05.04-01/01/97-01976

PUBLIC HEALTH ASSESSMENT

U.S. MARINE CORPS CAMP LEJEUNE MILITARY RESERVATION

CAMP LEJEUNE, ONSLOW COUNTY, NORTH CAROLINA

CERCLIS NO. NC6170022580

Prepared by:

Agency for Toxic Substances and Disease Registry
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Federal Facilities Assessment Branch
Atlanta, Georgia

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.

Additional copies of this report are available from:
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FOREWORD

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

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements.

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

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists then evaluate whether or not there will be any harmful effects from these exposures. The report focuses on public health, or the health impact on the community as a whole, rather than on individual risks. Again, ATSDR generally makes use of existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies, and the data collected in disease registries. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further research studies are needed.

Conclusions: The report presents conclusions about the level of health threat, if any, posed by a site and recommends ways to stop or reduce exposure in its public health action plan. ATSDR is primarily an advisory agency, so these reports usually identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies, or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state, and federal agencies; the companies responsible for cleaning up the site; and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

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

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

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SUMMARY

As a result of environmental contamination, the U.S. Marine Corps Base (MCB) Camp Lejeune was listed on the U.S. Environmental Protection Agency's National Priorities List on October 4, 1989. Located in Onslow County, North Carolina, near the city of Jacksonville, the base covers a large area, approximately 151,000 acres (about 233 square miles) with 14 miles of beach on the Atlantic Ocean. It is densely populated, with over 43,200 active duty military personnel and 51,656 dependents.

Before the current established environmental regulations, previously accepted hazardous material handling and disposal led to environmental contamination at several areas on base. In 1983, MCB Camp Lejeune conducted an initial assessment of the potentially contaminated areas. Seventy-six waste disposal sites were identified as potentially contaminated from records reviews and personnel interviews. MCB Camp Lejeune listed 22 of those sites for further investigation. Basewide environmental investigations have been ongoing since that time and continue under the Installation Restoration Program. A total of 94 sites have been identified as potential areas of contamination. Forty-two of those sites required further investigation. Thirteen of the 42 sites require no further action. Seven sites require long-term monitoring or clean-up action. The remaining 22 sites are currently being investigated. Thirty-four of the total 94 potential sites are grouped into 18 Operable Units because of proximity or similar nature of contaminants present.

ATSDR evaluated the environmental information on all sites and identified ten sites where the potential for human exposure existed. Two exposure situations were evaluated at Site 28. In addition to the environmental data, ATSDR evaluated information on base plumbing as a possible source of lead contamination of drinking water, a common problem in older buildings. We also evaluated data on groundwater contamination where there was past exposure or there is potential for future exposure. Appendix B-2 describes our evaluation of the sites.

PAST PUBLIC HEALTH HAZARDS

We concluded that three situations posed past public health hazards. In order of health priority, they are (1) exposure to lead in the tap water in on-base buildings containing lead plumbing; (2) past exposure to volatile organic compounds (VOCs) in the three drinking water systems on base; and (3) past exposure to pesticides in the soil at Site 2, a former day-care center. MCB Camp Lejeune has taken action to stop or reduce exposure in all of these situations.

Lead levels in tap water on base were of immediate health concern. Sampling results, although variable, indicated a widespread problem with lead leaching from faucets or water pipes into drinking water. It is not possible to determine the exact number of people exposed to lead in drinking water or the exact amount of lead they were exposed to because lead levels in tap water are variable, dropping as the water pipes are flushed by running water. Blood lead samples taken from people who live or work in the two buildings containing the highest lead levels were considered within normal range. However, because of the extremely high levels found at some taps, ATSDR recommended exposure be reduced or in some cases stopped. As a result of ATSDR's recommendations, MCB Camp Lejeune took action to reduce lead exposure by

educating base employees, residents, and visitors on the importance of flushing the water lines before using them, and stopped exposure by restricting the use of sinks in certain buildings.

Volatile organic compound (VOC) levels in three base drinking water systems (Tarawa Terrace, Hadnot Point, and Holcomb Boulevard) were of health concern until 1985 when use of contaminated wells stopped. Well contamination was caused from leaks in off-base and on-base underground tanks that were installed in the 1940s and 1950s. Human exposure to trichloroethylene (TCE), tetrachloroethylene (PCE), and 1,2-dichloroethylene (DCE) in drinking water systems at MCB Camp Lejeune have been documented over a period of 34 months, but likely occurred for a longer period of time, perhaps as long as 30 years. Included in the population that used this water were approximately 6000 residents in base family housing. This population consisted of a large proportion of young married women. Even though adverse health effects are not expected in adults, concern was raised about potential toxic effects on developing fetuses. To help address the issue about pregnancy outcomes, ATSDR began a study in 1995. In an interim report released in 1997, ATSDR identified approximately 6000 infants whose mothers resided in VOC-exposed housing areas while pregnant. A statistically significant decrease in mean birth weight and a statistically significant increase in small for gestational age was observed for male infants born to mothers whose housing was supplied with water from Hadnot Point. No differences in mean birthweight or the condition small for gestational age were noted in most residents receiving water from Tarawa Terrace compared with residents of other housing areas. However, in Tarawa Terrace residents, the children of mothers who were 35 years of age or older and the children of mothers who had previously had a fetal loss were more likely to have been born small for gestational age. Infants whose mothers were very briefly exposed to VOCs from the Holcomb Boulevard system did not have decreased mean birthweight and were not more likely to be born small for gestational age.

Pesticide levels in surface soil at Building 712 at Site 2, a former day-care center, were of health concern. The pesticides of concern were chlordane and dichlorodiphenyltrichloroethane (DDT) and its breakdown products, dichlorodiphenyldichlorethane (DDD) and dichlorodiphenyldichlorethylene (DDE), which have remained in the surface soil since the 1950s, when the site was used for pesticide storage and handling. ATSDR recommended that MCB Camp Lejeune prevent further pesticide exposure for approximately 20 current office and lawn-care workers. Consequently, MCB Camp Lejeune restricted access to the contaminated soil areas and in 1994 removed the contaminated soil from the parking lot and lawn areas. Each year from 1966 to 1982, approximately 60 people, including adults and children, attended a day-care center located in Building 712. They were also exposed to pesticide-laden soil. Workers and other adults who used the parking lot over time may have inhaled or swallowed enough contaminated soil to increase their risk of developing cancer over their lifetime. However, noncancerous adverse health effects are unlikely in any of the people exposed.

POTENTIAL (INDETERMINATE) PUBLIC HEALTH HAZARDS

*ATSDR concluded that two possible exposure situations present potential public health hazards. In the first situation, **suspected fish contamination in Brinson Creek**, additional sampling is needed to determine the extent of mercury present in Brinson Creek fish and whether the levels present a public health hazard. In the second situation, **suspected contamination of fish and shellfish in Northeast Creek near the New River**, sampling of fish and shellfish in this area has not been conducted and would be required to determine if the contamination from Sites 7, 16, and 80 presents a health hazard to people eating fish and shellfish caught in Northeast Creek. In both of these locations, the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR) will be conducting additional fish sampling in late July 1997 to determine the public health implications of eating fish caught from both of these areas.*

Suspected contamination of largemouth bass in Brinson Creek is a potential health hazard because sampling results are not conclusive. In April 1997, only two largemouth bass were caught in Brinson Creek. One contained elevated mercury levels, the other did not. Therefore, before further actions can be taken, additional fish must be caught to provide a better understanding of the actual mercury levels in Brinson Creek fish. Camp Lejeune is working in cooperation with the NCDEHNR to determine the accuracy of previous sampling data before specific advisories are issued. Additional sampling by NCDEHNR is planned for July 1997. ATSDR will consult with NCDEHNR and MCB Camp Lejeune to coordinate actions needed to protect public health.

Suspected contamination of fish and shellfish in Northeast Creek near the New River is a potential health hazard because surface water and sediments were found to be contaminated. However, Northeast Creek fish and shellfish have not been included in the sampling at these sites. This area of the New River and Northeast Creek supports recreational as well as commercial fishing. Sampling results of soil, surface water, and sediments at these sites have shown elevated levels of metals, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and pesticides. These chemicals are persistent in the environment and can reach higher levels when concentrated by fish and shellfish up the food chain. Levels in fish and shellfish can be ten to thousands of times greater than levels found in soil, sediments, or surface water. For this reason, ATSDR recommended fish of edible species and size (i.e., crabs and mollusks/bivalves if present) be analyzed for metals (mercury, lead, arsenic, cadmium, and chromium), PCBs, PAHs, and pesticides to determine if any recommendations are needed to protect people who eat fish and shellfish caught in this area. NCDEHNR will be conducting the sampling at Northeast Creek and this area of the New River in July 1997 before MCB Camp Lejeune selects a remediation alternative for these sites.

NO APPARENT PUBLIC HEALTH HAZARDS

ATSDR concluded that three situations were no apparent public health hazards: (1) groundwate contamination on base, (2) exposure to contaminated fish from several locations on base, and (3 soil contamination at Site 69. In these situations, people are using these areas and contamination could be present. However, in each situation, certain conditions exist (e.g., the levels of contamination are low and long-term monitoring is being conducted to ensure that people do not come in contact with contaminants at levels that cause health problems, or an area was covered with clean fill, making human exposure unlikely.

Groundwater contamination on base is considered no apparent public health hazard because several programs are in place to detect, monitor, and predict groundwater contamination flow before people could be exposed to any contaminated drinking water. All drinking water on base is provided by on-base wells. All groundwater information is compiled and assimilated under several programs that can predict the likelihood of any wells being threatened by contamination and the estimated time that contamination could reach the wells. This information is vital for the protection of the base drinking water supply and for the protection of people on base who drink the water. This type of information could also be used to establish an optimum drilling location for future drinking water supply wells.

Exposure from Eating Fish from Wallace Creek, Bear Head Creek, Cogdels Creek, Orde Pond, Everett Creek, and the New River near Sites 28, 69, and 48 presents no apparent public health hazard. Levels of contaminants detected in fish and shellfish from the specified locations on base were low and, therefore, do not present a health hazard to people (children, pregnant women, or other adults) who eat them. ATSDR evaluated fish consumption based on an 8-ounce meal for adults and a 4-ounce meal for children. We assumed that people would eat no more than one fish meal per week of fish from these areas containing the maximum detected contaminant levels. Because these assumptions are conservative, they are protective of even the most sensitive fish consumers. Fishing is permitted at all these locations with a North Carolina state fishing license. For fishing at Orde Pond or any other on-base pond, a MCB Camp Lejeune fishing permit is required.

Soil contamination at Site 69—Rifle Range Chemical Dump is considered no apparent health hazard because the hazardous substances deposited here were buried and all waste was covered with clean fill dirt; therefore, it is unlikely that contaminated soil could migrate from this site. Additionally, a fence surrounding the site prevents people from readily accessing the site.

NO PUBLIC HEALTH HAZARDS

ATSDR concluded that two other situations are not public health hazards because no contamination was detected in the media or because debris and contaminated soil were removed.

Suspected soil contamination at Site 28-Orde Recreational Area, previously known as Site 28—Hadnot Point Burn Dump is considered no public health hazard because ashes from the burn area were covered with a tremendous volume of clean fill dirt (between 185,000 and 379,000 cubic yards) when the site was closed in 1971. MCB Camp Lejeune's Remedial Investigation indicates that surface soil in the playground and picnic areas are not contaminated.

Physical hazards and possible soil contamination at Site 43-Agan Street Dump present no public health hazard because various debris and contaminated surface soil was removed in 1995. Therefore children from the nearby housing area would not be exposed.

INTRODUCTION

This report is organized by exposure situations. These situations are discussed in the order of their public health importance. The exposure situations and the sites at which they occurred are listed below. The term *site* is used to describe a distinct area to which MCB Camp Lejeune has assigned a reference number. *Exposure situation* is used to describe conditions and circumstances by which people could come in contact with contaminants.

In preparing this public health assessment, ATSDR relied on the information provided in the referenced documents. Some references used to develop this public health assessment were MCB Camp Lejeune's preliminary documents that were undergoing Navy, EPA, and state review. ATSDR assumes that adequate quality assurance and quality control measures were followed with regard to chain of custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn for this public health assessment are determined by the availability and reliability of the referenced information. Data about which ATSDR had concerns are noted in the discussion for that situation.

During the environmental investigations at MCB Camp Lejeune, base personnel identified 76 sites from old documents and interviews with past and current employees. Environmental sampling was conducted at 22 of those sites where there was strong evidence to suggest environmental contamination. To date, MCB Camp Lejeune has identified 94 potentially contaminated sites. On further investigation, 34 of these 94 sites warranted inclusion into the Installation Restoration Program, requiring extensive environmental sampling to characterize the nature and extent of contamination. The 34 sites are grouped into 18 Operable Units (OU) based on proximity or contaminant similarities (see Figure 1). MCB Camp Lejeune will evaluate all OU sites for cleanup during the feasibility study phase.

ATSDR reviewed the available environmental data and information on sites included in the Installation Restoration Program. From this data and from the information gathered during our site visits and from our visual inspections, we identified 10 sites that had potential for human exposure (Sites 2, 48, 6, 9, 82, 43, 69, 7, 80, and 28). Additionally, exposure was identified from lead in tap water and volatile organic compounds in tap water, situations unrelated to a specific site. Appendix B-2 describes our evaluation of all 34 sites. The body of the report discusses the 10 exposure situations we identified and evaluated.

ATSDR assigns conclusion categories to sites based on their level of public health hazard. At MCB Camp Lejeune, we have further clarified the "Public Health Hazard" conclusion category by stating whether or not is a current or past hazard. ATSDR's conclusion categories are explained in Appendix C.

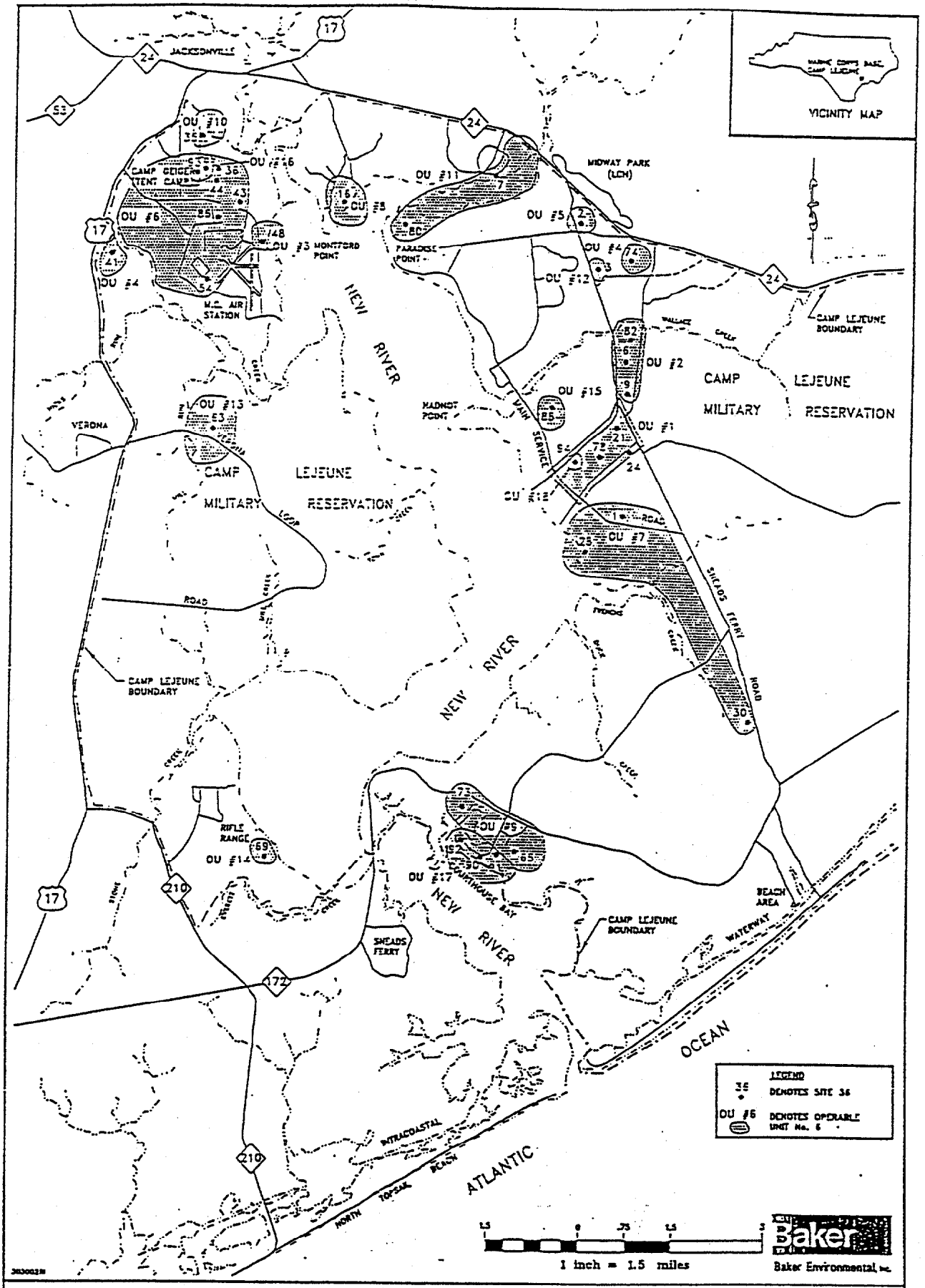


FIGURE 1
OPERABLE UNIT AND SITE LOCATIONS
REMEDIAL INVESTIGATION, CTO-0303

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

CONCLUSION CATEGORY	SITUATIONS/SITES
Past Public Health Hazards	A. Lead Exposure (Tap Water) B. Volatile Organic Compound Exposure (Tap Water) C. Pesticide Exposure (Soil at Site 2)
Potential (Indeterminate) Public Health Hazards	A. Exposure to Contaminated Fish and Shellfish from Brinson Creek (Sites 35 and 36) B. Suspected Fish and Shellfish Contamination in Northeast Creek near branch at New River
No Apparent Public Health Hazards	A. Groundwater Contamination (Base wide) B. Exposure from Eating Fish from Wallace Creek, Bearhead Creek, Cogdels Creek, Orde Pond, Everett Creek, and the New River near Sites 28, 69, and 48 C. Soil Contamination (Site 69)
No Public Health Hazards	A. Suspected Soil Contamination (Site 28) B. Physical Hazards and Possible Soil Contamination (Site 43)

BACKGROUND

SITE DESCRIPTION/HISTORY/DEMOGRAPHICS/LAND USE AND NATURAL RESOURCES USE

MCB Camp Lejeune covers a large area; approximately 233 square miles (151,000 acres) in Onslow County, North Carolina, bordering the Atlantic Ocean on the southeast. MCB Camp Lejeune consists of two major geographical regions divided by the New River: Mainside is east of the New River; Marine Corps Air Station (MCAS) New River is west of it.

Currently, there are six major Marine Corps commands and two Navy commands, which include reconnaissance, intelligence, infantry, artillery, and amphibious units. Camp Lejeune also operates training schools for infantry, engineers, service support, and medical support. Additionally, Marine Corps Air Station New River consists of helicopter and Marine Aircraft groups. Although the MCAS is a separate command, the real estate it occupies is owned by the Marine Corps Base. Camp Lejeune also operates the Naval Hospital and Naval Dental Center, which provide primary medical and dental care to 110,000 marines, sailors, and their families (1).

MCB Camp Lejeune is a densely populated base; over 43,200 active duty military personnel were stationed there in January 1990, with 51,656 dependents. The base has a relatively young population; 63% of the 30,764 military personnel and dependents living on the base are between the ages of 15 and 24, and only 1% of the population is age 60 or over. Over 75% of the population is male (2). Base housing consists of barracks for unmarried service personnel (enlisted and officer), enlisted family housing, and officer family housing in many areas throughout Mainside and MCAS.

The city of Jacksonville, adjacent to the northern edge of the base, has a current population of approximately 31,000. This is an 80% increase from the 1990 population of just over 17,000 people. Jacksonville's 1990 population was 80.1% white, 16.4% black, and 2.8% Hispanic. Approximately 9% of the 1990 population was under age 5, with greater than 8% at age 60 and over. The percentage of families in Jacksonville with incomes below poverty level in 1979 was 14.8%, nearly the same as the state percentage of 14.5%.

Onslow County's current population is approximately 131,000 people. The county population grew by 12.2% from 1980 to 1986, despite a net loss of 2,600 people through migration (i.e., more people moved away than moved in). There were approximately 19,400 births and only 3,000 deaths in the county during this period. This accounts for the entire population increase. These figures reflect the unusually high percentage of young couples in their childbearing years typically found residing at major military bases. Only about half of those who lived in the county in 1975 still lived there in 1980, a trend that indicates the transient nature of military populations. There were approximately 145 males for every 100 females in Onslow County in 1984. This high ratio is also typical of the areas around military bases.

Environmental contamination has occurred at many areas on base since MCB Camp Lejeune began operation in 1942 because of the use, handling, and disposal of hazardous chemicals. The potential for human contact with contamination is great because of the large number of people on base and the number of suspected contaminated areas scattered within the industrial, training, and near residential areas on base.

In 1983, MCB Camp Lejeune began an initial assessment of the potentially contaminated areas. Seventy-six waste disposal sites, as listed in Appendix B-1, were identified as potentially contaminated. MCB Camp Lejeune listed 22 of those sites and grouped them into operable units (shown in Appendix B-2) for further investigation. Basewide environmental investigations have been ongoing since 1983 and continue under the Installation Restoration Program. As a result of environmental contamination, the base was listed on the U.S. Environmental Protection Agency's National Priorities List (NPL) in October 1989. Twelve additional sites have been included for a total of 34 sites in 18 Operable Units (3). Operable Units at Camp Lejeune are formed to simplify the specific problems associated with a site or group of sites. Numerical values were placed on the sites as they were identified over time. The site number does not indicate a priority. Sites in close proximity may be included in the same operable unit.

After entering into a Memorandum of Understanding with the Department of Defense (DOD) in 1991, ATSDR visited the 96 DOD installations then on the NPL and ranked them according to their potential public health hazard. ATSDR ranking took into account the extent of contamination, the potential for people to come in contact with site contaminants, and the number and plausibility of community health concerns. On the basis of those criteria, MCB Camp Lejeune received a high priority ranking for a public health assessment compared with other NPL sites. To evaluate the public health impact that exposures to environmental contamination at MCB Camp Lejeune might have on people, ATSDR conducted four site visits to MCB Camp Lejeune. During those site visits, we reviewed sampling plans, met with base personnel and citizens in the community, and visually evaluated site conditions.

This report, as previously mentioned, focuses on the 10 identified exposure situations. It also includes our conclusions on all the 34 ranked sites (Appendix B-2) from which environmental sampling data was collected.

MCB Camp Lejeune has completed investigations for sites 2, 21, 24, 78, 48, 7, 80, 6, 9, and 82 (see Figure 1). Although exposure in the remaining sites is unlikely, we lack the environmental data to conclude definitely that health threats do not exist in these areas. The Marine Corps continues to monitor and characterize environmental contamination and to evaluate options for environmental cleanup in conjunction with federal, state, and local environmental and health agencies. For detailed information on the Marine Corps' continued environmental investigation and remediation plans, refer to MCB Camp Lejeune's documents at the public repositories: Onslow County Public Library and MCB Camp Lejeune Library.

ENVIRONMENTAL CONTAMINATION/PATHWAYS ANALYSES/ PUBLIC HEALTH IMPLICATIONS

INTRODUCTION

The emphasis in this section will be on the three known past exposure situations that posed public health hazards. Additionally, we describe the two situations that we think pose potential public health hazards and include a list of information that we need in order to make definite conclusions about them. We also briefly describe five additional situations that we have determined do not pose public health hazards.

ATSDR's public health assessments are exposure, or contact, driven. Chemical contaminants disposed or released into the environment at MCB Camp Lejeune have the potential to cause adverse health effects. However, a release does not always result in exposure. People can be exposed to a chemical only if they come in contact with the chemical. Exposure may occur by breathing, eating, or drinking a substance containing the contaminant or by skin (dermal) contact with a substance containing the contaminant.

The type and severity of health effects that occur in an individual from contact with a contaminant depend on the exposure concentration (how much), the frequency and duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), 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.

ATSDR reviews existing health outcome data (e.g., birth and death certificates, birth defects registries, and cancer registries), when available, if people have been exposed to site contaminants or if the community has concerns related to specific health outcomes.

I. PAST PUBLIC HEALTH HAZARDS-PAST EXPOSURE SITUATIONS

In the past, people were exposed to contaminants on base in the following situations that, at the time, posed a public health hazard. In order of health priority, they are (1) acute exposure to lead in the tap water in on-base buildings containing plumbing with lead solder; (2) past exposure to VOCs in three drinking water systems on base; and (3) past exposure to pesticides in the soil at Site 2-Former Day-Care Center (Table 1). MCB Camp Lejeune has taken action to stop or reduce exposure in all of these situations; therefore, they are no longer a public health hazard. Table 1 outlines those cases. None of the exposed populations received combined exposures from any other identified situations.

A. Lead Exposure (Tap Water)

Base employees and residents could have been exposed to extremely high levels of lead in tap water in some of the buildings on base. The source of the lead is the plumbing containing lead solder or brass fixtures. In 1994, lead testing of 102 adults did not show blood lead levels of health concern, but it is not known if these individuals drank water containing high levels of lead. If people consume water contaminated with lead at levels detected in many of the taps on base, they could absorb enough lead to experience long-term health consequences. Therefore, we recommend that people highly sensitive to the effects of lead, such as children, pregnant women, and women considering pregnancy not drink water from taps where lead is ever detected at 15 parts per billion (ppb) or higher. We also recommend that other adults should not drink water containing lead above 50 ppb. Furthermore, everyone on base should try to reduce their exposure to lead by flushing water lines before using them. MCB Camp Lejeune has taken action on all three of these recommendations. (See Summary and Follow-up of this section.)

What is lead?
Lead is a naturally occurring, bluish-gray metal found in small amounts of the earth's surface. It is often used in batteries, pipes, brass, solder, and paints. The amount and wide-range use of lead has decreased over the last several years because of the harmful neurotoxic effects of lead in people. Lead can get into drinking water several different ways, including corrosion of lead piping, lead-based solder, and brass water faucets.

Table 1. Past Public Health Hazard Situations

PATHWAY NAME	CONTAMINANT	EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
		SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION		
A. Lead in Tap Water	Lead	On-Base Lead Plumbing	Drinking Water	Tap Water	Ingestion	Base Workers and Base Residents (Adults)	Past 19??-1993	Tap water sampling survey, in accordance with Lead and Copper Rule, reported for medium-sized systems since December 1992 and for small-sized systems since December 1993. Data separate from Installation Restoration Program.
						Base Residents (Children and Pregnant Women)		
B. Pesticides in Soil at Site 2	Chlordane, DDT, DDE, and DDD	Former Pesticide Storage, Handling, and Dispensing Area	Surface Soil	Parking Lot	Ingestion, Inhalation, and Skin Absorption	Adult Workers Using Parking Lot	Past Until 1993	Used for pesticide handling from 1945-1958. Used as day-care for military and civilian employee's dependents from 1966-1982. Currently used as a personnel office.
				Lawn		Lawn Care Workers	Past Until 1993	
				Parking Lot		Children and Adults Using Parking Lot	Past 1966-1982	
				Surface Soil at Playground		Children Playing in Playground and Day Care Workers	Past 1966-1982	
C1. VOCs in Drinking Water at Hadnot Point	TCE, DCE, Methylene Chloride, and Vinyl Chloride	Leaking Underground Lines and Storage Tanks	Groundwater	Tap Water	Ingestion, Inhalation, and Skin Absorption	Base Workers and Base Residents (Adults)	Past 1982-1985	Leaks from tanks have been reported since operations began in 1940s. Tap water data was first collected in 1982 and contamination was present at that time. Actual exposures may have occurred earlier.
						Base Residents (Children and Pregnant Women)		
C2. VOCs in Drinking Water at Tarawa Terrace	PCE, TCE, and DCE	Leading Tank from Off-base Dry Cleaners	Groundwater	Tap Water	Ingestion, Inhalation, and Skin Absorption	Base Workers and Base Residents (Adults)	Past 1982-1985	Contamination discovered in 1982. Dry cleaner began operating in 1954. Estimated duration of exposure is 3 years when data are available. Actual exposures may have occurred earlier.
						Base Residents (Children and Pregnant Women)		
C3. VOCs in Drinking Water at Holcomb Boulevard	TCE and DCE	Back-up Water Piped in from Hadnot Point	Groundwater	Tap Water	Ingestion, Inhalation, and Skin Absorption	Base Workers and Base Residents (Adults)	Past Two Weeks in 1985	Holcomb Boulevard system was shut down and back up water was piped in from Hadnot Point which unknowingly was also contaminated. Data are only available for water piped from Hadnot Point; therefore, estimated duration of exposure is two weeks.
						Base Residents (Children and Pregnant Women)		

Lead Sampling

During 1992, in accordance with EPA's Lead and Copper Rule, MCB Camp Lejeune began regularly testing the tap water on base for lead and copper (4). The findings we discuss here are based on three sampling rounds for the major drinking water systems (serving 10,001-50,000 people) on base, Holcomb Boulevard, Hadnot Point, and MCAS New River, beginning in July 1992. Sampling for the minor drinking water systems (serving 501 to 3,300 people), Courthouse Bay, Rifle Range, and Onslow Beach, began in December 1993. Our findings are based on two sampling rounds each year for those systems from 1992 to 1996. We have received sampling data from 260 different faucets.

The base is carrying out all the procedures required by the Lead and Copper Rule, i.e., regularly sampling tap water (every 6 months) and developing a water treatment plan to reduce lead and bring the base systems into compliance with EPA's established action levels of 15 ppb for lead and 1300 ppb for copper (5).

The sampling priority scheme established by EPA concentrates on buildings that had copper pipes and lead-containing solder installed between 1983 and 1987 because the solder used during that time was more apt to leach lead into the tap water (5). MCB Camp Lejeune conducted a materials evaluation of records kept for each building on base. They found no buildings with lead piping, but for all the drinking water systems, they did find buildings with copper piping and lead-containing solder. The base's sampling plan, in accordance with EPA regulations, concentrated on those buildings and focused on single-family homes, where the population at greatest health risk lives (4). Lead was detected in tap water samples from buildings on each of the water systems. No lead or copper were detected in any of the water plants, which indicated that the source of the contamination in each system was the plumbing (4). We reviewed the tap water sampling data for potential health hazards. Copper levels did not pose a health concern.

Lead levels were consistently low in nearly all the single-family homes tested. However, since 1994 when the sampling began, tap water in seven houses tested at levels above 15 ppb (levels ranged from 17 - 65 ppb. Four homes have had filter units already installed and three homes are awaiting the filter unit installation (6). Once a home sample contains elevated lead levels above 15 ppb, the base carries out an investigation to determine if the elevated lead is confined to one tap faucet or if others in the home are elevated as well. If more than one faucet has elevated lead level, the entire home is connected to a lead-removing water filtration system (7). Since the base began this procedure in 1994, four homes have had filters installed on at least one faucet. All schools and day-care centers were sampled for lead and copper. None were found to be above EPA action levels (8).

The lead levels from the other buildings sampled on base fluctuated tremendously with each sampling and ranged from less than 2 ppb (lower limit of detection) to 10,100 ppb. The highest level, 10,100 ppb, was much higher than the next highest concentration of 2720 ppb and possibly could be a piece of lead solder that broke away from the pipe and

was collected in the sampling bottle. Even though the 10,100 ppb may be a rare case, many faucets (11.5%) contained lead at extremely high levels, above 200 ppb.

Although water from a high percentage of "deep sink" faucets tested showed elevated lead levels, extremely high lead levels detected in one sampling round were often not detected in a subsequent sample from the same tap. The reasons for the inconsistency are not clear. However, the levels detected in many samples throughout the base, which ranged from 16 ppb to 10,100 ppb, were of immediate health concern. The base has posted signs on all "deep sink" faucets commonly found in janitor's closets and in laundry rooms not to drink water from that faucet. Additionally, the base provides educational material in their housing guide to all newcomers and puts articles in the base paper several times per year updating and reminding individuals to flush their tap water faucets before use in the morning and after the faucet has not been used in the past 6 hours.

Human Exposure Routes and Public Health Implications

ATSDR has identified these specific areas where people were being exposed: (1) residents of single-family homes (approximately 28 individuals including adults and children), (2) residents of multifamily buildings and bachelor enlisted quarters (approximately 10,000 individuals), and (3) workers exposed to lead at various office buildings on base (approximately 15,000 individuals).

How Can I Reduce My Exposure To Lead In Tap Water?

Because you cannot see, taste, or smell lead in your drinking water, it is important to perform these precautionary steps.

(1) Let the water run from the tap for 30 seconds to 2 minutes before using it for drinking or cooking. Water that has sat in the pipes more than 4 hours should be flushed for 3 to 5 minutes, and

(2) Use cold water even for cooking or making infant formula because water from the hot water tap dissolves lead more quickly.

For additional information, see Appendix D.

Since 1992, the base has maintained a blood lead screening program for all children receiving their 1-year well baby check-up and once a year for all children under 6 years of age. Approximately 1200 child blood lead levels are tested per year. This program will be discontinued in 1997 for all children seeking medical attention at the base hospital. The Primary Care Clinic will continue this practice at least until October 1997. However, parents of all children seeking medical attention are required to fill out a potential lead exposure questionnaire to help identify children at risk for lead exposure. All children whose parents answer yes to any question will automatically have their blood levels tested. To date, there have only been seven cases of elevated blood lead levels in children 6 years old or younger. The medical personnel in conjunction with facilities personnel have carried out investigations on all children with elevated blood lead levels. In several cases, the paint in the children's home has been implicated as the probable source of the lead exposure. In these cases, the residents were relocated and their homes abated for lead paint. One child was treated for lead poisoning as a result of

his exposure to lead paint. In other cases no lead source was identified. In two cases, the families moved to other military installations, eliminating the likelihood of continued lead exposure.

In response to ATSDR's concern about extremely high lead levels found in two base buildings, the base tested the blood lead levels of 102 adults. One of the buildings is a barracks where the highest lead levels were detected in tap water of the laundry room deep sink used for filling the canteens of field training personnel. The other building is an office building, where people are known to make coffee from tap water. Ninety-nine out of 102 blood lead levels were within the expected national average range for adults (9,10). Three individuals had only slightly elevated blood lead levels at 10, 11, 12 micrograms lead per deciliter blood (μg/dL) respectively (11). No adverse health effects associated with these blood lead levels are expected to occur in these three adults. However, there is no information on whether or not individuals who had their blood lead tested drank water from those taps containing high lead levels. Therefore, the blood sampling results are inconclusive because they do not provide a correlation between people drinking lead contaminated water and blood lead levels. For this reason, we must interpret the blood lead data cautiously, and we have recommended that individuals not drink water from taps containing high lead levels. Our recommendations are based on the known health risks posed by lead, particularly at the very high levels detected intermittently in some of the taps at MCB Camp Lejeune.

Because lead levels at MCB Camp Lejeune fluctuated above and below the action level of 15 ppb (less than 2 ppb to 10,100 ppb) and some of these lead levels were extremely high, two aspects of lead exposure are of concern. One is exposure, even once, to extremely high levels of lead. The second is intermittent exposure to even moderate levels of lead over an extended period of time, e.g., more than a year. Under both of these exposure conditions, people can absorb enough lead to raise their body burden of lead to levels that could pose health problems. People swallowing lead-contaminated water at the highest concentrations detected (1000 to 10,100 ppb) can experience acute effects, such as nausea and vomiting, but they can also absorb enough lead to cause serious long-term adverse health effects (12).

In order to evaluate the likelihood of adverse health effects in people at MCB Camp Lejeune who drink lead contaminated water, we reviewed the available scientific information. Studies of lead's health effects on people are based on blood lead levels, a measure of the amount of lead absorbed by the body, not the amount of lead detected in water or some other medium. Blood lead is measured in micrograms per deciliter (μg/dL). Several studies have analyzed the correlation between lead levels in drinking water and resulting blood lead levels in infants, older children, and adults (13-21).

ATSDR used these mathematical factors for estimating the likelihood of adverse health effects in people at MCB Camp Lejeune who drink lead-contaminated water. Based on these calculations, people drinking water containing lead at levels above 50 ppb could

absorb enough lead to experience long-term health consequences. Moreover, people highly sensitive to the effects of lead, particularly children, infants, and fetuses, could experience irreversible adverse health effects such as decreased IQ and compromised mental development (22).

The health effects of lead are not immediately apparent. Once in the blood, lead is distributed to soft tissue (kidneys, bone marrow, liver, and brain) and mineralizing tissue (bones and teeth). Bones and teeth contain about 95% of the total body burden of lead in adults (12).

It is the total body burden of lead that is related to the risk of adverse health effects. Because the body accumulates lead over a lifetime and releases it slowly, even small doses of lead over time can cause lead poisoning. Further, relatively low blood lead levels can cause adverse health effects, some of which, like decreased IQ or mild behavioral disorders, may not produce noticeable signs or symptoms.

Exposure to high levels of lead can damage the brain, red blood cells, and kidneys of adults at blood lead levels ranging from 40 to 100 μg/dL and children at blood lead levels of 35 to 50 μg/dL. Acute effects of exposure to high lead levels are nausea, vomiting, and headache. Lead exposure in adults may increase blood pressure. High levels of blood lead (40 μg/dL) may affect sperm or damage other parts of the male reproductive system, making it difficult for a couple to have children (12).

Fetuses and children are especially sensitive to the effects of lead. Additionally, when women are pregnant, lead stored in their bone can enter their bloodstream, increasing the amount of lead reaching the fetus and resulting in premature birth, low birthweight, and decreased mental ability. In infants and young children, lead exposure has been shown to decrease intelligence, slow growth, and cause hearing problems at blood lead levels at or below 10 μg/dL, a level previously thought to be safe. These effects can persist as children get older and interfere with successful performance in school (22).

Summary and Follow-up

Lead was detected throughout the drinking water systems of MCB Camp Lejeune, but the data were inconsistent upon repeat sampling, with lead levels fluctuating above and below the EPA action level. Given the very wide range of lead levels detected in the tap water and the inconclusiveness of the blood lead sampling, ATSDR made the following recommendations to protect the health of base personnel, residents, and visitors: (1) stop exposure of personnel, residents, and visitors at taps that showed elevated lead results; and (2) educate all MCB Camp Lejeune employees, residents, and visitors about how to reduce their lead exposure (i.e., by flushing taps). As a result of ATSDR's recommendations, MCB Camp Lejeune took the following actions:

- posted "DO NOT DRINK" signs at deep sink faucets basewide to stop people from drinking water from those faucets because they seem to release more lead than other faucets

- posted signs at faucets where water samples show lead levels above 50 ppb, and

- installed filters on water lines to stop residents of single-family homes from drinking water from faucets that show lead levels above 15 ppb.

In addition to the educational efforts carried out by MCB Camp Lejeune, ATSDR provided a pamphlet (included as Appendix D) for MCB to distribute to the base community (personnel, residents, and visitors). In general, we recommend that pregnant women and children not drink water containing lead at levels greater than 15 ppb, and adults not drink water containing lead at levels above 50 ppb (23). MCB Camp Lejeune has already implemented all of these recommendations and continues to educate new base employees, residents, and visitors. The base also continues to monitor lead levels in drinking water basewide (24, 25, 26).

Because lead levels at MCB Camp Lejeune fluctuated above and below the action level of 15 ppb (less than 2 ppb to 10,100 ppb) and some of these lead levels were extremely high, we could not evaluate the likelihood of adverse health effects in people who drank tap water. People who drank lead-contaminated water at the highest concentrations detected (1000 to 10,100 ppb) would have experienced acute effects, such as nausea and vomiting. Because these people could absorb enough lead to cause serious long-term adverse health effects, they can contact their physician for a blood lead screening or follow-up evaluation.

Health Outcome Data

The health outcome data collected to address this exposure were obtained from the Naval Hospital at MCB Camp Lejeune. Blood lead levels were collected from 102 individuals who may have been exposed to lead in drinking water from the two buildings that had the highest detected lead levels. Only three people had blood lead levels slightly above the national average for adults. However, there is no information on whether or not individuals drank water from taps with elevated lead levels. Therefore, ATSDR has recommended that exposure cease in all buildings showing lead levels above 50 ppb.

Additional health outcome data was collected regarding elevated blood lead levels in children of military personnel at MCB Camp Lejeune. All children of Camp Lejeune personnel are required to have their blood lead levels tested on their first birthday and again annually after that. Seven children who were tested in 1993 had blood lead levels above the Centers for Disease Control and Prevention's maximum recommended level of 10 μg/dL for children. MCB Camp Lejeune conducted investigations to determine the possible source of the lead to which the children may have been exposed. Tap water from all base schools, day-care centers, and single-family residences was tested. Lead paint in the homes of these children

was determined to be the source of the lead. Lead paint abatement programs have been initiated by the base. One child was treated for lead poisoning as a result of his exposure to lead paint.

Conclusion and Public Health Action Plan for Lead Exposure (Tap Water)

Conclusion:

1. Even though MCB Camp Lejeune was following all current EPA regulations for the Lead and Copper Rule, the concentrations of lead detected at drinking water taps collected from 1992 to 1996 in several buildings on base were of immediate health concern. People drinking lead-contaminated tap water may have absorbed enough lead to experience acute or long-term adverse health effects.

Completed Actions:

1. MCB Camp Lejeune placed notices in the base newspaper and posted educational material to notify people of possible lead in drinking water.

2. In response to ATSDR's concerns, MCB Camp Lejeune sampled blood lead levels of workers and residents of the two buildings on base that had the highest lead levels detected in the tap water. Although no elevated blood lead levels were found, no information is available on whether the individuals tested drank from the water taps containing high lead levels.

3. Based on ATSDR recommendations, MCB Camp Lejeune took further action to stop exposure by restricting the use of taps in certain buildings. Additionally, ATSDR developed a flyer addressing frequently asked questions and ways to reduce lead exposure. MCB Camp Lejeune distributed the flyer to all employees, residents, and visitors.

4. As a result of ATSDR's recommendation, MCB Camp Lejeune continues to provide educational material to all base employees, residents, and visitors on ways people can reduce their lead exposure from drinking water.

5. MCB Camp Lejeune continues to monitor lead levels in base drinking water. Additionally, corrosion control devices have been installed in the Hadnot Point, New River Air Station, Courthouse Bay, and Onslow Beach systems to reduce the ability of the water to leach lead from the plumbing.

6. As a result of ATSDR's recommendation, MCB Camp Lejeune posted "DO NOT DRINK" signs at deep sink faucets basewide to stop people from drinking water from those faucets because they seem to release more lead than other faucets. To prevent people from drinking contaminated water, the base has also posted signs at faucets where water samples show lead levels above 50 ppb.

7. As a result of ATSDR's recommendation, MCB Camp Lejeune installed filters on water lines to stop residents of single-family homes from drinking water from faucets that show lead levels above 15 ppb. The water lines in several homes were replaced.

Planned Action:

1. MCB Camp Lejeune continues to sample tap water for lead and copper contamination in accordance with EPA regulations as overseen by NCDEHNR.

2. MCB Camp Lejeune continues to finalize the corrosion control measures on their water systems to reduce lead from leaching into the water from the plumbing.

Recommended Action:

1. If future water samples show lead levels that exceed 15 ppb, MCB Camp Lejeune should promptly advise women and children not to drink water from those faucets. Adults should be advised not to drink water from any faucet where lead exceeds 50 ppb.

B. Volatile Organic Compound Exposure (Tap Water)

In the past, the Tarawa Terrace, Hadnot Point, and Holcomb Boulevard water distribution systems on base were contaminated with volatile organic compounds (VOCs) (see Table 2). The sources of contamination were leaks from off-base and on-base underground tanks, some of which were installed in the 1940s. People who used water from these systems between 1982 to 1985 were exposed to VOCs. Exposure was intermittent and stopped when the contaminated wells were closed in 1985. From the sampling data, we estimated probable exposure dose levels for adults and concluded that noncancerous and cancerous health effects are unlikely to occur in those adults exposed. For children, we could not determine the likelihood of either noncancerous or cancerous health effects because there is not enough scientific information on the adverse health effects these compounds might have on children. However, there is evidence that suggests that, because of their developing systems, fetuses are potentially more sensitive to the effects of VOCs than either adults or children. Several epidemiologic studies have suggested associations between exposure to VOCs and birth defects, low birthweight, and late fetal death. ATSDR conducted a study of birth outcomes of women who were exposed to VOCs in drinking water at MCB Camp Lejeune during their pregnancy. Interim results of that study, reported in 1997, indicate that for most live births, there was no association between housing supplied with water from the Tarawa Terrace system and decreased mean birthweight (MBW) and increased numbers of babies born small for gestational age (SGA). Associations between the Tarawa Terrace water system and MBW and SGA were observed in two potentially susceptible subgroups: infants of mothers age 35 and older and infants whose mothers had histories of fetal deaths. For mothers whose housing was supplied with water from the Hadnot Point system, decreased MBW and increased SGA were observed in male, but not in female, infants. Decreased MBW and increased SGA were not associated with housing supplied by the Holcomb Boulevard system. The findings for both Hadnot Point and Tarawa Terrace were unanticipated because associations were observed in certain subgroups but not others. ATSDR is conducting more research on VOCs in other populations that may confirm or refute the importance of these associations. Final analyses of fetal death and pre-term delivery data collected for the Camp Lejeune pregnancy study will be completed in 1997.

What are VOCs?

VOCs make up a group of chemicals having similar physical properties. VOCs readily evaporate or volatilize into gases when exposed to air. Chemicals in this group include trichloroethylene (TCE), dichloroethylene (DCE), benzene, tetrachloroethylene (PCE), methylene chloride, and vinyl chloride and in general may be used as dry-cleaning solutions, additives in fuels, or as solvents to dissolve grease or other compounds. The major health concerns of these low-level VOC exposures are adverse birth outcomes and cancer in children exposed to VOCs *in utero*. ATSDR's ongoing health study will address birth outcomes. In addition, a study of childhood cancer is recommended.

VOC Sampling

In 1982, MCB Camp Lejeune performed basewide routine sampling of treated drinking water for THMs, a procedure to test for chlorine disinfection by-products. In May 1982, the laboratory noted difficulty in measuring THMs in two of the eight water systems in operation at that time because of interference by unidentified compounds. The analysis was then expanded to include trichloroethylene (TCE) and tetrachloroethylene (PCE), which were thought to be the interfering compounds (27). The findings for each distribution system are summarized below.

Hadnot Point Water Distribution System

At Hadnot Point, tap water samples contained TCE at 1400 ppb and 1,2 dichloroethylene (DCE) at 407 ppb in May 1982, but in July 1982, levels dropped to 20 ppb TCE and 1,2 DCE was not detected (see Table 2) (27). The drop in these levels can be explained by the use of different supply wells (a few containing contamination and others not) on different days. In the Hadnot Point system, any given well would have been in use about two-thirds of the time because water demand did not require using all wells at the same time (28). There were 39 operational wells in the system, but only 20 of those wells were used at any one time. The wells pump water to the distribution system where the water is blended and treated. This process means that although the contamination is then spread from the one well to the entire distribution system, it is also diluted by being combined with water from uncontaminated wells. Chlorine, fluoride, and softeners are added to the water before it is pumped to water towers before distribution (28). The possible sources of contamination at the Hadnot Point distribution system are leaking underground storage tanks containing TCE and fuels, spills during vehicle maintenance operations, and disposal of drums at Sites 6, 9, and 82 and associated storage lots in OU 2 (29, 79).

In July 1984, as part of the Navy Assessment and Control of Installation Pollutants (NACIP) Program, MCB Camp Lejeune conducted water quality sampling in wells on base. They found that eight of the 39 wells in use at Hadnot Point and one of the seven wells in use at Tarawa Terrace were contaminated with various VOCs. All nine wells were abandoned and have not been used in the drinking water system since 1985 (28).

Table 2. Maximum Contaminant Concentrations Detected in On-Base Drinking Water Tap Samples in 1982–1985

Chemical	Maximum Concentration (ppb)			Drinking Water Standard Established 1991* (ppb)
	Hadnot Point	Tarawa Terrace	Holcomb Blvd	
Trichloroethylene (TCE)	1400	8	1148	5
Dichloroethylene (DCE)	407	12	407	7
Tetrachloroethylene (PCE)	ND	215	ND	5
Methylene Chloride	54	ND	ND	5
Vinyl Chloride	3 J†	ND	ND	2

* - EPA's Drinking Water Standard, referred to as the Maximum Contaminant Level (MCL) allowable
ND - None Detected
J - Estimated Value
† - Detection limit was 10 ppb.

Tarawa Terrace Water Distribution System

Tap water sampling in the Tarawa Terrace water system in May 1982 detected PCE at 80 ppb, a level that remained consistent during the July sampling. 1,2-DCE was detected at 12 ppb. Trace amounts TCE were detected, but because of the laboratory instrument detection limit of 10 ppb, TCE was estimated to be 8 ppb. At the time of the 1982 sampling, no source for the contamination at either Hadnot Point or Tarawa Terrace system had been identified (31). Furthermore, there were no drinking water standards for these chemicals in 1982; TCE, PCE, and 1,2-DCE levels in drinking water were not regulated until the Safe Drinking Water Act was amended in 1991 (32). Sampling in February 1985 detected PCE at 215 ppb. Table 2 shows the maximum detected concentrations of VOCs at the tap and the current drinking water standard, referred to as the Maximum Contaminant Level (MCL) allowable.

Subsequently, it was determined that contamination at the Tarawa Terrace distribution system was caused by an off-base dry-cleaning operation (ABC Cleaners) whose septic system released the cleaning fluid PCE into the ground (33). The septic system was installed in 1954 and used until 1985. In 1958, a well supplying the Tarawa Terrace system was drilled approximately 900 feet from the dry-cleaners. Because the well was so close to the septic field, the well was probably contaminated soon after it was built. That well could have contaminated the water distribution system with PCE for as long as 30 years. Over time, contaminants migrated into a second base well, located approximately 1800 feet south of the septic system, but the PCE contamination was detected before this well was put into use. In 1985, both of these contaminated wells were shut down (31). Unable to meet the increasing water demand without those wells, the Tarawa Terrace distribution system was closed (28). This public health assessment evaluates exposures that occurred during the time for which sampling data are

available. However, the ATSDR study of birth outcomes reviewed available birth records over the longer estimated exposure duration (1958–1985).

Holcomb Boulevard Water Distribution System

On January 27, 1985, a generator fuel line at the Holcomb Boulevard water distribution plant burst, leaking fuel into the system. This situation was identified after the base received complaints of a gasoline smell in on-base residential tap water (31). MCB performed sampling of the system and found that gasoline had entered the Holcomb Boulevard distribution system. The system was immediately shut down and flushed out. Emergency back-up water was then pumped from the Hadnot Point system, whose VOC contamination was not yet identified, into the Holcomb Boulevard distribution lines. Tap water samples taken from Berkeley Manor Elementary School in the Holcomb Boulevard system on January 31, 1985, contained TCE at 1148 ppb and DCE at 407 ppb (Table 2). Contaminants measured at several points in the Holcomb Boulevard system were consistent with samples taken from the Hadnot Point Water treatment plant on the same date. Therefore, the source of TCE and DCE in the Holcomb Boulevard system originated from the contaminated emergency water supplied by the Hadnot Point system. People were switched back to the clean Holcomb Boulevard system 12 days later when the generator fuel line was repaired (31).

Human Exposure Route and Public Health Implications

Our exposure estimates assume that people were exposed to VOCs in drinking water during the time tap water sampling data showed contamination of the water systems. People drinking or bathing with water supplied by Hadnot Point and Tarawa Terrace water distribution systems during 1982 to 1985 were exposed to VOCs. Most likely, contamination was present before 1982, but there is no sampling information to confirm this assumption. Because of the random use of contaminated wells (water demand did not require all wells to be in use at the same time), we estimated exposures to be intermittent, occurring off and on, for 3 years, 1982–1985. See Table 3. The base residents and employees exposed included adults, children, and fetuses.

Holcomb Boulevard distribution system received contaminated drinking water for 12 days in 1985 when a broken pipe emergency required that back-up water be piped in from the Hadnot Point system, which contained VOC contamination. Therefore, people drinking or bathing with water from Holcomb Boulevard water distribution system from January 27 to February 7, 1985, were exposed to VOCs on a short-term basis (less than 14 days).

In general, exposure to VOCs in water can occur from ingestion, inhalation, or skin contact with contaminated water. Because these chemicals readily change from liquid form to vapor, showering, bathing, and cooking can contribute to the estimated exposure dose. Reports in the scientific literature indicate that, while showering, people generally inhale an amount of VOCs equivalent to drinking 2 liters of water (34). Our VOC exposure estimates assume exposure to

VOCs from ingesting 2 liters of water per day and inhaling an equivalent concentration of VOCs during showering. The estimated exposure doses for people drinking contaminated water in these three systems are presented in Table 3.

TCE is similar to PCE in chemical composition and in the way the body metabolizes it. However, we have evaluated the effects of each chemical separately, and those results are presented in Table 3. We also qualitatively consider the combined effects of the chemicals on the body when evaluating the likelihood of cancer.

Noncancerous adverse health effects are not expected for the adults who were exposed to VOCs by drinking or bathing in the contaminated water at MCB Camp Lejeune. During the 1940s and early 1950s, TCE and PCE were used to anesthetize patients during operations. A review of available information on those people and also information on occupational exposures indicates that short-term exposure to TCE, regardless of route (ingestion, inhalation, or skin absorption) at concentrations of 100 to 10,000 times greater (160,000–1,000,000 ppb) than those detected at MCB Camp Lejeune depress the central nervous system, causing headache, dizziness, nausea, vomiting, and intoxication (35). Long-term exposure to TCE at 200,000–400,000 ppb, which is 142 to 285 times higher than the levels detected at MCB Camp Lejeune, as reported in the scientific literature caused vertigo, short-term memory loss, and harmful liver and kidney effects (35). Because the concentrations of TCE detected in the drinking water at MCB Camp Lejeune are so much lower (100 to 10,000 times lower) than the levels causing the previously mentioned effects, it is unlikely that adults would have developed noncancerous adverse health effects. More recently, very subtle effects of TCE on nervous system reflexes have been observed after long-term exposure to no more than 35,000 ppb (36). However, these subtle effects were observed in a population exposed to TCE for 20 years, which is much longer than most residents at MCB Camp Lejeune would have received contaminated water.

Certain people are potentially more sensitive to the effects of VOCs. These more sensitive groups include chronic consumers of alcohol, people with heart disease, people taking disulfiram (a medication used to treat alcoholism), and people taking the anticoagulant warfarin (37). These medications increase the toxicity of VOCs on the liver.

Table 3. Potential Health Effects for VOC Exposures

Water System	Exposed Population	Exposure Time Frame	Exposure Activity	Drinking Water Contaminant		Estimated Exposure Dose (mg/kg/day)	Potential Health Effects	
				Chemical	Maximum Concentration (ppb)		Noncancer Effects	Cancer Risk Increase†
Hadnot Point	Base residents and workers (Adults, children, and fetuses)	Past known 1982–1985, unknown 1940s–1982	People in the Hospital Point housing complex and other buildings supplied by the Hadnot Point Drinking Water System ingesting, inhaling, and having dermal contact with contaminated drinking water	TCE	1400	Adult 1.7E-03	Not Likely	No
						Child 3.7E-03	Unknown	Unknown
				DCE	407	Adult 4.9E-04	Not Likely	No
						Child 1.1E-03	Not Likely	Unknown
				Methylene Chloride	54	Adult 6.6E-05	Not Likely	No
						Child 1.4E-04	Not Likely	Unknown
				Vinyl Chloride	3 J	Adult 3.6E-06	Not Likely	No
						Child 8.1E-06	Not Likely	Unknown
Tarawa Terrace	Base residents (Adults, children, and fetuses)	Past known 1982–1985, unknown 1954–1982	People in the Tarawa Terrace housing complexes ingesting, inhaling, and having dermal contact with contaminated drinking water supplied by Tarawa Terrace Drinking Water System	TCE	8	Adult 9.8E-06	Not Likely	No
						Child 2.2E-05	Not Likely	Unknown
				DCE	12	Adult 1.5E-05	Not Likely	No
						Child 3.2E-05	Not Likely	Unknown
				PCE	215	Adult 2.6E-04	Not Likely	No
						Child 5.8E-04	Unknown	Unknown
Holcomb Blvd	Base residents and workers (Adults, children, and fetuses)	Past known January 27 –February 7, 1985	People in the Paradise Point, Watkins Village, Berkeley Manor, Midway Park housing complexes, and other buildings supplied by the Holcomb Boulevard Drinking Water System ingesting, inhaling, and having dermal contact with contaminated drinking water	TCE	1,148	Adult 3.3E-05	Not Likely	No
						Child 7.2E-05	Unknown	Not Likely
				DCE	407	Adult 1.2E-05	Not Likely	No
						Child 2.5E-05	Not Likely	Not Likely

† - Increased cancer risk is based on ≥ 5.5×10^{-6}.
J - Estimated value
NOTE: Dose calculations and cancer risk estimates are included in Appendix F-2.
The Probable Health Effects does NOT include those for fetuses, which would be unknown.

Cancerous Effects

Typically, ATSDR uses human epidemiologic and occupational studies when evaluating the likelihood of cancerous effects or cancer risk. However, too few epidemiologic studies have been carried out on low-level exposure to VOCs to make sound cancer estimates. Therefore, we decided to base our assessment of cancer risk from exposure to VOCs at MCB Camp Lejeune on data from animal studies. The International Agency for Research in Cancer (IARC) classifies TCE and PCE as "probably carcinogenic to humans" based on "sufficient" evidence of carcinogenicity in animals and "limited" evidence in humans (38). The animal studies evaluated the cancer effects from known exposure to VOCs. On the basis of these animal studies, mathematical formulas were derived using factors to convert animal data into values relevant to humans.

Using cancer risk estimates, ATSDR determined that cancerous health effects are unlikely in adults who were exposed to VOCs in drinking water at MCB Camp Lejeune (Appendix E-1). Although cancer is not expected to occur, not enough scientific information on humans is available to rule out the possibility of cancerous health effects from low-dose exposure to VOCs. A few epidemiologic studies have suggested that exposure to VOCs may be associated with leukemia, non-Hodgkins lymphoma, and bladder and kidney cancer (39, 40, 41, 42). The exposure doses in these studies were similar to or slightly higher than what was estimated for people at MCB Camp Lejeune. However, there are too few studies to see any definite pattern of cancers related to VOC exposure. In addition, these studies are further limited methodologically because of the difficulty of verifying and quantifying people's exposure to VOCs. Because the results of the epidemiologic studies suggest a possibility of cancer from exposure to VOCs at low doses, more studies are needed to adequately address the issue of human cancer associated with low-dose VOC exposure.

Health Outcome Data

Cancer Data

At this time, ATSDR is not planning a follow-up cancer statistics evaluation of adults at MCB Camp Lejeune for the following reasons. A simple review of cancer statistics from the North Carolina cancer registry would not be useful because cancer registries contain cancer cases diagnosed each month for a specific county. When exposures occur, generally all residents of the county are not equally affected. Instead, the people exposed would be a smaller, localized group such as the small group of residents at Tarawa Terrace, MCB Camp Lejeune. Therefore, evidence of higher cancer rates in groups this small may be hidden within the rates of cancer for the entire county.

In addition, latency for most types of cancer is between 10 and 20 years. This creates two problems. First, those exposed to potential VOC carcinogens in the 1982–1985 time frame, would just now be beginning to be diagnosed with cancer. Secondly, the average stay of residents at MCB Camp Lejeune at that time was 3 years, and most of the exposed individuals

who develop cancer are likely to have moved before they are diagnosed. Hence, most of the cancer cases that might have occurred among exposed individuals would not be recorded in the North Carolina cancer registry as occurring to MCB Camp Lejeune residents.

The potential effects of VOC exposure on children have been evaluated only in Woburn, Massachusetts, where a cluster of childhood leukemia cases has been investigated in several different studies. The Woburn studies suggested an association between childhood leukemia and access to VOC-contaminated drinking water (42, 43, 44). This association was quite strong in children who were exposed to the largest quantities of VOCs *in utero* (43). In addition, cancer rates declined to expected levels about 8 years after the contaminated wells were closed, which is a reasonable latency period for childhood cancer. The contaminant levels in the Woburn wells were TCE, 267 ppb; PCE, 21 ppb; chloroform, 12 ppb; and other VOCs. The wells were used 59% of the time, and water was blended with water from six other municipal wells, thus lowering the actual concentrations of VOCs people would be drinking at their taps. The risk of childhood leukemia associated with VOC-contaminated drinking water in Woburn was impossible to estimate precisely because the overall number of childhood leukemia cases in Woburn was small, the number of years during which Woburn water was contaminated was not known, and what VOC concentrations were present in tap water was not known. In addition, some associations between chemical exposure and disease arise by coincidence. This is why it is necessary to conduct epidemiologic studies in several different populations to establish a definitive link between exposure and disease. Nevertheless, the findings at Woburn raise concerns about potential childhood cancer risks associated with VOC exposure *in utero*. Therefore, we recommend that, if feasible, ATSDR conduct a study of cancer in children potentially exposed to VOCs *in utero* while their parents resided at Camp Lejeune.

Noncancerous Effects

Adverse Birth Outcomes

Women may experience adverse pregnancy outcomes from exposure to toxic substances even when their own health is not threatened, because fetuses are potentially more sensitive to the effects of VOCs (45, 46). Several epidemiologic studies suggested the possibility that pregnant women exposed to VOCs (at levels similar to those detected at MCB Camp Lejeune) may have an increased risk of adverse pregnancy outcomes. The outcomes include birth defects such as heart malformations, neural tube defects, oral clefts, low birthweight, and increased fetal death (45, 46-51). Some of these studies have significant limitations, including questions about whether all of the study population was exposed, how long exposure took place, and the exact concentrations of VOCs to which these mothers were exposed. Due to these limitations, more studies are needed to better evaluate the relationship between VOC exposure and adverse pregnancy outcomes.

To help address the issue about pregnancy outcomes, ATSDR began a study at Camp Lejeune in 1995. In an interim report released in 1997, ATSDR identified approximately 6000 infants whose mothers resided in VOC-exposed housing areas while pregnant (52, 53). A statistically

significant decrease in mean birthweight and a statistically significant increase in the condition small for gestational age was observed in *male infants* born to mothers whose housing was supplied with water from *Hadnot Point*. Birthweight in this group was compared with birthweight of infants of women living in other officers' housing. No differences in mean birthweight or the condition small for gestational age were noted in most residents receiving water from Tarawa Terrace compared with residents of other housing areas. However, in Tarawa Terrace residents, the children of mothers who were *35 years of age or older* and the children of mothers who had *previously had a fetal loss* were more likely to have been born small for gestational age. Infants whose mothers were very briefly exposed to VOCs from the Holcomb Boulevard system were not more likely to have lower mean birthweight or to be born small for gestational age.

Summary and Follow-up

Human exposure to TCE, PCE, and 1,2-DCE in drinking water systems at MCB Camp Lejeune has been documented over a period of 34 months, but likely occurred for a longer period of time perhaps as long as 30 years. Included in the population that used this water were approximately 6000 residents in base family housing (52, 53). This population consisted of a large proportion of young married women. Even though adverse health effects are not expected in adults, concern was raised about potential toxic effects on developing fetuses.

As discussed previously, it is difficult to draw conclusions from a single epidemiologic study, and most of the other epidemiologic studies completed to date have been so different in study design that their results cannot be adequately compared. Also, finding associations in some subgroups but not others is plausible, but was not expected. Research conducted in other groups of infants exposed to these chemicals *in utero* will be necessary before firm conclusions about the effects of low-level VOC exposure on birthweight can be drawn. ATSDR is currently conducting another study of TCE in drinking water and birthweight as part of its National Exposure Registry activities. The Exposure Registry study may confirm or refute some of these observations. A future report based on the Camp Lejeune birth data will examine the potential association between VOC exposure and preterm delivery and late fetal death. Birth defects will be studied only briefly because the data are too limited for an adequate evaluation.

Another potential effect of fetal exposure to VOCs is childhood cancer. Information about the potential for this effect is limited, but provocative. Therefore, ATSDR recommends a study of cancer in children who were exposed to VOCs at MCB Camp Lejeune while *in utero*.

Conclusions and Public Health Action Plan for VOC Exposure (Tap Water)

Conclusion:

1. Before 1986, people drinking and showering with water from the Tarawa Terrace, Hadnot Point, and the Holcomb Boulevard water distribution systems on base were exposed to volatile organic compounds (VOCs). There is information documenting drinking water contamination in the Tarawa Terrace and Hadnot Point water systems from 1982 until 1985, although contamination could have been present longer. Contamination in the Holcomb Boulevard system was present only for two weeks, January 27– February 7, 1985. At the estimated exposure levels, we do not expect cancerous or noncancerous health effects in adults. Even though ATSDR determined that cancerous health effects are unlikely in children, not enough scientific information is available to rule out the possibility of cancerous health effects from low-dose exposure to VOCs such as those at MCB Camp Lejeune. Additionally, fetuses are potentially more sensitive than children to VOCs. Previous studies have suggested associations between childhood cancer, low birthweight, late fetal death, and fetal exposure to VOCs.

2. ATSDR's Health Study suggests that a statistically significant decrease in mean birthweight and a statistically significant increase in the condition small for gestational age was observed in *male infants* born to mothers whose housing was supplied with water from *Hadnot Point*. A copy of the health study can be obtained at the Onslow County Library, Jacksonville, NC, or from ATSDR.

3. ATSDR also found that in Tarawa Terrace residents exposed to VOCs, the children of mothers who were *35 years of age* or older and the children of mothers who had *previously had a fetal loss* were more likely to have been born small for gestational age. Infants whose mothers were very briefly exposed to VOCs from the Holcomb Boulevard system were not more likely to have lower mean birthweight or to be born small for gestational age.

Completed Action:

1. In 1985, MCB Camp Lejeune ceased use of VOC-contaminated drinking water wells at Hadnot Point, Tarawa Terrace, and Holcomb Boulevard.

Ongoing Action:

1. In 1995, ATSDR completed collecting data for a study of VOCs in drinking water and birth outcomes at MCB Camp Lejeune. An interim report was released in 1997. A final report is also expected in 1997.

Recommended Action:

1. ATSDR recommends that a study be conducted of cancer in children who were probably exposed *in utero* to VOCs at MCB Camp Lejeune. This study would further the understanding of the health effects of low-dose VOC exposure in susceptible populations, and provide parents with information about their children's health risks.

C. Pesticide Exposure (Site 2-Former Nursery/Day-Care Center)

The soil around Building 712 at Site 2 was contaminated with the pesticides chlordane and DDT and its breakdown products, DDD and DDE. At different times over the years, people working or playing on the surrounding grounds were exposed to different concentrations of these pesticides in surface soil from the parking lot, lawn, or playground. People exposed to contaminated soil include office workers, lawn-care workers, children, and adults who used the parking lot. Those exposures were estimated to be high enough to increase the lifetime risk for cancer in office workers, but noncancerous adverse health effects are not likely. Lawn-care workers and other adults are not expected to have noncancerous or cancerous effects as a result of their exposure to the pesticides at this site. However, because of the limited scientific information available on adverse effects in children exposed to pesticides, ATSDR was not able to adequately address the likelihood of either cancerous or noncancerous adverse health effects in them. All exposures were stopped in 1993 when access to the contaminated areas was physically restricted. Also, contaminated soil was removed in October 1994. Table 4 outlines the pesticide exposure situations.

What is DDT?

From 1946 to 1972, DDT (dichlorodiphenyltrichlorethane) was one of the most widely used man-made insecticides in the world. On January 1, 1973, all uses of DDT in the United States and Canada were banned. DDT is still used in Mexico and many tropical countries. DDT does not readily dissolve in water, but instead binds tightly to the soil. Breakdown of DDT is very slow, resulting in its persistence in the environment. In the presence of oxygen, DDT breaks down to form DDE, and in the absence of oxygen, DDD is formed. The major health concern with DDT exposure is possible increased risk of developing cancer.

Site 2-History and Use

Building 712 is located in the northeastern portion of MCB Camp Lejeune just off Holcomb Boulevard (Figure 1). From 1945 through 1958, the building was used as a pesticide storehouse and as an office for the pesticide workers. Two outside concrete pads, level with ground surface, were used as platforms for mixing pesticides and washing pesticide containers. These pads and the surrounding soils contain the highest level of contamination (Figure 2). In 1958, pesticide handling was relocated to a different area on base and Building 712 remained unused until 1966 (3). There is no record that Building 712 was ever decontaminated. The surrounding grounds were not

What is chlordane?

Chlordane is a man-made pesticide used in the United States from 1948-1988 primarily to control termites. It was used in agriculture until 1978. Chlordane is a mixture of many chemicals; e.g., cis-chlordane, trans-chlordane, B-chlordane, heptachlor, and trans-nonachlor. Chlordane does not dissolve in water and readily binds to soil. Limited information is available on how chlordane degrades in soil, but the degradation process is slow, resulting in chlordane's persistence in the environment. The major health concern with chlordane exposure is possible increased risk of developing cancer.

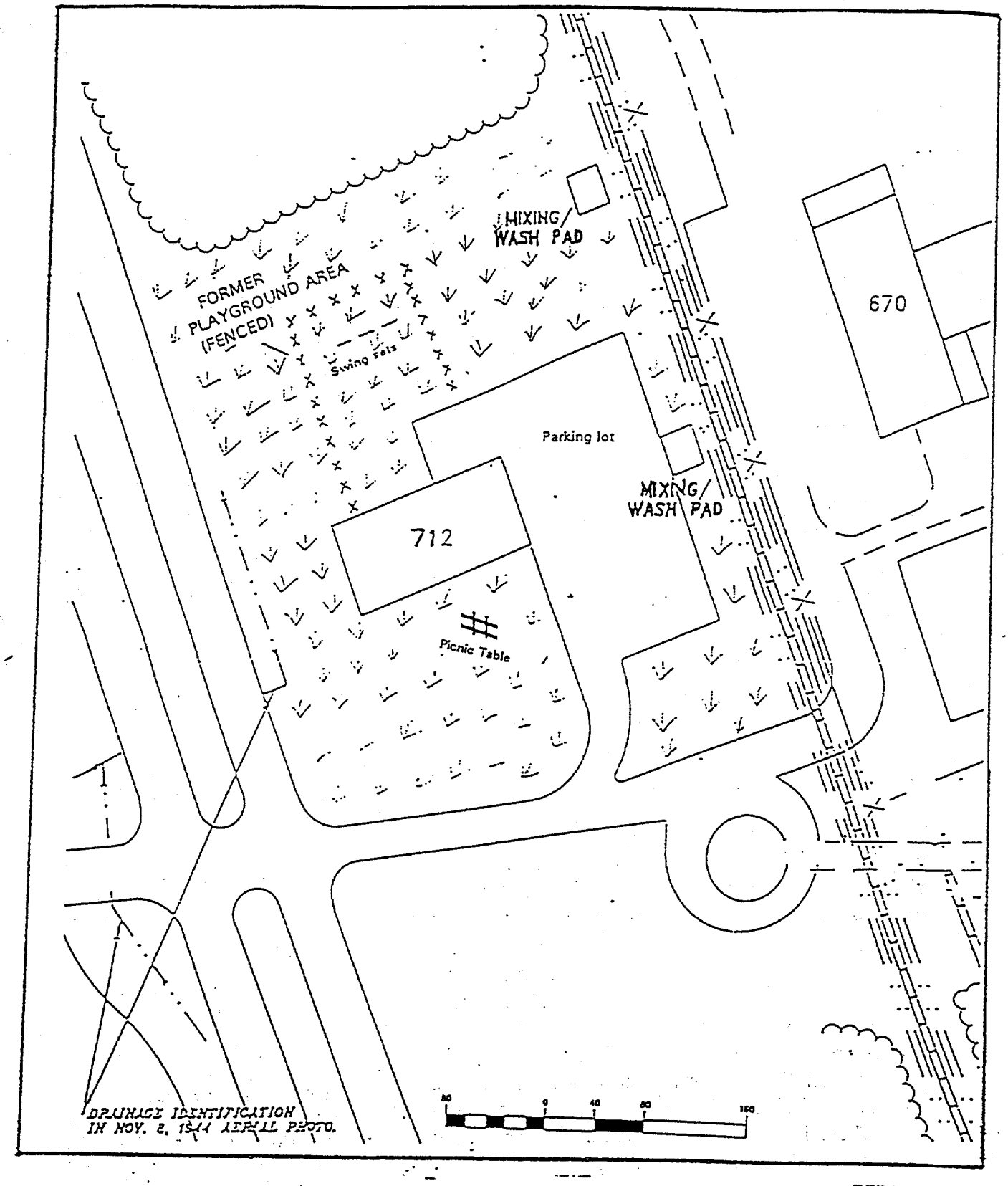


Figure 2
Site 2 Former Day Care Center
Marine Corps Base, Camp Lejeune

Source: Modified from Baker Draft Report 1993

decontaminated until 1994, when the contaminated soil was removed from the parking lot and lawn areas (24, 25).

In 1966, Building 712 was opened as a day-care facility for the children of MCB Camp Lejeune employees. The day-care center had an enrollment of approximately 45 children ranging in age from 6 weeks to 12 years; most were about 5 years old (55). The children's playground area was fenced and approximately 100 feet from the old concrete wash pad. A gravel parking lot is located at the rear of the building. The old concrete mix pad was adjacent to the parking lot, and cars could actually park on the concrete pad.

In 1982, during environmental contamination investigations at MCB Camp Lejeune, pesticides in surface soil were detected at several locations around the building, i.e., near the mix and wash pads, in the lawn area, in the parking lot, in the day-care playground area, and in the drainage ditch (3). Figure 2 diagrams those locations at Site 2. The pesticides detected (DDT and chlordane) are not water soluble. They bind tightly to soil particles and are not easily washed away from the soil. Therefore, movement of pesticides from the immediate area where they were released is not expected. However, migration of the soil particles from erosion due to heavy rains or winds may explain the presence of pesticides in the adjacent drainage ditch.

In June 1982, after environmental contamination was detected, the Marine Corps relocated the day-care center to another area on base (56). In 1989, Building 712 was used as a personnel office. In 1994, the office workers consisted of one part-time and fifteen full-time employees (57). The area previously used as a playground is now covered with grass. Exposures were stopped in December 1993 when MCB Camp Lejeune installed a fence and posted signs in the lawn and parking lot warning people not to enter the contaminated areas (58). In 1994, the concrete pads and contaminated soil from the parking lot and lawn areas were removed (24, 25). The parking lot was backfilled with clean gravel. The lawn was backfilled with clean soil and seeded with grass.

Human Exposure Routes and Public Health Implications

Exposures to pesticide at Building 712 stopped in December 1993, so the discussion here is for estimates of past, not current, exposure. ATSDR identified four groups of people who were exposed to pesticide-laden soil. In the past, (1) office workers were exposed to parking lot dust, (2) lawn-care workers were exposed to soil stirred up by lawn mowers. During the time period from 1966 to 1982, (3) children were exposed to dust from the parking lot and soil in the playground, and (4) adults were exposed to dust from the day-care parking lot.

In 1982 and 1993, soil samples were collected from different locations surrounding Site 2. We discuss here the levels of exposure we estimate for each group beginning with the most highly exposed. The exposure levels are dependent on assumptions we make about the length of time people were exposed, their contaminant dose, and their own sensitivity based

on age. We have evaluated the exposure dose for each group of people who would have been exposed to contaminated soil at each sampling location. See Table 4 and Appendix E-2 for details.

ATSDR determined the likelihood that either cancerous and noncancerous adverse health effects will result from the exposure dose of the chemical contaminant. Because cancerous and noncancerous health effects occur through different biological mechanisms, they are evaluated separately, using different health guidelines and scientific information. If either cancerous or noncancerous health outcomes are likely to result from exposure to contaminants, the exposure is considered a public health hazard.

ATSDR's approach is conservative. (In other words, we include a wide margin of safety in our estimates of risk.) We use the maximum concentrations detected for estimating exposure dose. This estimate gives us a "worst case" estimate of the likelihood of adverse health effects. Thus, our public health recommendations are protective of the most sensitive members of the public.

1. Office Workers-Past Exposure

Office workers were exposed to pesticide contaminated dust when they parked their cars in the parking lot. The contaminated dust would have been absorbed by breathing or swallowing it. We assume that exposure would have lasted longer than 1 year because the length of employment is commonly longer than 1 year. The personnel office employs 16 employees.

Surface soil samples collected in 1993 from the parking lot area adjacent to the old concrete mix pad (the area with the highest concentrations of pesticide) contained these maximum levels: DDD at 1200 parts per million (ppm), DDT at 930 ppm, DDE at 30 ppm, and chlordane at 0.31 ppm (59).

The estimated exposure doses for office workers are listed in Table 4. Noncancerous adverse health effects resulting from those exposures are unlikely. However, when evaluated using the cancer risk values, we estimate that, as a result of their exposure, office workers may have an increased risk of developing cancer over their lifetime (Appendix E-2). Simultaneous exposures to those pesticides may increase this risk. Therefore, we concluded that exposure to pesticides at the levels detected in the parking lot area posed a public health hazard.

2. Lawn-Care Workers-Past Exposure

Lawn-care workers were exposed to pesticides by breathing or swallowing dust stirred up by the lawn mowers. We estimate those exposures would have been seasonal, occurring for 4

months of the year, 1 day per week, and possibly could have lasted more than 1 year for an estimated five individual lawn-care workers (24).

Surface soil samples collected in 1993 (Table 4) at the grass-covered areas contained maximum levels of DDT at 3000 ppm, DDD at 1200 ppm, DDE at 30 ppm, and chlordane at 7.4 ppm (59).

The estimated exposure doses for lawn-care workers are listed in Table 4. Most likely, lawn-care workers were exposed to lower doses of pesticides than are people who apply pesticides. However, pesticide applicators are aware that safety equipment such as respirators, gloves, and coveralls greatly reduce their chance of exposure, whereas lawn-care workers would not usually wear such equipment when mowing the lawn.

Noncancerous adverse health effects resulting from those exposures are unlikely. Additionally, we evaluated the likelihood of increased cancer risk to lawn-care workers from exposure to the chemicals (chlordane, DDT, DDE, and DDD). On the basis of the estimated duration of exposure, it is unlikely that lawn-care workers have any increased risk of developing cancer as a result of their exposure. Therefore, the exposure to lawn-care workers at Site 2 does not present a public health hazard. Appendix E-2 lists the exposure doses and cancer risk values estimated at Site 2.

3. Children at Day Care-Past Exposure: 1966–1982

Due to their hand-to-mouth activity, children ingest more soil than adults. As a result, children who attended the day-care center were exposed to higher doses of pesticides than were adults. Children at the day-care center absorbed the pesticides by touching the soil in the playground and by breathing or swallowing the soil. We estimated that approximately 225 individual children would have been exposed during the time the day-care center was in operation. We assumed that children would have attended the day care for longer than 1 year because the average tour of duty for military personnel at MCB Camp Lejeune at that time was 3 years. Therefore, we estimated exposure to be chronic.

When soil sampling was carried out in 1982, surface soil samples collected from the playground area contained DDT at 6.7 ppm and chlordane at 0.39 ppm. Because the breakdown of those compounds is slow, we assumed that the concentrations were within the same range throughout the 16-year period that the day-care center operated.

Table 4. Potential Health Effects of Pesticide Exposures at Site 2

Exposed Population	Exposure Time Frame	Exposure Activity	Surface Soil Contaminant		Maximum Estimated Exposure Dose (mg/kg/day)	Potential Health Effects	
			Chemical	Concentration Range (ppm)		Noncancer Effects	Cancer Risk Increase†
1. Office Workers (Adults)	Past 1989--1993	Swallowing contaminated dust stirred up when parking cars in the parking lot	Chlordane	ND - 0.310	0.000000	Not Likely	No
			DDD	5.7 - 1200	0.001714	Not Likely	Yes
			DDE	0.93 - 30.0	0.000043	Not Likely	No
			DDT	2.10 - 930	0.001329	Not Likely	Yes
2. Lawn-care workers (Adults)	Past 1989–1993	Swallowing contaminated dust stirred up during lawn mowing	Chlordane	ND - 7.4	0.000001	Not Likely	No
			DDD	ND - 1200	0.000154	Not Likely	No
			DDE	ND - 30.0	0.000004	Not Likely	No
			DDT	ND - 3000	0.000386	Not Likely	No
3a. Children	Past 1966–1982	Swallowing contaminated dust stirred up by cars being parked in the parking lot	Chlordane	0.06 - 45.7	0.000286	Unknown	Unknown
			DDD	0.100 - 644	0.004025	Unknown	Unknown
			DDE	0.02 - 68.7	0.000429	Unknown	Unknown
			DDT	0.061 - 7500	0.046875	Unknown	Unknown
3b. Day-Care Workers and Parents (Adults)	Past 1966–1982	Swallowing contaminated dust stirred up when parking cars in the parking lot	Chlordane	0.06 - 45.7	0.000065	Not Likely	No
			DDD	0.100 - 644	0.000920	Not Likely	No
			DDE	0.02 - 68.7	0.000098	Not Likely	No
			DDT	0.061 - 7500	0.010714	Not Likely	Yes
4a. Children (Pica)	Past 1966–1982	Swallowing and skin contact with contaminated surface soil while playing in the playground	Chlordane	< 0.10 - 0.390	0.000122	Unknown	Unknown
			DDT	0.030 - 6.7	0.002094	Unknown	Unknown
4b. Children (Nonpica)	Past 1966–1982	Swallowing and skin contact with contaminated surface soil while playing in the playground	Chlordane	< 0.10 - 0.390	0.000005	Not Likely	Unknown
			DDT	0.030 - 6.7	0.000084	Not Likely	Unknown

† - Increased cancer risk is based on $\geq 5.5 \times 10^{-5}$.
Values for children's cancer risk are reported here as unknown because generalizing cancer risk calculation for children is strongly questioned among the scientific community. Appendix E-2 contains the assumptions used in estimating dose and cancer risk.

We calculated exposure doses for pica and nonpica children, based on the amount of soil to which the children would have been exposed. Children are classified as "pica" if they intentionally eat nonfood items, in this case soil. Pica behavior occurs in about 16% of children age 6 months to 2 years old (60). The exposure dose for pica children usually is greater than for nonpica children and would represent a worst-case exposure dose. The estimated exposure doses for pica children exposed to pesticide contaminated soil in the playground are in Table 4.

Children received additional pesticide exposure from the dust in the parking lot. We assumed that exposure would have lasted longer than 1 year. The additional exposure doses for children are also listed in Table 4.

One difficulty in estimating the health risk posed by these exposures is that the effects of pesticides in children have not been well studied. The way pesticides are metabolized in the body has been studied for many years in adults, who have usually been exposed as a result of accidental or occupational exposure. However, no scientific studies were found that described how pesticides are metabolized in children. This is important when trying to estimate the effects on very young children because children less than 2 years old may not yet have developed the enzymes that metabolize these pesticides (60).

We assume that the sensitivity of children older than 2 is similar to that of adults. Therefore, as in the adult populations, we do not think noncancerous adverse health effects are likely in children as a result of this exposure.

Cancer mechanisms in children are not well understood, but could be similar to those in adults; therefore, children exposed at Site 2 may have some increased lifetime risk of cancer. However, generalizing cancer risk calculation for children is strongly questioned among the scientific community because of a child's changing metabolism. Metabolic changes can cause children to be either more sensitive or less sensitive to the effects of a carcinogen based on their ability to repair cell damage and other factors. Therefore, we do not think a numerical estimate of increased risk would be applicable for children because we cannot generalize from adult studies to children.

4. Adults at Parking Lot-Past Exposure: 1966–1982

Adults who used the parking lot of Building 712 when it was a day-care center were exposed to pesticide-contaminated dust. This group would have included day-care center employees and parents taking their children to the day-care center. The approximate number of exposed adults is difficult to estimate. However, we believe that more than 50 adults were exposed during the time the day-care center was in operation. The exposure would be through breathing or swallowing contaminated dust and may have lasted longer than 1 year.

Surface soil samples collected in 1982 from the parking lot area adjacent to the old concrete mix pad contained the highest concentrations of pesticides within the parking lot area: DDT at 7500 ppm, DDD at 644 ppm, DDE at 69 ppm, and chlordane at 45 ppm. The estimated exposure doses for adults exposed to pesticide contaminated soil are in Table 4.

At these exposure doses, we do not think noncancerous adverse health effects are likely. However, as with the other groups described here, we think that exposure was high enough to increase the lifetime risk of developing cancer. Simultaneous exposures to DDT, DDE, DDD, and chlordane may have further increased this risk. For these reasons, we concluded that the exposure in the past posed a public health hazard.

Chemical-Specific Considerations

DDT - p,p'-dichlorodiphenyltrichloroethane,
DDD - p,p'-dichlorodiphenyldichloroethane, and
DDE - p,p'-dichlorodiphenyldichloroethylene

Since it was first used in 1946, DDT has been studied extensively in humans and animals. We reviewed the available scientific literature and determined that DDT and its breakdown products, DDD and DDE, at concentrations higher than those detected at MCB Camp Lejeune are only mildly harmful to humans.

We do not predict noncancerous adverse health effects in people exposed to pesticides at Site 2. The scientific literature has reported cases in which workers were accidentally poisoned after drinking concentrated DDT. In these cases, which had DDT concentrations much higher than those estimated for people at MCB Camp Lejeune, health effects were limited to headaches, confusion, vomiting, nausea, increased sensitivity of the mouth and lower part of the face, and tremor of the extremities. In general, symptoms occurred as soon as 30 minutes after a large dose or as late as 6 hours after a small dose (60, 61). Complete recovery from the acute symptoms occurred within several weeks.

Even today, DDT's effect as a human carcinogen is unknown (62). EPA has classified it as a possible human carcinogen based on evidence that it causes cancer in animals. Epidemiologic studies of pesticide workers suggest an association between long-term exposures to high doses of DDT and pancreatic cancer (63). In the interest of public health, ATSDR's approach is cautious, and we have accepted the worst-case evaluation for these exposures. Although we have estimated the exposure doses to be representative of actual exposures, our cancer risk estimates are designed to be highly conservative. We have therefore estimated cancer risk as if DDT and its breakdown products DDD and DDE were human carcinogens (Appendix E-2). Combined chemical exposures may further increase this risk. Even though our cancer risk estimates are conservative, we consider these risks to be a public health hazard and have recommended that exposure be stopped. MCB Camp Lejeune has removed contaminated soil from this site.

Chlordane

The level of chlordane detected in the soil surrounding Site 2 during the 1982 and 1993 samplings are considered low. ATSDR estimated the exposure doses to chlordane in the area surrounding Building 712. These estimated exposure doses were much lower (10 to 100 times lower) than any dose reported to be associated with noncancerous adverse health effects (64). Further, the limited number of scientific studies of long-term human exposure to chlordane have shown no consistent detrimental effects in adults. There are only anecdotal reports suggesting a correlation between chlordane exposure and the subsequent development of aplastic anemia and leukemia (65).

When evaluated using the cancer risk values, the maximum concentration of chlordane detected is not expected to cause any increased risk of cancer in any of the exposed groups. Therefore, chlordane at the levels detected does not pose a public health hazard.

Summary and Follow-up

Workers in Building 712 were exposed to levels of DDT and its breakdown products in soil estimated to be high enough to increase the lifetime risk for cancer. In 1993, because surface soil sampling indicated that pesticides in the lawn and parking lot were of health concern, MCB Camp Lejeune installed a fence to prevent lawn-care and office workers from coming in contact with the contaminants and stopped mowing in that area. In 1994, MCB Camp Lejeune removed the concrete pad and contaminated soil. After the soil was removed, confirmation sampling was performed to ensure that the desired clean-up levels were achieved.

Health Outcome Data

ATSDR did not review the health outcome data of local cancer registries because such a review would provide inconclusive information for the following reason. Because pancreatic cancer (the cancer potentially associated with DDT exposure) only occurs in small numbers within the county's total population and because a very small number of workers were exposed, any evidence of excess cancer cases in this small group may be hidden within the rates of cancer for the entire county.

A local family had concerns that their child's current allergies might be caused from exposure to pesticides received while attending that day-care center. Because of these concerns, ATSDR contacted the director of Human Services at MCB Camp Lejeune to determine if records had been kept on individuals who attended the day-care center at Site 2. No records were kept on the children who attended the day-care center. Therefore, we could not review specific health outcome data for those individuals.

Because no health outcome data were reviewed, ATSDR conducted a literature search to determine if an increase in allergy cases had been reported from a similar exposure. No link between pesticide exposure and general allergies was identified. However, in this case, exposure to the pesticides found at Site 2 (DDT and chlordane) could possibly cause an allergic response if exposures to DDT or chlordane recurred, but would not cause general allergies to other substances such as cats, dusts, or grasses. Further, if the child was no longer being exposed to DDT and chlordane, then that child would not be expected to currently have allergic responses. DDT and chlordane have not been used in the United States since the 1970s. Moreover, one would not likely see a sustained reaction over the 12 years since the time the day-care center was closed.

Conclusions and Public Health Action Plan for Pesticide Exposure (Site 2)

Conclusions:

The soil around Building 712-Site 2 was contaminated with the pesticides chlordane and DDT, and its breakdown products DDD and DDE. At different times, four groups of people have been exposed to different concentrations of these pesticides in soil from the unpaved parking lot or the lawn.

1. The exposures of office and day-care workers and parents to contaminated soil in the parking lot were estimated to be high enough to increase their lifetime risk for cancer.
2. Lawn-care workers are not expected to have an increased cancer risk based on their exposure to contaminated soil in the lawn area.
3. Noncancerous health effects are not likely in any of the people exposed.

Completed Actions:

1. At Site 2, sampling data from 1993 indicated that pesticide levels in surface soils in the lawn and parking lot were of health concern. MCB Camp Lejeune installed a fence to prevent lawn-care and office workers from coming in contact with the contaminants and stopped mowing in that area.
2. MCB Camp Lejeune removed the concrete pads and contaminated soil. During this action, the removal action contractor conducted air monitoring and implemented dust control procedures, as needed, to prevent office workers and visitors from being exposed to site contaminants.
3. After the soil was removed, confirmation sampling was performed to ensure that the desired clean-up levels were achieved.

Planned Action:

No further actions planned or needed for the protection of public health.

Recommended Action:

No further actions recommended or needed for the protection of public health.

II. POTENTIAL (INDETERMINATE) PUBLIC HEALTH HAZARDS-POSSIBLE EXPOSURE SITUATIONS

ATSDR concluded that two possible exposure situations present potential public health hazards (Table 5). In the first situation, suspected fish contamination in Brinson Creek, additional sampling is needed to determine the extent of mercury present in Brinson Creek fish and whether the levels present a public health hazard. In the second situation, suspected fish and shellfish contamination in Northeast Creek near the New River, sampling of fish and shellfish in this area has not been conducted and would be required to determine if the contamination from Sites 7, 16, and 80 presents a health hazard to people eating fish and shellfish caught in Northeast Creek. NCDEHNR is conducting additional fish sampling in late July 1997 to determine the public health implications of eating fish caught from both of these areas.

A. Exposure to Contaminated Fish and Shellfish from Brinson Creek (Sites 35 and 36)

ATSDR has evaluated the environmental data and land use information and determined that people who eat largemouth bass from Brinson Creek may be exposed to elevated levels of mercury. However, sampling results of only two fish caught in 1997 and two fish caught in 1994 may not represent the actual level of mercury present in fish. Therefore, NCDEHNR will conduct additional sampling in late July 1997 of several Brinson Creek species to ensure that the results accurately represent the environmental conditions. If mercury in fish tissue are at levels of health concern, NCDEHNR will take measures to ensure that the health of the public is protected through such possible actions as fish advisories and public education. ATSDR will support NCDEHNR in efforts to protect public health.

What is mercury?

Mercury is a naturally occurring metal found in small amounts of the earth's surface. It is often introduced in larger amounts during the combustion of fossil fuels and medical or municipal waste. Mercury is commonly used in the mining of gold, and was used heavily in the past in photographic processing and medical instruments (i.e., thermometers). It exists in three forms: elemental, organic, and inorganic. Commonly used in the past in thermometers, switches, and batteries, elemental mercury is a silver-gray liquid at room temperature that vaporizes easily when heated. When mercury is present in water bodies, it is readily converted to the organic form, methylmercury, by fish dwelling in fresh and ocean water. People are exposed to this highly toxic form of mercury when they eat fish containing the methylmercury. Inorganic mercury, or mercury salts, were commonly used in medicines to prevent bacterial and fungal growth until its adverse health effects were known. The major health concerns of mercury exposure are its effects on the central nervous system causing brain function problems and its effects on the kidneys causing kidney failure.

Table 5. Potential Public Health Hazard Situations

PATHWAY NAME	CONTAMINANT	POTENTIAL EXPOSURE PATHWAY ELEMENTS					TIME	COMMENTS
		SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	POTENTIALLY EXPOSED POPULATION		
A. Fish contamination-Brinson Creek (Sites 35 and 36)	Mercury	Unknown	Largemouth bass taken from Brinson Creek	Eating mercury-contaminated fish	Ingestion	People eating mercury-contaminated fish (children and adults)	Current 1997 Future	Fish sampling results indicate that only largemouth bass contain mercury at levels close to ATSDR health comparison value and NCDEHNR action level. NCDEHNR is waiting for confirmatory sampling before taking any actions. ATSDR will support public health actions taken by NCDEHNR if needed to protect public health.
B. Suspected fish and shellfish contamination in Northeast Creek	Possibly metals, PCBs, pesticides, and PAHs	Sites 16, 80, and 7	Fish and shellfish from the Northeast Creek	Eating possibly contaminated fish and shellfish	Ingestion	People eating contaminated fish	Past, present, future	Sampling of fish and shellfish in Northeast Creek was not conducted during the remedial investigations of these sites. Because these contaminants were detected in soil, surface water, and sediments, and because of their toxicity and their tendency to bioconcentrate up the food chain, ATSDR recommends that fish and shellfish be sampled before remediation actions are complete. This area is heavily fished and shellfished.

Background

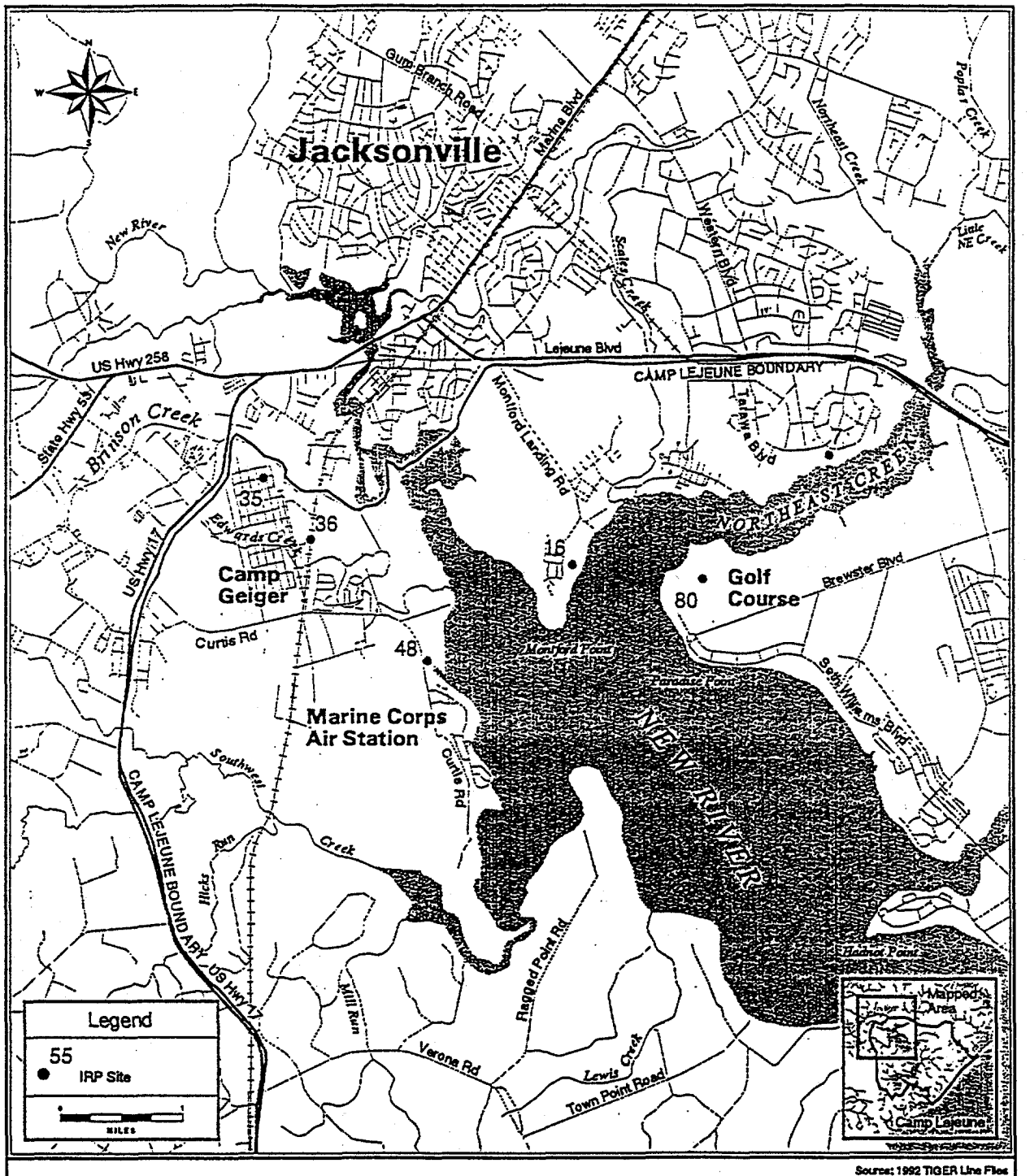
Brinson Creek is located in the uppermost northwest portion of the base at Camp Geiger (see Figure 3). Brinson Creek runs along the base boundary and forms the eastern boundary of Sites 35 and 36. Groundwater flow in this area is toward the creek and New River. Although Sites 35 and 36 have contributed contaminants to surface water and sediment in Brinson Creek, the presence of mercury in fish in the creek may not have come from those sites. Mercury was not detected in any media, nor was it thought to have been disposed of at the sites. Because fish migrate and because mercury is accumulated by fish and builds up to higher levels in the food chain as small fish are eaten by bigger fish, it will be extremely difficult to identify the exact source of mercury contamination. Initially, fish from Brinson Creek were sampled as part of the routine environmental investigation to identify the extent of contamination caused by Sites 35 and 36.

Surface water and sediments in Brinson Creek and in the unnamed tributary entering Brinson Creek did contain other contaminants such as pesticides, PAHs, petroleum hydrocarbons, inorganics (i.e., metals), and VOCs (in the unnamed tributary only), and chemicals associated with fuels. These chemicals are consistent with the source being Sites 35 and 36. However, the levels of these contaminants in fish, surface water, or sediments do not present a health hazard to people who may exposed to them by eating the fish or through recreational activities (swimming, boating, or picnicking) in the Brinson Creek area.

Site 35 and Site 36 History and Use

Site 35-Camp Geiger Area Fuel Farm is located at Camp Geiger, which was constructed in 1945, 4 years after MCB Camp Lejeune was established. Site 35 refers primarily to five 15,000-gallon aboveground storage tanks, a pump house, a fuel loading/unloading pad, an oil/water separator, and a distribution island. The area included in the remedial investigation for Site 35 incorporated 40 acres surrounding the site, which is covered with vegetation, woods, roadways, buildings, former building foundations and parking areas, eight warehouses, five barracks, two large fields used for training and recreation, and an armory. Originally, Site 35 housed aboveground storage tanks containing No.6 fuel oil. No.6 fuel oil was pumped below ground to the former Mess Hall Heating Plant boiler (demolished in the 1960s), which fueled the Mess Hall (66).

Routine fuel leaks onto the ground and in the below ground lines were reported and subsequently sealed. However, the surface and subsurface soils show contaminants consistent with fuel products. Additionally, Brinson Creek and an unnamed tributary run adjacent to the site. Sediment and surface water samples from these water bodies contain petroleum hydrocarbon contaminants (66).

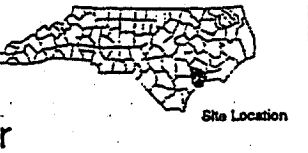


Source: 1992 TIGER Line Files

Figure 3
MCB, Camp Lejeune, N.C.

Northwest Quadrant including Brinson Creek, Northeast Creek, and portion of the lower New River

VICINITY MAP



Onslow County, North Carolina

ALD 050587

The North Carolina Department of Transportation has proposed the construction of a six-lane highway that would run through this area. MCB Camp Lejeune has already removed the fuel farm tanks, thus removing this contaminant source (66).

Site 36-Camp Geiger Area Dump is located about 500 feet from New River, adjacent to the Camp Geiger Sewage Treatment Plant. Site 36 encompasses nearly 20 acres, mostly open fields and wooded areas. Site 36 is bordered to the north and east by Brinson Creek and woods, to the south by an unnamed tributary to the New River, and to the west by a coarse gravel road (67).

Site 36 was reported to have been used for the disposal of municipal and mixed industrial wastes including solvents, paints, and waste oils that were generated at the Marine Corps Air Station, New River, directly south of the site. The dump was active from the 1940s to the late 1950s. Most of the material was burned then buried; however, some unburned material was also buried, such as several 5- and 55-gallon drums found during the environmental investigations (67).

Soil and groundwater contain VOCs, semivolatile organic compounds (SVOCs), pesticides, PCBs, and inorganic contaminants (i.e., metals). Inorganics were found in Brinson Creek and the unnamed tributary. VOCs were also present in the surface water of the unnamed tributary. Sediments were found to be contaminated with SVOCs, pesticides, and inorganics although mercury was not detected.

Fish Sampling

In 1994, as part of the remedial investigations for both sites, soil, groundwater, surface water, sediments, fish, shellfish, and macroinvertebrates were sampled. Three sampling stations in Brinson Creek were used to obtain 19 species consisting of 669 individual fish for Site 35. For Site 36, three additional stations in Brinson Creek were used to obtain 14 species consisting of 108 individual fish. Background samples taken from two stations in Webb Creek, four from Hadnot Creek, and three from Holland Mill Creek were used as comparisons (66).

The various species included pumpkinseed, bluegill, stripped mullet, white catfish, sheepshead minnow, summer flounder, pinfish, and largemouth bass, among others. Grass shrimp, blue crabs, American eel, and crayfish were also collected. Analysis was conducted on fish fillet and whole body fish. Crabs and shrimp were included in the fillet analysis. Eel and crayfish were included in the whole body fish analysis. Each individual fish was analyzed separately, which provides specific information on the contaminant body burden of each species and each size fish. This type of analysis allows for specific health recommendations, such as consumption limits, to be made for the species that contain

contaminants at levels of health concern and allows the other, noncontaminated species to be eaten without limit.

Results show that of all the various species collected, only the largemouth bass contained contaminants at levels of health concern. The May 1994 results reported the two largemouth bass samples containing mercury at 1.2 ppm and 1.3 ppm. Levels of mercury were higher in largemouth bass than in any other species sampled, probably due to their eating smaller fish, thus concentrating such chemicals as mercury in their tissue. Levels of mercury in the Brinson Creek largemouth bass were much higher than those from the reference or background stations selected for comparison (66).

In 1997, the MCB Camp Lejeune contractors pointed out the elevated levels to the base and to state officials. NCDEHNR recommended that the base collect additional fish samples to confirm the results from 1994. Specifically recommended for additional sampling were those fish commonly ingested by humans and most likely to contain the highest mercury levels. The species and number of individuals recommended were six fish of each of the following species: largemouth bass, bowfin (commonly known as blackfish), bluegill, and sunfish. After 3 days of trying to catch the recommended number and species using gill nets and poles, Baker Environmental, Inc., the base contractors, were able to collect only two largemouth bass, two bowfin, one bluegill, and five pumpkinseed (68). Results showed levels of mercury in largemouth bass at 1.6 ppm and 0.82 ppm. The ATSDR health comparison value and NCDEHNR's action limit is 1.0 ppm (68). Because one fish had higher than the 1.0 ppm value and one lower, the results are not conclusive.

Additionally, because so few samples were collected at Brinson Creek, fish sample results may not accurately represent the level of mercury present in most fish tissue. For this reason, NCDEHNR has requested that their Water Quality Section conduct additional sampling of largemouth bass, bowfin, and pumpkinseed in Brinson Creek and the New River to confirm the previous sampling results before they issue a fishing/consumption advisory. Additional sampling of Brinson Creek by NCDEHNR is projected for late July 1997 (69).

Human Exposure Routes and Public Health Implications

Recreational fishermen use Brinson Creek within and outside the base boundary. Reportedly this area is not heavily fished or crabbed. People who eat fish caught from Brinson Creek would be exposed to the contaminants in those fish. ATSDR estimates the number of women and children exposed to be fewer than 50 individuals.

Because of a child's rapidly developing brain, children and the fetuses of pregnant women are more vulnerable to the harmful effects of mercury (70, 71, 72). Methylmercury primarily affects the nerve cells within the brain and spinal cord (72). The exact amount of mercury that would cause these effects are difficult to determine because the amount of mercury in all food and the amount of all contaminated food eaten by any individual is not

known. However, there have been several studies of people who have accidentally eaten high levels of mercury-contaminated fish and grain. From these studies, health effects of lower levels of mercury, as found in the fish at Brinson Creek, have been estimated using mathematical formulas that incorporate many safety factors to account for variability and uncertainty (73). In this way, the 1.0 ppm action level is highly protective of human health, especially the most sensitive, children and fetuses.

Studies of children whose mothers were exposed to extremely high levels of mercury-contaminated food while pregnant have shown delayed walking and talking, inability to walk, crawl or talk, mental disturbances, speech retardation, cerebral palsy, and blindness. However, the levels of mercury in these studies were hundreds to thousands of times greater than even the maximum level of mercury detected in fish from Brinson Creek. The July 1997 sampling will allow specific public health recommendations to be made.

Summary and Follow-up

Although Brinson Creek is not heavily fished, people who eat fish caught in Brinson Creek are currently exposed to contaminants in those fish. Mercury levels in largemouth bass may pose a potential public health hazard to children and the fetuses of pregnant women. Therefore, additional sampling data are needed to determine if mercury levels in largemouth bass or other species could cause health problems for children and the fetuses of pregnant women who eat the fish from Brinson Creek. Fetuses and young children are especially sensitive to the neurological effects of mercury on the brain.

ATSDR plans to work in cooperation with the NCDEHNR and MCB Camp Lejeune to provide any assistance needed to protect public health if elevated contaminant levels are detected in Brinson Creek fish.

Conclusions and Public Health Action Plan for Fish Contamination-Brinson Creek (Sites 35 and 36)

Conclusions:

1. People who eat fish taken from Brinson Creek may be exposed to elevated levels of mercury found in the fish tissue. Confirmatory sampling is needed to determine the likelihood of exposure and any public health implications. NCDEHNR will be conducting additional confirmatory sampling in July 1997.

2. Sampling results for fish species other than largemouth bass did not show contaminants at levels that would pose a health hazard.

Completed Action:

1. MCB Camp Lejeune sampled various species of Brinson Creek fish in May 1994 and April 1997. Results indicate that only largemouth bass contain contaminants at levels that pose a health hazard. Data from 1994 showed that largemouth bass contained mercury at 1.2 ppm and 1.3 ppm. Data from 1997 showed the mercury levels in two largemouth bass to be 1.6 ppm and 0.82 ppm.

Planned Actions:

1. Because the low numbers of samples collected may not accurately represent the contaminant levels in Brinson Creek fish, NCDEHNR is planning to conduct confirmatory sampling of largemouth bass, bowfin, and pumpkinseed from Brinson Creek and the New River before taking further action. Sampling is planned for July 1997.

2. ATSDR is planning to work in cooperation with NCDEHNR and MCB Camp Lejeune to provide support needed to protect public health.

3. ATSDR has requested NCDEHNR to provide future sampling results for our review.

Recommended Action:

1. No additional recommendations are needed at this time until confirmatory sampling results are available.

B. Suspected Fish and Shellfish Contamination in Northeast Creek near New River (Sites 16, 80, and 7)

ATSDR is concerned that fish and shellfish in Northeast Creek near the New River may be contaminated with hazardous substances at levels of health concern. Environmental sampling in this area has been conducted under the Remedial Investigation Program for each site or operable unit (Sites 16, 80, and 7). However, Northeast Creek fish and shellfish have not been included in the sampling at these sites. This area of the New River and Northeast Creek supports recreational as well as commercial fishing. Sampling results of soil, surface water, and sediments at these sites have shown elevated levels of metals, PCBs, PAHs, and pesticides. These chemicals are persistent in the environment and can reach higher levels when concentrated by fish and shellfish up the food chain. Levels in fish and shellfish can be ten to thousands of times greater than levels found in soil, sediments, or surface water. For this reason, ATSDR recommended that MCB Camp Lejeune analyze edible species and size fish and shellfish (i.e., crabs and mollusks/bivalves if present) for metals (mercury, lead, arsenic, cadmium, and chromium), PCBs, PAHs, and pesticides to determine if any recommendations are needed to protect public health in people who eat fish and shellfish caught in this area. Because these sites are in the remedial feasibility study phase, it would be prudent to analyze fish before the remediation alternative selection. North Carolina Department of Environment, Health, and Natural Resources has agreed to include Northeast Creek in the July 1997 fish sampling area, based on ATSDR's recommendations.

Potential Sources

The potential sources of contamination are Sites 16, 80, and 7. **Site 16** is the **Montford Point Burn Dump** within Camp Johnson. It is approximately 4 acres and is located in the northern central part of the base near Montford Point. Northeast Creek is about 400 feet from the study area and flows in a southeasterly direction toward and into the New River. Camp Johnson is a restricted training area within MCB Camp Lejeune; there are residential barracks areas at this location. Site 16 opened in 1958 as a burn dump and closed in 1972. Not much information is available on the details of the waste that was burned there. Typically, the debris was burned and then graded to the perimeter of the disposal area to make room for more debris to be dumped and burned (74).

Remedial investigations began in 1994 to 1995, and sampling consisted of surface and subsurface soil, groundwater, surface water, and sediment from Northeast Creek. Sampling results show elevated levels of metals in sediment or surface water, and elevated levels of PCBs, mercury, and pesticides in soil. No fish or shellfish samples were collected. Commercial and recreational fishing is known to occur throughout the year near Montford Point.

Site 80, referred to as the **Paradise Point Golf Course Maintenance Area,** is about 1 acre and contains a machine shop, a concrete wash pad where golf course maintenance equipment

is cleaned, and a sump. The sump is used to collect water and oil that then travels into an oil/water separator located a few feet from the wash pad (75). Sites 80 and 7 are grouped into OU 11 due to their proximity. Information on the history of the maintenance facility, such as when it began, was not available. However, it is still being used. A drainage ditch runs from the southeast corner of the wash area toward the north/northeast to Northeast Creek. No contaminants were detected in the ditch, which receives intermittent water during rain (75). Soil, groundwater, sediments, and surface water from the drainage ditch were sampled. Results of soil analysis show elevated levels of PCBs and pesticides. No fish samples taken from Northeast Creek.

Site 7-Tarawa Terrace Dump is approximately 5 acres and public access is not restricted. Site 7 is located on the northern bank of Northeast Creek and Site 80 on the southern bank of Northeast Creek. Two unnamed tributaries are within the Site 7 boundary and flow southerly to Northeast Creek. These tributaries and Northeast Creek are influenced by tides. Reports and visual inspections have identified paint cans, motor oil cans, and other debris, but mainly construction debris. Site 7 is a former dump that was used during the construction of the Tarawa Terrace base housing. Precise years of operation are unknown. However, the housing area was built in the 1950s, and reports indicate the dump was closed in 1972 (76).

Site 7 sampling and analysis of soil, groundwater, sediments and surface water from four surface water bodies including Northeast Creek were taken as well as from the drainage ditch. Benthic macroinvertebrates were sampled, and gill nets were used in an attempt to determine if large fish were entering the Western Tributary. Although gill nets were set for 3 days, no large fish were caught; hence, no fish tissue samples were analyzed from the Western Tributary nor from Northeast Creek (76). Pesticides and PCBs were detected at elevated levels in soil. PAHs, pesticides, and metals were detected in sediment samples.

Summary and Follow-up

Due to the nature of chemicals detected at Sites 16, 80, and 7, their toxicity and persistence in the environment, and the proximity of these sites to Northeast Creek, ATSDR suspects that the levels of contaminants in edible fish could be at levels of health concern. Therefore, we recommend that fish and shellfish (if present) of edible species and size (a minimum of five individuals for each species) be analyzed for metals, PCBs, PAHs, and pesticides. NCDEHNR has agreed to conduct the sampling in July 1997. ATSDR will review the results of the sampling when available and work with NCDEHNR and MCB Camp Lejeune to ensure that measures are taken to protect public health.

Conclusion and Public Health Action Plan for Suspected Fish and Shellfish Contamination in Northeast Creek near the New River

Conclusion:

1. Soil, surface water, and sediments samples collected during remedial investigations of Sites 16, 80, and 7 detected elevated levels of metals, PCBs, PAHs, and pesticides. However, no fish or shellfish tissues were collected. Therefore, ATSDR cannot determine whether fish and shellfish from Northeast Creek near the New River are safe to eat.

Completed Action:

1. MCB Camp Lejeune has sampled soil, surface water, and sediments from Sites 16, 80, and 7 during the remedial investigations.

Planned Action:

1. Based on ATSDR recommendations, the North Carolina Department of Environment, Health, and Natural Resources is planning to conduct sampling of Northeast Creek near the New River in July 1997.

Recommended Action:

1. When sampling results are available, ATSDR will work with NCDEHNR, and MCB Camp Lejeune to ensure that public health is protected.

III. NO APPARENT PUBLIC HEALTH HAZARDS

ATSDR concluded that three situations were no apparent public health hazards: (1) groundwater contamination on base, (2) exposure to contaminated fish from several locations on base and (3) soil contamination at Site 69. In these situations, people are using these areas and contamination could be present. However, in each situation, certain conditions exist (e.g., the levels of contamination are low, and long-term monitoring is being conducted to ensure that people do not come in contact with contaminants at levels that cause health problems, or an area was covered with clean fill, making human exposure unlikely.

A. Groundwater Contamination (Basewide)

Previously, ATSDR had concerns that base drinking water wells might be at risk for contamination. MCB Camp Lejeune is taking action to identify, assimilate, track, and predict groundwater contamination migration through several programs. These programs are intended to protect the drinking water supply and to ensure that people do not drink contaminated groundwater. In some areas, contaminant plumes have been identified and groundwater is being treated to reduce groundwater contamination. Investigations are ongoing to identify and treat groundwater contamination through the Underground Storage Tank and Remedial Investigation studies. To prevent people from drinking contaminated water, ATSDR recommended that MCB Camp Lejeune initiate a semi-annual wellhead monitoring program (ATSDR Public Health Assessment Public Comment Release for MCB Camp Lejeune, January 6, 1995). As a result of our recommendations, an "annual program to monitor the active supply wells" was implemented by the base in 1996 (77). Under this program, (Sampling Analysis of Groundwater Wells at the Marine Corps Base, Camp Lejeune) drinking water supply wells are sampled at the wellhead. The annual sampling of groundwater wells was initiated by the base to protect the drinking water supply and the people who drink that water. This program is not required by law and is not under the jurisdiction of any off-base agency. Since this program was initiated, six drinking water supply wells have been closed because either contamination was detected at levels above drinking water standards or well locations are in close proximity to contaminated wells (7).

Sampling

In 1996, VOCs were detected in one well at levels slightly above drinking water standards. That well was immediately taken off line. Two other wells were also taken off line in 1996 due to potential contamination, because they were down gradient and near contaminated groundwater detected by monitoring wells installed during site remedial investigations (77).

The base policy for assessing contamination from the wellhead is that any well exceeding a primary drinking water standard will be taken offline. Since this program was initiated, six drinking water supply wells have been closed because either contamination was

detected at levels above drinking water standards or well locations are in close proximity to contaminated wells (7).

Although a total of 17 wells (approximately 20%) have been closed since 1985 because of groundwater contamination with VOCs and fuels, approximately 69 additional wells are still in operation on-base. These wells provide an average of 8.3 million gallons of water daily to MCB Camp Lejeune. Approximately 20 other wells are not in use due to low water pumping volume (28, 29). Almost all of these wells tap a tertiary sand and limestone aquifer that is permeable to contamination (54). For this reason, MCB Camp Lejeune has initiated several programs to protect the drinking water supply from contamination.

Five programs have been initiated. Three of these programs have been initiated since 1996. MCB Camp Lejeune currently conducts long-term monitoring of groundwater monitoring wells in conjunction with the Installation Restoration Program and Underground Storage Tank Program. Groundwater under this program is sampled at least annually and is reevaluated every 5 years. Additionally, MCB Camp Lejeune is working with the state of North Carolina to implement institutional controls such as land use restrictions and also deed restrictions should the base be turned over civilian jurisdiction.

On the basis of ATSDR recommendations, the base enacted an annual program - Sampling Analysis of Groundwater Wells at Marine Corps Base, Camp Lejeune, which monitors all drinking water supply wells at the wellhead. Results from all the sampling programs are assessed two ways. Data from the base and regional groundwater data collected by United States Geological Survey (USGS) is used in a three-dimensional computer model to determine the impact of groundwater withdrawal from the base's various groundwater treatment systems on regional groundwater conditions (78). This information will also be used in the Envrionmental Geographic Information System, which utilized maps and global positioning to determine exact geographic locations to track and predict groundwater migration. This system is scheduled to be on-line in summer 1997.

Summary and Follow-up

Implementation of the five groundwater programs at MCB Camp Lejeune will enable contaminated groundwater to be monitored and tracked for the purposes of predicting future impact and thus protecting the groundwater drinking water supply. These measure will ensure that MCB Camp Lejeune workers, residents, and visitors will not be exposed to contaminated drinking water in the future.

Conclusions and Public Health Action Plan for Groundwater Contamination (Basewide)

Conclusions:

1. MCB Camp Lejeune has several programs in place to protect people from drinking contaminated groundwater. These programs will allow for detecting contamination before the on-base drinking water supply has been affected, thereby preventing exposure of people to contaminated drinking water. The base still complies with the Safe Drinking Water Standards monitoring program.

2. Groundwater contamination on base does not appear to pose a threat to the safety of off-base county and community water wells at this time. Groundwater contamination on base has not been found to have migrated off base. The typical groundwater flow direction would be toward the New River and the Atlantic Ocean and away from community wells.

Completed Actions:

1. MCB Camp Lejeune has identified on-base groundwater contamination. In some areas, contaminant plumes have been delineated.

2. MCB Camp Lejeune operates several groundwater treatment facilities to clean up groundwater contamination.

3. MCB Camp Lejeune monitors groundwater contamination caused by underground storage tanks and Installation Restoration Program sites to prevent on- or off-base water supplies from being adversely affected.

4. As a result of ATSDR's recommendations to routinely monitor individual supply wells to prevent contamination of water distribution systems and to protect people from exposure to contaminated drinking water, MCB Camp Lejeune implemented an annual program to monitor active supply wells in 1996. Six wells have been taken off line because of detected or potential contamination.

5. MCB Camp Lejeune will be implementing a Basewide Remediation Assessment of Groundwater Study to model the impact of groundwater treatment operations on regional groundwater.

6. MCB Camp Lejeune has initiated an Environmental Geographic Information System and will be implementing a Basewide Remediation Assessment of Groundwater Study to map and track sampling data of all monitoring and drinking water wells.

Planned Actions:

1. Investigations to define and characterize groundwater contamination at MCB Camp Lejeune are ongoing.

2. MCB Camp Lejeune is planning to drill additional wells to help supply the base with drinking water.

Recommended Action:

1. ATSDR has no further recommendations at this time.

B. Exposure from Eating Fish from Wallace Creek, Bear Head Creek, Cogdels Creek, Orde Pond, Everett Creek, and the New River near Sites 28, 69, and 48

Levels of contaminants detected in fish and shellfish from the previously specified locations on base were low and therefore do not present a health hazard to people (children, pregnant women or other adults) who eat them. ATSDR evaluated fish consumption based on an 8-ounce meal for adults and a 4-ounce meal for children. We assumed that people would eat no more than one meal per week of fish from these areas containing the maximum detected contaminant levels. Because these assumptions are conservative, they are protective of even the most sensitive fish consumers. Fishing is permitted at all these locations with a North Carolina state fishing license. For fishing at Orde Pond or any other on base pond, a MCB Camp Lejeune fishing permit is required.

Fish Contamination at Wallace and Bear Head Creeks (Sites 6, 9, and 82)

Site 6-Storage Lots 201 and 203, Site 9-Fire Fighting Training Pit at Piney Green Road, and Site 82-Piney Green Road VOC Site have all been identified as having soil and groundwater contamination that has most likely migrated to adjacent surface water bodies of Wallace Creek and Bear Head Creek. Both creeks are designated as Class SB surface waters by NCDEHNR. This ranking indicates that these creeks or rivers are suitable for fish and wildlife habitats; aesthetically pleasing; suitable for recreational boating and, in some places, for swimming. Fishing is a popular sport in the area; therefore, we are particularly concerned about fish contamination.

MCB Camp Lejeune sampled sediment, surface water, and fish from Wallace and Bear Head Creeks. TCE, PCE, and other VOCs; PAHs; pesticides; and PCBs were detected at low levels in sediment, surface water, and fish of Wallace Creek and Bear Head Creek and may be attributable to surface water and possibly groundwater discharge from Sites 6, Site 9, and Site 82 (OU 2), which are contaminated with pesticides, solvents, paints, and various types of construction debris (79). Fish collected by electroshock, seines, and lines were of edible size and species (except the gar) (30). Levels of contaminants in fish would not present a health hazard to people who eat the fish from this area.

Fish Contamination at Cogdels Creek, Orde Pond, and New River at Site 28

Site 28-Hadnot Point Burn Dump, was a 23-acre burn dump that operated from 1946 to 1971. Solid wastes, including mixed industrial waste, trash, oil-based paints, pesticides and other refuse, were brought to the dump to be burned in an open pit to reduce waste volume. When the site was closed in 1971, the ashes were covered with dirt brought in from other areas on base. The volume of fill dirt was estimated to be between 185,000 and 379,000 cubic yards (80). The ground was then graded and planted with grass (3). The site is currently known as Orde Pond Recreational Area, a park for base personnel, their families, and their guests. The park includes Orde Pond, a 3-acre fishing pond, a playground and picnic areas. Cogdels

Creek runs within the site and discharges into New River at Site 28 near the domestic wastewater treatment plant located adjacent to the park and environmental investigation area. Bluegill, sunfish, and bass were stocked in the pond (81). Only military employees, their dependents, and their guests are allowed to fish at the pond. The pond is used for recreational fishing and not subsistence fishing.

Soil, groundwater, surface water, sediments, and fish were collected from Site 28. Fish fillet and whole body fish were analyzed for a full range of chemicals Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. Sediment and fish samples from Cogdels Creek and Orde Pond contained slightly elevated levels of metals, PAHs, and pesticides. Fish samples collected from the New River were similarly analyzed and contained slightly elevated levels of pesticides, PAHs, and metals. Fish samples from Cogdels Creek, Orde Pond, and the New River at Site 28 did not contain any contaminant at levels of health concern.

Fish Contamination at Everett Creek and the New River at Site 69

Site 69-Rifle Range Chemical Dump is a 6-acre site in a heavily wooded area east of the intersection of Range Road and Sneads Ferry Road. From the early 1950s to 1976, all hazardous materials generated or used at the base were deposited here in unlined trenches or pits; at least 12 disposal events are documented for the site. Various pesticides, pentachlorophenol, TCE, gas cylinders, PCBs, chloroacetophenone gas, and numerous other hazardous materials were buried at this site. Everett Creek runs adjacent to Site 69 and into the New River approximately 500 feet from the site (82).

Soil, groundwater, surface water, sediments, fish, oysters, and blue crab were collected from Site 69. Shellfish (oysters and crab), fish fillet, and whole body fish were analyzed for a full range of chemicals (TCL organics and TAL inorganics). Sediment, fish, and shellfish samples from Everett Creek and the New River contained slightly elevated levels of metals, PAHs, and pesticides. Fish samples collected from the New River were similarly analyzed and contained slightly elevated levels of pesticides, PAHs, PCBs, and metals. However, none of the fish, oysters, or blue crab from either Everett Creek or the New River at Site 69 contained contaminants at levels that would pose a health hazard to people eating those fish or shellfish.

Fish Contamination at New River near Site 48

The Site 48 (OU 3) study area covers approximately 4 acres and contains three buildings, one of which was used as a photographic laboratory from 1955 to 1990. The site is bordered by the New River to the east, a tributary of the river to the north, building AS 811 to the south, and Longstaff Road to the west. Mercury from the lab was reportedly disposed of at the site (83).

MCB Camp Lejeune conducted Remedial Investigations of Site 48. Soil and groundwater samples were collected near the buildings. New River sampling included fish, sediment, and surface water. Soil and groundwater samples did not show any detectable mercury. However, sediment and surface water sampling data from the New River near Site 48 showed low levels of mercury, possibly indicating that mercury was disposed of in the river and not on the ground near the buildings. Three fish were collected from different locations in the river, but none were collected near the detected mercury. The fish showed low levels of pesticides, PAHs, VOCs, and metals (mercury levels were below health standards) and do not present a health hazard to people who would be eating them.

Summary and Follow-up

Using the maximum contaminant concentrations detected in fish to estimate exposures, ATSDR concluded that no adverse health effects, either cancerous or noncancerous, would be expected for people ingesting fish or shellfish from Wallace Creek, Bear Head Creek, Cogdels Creek, Everett Creek, and the New River near Sites 28, 48, and 69. Fish tissue samples taken from the creeks and river showed low levels of VOCs, PCBs, PAHs, metals, and pesticides at which adverse health effects are have not been reported. Therefore the sites currently pose no apparent public health hazard.

Conclusion and Public Health Action Plan for Exposure from Eating Fish from Wallace Creek, Bear Head Creek, Cogdels Creek, Everett Creek, and the New River near Sites 28, 69, and 48

Conclusion:

1. Contaminants detected at low levels in fish from Wallace Creek, Bear Head Creek, Cogdels Creek, Orde Pond, Everett Creek, and from New River adjacent to Sites 28, 69, and 48 are not expected to cause any adverse health effects (cancerous or noncancerous) in people who routinely eat fish from those creeks or the New River at these locations.

Completed Actions:

1. MCB Camp Lejeune has completed the Remedial Investigation and a Supplemental Aquatic Survey for Sites 6, 9, and 82 (Operable Unit 2), including detailed fish sampling results for Wallace and Bear Head Creeks.
2. MCB Camp Lejeune has completed the Remedial Investigation for Sites 28, 69, and 28.

Planned Action:

1. No additional actions are planned at this time.

Recommended Action:

1. ATSDR is not recommending any additional actions at this time.

C. Soil Contamination (Site 69)

Site 69-Rifle Range Chemical Dump is a 6-acre site in a heavily wooded area east of the intersection of Range Road and Sneads Ferry Road. From the early 1950s to 1976, hazardous materials generated or used at the base were deposited here in unlined trenches or pits; at least 12 disposal events are documented for the site. Various pesticides, pentachlorophenol, TCE, gas cylinders, PCBs, chloroacetophenone gas, and numerous other hazardous materials were buried at this site. The total amount of waste present on this site is estimated at 93,000 cubic yards; However, the waste was covered with clean fill dirt and the site is now fenced (85). It is unlikely that contaminated soil from Site 69 could migrate off-base because the contaminated soil is buried. However, contamination was detected in groundwater monitoring wells at the site. MCB Camp Lejeune is considering groundwater treatment actions at this time. An elementary school is located within 2 miles. Because exposure to soil is unlikely to occur at this site, MCB Camp Lejeune recommends that the soil remain in place.

Conclusion and Public Health Action Plan for Soil Contamination at Site 69

Conclusion:

1. The remote wooded location of the site, the fence prohibiting access, and the plans not to dig up soil prevent people from coming into contact with buried contamination.

Completed Action:

1. MCB Camp Lejeune installed a fence around this site to prevent exposures to contaminants.

Planned Action:

1. MCB Camp Lejeune is considering groundwater treatment operations to clean up contaminated groundwater and to protect base supply wells.

Recommended Action:

1. ATSDR does not recommend any further actions at this time.

IV. NO PUBLIC HEALTH HAZARD

ATSDR concluded that two other situations were not public health hazards they are: 1) suspected soil contamination at Site 28 and 2) physical hazards and possible soil contamination at Site 43.

A. Suspected Soil Contamination (Site 28)

Site 28-Orde Recreational Area was previously known as Site 28-Hadnot Point Burn Dump, a 23-acre burn dump that operated from 1946 to 1971. Solid wastes, including mixed industrial waste, trash, oil-based paints, pesticides, and other refuse, were brought to the dump to be burned in an open pit to reduce waste volume. When the site was closed in 1971, the ashes were covered with dirt brought in from other areas on base. The volume of fill dirt was estimated to be between 185,000 and 379,000 cubic yards (80). The ground was then graded and planted with grass (3).

Today, the area is a recreational park for base personnel, their families, and their guests. The park includes Orde Pond, a 3-acre fishing pond, and playground and picnic areas. The pond is not used for swimming and the steep bank prevents toddlers from playing in the sediments. Surface soil contamination in the recreational area is unlikely because of the amount of fill that covers the waste. MCB Camp Lejeune conducted surface soil sampling here that confirmed that contaminants were not at levels of health concern. Therefore, this area is safe for recreational purposes.

Conclusion and Public Health Action Plan for Suspected Soil Contamination at Site 28

Conclusion:

1. Site 28-Orde Pond Recreational Area does not pose a public health hazard because sampling data of surface soil of the playground area do not show contamination.

Completed Action:

1. MCB Camp Lejeune completed a Remedial Investigation for this site. The Record of Decision proposed that no further action be conducted at this site.

Planned Action:

None.

Recommended Action:

None.

B. Physical Hazards and Possible Soil Contamination (Site 43)

ATSDR had concerns that Site 43 presented both a physical hazard and a potential health hazard due to soil contamination. However, in 1996, MCB Camp Lejeune removed the above ground debris and contaminated surface soil at the site. Therefore, removing both the physical hazards and health hazards associated with contaminated soil exposure. Site 43 does not pose a physical or potential hazard because children in the adjacent housing area are not able to come in contact with potential hazards at the site because the hazards have been removed. MCB Camp Lejeune has issued a No Further Action Proposal for this site in the Record of Decision. ATSDR does not recommend any further action be taken by MCB Camp Lejeune.

Site 43-Agan Street Dump is located near the old wastewater treatment plant and covers an area of about 20 acres. Boards, trash, fiberglass, an old tank, and wastewater treatment plant sludge were disposed of on the ground surface. The years of operation are not known (85). Family housing units are approximately 500 feet from the site.

Conclusion and Public Health Action Plan for Physical and Possible Soil Contamination (Site 43)

Conclusion:

1. This site no longer poses a physical or chemical hazard to children walking onto the site from the nearby family housing area because MCB Camp Lejeune has removed the trash and various debris scattered in the woods and surface soil contamination at this site.

Completed Actions:

1. MCB Camp Lejeune has removed various debris and surface soil contamination from this site.
2. MCB Camp Lejeune has completed the Remedial Investigation for this site. The Record of Decision proposes that no further action be taken.

Planned Action:

None

Recommended Action:

None

COMMUNITY HEALTH CONCERNS EVALUATION

Several health concerns were raised by citizens living at or around MCB Camp Lejeune during one-on-one meetings with ATSDR staff or during meetings with MCB personnel.

1. Is the New River contaminated? Are fish from the river contaminated?

New River fish and shellfish tissue caught at several locations along the river contained low levels of chemical contaminants that currently present no apparent public health hazard. Low levels of pesticides, metals including mercury, PAHs, PCBs, and VOCs have been detected in river sediments or surface water at several locations that would not pose a health hazard to people who recreate on the river. Creeks and tributaries that flow into the New River typically contain higher concentrations of these contaminants. MCB Camp Lejeune has sampled areas along the New River that are near identified contaminated Installation Restoration Program sites. Results of each site's sampling appear in the specific report for each site. New River data has not been compiled in one document. ATSDR has evaluated all available chemical contaminant data for each site and presented our health evaluation in this public health assessment.

Although chemical contaminant data has been collected on the lower portion of the New River at MCB Camp Lejeune contaminated sites, ATSDR is still concerned that no group or agency routinely evaluates New River fish and shellfish for chemical contaminants. Multiple sources of chemical contaminants exit at MCB Camp Lejeune, and it is unknown whether contaminant levels are increasing or decreasing. Shellfish and fish can bioaccumulate and bioconcentrate contaminants present in the New River. Barely detectable levels of contaminants in water or sediment could present a public health hazard to people ingesting fish or shellfish. Certain contaminants build up in the food chain, accumulating in larger and larger amounts as small invertebrates are eaten by small fish, which in turn are eaten by large fish.

ATSDR will continue to discuss possible future sampling options with the NCDEHNR and other federal and local entities to ensure the protection of public health regarding ingestion of New River fish and shellfish.

ATSDR does not evaluate biological contamination that may come from sewage treatment or septic outfalls or discharge points. NCDEHNR Division of Water Quality evaluates biological contamination and issues permits for discharges and shellfish harvesting based on bacterial contaminant levels.

2. **A family who used to live on base at the time during which contaminated water was unknowing being used at Tarawa Terrace is concerned that adverse health effects could be or have been caused by swimming in the pool supplied by that water in addition to drinking the contaminated water.**

ATSDR reviewed the information available on the outdoor pool in question. Since the pool was located outside and filled no more frequently than once per month during the summer months, evaporation of the volatile organic compounds would have been rapid due to the warm temperature outside and turbulence of the water in the filling process. Additionally, because the pool was outdoors, the vapors were allowed to dissipate quickly into the air and not be trapped in the breathing zone of the swimmers. Therefore, swimming in the outdoor pool supplied with the contaminated water would not have increased the likelihood of any adverse health effects among any of the people exposed.

3. **One family reports that their children, who attended the day-care center at Site 2 (1966-1982), suffer from allergies. Could their current allergies be caused by their exposure to pesticides in the past?**

ATSDR researched the available scientific literature to determine if there is any correlation between pesticide exposure and general allergies. No link between pesticide exposure and general allergies was identified.

Exposure to the pesticides found at Site 2, DDT and chlordane, could possibly cause a subsequent allergic response to additional exposures to DDT or chlordane, but would not cause general allergies to other substances such as cats, dusts, or grasses. DDT and chlordane have not been used in the United States since the 1970s. If the child is no longer being exposed to DDT and chlordane, then the child would not be expected to currently have allergic responses. Moreover, one would not likely see a sustained reaction over the past 12 years since the time the day-care center was closed.

4. **Does groundwater contamination on base pose a threat to the safety of county and community water wells?**

No, not at this time. The closest off-base drinking water wells are one-half mile from the base boundary. We have not found that groundwater contamination on-base has moved off-base. In addition, public water wells are routinely tested to ensure safe drinking water.

ATSDR does recommend that MCB Camp Lejeune continue to test for groundwater contamination on base. If monitoring shows that the contaminated groundwater is moving toward on- or off-base drinking water supplies, measures should be taken to ensure that people do not come in contact with the contaminants. If the contaminated groundwater is moving toward areas where the groundwater use is unknown, we recommend that a thorough well survey be conducted of those areas. However, we do not think it is likely that off-base wells will become contaminated. The typical groundwater flow direction is

toward the regional waterways (creeks, the New River, and the Atlantic Ocean) and away from off-base wells.

MCB Camp Lejeune is cleaning up the groundwater near the Hadnot Point Industrial Area by pumping the water and treating it. Treating the water while it is inside the base should also reduce the possibility of groundwater contamination migrating off-base.

5. **In 1991, the following concern was raised. Would rashes and illnesses reported by workers while installing a fence around the Rifle Range Chemical Dump (Site 69) be attributable to exposure to hazardous chemicals?**

ATSDR cannot make a health determination about these cases because more specific information would be needed since there are so many causes of rashes (contact dermititis) and non-descriptive illnesses. However, because these employees were installing a fence, they probably had contact with surface and subsurface soil. Soil sampling has been conducted at this site. Subsurface contaminant concentrations of PCBs or other chemicals may be at levels that could have caused skin irritation. However, no long-term adverse health effects are likely to result from worker exposures that occurred while building a fence because that type of exposure would be for only a short period of time. Nonetheless, all workers should take precautions to wear personal protective clothing while working with contaminated media, as required by the Occupational Safety and Health Administration (OSHA).

6. **Are children attending an elementary school near the Rifle Range Chemical Dump (Site 69) being exposed to contaminants in the environment that will result in adverse health effects?**

It is unlikely that soil contaminants from Site 69 are migrating at this time because the wastes are buried. Also, the site is fenced. The school is located far enough away (2 miles) that dust from clean-up operations would not present a public health problem. However, ATSDR recommends that MCB Camp Lejeune use appropriate measures (e.g., dust control procedures and air monitoring) during any site cleanup.

7. **Officer wives were concerned about the number of miscarriages in their neighborhood and whether or not contaminants present in their housing area could be a contributing factor.**

ATSDR contacted the base hospital and state regarding the number of miscarriages in the officer housing area. The number of miscarriages identified in the housing area do not appear to be unusual for the age, educational level, and number of people as compared with the number for the state. Furthermore, no contaminants have been detected in the housing area. ATSDR put the officer wives in contact with the base hospital obstetrician to discuss their concerns.

8. **Officers' wives were concerned about small vials of white powder that their children found along the banks of the New River and brought home.**

The base environmental group send the vials to the laboratory to have the white powder analyzed. Results show the white powder to be calcium hypochlorite typically used to kill bacteria in drinking water. Although these glass vials are not currently in use and no one who was contacted had knowledge of the history or use of the vials, base personnel speculate that because the vials are so small that they may have been part of a personal survival kit used by marine trainees to treat (sterilize) water in the field.

9. **Could illnesses reported by two workers on Storage Lots 201 and 203 (Site 6) be related to exposure?**

We would need to have additional information before we could answer this question. In particular, we would need to know what types of illnesses these workers were reporting, the setting in which the illnesses occurred; the workers' occupations, ages, and sexes; and their clinical symptoms. Further, we would have to know the substances to which they were exposed. Without all this information, ATSDR cannot determine if any health problems that developed in the workers are attributable to exposures.

10. **What will be done with contaminated soils and water found on base when they are removed from the base?**

Remedial investigations are still under way for some of the sites on the base. These investigations must be complete before a decision is made on what will be done with contaminated soils and materials. Federal and state agencies will consider alternative clean-up plans and will ask the public for its opinion on them.

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APPENDICES

APPENDIX A - Abbreviations and Acronyms

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ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DCE	dichloroethylene
DDD	dichlorodiphenyldichlorethane
DDE	dichlorodiphenyldichlorethylene
DDT	dichlorodiphenyltrichlorethane
DOD	Department of Defense
dL	deciliter
EPA	US Environmental Protection Agency
HOD	health outcome data
IRP	Installation Restoration Program
kg	kilogram
L	liter
m	meter(s)
MBW	mean birthweight
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
μg	microgram
mg	milligram
mL	milliliter
mm	millimeter
NACIP	Navy Assessment and Control of Installation Pollutants
NCDEHNR	North Carolina Department of Environment, Health, and Natural Resources
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OU	Operable Unit
PAHs	polyaromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PHA	public health assessment
ppb	parts per billion
ppm	parts per million
RA	remedial action(s)
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act (1986)
SGA	small for gestational age
SVOCs	semi-volatile organic compounds
TAL	Target Analyte List
TCE	trichloroethylene
TCL	Target Compound List
THMs	trihalomethanes
USGS	US Geological Survey
VOCs	volatile organic compounds

APPENDIX B - Site-Specific Background Information

APPENDIX B-1
List of MCB Camp Lejeune's Initial Assessment Sites

1 French Creek Liquids Disposal Area
2 Former Nursery/Day Care Center
3 Old Creosote Plant
4 Sawmill Road Construction Debris Dump
5 Piney Green Road
6 Storage Lots 201 and 203
7 Tarawa Terrace Dump
8 Flammable Storage Warehouse, Building TP-451 and TP-452
9 Fire Fighting Training Pit at Piney Green Road
10 Original Base Dump
11 Pest Control Shop
12 Explosive Ordnance Demolition (EOD)--G-4
13 Golf Course Construction Dump Site
14 Knox Area Rip-Rap
15 Montford Point Dump Site (1948-1958)
16 Montford Point Burn Dump (1958-1972)
17 Montford Point Area Rip-Rap
18 Watkins Village (E) Site
19 Naval Research Lab Dump
20 Naval Research Lab Incinerator Transformer Storage Lot 140
22 Industrial Area Tank Farm
23 Roads and Grounds, Building 1105
24 Industrial Area Fly Ash Dump
25 Base Incinerator
26 Coal Storage Area
27 Naval Hospital Area Rip-Rap
28 Hadnot Point Burn Dump
29 Base Sanitary Landfill
30 Sneads Ferry Road-Fuel Tank Sludge Area
31 Engineering Stockade-G4 Rang Road
32 French Creek
33 Onslow Beach Road
34 Ocean Drive
35 Camp Geiger Area Fuel Farm
36 Camp Geiger Area Dump Near Sewage Treatment Plant
37 Camp Geiger Area Surface Dump
38 Camp Geiger Construction Dump
39 Camp Geiger Construction Slab Dump
40 Camp Geiger Area Borrow Pit
41 Camp Geiger Dump Near Former Trailer Park
42 Building 705, BOQ Dump
43 Agan Street Dump
44 Jones Street Dump
45 MCAS JP Fuel Farm and Rapid Refuel Area
46 MCAS Main Gate Dump
47 MCAS Rip-Rap Near Stick Creek
46 MCAS Main Gate Dump
47 MCAS Rip-Rap Near Stick Creek
48 MCAS Mercury Dump Site
49 MCAS Suspected Minor Dump
50 MCAS Small-Craft Berthing Rip-Rap
51 MCAS Football Field
52 MCAS Direct Refuel Depot
53 MCAS Warehouse Building 3525 Area (Oiled Roads)
54 Crash Crew Fire Training Burn Pit
55 Air Station East Perimeter Dump
56 MCAS Oiled Roads to Marina
57 Runway 36 Dump
58 MCAS Tank Training Area
59 MCAS Infantry Training Area
60 EOD K-326 Range
61 Rhodes Point Road Dump
62 Race Course Area Dump
63 Vernon Road Dump
64 Marines Road-Sneads Ferry Road MOGAS Spill
64 Engineer Area Dump
66 AMTRAC Landing Site and Storage Area
67 Engineers TNT Burn Site
68 Rifle Range Dump
69 Rifle Range Chemical Dump
70 Oak Grove Field-Surface Dump
71 Oak Grove Buried Dump
72 Oak Grove Coal Pile
73 Courthouse Bay Liquids Disposal Area
74 Mess Hall Grease Pit Area
75 MCAS Basketball Court Site
76 MCAS Curtis Road Site
A MCAS Officers' Housing Area

APPENDIX B-2
Summary of Site Evaluations

Highlighted sites are Health Priority Sites discussed further in this public health assessment

Operable Unit	Site Number	Site Name	Contaminated Media[1]					Evaluations
			Ground water	Soil	Surface Water	Sediment	Food Chain	
OU-1	21	Transformer Storage Lot 140	•	•	NA[2]	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Because no one is coming in contact with contaminated media, ATSDR determined that it does not currently pose a health hazard.
	24	Industrial Area Fly Ash Dump	•	NA	•	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Because no one is coming in contact with contaminated media, ATSDR determined that it does not currently pose a health hazard.
	78	Hadnot Point Industrial Area	•	•	NA	NA	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Because no one is coming in contact with contaminated media, ATSDR determined that it does not currently pose a health hazard. This site was not originally included in the 22 priority site, but was subsequently added to OU-1.
OU-2	6	Storage Lots 201 and 203	•	•	•	•	•[2]	Low levels of contamination detected in fish (food chain) from Wallace and Bearhead Creeks present no apparent public health hazard to people who would eat them. No one is coming in contact with contaminated soil at this site.
	9	Fire Fighting Training Pit at Piney Green Road	•	NA	•[2]	•[2]	•[2]	Low levels of contamination detected in fish (food chain) from Wallace and Bearhead Creeks present no apparent public health hazard to people who would eat them. No one is coming in contact with contaminated soil at this site.
	82	Piney Green Road VOC Site	•[2]	•[2]	•[2]	•[2]	•[2]	Low levels of contamination detected in fish (food chain) from Wallace and Bearhead Creeks present no apparent public health hazard to people who would eat them. No one is coming in contact with contaminated soil at this site.
OU-3	48	MCAS Mercury Dump Site	•	•	•	•	ND[3]	Low level mercury contamination in sediments and surface water in New River near this site. However, limited fish sampling did not detect mercury at levels of health concern. Therefore it poses not apparent public health hazard. MCB, Camp Lejeune has issued a Record of Decision for No Further Action. NCDEHNR will conduct additional fish sampling north of this area in the New River to determine current contaminant levels in fish.
OU-4	41	Camp Geiger Dump Near Former Trailer Park	•	NA	•	•	NA	No one is coming in contact with sediments or soil at this site since the trailer park has been closed.
	74	Mess Hall Grease Pit Disposal Area	•	•	NA	NA	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. No one is coming in contact with sediments or soil at this site.
OU-5	2	Former Nursery/Day Care Center	•	•	•	•	NA	Past human exposure to contaminated soil at this site is categorized as a past public health hazard. A Time Critical Removal Action was issued and contaminated soil was removed. This site currently poses no health hazard. However, people exposed in the past may have a slight increased risk of developing cancer in their lifetime.

Food Chain are considered plants and animals which are food sources for humans. Fish and shellfish are considered food chain entities.

Summary of Site Evaluations (Continued)

Operable Unit	Site Number	Site Name	Contaminated Media[1]					Evaluations
			Ground water	Soil	Surface Water	Sediment	Food Chain	
OU-6	36	Camp Geiger Area Dump	•	•	•	•	•	Mercury levels in largemouth bass taken from Brinson Creek near this site may pose a public health hazard for women and children. NCDEHNR will conduct additional confirmatory sampling before issuing a fish advisory or public education. ATSDR will work in coordination with NCDEHNR to protect public health.
	43	Agan Street Dump	•	•[4]	ND	•	NA	Physical hazards and soil contamination are no longer a public health concern because the base conducted a removal action of the debris and surface soil contamination. Samples of surface water runoff did not contain contamination. This site was not originally included in the 22 priority sites, but was subsequently added to OU-6.
	44	Jones Street Dump	•	•	•	•		Portion of the site is fenced limiting access to the most contaminated areas.
	54	Crash Crew Fire Training Burn Pit	•	•	ND	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Institutional controls restriction use as written in the Base Master Plan of the shallow and Castle Hayne Aquifer. Additionally, no one is coming in contact with sediments or soil at this site.
	86	MCAS Tank Area AS 419 - AS 422	•	•	NA	NA	NA	*This site contained numerous above ground storage tanks which were emptied in 1988 and removed in 1992. Access to this area by non-authorized people is unlikely.*
OU-7	1	French Creek Liquids Disposal Area	•	NA	•	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Long-term groundwater monitoring and deed restrictions for land use will prevent people from contacting site contaminants.
	28	Hadnot Point Burn Dump	•	NA	•	•	ND[6]	Low levels of contaminants have been detected in surface water, sediments, and fish samples taken from Orde Pond, Cogdells Creek, and the New River. Levels of contaminants currently pose no apparent public health hazard. Soil at the recreational area did not contain contaminants of health concern probably due to the tremendous volume of clean fill covering the site.
	30	Sneads Ferry Road-Fuel Tank Sludge Area	•	•	•	•	•	Groundwater contamination at this site is being monitored and tracked under several base programs. *MCB, Camp Lejeune has issued a Record of Decision for No Futher Action at this site.*
OU-8	16	Montford Point Burn Dump (1958-1972)	•	•	•	•	NA	This site was not originally included in the 22 priority sites, but was subsequently added to OU-8. Contaminants detected in sediments and surface water; however, no fish from Northeast Creek were sampled. Although MCB, Camp Lejeune has proposed this site for No Further Action in their ROD, ATSDR recommends that fish sampling be conducted in Northeast Creek. NCDEHNR will be conducting fish sampling to determine if eating the fish pose a public health hazard. Sampling is proposed for late July 1997.
OU-9	65	Engineer Area Dump	•	•	•	•	•	This site contained two disposal areas used from before 1958 until 1972. One area was used for disposal of battery acid, the other for waste petroleum products and perhaps to burn construction debris. Two small recreational ponds are on the site. Sampling results of fish, surface water, and sediment show that contaminats have not impacted these ponds. The site is proposed for No Further Action.
	73	Courthouse Bay Liquids Disposal Area Amphibious Vehicle Maintenance Facility	•	NA	ND	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs and therefore do not pose a public health hazard.

Summary of Site Evaluations (Continued)

Operable Unit	Site Number	Site Name	Contaminated Media[1]					Evaluations
			Ground water	Soil	Surface Water	Sediment	Food Chain	
OU-10	35	Camp Geiger Area Fuel Farm	•	•	•	•	•	Mercury levels in largemouth bass taken from Brinson Creek near this site may pose a public health hazard for women and children. NCDEHNR will conduct additional confirmatory sampling before issuing a fish advisory or public health message. ATSDR will work in coordination with NCDEHNR to protect public health.
OU-11	7	Tarawa Terrace Dump	•	•	•	•	NA	This site was not originally included in the 22 priority sites, but was subsequently added to OU-11. Contaminants detected in sediments and surface water; however, no fish from Northeast Creek were sampled. Although MCB, Camp Lejeune has proposed this site for No Further Action, ATSDR recommends that fish sampling be conducted in Northeast Creek.
	80	Paradise Point Golf Course Pesticide Area	•	•	•	•	NA	This site was not originally included in the 22 priority sites, but was subsequently added to OU-11. Contaminants detected in sediments and surface water; however, no fish from Northeast Creek were sampled. Although MCB, Camp Lejeune has proposed this site for No Further Action, ATSDR recommends that fish sampling be conducted in Northeast Creek.
OU-12	3	Old Creosote Plant	•	•	NA	NA	NA	This site was not originally included in the 22 priority sites, but was subsequently added to OU-12. MCB, Camp Lejeune has issued a Record of Decision for this site for soil, source removal and compositing, for groundwater, institutional controls and monitoring are listed.
OU-13	63	Vernone Loop Road Dump	•	•	ND	•	NA	This site was not originally included in the 22 priority sites, but was subsequently added to OU-13.
OU-14	69	Rifle Range Chemical Dump	•	NA	•	•	NA	Groundwater contamination at this site is being monitored and tracked under several base programs. Surface water runs to the New River which is recreationally and commercially fished. Levels of contaminants in fish currently do not pose a public health hazard. No one is coming in contact with sediments or soil at this site. A fence surrounding the site was installed in 1993.
OU-15	88	Base Dry Cleaners	•	•	NA	NA	NA	This site was added to the Installation Restoration Program when chlorinated solvents were discovered in tanks thought to only hold petroleum products. The tanks were removed in 1995 as well as 120 tons of contaminated soil. The extent of contamination at this site is still being invvestigated. However, people are not likely to be exposed to below ground contamination.
OU-16	89	STC-868 (underground storage tank)	•	•	•	NA	NA	The underground storage tank was installed in 1983 and removed in 1993 due to petroleum releases and chlorinated solvents found in the groundwater. This site may be a contributor to contamination of Edwards Creek along with site 93. Investigations are still being conducted. ATSDR recommends that fish of edible species and size be analyzed in Edwards Creek as part of the investigation.
	93	TC-942 (underground storage tank)	•	•	•	NA	NA	The underground storage tank was removed in 1993 due to petroleum releases and chlorinated solvents found in the groundwater. This site may be a contributor to contamination of Edwards Creek along with site 89. Investigations are still being conducted. ATSDR recommends that fish of edible species and size be analyzed in Edwards Creek as part of the investigation.
OU-17	90	BB-9	•	•	NA	NA	NA	This site is a former underground storage tank site that was turned over to the IR Program when groundwater was found to be contaminated. The tanks were removed in 1992-1994 timeframe. This site is under initial investigation phase. People are unlikely to be exposed to underground contaminants present at this site.
	91	BB-51	•	•	NA	NA	NA	This site is a former underground storage tank site that was turned over to the IR Program when groundwater was found to be contaminated. The tanks were removed in 1992-1994 timeframe. This site is under initial investigation phase. People are unlikely to be exposed to underground contaminants present at this site.
	92	BB-46	•	•	NA	NA	NA	This site is a former underground storage tank site that was turned over to the IR Program when groundwater was found to be contaminated. The tanks were removed in 1992-1994 timeframe. This site is under initial investigation phase. People are unlikely to be exposed to underground contaminants present at this site.
OU-18	94	Building 1613 Hadnot Point PCX Gas Station	•	•	NA	NA	NA	This site is a former gas station containing underground storage tanks that was turned over to the IR Program when groundwater was found to be contaminated. The tanks were removed in 1995. This site is under initial investigation phase. People are unlikely to be exposed to underground contaminants present at this site.

Summary of Site Evaluations (Continued)

Operable Unit	Site Number	Site Name	Contaminated Media[1]					Evaluations
			Ground water	Soil	Surface Water	Sediment	Food Chain	
-	22	Industrial Area Tank Farm	•	NA	NA	NA	NA	This site was included in the original 22 priority sites. A separate investigation of Hadnot Point Industrial Area was conducted. Therefore, this site is not is not included in the Operable Unit Installation Restoration Program. Groundwater contamination (benzene, etc) was detected in base drinking water supply well 602. That well has not been used since 1984. Groundwater contamination at this site is being monitored and tracked under several base programs.
-	45	Campbell Street Underground Fuel Storage Area	•	NA	•	•	NA	This site was included in the original 22 priority sites. Groundwater, surface water, and sediment contamination at this site is being monitored and tracked under several base programs. contribute to ATSDR's overall concern for potential human health hazards. ATSDR is requesting additional information regarding the follow-up activities at this site and the rationale for this site's exclusion from the IRP.
-	68	Rifle Range Dump	ND	NA	NA	NA	NA	This site was included in the original 22 priority sites. No contamination was detected in the groundwater at this site indicating that contamination has not migrated from the landfill. Groundwater well monitoring would ensure that this site is not contributing to the base wide groundwater contamination. No further investigations or clean-up activities were recommended in the 1990 Site Summary Report.
-	75	MCAS Basketball Court Site	ND	NA	NA	NA	NA	This site was included in the original 22 priority sites. No contamination was detected in the groundwater at this site indicating that contamination has not migrated from the site. The geophysical survey, did not detect the presence of any buried objects. No further investigations or clean-up activities were recommended in the 1990 Site Summary Report.
-	76	MCAS Curtis Road Site	ND	NA	NA	NA	NA	This site was included in the original 22 priority sites. No contamination was detected in the groundwater at this site indicating that contamination has not migrated from the site. The geophysical survey, did not detect the presence of any buried objects. No further investigations or clean-up activities were recommended in the 1990 Site Summary Report.
-	A	MCAS (H) Officers' Housing Area	ND	NA	ND	ND	NA	This site was included in the original 22 priority sites. No contamination was detected in the groundwater or surface water at this site indicating that contamination has not migrated from the site. No further investigations or clean-up activities were recommended in the 1990 Site Summary Report.

1 - Contaminated Media as documented in Site Summary Report, September 1990
2 - Contamination as documented in the Remedial Investigation Report for Operable Unit 2, June 1993.
3 - Contamination not detected as reported in the Status of Installation Restoration Program Activities at Marine Corps Base, Camp Lejeune North Carolina, June 18, 1993.
4 - Information obtained during ATSDR site visit October 1993.
5 - Preliminary Fish Sampling Data received from MCB Camp Lejeune January 1994.

NA - "Not Analyzed", medium not sampled
ND - "Not Detected" medium sampled, contamination was not detected
• - documented contamination in that medium
☐ - ATSDR has requested information regarding these sites, but has not yet received that information.

Sites 22,45,68,75,76, and A were included in the original 22 priority sites, but are not included in the current Installation Restoration Program.
Sites 78,82,43,86,16,65,7,80,3, and 63 were not originally part of the 22 priority sites, but were subsequently added to the IRP for further investigation.

APPENDIX C - Public Health Assessment Conclusion Categories

APPENDIX C - ATSDR Public Health Assessment Conclusion Categories

Category	Definition	Criteria
A. Urgent public health hazard	This category is used for sites that pose an urgent public health hazard as the result of short-term exposures to hazardous substances.	• evidence exists that exposures have occurred, are occurring, or are likely to occur in the future AND • estimated exposures are to a substance(s) at concentrations in the environment that, upon short-term exposures, can cause adverse health effects to any segment of the receptor population AND/OR • community-specific health outcome data indicate that the site has had an adverse impact on human health that requires rapid intervention AND/OR • physical hazards at the site pose an imminent risk of physical injury
B. Public health hazard	This category is used for sites that pose a public health hazard as the result of long-term exposures to hazardous substances.	• evidence exists that exposures have occurred, are occurring, or are likely to occur in the future AND • estimated exposures are to a substance(s) at concentrations in the environment that, upon long-term exposures, can cause adverse health effects to any segment of the receptor population AND/OR • community-specific health outcome data indicate that the site has had an adverse impact on human health that requires intervention
C. Indeterminate (potential) public health hazard	This category is used for sites with incomplete information.	• limited available data do not indicate that humans are being or have been exposed to levels of contamination that would be expected to cause adverse health effects; data or information are not available for all environmental media to which humans may be exposed AND • there are insufficient or no community-specific health outcome data to indicate that the site has had an adverse impact on human health
D. No apparent public health hazard	This category is used for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.	• exposures do not exceed an ATSDR chronic MRL or other comparable value AND • data are available for all environmental media to which humans are being exposed AND • there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health
E. No public health hazard	This category is used for sites that do not pose a public health hazard.	• no evidence of current or past human exposure to contaminated media AND • future exposures to contaminated media are not likely to occur AND • there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health

APPENDIX D - LEAD INFORMATION

APPENDIX D

Educational Lead Flyer

Lead in Drinking Water

We now have sampling results from buildings at Camp Lejeune using the medium-sized water distribution systems; Hadnot Point, Holcomb Boulevard, and Marine Corps Air Station - New River and the small-sized water distribution systems; Courthouse Bay, Rifle Range, and Onslow Beach. These results indicated that many of the buildings on base have lead levels above the Environmental Protection Agency's (EPA) action level of 15 parts per billion (ppb). The results from the buildings sampled ranged from < 2 ppb to 10,000 ppb. Although many of the buildings had elevated lead levels, the lead levels in 60 single family homes tested in Tarawa Terrace neighborhoods were not elevated. Schools and day care facilities also did not have elevated levels of lead in drinking water.

Lead can get into drinking water several different ways including; corrosion of lead piping, lead-based solder, and brass water faucets. Lead is not naturally present in the local groundwater. Currently, we are working with the State of North Carolina to reduce the amount of lead that gets into drinking water. Additionally, plans are now in place to replace piping in several of the affected buildings.

The following pages provide information on the health effects of lead exposure, ways to reduce your exposure, and the available blood lead screening test. It also lists organizations you can call for more information.

How might I be exposed to lead in drinking water?

The major contributors of lead in drinking water come from lead-containing brass fixtures and pipe solder, which are commonly used in public buildings, schools, and homes. In some areas lead is also naturally present at low levels in groundwater, which may be used for drinking water. Additionally, tea and coffee made with tap water containing lead may have an increased lead concentration due to evaporation of the water, particularly if the coffee or tea sits on a hot plate.

How can lead affect my health?

Studies on lead's health effects are based on blood lead levels (μg/dL, micrograms per deciliter), not the amount of lead detected in water or some other medium. The health effects of lead are not immediately apparent. Some health effects may not produce noticeable signs or symptoms such as decreased IQ or mild behavioral disorders which can occur when blood lead levels are $\leq$ 10 μg/dL in children. Lead is not readily eliminated from the body, but is stored in the bones and teeth. Exposure to high levels of lead can badly damage the brain, red blood cells, and kidneys of adults (40 - 100 μg/dL) and children (35 - 50 μg/dL). Acute effects of exposure to high lead levels are nausea, vomiting, and headache. Lead exposure in adults may increase blood pressure. High levels of blood lead (40 μg/dL) may affect sperm or damage other parts of the male reproductive system making it difficult for a couple to have children.

Unborn babies and children are especially sensitive to the effects of lead. If a pregnant woman is exposed to lead, it can be carried to the unborn child and is associated with premature birth, low birth weight, and decreased mental ability. In infants and young children, lead exposure has been shown to decrease intelligence (IQ) scores, slow their growth, and cause hearing problems in children with blood lead levels $\leq$ 10 μg/dL. These effects can last as children get older and interfere with successful performance in school.

What are some factors that can influence lead's effects?

The amount of lead you absorb can not be directly correlated with the amount in drinking water due to several factors. These factors include the dose (how much lead is in your body), the duration (how long you were exposed), and your individual characteristics such as age, sex, nutritional status, life style, and overall state of health and they influence the type and severity of harmful health effects.

Age is a key factor. Children and unborn infants are more sensitive to the harmful effects of lead. Nutrition also plays a role in how much lead is absorbed by the body. If a person doesn't have a well-balanced diet rich in iron and calcium, more lead will be absorbed. The consumption of alcoholic beverages also increases the amount of lead absorbed. Tobacco use causes an increase in blood lead levels partly because tobacco products contain lead.

What are other sources of lead exposure?

You can also be exposed to lead and lead compounds from breathing air, and eating soil and foods that contain lead. Breathing air with dust that contains lead or swallowing lead-containing soils that might be found near areas with heavy automobile traffic are also sources of exposure.

Adults may also be exposed to lead through occupational exposure which may occur through plumbing work where lead-base solder and brass fixtures are used. Other sources of occupational lead exposure may be from automobile or mechanical repair operations, battery or radiator reclamation, electronics work, welding, lead-based paints, and lead-containing sheet metal work. Certain hobbies may also contribute to your lead exposure such as ceramics, artisan painting, stained glass, and furniture refinishing.

Children may be exposed to lead by swallowing nonfood items such as chips of lead-containing paint. Children who put toys, other items, or their hands in their mouths may also swallow lead if lead-containing dust and dirt are on these.

How can I reduce my exposure to lead in drinking water?

Short-term remedies you can take individually to reduce the lead concentrations in your drinking water and thus your exposure to lead are included below. You cannot see, taste, or smell lead in your drinking water, so it is important to perform these precautionary steps.

1) Let the water run from the tap for 30 seconds to 2 minutes before using it for drinking or cooking. The longer water stays in a building's pipes, the more lead it may contain. Water that has sat in the pipes for more than four hours should be flushed for 3 to 5 minutes: for example, first thing in the morning and when you arrive home in the evening. A good indication of when to stop flushing the cold water tap is when the water becomes noticeably colder.

2) Use cold water even for cooking or making infant formula because water from the hot water tap dissolves lead more quickly.

If a water sampling test for lead indicates that your tap water at home or at work contains lead in excess of 15 ppb even after flushing, then you may want to consider taking the following additional measures.

1) You may chose to use bottled water instead of tap water for drinking or cooking purposes.

2) You may chose to use a water purification system. Purification systems range in size and cost from the water pitcher filtration systems to entire home-sized purification systems.

Is there a medical test to determine if I have been exposed to lead?

If you are concerned about your blood lead levels either because of the lead levels in your drinking water or other possible lead exposure sources, there is a simple medical test available to screen for blood lead levels.

What recommendations has the federal government made to protect human health?

In 1991, EPA issued the Final Lead and Copper Rule. The primary purpose of this rule is to protect public water supply users from chemical contamination produced by corrosion of drinking water piping systems. The rule establishes threshold levels for lead and copper measured at consumer water taps.

EPA recommends that drinking water contain less than 15 ppb. If lead levels exceed 15 ppb, further sampling is required at the tap and at the source to confirm elevated lead levels. Recommendations for water treatment to reduce the lead at the tap are required to be submitted to the state for approval.

How can I get more information?

To find more about the health effects of lead or to have a blood lead test contact:

Naval Hospital Camp Lejeune
Occupational Health and Preventive Medicine Department
Camp Lejeune, North Carolina
451-5707

For general information on lead exposure contact:

Dr. Fredric Rosenberg
Agency for Toxic Substance and Disease Registry
1600 Clifton Road
Atlanta, Georgia 30333
404-639-6215

For general information on lead in drinking water contact:

U.S. Environmental Protection Agency
Office of Water
Safe Drinking Water Hotline
1-800-426-4791
Monday - Friday, 8:30 am to 5:00 pm EST.

For written information, call 1-800-LEAD-FYI (1-800-532-3394) and leave your name and mailing address.

APPENDIX E - Exposure Specific Estimates

APPENDIX E-1

APPENDI

VOC Exposure Estimates

Chemical	Maximum Concentration (ppm)	Ingestion Rate Child (L/day)	Ingestion Rate Adult (L/day)	Exposure Factor	Estimated Dose Child (mg/kg/day)	Estimated Dose Adult (mg/kg/day)	Cancer Slope Factor (1/[mg/kg/day])	Exposure Duration	Cancer Risk Adult
Hadnot Point (1982-1985)									
TCE	1.4	1	2	0.57	0.099750	0.045600	0.011	0.043	2.16E-05
DCE	0.4	1	2	0.57	0.028500	0.013029	0.091	0.043	5.10E-05
Methylene Chloride	0.054	1	2	0.57	0.003848	0.001759	0.0075	0.043	5.67E-07
Vinyl Chloride	0.003	1	2	0.57	0.000214	0.000098	N/A	-	-
Tarawa Terrace (1982-1985)									
PCE	0.215	1	2	0.57	0.015319	0.007003	0.052	0.043	1.57E-05
TCE	0.008	1	2	0.57	0.000570	0.000261	0.011	0.043	1.23E-07
DCE	0.012	1	2	0.57	0.000855	0.000391	0.091	0.043	1.53E-06
Holcomb Blvd (1985)									
TCE	1.15	1	2	0.57	0.081937	0.037457	0.011	0.014	5.77E-06
DCE	0.407	1	2	0.57	0.028999	0.013257	0.091	0.014	1.69E-05

N/A = Not Available

Assumptions:

Body Weight
child = 16 kilograms
adult = 70 kilograms

Exposure Factor (unitless)
4 out of 7 days per week

Exposure Duration (unitless)
3 out of 70 years (Hadnot Pt. and Tarawa Terrace)
1 year out of 70 years (Holcomb Blvd)

Where: $\frac{\text{Max Conc} \times \text{Ing Rate} \times \text{Exp Fac}}{\text{Body Weight}}$ = Est Dose x Cancer Slope x Exp Duration = Cancer Risk (cancer risk is based on a lifetime exposure of 70 years)

APPENDIX E-2

Pesticide Exposure Estimates for Site 2

Chemical	Maximum Concentration Detected (ppm)	Ingestion Rates: Pica Child (mg/day)	Ingestion Rates: Non-Pica Child (mg/day)	Ingestion Rates: Adult (mg/day)	Exposure Factor	Estimated Dose: Pica Child (mg/kg/day)	Estimated Dose: Non-Pica Child (mg/kg/day)	Estimated Dose: Adult (mg/kg/day)	Cancer Slope Factor (1/[mg/kg/day])	Exposure Duration	Cancer Risk: Adult
Parking Lot (1989-1993)											
Chlordane	0.31	n/a	n/a	100	1	n/a	n/a	0.000000	1.3	0.122	7.02E-08
DDD	1200	n/a	n/a	100	1	n/a	n/a	0.001714	0.24	0.122	5.02E-05
DDE	30	n/a	n/a	100	1	n/a	n/a	0.000043	0.34	0.122	1.78E-06
DDT	930	n/a	n/a	100	1	n/a	n/a	0.001329	0.34	0.122	5.51E-05
Lawn (1989-1993)											
Chlordane	7.4	n/a	n/a	200	0.045	n/a	n/a	0.000001	1.3	0.057	7.05E-08
DDD	1200	n/a	n/a	200	0.045	n/a	n/a	0.000154	0.24	0.057	2.11E-06
DDE	30	n/a	n/a	200	0.045	n/a	n/a	0.000004	0.34	0.057	7.48E-08
DDT	3000	n/a	n/a	200	0.045	n/a	n/a	0.000386	0.34	0.057	7.48E-06
Parking Lot (1966-1982)											
Chlordane	45.7	n/a	100	100	1	n/a	0.000286	0.000065	1.3	0.071	6.03E-06
DDD	644	n/a	100	100	1	n/a	0.004025	0.000920	0.24	0.071	1.57E-05
DDE	68.7	n/a	100	100	1	n/a	0.000429	0.000098	0.34	0.071	2.37E-06
DDT	7500	n/a	100	100	1	n/a	0.046875	0.010714	0.34	0.071	2.59E-04
Playground (1966-1982)											
Chlordane	0.39	5000	200	n/a	1	0.000122	0.000005	n/a	1.3	0.071	n/a
DDT	6.7	5000	200	n/a	1	0.002094	0.000084	n/a	0.34	0.071	n/a

n/a = not applicable

Assumptions:

Body Weight
child = 16 kilograms
adult = 70 kilograms

Exposure Factor (unitless)
1 days per week for 16 weeks (Lawncare workers)
default of 1 (All others)

Exposure Duration (unitless)
4 years out of 70 years (Lawncare and office workers)
5 years out of 70 years (Day care workers and attendees)

Where: $\frac{\text{Max Conc} \times \text{Ing Rate} \times \text{Exp Fac}}{\text{Body Weight}}$ = Est Dose x Cancer Slope x Exp Duration = Cancer Risk (cancer risk is based on a lifetime exposure of 70 years)