of the observed contamination, as long as people adhere to the fish consumption limits recommended by the Maryland Department of the Environment (MDE).

The level of lead in the meat of some turtles is elevated, and could contribute to any existing lead exposure to children.

Many contaminants have been found at APG-EA within a quarter-mile of the shoreline, and so may potentially contaminate water bodies and the fish and aquatic animals living in them. Table 14 lists major contaminants which have bioaccumulation potential and were found in sediment, or surface or ground water near the APG-EA shoreline. The contaminants include munition-related substances, PCBs, pesticides, metals, and solvents. Except for the solvents, all of these substances were analyzed for in fish. The solvents were found in groundwater, but to a much lesser extent in surface water, indicating very little potential for them to accumulate in aquatic species. No samples were analyzed for perchlorate within a quarter-mile of the shoreline because no perchlorate contamination was suspected in these areas.

Environmental contaminant concentrations in Table 14 are compared against CVs which were developed regarding the bioaccumulation potential of each substance

(see Appendix). For surface water and ground water, the CV based on fish consumption is divided by the Fish Bioaccumulation Factor, which is provided by the EPA [EPA 2000]. These values are also conveniently available through the Oak Ridge National Laboratory's Risk Assessment Information System [ORNL 2005]. For sediment, the fish CV is divided by the Biota to Sediment Accumulation Factor (BSAF), also provided by the EPA [EPA 2005c].

Table 14: Noteworthy contaminants with bioaccumulation potential, within one quarter-mile of the APG-EA shoreline [USAG 2004]

Medium	Substance	Median and [Range] of Detected Concentrations	No of Detects / No of Samples	Comparison Value[a]
Sediment	PCBs			
	Aroclor 1016	8 [0.003 to 8] ppm	(3/285)	0.003 ppm (CREG)
	Aroclor 1242	0.6 [0.004 to 4.5] ppm	(3/299)	
	Aroclor 1248	0.7 [0.007 to 1.4] ppm	(4/285)	
	Aroclor 1254	0.07 [0.007 to 1.8] ppm	(15/285)	
	Aroclor 1260	0.24 [0.007 to 8] ppm	(37/299)	
	Pesticides			
	DDD	0.02 [0.0001 to 6.55] ppm	(159/305)	0.01 ppm (CREG)
	DDE	0.02 [0.0002 to 1.9] ppm	(197/306)	0.002 ppm (CREG)
	DDT	0.01 [0.00006 to 8] ppm	(99/306)	No BSAF[b]
	Metals			
	Arsenic	3.9 [0.001 to 539] ppm	(343/351)	No BSAF[b]
	Lead	21 [0.07 to 26,300] ppm	(350/351)	None[b]
	Mercury	0.3 [0.00006 to 149] ppm	(186/336)	No BSAF[b]
Surface Water	Munitions-Related			
	Beta-thiodiglycol	25 [4.4 to 170] ppb	(8/263)	None[b]
	IMPPA	902 [0.9 to 1,720] ppb	(14/221)	None[b]
	MPPA	405 [21 to 10,700] ppb	(4/225)	None[b]
	Pesticides			
	Chlordane	0.01 [0.001 to 0.05] ppb	(9/266)	0.001 (CREG)
	DDD	0.008 [0.003 to 1.4] ppb	(26/266)	0.003 ppb (CREG)
	DDE	0.007 [0.0003 to 0.14] ppb	(24/266)	0.0009 ppb (CREG)
	DDT	0.02 [0.002 to 14] ppb	(14/261)	0.0004 ppb (CREG)
	Dieldrin	0.007 [0.003 to 0.01] ppb	(12/266)	0.0002 ppb (CREG)
	Heptachlor	0.009 [0.001 to 0.05] ppb	(13/322)	0.0001 ppb (CREG)
	Metals			
	Arsenic	3 [0.7 to 74.5] ppb	(68/327)	1 ppb (CREG)
	Chromium	3.7 [0.6 to 80.9] ppb	(14/207)	10 ppb (RMEG)
	Lead	3.7 [0.36 to 619] ppb	(211/318)	None[b]
Ground-water	Pesticides			
	Chlordane	0.01 [0.01 to 0.05] ppb	(5/74)	0.001 ppb (CREG)
	Heptachlor	0.02 [0.004 to 0.05] ppb	(17/74)	0.0001 ppb (CREG)
	Heptachlor Epoxide	0.05 [0.02 to 0.05] ppb	(5/74)	0.0005 ppb (CREG)
	Metals			
	Arsenic	5 [2 to 44] ppb	(21/79)	1 ppb (CREG)
	Cadmium	11 [4 to 13,000] ppb	(6/45)	300 ppb (CREG)
	Chromium	7 [0.8 to 225] ppb	(16/79)	10 ppb (RMEG)
	Lead	2 [0.3 to 187] ppb	(23/79)	None[b]
	Solvents			
	1122-PCA	7 [0.9 to 22,000] ppb	(20/81)	20 ppb (CREG)
	112-TCA	4 [1 to 150] ppb	(6/80)	20 ppb (CREG)
	Trichloroethylene	9 [0.3 to 2,400] ppb	(14/81)	1 ppb (CREG)

a: CVs are for long-term exposure (> 1 year) of children and adults to fish which have lived in contaminated sediments and surface water

b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

In addition to the contamination detailed in Table 14, other wastes may also cause contamination of aquatic species. Lab wastes and munitions and explosives have been disposed of in the past across APG-EA. Any of these wastes which remain may potentially contaminate surface water, sediment, and aquatic species.

Nature and Extent of Known Contamination – Fish

The Army, the Maryland Department of the Environment (MDE), and the University of Maryland have conducted food chain studies that investigate contaminant concentrations in fish. The purpose of these studies has been to determine whether local fish are contaminated, and how any observed contamination might impact human health.

Several studies of fish health have been conducted in the waters surrounding APG. Kidney and brain lesions were found in fish and eels. These problems were attributed to diseases, parasites, and naturally poor water quality [U of MD 1991; Kane 2005; DSHE 1992; and MFHDP 1992].

The Army has sampled fish tissue for environmental contaminants. In 1995 and 2005, the Army collected fish from the following areas:

- Bush River
- Gunpowder River
- Canal Creek
- Doves Cove
- Kings Creek
- Lego/Sandy Point
- Background rivers (Magothy, Patapsco, and Choptank)
- Lauderick Creek
- Reardon Inlet
- Rickett Point
- Swaderick Creek
- Wrights Creek

These samples were analyzed for PCBs, pesticides, and metals. Contaminants which exceed CVs were PCBs, DDTs, and lead [USAG 1995, 2005]. Additional details about contaminants which exceed CVs observed in this and the following studies are given in Table 15.

MDE has been sampling fish tissue from the Chesapeake Bay since the 1980s. Data prior to 2000, however, has significant quality assurance/quality control issues and is not appropriate for assessing impacts to public health. Currently, MDE collects and tests fish from the Chesapeake Bay each year and from the vicinity of APG about every 4 years.

In 2000, MDE analyzed channel catfish and white perch fillets from the Bush River for PCBs, pesticides (chlordane and DDT), and metals. Contaminants which exceed CVs were PCBs, total DDTs (including DDD, DDE, and DDT), and lead [MDE 2005b].

Table 15: Contaminants which exceed comparison values (CVs) in fillets from fish caught on or near APG-EA [MDE 2005b and USAG 1995 and 2005].
Note: Gray entries are concentrations below the CV; bold entries are concentrations above both the CV and the background concentration.

Substance	Species	Maximum Concentration (ppb)												CV_a (ppb)
		Waters from which Fish May be Eaten						Waters from which Fish May Not be Eaten					Background	
		Bush River	GP River	Doves Cove	Lego/ SP	Laud Creek	Rick Point	Canal Creek	Kings Creek	Rear Inlet	Swad Creek	Wright Creek		
PCBs														
PCBs	BB			**23**						ND	ND			3 (CREG)
	CC	**347**	**278**		**66**				**9.6**				$ND_{c,d,e}$	
	WC					**39**	**150**	**57**				ND		
	WP	**312**	**330**	**33**	ND	**4**	**115**	ND	ND	ND	ND	ND	$ND_{c,d,e}$	
	YP	**136**												
Pesticides														
Dieldrin	BB							**32.2**					ND_f, 13.6_g	0.4 (CREG)
	CC							**11.4**	**27**	5.1			4.8_f, 10.1_g	
DDTs	BB		**67**	**36**				**544**		**127**	ND		10_g	20 (CREG)
	CC	**169**	**54**		**99**	**190**		**169**	**412**	**72**			$ND_{c,d,e}$, 3_g, 159_f	
	WC					**56**	ND	**37**				6		
	WP	**39**	**41**	**35**	ND	14	**46**	**29**	10	**31**	18	8	$ND_{c,d,e}$, 13_f	
Metals														
Lead	BB			ND				ND					ND_f, 380_g	None[b]
	CC	18	13		ND	**4,600**		**550**	**660**	**300**			$ND_{b,c,d}$, 200_g, 230_f	
	WC					ND	ND	ND				ND		
	WP	**15**	**15.5**	ND	ND	ND	ND	ND	ND	ND	ND	ND	$ND_{c,d,e,f}$	
Mercury	BB		150					**800**		**310**			170_f, 150_g	250 (EMEG)
	CC	21	71					**450**	38	90			64_f, 71_g	

a: CVs are for long-term exposure of children and adults to contaminated fish
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.
c: Magothy River
d: Patapsco River
e: Choptank River
f: Dundee Creek, north of post
g: Gunpowder River, north of post

GP River = Gunpowder River
SP = Sandy Point
Laud Creek = Lauderick Creek
Rear Inlet = Reardon Inlet
Rick Point = Rickett Point
Swad Creek = Swaderick Creek

BB = Largemouth Bass
CC = Channel Catfish
WC = White Crappie
WP = White Perch
YP = Yellow Perch

In 2002, MDE sampled yellow perch fillets from the Bush River for PCBs and methyl-mercury. Although both were found in every composite sample, only PCBs were elevated to a level of concern [MDE 2005b].

In addition to environmental monitoring of fish tissue, MDE investigates fish for signs of poor health and encourages the public to report fishkills and unhealthy or malformed catch, which can be indicators of contamination. MDE scientists study the cause of abnormalities and poor health in the fish population. In most cases, the cause is unrelated to chemical contamination [MDE 2005c]. Between 2000 and 2004, MDE reported seven fishkills and four unhealthy or malformed fish near APG, including two large fishkills on the Bush River in May 2000 (700 fish) and in July 2003 (1,842 fish) caused by bacterial disease and toxic algal blooms. The other fishkills and sick or deformed fish reported to MDE were attributed to natural causes, low levels of dissolved oxygen, or fishing pressures [MDE 2005c].

Nature and Extent of Known Contamination – Crabs

The Army sampled crabs for environmental contamination in 1995. Three crabs each were taken from Kings Creek, Gunpowder River, and Rickett Point. The crabs were analyzed for PCBs, pesticides, and metals. No contaminants which exceed CVs were found [USAG 1995].

Nature and Extent of Known Contamination – Turtles

The Army sampled snapping turtle meat for environmental contamination in 1994. Six turtles each were taken from Canal Creek, Watson Creek, and Carroll Island. Five turtles were taken from a background area, the Van Bibber drinking water treatment facility, which is five miles upstream from APG. Contaminants which exceed CVs in the turtles include PCBs, pesticides, copper, chromium, and lead. Details are included in Table 16.

Table 16: Contaminants which exceed comparison values (CVs) in snapping turtle meat caught on APG-EA [AEHA 1994]

Substance	[Range] of Detected Concentrations (ppb) And (Number of Detects / Number of Samples)				Comparison Value[a] (ppb)
	Canal Creek	Watson Creek	Carroll Island	Back-ground	
PCBs					
Aroclor 1260	[**709**] (1/6)	[**200** to **220**] (2/6)	ND (0/6)	ND (0/5)	3 (CREG)
Pesticides					
Chlordane	[**72**] (1/6)	[5] (1/6)	ND (0/6)	ND (0/5)	20 (CREG)
DDE	[**53**] (1/6)	[10] (1/6)	ND (0/6)	ND (0/5)	20 (CREG)
Metals					
Copper	[**33,000** to **47,180**] (6/6)	ND (0/6)	ND (0/6)	ND (0/5)	8 (iEMEG)
Chromium	[**2,900** to **5,800**] (4/6)	ND (0/6)	ND (0/6)	ND (0/5)	3 (RMEG)
Lead	ND (0/6)	[**390** to **2,290**] (6/6)	ND (0/6)	ND (0/5)	None[b]

a: CVs are based on long-term exposure (> 1 year) of children and adults to contaminated turtle meat
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Evaluation of Potential Public Health Hazards

Fishers, trappers, and their families (adults and children) may have been exposed to contaminants in fish, crabs, and turtles caught on or near APG-AA. To assess exposures to contaminants which exceed CVs in fish, crabs, and turtles, ATSDR calculated CVs for fish, and exposure doses based on assumptions about how much fish, crab, or turtle a person may eat on a regular basis. ATSDR assumed that adults would eat a 4 ounce meal of fish, crab, or turtle once or twice a week for 30 years, and children would eat a 2 ounce meal once or twice a week for six years[6]. These levels are within the recommended consumption limits for several species of fish, which are provided by MDE [MDE 2005a]. These recommendations are intended to protect individuals from exposure to potentially harmful levels of contamination in affected species.

The amount of contaminant that people ingest with these foods was estimated by using the maximum concentration observed for each animal. This assumption overestimates actual exposures. Exposures of children to lead in fish and turtles were estimated by using EPA's IEUBK for Lead in Children [EPA 2005b].

Based upon the amount ingested, none of the contaminants which exceed CVs are expected to cause adverse health outcomes. However, the exposure to mercury in fish and lead in fish and snapping turtle meat was sufficiently elevated to warrant additional discussion.

6 Assumptions about fish, crab, and turtle consumption are based on studies of aquatic food consumption [EPA 1997].

Lead in Fish and Turtle Meat

Lead was detected at 4,600 ppb in one catfish fillet in Lauderick Creek, an area where fishing is permitted. All other fish which were caught in fishing waters had lead concentrations below 20 ppb. Fish which were caught in waters where fishing is not permitted had lead levels at or below 660 ppb.

Lead was detected in turtle meat only at Watson Creek. All six animals at Watson Creek had detectable lead levels, ranging from 390 to 2,290 ppb.

If a child occasionally ate a fish or turtle meal that had the maximum level of lead, his or her blood lead level might become slightly elevated. Under usual circumstances, this slight increase would not lead to any adverse health effects. However, should the child also be exposed to other sources of lead, the increase in blood lead levels would be cumulative, increasing the potential for adverse health effects to occur [ATSDR 1999a, EPA 2005b].

An important consideration is that the size of fish and snapping turtles dictates that each animal can provide meat for only a few meals. Any child who often eats fish or turtle meat is likely eating meat from several different animals over time. Therefore, the child would likely be exposed to the maximum level of lead for only a few meals. This decreases the potential for adverse health effects from cumulative exposure to lead.

Adverse health effects are not expected to occur as a result of eating fish or turtle meat with the observed levels and patterns of lead contamination at APG-EA.

Mercury in Fish

Mercury was elevated in fish in the Canal Creek to a maximum level of 800 ppb in largemouth bass, and 450 ppb in catfish. Although fishing is permitted in Canal Creek, there is a posted advisory warning against consuming fish from Canal Creek. Fish may migrate in and out of Canal Creek and into Gunpowder River. Mercury levels in Gunpowder River, Bush River, and Lauderick Creek (all fishing waters) were at or below 150 ppb.

Children and pregnant women who often eat fish at the maximum level found in Canal Creek, where fishing is prohibited, might experience adverse health effects, such as developmental delays. However, the infrequent occurrence of the highest levels, along with the low levels found in fish from waters where fishing is permitted, decreases the potential for adverse health effects [ATSDR 1999b].

For this reason, adverse health effects are not expected to occur as a result of eating fish with the observed levels and patterns of mercury contamination at APG-EA.

Additional Consideration – Perchlorate in Aquatic Animals

Perchlorate has been found in groundwater and subsurface soils in north-central APG-AA. Since perchlorate contamination is not expected, no samples have been analyzed for perchlorate near the APG-EA shoreline.

Preliminary studies at Lake Meade and Longhorn Army Ammunition Plant address the potential for perchlorate to accumulate in fish in freshwater environments and suggest that perchlorate can bioaccumulate in at least some species of fish. These studies reported perchlorate in tadpoles and small fish, such as minnows and shiners that live in creeks and ponds. However, no perchlorate was detected in larger game fish, such as large mouth bass and catfish, which typically live in larger bodies of water where perchlorate contamination may have been highly diluted [Parsons 2001 and Smith et al 2001]. Unlike the smaller, freshwater environments considered in these studies, a larger brackish environment exists in the vicinity of APG. The dynamics of a large water body such as the Chesapeake Bay will likely decrease the impacts that could stem from a perchlorate release. Perchlorate, which is water soluble, will be more dilute in large bodies of water than in smaller ones, and will likely be dispersed and diluted further by the tide. This dilute amount of perchlorate will decrease the amount of contaminate that large fish can accumulate

Based on these findings, the potential for perchlorate to bioaccumulate to harmful levels in aquatic animals in the vicinity of APG is unlikely.

Ingestion of Contaminated Deer

Deer hunting occurs on APG-EA. Some contaminants on the post can be taken up by deer. These contaminated animals can then pass this contamination on to people who eat them.

Potential for Contamination of Deer

Many of the contaminants found in the environment at APG-EA can accumulate in game animals. Those contaminants which are known to accumulate in animals are PCBs, pesticides, and some metals. Other contaminants with less potential for accumulation are solvents and munitions-related substances. The potential for perchlorate to accumulate in animals is currently unknown.

Summary

Deer were found to have levels of lead which are of concern. However, it is not clear whether this contamination is from post activities or other sources.

The level of lead in the meat and liver of some deer could contribute to any existing lead exposure to children.

Many contaminants have been found in surface water and surface soil across APG-EA, and so may potentially accumulate in game animals. Table 17 lists major contaminants with bioaccumulation potential in surface water or surface soil across APG-EA. No samples of surface water or surface soil were analyzed for perchlorate.

Environmental contaminant concentrations in Table 17 are compared against CVs, if available, which were developed regarding the bioaccumulation potential of each substance (see Appendix). For surface water, the CV is divided by the Beef Transfer Coefficient, which is provided by the EPA [EPA 2005c]. These values are also

conveniently available through the Oak Ridge National Laboratory's Risk Assessment Information System [ORNL 2005]. For surface soil, the CV is used, along with the Beef Transfer Coefficient and the Soil-to-Dry Plant Uptake, also provided by the EPA [EPA 2005c].

Table 17: Noteworthy contaminants which exceed comparison values (CVs), if available, across APG-EA, considering bioaccumulation potential in deer [USAG 2004].

Medium	Substance	Median and [Range] of Detected Concentrations	Number of Detects / Number of Samples	Comparison Value[a]
Surface Soil	Munitions-Related			
	Beta-Thiodiglycol	4.2 ppm [1 to 18 ppm]	26/989	None[b]
	Pentaerythritol tetranitrate	23.5 ppm [4 to 56.6 ppm]	11/337	None[b]
	PCBs			
	Aroclor 1248	0.41 ppm [0.04 to 9,370 ppm]	84/1100	0.07 ppm (CREG)
	Aroclor 1254	0.4 ppm [0.01 to 325 ppm]	49/1101	0.07 ppm (CREG)
	Aroclor 1260	0.2 ppm [0.003 to 75 ppm]	160/1101	0.07 ppm (CREG)
	Pesticides			
	DDD	0.006 ppm [0.00005 to 7 ppm]	427/1123	0.5 ppm (CREG)
	DDE	0.02 ppm [0.00005 to 10 ppm]	844/1116	0.4 ppm (CREG)
	DDT	0.02 ppm [0.00012 to 12 ppm]	785/1170	0.01 ppm (CREG)
	Dieldrin	0.002 ppm [0.00005 to 15 ppm]	171/1182	0.09 ppm (CREG)
	Metals			
	Arsenic	3.5 ppm [0.2 to 1,370 ppm]	1311/1383	0.6 ppm (CREG)
	Chromium	14 ppm [2 to 1,900 ppm]	1378/1384	70 ppm (RMEG)
	Copper	14 ppm [0.9 to 40,900 ppm]	1352/1384	70 ppm (iEMEG)
	Lead	34 ppm [1 to 94,200 ppm]	1382/1396	None[b]
	Mercury	0.1 ppm [0.01 tp 594 ppm]	812/1406	2 ppm (EMEG)

a: CVs are for long-term exposure (> 1 year) to children and adults to contaminated venison
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

Table 17 (continued):

Medium	Substance	Median and [Range] of Detected Concentrations	Number of Detects / Number of Samples	Comparison Value[a]
Surface Water or Seep	Munitions-Related			
	Beta-thiodiglycol	12 ppm [4.4 to 219 ppm]	31/552	None[b]
	Isopropyl methyl phosphonic acid	94 ppm [0.9 to 1720 ppm]	33/496	None[b]
	Methyl phosphonic acid	405 ppm [21 to 10,700 ppm]	4/463	None[b]
	Pesticides			
	DDT	0.02 ppm [0.002 to 14 ppm]	16/496	6 ppm (CREG)
	Metals			
	Arsenic	3.2 ppm [0.7 to 1,240 ppm]	145/623	40 ppm (CREG)
	Lead	3.8 ppm [0.35 to 1,590 ppm]	394/616	None[b]

a: CVs are for long-term exposure (> 1 year) to children and adults to contaminated venison
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature.

In addition to the contamination detailed in Table 17, other wastes may cause contamination of game species. Lab wastes and munitions and explosives have been disposed of in the past across APG-EA. Any of these wastes which remain may potentially contaminate surface water, sediment, and game species.

Nature and Extent of Known Contamination – Deer

In May 1995, the Army completed an assessment of contaminants found in deer at APG and at a background location relatively free from contamination—Gunpowder Falls State Park. The Army collected deer muscle and liver samples from hunters during the 1993 hunting season. These samples were analyzed for PCBs, pesticides, metals, explosives, and munition-related substances [CHPPM 1995]. All of the contaminants which exceed CVs listed in Table 17 (environmental contaminants with potential for bioaccumulation) were included in the analyses, with the exceptions of copper, dieldrin, and the munition-related substances. The bioaccumulation potential of the munition-related substances is unknown, but is not expected to be high. Details of the contaminants which exceed CVs, if available, observed in the deer samples are listed in Table 18.

Table 18: Contaminants which exceed comparison values (CVs), if available, in deer caught on APG-EA [CHPPM 1995].
Note: Arsenic and lead were detected in all samples of both muscle and liver at each location, except lead in liver at the Nike area (18 detects/21 samples) and lead in liver at Canal Creek (14 detects/15 samples).

Portion	Substance	Median and [Range] of Detected Concentrations (ppb)					Comparison Value[a] (ppb)
		J & O-Fields (20 deer)	Nike Area (21 deer)	Canal Creek Area (15 deer)	Carroll Island & Graces Quarters (13 deer)	Back-ground[b] (20 deer)	
Muscle	Metals						
	Arsenic	650 [550 to 850]	800 [80 to 910]	250 [140 to 810]	710 [470 to 900]	323 [125 to 815]	4 (CREG)
	Lead	100 [10 to 440]	130 [60 to 2,590]	150 [40 to 1,640]	280 [140 to 1,530]	230 [134 to 1,600]	None[b]
Liver	Metals						
	Arsenic	620 [60 to 700]	720 [330 to 830]	260 [160 to 960]	880 [830 to 1,140]	394 [232 to 909]	4 (CREG)
	Lead	90 [60 to 260]	90 [10 to 510]	130 [10 to 1,750]	150 [90 to 200]	170 [86 to 596]	None[b]

a: CVs are for long-term exposure (> 1 year) to contamination by eating venison or deer liver
b: Since no CV is available, this substance will be evaluated based upon a review of the toxicological literature

With a few exceptions, all lead levels in deer muscle were below 760 ppb. The exceptions are two deer in the Nike area (2,590 ppb and 2,010 ppb), one deer from the Canal Creek area (1,640 ppb), one deer from Carroll Island & Graces Quarters (1,530 ppb), and one deer from Gunpowder Falls State Park (1,600 ppb). It is unclear why these high levels were observed, particularly in Gunpowder Falls State Park, which is relatively free from known contamination. These high levels may be the results of environmental contamination from post operations. Alternatively, these levels may result from the past or current use of lead ammunition for hunting that may have contaminated the environment where deer feed. The Maryland Department of Natural Resources allows hunting with all-lead or lead alloy bullets [MDNR 2006].

Evaluation of Potential Public Health Hazards

Hunters and their families (adults and children) may have been exposed to contaminants in game caught on APG. To assess exposures to contaminants which exceed CVs in deer, ATSDR calculated exposure doses based on assumptions about how much venison a person may eat on a regular basis. ATSDR assumed that adults would eat a 4 ounce venison meal once or twice a week for 30 years, and children would eat a 2 ounce venison meal once or twice a week for six years.[7] We recognize that some hunters ingest more

7 These assumptions are based on studies of deer consumption [EPA 1997].

deer than described in this section at some times of the year, this will be addressed later. Exposures of children to lead in deer were estimated by using EPA's IEUBK for Lead in Children [EPA 2005b]. Arsenic and lead will be addressed later

Arsenic in Deer

The levels of arsenic found in deer liver and muscle were elevated to as high as 1,140 ppb in liver, and 910 ppb in muscle. People who eat deer which has the maximum level of arsenic would receive a moderately high amount of arsenic. However, much of the arsenic in animal tissue is in the relatively non-toxic organic form, which is rapidly excreted from the body in urine. Because little of the arsenic in animal tissue is in the toxic inorganic form, no adverse health effects are expected to occur because of arsenic in deer harvested on or near APG-EA [ATSDR 2000].

What Should You Know About Lead?

Lead exposure can cause serious health effects, such as mental and physical developmental delays, especially in young children. Before discovery of these effects, lead was used in paint, gasoline, pipes, and other common household products. Lead may still be a part of hunting ammunition. You, however, can protect your children from lead by taking the following steps:

- Test you child regularly for blood lead levels. Maryland currently has laws requiring lead testing for some children.
- Properly address deteriorated or peeling lead-based paint, which is the most common cause of lead exposure. Lead paint, which was commonly used in homes until the 1970s, can deteriorate and contaminate dust and soil.
- Do not allow your children to handle lead-based ammunition.
- Completely remove lead-based ammunition from game before consumption.
- Remove clothing that may contain lead dust from work or hobby tasks (e.g., packing lead shot).

ATSDR 1999 b

Lead in Deer

Most of the levels of lead found in deer muscle were found to be at or below 760 ppb. This level should be safe for all people who eat venison in the amounts assumed for this analysis. However, a few deer were found to have elevated lead levels in meat as high as 2,590 ppb at APG-EA, and 1,600 ppb at Gunpowder Falls State Park. If a child often ate deer meat over a long period of time at the maximum level of lead, his or her blood lead level might become slightly elevated.[8] Under usual circumstances, this increase would not lead to any adverse health effects. However, should the child also be exposed to other sources of lead, the increase in blood lead levels would be cumulative, increasing the potential for adverse health effects to occur [ATSDR 1999a].

Adverse health effects are not expected to occur solely as a result of eating deer meat which has been contaminated with lead at APG-EA.

8 The 1995 Risk Assessment which the Army performed using these data concluded that lead in deer was not a problem. This assessment was based on site-specific consumption values and assumed an annual deer intake within the consumption range assumed by ATSDR. The Army conclusion was based upon the FDA guidelines for shellfish, which was an appropriate method for that time. The determination for this PHA is based upon EPA's IEUBK for Lead in Children, a model freely available from EPA [EPA 2005b].

Contact with Munitions and Explosives of Concern (MEC)

APG-EA has been used as a testing area for ammunition and materials since its creation in 1917. As a result of over 80 years of testing, ammunition debris, UXO, and other munitions are located at former and current firing ranges, disposal areas, and target areas in the Bush River and Gunpowder River. Most firing ranges and disposal areas are located in areas of the post with restricted access. The Army, however, cannot guarantee that all areas of the post frequented by members of the public are free of MEC (e.g., along the shoreline or unknown disposal locations). As such, the Army has implemented investigations to further understand the extent of UXO at APG and plans to address MEC upon discovery [USAG 1996b, 2000b].

Nature and Extent of Contamination

Summary

Munitions and explosives have been fired or disposed of on the post for many years. Workers and trespassers might contact unexploded munitions in restricted areas of the post. Recreational users may contact unexploded munitions if they do not follow post restrictions regarding shoreline contact.

As a result of weapons testing, the Army estimated that 4 million UXO and 16 million projectiles of all calibers may remain in open water impact areas around all of APG [ATHAMA 1980]. In 1995, the Army conducted a UXO survey along the fence line between Canal Creek and off-post areas to the north. The survey area was 0.25 miles wide and extended from Westwood, through Canal Creek, to Lauderick Creek. Along this 5.95 miles of fence, only 32 UXO or related hazardous items were identified and removed [HFA 1995]. In 2000, the Army completed a random statistical sampling of APG firing records for both APG-EA and APG-AA. The Army reviewed 7,500 records, which reported the firing of approximately 12 million rounds of ammunition. Of the 12 million, over 11 million were small arms and less than 1 million were large caliber ammunition. The firing records also include information about ammunition firing and impact locations.

Areas which have been affected by unexploded ordnance and munitions are shorelines, impact areas and ranges within the restricted area of the post, and munitions disposal areas. In addition, munitions were disposed of in landfills on the post. Examples of disposal areas include the Bush River Bomb Disposal Area, the Abbey Point Shoreline Piles, and the White Phosphorus Munitions Burial Area, all of which are within the restricted area of APG-AA.

On several occasions, UXO have been found in Canal Creek, including near a playground and recreational area associated with the officer housing area along the Gunpowder River. On each occasion, the Army Technical Escort Unit, which is trained and equipped to handle and dispose of UXO, removed the UXO without incident [USAG 2001].

Activities at Lauderick Creek during the mid-1990s uncovered UXO filled with CWM. These UXO were likely present due to historic use of this study area for training by the Army Chemical School. Training included using and firing chemical ordnance and possibly disposing of CWM. Discovery of CWM-filled UXO led to the Lauderick Creek Removal Action, which began in 1997. The Lauderick Creek Removal Action involved an extensive

planning program and community involvement and education programs because the CWM-filled UXO were located along APG-EA's northern boundary near a residential community and several schools. The Army has uncovered many munitions, including projectiles, mortars of differing sizes, and rockets. Most of these munitions have been transported to the Other Edgewood Areas for storage and disposal. Several, however, were detonated at Lauderick Creek because they were too unstable to transport safely. A foam and tent system has been used for detonations at Lauderick Creek to prevent releases of CWM or harmful debris [USAG 1999, 2000b; RAB 2000].

The Army continues to study the nature and extent of MEC contamination at APG and is conducting remedial actions along study area shorelines to prevent the erosion of MEC into water bodies. Procedures for MEC discovery and removal at APG are detailed in the document *Annex S (UXO Operations) to the APG Disaster Control Plan* [USAG 1996b]. The Department of Defense (DOD) also established the Military Munitions Response Program as a national program to manage the environmental, health, and safety concerns presented by UXO. APG serves as a pilot site for this program [USAEC 2008, EPA-Region III 2008].

Evaluation of Potential Public Health Hazards

On-post workers and trespassers may contact MEC located in restricted areas of the post that were formerly used as firing ranges or MEC disposal areas. If recreational users ignore post restrictions and access the shoreline, they may contact MEC which were fired into water bodies surrounding the APG.

No incidents of past harm from UXO have been reported at APG-EA. A single, unconfirmed incident of past harm from UXO may have occurred at APG-AA. This incident involved an on-post worker who removed a piece of UXO from APG-AA and forcefully hit the UXO causing detonation and personal harm. No reports documenting this incident have been identified. No incidents of detonation have been reported in recent memory [USAG 2001].

To prevent potential harm to current and future on-post workers or recreational users who may discover MEC, the Army has implemented access restrictions. To enforce restrictions, the Army has placed buoys marking restricted waters to inform boaters about limitations. Pamphlets detailing boating restrictions are handed out at marinas and boat launches. Signs reading "DANGER, No Trespassing, Unexploded Ordnance, U.S. Army Property - Keep Out" are posted along the shorelines. The Army also operates land and boat patrols to police APG and to ensure that people are abiding by the use restrictions. Moreover, the Army is conducting ongoing investigations to better understand the possible distribution of UXO at APG-EA.

Additional Consideration – Radionuclides and Depleted Uranium

Radionuclides may be present at APG-EA from past operations, including the transfer and storage of radioactive materials, weapons laboratories, and waste disposal areas across the post.

Summary

Most areas with a known potential for contamination by radionuclides have been sampled, with radionuclides found at levels that were not of concern.

Depleted uranium was tested at restricted firing ranges. Workers and hunters may access these areas infrequently. However, infrequent exposures are not likely to result in adverse health effects.

Areas with the greatest concern for radiation are the former radioactive material disposal areas in Westwood and Bush River. Neither of these areas was used to actually dispose of radioactive wastes, rather the Army used these areas to handle and repackage radioactive materials for off-post disposal. Small amounts of low-level radioactive materials were also present in some of the research and development laboratory equipment, which may have been disposed of in Canal Creek or O-Field landfills. The Nike missiles stored in the launch area at Lauderick Creek may have contained high explosives or nuclear warheads. When missiles contain nuclear warheads, soldiers have Army guidelines for monitoring and testing to ensure that radiation does not leaking from the missiles.

To assess possible radiation releases on a large scale, the Army conducted a radiation survey in the late 1990s. The radiation survey consisted of flying over the post and assessing surface radiation levels using radiation detection equipment [USAG 1999]. To assess possible radiation releases on a smaller scale, environmental samples were analyzed for radionuclides at most of the identified potentially-contaminated sites. Elevated gamma-radiation was found at the Bush River Radiation site. This area was historically used to concentrate liquid radioactive wastes, which resulted in soil contamination. The Army completed remediation activities and is working to have the site de-licensed from containing radioactive materials [EPA-Region III 2008].

The radioactive waste disposal areas in Westwood and Bush River and landfills in Canal Creek and O-Field are located in areas of the post with restricted access. Much of the radioactive contamination at the Westwood and Bush River waste areas has been removed, with additional removals planned. No past, current, and future public health hazards were identified associated with radioactive materials at APG-EA. Use and disposal of radioactive materials was and is limited to areas with restricted access. Members of the public would not be expected to enter these areas and be exposed to radioactive materials.

A related consideration is the testing of depleted uranium (DU) ordnance at APG-EA. The Army began testing DU ordnance in the 1970s, possibly at firing ranges in the Other Edgewood Areas.

DU is the by-product of uranium enrichment, which produces fuel for nuclear reactors and weapons. Natural uranium is a mixture of uranium isotopes, containing around 99.27% by weight of ^{238}U, and around 0.72% of ^{235}U. ^{235}U is more radioactive than ^{238}U and more valuable as nuclear fuel. The enrichment process increases the percentage of ^{235}U in enriched uranium. It also decreases the percentage of ^{235}U in DU, making DU less radioactive than natural uranium. For this reason, the toxicity of DU is governed more by its chemical properties than by its radioactive properties.

Because DU testing was only conducted in areas with restricted access, members of the public are not exposed directly to any residual DU contamination. However, on-post workers and hunters may be exposed to DU-contaminated sediments and surface soils on or immediately adjacent to firing range where DU was used. On-post workers occasionally access these ranges. Hunters have access to a few of these areas. Since the exposures to workers and hunters are expected to occur rarely and for short periods of time, adverse health effects are not likely to occur.

It is possible that people living near APG-EA may be intermittently exposed to DU when range fires occur. At APG-AA, studies were conducted to assess the potential for airborne DU contamination from these range fires. A computational model predicted that DU would not be released in concentrations high enough to impact human health [ANL 1998]. In addition, uranium was analyzed for in air samples taken downwind from range fires (Table 13). Uranium was found at low concentrations downwind of a fire at a range where DU ammunition had been used. No uranium was found in air samples taken downwind of fires at ranges where DU had not been used. The observed concentrations of uranium in the air samples were not elevated to a level of concern. As such, no adverse health effects are expected to occur from exposure to DU through inhaling smoke from range fires.

Summary of Exposure Pathways and Public Health Implications

Although APG-EA is highly contaminated in some areas, the potential for people to be exposed to this contamination is decreased by access restrictions to the most contaminated portion of the post, and restrictions on contact with affected shorelines. However, there are a few ways in which people are or could be exposed to contamination or unexploded munitions. These are detailed below and listed in Table 19.

An evaluation of post-wide soil contamination data collected prior to remediation activities conducted since 2005 identified copper and lead as possible concerns. Localized contamination of sediment with lead and surface soils with copper and lead might cause minor, temporary adverse health effects to workers, hunters, or trespassers who are exposed to the highest levels of contamination for an extended period of time, although this is unlikely to occur. The localized nature of the contamination and the infrequent access to contaminated areas minimize these potential exposures. Ongoing and completed remediation activities eliminate these potential exposures.

Representative range fires were found to contaminate the air to some extent, but not to levels of concern.

Although some site contaminants were observed in fish and turtles, no adverse health effects are expected to occur to people who follow the MDE recommendations on consumption of fish caught in the area.

Lead was found in venison and deer liver harvested on the post, as well as from a background location. The source of the lead is uncertain. Adverse health effects are not expected to result solely from eating deer meat.

Unexploded munitions continue to be a major concern regarding public health safety. Workers, trespassers, and recreational users who do not follow access restrictions could contact munitions and explosives of concern.

Table 19: Summary of known potential public health hazards at APG-AA

Exposed Population	Groundwater Ingestion	Surface Water and/or Sediment Ingestion	Surface Soil Ingestion	Air Inhalation	Food Chain	Munitions and Explosives of Concern (MEC)
On-Post Workers		O	O	○		■
On-Post Residents		○	○	○		
Off-Post Residents	○			○		
Recreational Users		○	○	○		■
Hunters & Trappers		○	O	○	○	
Fishers & Crabbers		○		○	○	
Trespassers		O	O	○		■

○ No adverse health effects are expected to occur as a result of exposure
O Minor, reversible adverse health effects could occur as a result of exposure
● Adverse health effects could occur as a result of exposure
■ Physical hazard

Health Outcome Data Evaluation

Health outcome data, which come from sources such as state tumor registry databases, birth defects databases, vital statistics records, or other records, may provide information about the general health of the community living near a site. Other more specific records, such as hospital and medical records and records from site-specific health studies, may be used to evaluate the prevalence of diseases in the community. Evaluation of health outcome data can confirm the presence of excess disease or illness in a community. However, evaluations are not meant to establish a cause and effect between a substance and a disease. Elevated rates of a particular disease are not necessarily associated with hazardous substances in the environment.

When exposures that may lead to harm are identified, ATSDR reviews appropriate health outcome data to assist in identifying appropriate measures to further evaluate potential public health impacts and to identify actions to ensure the protection of public health. After a review of potential exposure scenarios, environmental data, and toxicity data, ATSDR determined that a review of health outcome data at APG-EA for adverse health outcomes that might be due to contamination at the post was not necessary at this time.

No health studies have been conducted for the populations living near APG-EA. The Harford Board of Health uses the Maryland Cancer Registry and the Directory of Vital Statistics as sources of health outcome data. No disease or cancer clusters have been

noted near APG that would prompt a health study, although a targeted study of APG has not been conducted [HCHD 2001a]. Cancer registries and vital statistics databases usually report data for population groups, such as counties. If exposures to hazardous substances in the environment occur, generally, all residents within the county are not affected. Instead, the people exposed would be a smaller, localized group. Any evidence of excess illness in that smaller group may be hidden within the rates of illness for the larger group. As such, the amount of information that can be obtained from these health outcome data pertinent to illness caused by environmental contaminants is limited.

Child Health Considerations

ATSDR recognizes that infants and children may be more sensitive to exposures than adults in communities with contamination in water, soil, air, or food. This sensitivity is a result of a number of factors. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. Children are shorter than adults, so that they breathe dust, soil, and heavy vapors closer to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. Of the chemicals found at elevated levels at APG-EA, lead poses a unique toxicity for children.

ATSDR has attempted to identify populations of children in the vicinity of APG-EA. Four elementary schools, one middle school, and one high school are located in the communities north of APG-EA [HCG 2000]. Approximately 1,700 children 6 years of age or younger are estimated to live within one mile of APG [Census 2001].

Like other people living or working at or in the vicinity of APG-EA, children may contact contaminated site media, as discussed in the Evaluation of Environmental Contamination and Potential Exposure Pathways section of this PHA. ATSDR considered that the populations identified and assessed at APG-EA, including on-post residents, off-post residents, recreational users, and hunters and fishers, would include children as well as adults. As such the evaluations of the following exposure pathways considered exposures to children:

- Ingestion of contaminated groundwater
- Contact with surface water and sediment contamination
- Contact with surface soil contamination
- Inhalation of air emissions from range fires
- Ingestion of contaminants in the food chain (aquatic animals and deer)
- Contact with MEC

Using available information about potentially exposed children, site and area use, access restrictions, sampling data, and remedial actions, ATSDR evaluated to what extent, if any,

children were exposed to contaminants in groundwater, surface water and sediment, surface soil, air, and the food chain, as well as MEC.

Community Involvement and Health Concerns

As part of the PHA process, ATSDR staff met with community members to gather information about their concerns regarding APG-EA and its potential health impacts. Community health concerns at APG-EA, were identified through several activities. ATSDR staff attended meetings of the APG RAB, which is comprised of several representatives of community organizations. Discussions with RAB members were extremely helpful in identifying concerns. The minutes of RAB meetings continue to aid in identifying concerns. Other community members were given opportunities to voice their concerns at public availability sessions. An additional source is the comments to the PHA for APG-EA which was released in 1993. As a result, ATSDR identified the following community concerns.

Community members were concerned that limited data were available for drawing conclusions about potential public health hazards.

In conducting a PHA, ATSDR identifies possible site-specific exposures to environmental contaminants to assess health implications for the surrounding community. Because public health assessments are exposure driven, ATSDR considers whether community members contacted or could come into contact with harmful substances in the environment. Although contaminants may exist in the environment, these contaminants may only cause harm if people are exposed to them (i.e., come in contact with contaminants).

Once ATSDR establishes that exposures could occur, environmental sampling data are reviewed to determine if these exposures are likely to result in harm to community members. ATSDR determines if available sampling data were collected from areas where exposures could occur and if available data are sufficient to draw public health conclusions as part of the data review. No one approach is available for assessing data because of the vast number of available data collection techniques and unique site conditions. As such, ATSDR considers site-specific conditions to determine if data are sufficient to draw public health conclusions.

In 1993, when the PHA for APG-EA was first released, ATSDR concluded that the overall potential for contact with contaminants from APG-EA to result in harm could not be assessed because insufficient data were available. Additional sampling was recommended. ATSDR, however, reviewed the data that were available at that time and found no exposures that were expected to result in harm.

Since release of the PHA in 1993, the Army has conducted numerous investigations throughout APG-EA to further characterize site contamination and identify necessary remedial actions. ATSDR reviewed data from these additional investigations and considered remedial actions when evaluating potential public health hazards at APG-EA. Additional information about site contamination, site uses, remedial actions, and access restrictions were considered sufficient to draw public health conclusions.

In reviewing this PHA, you should be aware that site characterization and remediation at NPL sites may continue for years after releases have first been suspected. Likewise, remediation may occur before, during, or after ATSDR's involvement. Sometimes, additional data are generated after remediation and after the PHA has been released to the public. As such, the ATSDR's involvement at this site should not be considered as a single fixed document, but should be viewed as an evolving process that reflects the dynamic progression of collection and evaluation of new information. Therefore, if new data are collected or additional information is compiled that suggests the public health may be adversely affected, ATSDR may modify or add to the PHA to reflect the public health implications of the additional data and recommend actions to stop or reduce exposures.

Community members are concerned about whether rates of illness, specifically cancer, are elevated in communities surrounding APG-EA. They questioned whether exposure to contaminants from APG-EA may be the cause. Community members requested that ATSDR conduct health studies in the neighborhoods surrounding APG-EA.

ATSDR understands the concerns about possible illnesses and cancers resulting from exposures to chemicals used and released at APG. Before recommending health studies, however, ATSDR first considers available information about potential exposures and data regarding chemical toxicity. If exposure and chemical toxicity data indicate potential harm, ATSDR then reviews existing health outcome data to further understand possible health effects. A health study may be recommended if there is exposure at levels plausibly associated with illness or cancer rates or otherwise indicate that public health effects may be occurring.

At APG-EA, ATSDR identified and evaluated potential exposures and chemical toxicity. ATSDR then evaluated whether these exposures were frequent enough or chemical concentrations were high enough to possibly affect public health. Potential health effects associated with contamination at APG-EA include:

- Hazards from unexploded munitions to workers, trespassers, and recreational users who do not follow post access restrictions; and
- Temporary changes in blood chemistry and gastrointestinal discomfort in workers, hunters, and trespassers who access certain areas and remain in these areas long enough to accidentally ingest surface soil containing the highest levels of lead and copper.

These health effects, if they occur, are most likely limited to a very small subset of the larger population. They are most efficiently addressed through access restrictions and additional environmental studies and remediation. In addition, the conclusions regarding potential health effects associated with copper and lead in soil are based on data collected prior to the recent remediation activities (e.g., actions conducted since 2005). The localized nature of the soil contamination and the infrequent access to contaminated areas minimize potential exposures to elevated copper and lead concentrations in soil. Ongoing and completed remediation activities eliminate these potential exposures.

What are the potential health impacts to workers from exposures to environmental contamination at APG-EA?

The health of workers in the workplace is protected under the Occupational Safety and Health Act, which Congress passed in 1970. This act requires that employers provide "employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees" (section 5(a)(1)). As required, the Army and tenants at APG-EA follow OSHA standards and guidelines to protect their worker population.

However, in addition to potential workplace exposures, workers may also contact contamination or UXO that has been released to the environment. Contact with copper in sediment and lead in sediment and surface soil in certain areas of the post may lead workers to experience gastric distress or temporary changes in blood chemistry. These effects end soon after the exposure ends. In addition, there is a hazard from UXO. The potential for experiencing these effects can be greatly diminished by avoiding the affected areas whenever possible, and using appropriate caution and protective equipment and/or procedures when it is necessary to access these areas.

Community members requested that the Army install better signs and buoy markers to identify areas where contamination and UXO may be present and to better educate the public about these areas to prevent or reduce exposures during recreational use of water bodies near APG-EA.

Since 1993, the Army has improved signs, buoys, and access restrictions to prevent or reduce possible exposures to UXO, MEC, and site contamination. Large signs, approximately 4 feet by 5 feet, are posted along the APG shorelines and read "DANGER, No Trespassing, Unexploded Ordnance, U.S. Army Property - Keep Out." These signs are located every 200 to 300 feet along the shoreline and can be easily read from boats. The Army has placed buoys in the Chesapeake Bay to mark APG's restricted water zones. These buoys correspond to waterway use restrictions outlined in the Boaters Guide to Restricted Water Zones. This guide details boating restrictions in place in APG's waterways, including permitted activities (boating, fishing, and water skiing), hours when all waterways are closed for public use (weekdays 7:30 a.m. 5 p.m.), and streams and shorelines closed to the public at all times. The boaters guide is available at marinas and boat launches throughout the Chesapeake Bay area. The Army also operates patrol boats that police the APG waters to ensure that people are abiding by the use restrictions [USAG 1996a, 1999b].

Conclusions

Conclusions regarding media- and site-specific exposures are as follows:

1. High lead levels were found in a few of the many samples of deer muscle and liver. The source of this contamination is unknown, and may include many sources

throughout the area. If a young child often eats deer meat or liver with the highest observed levels of lead, he or she could experience slight increases in blood lead. However, no adverse health effects are expected to result solely from eating deer meat. As a result, ATSDR categorizes lead in deer as no apparent public health hazard.

2. UXO present a physical hazard in areas throughout the post. As such, on-post workers, hunters, and trespassers may contact UXO. A single incident of past harm may have occurred at APG-AA. To minimize or prevent potential current and future harm, the Army has implemented access and use restrictions, as well as posted buoys and signs and distributed educational materials to notify people about areas potentially containing UXO. The Army also operates land and boat patrols to police APG-EA to ensure that people are abiding by the use restrictions. Army guidelines for addressing UXO discovered at APG-EA are in place to further minimize the potential for harm. As long as the Army continues its vigilance in maintaining access restrictions and public education, ATSDR categorizes UXO as no apparent public health hazard.

3. Localized soil and sediment contamination only poses hazards under extreme circumstances. Lead in some sediments and lead and copper in some soils might cause temporary health effects to trespassers (workers, hunters, etc) who ingest soil frequently. This conclusion, however, is based on data collected prior to recent remediation activities (e.g., actions conducted since 2005), which was the data set available to ATSDR during the PHA process. The likelihood of health effects happening is small because people access these areas infrequently and soil contamination is localized. In addition, ongoing and completed remediation activities eliminate most of these potential exposures. For this reason, ATSDR classifies this pathway as no apparent public health hazard.

4. People who follow MDE guidelines on fish consumption are not expected to experience adverse health effects from eating fish caught in permissible areas at APG-EA. Likewise, people who eat a similar amount of crab or turtle are not expected to experience adverse health effects. Although no animals were sampled for perchlorate, and the bioaccumulation potential for perchlorate remains a question, the potential for contamination by perchlorate remains low. For these reasons, ATSDR categorizes the consumption of fish from permissible areas of APG-EA as no apparent public health hazard.

5. Observed levels of air contamination downwind of range fires were not at levels of concern. For this reason, air contamination by accidental range fires is not expected to cause adverse health effects, and ATSDR classifies this pathway as the category no apparent public health hazard.

6. Lead was found in groundwater from off-site, private wells. However, the wells are upgradient from the post, and so are not likely impacted by groundwater quality on

the post. ATSDR classifies this pathway as posing no apparent public health hazard.

Recommendations

ATSDR recommends that the following actions be taken to ensure the protection of public health at APG-EA and in surrounding communities.

1. Additional studies of contaminants, specifically lead, in deer harvested from the post by hunters should be conducted. These studies should gather information about trends in lead levels in deer muscle and liver samples. To prevent elevation in blood lead levels, hunters should limit the amount of venison from deer harvested state wide served to children until additional information about deer contamination and lead levels is obtained.

2. The Army should continue to maintain access restrictions and educational efforts to advise and protect members of the public and the on-post community from unexploded munitions.

3. Remediation activities are ongoing for many areas with surface water, sediment, and surface soil contamination. Workers, who access these areas, whether during investigation, remediation, or other activities, should be made aware of the status of the area and should use appropriate protective equipment or procedures when working in areas with contamination. Signs or access restrictions in these areas could also deter hunters and trespassers from entering them.

4. The Army should continue efforts to decrease the potential for range fires, and to improve firefighting capabilities to extinguish range fires quickly and safely.

Public Health Actions

The Public Health Action Plan for APG-EA contains a description of actions taken and those to be taken by ATSDR and the Army subsequent to the completion of this PHA. The purpose of the PHAP is to ensure that this PHA not only identifies potential and ongoing public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment.

In the 1993 PHA, ATSDR recommended that the Army conduct additional sampling to further characterize contamination, abandon contaminated wells according to federal and state regulations, install access controls to minimize contact with media contamination and unexploded munitions, and obtain information about fish and game, and recreational activities. The actions completed or underway to address these recommendations, as well as additional measures completed and ongoing or planned are listed below.

Completed Actions

1. The Army has conducted investigations and remedial activities throughout the post. Remedial activities have included, but were not limited to, removal of USTs and associated contamination, contaminated media (e.g., soil, sediment, standing water), surface materials, debris, and UXO; decontamination and removal of buildings and equipment (e.g., vault at Bush River, wind tunnel at Carroll Island); abandonment of sewer and septic systems; construction and operation of groundwater treatment systems; installation of soil caps and landfill covers; and installation of shoreline stabilization measures. The Army has also installed access restrictions (e.g., fences, warning signs) and maintains a geographical information system (GIS) to track land use controls and inform planners when determining appropriate land use.

2. Following federal and state guidelines, the Army abandoned 16 former drinking water supplies wells. In 1984, the Army stopped using the six standby wells located in Canal Creek because of contamination. The wells were permanently abandoned in 1994. The Army also abandoned 10 of the 14 wells located at Carroll Island and Graces Quarters in 1994. One well could not be located and three wells were left intact as non-potable supplies.

3. In 1994, the Army completed a private well survey to identify homes along the boundary of APG with private wells. Private wells were identified along the northern and western post boundaries. The Army sampled six residential wells north of the main portion of APG-EA in 1995 and two additional residential wells in this area in 1996. Between 1992 and 1995, the Army sampled 14 residential wells located along the western post boundary near Carroll Island and Graces Quarters.

4. The Army has conducted two studies assessing possible exposures to contaminants released to the air during range fires. A study modeling possible releases was completed in 1998. In 2001, the Army reported the results of a study in which air samples were collected during a series of controlled burns designed to simulate worst-case scenario range fires.

5. To minimize possible contact with UXO, the Army installed large signs reading “DANGER, No Trespassing, Unexploded Ordnance, U.S. Army Property - Keep Out” along the shorelines of APG. The Army also distributes educational materials informing boaters and users of APG waters about access restrictions. Land and water patrols are operated to minimize possible trespassing in areas with UXO.

6. The Army has completed a large effort to remove UXO from the Lauderick Creek area. This removal action involved identifying, removing, and disposing of UXO, specifically CWM-filled UXO, located along the northern APG-EA boundary in Lauderick Creek. The removal action also included an intensive community outreach program.

7. The Army completed studies of fish, turtle, and deer consumption and sampling.

Ongoing and Planned Actions

8. The Army is continuing investigations throughout APG to identify and remediate sources of contamination.

9. The Army conducts ongoing operations and maintenance activities for selected remedial actions, and continues regular monitoring as required by agreements with the EPA.

10. Community education and involvement activities are ongoing. The Army participates in regular RAB meetings to provide community members with information about ongoing activities at APG. Information is also distributed through information repositories, mailings, press releases to the media, community meetings outside the RAB, site tours, and the APG web site. The community is provided with opportunities to comment on proposed cleanup plans during public comment periods.

11. The Army continues to maintain access restrictions and educational efforts to advise and protect members of the public and the on-post community from unexploded munitions.

12. The Army follows ordnance testing and firing restrictions designed to minimize off-post migration of smoke from testing or range fires ignited during testing activities. In addition, firefighting protocols are in place to ensure that range fires are extinguished as quickly as possible without compromising the safety of APG personnel. The Army continues its efforts to decrease the potential for range fires, and to improve firefighting capabilities to extinguish range fires quickly and safely.

13. The Army is conducting ongoing studies to understand distribution of UXO at APG-EA. As these studies continue, the Army conducts remedial activities to remove UXO located throughout the post. Removals are conducted in accordance with *Annex S (UXO Operations) to the APG Disaster Control Plan*, which outlines guidelines and protocols to follow to minimize potential harm to APG personnel. Ongoing UXO removal also occurs under the DOD Military Munitions Response Program. Most areas of APG evaluated under the site investigation phase of the program are being carried into the remedial investigation phase.

14. The Army plans to sample tissue from deer harvested on APG. The sampled tissue will be taken from portions of the carcass which are not near any bullet wounds. Tissues will be analyzed for lead contamination.

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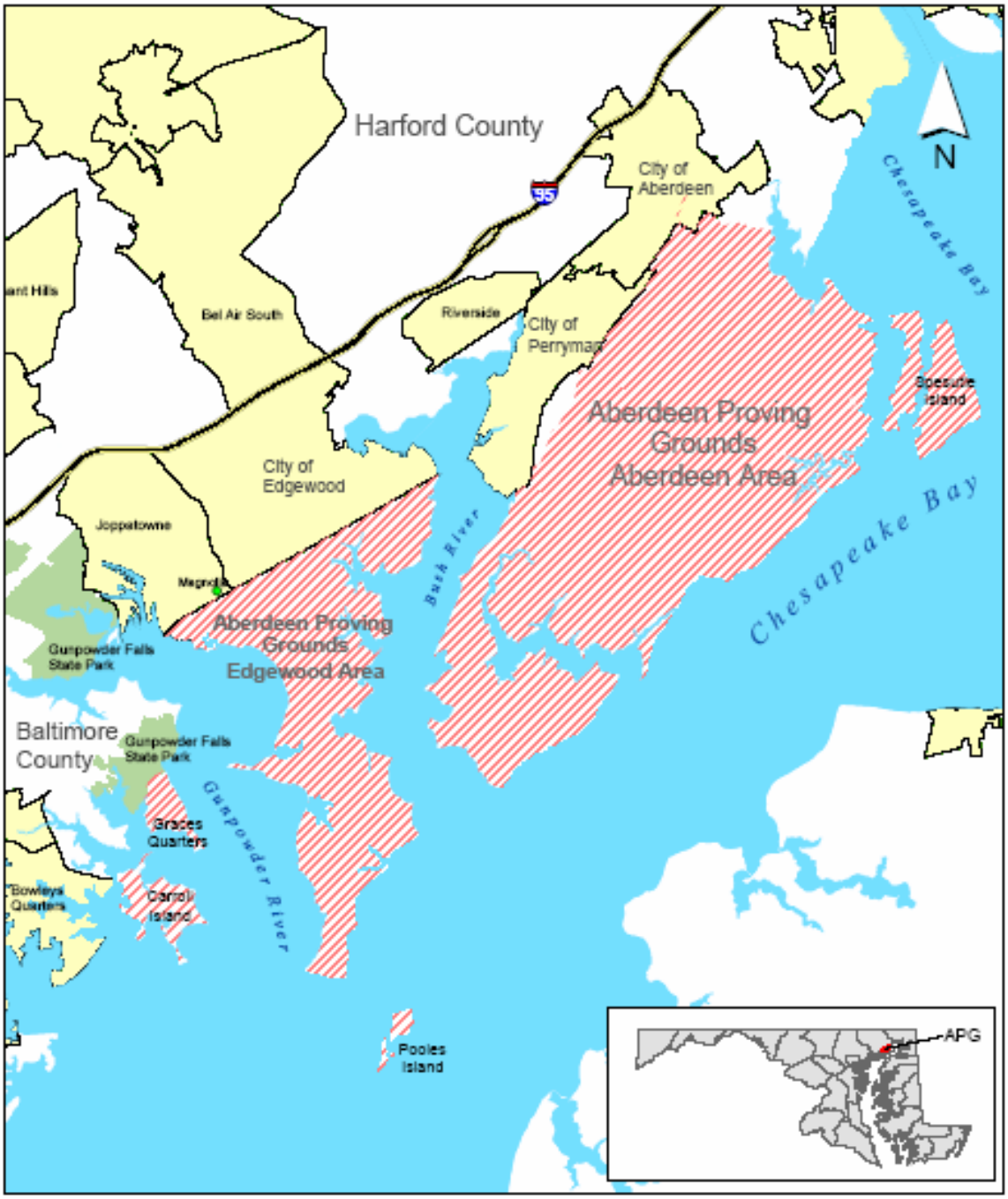
Figures


Harford County
City of Aberdeen
N
Chesapeake Bay
Bel Air South
Riverside
City of Perryman
Spesutie Island
Aberdeen Proving Grounds Aberdeen Area
City of Edgewood
Joppatowne
Magnolia
Bush River
Chesapeake Bay
Aberdeen Proving Grounds Edgewood Area
Gunpowder Falls State Park
Baltimore County
Gunpowder Falls State Park
Graces Quarters
Gunpowder River
Bowleys Quarters
Carroll Island
Pooles Island
APG
Aberdeen Proving Grounds and Surrounding Area
Harford County, Maryland
Miles
0
1.25
2.5
5
Figure 1
GRASP

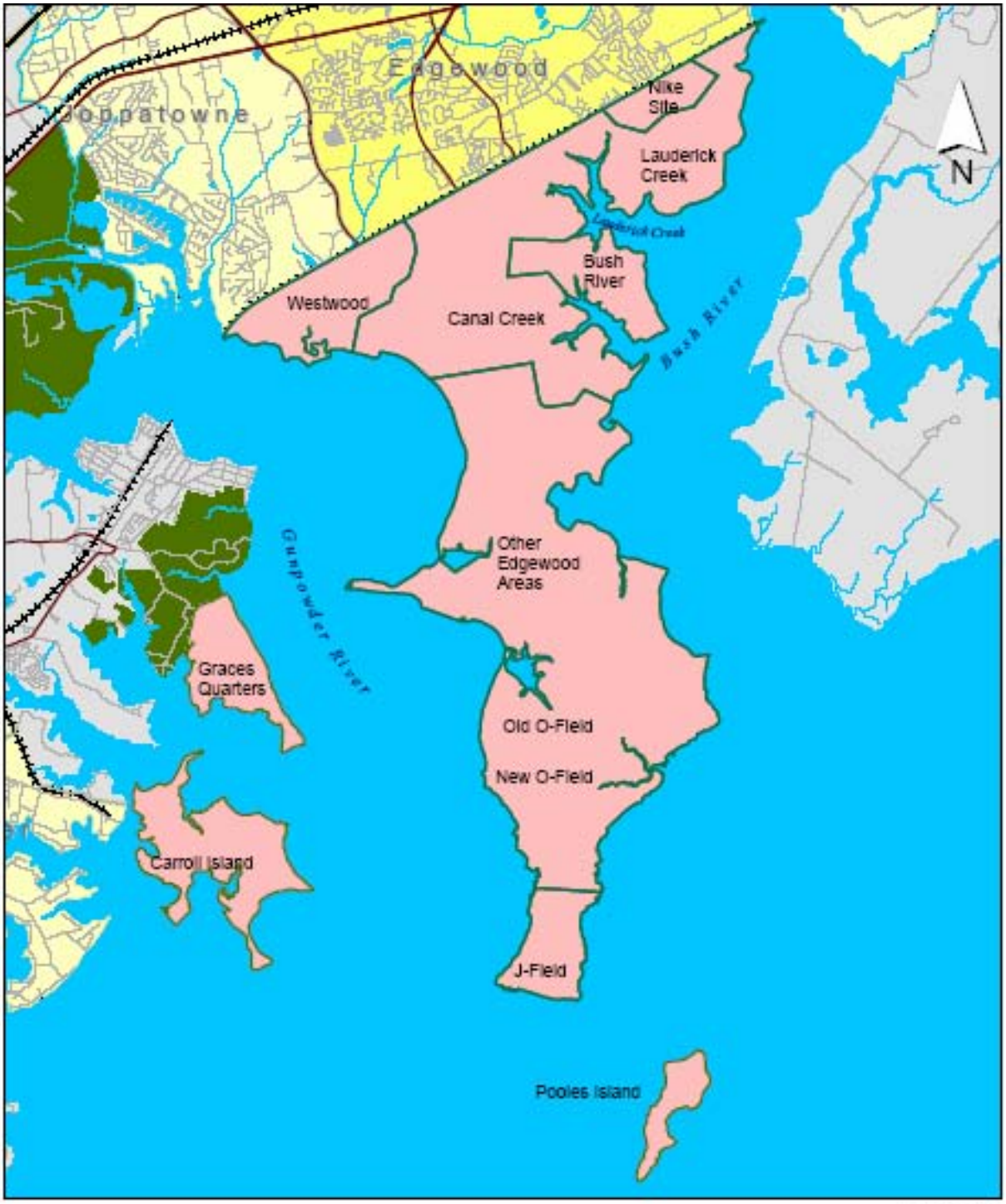


Figure 2

Edgewood Area

Aberdeen Proving Grounds

Harford County, Maryland

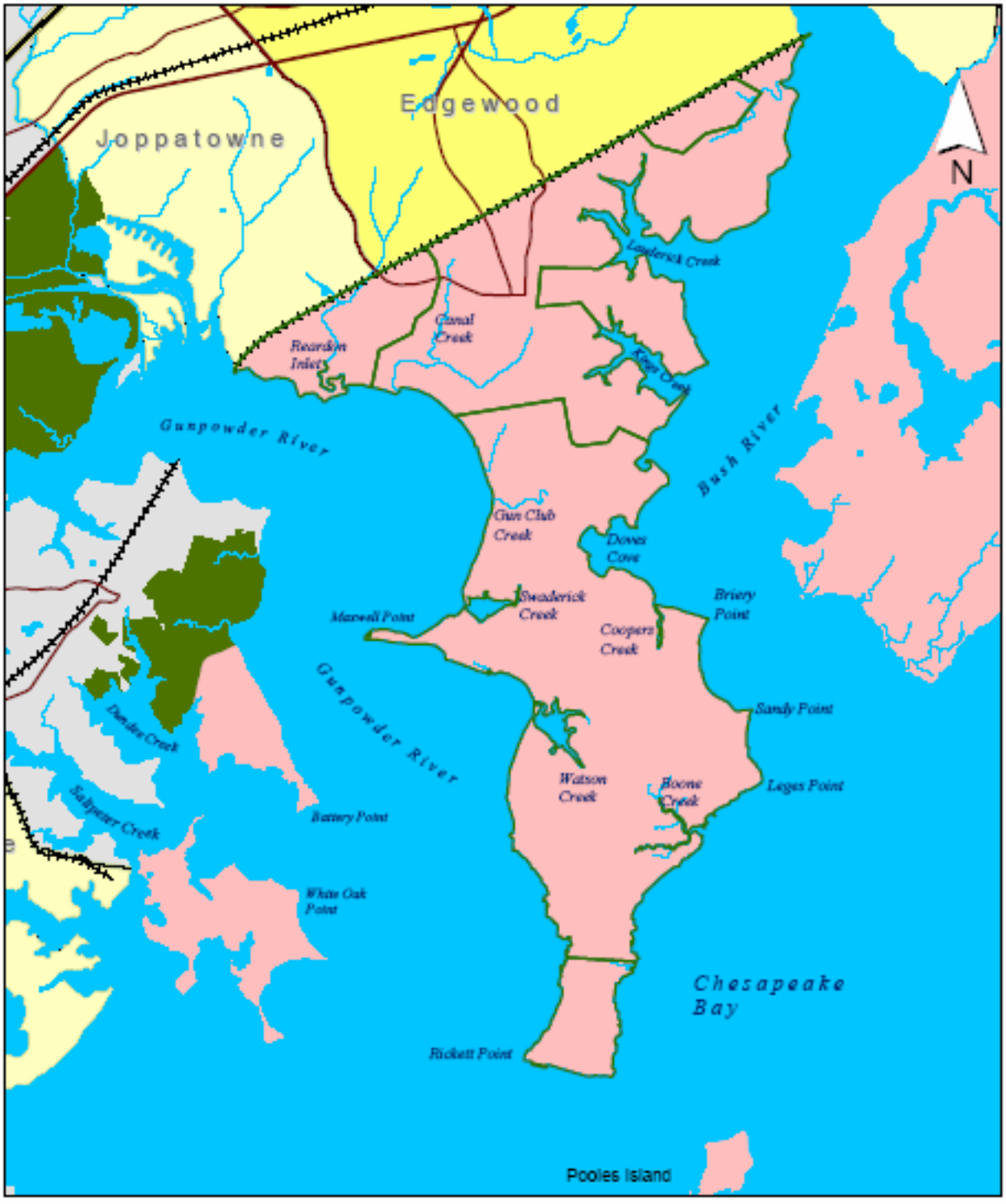


Figure 3

Water bodies on or near the Edgewood Area
Aberdeen Proving Grounds
Harford County, Maryland

Appendix A – Comparison Values

For this public health assessment, ATSDR selected contaminants for further evaluation by comparing the maximum environmental contaminant concentrations against conservative health-based comparison values. Comparison values are developed by ATSDR from available scientific literature concerning exposure and health effects. Comparison values are derived for each environmental medium (such as air, soil, water, and fish), and reflect an estimated contaminant concentration that is not expected to cause harmful health effects. This is based upon assumptions regarding exposure, body weight, and bioaccumulation (if appropriate). Because the concentrations reflected in comparison values are much lower than those that have been observed to cause adverse health effects, comparison values are considered to be protective of public health. As a result, contaminants detected at or below ATSDR's comparison values are not considered for further evaluation.

While concentrations at or below the relevant comparison value can reasonably be considered safe, it does not automatically follow that any environmental concentration exceeding a comparison value would be expected to produce adverse health effects. Comparison values are not thresholds for harmful health effects. The likelihood that adverse health effects will actually occur depends on site-specific conditions, individual lifestyle, pre-existing health conditions, and genetic factors that affect the route, magnitude, and duration of actual exposure. If contaminant concentrations are above comparison values, ATSDR further analyzes these exposure variables, along with relevant toxicological and epidemiological studies to determine whether adverse health effects might occur.

Comparison values can be generated for several different types of exposure, and for different media. Each different type of comparison value which was used in this PHA is discussed in detail below.

Ingestion of Contaminated Media

The comparison value for exposure by drinking or eating contaminated media (such as soil, water, or fish) can be chosen from many sources, depending upon which are available. Most of these are calculated by assuming various factors about the exposure and the person being exposed. Adults are assumed to weight 70 kilograms (kg) (154 pounds). Children are assumed to weigh 10 kg (22 pounds). The amount of the medium that is eaten (the ingestion rate) varies depending upon the environmental medium. The ingestion rates used in this PHA are given in the following table:

Ingestion rates used in this PHA to generate comparison values

Medium	Children	Adults
Drinking Water	1 L/day	2 L/day
Surface Water	10 mL/day	10 mL/day
Soil and Sediment	100 mg/day	200 mg/day
Fish, Crabs, Turtles or Deer	12 g/day (represents a 2 oz meal, once or twice a week)	26 g/day (represents a 4 oz meal, once or twice a week)

g gram
L liter
mL milliliter
mg milligram
oz ounce

Following are details on the types of comparison values that were used:

CREG
If the contaminant can cause cancer, detected concentrations are compared to the Cancer Risk Evaluation Guide (CREG), which is the estimated concentration of a contaminant at which a lifetime exposure could cause cancer in one person out of a million people who were exposed. The CREG is based on EPA's oral cancer slope factor, which assumes a theoretical cancer risk following low-level exposure to chemicals. EPA's oral cancer slope factors are available in EPA's IRIS database at www.epa.gov/iris. Exposure is assumed to occur every day over a 70-year lifetime. CREGs are calculated as follows:

$$CREG = \frac{(\text{Target Risk}) * (\text{Body Weight})}{(\text{Ingestion Rate}) * (\text{EPA's oral cancer slope factor})}$$

where the target risk is 10^{-6}, which represents a theoretical risk of one excess cancer in a population of one million people. CREGs are calculated only for adults, since they assume a lifetime exposure.

CREGs are usually *extremely* protective of public health. Since they are based upon a target risk that is very small (0 -10^{-6} range), they are often much smaller in value than is necessary for an effective screening tool.

EMEG, iEMEG, aEMEG, and RMEG
The EMEGs and the RMEG are calculated from values that consider only non-cancer adverse health effects. These values can be available for substances that don't cause cancer, as well as for those that do. EMEGs are calculated from ATSDR's Minimal Risk Levels (MRLs). MRLs are available for different exposure timeframes:

- chronic, lasting a year or longer;
- intermediate, lasting from two weeks to a year; and
- acute, lasting up to two weeks.

RMEGs are calculated from EPA's oral Reference Dose (RfD), which considers only the chronic exposure timeframe. RfDs are available in EPA's IRIS database.

EMEGs and RMEGs are calculated as follows:

$$EMEG\ or\ RMEG = \frac{(MRL\ or\ RfD) * (\text{Body Weight})}{(\text{Ingestion Rate})}$$

These values can be derived for exposure to either adults or children. In the case of EMEGs, different exposure timeframes can be used.

Additional Values
A few substances do not have sufficient information to derive a CREG, EMEG, or RMEG. For these substances, a few additional sources have been used to provide comparison values.

- For drinking water, EPA's Maximum Contaminant Level (MCL), which can be found at www.epa.gov/safewater/mcl.html
- For soil, EPA's Soil Screening Level (SSL), which can be found at www.epa.gov/superfund/resources/soil

Ingestion of Food Living in a Contaminated Environment
For this PHA, comparison values were derived to consider whether contamination in the environment might bioaccumulate to levels of concern in the food chain. Specifically, fish and deer were considered. Each of these special environmental comparison values began with a comparison value based on the ingestion of the fish or deer (as calculated in the previous section). A value is then estimated in the environment which would cause that concentration to bioaccumulate in the fish or deer.

Effects of Sediment on Fish
To derive a sediment comparison value based on fish ingestion, EPA's Biota to Sediment Accumulation Factor (BSAF) was used. These values can be found on EPA's website [EPA 2005b]. The comparison value is calculated as follows:

$$CV_{\text{sediment}} = \left(\frac{CV_{\text{fish}}}{\text{BSAF}}\right) * \left(\frac{\text{Organic carbon fraction in sediment}}{\text{lipid fraction in fish}}\right)$$

The organic fraction in the sediment, and the lipid fraction in the fish are not always known, but are usually of the same magnitude, so this parameter was considered to be equal to 1, simplifying the equation to:

$$CV_{\text{sediment}} = \left(\frac{CV_{\text{fish}}}{\text{BSAF}}\right)$$

Effects of Surface Water on Fish
To derive a surface water comparison value based on fish ingestion, EPA's Fish Bioaccumulation Factor (BAF) was used. These values can be found on EPA's website [EPA 2005b], but are conveniently available at [ORNL 2005]. The comparison value is calculated as follows:

$$CV_{\text{surface water}} = \left(\frac{CV_{\text{fish}}}{\text{BAF}} \right)$$

Effects of Surface Water on Deer
No data are available for the bioaccumulation in deer of contamination in surface water. However, this may be estimated for beef, which is then used as an estimate for bioaccumulation in deer. The comparison value for surface water based on deer (beef) ingestion is based on EPA's Beef Transfer Coefficient (BTC), which can be found on EPA's website, but is conveniently available at [ORNL 2005]. The comparison value is calculated as follows:

$$CV_{\text{surface water}} = \frac{\left(CV_{\text{deer}}\right)}{\left(\text{BTC}\right) * \left(\text{surface water ingestion rate}\right)}$$

where the surface water ingestion rate for beef is 53 L/day. Although this is much higher than the surface water ingestion rate for deer, it is balanced by the fact that cattle are larger than deer.

Effects of Surface Soil on Deer
No data are available for the bioaccumulation in deer of contamination in surface soil. However, this may be estimated for beef, which is then used as an estimate for bioaccumulation in deer. The comparison value for surface soil based on deer (beef) ingestion is based on EPA's BTC and the Soil-to-Plant-Dry uptake (Bv_{dry}), also found at [EPA 2005b] and [ORNL 2005]. The comparison value is calculated as follows:

$$CV_{\text{surface soil}} = \frac{\left(CV_{deer}\right)}{\left(BTC\right) * \left[Quantity\,of\ \ pasture\,ingested * \left(Bv_{dry} + Plant\,mass\,loading\ \ factor\right)\right]}$$

where the quantity of pasture ingested is 11.77 kg/day, and the plant mass loading factor is 0.25. Based on the difference in feeding habits between cattle and deer, this value may be overly protective.

Inhalation of Contaminated Air
The comparison value for exposure by inhaling contaminated air may be chosen from many different sources. Assumptions about exposure variables such as inhalation rates are built into these values. Separate values are *not* derived for children and adults.

CREG

If the contaminant can cause cancer, a CREG can be derived for inhalation in a similar manner as it was derived for ingestion. The CREG for air is based on the EPA's Inhalation Unit Risk (IUR), which is available in EPA's IRIS database, www.epa.gov/iris. It is calculated as follows:

$$CREG = \frac{(\text{Target Risk})}{(\text{IUR})}$$

Where the upper bound target risk is 10^{-6}, and represents a risk of less than one excess cancer in a population of one million people.

CREGs are usually *extremely* protective of public health. Since they are based upon a target risk that is very small (0 -10^{-6} range) they are often much smaller in value than is necessary for an effective screening tool.

EMEGs and RfCs

Non-cancer adverse health effects are considered in ATSDR's EMEGs and EPA's Reference Concentrations (RfCs). Since each of these values is already in the form of a concentration in air, no additional calculations are necessary. ATSDR's EMEGs are available for chronic, intermediate, and acute exposure timeframes. EPA's RfCs are available only for the chronic timeframe.

Additional Values

Additional values were used in this PHA when no acute EMEG was available. These values were for occupational exposures, and included the Permissible Exposure Limit (PEL) from the Occupational Safety and Health Agency, and the Recommended Exposure Limit (REL) from the National Institute of Occupational Safety and Health. These values are derived to be protective of workers exposed over the course of their working life for 8 hours (PEL) or 10 hours (REL) a day during a 40-hour work week [NIOSH 2004].

Appendix B – Responses to Public Comments

The Agency for Toxic Substances and Disease Registry (ATSDR) received the following comments during the public comment period (December 19, 2007 to February 15, 2008) for the U.S. Army Aberdeen Proving Ground, Edgewood Area (APG-EA) Public Health Assessment (PHA). For comments that questioned the validity of statements made in the public health assessment, ATSDR verified or corrected the statements. The list of comments does not include editorial comments, such as word spelling or sentence syntax.

	Comment	*How Addressed*
1	General: ATSDR used some old information, not the most recent information. We have completed and have on-going the majority of the ATSDR recommendations, except for additional studies on deer meat.	Throughout the PHA, ATSDR modified text to indicate that the Army has completed or is conducting remediation activities to address contamination throughout the post. ATSDR also clarified that conclusions about health effects associated with copper and lead in surface soil are based on data collected through 2005, which was the data set available to ATSDR during the PHA process.
2	Page 7, Last paragraph: OPSEC may be concerned with this statement.	ATSDR deleted this paragraph and added the following text to the end of the first paragraph in this section: Fences also separate APG-EA from the surrounding neighborhoods.
3	Page 9, Third full paragraph, Last sentence: Standby wells have been closed. There are no wells currently being used for potable uses. Wells from this era (WWI/WWII) are no longer visible or can be found.	ATSDR modified the text as follows: Groundwater has served as a secondary source of industrial and potable water. Since World War I, as many as 43 supply wells have been used at APG-EA. The few that remain active are used for non-potable water. Many others have been properly closed. The wells that have not been documented as closed are no longer visible and cannot be located.
4	The assessment mentions elevated lead levels in off-site, private wells. Are these off-site wells located in Harford County? If so, what are the actual levels and what is the suspected source of the lead contamination?	Private wells containing elevated lead levels (to a maximum of 40 parts per billion) are located in Baltimore County, near Carroll Island and Graces Quarters. The source of this lead is unknown. ATSDR clarified the text to identify whether the location of private wells was in Baltimore County or Harford County.

	Comment	*How Addressed*
5	Page 17, Table for Westwood Area near border -The table lists high levels of metals near the border. I am not sure specifically which area this is referring to, but most of the areas with high levels of metals have already been addressed by excavation and disposal of contaminated soils. The areas already excavated were the gas mask factory, the brine sludge pile near the old chlorine plant, the WW-90 drum dump, the HRC grenade pit and WRMDF dump. The excavations have been backfilled with clean soil. Additionally, there is a ROD for the WW-90 fill area where a soil cover will be installed and the Hog Point areas with high levels of arsenic and other metals will be excavated this year. Land use controls were implemented which prohibit residential use.	Table 5 on page 17 refers to contaminants found in groundwater in the Westwood Area. ATSDR evaluated exposures to soil contaminants, including metals, in the section "Contact with Surface Soil Contamination." Text and tables in this section have been updated to reflect ongoing remediation activities.
6	Page 21, Paragraph 2, Sentence 4: More recent work with GP and subsequent ROD [Record of Decision] concluded that this area is a No Further Action (NFA) site—CWM [chemical warfare material] degradation products could not be verified as present in re-sampling done by GP.	ATSDR revised sentence 4 as follows: More recent sampling found no CWM degradation products. A Record of Decision (ROD) concluded that no further action is warranted at this site [USAG 2008]. ATSDR also added information about the ROD and the decision for no further action in the discussion of the nature and extent of contamination at recreational areas in the section "Contact with Surface Soil Contamination."
7	Page 25, first paragraph under table 10- This paragraph again refers to the Westwood area where most of the metals contaminated soil has already been removed or will be removed later this year. Land use controls prohibit residential use.	ATSDR added the following text to the paragraph: Contaminated soils in the Westwood area, however, have been removed as part of ongoing remediation activities. Remediation activities, including installation of soil cover over toxic burn pits at J-Field and reforestation of the area, are completed or ongoing as part of the ROD for J-Field [EPA-Region III 2008].
8	Page 28, Copper in surface soil -again metals in Westwood have been removed or will be addressed this year. Same response on lead in Westwood Area -Land use controls prohibit residential use. Also, I am not sure what area of J-Field the report is referring to, but the Army did more extensive sampling of the J-Field White Phosphorous Pits area and only low levels of metals were found. The J-Field White Phosphorous Pit trench will be filled in and the entire area reforested per a ROD that has been issued. Land use controls prohibit residential use. The toxic burn pits at J-Field had a soil cover installed over the waste years ago.	The evaluation of possible health effects associated with copper exposures applies to possible exposures prior to remediation (i.e., past exposures). Therefore, ATSDR revised the text throughout the section "Contact with Surface Soil Contamination" to indicate that the data presented represent soil contamination prior to remediation activities that have occurred since 2005 (this was the data set available to ATSDR during the PHA process). ATSDR added information about completed and ongoing remediation activities that would eliminate exposures.

	Comment	*How Addressed*
9	Page 28, Lead in Surface Soil -The report mentions the Gun Club Creek. I assume that this is referring to the skeet range which has elevated lead levels, but this area is very marshy and is covered with phragmites so thickly, that the contractor had to cut through the phragmites to sample the area. This area is being further investigated.	ATSDR added the following text to the paragraph: Dense vegetation (*Phragmites sp.*, which is a tall, dense invasive grass) covers soil near Gun Club Creek and limits access to the area.
10	Page 45, Paragraph 2, Sentences 5-8: Clarify that the records include both AA [Aberdeen Area] and EA [Edgewood Area]. It is unclear why the AA data should be included in the EA report.	ATSDR clarified the text that refers to both APG-EA and APG-AA. ATSDR included post-wide data because the available references did not break down the number of unexploded Ordnance (UXO) and projectiles, or firing records by specific areas of the post.
11	Page 45, Paragraph 3, Sentence 3: It is unclear why these areas are included in a report about EA; these are in AA.	ATSDR included references to the Bush River Bomb Disposal Area, the Abbey Point Shoreline Piles, and the White Phosphorus Munitions Burial Area as examples of munitions disposal areas. ATSDR modified the text to clearly indicate that these areas are located within the restricted area of APG-AA.
12	Page 45 -Section on Munitions and Explosives of Concern (MEC) -In addition to the work done under CERCLA to address disposed munitions in pits, etc., the Department of Defense has a new program called the Military Munitions Response Program, which the military is implementing currently. Aberdeen Proving Ground was added to a pilot program of the MMRP program to address munitions at APG as a high priority. The Preliminary Assessment Phase is completed, a Historic Records Review Report was reviewed/approved, and a final Site Inspection Report was reviewed/approved by EPA and MDE [Maryland Department of the Environment]. Most of the areas evaluated in the SI report are being carried into a remedial investigation phase, but a few areas did not need further action. You may want to mention this MMRP program in your report.	ATSDR added the following text to the paragraph: The Department of Defense (DOD) also established the Military Munitions Response Program as a national program to manage the environmental, health, and safety concerns presented by UXO. APG serves as a pilot site for this program [USAEC 2008, EPA-Region III 2008].
13	Page 46, Third full paragraph, Sentence 2: Unclear why an AA incident is reported in an EA report.	ATSDR added the following to the paragraph: No incidents of past harm from UXO have been reported at APG-EA. ATSDR clarified that the unconfirmed incident of past harm from UXO likely occurred at APG-AA. ATSDR included this information in the PHA for APG-EA to address rumors about the incident.
14	Page 47, Paragraph 1, Sentence 2, "J-Field landfills:" There are no landfills at J-Field	ATSDR removed references to J-Field landfills throughout the PHA.

	Comment	*How Addressed*
15	Page 47, Second paragraph -Is this paragraph only referring to the Lauderick Creek Nike Site? There was a flyover of the Edgewood area which did reveal elevated gamma radiation at the Bush River Radiation Site. This area used to be referred to as the toxic gas yard, before it was used as a transfer station for military related radioactive waste from the eastern United States. The site contained a processing building which concentrated liquid radioactive wastes by boiling off water from dilute radioactive wastes. This process produced Cesium 137 soil contamination in this area. There has been a multi-million dollar removal action at this site and all waste above the remedial goal (5 pCi/g) was removed and sent to offsite disposal. A MARSSIM survey report has been sent to the NRC and APG is working to get the site de-licensed.	ATSDR modified the text as follows: Elevated gamma-radiation was found at the Bush River Radiation site. This area was historically used to concentrate liquid radioactive wastes, which resulted in soil contamination. The Army completed remediation activities and is working to have the site de-licensed from containing radioactive materials [EPA-Region III 2008].
16	Page 55, Number 1 under Completed Actions, Mid-paragraph, "installation of access restrictions (e.g., fences warning signs):" A GIS [geographic information system] with Land Use Controls is maintained for use by planners to determine appropriate land uses.	ATSDR modified the text as follows: 1. The Army has conducted investigations and remedial activities throughout the post. Remedial activities have included, but were not limited to, removal of USTs and associated contamination, contaminated media (e.g., soil, sediment, standing water), surface materials, debris, and UXO; decontamination and removal of buildings and equipment (e.g., vault at Bush River, wind tunnel at Carroll Island); abandonment of sewer and septic systems; construction and operation of groundwater treatment systems; installation of soil caps and landfill covers; and installation of shoreline stabilization measures. The Army has also installed access restrictions (e.g., fences, warning signs) and maintains a geographical information system (GIS) to track land use controls and inform planners when determining appropriate land use.
17	Page 55, Recommendations, Page 55, 3. -Many of the soil/sediment areas have already been remediated at the Westwood Area Chlorine Factory, Gas Mask Factory and J-Field.	ATSDR modified the text as follows: Remediation activities are ongoing for many areas with surface water, sediment, and surface soil contamination. Workers, who access these areas, whether during investigation, remediation, or other activities, should be made aware of the status of the area and should use appropriate protective equipment or procedures when working in areas with contamination. Signs or access restrictions in these areas could also deter hunters and trespassers from entering them.

	Comment	*How Addressed*
18	Page 57, 13. -I am not sure whether you are referring to the Army's routine UXO response to address munitions found during routine construction/excavation, CERCLA discarded UXO cleanups or the MMRP program.	ATSDR added the following text to the paragraph: Ongoing UXO removal also occurs under the DOD Military Munitions Response Program. Most areas of APG evaluated under the site investigation phase of the program are being carried into the remedial investigation phase..
19	Page 57, Number 13, Sentence 2: Clarify that UXO removed safely for the removal of UXO is now an MMRP initiative. Incident removal of UXO's are conducted when UXO's co-exist with other environmental contaminants.	

Notes:
* Army comments provided by the Aberdeen Proving Ground-Directorate of Safety, Health and Environment