The History and Health Consequences of the Arsenic Contamination in and Around the CMC Heartland Lite Yard Site in South Minneapolis

Prepared by
Sing-Wei-Ho
Graduate Research Assistant, University of Minnesota
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Neighborhood Planning for Community Revitalization
330 Hubert H. Humphrey Center
301 - 19th Avenue South
Minneapolis, MN 55455
phone: 612/625-1020
e-mail: ksn@umn.edu
website: http://www.npcr.org/

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by
Sing-Wei Ho
Graduate Research Assistant
Neighborhood Planning for Community Revitalization
Center for Urban and Regional Affairs
University of Minnesota
Minneapolis, MN

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Executive Summary

The Phillips neighborhood of south Minneapolis has dealt with numerous environmental pollutants in the last few decades. Arsenic is the latest contaminant to be added to this burden. This paper examined the issue of arsenic contamination in soil and groundwater in Phillips and surrounding communities by explaining the context of location, identifying potential health effects, summarizing the history of this contamination, and identifying options for community involvement.

Due to the proximity of arsenic-contaminated soils at a former pesticide manufacturing plant to residential areas of east Phillips, government agencies sampled soils in approximately 500 residential yards to determine the spread and scope of the contamination. From these surveys, many residential yards were found to contain moderate (chronic, 30-95 mg/kg) levels of arsenic while a smaller percentage was found to contain very high (acute, >95 mg/kg) levels of arsenic. The potentially adverse human health effects related to these arsenic levels over a long or short period of time, respectively, were identified as peripheral vascular and nervous disorders, skin lesions, gastrointestinal irritation, and cancers of the skin, lung, bladder, and liver. The approximately 30 residential yards found to be highly contaminated were immediately excavated. These findings also prompted the federal government to expand the investigation to include other neighboring communities and perform more soil samplings.

Citizens in the area are encouraged to take precautions to minimize arsenic exposure and get involved with community leaders to help raise awareness and ensure quality of remediation.

Introduction

Because the Phillips neighborhood of Minneapolis is an economically disadvantaged and ethnically diverse community (see Table 1), the numerous environmental contamination issues need to be recognized as an environmental justice issue. Like many communities experiencing economic hardship, the priorities of its residents lie not with environmental pollutants, but with housing, food, clothing, violence, and employment (Jordan, Lee, & Shapiro, 2000). According to the 2000 census, there were 19,805 residents living in the Phillips community at an average density of about 13,000 persons/mi^2 (Minneapolis Planning Department, Research and Strategic Planning Division, 2001). The median family income in Phillips was $27,136, with 31.3% of families living in poverty. Although the community has shown a reduction in the number of persons living in poverty, from seven tracts with highest concentration of poverty in 1990 falling to only two tracts at the highest level in 2000, Phillips is still an "at risk" community in terms of poverty, housing conditions, morbidity and mortality, and single-parent households (Department of Community Planning and Economic Development - Planning Division, 2003).

Table 1. Characteristics of the Phillips neighborhood (2001)
(Minneapolis Planning Department, Research and Strategic Planning Division, 2001).

	Statistic	
Population	19,805	
Children < 5 years	1,955	
Family households	3,155	
Single parents with children		40.8%
Living in poverty		31.3%
Occupied housing units	6,333	
Renter-occupied		78.4%
No telephone service		5.7%
Vacant housing units	401	
Race		
Caucasian		31.6%
African-American		29.4%
Native American		11.9%
Asian/Pacific Islander		6.1%
Other		11.9%
Two or more		9.1%
Of Hispanic ethnicity *	22.1%	
Structures built March 2000 or earlier	4,275	
Built 1959 or earlier		58.5%
Built 1960 – March 2000		41.5%
Families	2,235	
Income less than $25,000		45.2%
Median value of owner-occupied units	$65,400	

* The 2000 Census did not consider 'Hispanic' as a race.

To understand the environmental context for the challenges faced by residents of the Phillips neighborhood, it is useful to compare its population density and average household income to a more affluent neighborhood in Minneapolis, such as Kenwood, because population density suggests the scope of the problem in terms of human exposure to chemical contamination while income levels reflect the economic and social capital that communities have to address environmental problems. As of the 2000 census, Kenwood had a population of 1,500 people spread out over about 0.5 square miles of land. Citizens in this neighborhood live at an average density of about 3,000 people/mi^2, which is less than a quarter of the population density of the Phillips neighborhood (Minneapolis Planning Department, Research and Strategic Planning Division, 2001). The median family income in Kenwood was $155,156, with 0.9% of families living in poverty (Community Planning and Economic Development Department, 2005). While the Kenwood neighborhood has faced relatively few environmental health problems other than the clean-up of an old railroad yard, it was able to efficiently complete the needed clean-up a few decades ago (Lotz, 2005). It seems like communities, like this one, that are well-organized and have access to resources are the ones who are most aware of their environmental health problems and receive the most benefit in terms of research and clean-up.

The environmental burden in Phillips is disproportionately higher than neighborhoods such as Kenwood, creating challenges for a community at-risk for public health problems and with limited financial resources. Residents of Phillips are exposed to environmental pollutants due to housing age and condition, proximity to highways and busy thoroughfares, and presence of industry. In recent decades, the Phillips community has been a victim of toxic spills and unpermitted dumps caused by various sources such as Abbott Northwestern Hospital and the Smith Foundry (Minnesota Pollution Control Agency, 2005). Citizens have also wrestled with the establishment of a Hennepin County garbage transfer station, which would have brought tons of waste and heavy truck traffic through the community to the current site of the Phillips Eco-Enterprise Center. Fortunately, after ten years of neighborhood opposition, plans for the garbage transfer station were dropped (Zoll, 2005). The major environmental health problem in the Phillips neighborhood in the last decade, however, has been its lead burden, which is thought to come from lead-based paint on old properties. Compared to other Minneapolis neighborhoods, children in Phillips had consistently higher blood-lead levels in all ranges above the Center for Disease Control's (CDC's) recommended safety standard of 10 µg/dL (Jordan et al., 2000). Because of lead's neurotoxic effects on children, this is another factor contributing to poor development and academic-performance in addition to the economic and social conditions of the community. The Phillips Neighborhood Lead Collaborative was then launched to combat this injustice by educating families about lead poisoning prevention and maintaining blood-lead in children at levels below the safety standard (The Minneapolis Center for Neighborhoods, 1995).

Unfortunately, lead, air/noise pollution, and toxic spills are not the end of the pollution problems in Phillips. Recently, within the last five years, arsenic has emerged as another serious environmental pollutant with possibly complicated health effects. During the arsenic clean-up of a former pesticide plant now called the CMC Heartland Lite Yard Site, on the northwest corner of the 28th St. & Hiawatha Ave. intersection, residential contamination became a concern due to the high levels found on the industrial site itself (commonly known as the arsenic triangle) and the possibility that arsenic-laced dust blew onto area residences during the sixty-some years that the on-site arsenic contamination went uncovered (Minnesota Department of Agriculture, 2004a). Investigation and clean-up has so far concentrated on the Phillips neighborhood and soil samplings have revealed that the arsenic contamination in the area residences is real and moderately high. In addition, the boundaries of where there is known contamination continue to grow outwards as the investigation enlarges, now affecting the estimated 12,000 people who live within three-fourths of a mile of the former industrial site (Matson, 2005). The challenge for the Phillips neighborhood and surrounding communities is to work with all the involved stakeholders to make the area “arsenic safe.”

The main purpose of this study is to examine this particular aspect of the environmental burden facing the Phillips neighborhood and surrounding communities—the arsenic contamination in soil and groundwater. The following pages will highlight the relevant health effects of arsenic, explain the history of the contamination, and make suggestions for community involvement. This is not intended to be a comprehensive analysis of the arsenic problem in South Minneapolis, but it should give the reader an excellent awareness of the situation and some ideas for future initiatives.

Health Effects of Arsenic

Arsenic is an element that is widely distributed in the earth’s crust and present at an average concentration of 2 mg/kg (International Programme on Chemical Safety, 2001). As a heavy metal, arsenic has long been recognized as a valuable substance in many industrial processes as well as a highly effective poison that is toxic to virtually all members of the animal kingdom (American Academy of Pediatrics Committee on Environmental Health, 2003). This element cannot be destroyed in the environment, and as most arsenic compounds are colorless and have no smell nor special taste, it is also hard to detect in food, water, and air without chemically testing the medium. Although naturally occurring forms of organic arsenic are considered relatively non-toxic, arsenic, on the whole, is dangerous at “unnatural” doses and is no longer explicitly produced in the United States (Agency for Toxic Substances and Disease Registry, 2000).

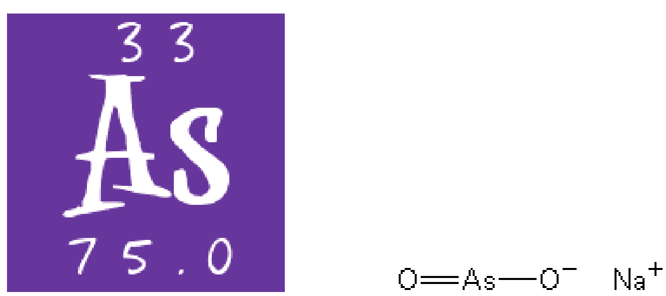
Types of Arsenic

Arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. This type of arsenic occurs naturally in soil and in many kinds of rock, which is why it is a common product of smelter operations, and is mainly used in the preservation of wood. In the past, inorganic arsenic was also used as a pesticide (Agency for Toxic Substances and Disease Registry, 2000). When arsenic combines with carbon and hydrogen in animals and plants, it is referred to as organic arsenic. Organic arsenic compounds are typically used as pesticides, principally on cotton fields and in orchards (Agency for Toxic Substances and Disease Registry, 2000). While naturally-occurring organic forms of arsenic are usually less harmful than the inorganic forms, organic arsenicals developed as pesticides are very toxic (American Academy of Pediatrics Committee on Environmental Health, 2003).

Once released into the environment, arsenic can change form, becoming attached or separated from particles. It may react with oxygen or other molecules present in air, water, or soil (Agency for Toxic Substances and Disease Registry, 2000). Microorganisms may also convert arsenic into a different form. As arsenic interacts with different particles, the properties of the arsenic atom itself can change valency states. Valency is related to the number of spaces left in an atom’s electron shells and corresponds to the ability of an atom to combine with other atoms. The arsenic atom can exist in four of these states: -3, 0, +3, and +5 (International Programme on Chemical Safety, 2001). These four states correspond to the names arsenide, elemental arsenic, arsenite (As(III)), and arsenate (As(V)), respectively (Agency for Toxic Substances and Disease Registry, 2000). Distinguishing the valency state of arsenic is important because each form has its own unique properties. Under reducing conditions, arsenite is the dominant form; arsenate is generally the stable form found in oxygenated conditions (International Programme on Chemical Safety, 2001). Elemental arsenic is not soluble in water, and arsenide salts exhibit a wide range of solubilities depending on pH and the ionic environment. Different properties equate to different environmental fates as well as divergent health effects.

Type of Arsenic Found on Site[1] and in Neighborhood Soils

Reade Manufacturing (1938 – 1963) manufactured, blended, and stored pesticides and herbicides on the Site. Some of their products contained arsenic and/or sodium arsenite (Figure 1). US Borax (1963 – 1968) manufactured, blended, and stored pesticides and herbicides on the Site. Some of their products also contained arsenic and/or sodium arsenite. US Borax may have blended and sold arsenic-based formula for anti-freeze as well (CMC Heartland Partners, 2004). According to soil samples collected in 2003 and 2004, the current form of arsenic detected on the Site and in neighborhood soils is arsenic trioxide (Figure 2), an inorganic arsenic compound with the arsenic molecule having a valency corresponding to As(III) or arsenite (Exponent, 2004, Agency for Toxic Substances and Disease Registry, 2000).



a. **b.**

Figure 1. a) Properties of arsenic atom. As = symbol; 33 = atomic number, number of protons in nucleus; 75.0 = atomic mass in grams/mole (Vignola, Prendeville, Farukh, & Enrique).
b) Structure of sodium arsenite (Wood, 2005).

[1] CMC Heartland Lite Yard Site.

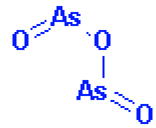


Figure 2. Structure of arsenic trioxide (National Institute of Allergy and Infectious Diseases, National Institutes of Health).

Exposure Pathways

Citizens in the area near the Site may be exposed to higher than average arsenic levels by ingesting soil and food contaminated with soil residues, drinking water from prohibited sources such as private wells, and breathing in contaminated dust particles (Minnesota Department of Agriculture, 2000). One may also be exposed to arsenic through skin contact with soil or groundwater. However, only a small amount of arsenic will pass through human skin and into the body, so this exposure pathway is usually not a concern (Agency for Toxic Substances and Disease Registry, 2000).

Eating ferns grown in the area near the Site may also expose a person to high levels of arsenic. The Chinese brake fern (Pteris vittata), especially, has been reported to hyperaccumulate arsenic to extremely high concentrations, up to 23,000 µg arsenic/g, in its shoots (fronds) (Alkorta, Hernandez-Allica, & Garbisu, 2004). Ferns are not typically found in a western diet, but certain ethnic groups have been known to use them. In general though, eating vegetables grown in soils with elevated arsenic levels does not pose a serious hazard to human health if consumed as part of a normal diet (Warren et al., 2003).

Metabolism

Ingestion and inhalation are the two main ways that arsenic trioxide can enter the body of a person living or working in the vicinity of the Site. The inorganic arsenic compound is well absorbed through both pathways, and animal models have demonstrated that gastrointestinal absorption (via ingestion) is further enhanced in persons with iron deficiency (American Academy of Pediatrics Committee on Environmental Health, 2003). Once absorbed in the body, this trivalent (As(III)) arsenical has a half-life in blood of about 10 hours and is distributed to all tissues with little tendency to accumulate preferentially in any internal organs (American Academy of Pediatrics Committee on Environmental Health, 2003, Agency for Toxic Substances and Disease Registry, 2000). The liver, however, is the major site of biotransformation. Enzymes in the liver methylate (add carbons and hydrogens to) some of the arsenic trioxide to less harmful organic forms such as monomethylarsenate (MMA) or dimethylarsenate (DMA), which are more readily excreted in urine (Agency for Toxic Substances and Disease Registry (ATSDR), 2000). It is estimated that more than 75% of the absorbed arsenic trioxide dose will be excreted in urine as a methylated organic form or the original inorganic form within several days of exposure (Mahieu, Buchet, Roels, & Lauwerys, 1981). Much smaller amounts are excreted in feces. The inorganic arsenic and dimethylated arsenic that are not eliminated can be characterized through nails and hair, where it can be present for weeks and potentially months after the initial exposure (Rodriguez, Jimenez-Capdeville, & Giordano, 2003).

Since arsenite (As(III)) is the most reactive species of arsenic, the arsenic trioxide and its metabolites that are not readily eliminated can cause some serious toxicity. Within various organs, arsenite is able to easily enter cells through diffusion along a concentration gradient (Peraza, Carter, & Gandolfi, 2003). Once in the cell, the inorganic arsenic can react strongly with sulfhydryl groups in proteins and inactivate many enzymes (Agency for Toxic Substances and Disease Registry, 2000). Arsenite can also accumulate in the mitochondria of cells and decrease the ability of cells to produce energy, which affects virtually all cellular functions (Brown, Rhyne, & Goyer, 1976). These toxic effects may be minimal when the duration of exposure is short, the dose is small, and the body is normally nourished. When there are severe dietary restrictions, the methylating capacity of the liver can be compromised as the pool of available methyl donors is sparse (Buchet & Lauwerys, 1987). This can hinder the detoxification process. At high doses, the enzymes involved in methylation can become overwhelmed and result in a higher incidence of arsenic toxicity. Ingestion of inorganic arsenic at doses in the range of 20 mg As/kg and higher has caused death in humans. Long-term exposure can also cause chronic effects which appear to be a result of direct cellular toxicity (Agency for Toxic Substances and Disease Registry, 2000).

Children can be exposed to arsenic trioxide in the same manner as adults. The ingestion of soil, however, may be an even more significant source of exposure since children often play in dirt and put their hands in their mouths. Inorganic arsenic also passes easily through the placenta, coming in contact with a developing fetus, and has been detected in human breast milk (Concha, Vogler, Lezcano, Nermell, & Vahter, 1998, Somogyi & Beck, 1993). There is also information suggesting that children may be less efficient at converting inorganic arsenic to less harmful organic forms than adults (Concha, Nermell, & Vahter, 1998). For these reasons, children may be more susceptible to health effects from arsenic trioxide than adults.

Health Effects

Since arsenic is present in food and water, all humans have some arsenic in their bodies. A deficiency of this element in humans has apparently never been observed, which means that arsenic may actually be necessary for good health (Agency for Toxic Substances and Disease Registry, 2000). An arsenic trioxide has even been approved by the U.S. Food and Drug Administration (FDA) to treat a rare and deadly form of leukemia called acute promyelocytic leukemia (APL) (Mineral Information Institute). But, as with most chemicals, the dose and the frequency of exposure determine the toxic effects of the compound.

Inorganic arsenic is classified as a known human carcinogen by the National Toxicology Program, the U.S. Environmental Protection Agency (EPA), and the International Agency for Research on Cancer (IARC). It affects every organ, although its primary target organs for health effects are the gastrointestinal tract and skin because these are the most metabolically active tissues in the body (American Academy of Pediatrics Committee on Environmental Health, 2003). Arsenic has also been associated with human cancers such as skin, lung, bladder, and other cancers, as well as non-carcinogenic effects such as diabetes mellitus, peripheral neuropathy, and hypertension (Abernathy et al., 1999).

When high levels (> 100 $\mu g/m^3$) of inorganic arsenic are inhaled for a brief amount of time, a person is likely to experience a sore throat and irritated lungs (Agency for Toxic Substances and Disease Registry, 2000). A person may also develop certain skin conditions such as a darkening of the skin, skin lesions, and small warts on the extremities and torso. It is difficult, however, to inhale a fatal dose, which is thought to range from 0.1 to 10 grams of arsenic (Lamm, 2001). Inhaling lower concentrations for longer periods of time can lead to similar skin effects as for acute exposures, and also to circulatory and peripheral nervous disorders. People are also at increased risk for lung cancer, especially if they work in smelters, mines, and chemical factories (Agency for Toxic Substances and Disease Registry, 2000).

Ingestion of very high levels (0.1–10 g, > 60,000 parts per billion (ppb) in food or water) of inorganic arsenic can lead to death from gastric bleeding. At these amounts, the use of inorganic arsenic would be considered intentional—suicidal or homicidal (Lamm, 2001). At acute, lower-dose exposures (300-30,000 ppb in food or water), ingesting inorganic arsenic may cause stomach and intestinal irritation, with symptoms of stomach ache, nausea, vomiting, and diarrhea. Chronic low-dose exposures may produce fatigue, malaise, malnutrition, skin rashes, and Mees lines (white, transverse creases) on the fingernails. This long-term oral exposure may also increase a person's risk for skin, liver, bladder, kidney, prostate, and lung cancer (Agency for Toxic Substances and Disease Registry, 2000).

Direct skin contact with inorganic arsenic may result in skin irritation, redness, and swelling. This route of exposure, however, is unlikely to lead to any serious internal effects (Agency for Toxic Substances and Disease Registry, 2000).

Children may experience many of the same health effects as adults, which include stomach irritation, blood vessel damage, skin changes, and reduced nerve function. Children are also affected in the womb because pregnant women who are chronically exposed to arsenic-contaminated water are at increased risk for spontaneous abortion, stillbirth, and pre-term birth. While inorganic arsenic is teratogenic in animals, it is not known whether prenatal exposure to inorganic arsenic will result in birth defects in humans (American Academy of Pediatrics Committee on Environmental Health, 2003).

Health Standards

Table 2. Recommended limits for total arsenic exposure.

Standard	Value	Organization	Year	Reference
Drinking water	10 ppb or μg/L	EPA	2003	(Agency for Toxic Substances and Disease Registry, 2003)
Workplace air	10 $\mu g/m^3$ over 8-hr period	OSHA[a]	2003	(Agency for Toxic Substances and Disease Registry, 2003)
Unrestricted land use (soil)	10 mg/kg or ppm[b]	MPCA[c]	2004	(Tetra Tech EM Inc., 2004)
Diet	130 μg/day	FDA	2001	(Lamm, 2001)

[a] Occupational Safety and Health Administration
[b] parts per million
[c] Minnesota Pollution Control Agency

The federal drinking water standard listed in Table 2 confers a risk for bladder or lung cancer of 1 to 3 cases per 1,000 people. There have been recommendations to reduce this standard to 3 ppb, but even at 3 ppb, the cancer mortality risk exceeds 1 in 10,000. Given that federal standards for environmental carcinogens are typically set to produce a cancer risk of 1 in 1 million, the allowable amount of arsenic in drinking water presents an unusually high risk. Currently, concentrations of arsenic in water lower than 3 ppb are not achievable by municipal systems at reasonable cost with existing technology (American Academy of Pediatrics Committee on Environmental Health, 2003).

The recommended limit for arsenic in soil is less defined. The MPCA standard in Table 2 is considered a conservative estimate (Peña, 2005, Minnesota Department of Agriculture, 2003a). Superfund arsenic clean-up goals are often in the range of 5 to 65 ppm (Lamm, 2001).

History of Arsenic Contamination

The arsenic contamination associated with residential areas of South Minneapolis purportedly originated from a piece of land currently owned by CMC Heartland, a real estate firm located in Chicago, Illinois. This six-acre, triangular-shaped piece of land on the northwest corner of the Hiawatha Avenue and 28th Street intersection (Site) was the home of pesticide manufacturing and storage for at least thirty years (Minnesota Department of Agriculture, 2003b). From 1938 to 1963, Reade Manufacturing Company leased and operated on the Site and was a recognized arsenical pesticide manufacturer (Minnesota Department of Agriculture, 2004a). The pesticide produced was used to control grasshopper populations on railroad rights-of-way, and for at least several years, this poison came in the form of sodium arsenate and/or lead arsenate (Minnesota Pollution Control Agency, 2002). US Borax sub-leased the land from 1963 to 1968, and the storage of arsenic-based pesticides remained on the Site during that time. It wasn't until 1994, during the reconstruction of the Hiawatha Avenue corridor, that the

Minnesota Department of Transportation (MnDOT) discovered the toxic residues of the Site's industrial past (Minnesota Department of Agriculture, 2004a).

In conjunction with the Minnesota Department of Agriculture (MDA), CMC Heartland began investigating the arsenic contamination in the Site's soil and groundwater starting in 1995. Levels of total arsenic in the surface soils was found to range from background levels to 5,200 mg/kg, soils at greater depths were documented as high as 24,000 mg/kg, and the groundwater was measured at concentrations as high as 320,000 µg/L with a plume extending approximately 1,500 feet southwest of the Site (Minnesota Department of Agriculture, 2003b), (Delta Environmental Consultants, Inc., 2003), (Minnesota Department of Health, 2005). These concentrations were hundreds to tens of thousands of times greater than the recommended limits listed in Table 2. Upon these findings, CMC Heartland immediately had the Site covered with a one to two foot thick layer of crushed bituminous (asphalt) and clean fill to prevent further wind erosion of contaminated soils. The Site was also fenced off to prevent citizens from using or occupying the land (Minnesota Department of Agriculture, 2003b).

During this same time period, CMC Heartland enrolled itself into the Agricultural Voluntary Investigation and Cleanup (AgVIC) program. This program can help protect the company from Minnesota Environmental Response and Liability Act (MERLA, Minnesota's version of Superfund) liability if it voluntarily made the effort to clean up contaminated property before government agencies were forced to intervene for the sake of public health. By the spring of 2002, however, CMC Heartland indicated that they did not have the resources to complete an acceptable response action plan. Levels of arsenic contamination were quite high and, in some spots, reached a depth of 25 feet below the surface. The Site was then listed on the Minnesota State Superfund List, which enabled CMC Heartland to receive priority assistance with designing and implementing a response action (Minnesota Pollution Control Agency, 2002).

Actual clean-up of the Site began in Fall 2004 and was funded by the responsible parties, CMC Heartland Partners (landowner) and US Borax (last operator). In a central hot spot area, where the highest levels of arsenic were found at great depths, 17,000 cubic yards of soil was excavated to a depth of 24 feet. Moderately contaminated soils that did not meet the soil clean-up goal of 20 mg/kg were left in place but buried with three feet of clean soil and one foot of the crushed bituminous cover. Excavated soil that was highly contaminated was treated to prevent further arsenic leaching and shipped off-site to an approved landfill in Dakota County. As of June 2005, Site clean-up is just about complete, with the remaining excavation/clean-ups to be coordinated with the developer, Ryan Companies, and the MDA (Anderson, 2005). Groundwater sampling will continue beyond the end of the clean-up. It is expected, however, that removal of the highly contaminated soil in the central hot spot area will reduce the release of arsenic into ground water from the contaminated soil by 95% (Minnesota Department of Agriculture, 2004b).

While the arsenic investigation of the Site was taking place in the late 1990s, the Minnesota Department of Health (MDH) became aware of the fact that the contaminated surface soils at the Site were uncovered and exposed from the time of the manufacturing operations to the early 1990s, for potentially sixty years. MDH investigators were concerned about the possibility of highly contaminated dust being windblown or carried off the Site and suggested that the arsenic investigation spread to area residences. In the Health Consultation dated April 8, 1999, MDH, in conjunction with the Agency for Toxic Substances and Disease Registry (ATSDR), recommended that soil samples be taken from residential yards located downwind (northwest) of the Site (Delta Environmental Consultants, Inc., 2003). The MDA and MDH then conducted a limited soil sampling in June 2001. Of the 22 properties sampled in the Phillips neighborhood northwest of the Site, 10 properties exhibited elevated arsenic levels, ranging from 24 to 210 mg/kg at a depth of 0 to 3 inches below the surface (Tetra Tech EM Inc., 2004). Although these levels did not appear to require emergency removal action, it was determined that further investigation was needed to establish the extent of the surface contamination and possible attribution to the Site (Delta Environmental Consultants, Inc., 2003).

In September 2003, Delta Environmental Consultants Inc., under contract to the MDA, conducted a more extensive sampling event in the Phillips neighborhood. A total of 242 locations were sampled, and of those locations, 35 of them indicated arsenic concentrations greater than the MPCA unrestricted land use standard of 10 mg/kg. Eleven samples contained arsenic at concentrations 10 times that standard (100 mg/kg), and four samples contained arsenic concentrations exceeding 250 mg/kg (Tetra Tech EM Inc., 2004). These highly contaminated areas now posed a possible threat to human health, and the EPA was called in in 2004 to review data and assist with future actions. After approximately 500 residential yards had been sampled in the Phillips neighborhood, the EPA initiated a federal Emergency Response Program as a short-term solution to clean up acute levels of arsenic (Adelsman, 2005, Anderson, 2005). This acute level was deemed to be any concentration above 95 ppm or 95 mg/kg (Prendiville, 2005). At this standard, 29 of the yards that had already been sampled qualified for clean-up, and subsequently, had twelve inches of topsoil removed and replaced with clean soil. This initial excavation started in October 2004 and was completed within six months (Adelsman, 2005).

Since fall of 2004, the EPA has determined that chronic levels of arsenic (30-95 ppm) were the next targets for remediation. Soil sampling events revealed that chronic levels of arsenic were rather widespread. As the investigation spread outward from the Site, more and more chronic contaminations were found (Rhame, 2005). Increased funding and man-power would be needed for clean-up and investigation of other neighborhoods surrounding the Site, and thus, the MDA applied for a Federal Superfund Site listing. It is anticipated that the South Minneapolis Soil Contamination Site, the name given to this residential soil arsenic contamination, will be officially added to the National Priority List (NPL) and handed over to the EPA's Remedial Program for long-term clean-up sometime in Fall 2005 (Anderson, 2005).

Table 3. Summary of Events

1938	Reade Manufacturing Company operates on the Site, produces arsenical pesticides.
1963	US Borax sub-leases the Site, continues to store arsenical pesticides
1994	Reconstruction of Hiawatha Ave. corridor, MnDOT discovers arsenic near Site
1995	CMC Heartland & MDA investigates arsenic contamination at the Site

1996	CMC Heartland covers Site soil with one foot of crushed bituminous and clean fill to prevent further wind erosion
June 2001	MDA & MDH conduct limited soil sampling in residential yards in Phillips
2002	Site is enlisted as State Superfund site
September 2003	Delta Environmental Consultants, Inc., under contract to MDA, conducts more extensive soil sampling in east Phillips
2004	EPA performs additional soil sampling in residential yards and reviews data, Emergency Response Program is initiated to clean up acute levels
Fall 2004	CMC Heartland & MDA begin Site clean-up
Late Summer 2005	EPA conducts soil sampling of every residential yard within certain boundary near Site and expands the radius of random sampling to include parts of Seward, Longfellow, and Powderhorn neighborhoods
Fall 2005	Expected listing of residential areas surrounding Site on the National Priority List (a list of Federal Superfund sites)

Other Sources of Arsenic

In a limited soil sampling event conducted in 2004 by Exponent, under contract to US Borax and possibly CMC Heartland as well, lead arsenate was observed in two off-site samples and arsenic trioxide was observed in four off-site samples (Exponent, 2004). The significance of this finding is that lead arsenate is a separate compound that would not form in residential soils even if lead and arsenic were placed there separately. This indicates that there may be an additional arsenic source other than the Site. The source of the lead arsenate is difficult to pinpoint, but since lead arsenate was commonly used as a pesticide/insecticide prior to 1988, the chemical probably landed in residential soils through the application of arsenical consumer products (Peryea, 1998).

Options for Community Involvement

The goal of this paper is primarily to inform the public about arsenic in and around the Site. Awareness, however, is only half the battle. In order to change the arsenic conditions in Phillips and other potentially affected neighborhoods such as Seward, Longfellow, and Powderhorn, citizens must become actively involved in protecting their own health and the well-being of their communities. This section highlights certain actions that individuals can take to help insure their own safety and the quality of clean-up efforts.

Protect Your Family

Even if your residence has already undergone arsenic remediation, the following steps are good guidelines to follow to reduce exposure to contaminants in the soil. In addition to arsenic, people in this area must also guard against lead exposure.

Table 4. Guidelines to reduce exposure to soil arsenic and other toxins (Department of Public Health, 2004, Agency for Toxic Substances and Disease Registry, 2000, Agency for Toxic Substances and Disease Registry, 2003).

Inside your home	• Take off your shoes when entering your home. • Wash garden vegetables and fruits carefully to remove all soil particles. • Eat a balanced diet. • Wash hands and face thoroughly after working or playing in the soil, especially before eating. • Wash soil-laden clothes separately from other clothes. • Frequently wash toys, pacifiers, and other items that go into children's mouths. • Control dust by using damp mops or rags.
Outside your home	• Keep children from playing in and ingesting contaminated dirt. • Cover bare soils with grass or other material. • Wear gardening gloves. • Do not eat or drink in contaminated areas. • Wear a mask in dusty environments. • Do not eat ferns.

Since the groundwater in this area is also contaminated with arsenic, people should avoid drinking water from unregulated sources such as rivers, lakes, puddles, and wells.

Be Aware of Your Surroundings

If neighboring soils are being sampled or cleaned up, ask your neighbor about their soil conditions. Even though the arsenic levels in your yard could differ drastically from the levels found in a neighboring residence, you are better off knowing about a potential hazard, especially if you have children, than being unaware and not taking precautionary measures. On the flip side, if your yard is the one being sampled or cleaned up, be a good citizen and let your neighbors know about it. We are all in this together, to rid our community of the toxic effects of this chemical.

Express Concerns

Whether they are concerns about health, extent of sampling, or quality of communications and clean-up, if you live or work in Phillips and other affected areas, your concerns are very important to this remediation process and should be directed to organizations that are interested or involved in this arsenic problem. Organizations such as Environmental

Justice Advocates of Minnesota (EJAM) and the East Phillips Improvement Coalition (EPIC) are designed to give a voice to citizens in this area who are experiencing environmental problems and push for the best interests of the community. Another local contact in the community is the Community-University Health Care Center (CUHCC). Health professionals at this local clinic may be able to field your questions about the health effects of arsenic exposure and alert MDH officials about possible health patterns. The legislative offices of Karen Clark, a State Representative who represents district 61A, would also be interested in hearing your concerns about the health effects of arsenic. Government agencies such as the EPA are available as well, especially if the topic of concern is on arsenic measurement or clean-up. These and other resources, along with contact information, are listed in section five.

Apply for a TAG

As this arsenic-contaminated area in south Minneapolis becomes an official Superfund site, the community may benefit from hiring an independent technical advisor to interpret and comment on site-related documents. The EPA offers a Technical Assistance Grant (TAG) to communities that want to hire such an advisor in order to better understand what is happening at their Superfund site. Essentially, this grant helps to finance a community organization that will be involved in the clean-up process and the communication of information to its citizens. Information about the TAG and its application is available at the Green Institute and at the website address listed in the "Resources for the Community" section.

Push for a Health Study

It is difficult to understand the impact of toxic compounds on human communities without conducting a study on human health. Understanding impact is of course important because it corresponds to a certain level of urgency and thoroughness in remediation and preparedness in treating the effects. The MDA and EPA have found alarming levels of arsenic in the soils of the Phillips neighborhood in the last decade, most of which has probably been there for several decades prior to its discovery. Thus, in order to push for higher standards and attain environmental justice, we must understand the impact of this arsenic contamination by studying the health of people who have been chronically exposed to arsenic and other contaminants for decades. Not only will we have stronger leverage to negotiate for more thorough clean-up measures and be more prepared to treat the harmful health effects, but conducting a health study will also recognize a group of people who may have quietly suffered from the toxic effects of this compound.

In spite of the general opinion of the state government that a health study in this area is unnecessary and too expensive, state legislator Karen Clark has been working on initiating a longitudinal health study of people who have lived in the Phillips neighborhood for several decades (Peña, 2005). If you are interested in contributing to or supporting this vital cause, please contact her office using the information listed in "Resources for the Community."

Further Research

Now that there is a better understanding of arsenic and its history in the community, more research is still needed to evaluate the adequacy of the clean-up efforts put forth by government agencies and the responsible parties. First of all, this urban area is not the first to discover arsenic contamination and undergo remediation. Communities in Denver, Colorado; East Helena, Montana; and Heidelberg Township, Pennsylvania are all going through a similar process. It would advantageous to learn how these communities are utilizing their resources in similar situations and understand what the EPA is required to do and where there is some flexibility in the regulations. This would help our community monitor the clean-up process and improve upon past uncertainties.

Just as important as understanding precedent is the identification of issues right here in the community. This paper has outlined actions that community members can take to get involved in remediation efforts, and one of them recommends the expression of concern. The next step would be for a group or an individual to collect these concerns and begin to address them properly. Research would also be needed to identify community needs and where certain infrastructures are lacking the ability to help its citizens on this matter. As the groundwork has already been laid to deal with the lead burden in the Phillips neighborhood, perhaps this could be applied to the arsenic problem as well.

Resources for the Community

Community-University Health Care Center (CUHCC)
2001 Bloomington Avenue
Minneapolis, MN 55404
(612) 638-0700
http://www.ahc.umn.edu/CUHCC/

East Phillips Improvement Coalition (EPIC)
c/o: Carol Pass
2536 18th Ave. S.
Minneapolis, MN 55404
(612) 721-4509

Environmental Justice Advocates of Minnesota (EJAM)
c/o: Alecia Carter
alecia.carter@sierraclub.org
(612) 436-5402

Health Effects of Arsenic
http://www.atsdr.cdc.gov/tfacts2.html
♦
http://www.atsdr.cdc.gov/toxprofiles/phs2.html
♦

http://www.atsdr.cdc.gov/toxprofiles/tp2.pdf

Karen Clark, State Legislator
(DFL) District 61A
303 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.
Saint Paul, Minnesota 55155
(651) 296-0294

Other Information about the Site & Residential Arsenic Contamination
http://www.epa.gov/region5/sites/cmcheartland/index.htm
♦
http://www.mda.state.mn.us/cgi-bin/MsmGo.exe?grab_id=28&EXTRA_ARG=&host_id=42&page_id=1967104&query=arsenic&hiword=arsenic+ARSENICAL+
♦
The Green Institute
2801 21st Ave. S., Suite 100
Minneapolis, MN 55407
♦
Sustainable Resources Center
1916 Second Ave. S
Minneapolis, MN 55403
♦
Minneapolis Public Library
East Lake Branch
2727 E. Lake St.
Minneapolis, MN 55406

Technical Assistance Grants (TAGs)
http://www.epa.gov/superfund/tools/tag/index.htm
♦
The Green Institute
c/o: Carl Nelson
2801 21st Ave. S., Suite 110
Minneapolis, MN 55407
(612) 278-7117

U.S. Environmental Protection Agency (EPA)
c/o: Cheryl Allen, Community Involvement Coordinator
allen.Cheryl@epa.gov
(312) 353-6196

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