



Public Health Assessment for

KERR-MCGEE CHEMICAL CORPORATION
(a/k/a TRONOX)
COLUMBUS, LOWNDES COUNTY, MISSISSIPPI
EPA FACILITY ID: MSD990866329
SEPTEMBER 22, 2008

For Public Comment

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE

Agency for Toxic Substances and Disease Registry

Comment Period Ends:

NOVEMBER 24, 2008

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

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

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1.0. STATEMENT OF ISSUES AND BACKGROUND

1.1. Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this public health assessment in response to a petition received from a citizen of Columbus, Mississippi. The petitioner was concerned about potential health effects from exposures to hazardous substances associated with the Kerr-McGee Chemical Corporation. This health assessment evaluates available information about hazardous substances in soil, sediment, and surface water on or near the Kerr-McGee Chemical facility to determine whether exposure to these substances is likely to cause harmful health effects.

1.2. Site Description and Background

The Kerr-McGee Chemical Corporation, Forest Products Division (herein referred to as Kerr-McGee), now known as Tronox LLC, owns a wood-preserving facility at 2300 North 14th Avenue in Columbus, Lowndes County, Mississippi. Kerr-McGee purchased the facility from Moss American Corporation in 1964. The site occupies approximately 90 acres. The facility was operational from approximately 1928 to 2003 [1]. It is now closed.

While operational, Kerr-McGee manufactured pressure-treated railroad products such as wooden crossties, switch ties, and timbers. The production processes at the site utilized creosote and creosote coal tar solutions to produce pressure-treated wood products. The facility also used pentachlorophenol (PCP) for wood-treating from the 1950s until the mid-1970s [2]. As part of facility operations, the facility generated hazardous waste, now regulated under the Resource Conservation and Recovery Act (RCRA). Past operational practices at the facility caused hazardous materials to be released to the environment. These historical releases have impacted local groundwater quality and off-site soils and sediments [1].

Kerr-McGee previously maintained an unlined hazardous waste surface impoundment as part of their wastewater treatment system. This impoundment was used to settle out solids and preservatives from the process wastewater prior to final discharge to the city's publicly owned treatment works (POTW). Preservative was recovered from the impoundment and recycled to the production process [6].

Kerr-McGee instituted several modifications to the production process over the years designed to reduce the potential for impact on the local environment. These included upgrading the process oil/water separators, installing a concrete drip track that meets §40 CFR Part 264, Subpart W standards, and installing concrete containment systems for the tank farms. In conjunction with the production changes, the facility has excavated visually impacted soils from the drip track, work tank, and black tie storage areas. In accordance with a closure plan approved by Mississippi Department of Environmental Quality (MDEQ), Kerr-McGee closed their surface impoundment in 1986. In November 2004, Kerr-McGee remediated approximately 1,800 linear feet of the soil and sediment in ditches near the facility [1].

1.3. Demographics and Land Use

Figure 1 in Appendix A displays the ATSDR site map with basic demographic information about the community near the Kerr-McGee facility. According to data from the 2000 U.S. Census, approximately 8,976 people live within 1 mile of the Kerr-McGee site. Approximately 1,030 persons living within one mile of the site are children aged 6 or younger. Approximately 1,186 persons are aged 65 years or older.

A mix of residential, commercial and industrial properties surrounds the facility. Six public school sites are located within approximately one mile of the facility (See Figure 2 in Appendix A). The nearest school to the site is Hunt Intermediate School. Hunt Intermediate is located southwest of the site. The school has approximately 863 students in grades 5 through 6 [3]. The other schools located within approximately one mile of the site are Stokes Beard Elementary School, S.D. Lee Jr. High School, Hughes Alternative School, Mitchell Elementary, and Warden-Carden School. Approximately 16 daycare facilities are located within one mile of the site [4]. The closest hospital is Baptist Memorial Hospital—Golden Triangle, located 1.6 miles from the site. It is a 328-bed hospital that serves as a Level 2 trauma facility [5].

1.4. Natural Resources

a. Groundwater

Underlying the facility are three aquifers [6]. The geology underneath the site consists of quaternary age alluvial deposits consisting of interbedded clays, silts, sands, and gravels that are generally coarser with depth. The thickness of the alluvium averages about 25 feet in the area of the Kerr-McGee facility. Groundwater flow in the alluvium was determined to be in a southeasterly direction [6]. Underlying the alluvium is the Eutaw Formation, which is composed of two members. The uppermost member is the Tombigbee Sand; the lower is referred to as the “typical” Eutaw [7,8]. The Tombigbee is a fine, medium-grained, glauconitic, calcareous, fossiliferous massive sand. The lower “typical” Eutaw is less glauconitic sand with a slightly coarser texture, with associated clay layers [7, 8]. The Eutaw is a regional source of both industrial and domestic water supplies. At the site, groundwater flow in the Eutaw formation is in the east-southeasterly direction [6]. In the area of the Kerr-McGee facility, the Eutaw consists of finer grained material that is less permeable [7]. Beneath the Eutaw is the McShan aquifer [6].

The Eutaw and McShan formations are sometimes considered one formation, the Eutaw-McShan aquifer, because they are hydraulically interconnected [8]. Of the major aquifers in Mississippi, the Eutaw-McShan ranks lowest in the capacity to transmit and yield water. Values for hydraulic conductivity (the rate of flow through a 1-foot-square section of the aquifer under unit hydraulic gradient) average the lowest of all major aquifers in Mississippi. Transmissivity, related to hydraulic conductivity and aquifer thickness, is low because sand beds are rare and the screened zone in large wells commonly includes multiple layers of clay [8]. The hydraulic characteristics of the aquifer, according to 41 aquifer tests, showed transmissivity values ranging from 200 to 4,900 (ft³ /d)/ft [8]. The aquifer tests showed a median value for hydraulic conductivity of 13.4 (ft³/d)/ft²[8].

b. Luxapalila Creek

The Kerr-McGee facility is located in the drainage basin of the Luxapalila Creek. Luxapalila Creek is located approximately 0.5 miles east of the facility. Luxapalila Creek is classified as a public water supply upstream of the facility. The downstream portion of the creek, to the confluence with the Tombigbee waterway system, is classified for fish and wildlife [9]. The classification of fish and wildlife denotes secondary usage for recreation such as swimming and wading [10]. The creek waters are intended for fishing and propagation of fish and for public water supply. During the public meeting with ATSDR, residents stated that they catch fish from the Luxapalila Creek. Interested anglers may be attracted to this area because the state fly-fishing record for a spotted bass (3.56 lbs) was set on this creek in 2004 [11].

1.5 Site Visit

Staff from ATSDR visited the Kerr-McGee site on several occasions. The initial scoping visit was conducted on October 28, 2002, after receiving the initial petition in July 2002. The purpose of the scoping visit was to observe activities at the site and to note the location of potential human receptors. ATSDR made additional visits to the site in April 2003, June 2006, November 2006, and June 2007. The purpose of these visits was to meet with key officials and community members who have knowledge of the site, to gather community health concerns, and to conduct public health education activities in the community. Public meetings were also held in April 2003, June 2006, and June 2007.

During the site visit in November 2006, the site team walked the fenceline and ditches adjacent to the site. The ditches along 14th Avenue, 7th Avenue, and Moss Street and the ditches behind the residential area near Waterworks Street were also observed. These drainage ditches contained approximately 2-3 feet of standing water at the time of our inspection. However, no children were seen playing in the ditches behind the residential houses. We followed the drainage ditch along 7th Avenue to the city park, Propst Park. At the time of our visit, the city was in the process of installing new drainage systems in the vicinity of the park. According to local residents, city employees encountered creosote contamination during excavation activities in this area and had to temporarily halt their activities. At the time of our visit, the drainage ditch appeared freshly dug and contained approximately 2-3 feet of standing water. No workers were observed at the excavation site at the time of our visit.

Staff made the following observations about current conditions at the site:

- The facility is closed and all structures on the site have been dismantled
- The areas surrounding the site are a mix of residential, commercial, and industrial properties
- The nearest school to the site is Hunt Intermediate School, which is approximately 200 feet southwest of the site
- The closest residential property is approximately 100 feet from the site boundary
- The unlined, open drainage ditches run throughout the neighborhood and oftentimes abut residential properties (See Figure 3 in Appendix A).

To date, ATSDR has:

- participated in community meetings, public availability sessions, and health education workshops;
- met with concerned citizens, community liaisons, and public officials to discuss the site;
- gathered environmental data and community concerns; and
- maintained active communications with involved stakeholders to keep informed of activities at the site, including facility operations, clean-up (removal) efforts, and activities that may result in potential impacts to human receptors.

2.0 ENVIRONMENTAL CONTAMINATION

An integral part of the evaluation of a site is the identification of relevant, site-specific environmental data. The findings in this document are based on sampling results obtained from parties that conducted investigations at the site. In the following sections, the results of the environmental sampling conducted at the Kerr-McGee site are discussed for each environmental medium of concern in this document.

2.1. Data Quality Evaluation

In preparing this report, ATSDR staff reviewed information provided by several sources. ATSDR reviewed environmental data from the contractors (ERM) representing Kerr-McGee Chemical Corp [6,7,12,13,14,15,16], contractors/scientists (Lundy & Davis) representing the plaintiff's side of a community lawsuit against Kerr-McGee [2,17,18,19,20,21,22,23,24], and a private third party [58]. ATSDR assumed that adequate quality control measures were followed with regard to chain-of-custody, laboratory procedures and data reporting. However, some of the plaintiff's data used in this report are from reports or materials that had no or limited quality assurance/quality control (QA/QC) information, and there may be some questions as to the validity and accuracy of the data.

ATSDR acknowledges that the validity of the analysis and the conclusions drawn for this assessment is determined by the availability and reliability of the referenced materials. However, the environmental data contained in this document is deemed sufficient for health assessment purposes.

2.2. Identifying Contaminants of Potential Concern

The reports and documents made available to ATSDR contain a list of all contaminants found in environmental media. In the included tables, concentrations of chemicals in each medium are compared to appropriate comparison values to determine which chemicals should be selected for further evaluation. Contaminant levels that do not exceed a comparison value are dropped from further analysis because these concentrations are too low to cause adverse health effects. A contaminant level found to exceed a comparison value indicates that a more detailed analysis is necessary for that chemical.

Those chemicals selected for further evaluation pose the greatest likelihood of contributing to potential health risks and are designated as contaminants of potential concern. (See Appendix E for a more detailed discussion of ATSDR's evaluation process).

Comparison values are used only to screen for chemicals that require further evaluation. Levels of contamination greater than these values do not necessarily mean that adverse health effects will occur. The amount of the chemical, the duration of exposure, the route of exposure, and the health status of exposed individuals are also important factors in determining the potential for adverse health effects.

Analytical results for soils and sediments collected during the various sampling events indicate that *polyaromatic hydrocarbons (PAHs), dioxins, and pentachlorophenol (PCP)* are the primary chemicals of potential concern at the site.

Concentrations of these chemicals exceed comparison values most often. Therefore, the following discussion focuses on these chemicals. Arsenic exceeds its applicable comparison value in some sediment samples; therefore, it will also be identified as a contaminant of potential concern for evaluation purposes.

2.3 Environmental Sampling

The nature and extent of contamination (environmental characterization) at the Kerr-McGee facility has been documented through previous investigations conducted by Kerr-McGee Chemical Corp. and by Lundy & Davis LLC, representing the plaintiff.

Kerr-McGee Environmental Data

From June 1996 to February 2002, Kerr-McGee conducted multiple phases of a RCRA field investigation (RFI) at the site. As part of its RCRA permitting process, Kerr-McGee was required to investigate and delineate impacted media associated with solid waste management units (SWMUs) at the Columbus, Mississippi facility [7]. The investigation occurred in three phases, which are summarized below.

RFI Phase I

The Phase I RFI, completed in November 1996, included on- and off-site ditch sediment sampling, groundwater sampling, and on-site surface soil sampling. (Groundwater sampling results are not discussed in this document because groundwater is eliminated as a potential exposure pathway; see discussion below.) Sediment samples were collected at each of the 5 discharge points (outfalls) at the facility boundary that collect surface-water run-off. Two sediment samples were collected from each outfall area: one sample was collected within the property at the beginning of the ditch (designated as sample "A") and the other was collected at the point at which the ditch left the property (designated as sample "B"). Surface soil samples were collected at locations most likely to receive releases from run-off. Sediment and surface soil sampling was conducted at areas identified as Solid Waste Management Areas (SWMAs) IV (creosote recovery system/wastewater treatment system), V (cooling tower basin), VII (black tie storage), and VIII (unlined drainage ditches that collect surface water runoff).

The analytical results indicated the presence of creosote constituents, mostly PAHs, in on-site surface soils at levels above health-based comparison values. PAHs were detected in surface soil samples from SWMAs IV, V, and VII (surface soil samples were not collected from SWMA VIII). Also, pentachlorophenol (PCP) was detected up to 1,000 ppm in on-site surface soil samples. On-site areas historically found to contain contaminated surface soil include the retort area, drip pad area (site of soil excavation/removal in 1988), tank farm area (site of soil excavation/removal in 1988), the recovery system/wastewater treatment system, the former cooling tower basin, and the black tie storage area.

The analytical results for the sediment samples (identified as 001A through 005B in Table 4 in Appendix B) indicate the presence of creosote constituents, mostly PAHs (up to 188 ppm BaP Equivalents^a), in each of the 10 samples. Pentachlorophenol (up to 20 ppm) was also detected in sediment samples. See Figures 4 and 6 in Appendix A.

RFI Phase II

The Phase II RFI, performed in March 1998, included an additional investigation of shallow soil and groundwater on-site. In July 1999, the Mississippi Department of Environmental Quality (MDEQ) conducted an investigation of the off-site drainage ditches downgradient of the facility in response to a request by the Maranatha Faith Center [7]. The samples (identified as MFC1 through MFC10 in Table 4 in Appendix B) were split between MDEQ and Kerr-McGee.

Analytical results for on-site surface soil samples indicated the presence of PAHs and PCP. Analytical results for sediments indicated the presence of PAHs (up to 50.2 ppm BaPE). Pentachlorophenol (PCP) was detected at concentrations up to 11 ppm in sediment samples. See Figures 4 and 6 in Appendix A.

Supplemental RFI Phase II

Kerr-McGee conducted a Supplemental Phase II investigation in February 2001 and February 2002 to further characterize sediment and surface water contained in off-site drainage ditches proximate to the site. During the February 2001 Supplemental Phase II investigation, Kerr-McGee collected 5 surface water samples from off-site ditches and 15 sediment samples (identified as SB-01A through SB-06B in Table 5 in Appendix B). Sediment samples were

^a In order to calculate the carcinogenic potential of the PAHs, each carcinogenic PAH is assigned a toxic equivalence factor (TEF), which is an estimate based on its relative potency to benzo(a)pyrene. The concentration of each PAH is multiplied by its TEF, and the sum of the products is described as the benzo(a)pyrene equivalent (BaPE). The following TEFs were used in the calculation of the BaPE:

benzo(a)anthracene	0.1
chrysene	0.001
benzo(b)fluoranthene	0.1
benzo(k)fluoranthene	0.01
benzo(a)pyrene	1.0
indeno(1,2,3-cd)pyrene	0.1
dibenz(a,h)anthracene	1.0

collected at different depth intervals (0-6 and 6-12 inch depth intervals) and at locations where there was an increase in sediment deposition [7]. Buried sediments (greater than one foot) were not evaluated because most people are not likely to come into contact with these deeper sediments.

The analytical results for the surface water samples indicate the presence of bis(2-ethylhexyl)phthalate in all 5 samples and indeno(1,2,3-cd)pyrene in one sample (See Figure 8 in Appendix A). Since bis(2-ethylhexyl)phthalate was also reported in rinsate blanks, it is reasonable to conclude that it is a laboratory contaminant^b, and will not be evaluated for potential toxicity. Analytical results for sediment samples indicate the presence of PAHs (up to 20 ppm BaPE) at each depth interval. Pentachlorophenol (PCP) was detected (up to 15.0 ppm) in 5 sediment samples. See Figures 5 and 7 in Appendix B.

During the February 2002 Supplemental Phase II investigation, Kerr-McGee collected 8 additional sediment samples (identified as SB-07A through SB-10B in Table 5 in Appendix B) from 4 locations historically identified as containing elevated contaminant levels. Analytical results indicate the presence of PAHs (up to 51.3 ppm BaPE) in these sediment samples. PCP was detected (up to 6.0 ppm) in 4 sediment samples. See Figures 5 and 7 in Appendix B.

Table 1 in Appendix B contains a list of all the contaminants detected in sediment samples during the Supplemental Phase II investigation, and shows whether the contaminants exceed their applicable comparison value (CV). Polycyclic aromatic hydrocarbons (PAHs) were detected most often in the sediment at levels above applicable comparison values. Pentachlorophenol was also detected at levels which exceeded the comparison value for that chemical. Therefore, PAHs (expressed as benzo(a)pyrene equivalents, BaPE) and PCP are retained as contaminants of potential concern in sediments.

Lundy & Davis Environmental Data

From 1999 to 2001, Lundy & Davis conducted several investigations (Phases I through V) to characterize off-site contamination near the Kerr-McGee facility. During these investigations, Lundy & Davis collected soil, sediment, and groundwater samples from several locations surrounding the facility, including residential areas. (Groundwater samples will not be included in this discussion since groundwater is eliminated as a potential human exposure pathway; see discussion below.) In addition to the major chemicals of concern, dioxin and furans were also analyzed in a selected number of samples.

Phase I

During the Phase I investigation, conducted September through November 1999, Lundy & Davis collected soil, groundwater, and ditch sediment samples from residential and commercial areas surrounding the Kerr-McGee facility. Soil samples were collected using a Geoprobe sampling device and were inspected for evidence of creosote materials. Continuous soil samples were

^b Laboratory contamination is defined as the inadvertent addition of target analytes to samples during the sample collection, transportation or analysis process.

collected at nine locations from ground surface to sufficient depth into the Eutaw formation. Specific sampling locations for soil samples included residential areas south (near N 7th Ave.), east (near Moss St.), north (near N. 14th Ave.) and west (near N. 13th Ave.) of the facility. Sediment samples (identified as DS-1 through 11 in Table 7 in Appendix B) were collected from 10 locations using grab samples and/or hand auger techniques. Sediment samples were collected from the portion of the ditch that extends downgradient from the Maranatha Faith Center property towards the city park. One ditch sample each was collected from a ditch between Moss Street and Waterworks Street, and in a shallow open drainage way bounding the Kerr-McGee finished tie storage yard (near N. 27th St). All samples were analyzed for semi-volatiles and total petroleum hydrocarbons (TPH). Selected samples were also analyzed for dioxin and furans.

Analytical results for the soil samples indicated the presence of low levels of PAH contamination in one sample collected at 14 feet below ground surface. ATSDR did not conduct further evaluations of these soil samples because 1) the concentration of PAHs is too low to cause health effects and 2) the subsurface depth makes the soil inaccessible to most people. No dioxins or furans were detected in the two soil samples tested. Analytical results for the sediment samples indicated the presence of low level PAH contamination (up to 0.22 ppm BaPE) in 7 of the 11 samples. No dioxins or furans were detected in the two sediment samples tested.

In the second field campaign in November 1999, additional ditch samples (identified as DS-12 through DS-21 (not including samples denoted with an A-E) in Table 7 in Appendix B) were collected from 10 locations between 14th St. and Waterworks Street. All samples were collected between 0 to 1 foot below ground surface. PAHs (up to 40.1 ppm BaPE) were detected in all of the 10 sediment samples. PCP was not detected in any samples. See Figures 9, 11 and 12 in Appendix A.

Phase II

Phase II, conducted in November through December 1999, represented a continuation of the work performed in Phase I. Lundy & Davis collected additional continuous soil and groundwater samples at 13 locations in proximity to the ditch sampling locations where the Phase I results indicated the highest concentrations of creosote materials. The sampling protocol was similar to that used in Phase I. Samples were analyzed for semi-volatiles and TPH. Selected samples were analyzed for dioxins and furans.

Analytical results for the soil samples indicated the presence of low levels of PAH contamination in one subsurface sample (out of 25 total samples) collected at 8 to 10 feet below ground surface. Because no significant contamination is indicated and because the subsurface depth makes the contamination detected in the one sample inaccessible to most people, these soil samples are dropped from further analysis and discussion in this document.

Phase III

Additional sediment samples were collected by Lundy & Davis during the Phase III investigation conducted in March 2000. Eight sampling locations along the ditch selected during the second field campaign of Phase II (DS-12 through DS-21) were re-sampled. Then further sampling was

conducted by moving outward laterally from the approximate location of the previous sample. Samples noted with an “A” were collected from the approximate centerline of the ditch. Samples noted with “B, C, D, E, or F” were collected approximately 10-100 feet laterally off the centerline of the ditch (identified as DS-12A through DS-21A in Table 7 in Appendix B). Additional sediment samples were collected at 5 locations between the Kerr-McGee facility and the Sanderson Plumbing facility (identified as DS-22A through DS-26A in Table 7 in Appendix B). Samples were collected at 0-2.5 feet below ground surface and were analyzed for volatiles and semi-volatiles; selected samples were analyzed for dioxins.

Analytical results for the sediment samples indicate the presence of PAHs above applicable comparison values. PCP was not detected in any samples. Dioxins were detected in samples up to a maximum of 10.1 ppb TEQs. See Figures 9, 10, and 11 in Appendix A.

Phase IV

During the Phase IV investigation conducted in May 2000, Lundy & Davis collected 6 sediment samples from a 1500 foot long ditch near Mills Street, and 6 sediment samples from a 300 x 500 foot impoundment area northeast of Mills Street. All samples were analyzed for volatiles and semi-volatiles.

Analytical results indicate the presence of PAHs in one sample from the ditch (0.85 ppm BaPE) and in 2 samples from the impoundment area (up to 8.6 ppm BaPE). Bis(2-ethylhexyl)phthalate was detected in two samples collected from the ditch (up to 0.8 ppm) and in three samples (up to 5.9 ppm) collected from the impoundment area. None of the bis(2-ethylhexyl)phthalate detections were above the applicable comparison value for the chemical.

Phase V

In March 2001, Lundy & Davis initiated Phase V of their investigation. They collected 39 samples from 18 locations near the facility. Twenty-six of the 39 samples were surface soil samples (identified as CS-1 through CS-38 in Table 6 in Appendix B); eight of the 39 samples were sediment samples (identified as CS-15 through CS-22 in Table 7 in Appendix B). The other five samples were of other bulk materials not classified as either surface soil or sediments, and were therefore not considered for further analysis in this document. Sampling locations included residential properties, public property, and commercial properties located in proximity to the Kerr-McGee facility.

Analytical results for the surface soil samples indicate the presence of low levels of PAHs (up to 1.2 ppm BaPE) in 8 of 26 samples collected. Pentachlorophenol was not detected in any surface soil samples. Analytic results for the sediment samples indicate the presence of PAHs (up to 29.6 ppm BaPE) in 7 of the 8 sediment samples collected. Pentachlorophenol (PCP) was detected in one sediment sample at a concentration of 0.28 ppm, which is below the applicable comparison value of 6 ppm for PCP. See Figure 10 in Appendix A.

Table 2 in Appendix B contains all contaminants detected in sediment during the various sampling events conducted by Lundy & Davis, and show whether the contaminants exceed their

respective comparison value. Polycyclic aromatic hydrocarbons (PAHs) were detected most often in the sediment at concentrations above applicable comparison values. Dioxins were also detected in selected samples above the applicable comparison value for dioxins. Arsenic was also detected at levels which exceeded the comparison value for that chemical. Pentachlorophenol was detected in only one sample at a level below its applicable comparison value. Therefore, PAHs (expressed as benzo(a)pyrene equivalents, BaPE), arsenic and dioxins are retained as contaminants of potential concern in sediments.

Table 3 in Appendix B contains all contaminants detected in surface soil during the various sampling events. PAHs and arsenic were detected in surface soil samples at concentrations that exceed their applicable comparison values; therefore, these chemicals are retained as contaminants of potential concern in surface soil.

Private Third Party Environmental Data

In May 2008, a private third party collected sediment samples from 3 locations in the ditch near the Maranatha Church. The sampling results were submitted to ATSDR for evaluation. (The exact sampling locations and methods were not included in the submitted report.) Analytical results indicate the present of PAHs, up to 5.1 BaPE in one of the three samples. Therefore, PAHs were retained as a contaminant of potential concern in sediment based on this sampling.

3.0 PATHWAYS ANALYSIS

ATSDR's public health assessment analyses are based on exposure to, or contact with, an environmental contaminant. Contaminants released into the environment have the potential to cause harmful health effects. However, 1) *not every release results in an exposure* and 2) *not every exposure results in harmful health effects*.

People can only be exposed to a contaminant only if they breathe it in (inhale), ingest it, or come into skin contact (dermal) with the substance. If no one is exposed to a contaminant, then no health effects can occur. Additionally, harmful health effects will not occur with every exposure. The type and severity of health effects a person may experience depend on a number of variables, including 1) the exposure concentration (how much chemical), 2) the exposure frequency (how often), 3) the exposure duration (how long), and 4) the route or pathway of exposure. 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.

3.1. Exposure Pathways Defined

An exposure pathway is the process by which an individual is exposed to contaminants that originate from some source of contamination. The route of a contaminant's movement through the environment is the pathway. ATSDR identifies and evaluates exposure pathways by

considering how people might come into contact with a contaminant. ATSDR identifies exposure pathways by the following 5 elements:

1. a source of contamination
2. transport through the environmental medium
3. a point of exposure
4. a route of human exposure
5. a receptor population

ATSDR categorizes an exposure pathway as completed or potential, or eliminates the pathway from further evaluation.

Completed exposure pathways exist for a past, current, or future exposure if contaminant sources can be linked to a receptor population. All five elements of the exposure pathway must be present. In other words, people have or are likely to come in contact with site-related contamination at a particular exposure point via an identified exposure route. For an exposure to occur, a completed pathway must exist. Completed pathways require further evaluation to determine if exposures are likely to result in adverse health effects.

Potential exposure pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future.

A pathway is potential if one or more of the five elements is missing but available information indicates possible human exposure. A potential exposure pathway cannot be ruled out, even though not all of the five elements are identifiable.

An exposure pathway can be *eliminated* if at least one of the five elements is missing. Eliminated exposure pathways can be ruled out if the site characteristics make past, current, and future human exposures extremely unlikely.

The tables below show the completed, potential and eliminated exposure pathways for this site.

A *source* of contamination is the place where the contamination was released. The *environmental medium* is the groundwater, soil, sediment, surface water, air, or biota that may serve to transport contaminants from the source to possible points of human contact. The *point of exposure* is the place where people come into contact with the contaminated media. The *route* is the means by which contaminants enter the human body. The *receptor population* is the population that is exposed or potentially exposed to contaminants through identified exposure routes.

3.2 Completed Exposure Pathways*

Completed exposure pathways associated with the Kerr-McGee Site are summarized in Table A below:

Table A. Completed Exposure Pathways*

Pathway Name	EXPOSURE PATHWAY ELEMENTS					Time
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population	
On-Site Soils	Past releases from wood treating operations at the Kerr-McGee facility	Surface soil; waste products	On-site	Dermal Ingestion Inhalation	Former employees, remedial workers, trespassers	Past
Sediment		Sediment	Nearby drainage ditches or creek/streams that receive runoff from the site; on-site drainage outfalls	Dermal Ingestion	Children playing in or crossing contaminated ditches or creeks; adults who contact contaminated sediments	Past Present Future
Surface Water		Surface Water	Nearby ditches or creek/streams that receive runoff from the site; on-site drainage outfalls	Dermal Ingestion	Children playing in or crossing contaminated ditches or creeks; adults who contact contaminated surface water	Past Present Future

**Note: Ambient air is a past completed exposure pathway that is addressed by ATSDR in a separate document.*

a. On-Site Surface Soil

A completed pathway for on-site soil existed in the past. As part of their previous investigations, Kerr-McGee determined that creosote constituents, including PAHs and PCP, were present in on-site surface soils at levels that exceed applicable comparison values.

Past exposures were likely from contact with contaminated on-site soils. Incidental ingestion of, inhalation of, and dermal contact with soil are considered primary routes of exposure, particularly for workers on the site who were involved in remediation, and for residents who trespassed on the site, particularly children. (Ingestion of, and dermal contact with soil is often considered an exposure route that applies only to young children. However, adults are known to

inadvertently ingest small amounts of soil through direct contact with soil and subsequent inadvertent ingestion through associated hand-to-mouth contact.) When the facility was operating, employees who worked at the facility likely inhaled contaminants in the air, absorbed contaminants through their skin, and ingested contaminants via hand-to-mouth activities. These exposures likely occurred while workers were performing their work-related duties. According to personal accounts from individuals who previously worked at the facility and their families, facility workers often came in contact with the various chemicals used in the wood-treating operations. Workers reported being covered in chemicals and bringing their dirty clothes home to be laundered, thereby potentially exposing their families. However, the contaminants and their concentrations in the environment were not measured; therefore, no estimate of actual exposures can be made. (Note: Air exposures are evaluated in a separate document by ATSDR.)

Actions Taken to Reduce Exposures

The Kerr-McGee facility was closed at the end of 2003. Currently, all but the eastern entrance of the facility is protected by a fence, which should limit and/or reduce the amount of trespassing on the site. Kerr-McGee has performed source removal of impacted on-site soils in selected areas, including the former drip pad area, tank farm area and black tie storage area [7]. Kerr-McGee excavated and removed impacted soil and back filled the areas with clean soil. In addition, Kerr-McGee constructed a concrete secondary containment around the tank farm and constructed a drip pad in 1988. The removal of these source areas reduces the potential for on-site exposures and continuing contaminant releases to soil and the subsequent overland transport (e.g., via surface water runoff or wind dispersion) of these contaminants to off-site locations.

However, the fate of the property has not yet been determined. Future exposures to the on-site soils, including soil gas, could occur to workers and others if the property is redeveloped for other industrial, commercial, or residential uses. Future exposures could also occur to trespassers if access is not monitored or the fence is not maintained. Therefore, this pathway should be re-evaluated as additional information becomes available about the fate of the property.

b. Ditch Sediments

A completed exposure pathway that existed in the past, and that may continue to the present and future, was exposure to ditch sediments. In previous investigations, Kerr-McGee collected sediment samples from nearby ditches (including residential and industrial/commercial locations) and from discharge points at the facility boundary (stormwater at the facility flows into an on-site ditch system and is directed to designated outfall locations) [7]. Sampling results indicated the presence of PAHs and PCP above applicable comparison values in both surface and subsurface sediments. Lundy & Davis also collected sediment samples from several off-site locations, including Sanderson Ditch; ditches along 7th Avenue, Moss Street, and 14th Avenue; and a ditch near an impoundment area. These sampling results also indicate the presence of contaminants in sediment, including dioxins, at levels above applicable comparison values.

During the public meetings and availability sessions held by ATSDR, many people reported having played in the ditches in the community during their childhood. They also complained that the ditches closest to the site were dirty, malodorous, and were making their children sick when

they played in them. Residents reported that the ditches occasionally overflowed, causing contamination to move outward from the ditches into surrounding residential yards and properties.

Contact with contaminated sediment could create exposure through dermal (skin) contact and through incidental ingestion. The primary exposed population would be children who live near the site who played in the ditches in the past or who currently play in the ditches. Other exposures could occur from residents coming into contact with contaminated sediments washed into their yards through flooding, or from touching creosote material that collects in the bottom of the ditches or is washed into yards by rainfall runoff. Figure 16 in Appendix A shows a photograph of the one of the downstream ditches and the proximity of the ditch to housing in the community.

Actions Taken to Reduce Exposures

In September 2004, Kerr-McGee removed approximately 1,800 linear feet of contaminated sediment from four areas within the drainage ditches bordering the facility. The four excavated areas are shown in Figure 13 in Appendix A. Excavation area 1 is located in the northwestern part of the Kerr-McGee property. Excavation area 2 is located outside the Kerr-McGee property, south of 14th Avenue and west of the railroad. Excavation area 3 is located south of 14th Avenue and east of railroad line. Excavation area 4 is located between the two railroad lines, cutting west onto the facility property. Confirmatory samples were collected from the excavation areas to ensure that residual contamination, if any, did not exceed the target cancer risk of 1×10^{-4} . Removal of these sediments reduces exposures to children playing in these areas of the ditches or adults who might contact the sediments washed into their yards.

Levels of contaminants were likely higher in the past before the ditches were remediated (excavated) by Kerr-McGee. Possible current and future exposures to contaminated sediments can occur at this site if 1) children come into contact with sediments in un-remediated areas of the ditch drainage system or 2) people come into contact with subsurface (buried) contamination while digging in or excavating contaminated areas.

c. Surface Water

A completed pathway associated with the site is exposure to contaminated surface water contained in drainage ditches. As previously reported, an extensive network of unlined drainage ditches runs throughout the community. Some of these drainage ditches receive discharge from the facility^c and contain standing water. The facility is located within the drainage basin of the Luxapalila Creek, which is located 0.5 miles east of the facility. Luxapalila Creek is classified as a public water supply upstream of the facility. The downstream portion of the creek is classified for fish and wildlife support and for incidental recreational use during the months of May through October.

^c The facility had a National Pollution Discharge Elimination System (NPDES) permit to regulate pollutant discharges from the facility into surface waters. Stormwater runoff from the facility is handled by a series of unlined ditches which flow into five permitted NPDES outfalls.

Residual sediment contamination has been detected in drainage ditches that drain from the facility toward Luxapalila Creek [19]. Additionally, in the future, these drainage ditches could receive subterranean seepage of creosote wastes that appear to have infiltrated into the soil. During the public meetings and public availability sessions held by ATSDR, residents expressed concern about coming into contact with contaminated water in the ditches and in Luxapalila Creek.

People could be exposed to surface waters if they had contact with water in contaminated ditches or creeks. If persons had contact with the creek water during activities such as swimming or wading, they could have been exposed to the contaminants via skin (dermal) contact or incidental ingestion.

ATSDR evaluated only a limited amount of sampling data for surface water. Two contaminants, bis(2-chloroisopropyl) ether and indeno(1,2,3-c,d)pyrene, exceeded their respective comparison values in surface water samples (See Table 8 in Appendix B). The lack of creosote constituents, such as PAHs, in surface water suggests that the PAHs are adsorbed to the sediments and have low solubility in water.

3.3. Potential Exposure Pathways

Potential exposure pathways associated with the Kerr-McGee Site are summarized in Table 2 below:

Table 2. Potential Exposure Pathways

Pathway Name	EXPOSURE PATHWAY ELEMENTS					Time
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population	
Off-site Surface Soil	Past releases from wood treating operations at the Kerr-McGee facility	Soil	Nearby Residential yards, playgrounds	Dermal Ingestion Inhalation	Residents, children, gardeners, or anyone working in the contaminated soils	Past Present Future
Residential Dust		Dust	Residential Home	Inhalation Ingestion	Occupants of homes with contaminated dust	Past Present Future

a. Residential (off-site) Surface Soils

Residents have expressed concerns about periodic flooding occurring in the residential neighborhoods surrounding the site. Flooding would cause the contamination to spread out of the ditches into residential yards and properties.

Residential surface soil samples were collected as part of the Phases V sampling investigation performed for Lundy & Davis [21, 23]. PAHs, constituents in creosote, were detected in residential soil samples.

The Phase V samples were collected to the north and west of the site; most samples were not taken in the most potentially impacted residential areas near ditches. Because of the limited number of residential soil samples near the ditches, ATSDR cannot rule out that contamination has spread out of the ditches into residential yards.

Exposure could have occurred in the past, and could continue into the present and future, through ingestion of or dermal contact with contaminated surface soil in residential yards. Since children play in their yards and adults engage in gardening, yardwork or other activities in their yards, they may have been exposed to some contaminated soil. Because so few samples were taken in potentially impacted residential yards, this pathway cannot be eliminated as a potential exposure pathway.

Residents also expressed concern about ponds that received contaminated runoff from the plant outside the plant boundaries. These ponds, according to residents, were filled in and homes were built on top of them. Some community members complain that they still smell creosote odors when they dig in their gardens. To investigate this concern, ATSDR reviewed aerial photographs of the site from 1952, 1974, 1980, 1985, and 1992 (See Figure 18 in Appendix A). Making conclusions about the presence of contamination based on aerial photography alone is difficult. We do note the construction of residential houses north of the site between 1952 and 1974. There also appear to be some ponds that had been located in this area. Residents who are concerned that there is contamination from the facility on their property should contact EPA at 1-800-241-1754 and ask for the remedial project manager for the Kerr-McGee site (currently Russ McLean) to discuss their concerns.

b. Residential Dust (Indoors)

Residential dust present in people's homes was collected and analyzed. These results were reported by Dahlgren *et al.* [2]. Screening analysis of the contaminants detected is presented in Tables 11 and 12 in Appendix B. An analysis was performed to identify the levels of specific PAHs found in a selected number of samples. Additionally, dioxin wipe samples were reported by Dahlgren *et al.*, and the results are presented in Table 13 in Appendix B.

Because of the presence of PAHs and dioxins in residential dust, an exposure pathway via inhalation may have existed. A secondary pathway existed via incidental ingestion or dermal contact if people touched a contaminated surface with their hand and then transferred the contamination to their mouth.

3.4. Eliminated Exposure Pathways

Eliminated exposure pathways associated with the Kerr-McGee Site are summarized in Table 3 below:

Table 3. Eliminated Exposure Pathways

Pathway Name	EXPOSURE PATHWAY ELEMENTS				
	Source	Environmental Media	Point of Exposure	Potentially Exposed Population	How Eliminated
Tap Water	Past releases from wood treating operations at the Kerr-McGee facility	Water	Residential faucet/tap	Residents who receive public drinking water	<i>No elevated levels of chemicals in tested tap water</i>
Groundwater Private wells		Water	Residential or industrial wells	Residents who use wells for potable purposes	<i>No one currently using private wells for potable purposes</i>
Biota		Fish	Dinner Table	People who eat fish caught from nearby creeks	<i>No elevated levels of chemicals in tested fish</i>
Buried Sediments		Sediment	Areas of ground excavation or digging; above-ground seeps	Workers or others who contact contaminated sediments	<i>No one (except trained workers) coming into contact with below ground sediments</i>

a. Drinking Water

Despite the fact that most community members are connected to the public water system, the community reported concerns about its drinking water supply. Residents complain of black residues in their water and foul odors emanating from their drinking water. The intake for the

community water is located directly upstream of the locations where the ditch connecting Kerr-McGee drains into the creek. ATSDR requested and received municipal well testing data from Columbus Light and Water and the Mississippi Department of Health to investigate this potential concern. The submitted data (for years 2000–2006) did not reveal contamination in the municipal supply wells at levels above applicable drinking water standards or EPA's Maximum Contaminant Levels (MCLs). Lead was detected in one well (in year 2000) at a level (16 ppb) that slightly exceeds ATSDR's action level of 15 parts per billion (ppb) for lead in drinking water. However, it is difficult to determine whether this well is experiencing on-going contamination or whether this result was a one-time event. The source of the lead contamination should be identified and removed (if present), and proper follow-up actions should be undertaken to reduce exposures to lead.

In April 2008, ATSDR conducted an exposure investigation (EI) to determine if resident's drinking water was contaminated with site-related chemicals. During the EI, ATSDR collected and analyzed tap water samples from 13 residential homes near the site. Homes were selected for testing based on the distance of the home from the site, the age of the home (as an indication of age of the pipes), and the distance of the home from the city water treatment plant. ATSDR tested for minerals and for pollutants found in the soil near the Kerr McGee site. The results revealed no harmful chemicals in the tested tap water. Therefore, public drinking water is eliminated as a potential exposure pathway at this site.

b. Groundwater/Private Wells

Past releases from the Kerr-McGee facility have contaminated groundwater at concentrations above applicable health-based comparison levels [7]. The RCRA facility investigation identified that the alluvial and Eutaw aquifers underneath the facility are contaminated with chemicals from the wood-treating operations [57]. While contamination is present in the groundwater beneath the facility, this pathway is incomplete because no one is currently drinking the contaminated groundwater.

Kerr-McGee has conducted extensive field investigations to delineate on- and off-site groundwater contamination at the site. Past groundwater monitoring programs have shown that releases from former operations at the facility have impacted local groundwater quality [6]. Two separate contaminant sources are present at the facility which produced separate free product plumes. The contaminant plumes are composed of both free creosote product and dissolved constituents. The western free product plume extends from the facility production process area southward toward 7th Avenue, and may be present in the vicinity of 23rd Street [6]. The eastern free product plume extends from the vicinity of the railcar loading and unloading area toward Moss Street [6]. Groundwater sampling results reveal the presence of creosote constituents such as PAHs and phenols, and xylenes and PCP.

A corrective action plan was instituted under EPA guidance. The facility uses a number of methods to intercept groundwater contamination, such as recovery trenches and recovery wells.

This pathway is currently incomplete as a potential exposure source because few, if any, people in the area utilize private groundwater wells for potable purposes. Most residents near the site are served by the municipal water supply from the City of Columbus. A GIS map showing private, public, and permitted wells is shown in Figure 17 in Appendix A. Groundwater use

downgradient of the facility is from much deeper aquifers that have no hydraulic connection with the alluvial aquifer system [6].

There is significant contamination of groundwater beneath the site. The uppermost alluvial and the Eutaw aquifers underlie the plant site and are contaminated. The Eutaw aquifer is a source of both industrial and domestic water supplies on a regional basis [7]. Future development of the site may require installing a new well or re-commissioning the use of a currently contaminated well. Therefore, this pathway should be re-evaluated as additional information becomes available about the future development of the site.

c. Biota

The Luxapalila Creek, located approximately 0.5 miles east of the site, is the largest perennial drainage in the vicinity of the facility (September 2002). Luxapalila Creek is classified for fish and wildlife support downstream of the facility. Some community members have expressed concern about the ditches discharging into the Luxapalila Creek, which is used for recreational fishing. Contaminated sediments or surface water may have washed into the creek and may have been a source of dioxin and dioxin-like compounds to the food chain. Bioaccumulation of site-related contaminants in fish and other aquatic organisms is possible under this scenario. Since these compounds are concentrated in higher trophic species, there is a potential for exposure.

ATSDR did not have data about the levels of contamination in fish species, nor in sediments in Luxapalila Creek, to evaluate this potential exposure pathway. Therefore, ATSDR conducted an Exposure Investigation (EI) in June 2008 to determine if fish in the Luxapalila Creek have been impacted by site-related contaminants. During the EI, ATSDR collected fish from the creek to test for dioxins. The analytical results indicate that the fish in Luxapalila Creek do not contain elevated levels of dioxins. Therefore, this potential exposure pathway is eliminated from further evaluation.

d. Buried Sediments

Some community members expressed concern about the city finding subsurface creosote contamination while digging in the drainage ditches near their homes and the city park (Propst Park). Because this contamination is beneath the ground, most people, other than those engaged in earth-moving activities, should not come into contact with this subsurface contamination. Buried sediments can be eliminated as a potential exposure pathway so long as 1) excavation or other earth-moving activities do not uncover and expose the contaminated sediments, 2) naturally-occurring seeps do not allow the contamination to move to the surface, and 3) subsurface vapors do not infiltrate aboveground structures.

4.0 PUBLIC HEALTH IMPLICATIONS

In this section, ATSDR discusses the health effects that could possibly result from exposures to contaminants at the Kerr-McGee site. For a public health hazard to exist, people must contact contamination at levels high enough and for long enough time to affect their health. The environmental data and conditions at the site revealed three completed exposure pathways – contact with on-site soils, off-site ditch sediment and surface water. However, because the

contaminants and their concentrations in the work environment were not measured, no estimate of past exposures to on-site soils can be made. Therefore, the following section discusses the public health implications of the ditch sediment and surface water exposure pathways.

For chemicals found to exceed comparison values, ATSDR performed calculations referred to as exposure doses (or the amount of a contaminant that gets into a person's body) and cancer risk estimates. These calculations estimate the amount of the chemicals of concern that individuals may have been exposed to and the likelihood of cancer and non-cancer health impacts. The calculations are based on the types of activities that individuals may be involved in that result in contact with contaminated media. Calculated exposure doses were compared with the available health guidelines to determine whether the potential exists for adverse non-cancer health effects. Information about the increased risk of cancer from exposure to these chemicals is also provided in each exposure scenario. In the event that calculated exposure doses exceed established health guidelines (e.g., ATSDR Minimal Risk Levels or EPA Reference Doses), an in-depth toxicological evaluation is necessary to determine the likelihood of adverse health effects.

The primary contaminants of potential concern at this site are polycyclic aromatic hydrocarbons (PAHs), expressed as benzo(a)pyrene equivalents (BaPE), dioxins, expressed as 2,3,7,8-TCDD toxicity equivalent quotients (TEQs), and pentachlorophenol (PCP). A summary of the calculated exposure doses (for non-cancer health effects) and cancer risk estimates is presented in Tables 8 and 9 in Appendix B.

A1. Ditch Sediment: Pre- Removal Health Implications

The Kerr-McGee facility was closed at the end of 2003. In September 2004, Kerr-McGee removed approximately 1,800 linear feet of contaminated sediment from four areas within the drainage ditches bordering the facility. This section evaluates sediment samples gathered prior to Kerr-McGee completing the 2004 removal action.

Both Kerr-McGee and Lundy & Davis data indicate the presence of chemicals potentially associated with the past operations of the Kerr-McGee facility. The detection of pentachlorophenol (PCP) in sediment samples gives an indication that in the past, releases from the facility contaminated sediment in ditches surrounding the facility. The source of the polychlorinated aromatic hydrocarbon (PAH) contamination is less certain, since these ditches are located near roadways and motor vehicle traffic, asphalt paving, and other man-made sources that can contribute to PAH loading near roadways.

Dioxins^d have been detected in sediment samples from the ditch in samples collected by Lundy & Davis [2]. The source of dioxin and dioxin-like compounds is also difficult to determine with complete certainty. The source of the dioxins could be historical plant operations that used PCP, since manufacturing of this chemical also results in production of chlorinated dibenzo-dioxins

^d For simplicity, the term "dioxins" is used generically throughout this document to describe any mix of TCDD and dioxin-like compounds.

and chlorinated dibenzo-furans [26]. However, the same congeners^e are associated with burning trash and burning tires. While the source of all the dioxins is not completely certain, the presence of dioxins is not unexpected, given the fact that ATSDR has evaluated other wood-treating sites where dioxins are present in off-site surface soil and ditch sediments [27].

PCP was detected in some areas of the ditch [7]. However, there are some types of dioxin (e.g. 2,3,7,8-tetrachlorodibenzodioxin, or TCDD) that are not seen in technical-grade PCP [28]. Sediment samples from the ditch were tested for dioxins by Lundy & Davis. One important note is that for most of the dioxin samples, congener-specific data were not reported. Therefore, transformation of the data using the new WHO 2005 TEFs (Toxicity Equivalent Factors)^f is not possible. It is unclear whether calculating TEFs with the new WHO 2005 TEFs would significantly change the dioxin levels reported.

As part of their exposure assessment of community members near the site, Dahlgren *et al.* presented results of blood dioxin testing of 10 residents who had lived near Kerr-McGee for more than 25 years. [2]. Dioxin blood levels, expressed in WHO 1998 TEQs, ranged from 19.6–37.1 parts per trillion (ppt). Dahlgren *et al.* did not discuss how these persons could have been exposed to dioxin-like compounds from the Kerr-McGee facility, or what other potential exposures to dioxins could have existed in their lifetimes. Therefore, we cannot infer a site-specific completed exposure pathway from the dioxin blood testing data alone, because people typically have measurable levels of dioxins in their blood from the multiple sources of dioxin-like compounds in our environment [29,30]. For instance, one recent study found that for persons aged 45 through 59, dioxin-blood levels (in WHO 1998 TEQs) ranged from 0.8–55.4 ppt [31].

Examining the congeners of the blood data yields mixed and inconclusive fingerprinting results. Technical grade PCP contains OCDD, with lesser amounts of HpCDDs, OCDF, and HpCDFs. TCDD concentrations are generally very low or are not detectable [28]. Paepke found that workers exposed to chlorinated phenol had the highest TCDD blood levels of any occupation and that those levels remained elevated 36 years after exposure [32]. The Kerr-McGee residents reported in Dahlgren *et al.* were all below CDC's assessment of the 95th percentile of African Americans over 20 yrs of age, indicating that the TCDD portion of the fingerprint was not significantly elevated in the Kerr-McGee population [33]. Although OCDD, the predominant congener in PCP, which is highest in woodworkers, was found higher than average in the 10 residents who lived near Kerr McGee, it is also the most abundant congener found in population surveys [32, 33, 34]. Furthermore, there is evidence of a different dioxin source of exposure since 1,2,3,6,7,8 HxCDD was also elevated in the community while TCDD, OCDF, and HpCDF were not. As noted, Dahlgren *et al.* did not discuss exposure pathway information for these samples, so that we cannot infer a completed exposure pathway from the facility on the basis of these blood data alone. However, on the basis of site-specific data, we recommend that EPA

^e The family of chlorinated dibenzo-dioxins (CDDs) and chlorinated dibenzo-furans (CDFs) contain a class of structurally similar congeners, ranging from monochlorinated (MCDD, MCDF) through octachlorinated (OCDD, OCDF).

^f TEFs were developed to facilitate comparison of the relative toxicity of individual dioxin-like compounds to that of TCDD (the most studied dioxin congener), on the assumption that dioxin and dioxin-like compounds act through the same mechanism of action.

conduct further sampling for dioxin-like compounds in residential yards to ensure that the public is not being exposed to dioxin-like compounds.

1. Dioxins

The approximate locations of samples that were analyzed for dioxin-like compounds are shown in Figure 11 in Appendix A. For purposes of our analysis, children were assumed to be exposed for 182 days per year for 7 years. Adults were assumed to be exposed for 182 days per year for 30 years. For children who played in these locations, ATSDR calculated doses ranging from 2.89×10^{-8} milligrams per kilogram per day (mg/kg/day) to 1.22×10^{-7} mg/kg/day TEQs. This dose exceeds ATSDR's chronic oral Minimum Risk Level (MRL) of 1.00×10^{-9} mg/kg/day.

The calculated adult doses ranged from 7.28×10^{-9} to 3.1×10^{-8} mg/kg/day TEQs. The adult doses also exceed ATSDR's MRL. It is worth noting that ATSDR's MRL is about one to two orders of magnitude below any effect levels demonstrated either experimentally or in epidemiologic studies for both cancer and non-cancer health end-points [30].

A Minimum Risk Level (MRL) is an estimate of daily exposure to a contaminant below which non-cancerous health effects are unlikely to occur.

The estimated child low dose is one order of magnitude greater than and the estimated child high dose is two orders of magnitude greater than ATSDR's oral chronic Minimum Risk Level (MRL) of 1.0×10^{-9} mg/kg/day for TCDDs. The estimated adult low dose is approximately 7 times greater than, and the high dose is one order of magnitude greater than, the MRL. Because all of the adult and child doses were greater than the MRL, ATSDR next compared the doses to known toxicological values, starting with the LOAEL used to derive the MRL. The calculated child doses are approximately 1 to 4 times greater than the Lowest Observed Adverse Effect Level (LOAEL) of 1.2×10^{-7} mg/kg/day. Therefore, it is likely that the level of TCDDs in sediment posed a public health hazard to children who played in the ditch sediment.

Using the same analysis as above, ATSDR compared the adult doses to known toxicological values. The calculated adult doses are approximately 3 to 16 times greater than the LOAEL. Therefore, adults may similarly be at risk from exposure to ditch sediment.

Developmental and reproductive health effects have been noted in animal studies at doses close to the doses for the children exposed here [30]. At higher dioxin exposure doses, additional animal studies found more serious developmental and reproductive effects, such as endometriosis and reproductive problems [30].

TCDD is classified by EPA as a probable human carcinogen. The World Health Organization (WHO) has determined that TCDD is a human carcinogen [30]. The US Department of Health and Human Services (DHHS) has determined that TCDD may reasonably be anticipated to cause cancer [30]. The estimated child dose (1.2×10^{-7} mg/kg/day) is close to the effect level of 1.4×10^{-7} mg/kg/day that caused tumors in rats. Therefore, the increased risk for developing cancer

from exposure (ingestion and dermal contact) to dioxins in sediment was also considered. Theoretical lifetime cancer risks were calculated for an adult and a child. The predicted theoretical increased cancer risk for an adult would be low to moderate, or approximately 5×10^{-4} (or 5 cancers per 10,000 people exposed) to 2×10^{-3} (or 2 cancers per 1,000 people exposed), respectively. For a child, the predicted theoretical increased risk for cancer would also be low (5×10^{-4}) to moderate (2×10^{-3}). Cancer risks less than 1 in 10,000 are usually not considered a health concern.

Exposure to dioxins has been associated with an increased risk of cancer cases overall, but only in highly exposed workers with long latency periods [30]. The evidence for specific types of cancer from dioxin exposure is insufficient, although some data suggest a relationship between soft-tissue sarcoma, non-Hodgkin's lymphoma, and respiratory, thyroid, and liver cancer [30]. Many of the available studies found small relative risks and did not control for the possible impact of confounding factors [30].

2. Polycyclic Aromatic Hydrocarbons (PAHs)

Creosote is a complex mixture of many chemical compounds, including PAHs.⁸ Because PAHs exist in complex mixtures of different chemicals, the assessment of potential health effects is difficult. One approach that has been used is to calculate benzo(a)pyrene equivalents (BaPE) utilizing the toxicity equivalency factors (TEFs). In order to calculate the carcinogenic potential of the PAHs, each carcinogenic PAH is assigned a TEF, which is an estimate based on its relative potency to benzo(a)pyrene. The concentration of each PAH is multiplied by its TEF, and the sum of the products is described as the benzo(a)pyrene equivalent (BaPE). For this evaluation, ATSDR used the TEF method to assess potential health effects associated with exposure to PAHs.

During our meetings with the community, many members complained of dermatological effects. Some dermatological effects could be associated with exposure to creosote-contaminated sediments. Creosote workers report skin rash symptoms as their most frequent complaint, as well as a high rate of photosensitivity [38]. The dermatological system is particularly vulnerable to the effects of creosotes [38]. In an industrial health survey (cited earlier) involving 251 employees at 4 wood preservative plants where coal tar creosote and coal tar is used, there were 82 reported instances of dermal effects, ranging from mild skin irritation, eczema, and folliculitis to benign skin growths such as warts [38]. Skin irritation was described as a redness like a sunburn, lasting 2 to 3 days, along with photosensitivity that has been reported by workers who handle coal tar pitch products outdoors [38]. Dermal effects were also noted as part of a site surveillance program conducted by the Texas Department of Health involving residents living in a housing development that was built on part of an abandoned creosote wood treatment plant (Koppers Company, Texarkana, Texas) [39]. Residents reported a much higher prevalence of skin rashes in general (27.9%) during the first year of the survey compared to the prevalence of the control neighborhood (4.9%). Rashes were most often associated with digging in the yard, having contact with the soil, or wading in or having contact with a creek in the area. Most of these rashes were associated with significant itching or burning. In the Dahlgren *et al.* health

⁸ The major chemicals in creosote that can cause harmful health effects are PAHs, phenol, and cresols. Only PAHs were detected at levels above health-based guidelines at this site. Therefore, ATSDR evaluated exposure to PAHs.

study, there were significant differences between exposed individuals compared to the control population in the reporting of skin rashes following sun exposure (29.0% exposed vs. 5.0% controls) [24].

Several PAHs, including benzo(a)pyrene, have been found to cause tumors in laboratory animals when they breathed these substances in air (lung and respiratory cancer), when they ate them (gastric tumors), or when they had long periods of skin contact with them (skin cancer). Human studies showed that people who breathed or had skin contact with PAHs for long periods also developed cancer. Workers who had long-term skin contact with creosote, especially during wood treatment or manufacturing processes, reported increases in skin cancer and cancer of the scrotum. Cancer of the scrotum has been associated with long-term exposure to soot and coal tar creosotes of chimney sweeps. Animal studies have also shown an association between creosote exposure and skin cancer [38].

ATSDR calculated exposure doses for PAHs using the average and highest concentrations detected in sediment. The child exposure doses ranged from 1.22×10^{-5} (or 0.0000122) milligrams per kilogram per day (mg/kg/day), to 2.2×10^{-4} (or 0.00022) mg/kg/day. The adult doses for PAHs ranged from 2.7×10^{-6} (or 0.0000027) mg/kg/day to 4.8×10^{-5} (or 0.000048) mg/kg/day.

No acute or chronic Minimal Risk Levels (MRLs) have been derived for PAHs because no adequate human or animal dose-response data are available that identify threshold levels for appropriate non-cancer health effects. However, intermediate-duration oral MRLs of 0.4 mg/kg/day have been derived for fluoranthene and for fluorene; both were based on Lowest Observed Adverse Effect Levels (LOAELs) of 125 mg/kg/day for increased relative liver weight in male mice [38].

The estimated child and adult doses are several orders of magnitude lower than the most conservative MRL of 0.4 mg/kg/day. Therefore, it is unlikely that any non-cancerous adverse health effects would occur in children or adults.

DHHS has determined that some PAHs (including benzo(a)pyrene) are known animal carcinogens. The International Agency for Research on Cancer (IARC) and the US Environmental Protection Agency (EPA) have also indicated that several PAHs are probably carcinogenic to humans. Cancer classification information for all PAH compounds is unavailable [38].

ATSDR calculated that the theoretical excess cancer risk from exposure to the maximum concentration of PAHs in sediment is approximately 2 cancer cases per 10,000 individuals exposed (or 2×10^{-4}). The excess cancer risk slightly level exceeds the generally accepted level of 1 in 10,000 (or 1×10^{-4}). Therefore, there is a slightly increased theoretical cancer risk for children who frequently^h played in the ditches.

3. Arsenic

^h This conclusion is based on the assumption that a child was exposed to ditch sediment for 182 days a year (6 months) for 7 years.

Arsenic concentrations in sediment samples exceeded the applicable comparison value for arsenic. However, the arsenic levels were within the range of background levels of arsenic in soils in the United States. Here, sediment arsenic levels ranged from non-detect to 8.3 parts per million (ppm), with an average of 3 ppm. Typically, arsenic in soil ranges from 1 to 40 ppm, with an average level of 5 ppm [40]. Calculated exposure doses for adults and children were below applicable health-based guidelines. Therefore, adverse health effects are not expected from exposure to arsenic in sediments near the site.

4. Pentachlorophenol (PCP)

PCP was widely used as a pesticide and wood preservative until 1984, when its use was restricted to certified applicators [41]. It is no longer available to the general public, but it is still used industrially as a wood preservative for utility poles and railroad ties [41]. PCP is a manufactured chemical that does not occur naturally [41].

Long-term exposure in the workplace to large amounts of PCP can cause damage to the liver, kidneys, blood, and nervous system [41]. Studies of workers exposed to PCP reported an increase in body temperature, which can result in high fever, profuse sweating, and difficulty in breathing [41]. High body temperature can also injure various organs and tissues in the body [41]. Additional studies of workers exposed to high levels of PCP for long periods of time indicated liver and immune system effects [41]. Studies in animals also suggest that the endocrine system and immune system can be damaged following long-term exposure to low levels of PCP [41]. Laboratory animals exposed to PCP at high doses were found to experience damage to the thyroid and the reproductive system [41]. It is unknown whether PCP produces all of the same effects in humans that it causes in animals [41].

There is weak evidence that PCP causes cancer in humans [41]. Studies of workers exposed to high levels of PCP reported a possible association with several types of cancer, specifically Hodgkin's disease, soft tissue carcinoma, and acute leukemia. Other occupational studies did not have the same findings. Increases in liver, adrenal gland, and nasal tumors have been found in laboratory animals exposed to high doses of PCP.

The International Agency for Research on Cancer (IARC) has determined that PCP is probably carcinogenic to humans, and the EPA has classified PCP as a probable human carcinogen [41]. An increased risk of cancer has been shown in some laboratory animals given large amounts of PCP orally for a long time [41].

On the basis of site-specific exposure factors, the exposure dose of PCP from sediments for children and adults is below ATSDR's chronic MRL of 0.001 mg/kg/day. Likewise, there is no apparent increased cancer risk for children or adults from exposure to PCP in sediments. Therefore, no adverse health effects are expected from exposure to PCP in sediments. See Tables 9 and 10 in Appendix B.

A2. Ditch Sediments: Post-Removal Health Implications

As previously discussed, Kerr-McGee Corporation performed remedial activities at the Kerr-McGee facility in 2004. The interim remedial measures were performed to address areas of impacted sediments in drainage ditches bordering the Kerr-McGee property [1]. (Map 13 in Appendix A shows the locations of the 4 removal areas.) Impacted sediments were defined as sediments with concentrations of carcinogenic PAHs in excess of one in 10,000 (10^{-4}) target risk based on the land-use designation (i.e., residential or industrial) for the area proximal to the ditch [1].

Major work activities completed as part of the remedial measure included:

- Excavation of approximately 1,800 linear feet of impacted sediments from perimeter drainage ditches
- Confirmation soil sampling
- Transportation and off-site disposal of excavated sediments
- Ambient air monitoring during the performance of remedial activities
- Stormwater management and dust control
- Site restoration (backfilling and grading) [1]

The following section discusses the potential health effects associated with contaminants in sediments following the 2004 remedial activities. Based on the location of previous samples taken of ditch sediments, ATSDR was able to eliminate from further review those ditch sediments that were cleaned up as part of the removal action. The removed sediments are not part of the evaluation which follows. Only those samples which remained after the cleanup are evaluated. Figures 14 and 15 in Appendix A depict the locations of sediment samples still present after the 2004 removal action. This residual contamination forms the basis for evaluating current conditions at the site.

For the Lundy & Davis data, the residual (current) PAH concentration in sediment ranges from non-detect (ND) to 29.6 ppm BaPE. The average PAH concentration post-removal is 2.62 ppm BaPE. The average concentration corresponds to an adult dose of 2.5×10^{-7} and a child dose of 1.1×10^{-5} , both of which are below the MRL of 0.4 mg/kg/day for PAHs. These doses are too low to cause non-cancer health effects or an increased cancer risk. Using the Kerr-McGee data, the residual PAH concentration ranges from non-detect (ND) to 50.2 ppm BaPE. The average residual PAH concentration is 9.36 ppm BaPE. Using the average concentration, ATSDR calculated an adult dose of 8.9×10^{-6} and a child dose of 3.9×10^{-5} , both of which are below ATSDR's MRL of 0.4 mg/kg/day for PAHs. The calculated theoretical increased cancer risk is 3×10^{-5} . Therefore, neither non-cancer nor cancer health effects are expected from these residual PAH concentrations.

The residual dioxin concentrations in sediment ranged from non-detect (ND) to 4.6 ppb TEQ in sediment. Using the average residual dioxin concentration of 0.68 ppb TEQ, ATSDR calculated an adult dose of 2.1×10^{-9} and a child dose of 8.3×10^{-9} . These doses slightly exceed ATSDR's oral chronic Minimum Risk Level (MRL) of 1.0×10^{-9} mg/kg/day for TCDDs by a factor of 2 and 8, respectively. ATSDR's chronic MRL is based on social behavioral effects in primates, and incorporates a 90-fold uncertainty factor. Because the adult and child doses are greater than the MRL, ATSDR next compared the doses to known toxicological values, starting with the

LOAEL of 1.2×10^{-7} mg/kg/day. The calculated adult dose is approximately 57 times greater than the LOAEL. The calculated child dose is approximately 14 times greater than the LOAEL. The calculated theoretical increased cancer risk is approximately 1.3×10^{-4} and 1.2×10^{-4} , respectively. The calculated risk slightly exceeds a cancer risk estimate of 1.0×10^{-4} , which ATSDR has typically considered a level of concern for an increased theoretical cancer risk.

B. Surface Water

Indeno(1,2,3-c,d)pyrene was detected in one surface water sample at a maximum result of 6 mg/l, which exceeds the comparison value of 0.000092 mg/l for the chemical. However, the water solubility of indeno(1,2,3-c,d)pyrene is only 0.062 mg/l [43]. The higher level of indeno(1,2,3-c,d)pyrene is probably the result of suspended sediments in the water sample that are not dissolved. In any event, the detected level would not result in any additional risk or health effect other than what was previously assessed for sediments.

C. Residential Surface Soil

Contact with contaminants in residential surface soil is identified as a potential exposure pathway at this site. Low levels of PAHs were detected in residential surface soil samples. Arsenic was detected (up to 14.2 ppm) at concentrations that exceed the comparison value of 0.5 ppm for arsenic.

The calculated exposure dose for adults and children exposed to PAHs and arsenic in surface soil is several orders of magnitude below the health guidelines for each chemical, indicating that the levels of these chemicals in surface soil do not pose a risk of adverse health effects. Also, there would be no apparent increased theoretical cancer risk from exposure to arsenic or PAHs (increased cancer risk for both is 3 cancers per one million people exposed, or 3×10^{-6}). Based on these results, adverse health effects are not expected from exposure to PAHs or arsenic in surface soil.

Figure 12 in Appendix A shows the location of surface soil samples taken near the site thus far. Given the proximity of residential properties to the ditches, further surface soil sampling is needed to properly characterize the extent of contamination in nearby yards.

D. Residential Dust (Indoors)

Dahlgren *et al.* analyzed and detected the presence of PAHs and dioxins in residential dust samples. The presence of PAHs in the dust samples could be from a variety of sources; therefore, detection of PAHs alone in an environmental sample does not indicate a site-specific completed exposure pathway. Sources of PAHs include cigarette smoke, vehicle exhaust, asphalt roads, coal, coal tar, wildfires, agricultural burning, residential wood burning, municipal and industrial waste incineration, and hazardous waste sites. Background levels of some representative PAHs in the air are reported to be 0.02–1.2 nanograms per cubic meter (ng/m^3 —a nanogram is one-millionth of a milligram) in rural areas and 0.15–19.3 ng/m^3 in urban areas [43]. Scientists have found PAHs in National Institute of Standards and Technology Standard Reference Dust and in dust collected from homes in both urban and rural environments at levels similar to or near the levels detected by Dahlgren *et al.* in the household dust [44, 45, 46]. ATSDR did not locate

references for comparison to the attic dust levels reported by Dahgren *et al.* In the attic dust sample (Table 11 in Appendix B), however, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-c,d) pyrene were within background range for urban soil [43]. Benzo(a)pyrene was slightly above the urban soil background range. Dahlgren *et al.* do not discuss resident's exposure to attic dust.

As with the PAHs, the dioxins in dust samples in the area of the plant could be from a variety of sources. Dioxins are known to occur naturally, and they are also produced by human activities. They are naturally produced from the incomplete combustion of organic material such as a forest fire. Dioxins are also unintentionally produced by industrial, municipal, and domestic incineration and combustion processes. Currently, it is believed that dioxin emissions associated with human incineration and combustion activities are the predominant environmental source [30]. The dioxin levels in the dust at this site are below background levels seen in urban and rural soils. For an exhaustive discussion of the levels of dioxin measured in soils, refer to ATSDR's Toxicological Profile for Polychlorinated Dibenzo-p-dioxins.

The PAHs benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and indeno(1,2,3-c,d) pyrene all exceeded their respective comparison values for soils (since a comparison value for residential dusts does not exist). Since attic dust is not frequently contacted by residents, daily absorption of this dust by residents will likely be below the default intake rates used to calculate the remedial goals (i.e., EPA's Preliminary Remedial Goals (PRG's), which are risk-based tools for evaluating and cleaning up contaminated sites). Furthermore, since the dust samples were at or near background levels for dusts and urban soils, we do not find this pathway to represent an increased exposure risk or a health risk to residents near the Kerr-McGee facility.

5.0 COMMUNITY HEALTH CONCERNS

During our visits to the site, ATSDR obtained information from residents regarding their specific health concerns related to the site. In addition, ATSDR received several feedback forms, letters, and telephone calls regarding health concerns from residents after meetings, public availability sessions, or site visits. The entire list of health concerns received from residents is in Appendix D. ATSDR was unable to address all of the health concerns because 1) adequate scientific information on the particular health effect is not available or is limited or 2) the available scientific data are insufficient to assess whether the specific health effect is related to exposure to a particular chemical. Where feasible, ATSDR addressed the health concerns identified by the community. Below is a summary of community health concerns and ATSDR's response to those concerns.

1. *I know that the Kerr-McGee facility used creosote and creosote coal tar solutions in wood processing. Yet they tested for other chemicals but did not test for creosote. Why didn't they test for creosote and why didn't ATSDR look at the health effects of creosote?*

Creosote is a mixture of many chemicals. Between 300 to 10,000 individual chemicals may be present in the mixture. Therefore, a single test cannot be used to determine the presence of creosote. Instead, creosote is identified by its many chemical components. Some of the main

chemicals in creosote are PAHs (polycyclic aromatic hydrocarbons). Therefore, ATSDR has evaluated exposure to PAHs at this site.

2. *What are the health effects associated with creosote?*

Creosote is a complex mixture of many chemical compounds, including PAHs. Some of these substances are known to be carcinogens (cancer-causing) and others are known to cause conjunctivitis (an infection of the eye) as well as skin effects such as rashes, burns, and phototoxic (a reaction when exposed to the sun) effects.

ATSDR has developed a reference sheet entitled, *What You Need To Know About the Chemicals of Potential Concern*, in Appendix E of this document. This document discusses the health effects associated with all of the chemicals at this site. Please refer to this document for additional information on the health effects associated with exposure to creosote.

3. *What are the health effects associated with PCP?*

Long-term exposure in the workplace to large amounts of PCP can cause damage to the liver, kidneys, blood, and nervous system. Studies in animals also suggest that the endocrine system and immune system can be damaged following long-term exposure to low levels of PCP. There is weak evidence that PCP causes cancer in humans.

ATSDR has developed a reference sheet entitled, *What You Need To Know About the Chemicals of Potential Concern at the Kerr-McGee Site*, in Appendix E of this document. This document discusses the health effects associated with all of the chemicals at this site. Please refer to this document for additional information on the health effects associated with exposure to PCP.

4. *Is exposure to site chemicals causing rashes and other skin effects?*

It is possible that in the past some of the chemicals in the soil were at levels high enough to cause health effects. Direct, unprotected contact with creosote materials that may have migrated off-site could have resulted in rashes and other skin effects. However, rashes have many causes and should be evaluated by your physician. If residents notice creosote material in their yards, they should not touch it. They should contact the appropriate local agency or call Russ McClean of EPA at 1-800-241-1754.

5. *I live near the site and want to know if I am likely to experience respiratory problems such as asthma, lung infections, or other sinus problems.*

Currently the site is inactive so no chemicals are being released into the air. In the past, while the facility was active, chemicals were emitted into the air. To address whether potential health effects are expected from these past air emissions, ATSDR prepared a document entitled "Air Exposures to Wood Treatment, Kerr-McGee Chemical Corporation." This document focuses on air exposures only. Based on the findings of this evaluation, long-term respiratory health effects from past releases into the air are not expected.

6. *I have lived near the site for decades. I am worried that I might get cancer or other health effects. Do the chemicals at the site cause cancer or other diseases?*

High exposures to dioxins and PAHs may increase a person's risk for developing cancer. Studies in humans suggest that exposure to dioxins increases the overall risk of developing cancer. Human studies also showed that people who breathed or had skin contact with PAHs for long periods may also develop cancer.

The levels of PAHs and dioxins were high enough in some of the ditches near the Kerr-McGee facility to pose a potential public health hazard for children who played in the ditches. They may experience dermatological effects such as rashes and irritation. In cases of very frequent exposure, there is a possibility that the risk of skin cancer could be elevated. Children might also be at increased risk for developmental and reproductive effects from exposure to dioxins. Individuals who had frequent contact with sediments in the ditches have a low to moderate theoretical increased cancer risk.

If you are concerned about your health or the health of your child, you should contact your physician.

7. *I live near the site and have noticed a tar-like or greasy material in my yard. What is this and what do I do about it?*

Wood creosote is a colorless to yellowish greasy liquid with a smoky odor and burned taste. Coal tar creosote is a thick, oily liquid that is typically amber to black in color. Coal tar and coal tar pitch are usually thick, black, or dark-brown liquids or semisolids with a smoky odor. Since it is unknown if the material in your yard is from the site or from some other source, the most prudent measure is to not touch the material and to contact a professional for identification and possible removal.

Residents who are concerned about site related contaminants in their yard should contact the EPA at 1-800-241-1754 and ask for the remedial project manager for the Kerr-McGee site (currently Russ McLean).

8. *My home is connected to the municipal water system. However, I noticed black residues and foul odors in my tap water. Is the public drinking water safe?*

Yes. The Columbus City Water System supplies residents with water for use at their homes. The water from the system is routinely monitored to ensure that it meets bacteriological and chemical health standards. When ATSDR checked, the years for which we received chemical sampling and analysis data (2000-2006) met all federal requirements for safe drinking water as well. The chemical sampling includes metals, pesticides, herbicides, volatile organic compounds, trihalomethanes, radiological material, and sanitary chemicals (iron, sodium and other aesthetic secondary requirements).

In addition, ATSDR conducted an exposure investigation (EI) in April 2008 because people were concerned that pollutants from the former Kerr McGee site were getting into the public water line or the pipes that bring water to their homes. ATSDR tested several selected homes near the former Kerr McGee site. Based on this investigation, no harmful chemicals were found in residential tap water. Therefore, the public water system appears to be safe for drinking and other household uses.

9. *Is it safe to eat vegetables that I grow in my garden?*

The sampling results from residential yards show that levels of contaminants were too low to cause adverse health effects. Additionally, studies have shown that dioxins are not taken up readily by plants.

However, ATSDR has requested additional soil sampling in residential areas to rule out the possibility that chemicals have been deposited in yards. As a general precaution, you should remove excess soil from vegetables grown in the ground before taking them into your home. Vegetables should be washed thoroughly before being eaten. As a specific precaution, you should not grow vegetables in areas where there is visible contamination or areas that are prone to flooding.

10. Do the chemicals at the site cause learning disabilities or attention deficit disorder (ADD)?

The scientific information is unclear. Limited animal studies have shown some behavioral impact following dioxin exposure, but human studies are uncertain. Exposures associated with the Kerr-McGee site are less than those observed in animal studies; however, these effects may be possible in humans. To err on the side of caution, ATSDR has recommended that efforts be taken to reduce or eliminate harmful exposures to contaminants associated with this site.

11. Do the chemicals at the site cause strokes, high blood pressure, or heart problems?

It is unlikely. The concentrations of the chemicals at this site are too low to cause a stroke or heart-related problems.

12. Do the chemicals at the site cause reproductive problems?

High exposure to dioxins has been associated with reproductive effects, including endometriosis (abnormal growth of the mucous membrane lining the uterus) and reproductive problems. ATSDR's evaluation has concluded that individuals may be at risk for these effects at this site.

6.0 HEALTH OUTCOME EVALUATION

The community has expressed concerns about community cancer rates and birth defects. In fact, the original petition to ATSDR requested an "epidemiological study" of the community. ATSDR *can consider* health outcome data, such as mortality and morbidity data, as part of the public health assessment process. ATSDR evaluates the following criteria when determining if whether undertaking a study of health outcome data is reasonable:

- presence of a completed human exposure pathway,
- great enough contaminant levels to result in measurable health effects,
- sufficient people in the completed pathway for the health effect to be measured, and
- the existence of a health outcome database where disease rates for populations of concern can be identified.

This site does not meet the criteria for health statistics review for the following reasons:

- While historical exposure exists in the community, it is limited to certain specific pathways of exposure (for instance, playing in areas of ditches that were contaminated

with creosote). Analysis of existing health outcome databases would mix both exposed and non-exposed persons and would likely not detect any elevations in rates of disease.

7.0 CHILD HEALTH CONSIDERATIONS

Children are exposed to chemicals in the same way as adults; that is, they inhale, ingest, or absorb the chemicals through their skin. However, children require a special health consideration. They should not be viewed simply as small adults. Their unique physiology as well as their behavior can have a profound influence on their exposure risk. Physiologically, children will eat more and drink more than their adult counterparts. While playing or at rest, children breathe more rapidly and inhale more pollutants per pound of body weight than do adults. In addition, airway passages in children are more narrow, with irritation secondary to a pollutant resulting in proportionally greater airway obstruction. Behaviorally, children have a strong inclination toward hand-to-mouth activity, placing possible contaminated foreign objects in their mouths or ingesting creosote in the soil or dust. They may even chew on such objects as treated wood pieces used in fences or railings. Children also spend much more time outdoors, often while being more physically active than adults. They tend to be more adventurous by nature and often play in remote or potentially dangerous areas, such as contaminated creeks or ditches, without the benefit of maturity to permit the exercise of good judgment.

8.0 UNCERTAINTIES AND LIMITATIONS

There are sources of uncertainty that we have identified that could affect the conclusions and recommendations in this health assessment. Major sources of uncertainty include:

Exposure assessment:

- As noted, ATSDR could not locate established exposure factors for the number of times per week children contacted sediments in the ditch. If the frequency of contact was different from what ATSDR assumed, exposure doses calculated could have been higher or lower.
- ATSDR assumed in some cases that individuals were exposed to the maximum concentration of a chemical for extended periods of time (6 months to one year). As is true with most sites, assuming long-term contact with the maximum concentration is not reasonable; therefore, any conclusions based on this exposure scenario should be viewed as an overestimation of the true risk.
- The amount of sediment ingested from play activities in the ditch is uncertain. ATSDR used a soil ingestion factor for this pathway. For soil pathway evaluations, ATSDR normally assumes that a child ingests 200 mg of soil per day [25]. Given the potential for contaminants to have migrated from the ditches to residential soils, the default ingestion rates are reasonable, but they probably are an overestimation.
- For dose calculations, dioxins are expressed as toxic equivalency quotients (TEQs). The TEQ is calculated by multiplying the exposure level of a particular dioxin-like compound by its toxicity equivalency factor (TEF). However, the TEFs for the dioxin congeners

contributing to the TEQ calculations for these samples were not available to ATSDR. Therefore, ATSDR cannot determine from the available information whether the dioxins detected are indicative of historical contamination of PCP (i.e., site-related) or some other anthropogenic source; nor can it be determined whether transforming the data using the new WHO 2005 TEFs would significantly alter the results.

- This document does not evaluate all potential exposure pathways associated with the site. This PHA evaluates only those exposures associated with incidental ingestion and dermal exposures associated with soil/sediments in nearby ditches. An analysis of the air pathway associated with the site is addressed in a separate PHA document for the site.

Public health implications:

- For dioxins, estimated doses were below levels known to cause cancer in laboratory animals [40]. Some researchers contend that humans are expected to be 10–100 times less sensitive than most laboratory animals [55, 56].
- For non-cancer effects, ATSDR utilized the most sensitive toxicologic endpoints (i.e., toxic effects that were caused by the lowest doses) to interpret the significance of the toxicologic effect of the doses estimated [40].
- The TEF approach used by ATSDR for evaluating dioxins involves assessment of the comparative effects of individual compounds on various biological end points and the derivation of TEFs based on the upper range of potency data for these effects. The key assumptions unifying the diverse types of data that are considered in the derivation of TEFs are that congeners exert toxicity through a common receptor-mediated mechanism and that the effects of mixtures are additive. The TEF approach compares the relative toxicity of individual congeners to that of 2,3,7,8-TCDD, which is the most extensively studied of the halogenated aromatic hydrocarbons that interact with the Ah receptor [40].
- The TEFs used for PAHs are based on relative carcinogenic potency [43]. Interactions between PAHs toxicity is complex and poorly understood.

9.0 CONCLUSIONS

1. The Kerr-McGee site is a **past public health hazard**. Levels of PAHs were high enough in some of the ditches near the Kerr-McGee facility to pose a potential health hazard to children who frequently (6 months per year for 7 years) played in the ditches. On the basis of previous studies of humans exposed to creosote-contaminated soil, dermatological effects such as rashes and irritation are possible. In cases of very frequent exposure, the risk of skin cancer could be elevated.
2. Levels of dioxins were high enough in some of the ditches near the Kerr-McGee facility to pose a potential health hazard to children who frequently (6 months per year for 7 years) played in the ditches. Children might be at increased risk for developmental and reproductive effects from exposure to dioxins. Individuals who had frequent contact with sediments in the ditches have a moderate increased cancer risk from exposure to dioxins.
3. Based upon the available data, the level of contamination in residential surface soil is too low to cause adverse health effects. However, the residential surface soil samples available are not in areas expected to receive the overflow from ditch flooding. Given the proximity of residential properties to the ditches, further surface soil sampling is needed to properly characterize the extent of off-site contamination in nearby yards.
4. Currently, the site is an **indeterminate public health hazard**. Residual contamination has not been sufficiently defined in residential or public areas prone to flooding to determine the level of health hazard.

10.0 RECOMMENDATIONS

1. ATSDR recommends that proper measures be taken to reduce or eliminate human exposures to contaminants in sediments and soils around the facility. Continue to remove on-site sources that contribute to off-site migration of contaminants, and off-site buried sediments/creosote-contaminated materials that people might contact through digging or other excavation activities.
2. ATSDR recommends more characterization of surface soils in residential yards to evaluate for the presence of site-related contaminants. Consider testing for site-related contaminants of particular concern, such as dioxin-like compounds and carcinogenic polycyclic aromatic hydrocarbons (PAHs). The sampling should focus on yards near contaminated ditches and yards in areas that historically could have received run-off water from the site.
3. ATSDR recommends additional off-site sampling in the area to further define the nature and extent of contamination, with particular focus on areas where exposures to vulnerable populations may occur (e.g., daycare centers, schools, playgrounds, etc.).

11.0 PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) contains actions to be taken by ATSDR or other governmental agencies at the Kerr-McGee site. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and/or future exposures to hazardous substances at or near the site.

Public Health Actions Completed:

- In 2004, Kerr-McGee completed a partial clean-up of the ditches bordering the site. Approximately 1780 linear feet of sediments were removed from the ditch, including some of the areas with the highest levels of contamination.
- ATSDR has requested that EPA require additional sampling at this site to evaluate contamination runoff from the site to residential yards near the site.
- In June 2007, ATSDR hosted a health education workshop for the community. The following two presentations were made at the workshop:
 - “*Creosote Health Effects and How to Prevent Exposure*” and
 - “*Drinking Water Quality in Your Community*” presented by the Mississippi Department of Health, Drinking Water Program.
- In April 2008, ATSDR conducted an Exposure Investigation (EI) in response to residents’ concerns about their water quality. Tap water was tested from 13 homes near the Kerr-McGee facility. No chemicals of concern were detected in any of the tap water sampled.
- In June 2008, ATSDR conducted an Exposure Investigation (EI) to determine if fish in the Luxapalila Creek have been impacted by site-related contaminants. ATSDR collected fish samples from locations upstream and downstream of the site. The fish were analyzed for dioxins. The levels of dioxin in fish were not elevated in the fish sampled.
- ATSDR has prepared a separate document which evaluates health effects related to air ambient air exposures. This document will complement the current document and discuss potential impacts related to past air emissions from the site.

Public Health Actions Planned:

- ATSDR will continue to develop health education materials for the community, as appropriate.

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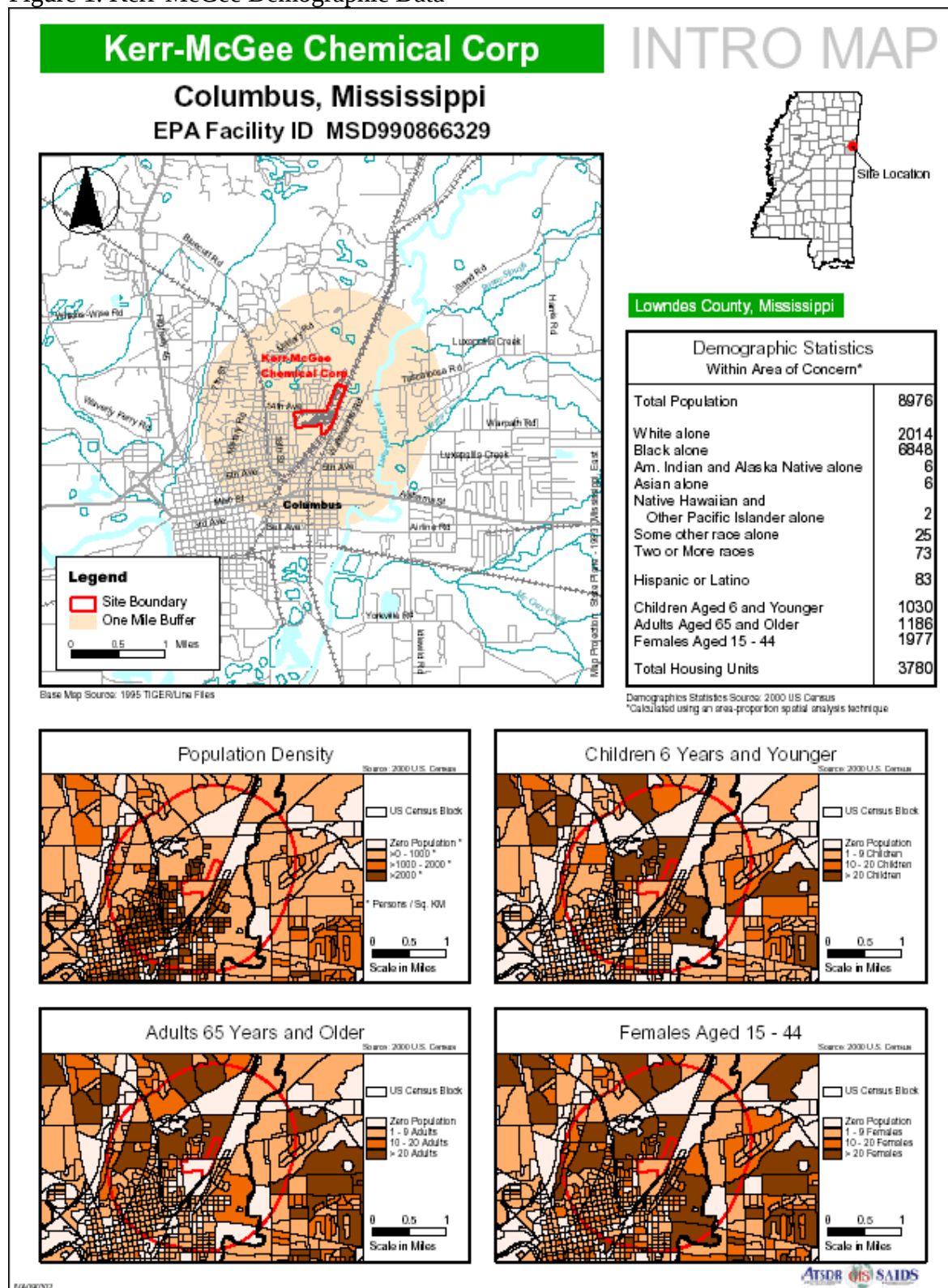
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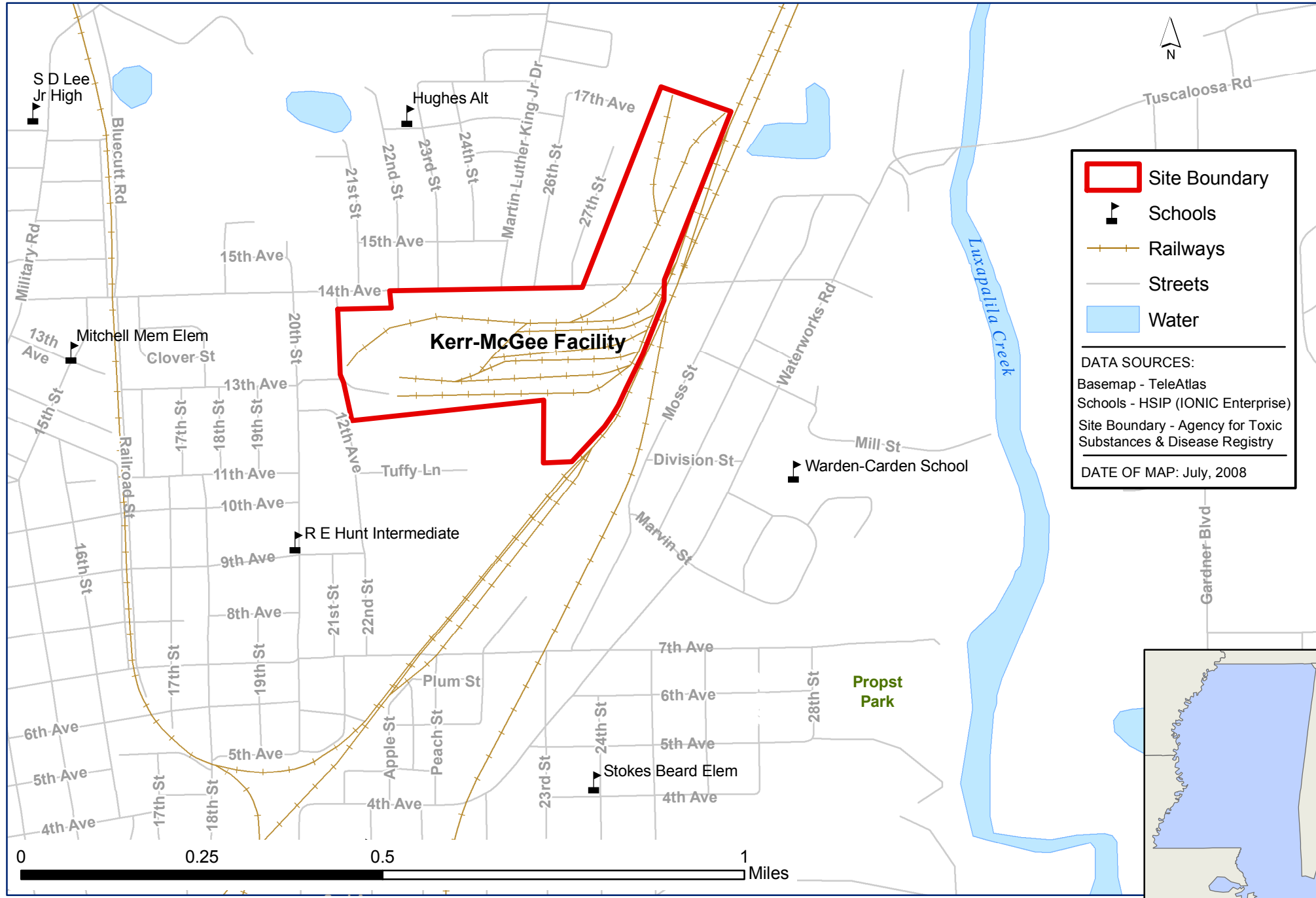
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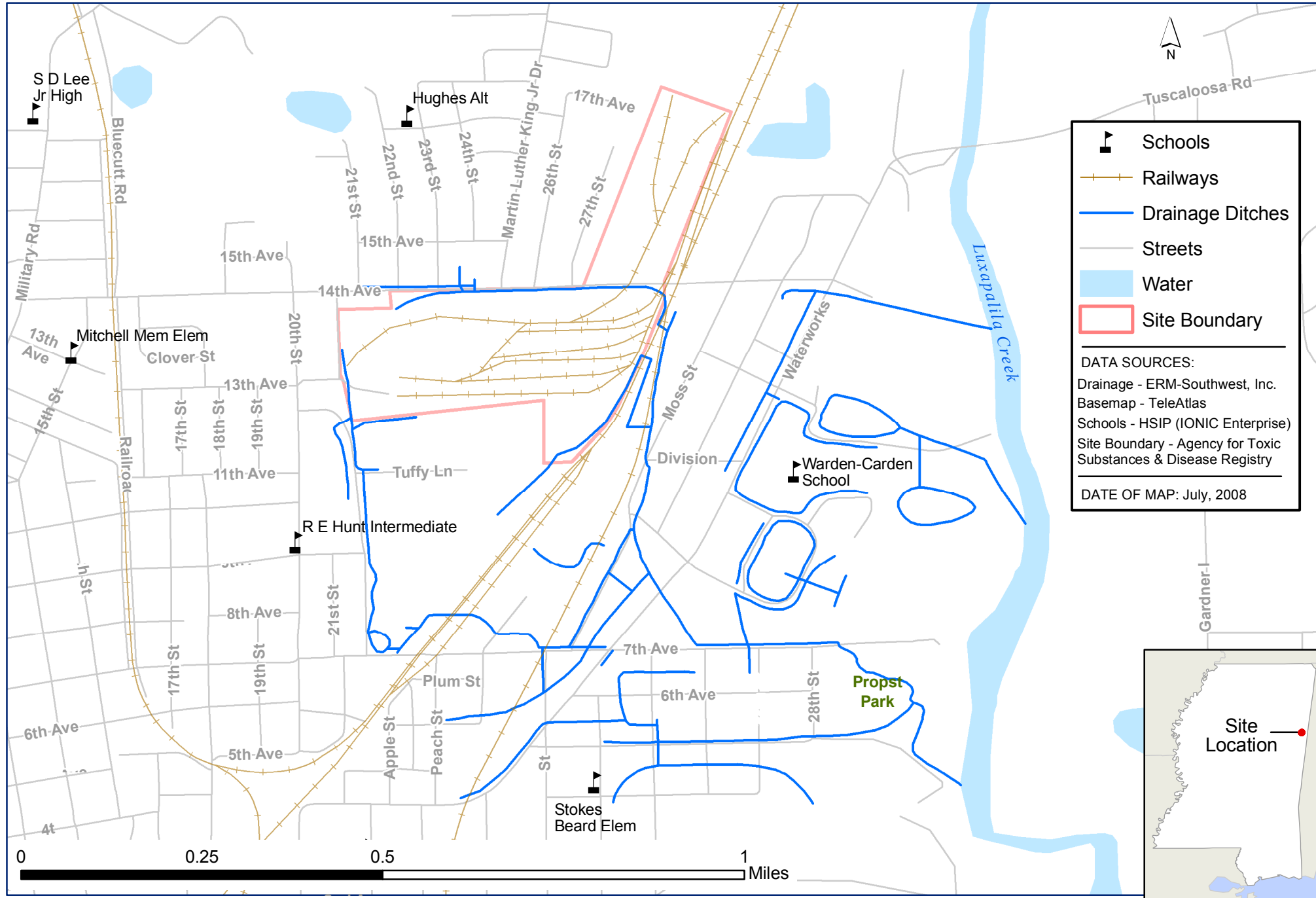
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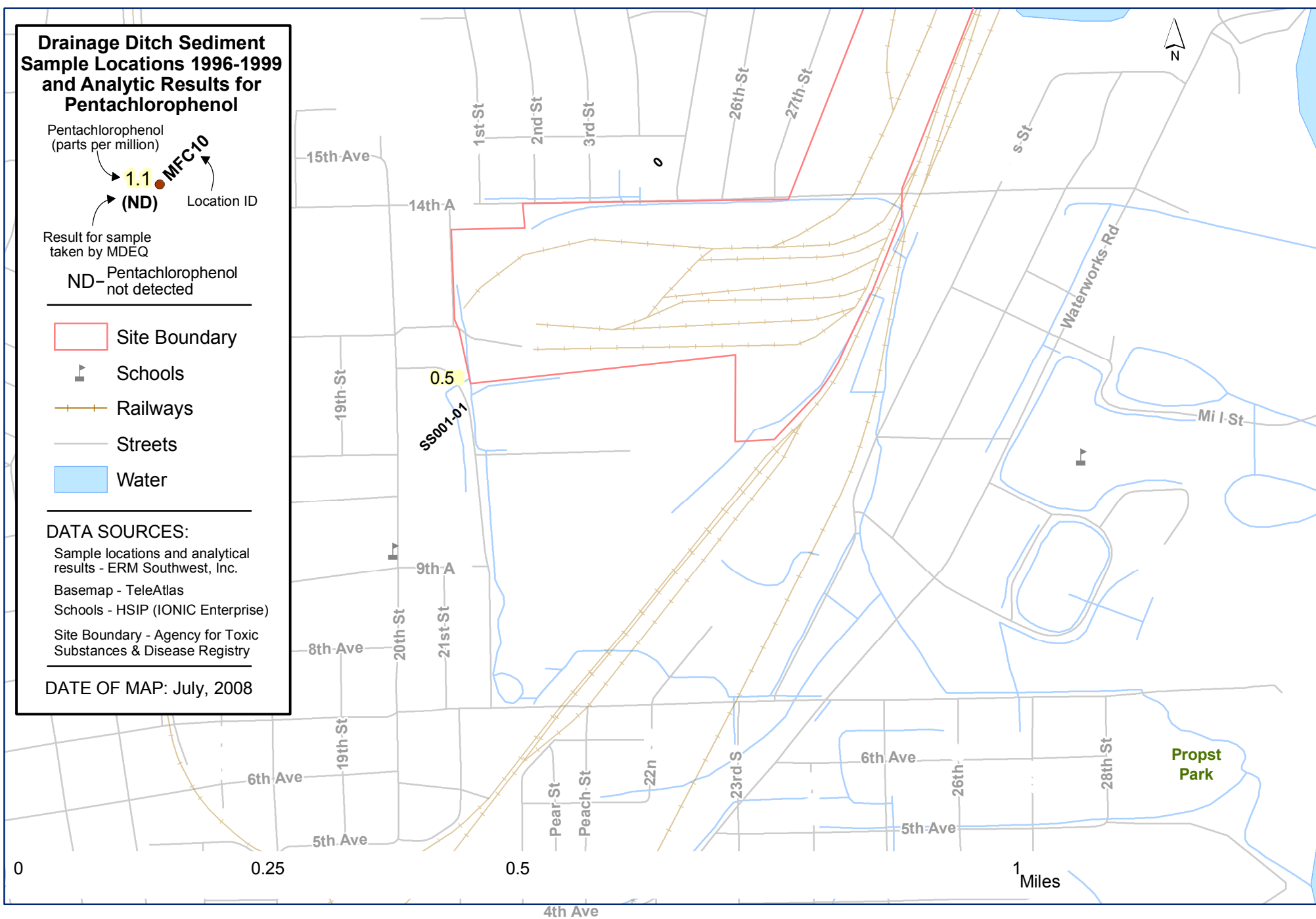
APPENDIX A: MAPS and FIGURES

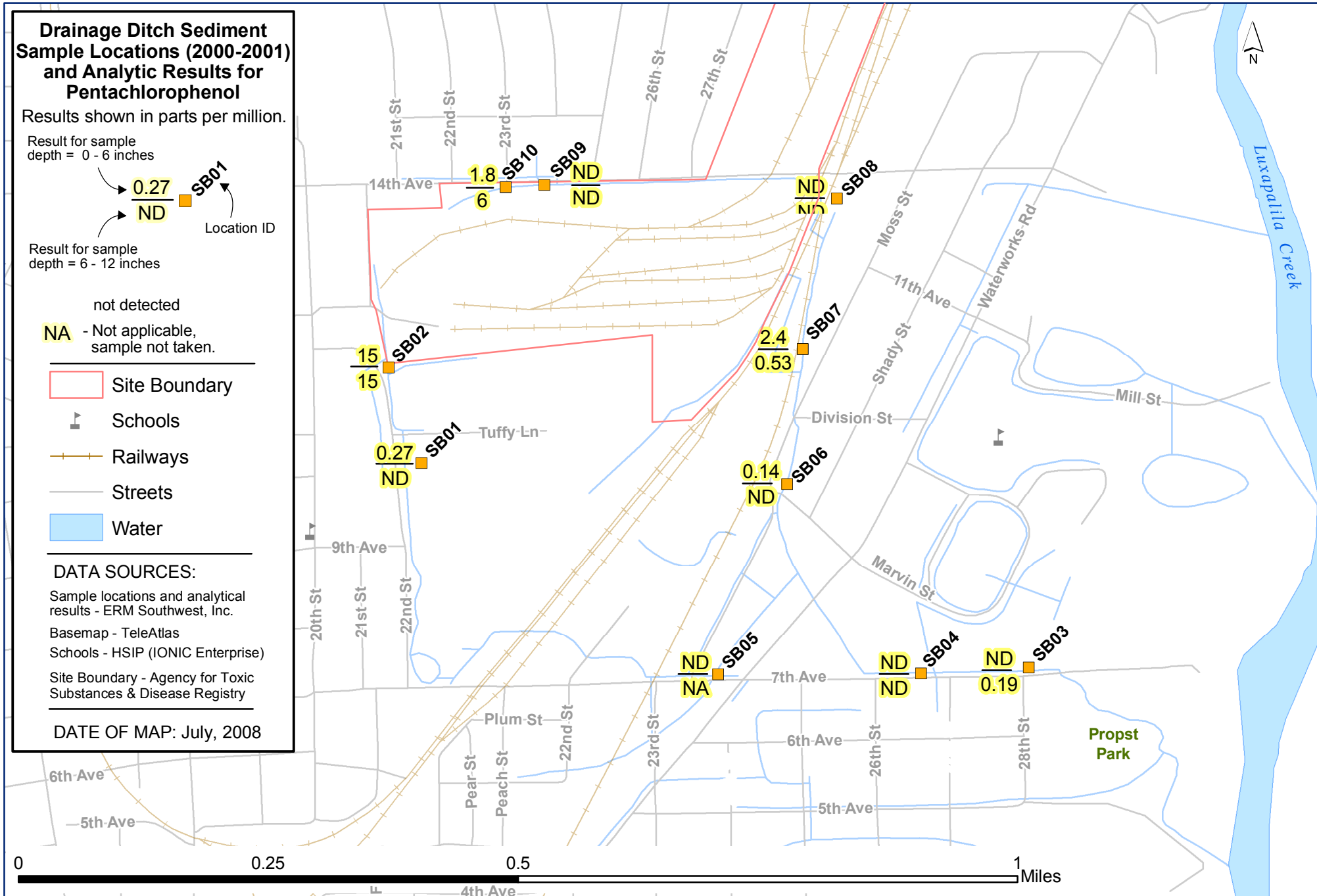
Figure 1. Kerr-McGee Demographic Data

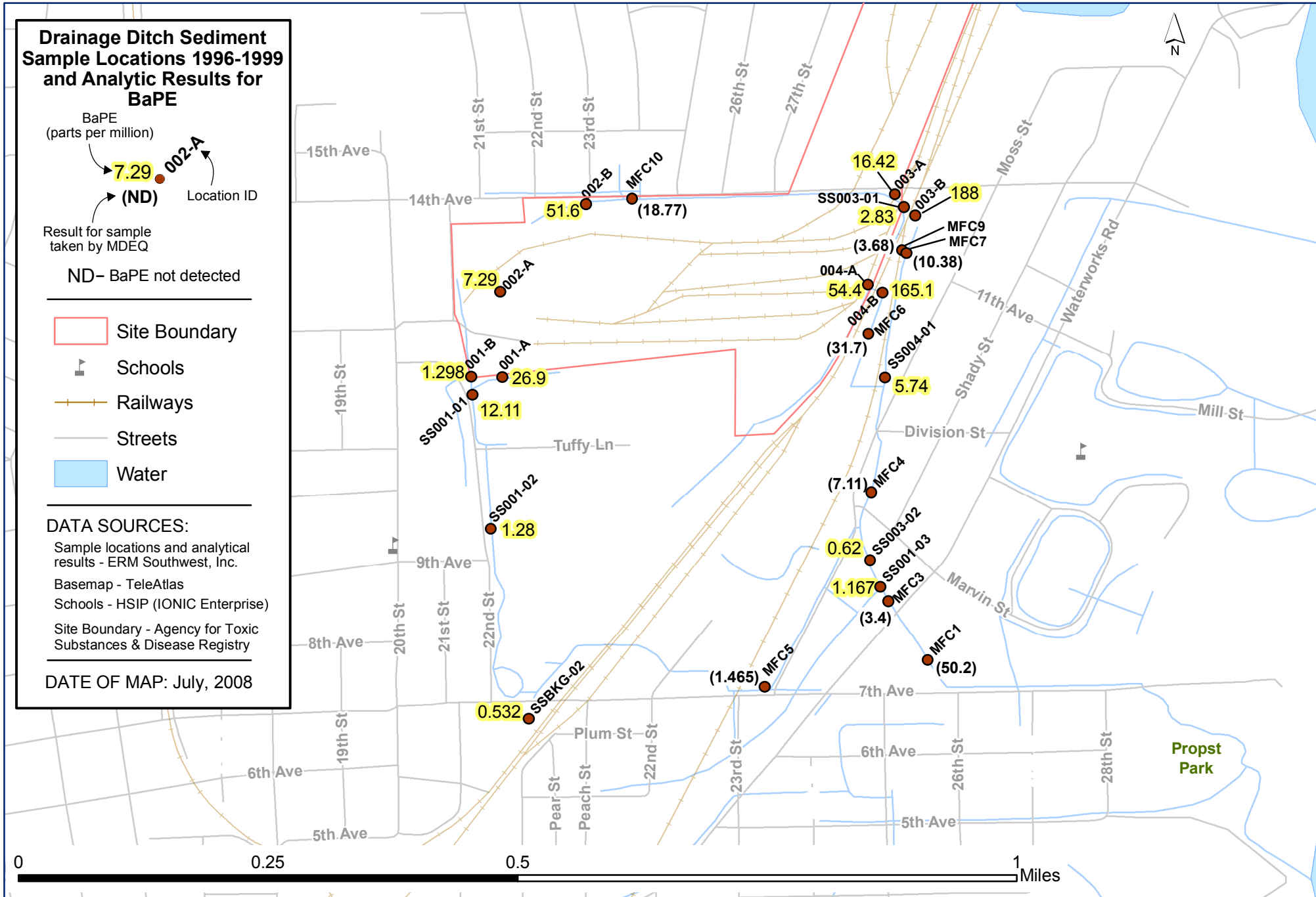


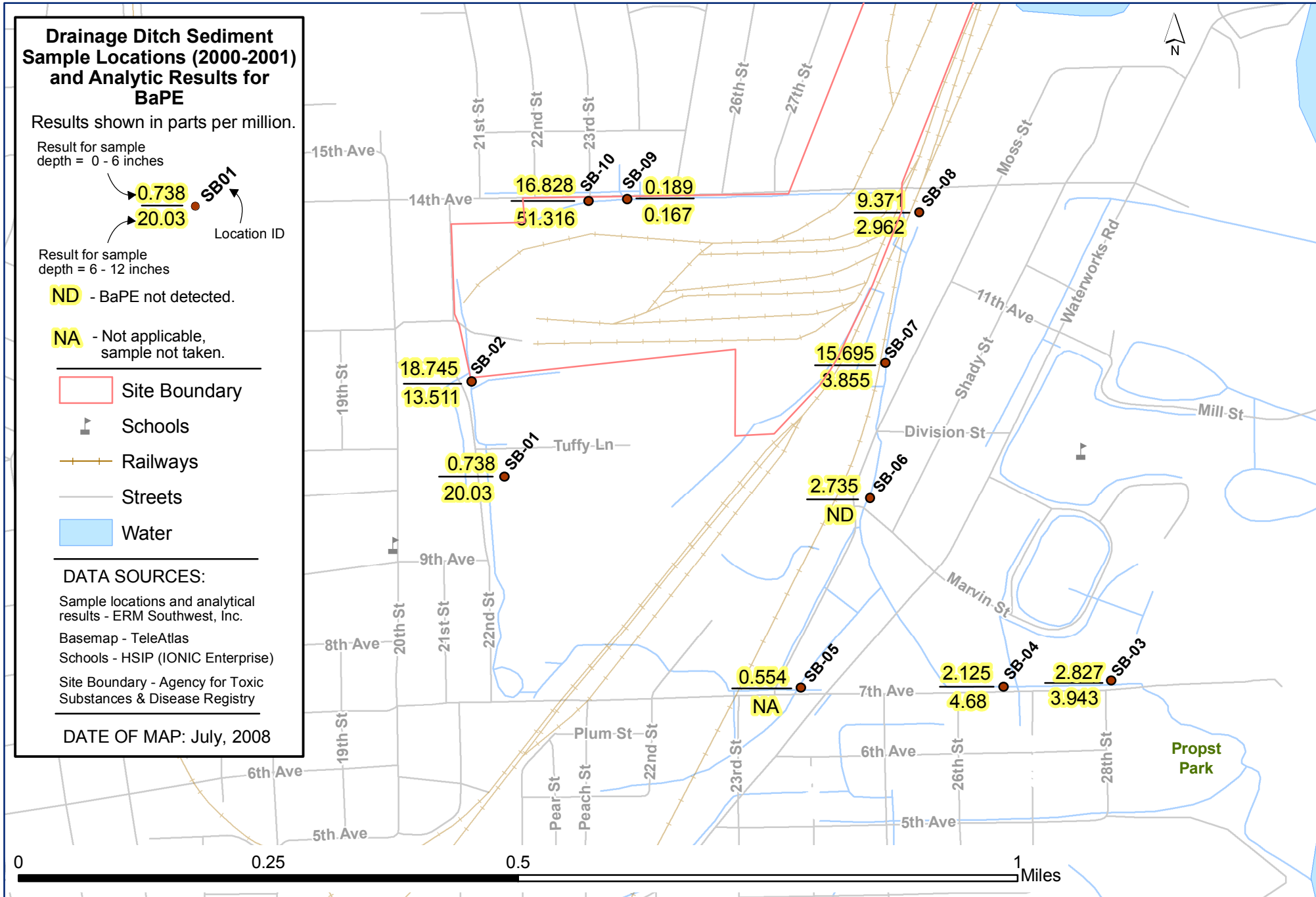


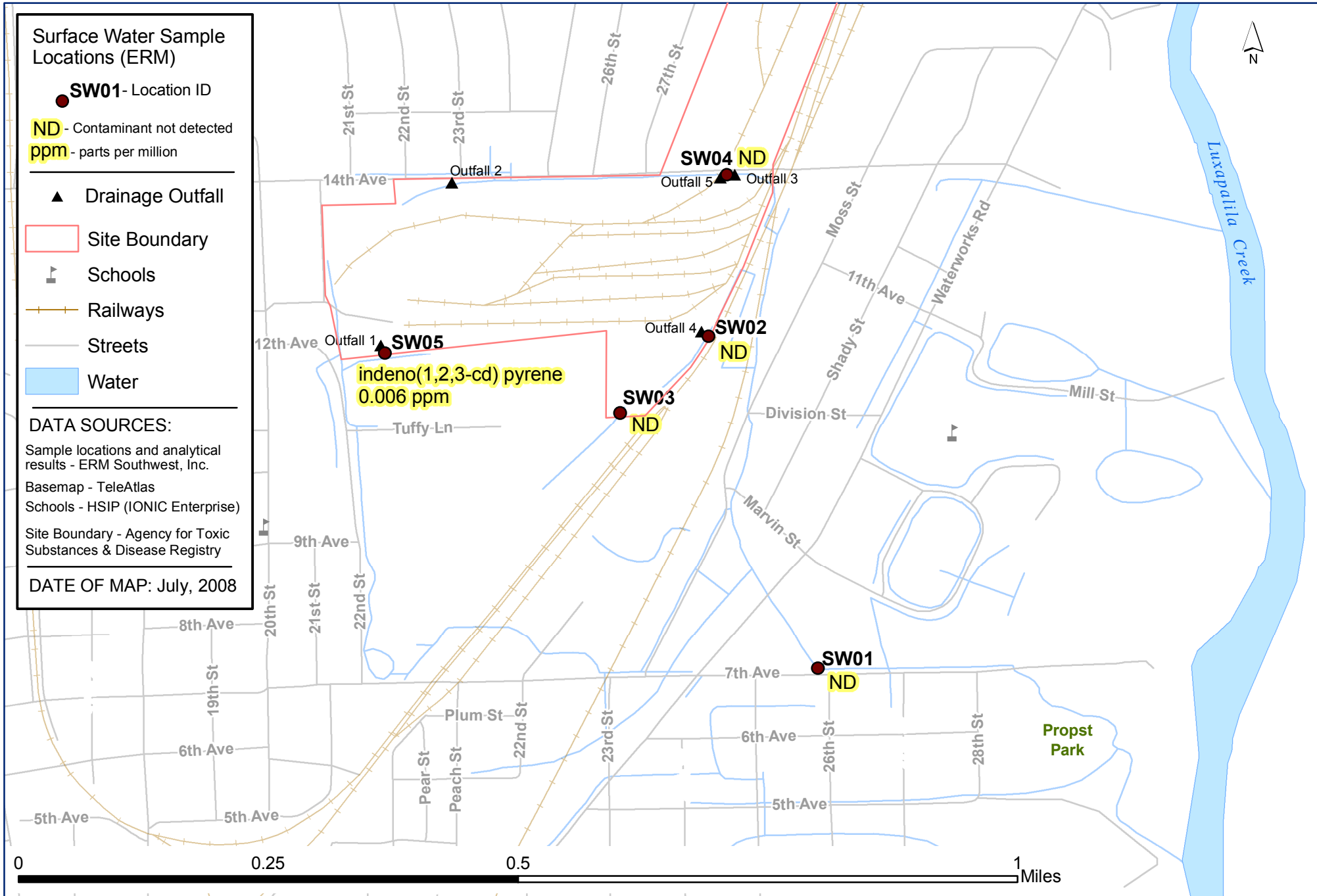


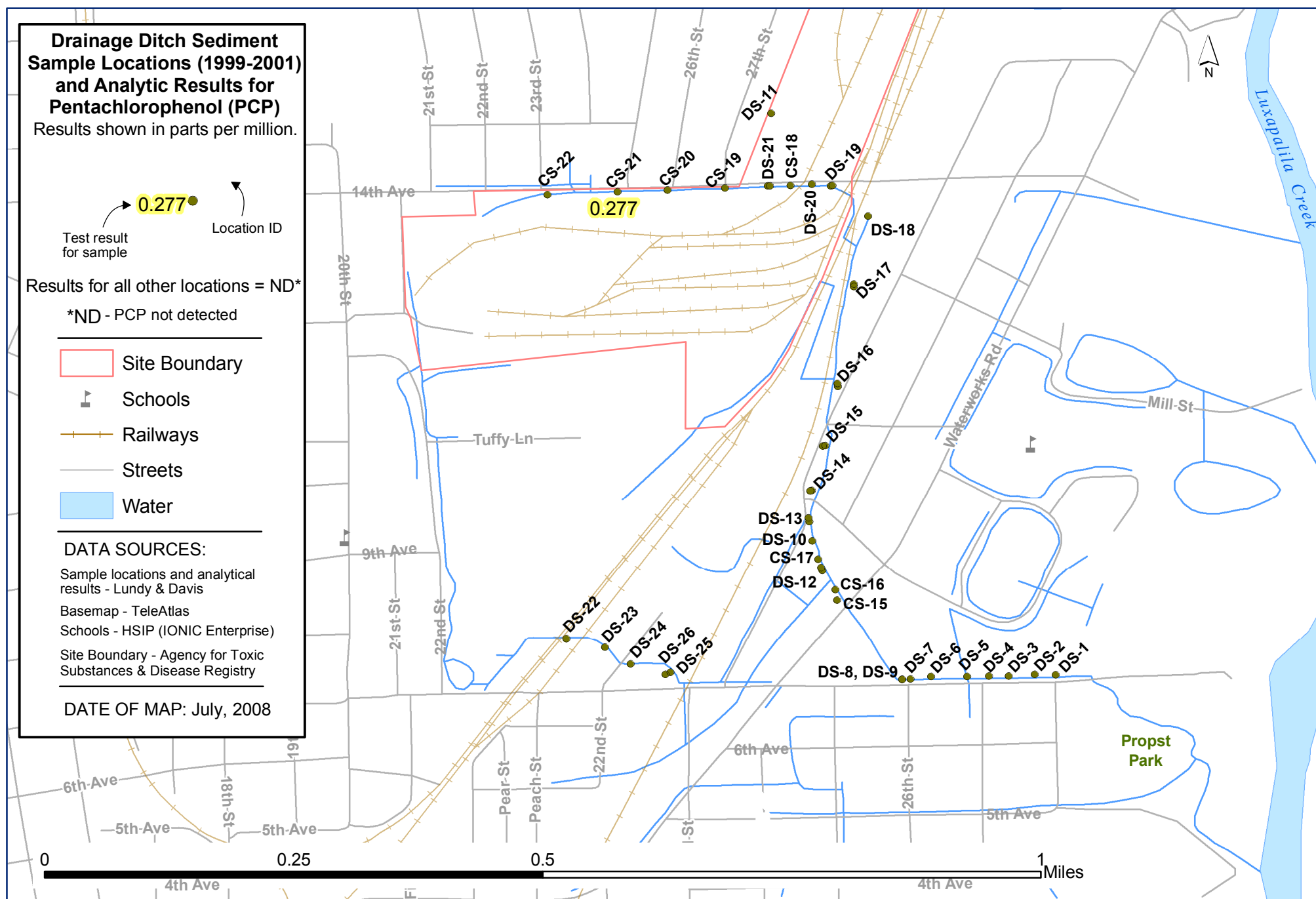


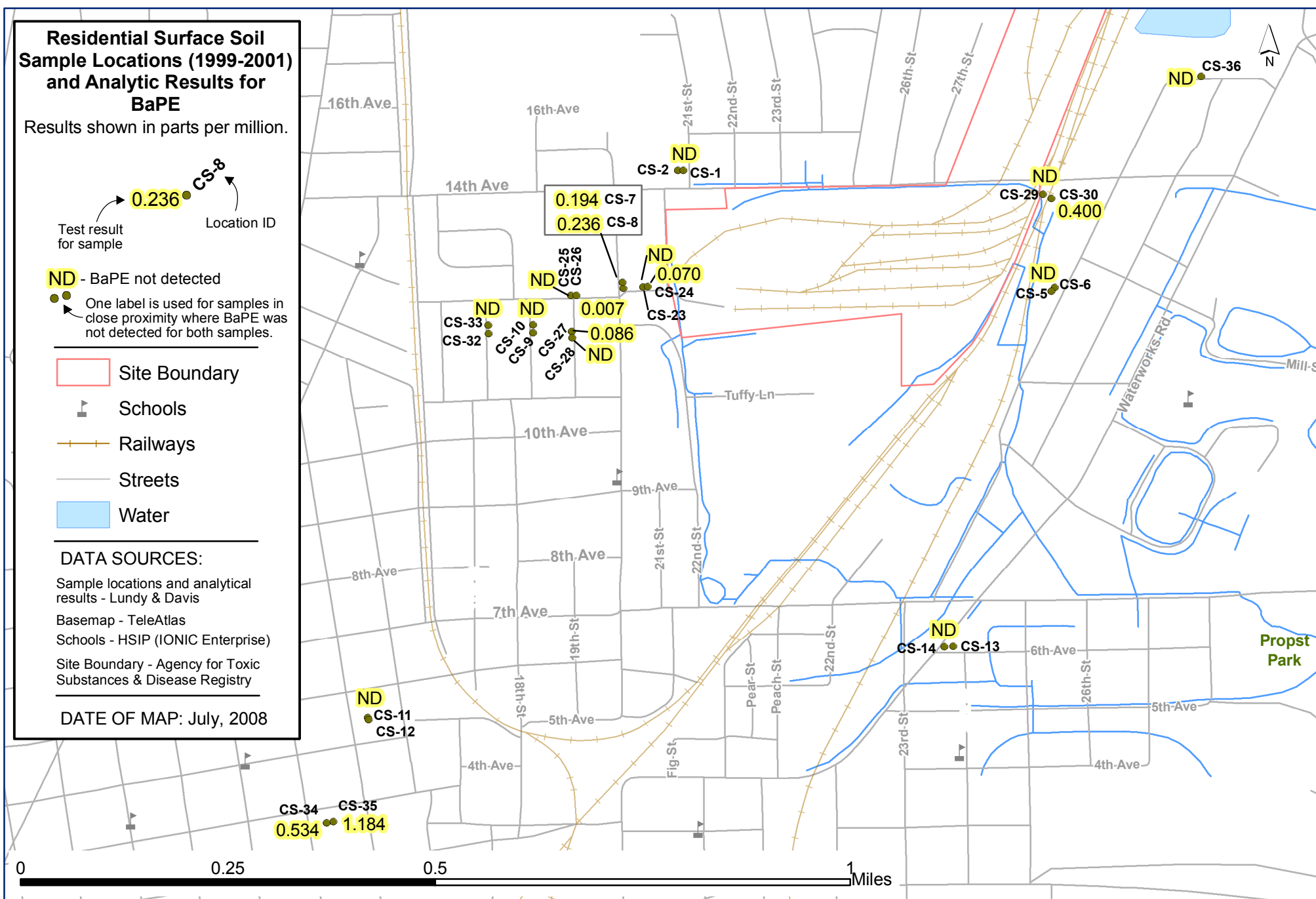


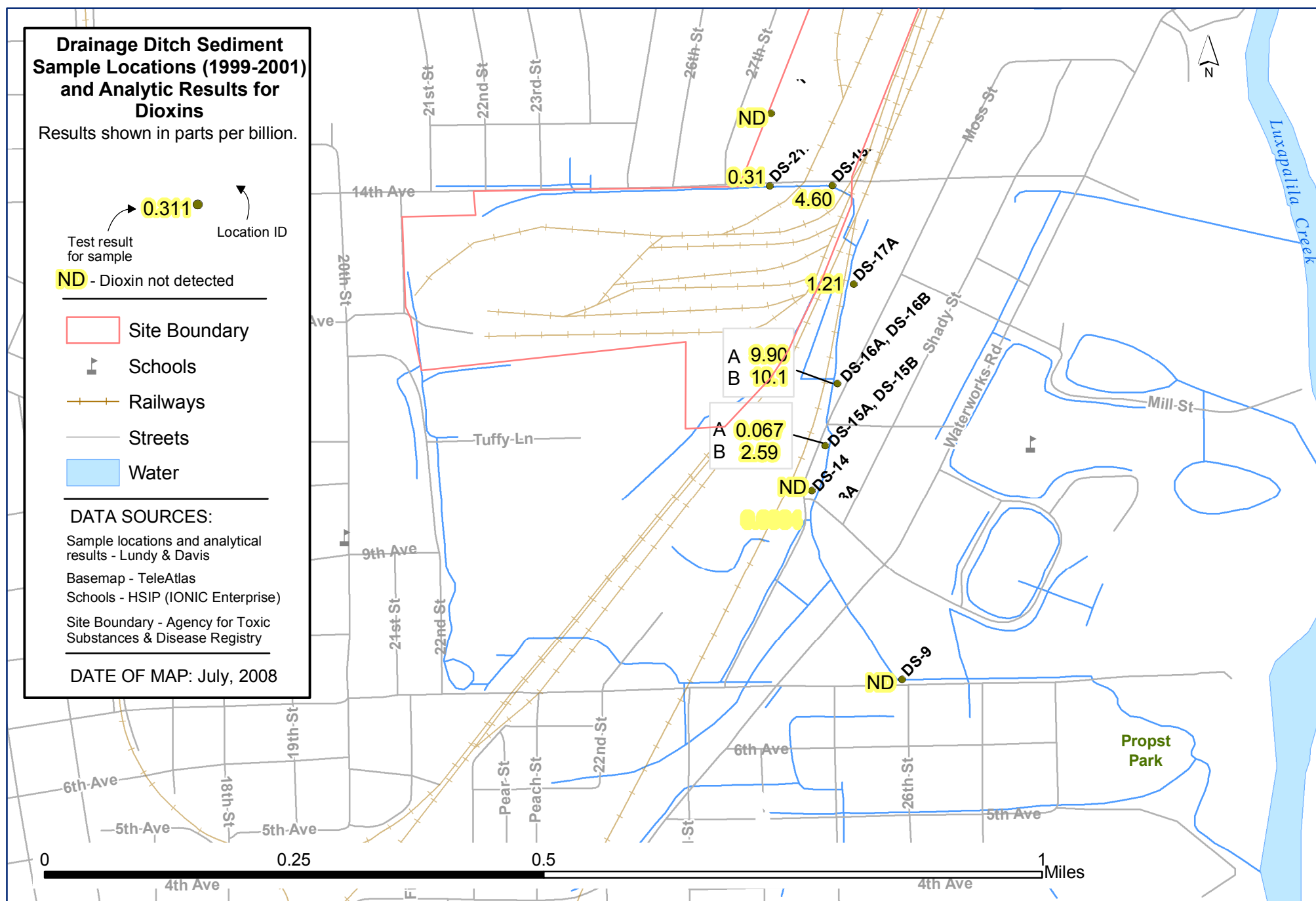


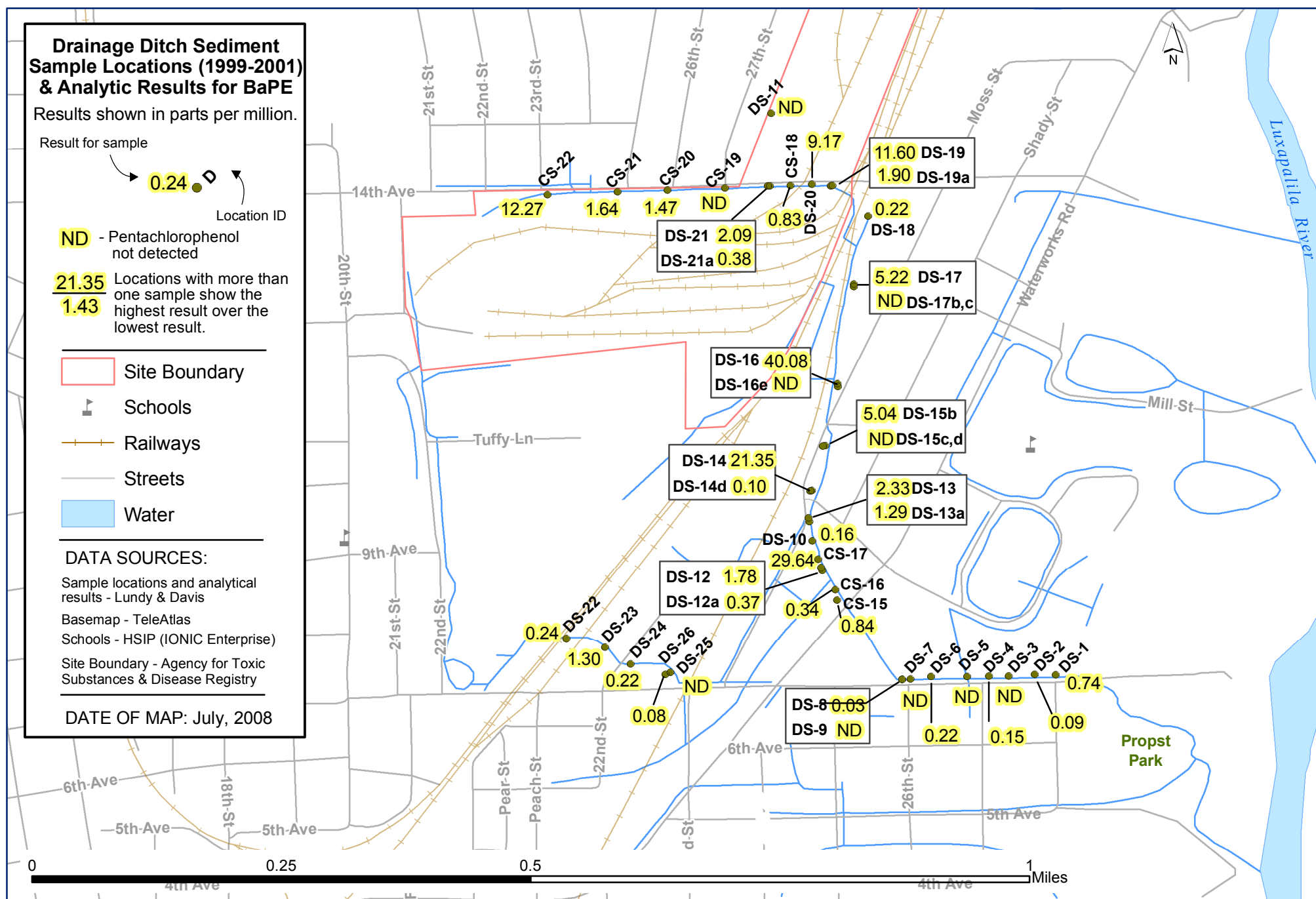


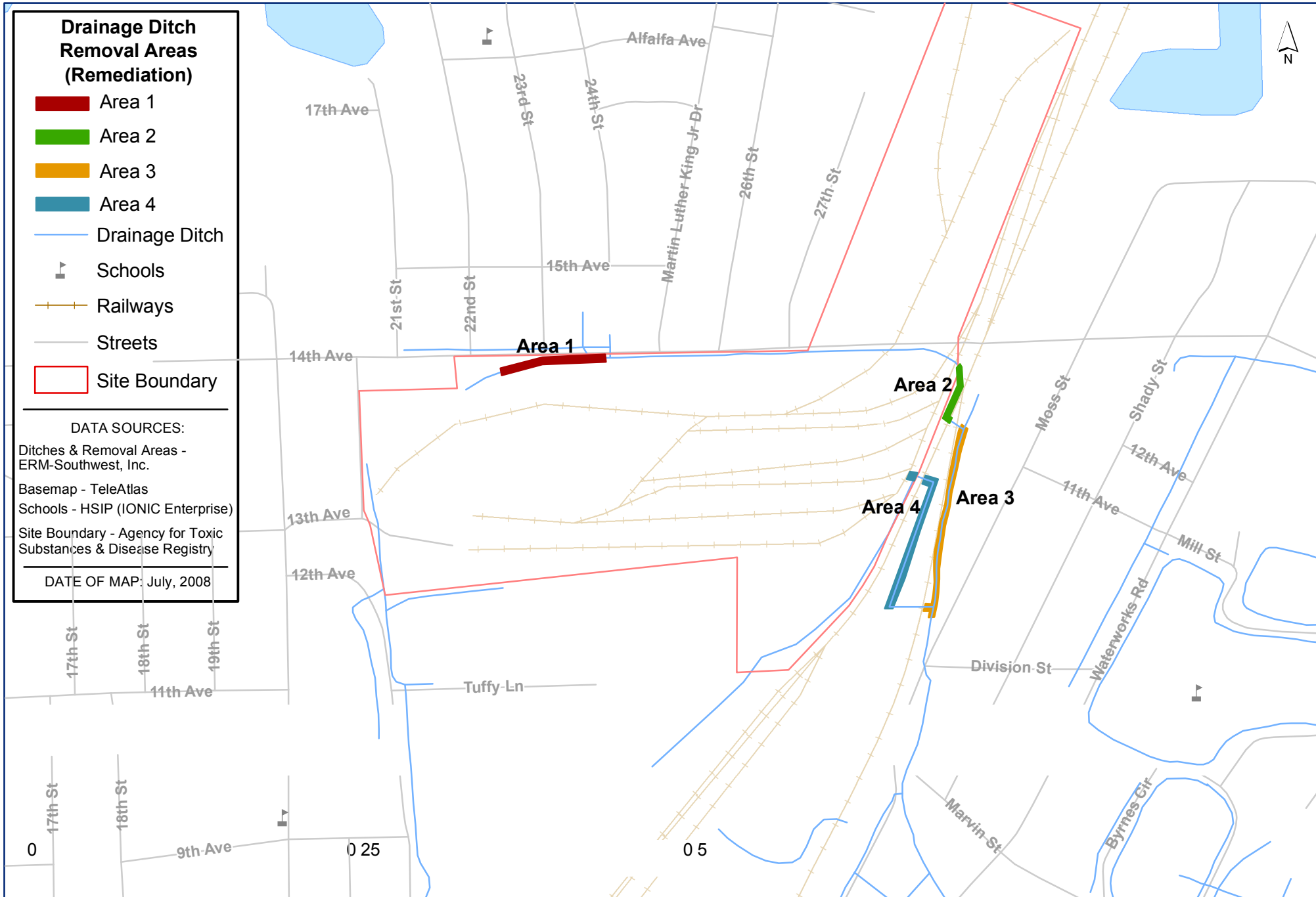




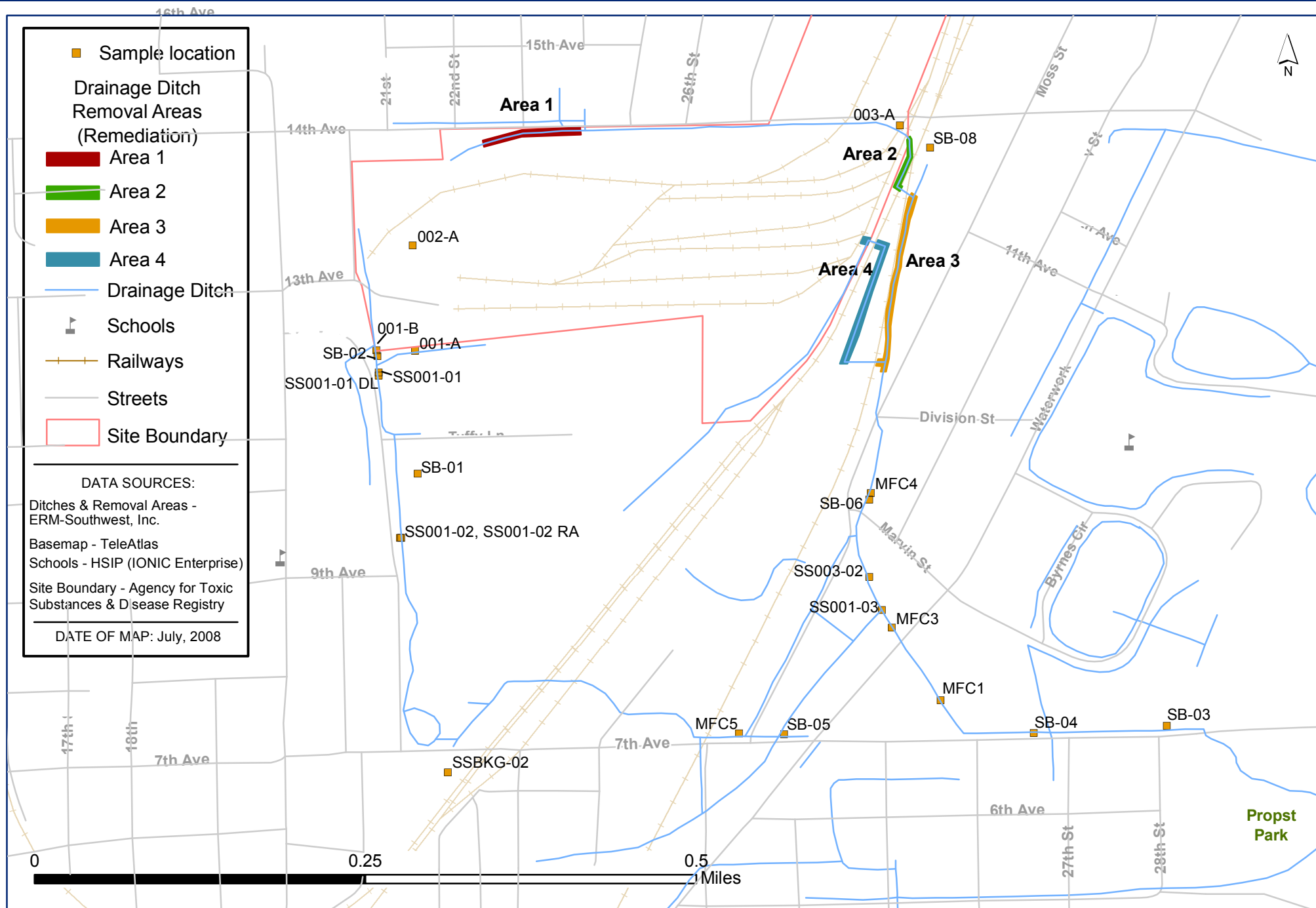








Sample Locations after 2004 Removal Actions (Kerr-McGee)



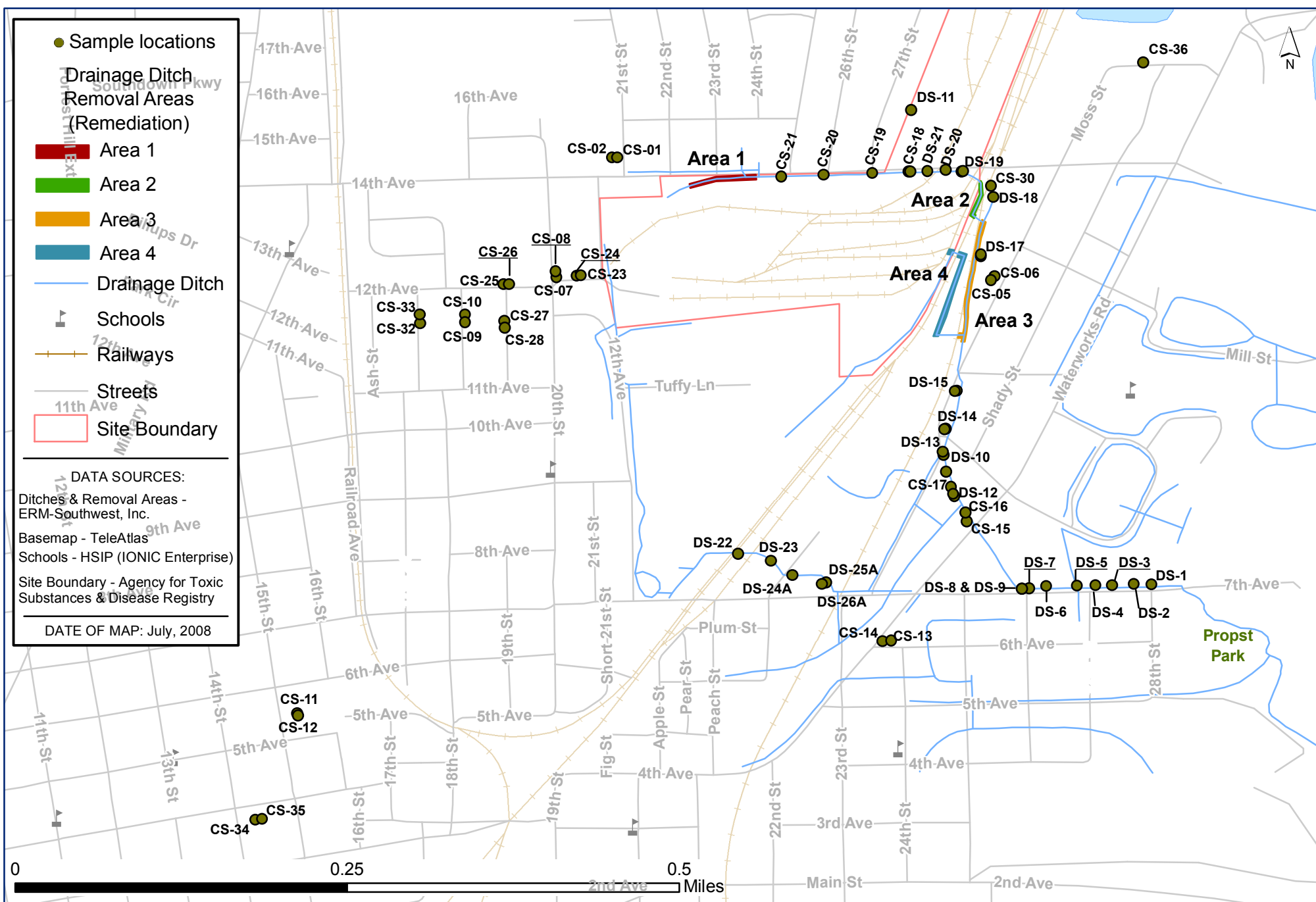
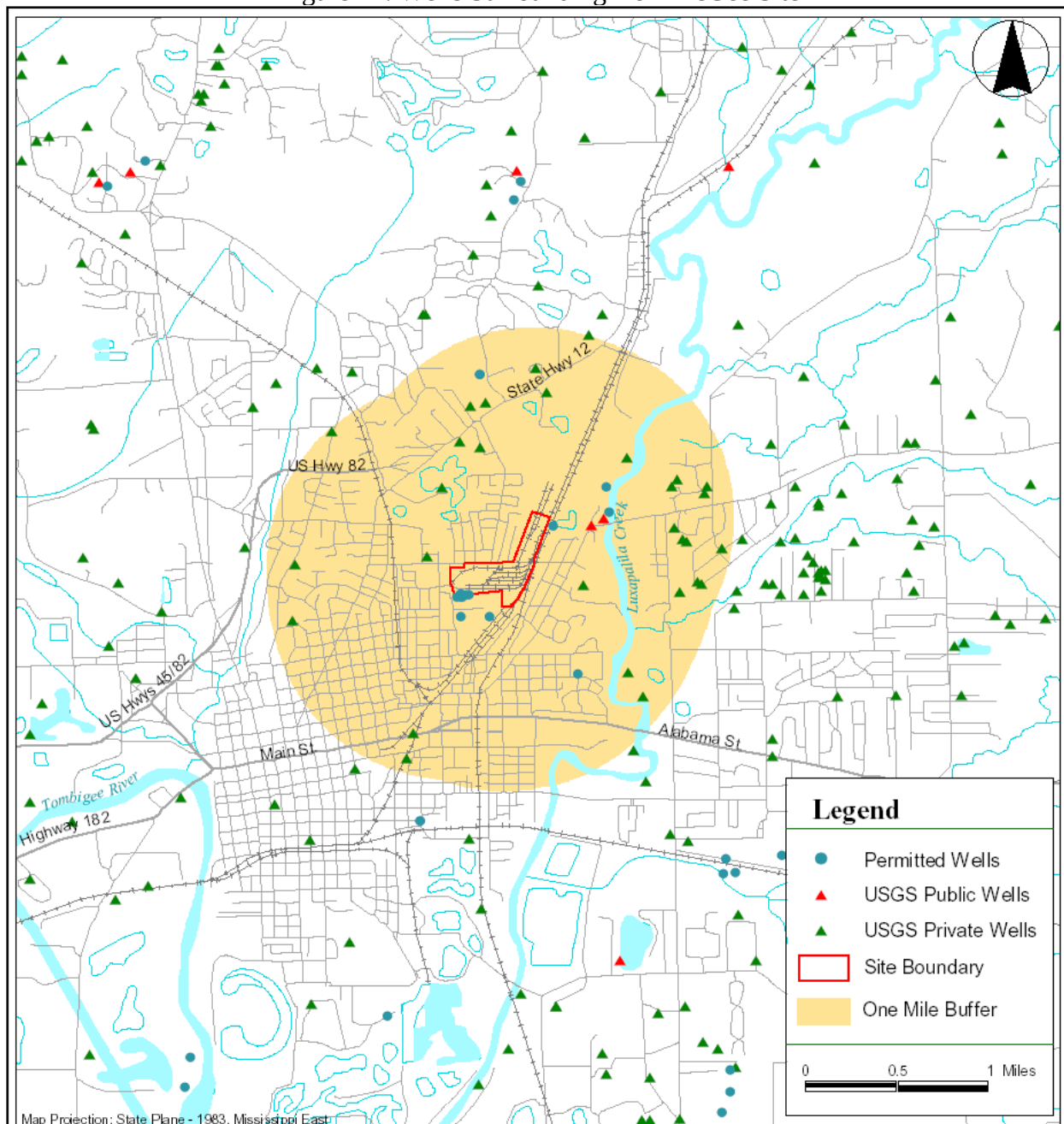


Figure 16: Photograph of Residential Homes near Ditch



Figure 17: Wells Surrounding Kerr McGee Site



Kerr-McGee Chemical Corp.

Columbus, Mississippi

EPA Facility ID MSD990866329

VICINITY MAP

Base Map Source: 1995 TIGER/Line Files

Well Data Source: State of Mississippi Automated Resource Information System (MARIS):

Permitted Wells - Water Wells permitted and monitored by the MS Office of Land and Water Resources.

USGS Private Wells - Privately owned water wells monitored by the United States Geological Survey.
USGS Public Wells - Publicly owned water wells monitored by the United States Geological Survey.



MM4_#1041

Figure 18. Aerial Photography

N
1952



Army Map Service Aerial Photo, 03/08/1952
Obtained from USGS

1974



NASA Johnson Space Center, 4/25/1974
Obtained from USGS

0 550 1,100 2,200 Feet

N
1980



USGS Aerial Photograph, 4/9/1980

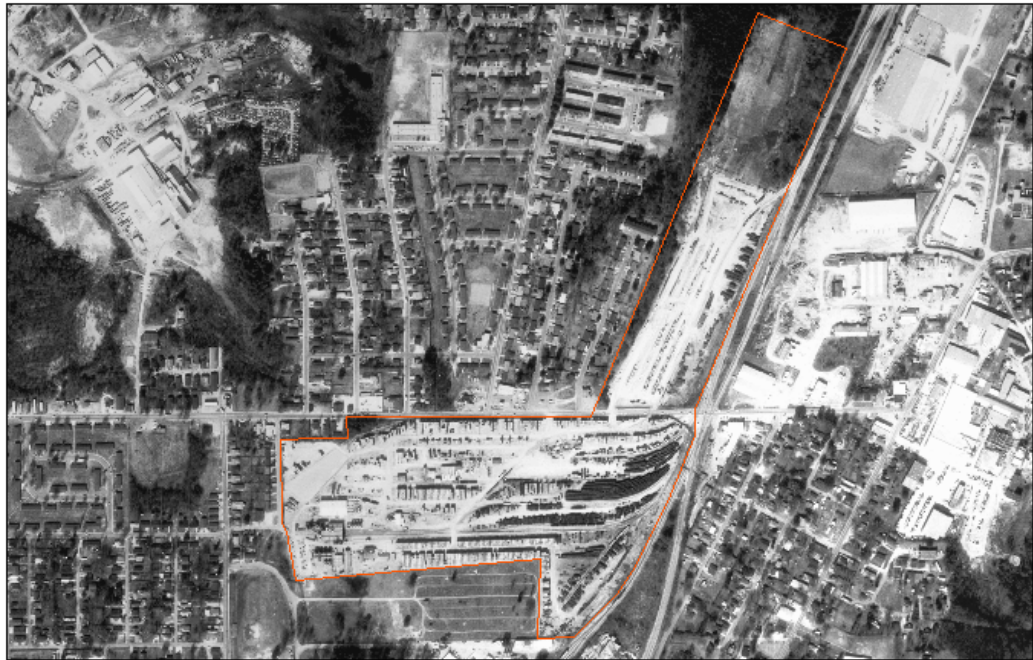
1985



USGS Aerial Photograph, 3/25/1985

0 550 1,100 2,200 Feet

1992



USGS Aerial Photograph, 2/20/1992

0 550 1,100 2,200 Feet

APPENDIX B: TABLES

Table 1. List of All Chemicals Detected in Ditch Sediments in
Areas Surrounding the Kerr-McGee Facility (Kerr-McGee Data, 2001-2002)
PRE-REMOVAL CONCENTRATIONS

Chemical	Frequency Detected	Average/ Mean (ppm)	Maximum Result (ppm)	Health- based Comparison Value (CV) (ppm)	Type of CV
2,3,4,6-Tetrachlorophenol	2/17	1.76**	0.73	2,000	RMEG
2-Methylnaphthalene	8/28	10.9	100	2,000	cMEG
4-Nitrophenol	1/17	7.72	120	NONE	NONE
Acenaphthene	18/28	12.5	130	3,000	RMEG
Acenaphthylene	21/28	4.07	46	NONE	NONE
Anthracene	26/28	7.89	89	20,000	RMEG
Benzo(a)anthracene	26/28	9.33	37	NONE	NONE
Benzo(a)pyrene	26/28	6.20	31	0.1	CREG
Benzo(b)fluoranthene	24/28	8.38	53	NONE	NONE
Benzo(g,h,i)perylene	19/28	4.38	29	NONE	NONE
Benzo(k)fluoranthene	21/28	5.38	32	NONE	NONE
Benzoic Acid	2/28	3.41	29	200,000	RMEG
bis(2-ethylhexyl) phthalate	12/28	1.2**	1.0	50	CREG
Carbazole	11/28	2.95	32	NONE	NONE
Chrysene	26/28	10.7	49	NONE	NONE
Dibenzo(a,h.)anthracene	17/28	1.06	8.7	NONE	NONE
Dibenzofuran	17/28	15.1	120	NONE	NONE
di-n-butyl phthalate	1/28	0.78**	0.18	5,000	RMEG
Fluoranthene	25/28	40.6	210	2,000	RMEG
Fluorene	19/28	19.7	160	2,000	RMEG
Indeno(1,2,3-c,d)Pyrene	21/28	3.98	26	NONE	NONE
Isophorone	1/28	0.92**	0.16	700	CREG
Napthalene	11/28	23.1	320	NONE	NONE
Benzo(a)pyrene Equivalents	18/19	8.97	51.3	0.1	CREG
Nitrobenzene	2/17	4.76	42	30	RMEG
Pentachlorophenol	14/28	2.98	15	6	CREG
Phenanthrene	25/28	51.3	430	NONE	NONE
Phenol	1/28	0.77	0.092	20,000	RMEG
Pyrene	26/28	36.1	180	2,000	RMEG

Bolded text indicates that the maximum concentration exceeds the comparison value (CV) for that chemical.

Averages were calculated using ½ the reported detection limit for non-detects (NDs).

**The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.

Table 2. List of All Chemicals Detected in Ditch Sediments in
Areas Surrounding the Kerr-McGee Facility (Lundy & Davis Data, 1999-2001)
PRE-REMOVAL CONCENTRATIONS

Chemical	Frequency Detected	Average/ Mean (ppm)	Maximum Result (ppm)	Health- based Comparison Value (CV) (ppm)	Type of CV
2-Methylnaphthalene	11/53	1.93	37.7	2,000	cEMEG
Acenaphthene	20/64	3.64	63.2	3,000	RMEG
Acenaphthylene	16/64	0.19	1.96	NONE	NONE
Anthracene	29/64	3.66	71.4	20,000	RMEG
Arsenic	6/13	3.02	8.3	0.5	CREG
Barium	13/13	65.4	288	10,000	cEMEG
Benzo(a)anthracene	38/64	3.81	70	NONE	NONE
Benzo(a)pyrene	35/63	1.90	24.5	0.1	CREG
Benzo(b)fluoranthene	41/64	3.93	67.9	NONE	NONE
Benzo(g,h,i)perylene	18/63	0.53	7.89	NONE	NONE
Benzo(k)fluoranthene	39/64	3.49	67.9	NONE	NONE
Benzyl butyl phthalate	1/43	0.34	0.423	10,000	RMEG
Bis(2-ethylhexyl)phthalate	7/53	0.45	4.26	50	CREG
Cadmium	3/13	0.27	0.35	10	cEMEG
Chromium	13/13	8.31	19.4	NONE	NONE
Chrysene	41/64	3.82	61.5	NONE	NONE
Dibenzo(a,h,)anthracene	6/63	0.14	1.72	NONE	NONE
Dibenzofuran	14/53	3.67	49.5	NONE	NONE
di-n-butyl phthalate	1/43	0.18	0.678	5,000	RMEG
Dioxins (TEQ, WHO equivalents)	9/12	.0024	0.0101	0.00005	EMEG
Fluoranthene	45/64	16.5	378	2,000	RMEG
Fluorene	23/64	5.00	66.4	2,000	RMEG
Indeno(1,2,3-c,d)pyrene	27/64	0.81	10.5	NONE	NONE
Lead	12/13	13.9	40.3	400	PRG
Mercury	2/13	0.09**	0.05	23	SSL
Napthalene	8/60	2.72	95.7	NONE	NONE
Benzo(a)pyrene Equivalents	42/63	2.9	40.1	0.1	CREG
Pentachlorophenol	1/43	0.66**	0.277	6	CREG
Phenanthrene	29/64	17.7	299	NONE	NONE
Phenol	1/43	0.33**	0.082	20,000	RMEG
Pyrene	38/64	11.9	238	2,000	RMEG
Selenium	2/13	2.18	0.45	300	cEMEG

Bolded text indicates that the maximum concentration exceeds the comparison value (CV) for that chemical.

Averages were calculated using ½ the reported detection limit for non-detects (NDs).

**The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.

Table 3. List of All Chemicals Detected in Surface Soils in
Areas Surrounding the Kerr-McGee Facility (Lundy & Davis Data, 1999-2001)
PRE-REMOVAL CONCENTRATIONS

Chemical	Frequency Detected	Average/ Mean (ppm)	Maximum Result (ppm)	Health- based Comparison Value (CV) (ppm)	Type of CV
Acenaphthene	1/26	0.00258	0.067	3000	RMEG
Acenaphthylene	2/26	0.0118	0.212	NONE	NONE
Anthracene	5/26	0.0171	0.141	20000	RMEG
Arsenic	14/26	2.61	14.2	0.5	CREG
Barium	25/26	100	389	4000	RMEG
Benzo(a)anthracene	6/26	0.0641	0.777	NONE	NONE
Benzo(a)pyrene	7/26	0.083	0.931	0.1	CREG
Benzo(b)fluoranthene	5/26	0.107	1.33	NONE	NONE
Benzo(g,h,i)perylene	5/26	0.0394	0.321	NONE	NONE
Benzo(k)fluoranthene	5/26	0.104	0.979	NONE	NONE
Benzyl alcohol	1/16	0.0141	0.226	18000	PRG
Benzyl butyl phthalate	3/26	0.0482	0.73	10,000	RMEG
bis(2-chloroisopropyl) ether	1/26	0.0105	0.272	2000	RMEG
bis(2-ethylhexyl) phthalate	21/26	0.355	1.83	50	CREG
Cadmium	10/26	0.221	1.8	10	CEMEG
Chromium	22/26	9.22	35.4	80,000	RMEG
Chrysene	7/26	0.1	1.1	NONE	NONE
Fluoranthene	13/26	0.201	2.1	2000	RMEG
Hexachloroethane	1/26	0.0075	0.195	50	CREG
Indeno(1,2,3-c,d)Pyrene	4/26	0.0301	0.32	NONE	NONE
Lead	25/26	73.5	432	400	SSL
Mercury	18/26	0.133	0.8	23	SSL
Benzo(a)pyrene Equivalents	13/26	0.13	1.18	0.1	CREG
Phenanthrene	8/26	0.107	1.05	7800	SSL
Phenol	1/26	0.00838	0.218	20000	RMEG
Pyrene	12/26	0.169	1.71	2000	RMEG
Selenium	7/26	0.115	0.65	10	CEMEG
Silver	11/26	0.721	6.05	300	RMEG

Bolded text indicates that the maximum concentration exceeds the comparison value (CV) for that chemical.

Averages were calculated using ½ the reported detection limit for non-detects (NDs).

**The calculated average is higher than the maximum detected concentration due to including ½ the detection limit in the calculation.

Table 4:
Contaminants of Potential Concern in Ditch *Sediment* – Areas Surrounding Kerr-McGee Facility
(Kerr-McGee Data, 1996-1999)
Benzo(a)pyrene Equivalents (BaPE) and Pentachlorophenol (PCP)
PRE-REMOVAL CONCENTRATIONS

Sample ID (see map for location)	PCP (ppm)	BaPE Total (ppm)	Depth (inches)
001-A	1.2	26.9	Unspecified
001-B	0.58	1.30	Unspecified
002-A	0.3	7.29	Unspecified
002-B	6.8	51.6	0-6
003-A	1.4	16.4	0-6
003-B	20	188.0	0-6
004-A	1.3	54.4	0-6
004-B	ND	165.1	0-6
005-A	ND	5.7	0-6
005-B	ND	11.5	0-6
SS001-01	2.4	12.1	0-1
SS001-02	0.79	1.28	Unspecified
SS001-03	0.35	1.16	Unspecified
SS003-01	0.29	2.83	0-1
SS003-02	ND	0.62	Unspecified
SS004-01	0.26	5.74	0-1
SSBKG-02	ND	0.53	0-12
(MDEQ) MFC1	ND	22.4	0-12
(KM) MFC1	ND	50.2	0-12
(MDEQ) MFC3	ND	0.39	0-12
(KM) MFC3	7.2	3.4	0-12
(MDEQ) MFC4	ND	0.97	0-12
(KM) MFC4	0.3	7.11	0-12
(MDEQ) MFC5	ND	N/A	0-12
(KM) MFC5	0.023	1.47	0-12
(MDEQ) MFC6	ND	24.6	0-12
(KM) MFC 6	1.1	31.7	0-12
(MDEQ) MFC7	ND	10.2	0-12
(KM) MFC7	0.92	10.4	0-12
(MDEQ) MFC9	ND	0.33	0-12
(KM) MFC9	0.092	3.68	0-12
(MDEQ) MFC 10	ND	21.2	0-12
(KM) MFC10	11	18.7	0-12

N/A = not applicable; sample not taken

ND = chemical not detected; contaminant level below analytical testing laboratory's reporting limits

Bolded = concentration exceeds applicable comparison value (CV) of 6 ppm for Pentachlorophenol (PCP) and 0.1 ppm for benzo(a)pyrene (BaPE)

Split samples designated "(MDEQ)" = MS Dept. of Env. Quality and "(KM)" = Kerr-McGee

Table 5:
Contaminants of Potential Concern in Ditch *Sediment* – Areas Surrounding Kerr-McGee Facility
(Kerr-McGee Data, 2001-2002)
Pentachlorophenol (PCP) and Benzo(a)pyrene Equivalents (BaPE)
PRE-REMOVAL CONCENTRATIONS

Sample ID (see map for location)	PCP (ppm)	BaPE (ppm)	Depth (inches)
SB-01A	0.27	0.74	0-6
SB-01B	ND	20.0	6-12
SB-02A	15.0	18.7	0-6
SB-02B	15.0	13.5	6-12
SB-03A	ND	2.83	0-6
SB-03B	0.19	3.94	6-12
SB-04A	ND	2.22	0-6
SB-04B	ND	4.68	6-12
SB-05A	ND	0.55	0-6
SB-05B	N/A	N/A	6-12
SB-06A	0.14	2.73	0-6
SB-06B	ND	ND	6-12
SB-07A	2.4	15.7	0-6
SB-07B	0.53	3.85	6-12
SB-08A	ND	9.37	0-6
SB-08B	ND	2.96	6-12
SB-09A	ND	0.19	0-6
SB-09B	ND	0.17	6-12
SB-10A	1.8	16.8	0-6
SB-10B	6.0	51.3	6-12

N/A = not applicable; sample not taken

ND = not detected; contaminant level below analytical testing laboratory's reporting limits

Bolded = concentration exceeds applicable comparison value (CV) of 6 ppm for
Pentachlorophenol (PCP) and 0.1 ppm for benzo(a)pyrene (BaPE)

Table 6:
Contaminants of Potential Concern in Off-site *Surface Soil* – Areas Surrounding Kerr-McGee
Facility (Lundy & Davis Data, 1999-2001)
Benzo(a)pyrene Equivalents (BaPE) and Pentachlorophenol (PCP)
PRE-REMOVAL CONCENTRATIONS

Sample ID (see map for location)	PCP (ppm)	BaPE (ppm)	Depth (inches)
CS-1	ND	ND	16
CS-2	ND	ND	14
CS-5	ND	ND	8
CS-6	ND	ND	10
CS-7	ND	0.19	8
CS-8	ND	0.24	8
CS-9	ND	ND	8
CS-10	ND	ND	8
CS-11	ND	ND	10
CS-12	ND	ND	10
CS-13	ND	ND	8
CS-14	ND	ND	8
CS-23	ND	0.07	10
CS-24	ND	ND	8
CS-25	ND	ND	8
CS-26	ND	0.007	8
CS-27	ND	0.085	10
CS-28	ND	ND	10
CS-29	ND	ND	8
CS-30	ND	0.399	8
CS-32	ND	ND	8
CS-33	ND	ND	8
CS-34	ND	0.53	8
CS-35	ND	1.18	8
CS-36	ND	ND	8
CS-38	ND	ND	6

ND= not detected; contaminant level below analytical testing laboratory's reporting limits
 Bolded = concentration exceeds the comparison value (CV) of 6 ppm for Pentachlorophenol (Penta) and 0.1 ppm for benzo(a)pyrene (BaPE)

Table 7:
Contaminants of Potential Concern in Ditch *Sediment* – Areas Surrounding Kerr-McGee Facility
(Lundy & Davis Data, 1999 - 2001): PRE-REMOVAL CONCENTRATIONS
Benzo(a)pyrene Equivalents (BaPE) and Pentachlorophenol (PCP)

Sample ID (see map for location)	PCP (ppm)	BaPE (ppm)	Dioxins	Depth (inches)
DS-1		0.74		2.5
DS-2		0.09		2.5
DS-3		ND		2.5
DS-4		0.148		2.5
DS-5		ND		2.5
DS-6		0.220		2.5
DS-7		ND		2.5
DS-8		0.036		2.5
DS-9		ND	ND	2.5
DS-10		0.17		1.0
DS-11		ND	ND	1.0
DS-12		1.78		0 - 1
DS-12A	ND	0.37	0.001	0-2
DS-12B	ND	ND		0-2
DS-12C	ND	ND		0-2
DS-12D	ND	ND		0-2
DS-12E	ND	ND		0-2
DS-12F	ND	ND		0-2
DS-13	NA	2.33		0 -1
DS-13A	ND	1.29	0.00044	0-2
DS-13B	ND	ND		0-2
DS-13C	ND	ND		0-2
DS-13D	ND	ND		0-2
DS-13E	ND	ND		0-2
DS-14	NA	21.36		0 -1
DS-14A	ND	1.43	ND	0-2
DS-14B	ND	2.72		0-2
DS-14C	ND	2.59		0-2
DS-14D	ND	0.11		0-2

Bolded = concentration exceeds the comparison value (CV) of 6 ppm for Pentachlorophenol (Penta); 0.1 ppm for benzo(a)pyrene (BaPE), or 0.05 ppb for dioxins.

ND= not detected; contaminant level below analytical testing laboratory's reporting limits

*A limited number of samples were analyzed for dioxins. Dioxins are expressed as toxic equivalency quotients (TEQs). The toxicity equivalent TEQ is calculated by multiplying the exposure level of a particular dioxin-like compound by its toxicity equivalency factor (TEF). The TEFs for the dioxin congeners contributing to the TEQ calculations for these samples were not available to ATSDR.

Table 7 continued:
Contaminants of Potential Concern in Ditch *Sediment* – Areas Surrounding Kerr-McGee Facility
(Lundy & Davis Data, 1999 - 2001): PRE-REMOVAL CONCENTRATIONS
Benzo(a)pyrene Equivalents (BaPE) and Pentachlorophenol (PCP)

Sample ID (see map for location)	PCP (ppm)	BaPE (ppm)	Dioxins	Depth (inches)
DS-15	ND	1.86		0-1
DS-15A	ND	0.098	0.067	0-2
DS-15B	ND	5.03	2.59	0-2
DS-15C	ND	ND		0-2
DS-15D	ND	ND		0-2
DS-15E	ND	0.0098		0-2
DS-16	NA	40.1		0-1
DS-16A	ND	9.92	9.9	0-2
DS-16 B	ND	7.10	10.1	0-2
DS-16D	ND	0.09		0-2
DS-16 E	ND	ND		0-2
DS-17	NA	5.23		0-1
DS-17A	ND	2.56	1.21	0-2
DS-17B	ND	ND		0-2
DS-17C	ND	ND		0-2
DS-18	ND	0.22		0-1
DS-19	NA	11.6		0-1
DS-19A	ND	1.90	4.6	0-2
DS-20	NA	9.16		0-1
DS-21	NA	2.09		0-1
DS-21A	ND	0.38	0.311	0-2
DS-22A	ND	0.24		0-2
DS-23A	ND	1.30		0-2
DS-24A	ND	0.22		0-2
DS-25A	ND	ND		0-2
DS-26A	ND	0.086		0-2
CS-15	ND	0.85		1.5
CS-16	ND	0.34		1.3
CS-17	ND	29.6		1.3
CS-18	ND	0.83		1.5
CS-19	ND	ND		1.5
CS-20	ND	1.47		1.5
CS-21	0.277	1.64		1.3
CS-22	ND	12.3		1.3

Bolded = concentration exceeds the comparison value (CV) of 6 ppm for Pentachlorophenol (Penta); 0.1 ppm for benzo(a)pyrene (BaPE), or 0.05 ppb for dioxins.

ND= not detected; contaminant level below analytical testing laboratory's reporting limits

*A limited number of samples were analyzed for dioxins. Dioxins are expressed as toxic equivalency quotients (TEQs). The toxicity equivalent TEQ is calculated by multiplying the exposure level of a particular dioxin-like compound by its toxicity equivalency factor (TEF). The TEFs for the dioxin congeners contributing to the TEQ calculations for these samples were not available to ATSDR.

Table 8: Kerr-McGee Chemical Corporation
Surface Water Samples

<i>Chemical</i>	<i>Number of Samples</i>	<i>Number of Detections</i>	<i>Minimum Result (mg/l)</i>	<i>Maximum Result (mg/l)</i>	<i>Comparison Value</i>	<i>Source</i>
Indeno(1,2,3-c,d)Pyrene	5	1	ND	6 J	0.000092	RBC

RBC = EPA Risk-Based Concentration

Table 9. Kerr-McGee Chemical Corporation
Summary of Calculated Exposure Doses & Theoretical Lifetime Cancer Risk
KERR-McGEE DATA

Calculated Exposure Doses

Chemical	Incidental Ingestion Dose (mg/kg/day)		Dermal Contact Dose (mg/kg/day)		Ingestion & Dermal Contact Dose (mg/kg/day)		Health Guideline (mg/kg/day)	Exceeds Health Guideline?
	Average	Maximum	Average	Maximum	Average	Maximum		
Adult – Sediment Pathway								
Pentachlorophenol	2.12E-06	1.07E-05	3.46E-06	1.74E-05	5.58E-06	2.81E-05	1.00E-03	No
B(a)P Equivalent	6.39E-06	3.65E-05	2.08E-06	1.19E-05	8.47E-06	4.84E-05	4.00E-01	No
Child – Sediment Pathway								
Pentachlorophenol	9.91E-06	4.99E-05	1.3E-05	6.54E-05	2.29E-05	1.15E-04	1.00E-03	No
B(a)P Equivalent	2.98E-05	0.000171	7.83E-06	4.48E-05	3.76E-05	2.16E-04	4.00E-01	No

Calculated Theoretical Lifetime Cancer Risk

Chemical		Ingestion & Dermal Contact Cancer Risk		Total Cancer Risk from All Chemicals in Pathway		Cancer Risk Conclusion	
		Average	Maximum	Average	Maximum	Average	Maximum
Adult – Sediment Pathway							
Pentachlorophenol		2.87E-07	1.45E-06	2.66E-05	1.52E-04	No Apparent Increased Cancer Risk	Low to Moderate Increased Cancer Risk
B(a)P Equivalent		2.65E-05	1.51E-04				
Child – Sediment Pathway							
Pentachlorophenol		2.75E-07	1.38E-06	2.76E-05	1.59E-04	No Apparent Increased Cancer Risk	Low to Moderate Increased Cancer Risk
B(a)P Equivalent		2.74E-05	1.58E-04				

Bolded value indicates that the calculated exposure dose exceeds its health guideline or the theoretical cancer risk is greater than 1×10^{-4} .

Table 10. Kerr-McGee Chemical Corporation
Summary of Calculated Exposure Doses
LUNDY & DAVIS DATA

Calculated Exposure Doses

Chemical	Incidental Ingestion Dose (mg/kg/day)		Dermal Contact Dose (mg/kg/day)		Ingestion & Dermal Contact Dose (mg/kg/day)		Health Guideline (mg/kg/day)	Exceeds Health Guideline?
	Average	Maximum	Average	Maximum	Average	Maximum		
Adult – Sediment Pathway								
Arsenic	2.15E-06	5.91E-06	7.01E-08	1.93E-07	2.22E-06	6.10E-06	3.00E-04	No
B(a)P Equivalent	2.07E-06	2.86E-05	6.73E-07	9.31E-06	2.74E-06	3.79E-05	4.00E-01	No
Dioxins	1.71E-09	7.19E-09	5.57E-09	2.34E-08	7.28E-09	3.06E-08	1.00E-09	Yes
Child – Sediment Pathway								
Arsenic	1.00E-05	2.76E-05	2.64E-07	7.24E-07	1.03E-05	2.83E-05	3.00E-04	No
B(a)P Equivalent	9.64E-06	0.000133	2.53E-06	3.5E-05	1.22E-05	0.000168	4.00E-01	No
Dioxins	7.98E-09	3.36E-08	2.09E-08	8.81E-08	2.89E-08	1.22E-07	1.00E-09	Yes
Adult – Surface Soil Pathway								
Arsenic	1.86E-06	1.01E-05	6.06E-08	3.3E-07	1.92E-06	5.22E-06	3.00E-04	No
B(a)P Equivalent	9.26E-08	8.41E-07	3.02E-08	2.74E-07	1.23E-07	1.12E-06	4.00E-01	No
Child – Surface Soil Pathway								
Arsenic	1.74E-05	9.47E-05	4.57E-07	2.49E-06	1.79E-05	9.72E-05	3.00E-04	No
B(a)P Equivalent	8.67E-07	7.87E-06	2.28E-07	2.07E-06	5.48E-07	9.94E-06	4.00E-01	No

Bolded value indicates that the calculated exposure dose exceeds its health guideline or the theoretical cancer risk is greater than 1×10^{-4} .

Table 10 cont'd. Kerr-McGee Chemical Corporation
Summary of Theoretical Lifetime Cancer Risk
LUNDY & DAVIS DATA

Calculated Theoretical Lifetime Cancer Risk

Chemical		Ingestion & Dermal Contact Cancer Risk		Total Cancer Risk from All Chemicals in Pathway		Cancer Risk Conclusion	
		Average	Maximum	Average	Maximum	Average	Maximum
Adult – Sediment Pathway							
Arsenic		1.43E-06	3.92E-06	4.78E-04	2.09E-03	Low to Moderate Increased Cancer Risk	Moderate Increased Cancer Risk
B(a)P Equivalent		8.57E-06	1.19E-04				
Dioxins		4.68E-04	1.97E-03				
Child – Sediment Pathway							
Arsenic		1.55E-06	4.25E-06	4.44E-04	1.96E-03	Low to Moderate Increased Cancer Risk	Moderate Increased Cancer Risk
B(a)P Equivalent		8.91E-06	1.23E-04				
Dioxins		4.34E-04	1.83E-03				
Adult – Surface Soil Pathway							
Arsenic		1.23E-06	3.36E-06	1.62E-06	6.86E-06	No Apparent Increased Cancer Risk	No Apparent Increased Cancer Risk
B(a)P Equivalent		3.85E-07	3.50E-06				
Child – Surface Soil Pathway							
Arsenic		2.69E-06	1.46E-05	3.09E-06	2.19E-05	No Apparent Increased Cancer Risk	No Apparent Increased Cancer Risk
B(a)P Equivalent		4E-07	7.26E-06				

Bolded value indicates that the calculated exposure dose exceeds its health guideline or the theoretical cancer risk is greater than 1×10^{-4} .

Table 11: Forensic Analysis of Total Dust Collected in Attic of SD-10

<i>Chemical</i>	<i>Concentration (mg/kg)</i>	<i>Urban Household Dust Concentration (mg/kg)⁹</i>	<i>Floor Dust Concentration (mg/kg)¹⁰</i>	<i>NIST SRM 2583 (mg/kg)¹¹</i>	<i>Comparison Value</i>	<i>Source</i>
Fluorene	2.93	0.02-1.22	0.005-0.028	NA	2,000	RMEG
Phenanthrene	7.92	0.13-2.15	0.044-0.598	NA	None	
Fluoranthene	15.7	0.09-1.89	0.074-1.56	NA	2,000	RMEG
Pyrene	12.2	0.06-1.65	0.057-1.20	NA	2,000	RMEG
Benzo(a)anthracene	2.98	0.04-0.69	0.016-0.294	0.88	0.87	RBC
Chrysene	7.06	0.05-2.41	0.037-0.838	1.72	87	RBC
Benzo(b)fluoranthene	14.1	0.17-1.34	0.053-1.44	1.39	0.87	RBC
Benzo(k)fluoranthene	14.1	0.17-1.34	0.019-0.496	1.46	8.7	RBC
Benzo(a)pyrene	3.26	0.07-0.63	0.024-0.768	0.97	0.1	CREG
Indeno(1,2,3-c,d)pyrene	2.93	0.05-0.7	0.035-0.963	0.99	0.87	RBC

N/A = not applicable

Table 12: Forensic Analysis of Dust Sample MG-8

<i>Chemical</i>	<i>Concentration (mg/kg)</i>	<i>Urban Household Dust Concentration (mg/kg)</i>	<i>Floor Dust Concentration</i>	<i>Comparison Value (mg/kg)</i>	<i>Source</i>
Fluoranthene	2.5	0.09-1.89	0.074-1.56	2,000	RMEG
Phenanthrene	3.1	0.13-2.15	0.044-0.598	None	

⁹ Values from Chuang *et al* , reference 40¹⁰ Values from Wilson *et al*, reference 41¹¹ Values from Lewis *et al* reference 39

Table 13: Screening Analysis of Dioxin Dust Samples

<i>Congeners</i>	<i>Kitchen on Moss Street (ng/kg)</i>	<i>Kitchen on 23rd Street North (ng/kg)</i>
TCDD	0.02	0.04
1,2,3,7,8 PCDD	Non-detect ¹²	0.2
1,2,3,4,7,8 HxCDD	Non-detect	0.22
1,2,3,6,7,8 HxCDD	Non-detect	0.25
1,2,3,7,8,9 HxCDD	Non-detect	0.23
1,2,3,4,6,7,8 HpCDD	0.1	0.25
OCDD	0.59	0.5
TCDF	Non-detect	0.03
2,3,4,7,8 PCDF	Non-detect	0.21
1,2,3,7,8 PCDF	Non-detect	0.22
1,2,3,4,7,8 HxCDF	0.01	0.22
1,2,3,6,7,8 HxCDF	Non-detect	0.23
1,2,3,7,8,9 HxCDF	Non-detect	0.21
2,3,4,6,7,8 HxCDF	Non-detect	0.23
1,2,3,4,6,7,8 HpCDF	0.03	0.24
1,2,3,4,7,8,9 HpCDF	Non-detect	0.20
OCDF	0.05	0.45
Total Dioxin/Furan TEQ	0.02385	0.37845
ATSDR EMEG (TEQ)	50	50

¹² ATSDR presumes these results are non-detect. Dahlgren *et al.* left values blank, detection limits were not reported.

APPENDIX C:
LIST OF PAH TEFs and COMPARISON VALUES USED

HOW ATSDR EVALUATED POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

In order to calculate the carcinogenic potential of the PAHs, each carcinogenic PAH is assigned a toxic equivalence factor (TEF), which is an estimate based on its relative potency to benzo(a)pyrene. The concentration of each PAH is multiplied by its TEF, and the sum of the products is described as the benzo(a)pyrene equivalent (BaPE). The following toxicity equivalency factors were used in the calculation of the BaPE:

benzo(a)anthracene	0.1
chrysene	0.001
benzo(b)fluoranthene	0.1
benzo(k)fluoranthene	0.01
benzo(a)pyrene	1.0
indeno(1,2,3-cd)pyrene	0.1
dibenz(a,h)anthracene	1.0

LIST OF COMPARISON VALUES USED IN THIS DOCUMENT

- A **Cancer Risk Evaluation Guide (CREG)** is a comparison concentration at which excess cancer risk is not likely to exceed one case of cancer in a million persons exposed over a lifetime. A CREG is calculated using EPA's cancer slope factor (CSF). The CREG is a very conservative comparison value that is used as a screening value for cancer. Exposure to a concentration equal to or less than the CREG is defined as an insignificant risk and is an acceptable level of exposure over a lifetime.
- An **Environmental Media Evaluation Guide (EMEG)** is an estimated contaminant concentration that is not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR MRLs and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.
- A **Reference Dose Media Evaluation Guide (RMEG)** is a concentration in water or soil at which daily human exposure is unlikely to result in adverse non-carcinogenic effects. ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluations.
- EPA's **Soil Screening Level (SSL)** is an estimate of a contaminant concentration not expected to result in non-carcinogenic health effects during a specified duration of exposure (similar to EMEGs), or to be associated with no more than an estimated one excess cancer in a million (10^{-6}) persons exposed during a 70 year life span (similar to CREGs). SSLs are derived by calculating exposure equations and pathway models to estimate an "acceptable" level of a contaminant in soil via ingestion, dermal, and inhalation pathways.
- An EPA Region 9 **Preliminary Remedial Goal (PRG)** is a concentration in environmental media (soil, air, and water) that is considered by EPA to be health protective of human exposures (including sensitive groups), over a lifetime. Chemical concentrations above these levels would not automatically designate a site as "dirty" or trigger a response action. However, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate.
- An EPA Region 3 **Risk-Based Concentration (RBC)** is a guideline used to assess the potential for harm from chemicals found at a hazardous waste site. They were developed by combining a substance's toxicologic properties with "standard" scenarios for encountering the substance. EPA Region 3 emphasizes that RBCs are not intended to be used as regulatory cleanup goals; however, they can be used as an initial screening of substances found in site media.

APPENDIX D:
LIST OF COMMUNITY HEALTH CONCERNS

Health Concerns Identified by the Community

Respiratory Effects

Asbestosis
Chronic obstructive pulmonary disease
Respiratory problems
Sinus problems
Sinus congestion due to allergies
Sleep apnea
Breathing problems
Shortness of breath
Lung problem
Chronic cough
Idiopathic pulmonary fibrosis
Asthma
Hospitalization due to lung infection
Bronchitis

Cardiovascular Effects

Heart Disease (unspecified)
Congestive Heart failure
Stroke
High Blood Pressure
Atherosclerosis

Immune System Effects

Lupus
Severe allergies
Severe rheumatoid arthritis

Gastrointestinal Effects

Severe stomach problem
Bowels trouble

Spastic colon
Gall Bladder surgery/removal
Hiatal hernia
Upset stomach
Stomach sickness

Hematological Effects

Hemolysis
Bone marrow dysfunction

Musculoskeletal Effects

Weakening of the legs

Hepatic Effects

Taking medicine for Liver
Liver problems

Renal Effects

Taking medicine for kidney
Kidney problems
Kidney stones

Dermatological/Ocular Effects

Loss of Hair
Skin Disease/Rash
Skin disorder
Eye problems
Burning of eyes
Dryness and itching of skin

Other System Effects

Diabetes
Increased mortality in young adults
Sarcoidosis
Arthritis
Labyrinthitis
Sore throat
Short toes
Antifungal
Thyroid
Growth on right leg
Weak a lot
Prostate problems
Leg problems (trouble walking)
Aching muscles
Severe pain not being able to walk
Leg problems
Blood in throat
Pain – so bad can't walk
Cramps and swelling in legs
Bad drainage of throat sometime with blood in it.

Chest hurts at times

Neurological Effects

Nerve Problems
Fainting spells
Depression
Parkinson's Disease
Headaches
Autism
Speech/Language impediments

Reproductive Effects

Multiple Miscarriages
"Can not have children"

Developmental Effects

Birth defect – extra fingers on hands

Cancers

Cancer
Lump behind ear

Note: These health concerns were recorded by ATSDR from conversations or other communications with community members. This list does not represent a determination by ATSDR that the listed health effect will occur from exposure to chemicals from the Kerr-McGee facility. This list is merely a summary of the communications with community members.

APPENDIX E: ATSDR'S EVALUATION PROCESS

A. USE OF COMPARISON VALUES

Step 1 – The Screening Process

To evaluate the available data, ATSDR uses comparison values (CVs) to determine which chemicals to exclude from further examination and which to examine more closely. CVs are the contaminant concentrations found in a specific media (for example: air, soil, or water) that are considered not likely to cause adverse health effects. Therefore, if the concentration of the chemical in the exposure medium is less than the CV, the exposures are not of health concern and the chemical is excluded from further evaluation. CVs are used as screening tools to select chemicals that need further evaluation; they are not intended as environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. The derivation of a comparison value uses conservative exposure assumptions, resulting in values that are much lower than exposure concentrations that have been observed to cause adverse health effects. These comparison values are therefore protective of public health in essentially all exposure situations. That is, if the concentrations in the exposure medium are less than the comparison values, the exposures are not of health concern and no further analysis of the pathway is required. While concentrations below the comparison value are not expected to lead to any observable health effect, it should not be inferred that a concentration greater than the comparison value will necessarily lead to adverse effects. Depending on site-specific environmental exposure factors (for example, duration of exposure) and human activities that result in exposure (time spent in area of contamination), exposure to levels above the comparison value may or may not lead to a health effect. ATSDR's comparison values, therefore, are not used to predict the occurrence of adverse health effects.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based comparison values are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation risk unit. CVs based on cancerous effects account for a lifetime exposure (70 years) with an unacceptable theoretical excess lifetime cancer risk of 1 new case per 1 million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the comparison for conservatism. The chemical and media-specific CVs utilized during the preparation of this PHA are listed below:

- **A Cancer Risk Evaluation Guide (CREG)** is a comparison concentration at which excess cancer risk is not likely to exceed one case of cancer in a million persons exposed over a lifetime. A CREG is calculated using EPA's cancer slope factor (CSF). The CREG is a very conservative comparison value that is used as a screening value for cancer. Exposure to a concentration equal to or less than the

CREG is defined as an insignificant risk and is an acceptable level of exposure over a lifetime.

- An **Environmental Media Evaluation Guide (EMEG)** is an estimated contaminant concentration that is not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR MRLs and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.
- A **Reference Dose Media Evaluation Guide (RMEG)** is a concentration in water or soil at which daily human exposure is unlikely to result in adverse non-carcinogenic effects. ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluations.
- EPA's **Soil Screening Level (SSL)** is an estimate of a contaminant concentration not expected to result in non-carcinogenic health effects during a specified duration of exposure (similar to EMEGs), or to be associated with no more than an estimated one excess cancer in a million (10^{-6}) persons exposed during a 70 year life span (similar to CREGs). SSLs are derived by calculating exposure equations and pathway models to estimate an "acceptable" level of a contaminant in soil via ingestion, dermal, and inhalation pathways.
- An EPA Region 9 **Preliminary Remedial Goal (PRG)** is a concentration in environmental media (soil, air, and water) that is considered by EPA to be health protective of human exposures (including sensitive groups), over a lifetime. Chemical concentrations above these levels would not automatically designate a site as "dirty" or trigger a response action. However, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate.
- An EPA Region 3 **Risk-Based Concentration (RBC)** is a guideline used to assess the potential for harm from chemicals found at a hazardous waste site. They were developed by combining a substance's toxicologic properties with "standard" scenarios for encountering the substance. EPA Region 3 emphasizes that RBCs are not intended to be used as regulatory cleanup goals; however, they can be used as an initial screening of substances found in site media.

Step 2 – Selecting Contaminants of Potential Concern

The next step in the evaluation process is to select those contaminants that are above their respective CVs (contaminants of potential concern, COPC) and to identify which chemicals and exposure situations are likely to be a potential health hazard. Contaminants of potential concern (COPCs) are the site-specific chemical substances that the health assessor selects for further evaluation of potential health effects. Identifying contaminants

of concern is a process that requires the assessor to examine contaminant concentrations at the site and the potential for human exposure.

In the first step of the contaminant of potential concern selection process, the maximum contaminant concentrations are compared directly to health comparison values. ATSDR considers site-specific exposure factors to ensure selection of appropriate health comparison values. If the maximum concentration for a chemical is less than the health comparison value, ATSDR concludes that exposure to that chemical is not of public health concern; therefore, no further data review is required for that chemical. However, if the maximum concentration is greater than the health comparison value, the chemical would be selected for additional data review, as a contaminant of potential concern (COPC). In addition, any chemicals detected that did not have relevant health comparison values would also be selected as a COPC. ATSDR comparison values have not been developed for some contaminants; therefore, other comparison values may be used that are appropriate for the specific type of exposure (e.g., EPA's Soil Screening Level).

The next step of the process requires a more in-depth review of data for each of the contaminants selected. Factors used in the selection of the COPC include the number of samples with levels above the minimum detection limit, the number of samples with detections above an acute or chronic health comparison value, and the potential for exposure at the sampling location.

B. CALCULATING EXPOSURE DOSES AND CANCER RISK ESTIMATES

Exposure Doses for non-cancer health effects

As previously stated, when chemical concentrations at the site exceed the established CVs, it is necessary for a more thorough evaluation of the chemical to be conducted. In order to evaluate the potential for human exposure to contaminants present at the site and potential health effects from site-specific activities, ATSDR estimates human exposure to the site contaminant from different environmental media by calculating exposure doses (or the amount of a chemical that gets into a person's body). Separate child and adult exposure doses are calculated for site-specific exposure scenarios, using assumptions regarding an individual's likelihood of contacting the contamination. Calculated doses are reported in units of milligrams per kilograms per day (mg/kg/day). Separate calculations are performed to account for non-cancer and cancer health effects for each chemical based on the health impacts reported for each chemical. The same dose equations have been used for non-cancer and cancer calculations with the indicated modifications.

A brief discussion of the calculations and assumptions is presented below. The equations and the assumptions are based on the EPA Risk Assessment Guidance for Superfund, Part A¹³ and the EPA Exposure Factors Handbook¹⁴, unless otherwise specified. A discussion of the cancer and non-cancer evaluation of exposure is presented following the equations for each pathway.

Incidental Ingestion of Contaminants Present in Soil or Sediment

Adult residents may be exposed to contaminants in soil gardening and yard work via unintentional ingestion. Children residents may also be exposed to chemicals in soil and sediment in residential yards, ditches and creeks near their homes while playing. The exposure dose equation for incidental ingestion of soil and/or sediment is:

$$\text{Dose (mg/kg/day)} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

where

C = chemical concentration (mg/kg)
IR = ingestion rate (mg/day)
EF = exposure frequency (days/years)
ED = exposure duration (years)
CF = conversion factor (1×10^{-6} kg/mg)
BW = body weight (kg)

¹³ U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund, December 1989.

¹⁴ U.S. Environmental Protection Agency. Exposure Factors Handbook, August 1997.

AT = averaging time (days)

Direct Skin (Dermal) Contact with Contaminants Present in Soil or Sediment

Dermal absorption depends on numerous factors, including the area of exposed skin, anatomical location of the exposed skin, length of contact, concentration of the chemical in contact with the skin, and other factors. Because chemicals differ greatly in their potential to be absorbed through the skin, each chemical needs to be evaluated separately. The exposure dose equation for direct contact with drinking water during showering or bathing is:

$$\text{Dose (mg/kg/day)} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

where

C = chemical concentration (mg/kg)

SA = surface area exposed (square centimeters/day or cm²/day)

AF = adherence factor (milligrams per square centimeters or mg/cm²)

ABS = absorption factor (unitless)

EF = exposure frequency (days/year)

ED = exposure duration (years)

CF = conversion factor (1 x 10⁻⁶ kg/mg)

BW = body weight (kg)

AT = averaging time (days)

The doses calculated for exposure to each individual chemical are then compared to an established health guideline, such as a MRL (Minimal Risk Level) or RfD (Reference Doses), in order to assess whether adverse health impacts are expected. These health guidelines, developed by ATSDR and EPA, are chemical-specific values that are based on the available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold; that is, a dose below which adverse health effects will not occur. As a result, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus,

exposure doses at or below the established health guideline are not expected to result in adverse health effects because these values are much lower (and more human health protective) than doses which do not cause adverse health effects in laboratory animal studies. For non-cancer health effects, the health guidelines are described below in more detail. It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for potential cancer-causing chemicals detected in samples at this site. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Minimal Risk Levels (MRLs) – developed by ATSDR

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at <http://www.atsdr.cdc.gov/mrls.html>.

References Doses (RfDs) – developed by EPA

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at <http://www.epa.gov/iris>.

If the estimated exposure dose for a chemical is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. Non-cancer health effects from dermal exposure were evaluated slightly differently than ingestion exposure. Since health guidelines are not available for dermal exposure, the calculated dermal dose was compared with the oral health guideline value (RfD or MRL). If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the PHA. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's Integrated Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

Cancer Risks Estimates

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk of cancer for evaluation purposes. The estimated increased excess risk of developing cancer (theoretical cancer risk) from exposure to chemicals from this site was calculated by multiplying the site-specific exposure doses by EPA's chemical-specific cancer slope factors (CSFs). The calculated doses, including dermal doses, were compared with the oral CSFs.

An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular contaminant. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year.

$$\text{Lifetime Average Daily Dose (LADD)} = \frac{\text{Exposure Dose (mg/kg/day)} \times \text{Exposure Duration (years)}}{70 \text{ years}}$$

Under quantitative risk assessment methodology, site-specific cancer doses and concentrations are multiplied by EPA's cancer slope factors (CSFs) to estimate a theoretical cancer risk. The following illustrates this calculation:

$$\text{Theoretical Cancer Risk} = \text{LADD} \times \text{CSF}$$

where:

LADD = Site-specific cancer dose (mg/kg/day)

CSF = Cancer slope factor ([mg/kg/day]⁻¹)

This calculation estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated cancer risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer.

The recommendations of many scientists and EPA have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-4}) is not typically considered a health concern. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate EPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

Because of the uncertainties involved with estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data. Therefore, the carcinogenic risk is also described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and the site-specific doses for the site is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

C. EXPOSURE ASSUMPTIONS

Adult Residents

Adult residents were assumed to be exposed to chemicals in soil and/or sediment while gardening or doing yard work or other outdoor activities. Incidental ingestion and direct skin contact with chemicals in residential yards or in the ditches adjacent to residential yards has been considered.

For purposes of this evaluation, adults were assumed to be exposed for 182 days (6 months) per year for a total of 30 years. It was also assumed that these individuals ingest 100 milligrams of soil per day (mg/day) and weigh 70 kilograms (kg) (153 pounds). The surface area available for direct skin contact is 4656 cubic centimeters per day (cm²/day) which represents exposure of the face, hands, and arms. A soil/skin adherence factor of 0.07 milligrams per cubic centimeter (mg/cm³) was used; bioavailability factors of 0.01, 1, and 0.1 were used for arsenic, dioxin, and benzo(a)pyrene, respectively. The mean and maximum soil/sediment concentrations were used for each calculation.

Child Residents

Children residents were assumed to be exposed to chemicals while playing in contaminated soil or sediment in their yards and/or nearby ditches. Incidental ingestion and direct skin contact with contaminants in yards and ditches while playing has been considered.

For purposes of this evaluation, children were assumed to be exposed to sediments for 182 days (6 months) per year for 7 years. For surface soil, children are assumed to be exposed for 365 days per year for 7 years. It was also assumed that a child ingests 200 milligrams of soil per day (mg/day) and weighed 30 kg (66 pounds). The surface area available for direct skin contact is 2625 cm²/day. A soil/skin adherence factor of 0.2 mg/cm² was used. Bioavailability factors of 0.01, 1, and 0.1 were used for arsenic, dioxin, and benzo(a)pyrene, respectively. The mean and maximum soil/sediment concentrations were used for each calculation.

APPENDIX F:
WHAT YOU NEED TO KNOW ABOUT THE
CONTAMINANTS OF POTENTIAL CONCERN

WHAT YOU NEED TO KNOW ABOUT **DIOXINS**

Dioxins (Reference: Tox Profile and ToxFAQs)

Dioxins are a group of 75 different chemicals that have varying harmful effects. One of the most toxic dioxin compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Dioxins are known to occur naturally and are also produced by human activities. Dioxins are not intentionally manufactured by industry except for research purposes. Dioxins may be produced by incineration and combustion processes. Dioxins (primarily TCDD) may also be formed during the chlorine bleaching process used by pulp and paper mills. Chemicals that are used to preserve wood (such as pentachlorophenol) contains some dioxin compounds, but TCDD is not usually found.

The most noted health effect in people exposed to large amounts of TCDD is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in people. Exposure to high concentrations of dioxins may induce long-term alterations in glucose metabolism and subtle changes in hormonal levels.

A variety of other effects, such as weight loss, liver damage, and disruption of the endocrine system have been reported in studies of animals that were exposed to low levels of dioxin compounds. In many species of animals, TCDD weakens the immune system and causes a decrease in the system's ability to fight bacteria and viruses. In other animal studies, exposure to TCDD has caused reproductive damage and birth defects.

Several studies suggest that exposure to TCDD increases the risk of cancer in people. Animal studies have also shown an increased risk of cancer from exposure to TCDD. Human Cancer Data: According to the tox profile, several studies suggest that TCDD may be a human carcinogen. An increased risk for all cancers was found in highly exposed workers. The evidence for site-specific cancers is weaker, with some data suggesting a possible relationship between soft-tissue sarcoma, non-Hodgkin's lymphoma, or respiratory cancer with TCDD exposure. The World Health Organization (WHO) has determined that TCDD is a human carcinogen. The Department of Health and Human Services (DHHS) has determined that TCDD may reasonably be anticipated to cause cancer.

WHAT YOU NEED TO KNOW ABOUT **PENTACHLOROPHENOL (PCP)**

Pentachlorophenol (Source: Tox Profile and ToxFAQs)

Pentachlorophenol (PCP) was widely used as a pesticide and wood preservative until 1984 when its use was restricted to certified applicators. It is no longer available to the general public but is still used industrially as a wood preservative for utility poles and railroad ties. PCP is a manufactured chemical and does not occur naturally.

Long-term exposure to low levels of pentachlorophenol that occur in the workplace can cause damage to the liver, kidneys, blood, and nervous system. Studies of workers exposed to PCP reported an increase in individuals' body temperature which can result in high fever, profuse sweating, and difficulty breathing. High body temperature can also injure various organs and tissues in the body. Additional studies of workers exposed to high levels of PCP for long periods of time indicated liver and immune system effects. Studies in animals also suggest that the endocrine system and immune system can also be damaged following long-term exposure to low levels of pentachlorophenol. Laboratory animals exposed to PCP at high doses were found to experience damage to the thyroid and reproductive system. It is unknown whether pentachlorophenol produces all of the same effects in humans that it causes in animals.

Human studies regarding PCP exposure and cancer have provided conflicting results. Studies of workers exposed to high levels of PCP reported a possible association with several types of cancer, specifically Hodgkin's disease, soft tissue carcinoma, and acute leukemia. Other occupational studies did not have the same findings. Increases in liver, adrenal gland, and nasal tumors have been found in laboratory animals exposed to high doses of PCP.

EPA has determined that PCP is a probable human carcinogen and the International Agency for Research on Cancer (IARC) also considers it possible of producing cancer in humans. An increased risk of cancer has been shown in some laboratory animals given large amounts of pentachlorophenol orally for a long time. There is weak evidence that pentachlorophenol causes cancer in humans.

WHAT YOU NEED TO KNOW ABOUT PAHs

Polyaromatic Hydrocarbons (PAHs) (Source: Tox Profile and Creosote fact sheet)

PAHs are a group of 100 different chemicals that are formed during the incomplete combustion of coal, oil, gas, wood, garbage, or other organic substances. PAHs can be found in substances such as crude oil, coal tar pitch, creosote, and roofing tar.

Creosote compounds are created by high-temperature treatment of woods (referred to as wood creosote), coal (referred to as coal tar creosote), or from the resin of the creosote bush. Coal tar creosote is a thick, black, oily liquid. Coal tar creosote is the most widely used wood preservative in the U.S. These chemicals are also used in medicines to treat skin diseases such as psoriasis, and are also used as animal and bird repellents, insecticides, pesticides, and fungicides.

Health Information: Mice fed benzo(a)pyrene during pregnancy had difficulty reproducing and so did their offspring. The offspring of mice fed this chemical also showed other harmful effects, such as birth defects and decreased body weights. Other short and long-term animal studies have shown that PAHs can cause harmful effects on skin, body fluids, and the body's system for fighting disease. Blood chemistry changes, as well as mild liver effects have been observed among animals exposed to PAHs. Eating large amounts of creosote may cause a burning of the mouth and throat, and stomach pains. Skin damage, such as blistering or peeling, may result from long-term exposure to creosote. The results of animal studies indicate liver and kidney effects following ingestion of creosote. Harmful effects have been observed among the offspring of animals whose mothers inhaled high concentrations of creosote during pregnancy. Several PAHs, including benzo(a)pyrene, have been found to cause tumors in laboratory animals when they breathed these substances in air (lung and respiratory cancer), when eaten (gastric tumors), or when they had long periods of skin contact with them (skin cancer). Human studies showed that people who breathed or had skin contact with PAHs for long periods also developed cancer. Workers who had long-term skin contact with creosote, especially during wood treatment or manufacturing processes, reported increases in skin cancer and cancer of the scrotum. Cancer of the scrotum has been associated with long-term exposure to soot and coal tar creosotes by chimney sweeps. Animal studies have also shown an association between creosote exposure and skin cancer.

The Department of Health and Human Services (DHHS) has determined that some PAHs (including benzo(a)pyrene) are known animal carcinogens. The International Agency for Research on Cancer (IARC) and EPA have also indicated that several PAHs are probably carcinogenic to humans. Cancer classification information for all PAH compounds are unavailable.