Public Health Assessment

Initial/Public Comment Release

Evaluation of Environmental Health Concerns at the Clinch River Corporation Site

CLINCH RIVER CORPORATION
728 EMORY DRIVE
HARRIMAN, ROANE COUNTY, TENNESSEE 37748

EPA FACILITY ID: TND987768587

Prepared by
Tennessee Department of Health

SEPTEMBER 22, 2016

COMMENT PERIOD ENDS: NOVEMBER 22, 2016

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

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's Cooperative Agreement Partner. This revised document has now been released for a 60-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner 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's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

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Prepared by:

Tennessee Department of Health
Environmental Epidemiology Program
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

This document summarizes an environmental public health investigation performed by the State of Tennessee Department of Health's Environmental Epidemiology Program. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. Health accessors perform several actions in order to answer an environmental public health question.

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials regarding contamination found at the site and any potential exposure. We rely on environmental sampling data provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination might be present, where it is located on a site, and how people might become exposed. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: Health assessors take steps to determine if human exposure to contamination could have harmful health effects. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the relevant scientific literature.

Make Recommendations: From our conclusions, we will recommend reducing or eliminating any potential health hazard posed by a site. Often, our recommendations will serve as action items for other agencies. However, for urgent public health hazards, the Tennessee Department of Health can issue a public health advisory warning people of the danger and will work with other agencies to resolve the problem. Environmental Epidemiology serves the role of advisor in dealing with hazardous waste sites

If you have questions or comments about this report, we encourage you to contact us.

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Table of Contents

Summary

Introduction

The Tennessee Department of Health's Environmental Epidemiology Program (EEP) conducted an evaluation of possible environmental exposures at the Clinch River Corporation (CRC) Superfund Site located in the city of Harriman. The U.S. Environmental Protection Agency (EPA) proposed to add the CRC Site to its National Priorities List (NPL) of hazardous waste sites on September 14, 2012. The CRC Site was officially listed on the NPL on June 24, 2013. The NPL is part of EPA's Superfund clean-up process intended to identify the nation's sites most in need of further investigation and cleanup.

Many local, state, and federal agencies are working together to understand the implications of decades of industrial activity on this site. All stakeholders with an interest in the CRC Site should be part of the long-term land use and planning. The U.S. Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure that the Tennessee Department of Environment and Conservation (TDEC) and the leaders of Harriman have the best information possible to safeguard the health of Harriman's citizens. EEP became involved with the CRC Site because Congress mandates that ATSDR conduct public health activities at Superfund sites EPA proposes adding to its NPL.

Overview Conclusions	EEP reached the following 10 conclusions for the CRC Site:
Conclusion 1	Open pits, ponds, building foundations filled with water, the barge loading and unloading platform, and other physical hazards at the CRC Site could harm people's health.
Basis for Decision	Trespassers use the site to fish and to access other areas of Harriman. Open ponds, open pits, former building basements, debris piles, and scattered debris exist throughout the former manufacturing area of the site. Former site buildings contain asbestos. Unstable building materials have been used to fill in former basements. The site is not securely fenced or guarded.
Next Steps	EEP recommends the property owners secure the site and post warning signs to prevent trespassing or injury. These safeguards would prevent human contact with site physical hazards. Should the City of Harriman or EPA request, EEP can provide health education on site-related physical or chemical hazards.
Conclusion 2	Touching onsite soil currently and in the future could harm people's health. Past exposure to onsite soil could have harmed people's health.
Basis for Decision	Trespassers use the site as a shortcut and as a fishing location. Some levels of polycyclic aromatic hydrocarbons (PAHs) and dioxins are present in onsite soil above health comparison values. There is a small increased risk for cancer if the trespassers, any future residents, or past workers accidentally eat, garden, or dig the soil. An increased risk for cancer might occur for children or young adults if they play or live at the site and touch or accidentally eat contaminated surface soils. In the past there likely would have been higher levels of PAHs and dioxins present in site soil due to the manufacturing and waste handling operations at the site. However, no onsite soil data was available for review from when the site was operating.
Next Steps	EEP recommends responsible parties provide sufficient contingencies in the final cleanup plan to protect workers on the site should it be redeveloped. We also recommend establishing institutional controls and precautions for future recreator and worker safety, and site redevelopment.

Conclusion 3	A small increased risk for cancer exists through touching or accidentally eating contaminated sediment near the Probable Point of Entry of surface runoff from the site into the Emory River.
Basis for Decision	Sediment is contaminated with naphthalene and 2-naphthalene, which are well above their estimated respective non-cancer and cancer screening levels at this location.
Next Steps	Responsible parties post signs along the Emory River to avoid contact with river sediment. It is unknown if remediation of the sediment will be performed.
Conclusion 4	Eating fish with mercury from the Emory River may harm people's health. Eating fish that contain current levels of copper, zinc, and chromium is not expected to cause adverse health effects.
Basis for Decision	Exposure doses for children and adults are not expected to cause adverse health effects from site-related levels of copper, zinc, and chromium. Levels of mercury are above the TDEC advisory limit of 0.3 parts per million but are unrelated to the CRC Site.
Next Steps	EEP recommends responsible parties implement engineering controls to prevent trespassing and to discourage fishing in the Emory River from the site.
Conclusion 5	EEP cannot currently conclude whether there is potential for vapor intrusion at the site for new or reused buildings if the site is redeveloped.
Basis for Decision	No soil-gas or indoor air sampling has been done at the site. Existing buildings may be repurposed as part of the site's reuse.
Next Steps	EEP recommends the responsible parties conduct soil-gas or vapor intrusion sampling to understand if this pathway could cause exposure if the site were to be redeveloped and existing buildings reused. If this pathway is evaluated, EEP can review data collected to provide an interpretation of potential exposure.
Conclusion 6	EEP cannot conclude whether unsampled soil areas at the site could harm people's health.
Basis for Decision	Environmental sampling at the CRC Site has focused on known and obvious waste areas, which make up only a small portion of the entire site. The surface soil has not been characterized in other areas of the site. These data are needed to fully assess the health implications of the site for future redevelopment.

Next Steps	More surface soil sampling is recommended to be done by the responsible party or EPA to understand the distribution of chemicals in the surface soils and if there are higher levels in unsampled areas of the site.
Conclusion 7	EEP cannot conclude whether former site workers were harmed by exposure to chemicals previously used or generated as a result of past manufacturing operations.
Basis for Decision	Historic sampling results and air monitoring results are unavailable during the time the CRC Site was in in operation,
Next Steps	None recommended or planned.
Conclusion 8	Contact with onsite surface water is not expected to harm people's health.
Basis for Decision	No metals or volatile organic compounds are present in onsite surface water above health screening values. Levels of diesel range organic compounds are above Tennessee Water Quality Values, but it is unknown if these levels could harm people using the site.
Next Steps	EEP recommends the responsible parties implement engineering controls to prevent trespassing.
Conclusion 9	Groundwater at the site will not harm people's health.
Basis for Decision	Groundwater at the site is inaccessible to people. No water production wells are present on the site and groundwater beneath the site is not used. Homes, schools and daycares near the site have municipal water service. Groundwater flows eastward toward the Emory River.
Next Steps	EEP recommends the responsible parties implement engineering and institutional controls to prevent trespassing and to prevent the future use of groundwater on the site if it is redeveloped.
Conclusion 10	Protective health measures are prudent if the site is redeveloped. Residential redevelopment would not be advisable for the site once remediation has been completed.
Basis for Decision	A recreational area has been suggested as a possible reuse of this site. Levels of various chemicals are present on the site and near the site in sediment and in fish. Accidentally touching the sediment or eating the fish could lead to a small increased risk for cancer. Based on current levels of chemicals in soil at the site residential redevelopment would not be a advisable

Next Steps	EEP recommends TDEC include institutional controls and precautions in the final cleanup plan to protect future workers and recreators if the site is redeveloped.

For More Information	If you have any questions or concerns about your health, you should contact your healthcare provider. For more information on this environmental site call TDEC toll free at 1-888-891-8332. For more information on this health report, please call TDH EEP at 615-741-7247 or 1-800-404-3006 during normal business hours. You can also email TDH EEP at eep.health@tn.gov.

Statement of Issues and Background

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) evaluated possible environmental exposures at the Clinch River Corporation (CRC) Superfund Site. The CRC Site is an inactive paper and pulp mill. The U.S. Environmental Protection Agency (EPA) proposed to add the CRC Site to its National Priorities List (NPL) of hazardous waste sites on September 14, 2012. The CRC Site was officially listed on the NPL on June 24, 2013. The NPL is part of EPA's Superfund clean-up process to determine the nation's worst hazardous waste sites needing investigation and possible cleanup.

Congress mandates the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) conduct public health activities at Superfund sites that EPA proposes adding to its NPL. EEP became involved with the CRC Site because Congress mandates that ATSDR conduct public health activities at Superfund sites EPA proposes adding to its NPL. ATSDR provides funding for EEP through a cooperative agreement to conduct environmental public health investigations in Tennessee.

Objectives

The specific objectives of this Public Health Assessment (PHA) were as follows:

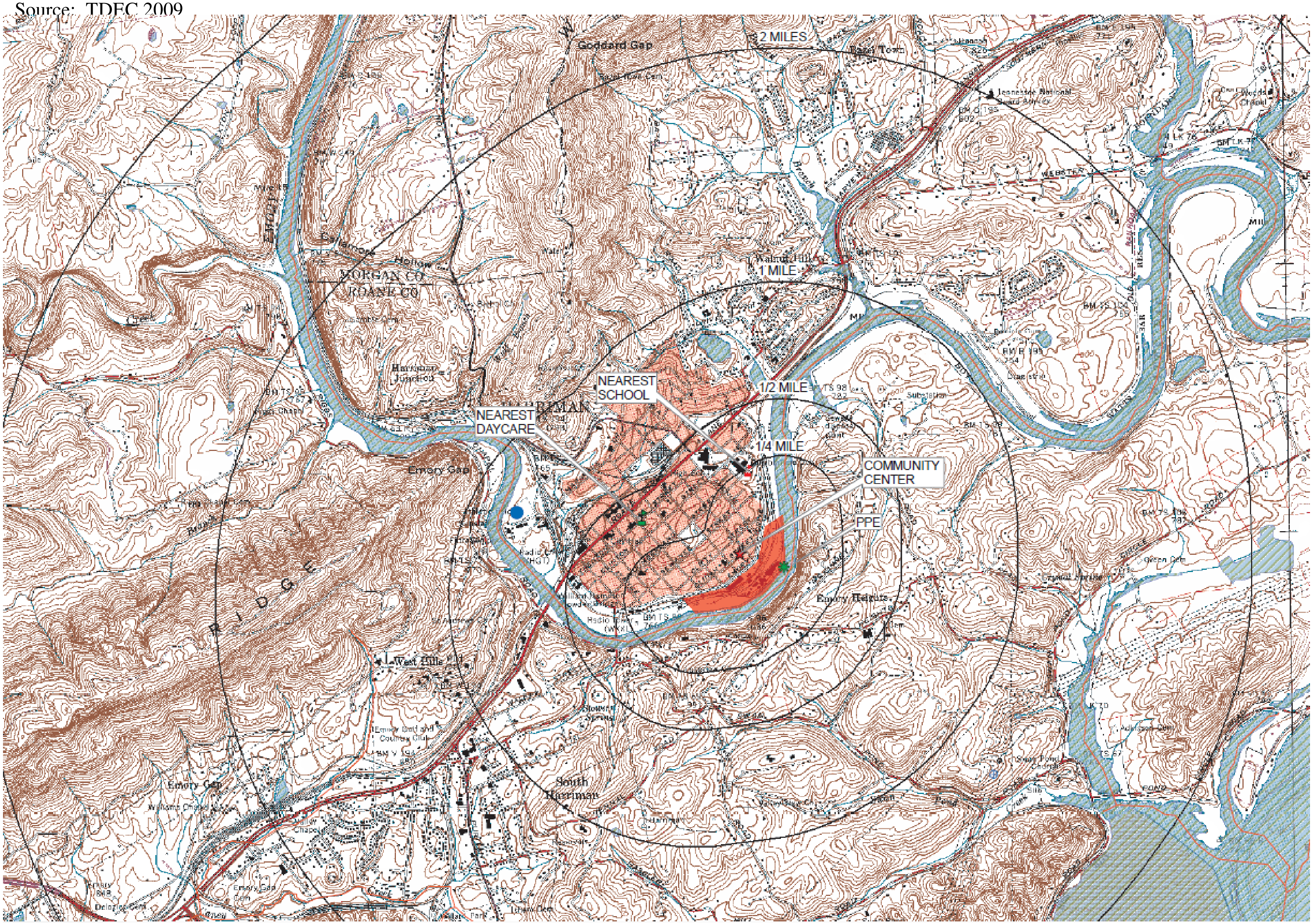
1. Assist EPA in determining what public health hazards the site poses.
2. Determine whether exposure to chemicals in the surface soils at the CRC Site could be a public health hazard.
3. Determine if eating fish caught in the vicinity of and one quarter-mile downstream from the CRC Site could be a public health hazard.
4. Identify physical hazards at the site.
5. Determine if exposure to surface water at the CRC Site could be a public health hazard.
6. Determine if exposure to site groundwater could be harmful to public health.
7. Understand if off-site groundwater or any vapors coming off any off-site groundwater could be a public health concern.

Site Location and Details

The CRC Site is located within the 100-year floodplain of the Emory River (FEMA 2012) within the Watts Bar Reservoir, the site is bounded to the west by Emory Drive, to the north by parcels owned by the Tennessee Valley Authority (TVA) and Bowater and Halbert, and to the east and south by the Emory River (TDEC 2011).

The physical address of the site is 728 Emory Drive in Harriman, Roane County, Tennessee, 37748 (Figure 1).The geographical coordinates for the site are latitude 35° 55' 55.02" north and longitude 84° 32' 21.77" west. The EPA identification number, as recorded in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database, is TND987768587 (EPA 2012a).

Figure 1. Site Location Map – Harriman, TN
Source: TDEC 2009



The CRC Site consists of four parcels of land, covers about 30 acres (Figure 1), and is located in the southwestern portion of downtown Harriman, along a broad crescent-shaped meander of the Emory River. The site has several entrances along Emory Drive at Walden Street, Queen Street, and Tennessee Street. The site area is a major portion of the riverfront area of the City of Harriman. Several railroad tracks and easements traverse the site from north to south (TDEC 2009).

The CRC Site and adjacent properties have had manufacturing and industrial uses since before the turn of the 20th Century (Shaw 2005). Properties to the west and northwest have remained residential since at least 1929. The nearest residential properties are within 250 feet of the site boundary. Figure 2 shows physical details of the site and building locations. Figure 3 shows parcels comprising the CRC Site.

Parcel 001.00 is located in the southwestern portion of the site. It covers 1.3 acres and included a scale house. Parcel 002.00 is located in the northwestern portion of the site. It covers 5.3 acres and included a clarifier, main office building, training building (referred to as a bath house), and waste paper pile (referred to as “Waste Paper Pile 4”) (EPA 2012a).

Parcel 003.00 is located in the northeastern portion of the site. It covers 10.48 acres and included the main industrial area of the facility with the following buildings, waste areas, and ponds:

- the location of the paper and pulp mill building (Process Area),
- the location of an unlined surface impoundment (what previous investigators called the “coal tar” pond),
- a chipper shed and associated drum storage area,
- a steam generation and turbine building,
- a time keeping building, several aboveground storage tanks (ASTs), including a 15,000-gallon AST,
- a waste paper pile (referred to as “Waste Paper Pile 1”) located about 525 feet north of the former paper and pulp mill building,
- a waste paper pile (referred to as “Waste Paper Pile 3”) located about 100 feet northwest of the former paper and pulp mill building, and
- a concrete surface located north of the former paper and pulp mill building and near Waste Paper Pile 1.

Figure 2. Site Details Map - 2008
Source: TDEC 2009

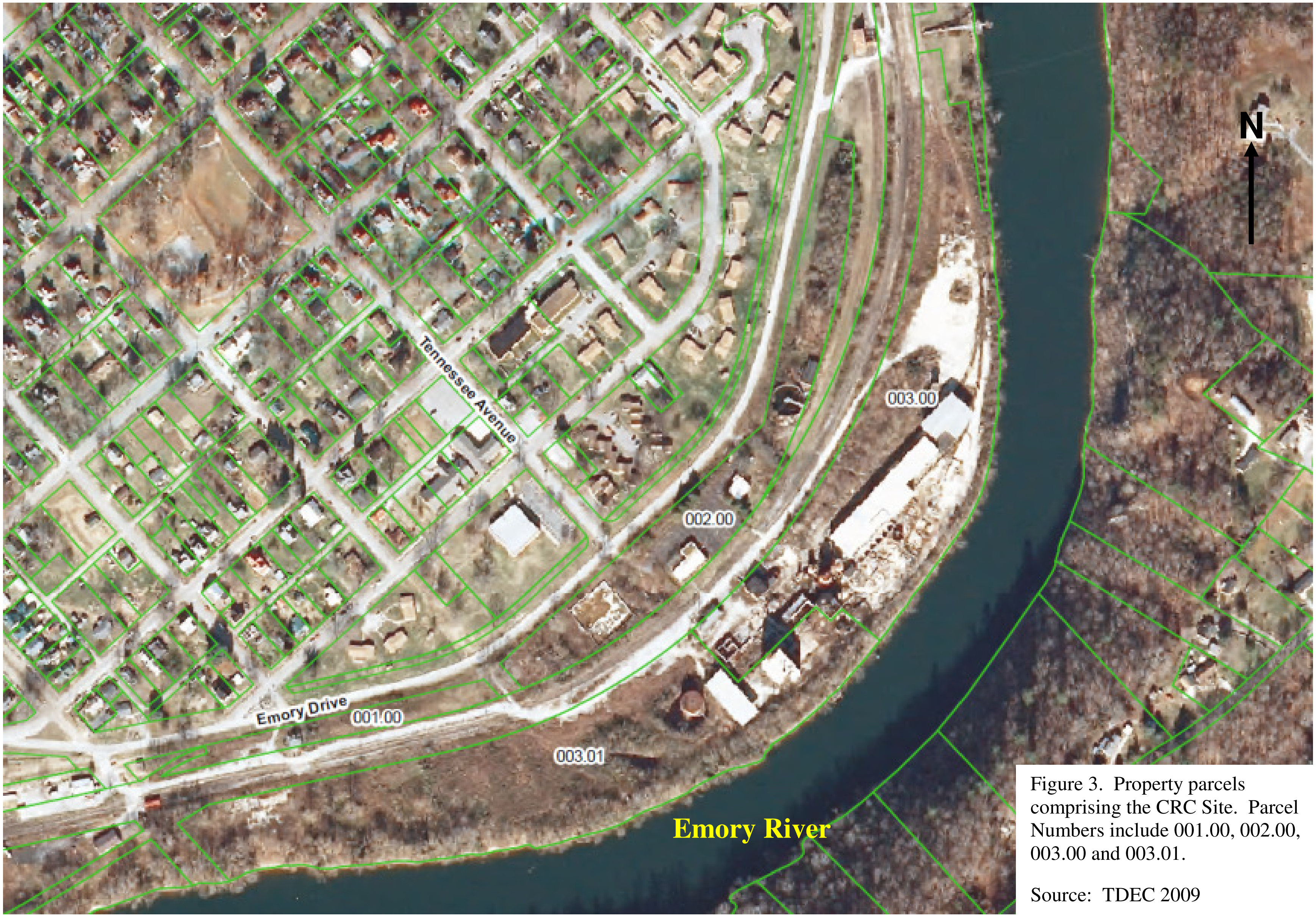


Figure 3. Property parcels comprising the CRC Site. Parcel Numbers include 001.00, 002.00, 003.00 and 003.01.

Source: TDEC 2009

Parcel 003.01, located in the southeastern portion of the site, covers at least 12 acres and included:

- the location of the boiler house,
- the former location of a south waste paper impoundment, a former 630,000 gallon AST which contained an unknown amount of liquid and solids,
- an unlined surface impoundment (black liquor pond), and
- a waste paper pile (referred to as "Waste Paper Pile 2") located next to the black liquor pond (EPA 2012a).

Three parcels of the site including parcel numbers 001.00, 002.00, and 003.00 are owned by WestRock Company, the successor to MeadWestvaco (MWV). MWV combined with Rock-Tenn Company to form WestRock Company on July 1, 2015. The fourth parcel, 3003.01, is owned by a local real estate investor who purchased it in a tax sale. The current owners have dismantled many of the buildings and recycled the salvaged metal from the site. This demolition and salvaging activity was sporadic and short-lived. Several waste oil drums were previously located on one of the land parcels. A 630,000-gallon AST containing black liquor remained on the fourth parcel (OTIE 2012a). In September 2014, the AST was drained and removed from the site. Bricks, concrete, and other hard construction material were used to fill building basements, pits, and piping tunnels inside and nearby the former buildings.

The site consists of one major source area and associated releases to the surface water migration pathway. The area designated as Source No. 1 consists of contaminated soil from discrete operations (disposal practices) around the process area. Source No. 1 is approximately 1,100 feet long and 190 feet wide at its widest part (Figure 4). It encompasses much of the former pulp and paper mill operations and where most of the soil and groundwater sampling has been conducted. At Source No. 1, hazardous substances found in soil include anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(k)fluoranthene; carbazole; chrysene; dibenz(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; 2-methylnaphthalene; naphthalene; phenanthrene; pyrene; 1,2,3,4,6,7,8-heptachlorodibenzodioxin (HpCDD); 1,2,3,4,6,7,8 heptachlorodibenzofuran (HpCDF); 1,2,3,4,7,8-hexachlorodibenzodioxin (HxCDD); 1,2,3,6,7,8-HxCDD; 1,2,3,7,8,9-HxCDD; cadmium; chromium; copper; lead; manganese; mercury; nickel; silver; and zinc.

Some of the same hazardous substances have also been found in sediment samples collected from the Emory River. The Emory River receives runoff from Source No. 1 (EPA 2012b).

Site Operational History

Prior to the site being developed as a pulp and paper mill, Harriman Extract Works occupied the area. That company manufactured tannic acid for the American Oak Leather Company. From 1929 to 2002, Harriman Corporation, a subsidiary of Mead Paperboard Corporation operated a pulp and paper mill on the CRC Site until 1975. Following its sale in 1975 several other companies operated at the mill site until it was shuttered in 2002 (TRC 2015). The following

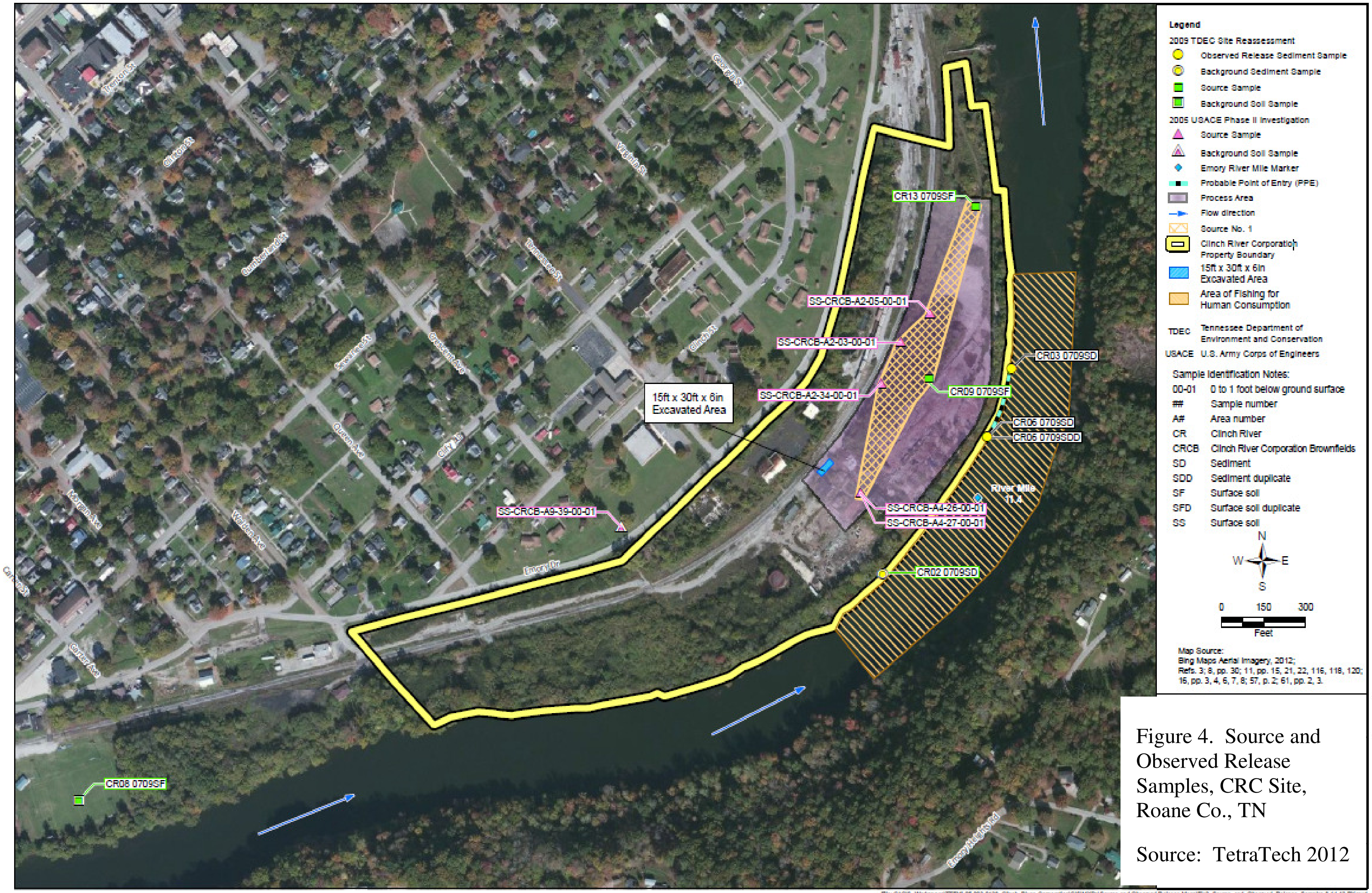


Figure 4. Source and Observed Release Samples, CRC Site, Roane Co., TN

Source: TetraTech 2012

companies owned or operated the paper and pulp mill throughout its operational history: the Mead Corporation, Inc.; the Harriman Paperboard Corporation; the Clinch River Corporation; the Gibson Group; Mid-South Cogeneration, Inc.; Power Paper, Inc.; Power Paper, Limited; Power Paper Recycling, Inc.; and American Kraft Mills of Tennessee, LLC.

Former operations on the CRC Site during 1929 to 1989 included manufacturing non-bleached corrugated containers and non-bleached corrugated medium paper using paperboard from pulp production. The manufacturing process included partially digesting raw hardwood chips with sodium sulfite, sodium carbonate, and live steam (steam under pressure). The wood chips were further refined using a mechanical pulping process. At some point over the years the virgin paper stock was then mixed with recycled paper stock at a rate of 75% virgin to 25% recycled. The blended paper stock was allowed to dry in mats that were cut into customer-specific widths (TDEC 1991, TDEC 2009). From 1990 to 2002, secondary fiber processing using all recycled product was conducted at the site (S. Miller, personal communication, January 14, 2016).

By-products of the pulp and paper mill manufacturing process included paper waste, black liquor also called spent processing waste and coal tar constituents. The treatment of the paper waste consisted of primary clarification after the material was screened through a 3-millimeter mesh screen. One half of the waste stream, called sludge, generated by the clarifier was recycled back into the plant. The other half, called mill effluent, was discharged to the Tennessee River through the Harriman Sewage Treatment Plant system. Skimmer waste from the clarifier was disposed of on the site. Waste paper was also disposed of in piles throughout the site (TDEC 1991, Shaw 2005).

Black liquor can be composed of phenols, sodium hydroxide, sodium oxide, and sulfur; as well as metals, such as calcium and magnesium (Shaw 2005). Coal tar consists of polycyclic aromatic hydrocarbons (PAHs), phenols, heterocyclic oxygen, sulfur, and nitrogen compounds (ATSDR 2002). Dioxins, furans, PAHs, and metals, such as chromium, copper, and manganese, can be produced as by-products of the paper manufacturing process (EPA 2006). According to Shaw (2005) and the U.S. Army Corps of Engineers (USACE 2006), black liquor and "coal tar" wastes may have been disposed of on the site in two unlined surface impoundments (the black liquor pond and the former "coal tar" pond) and in drums. MeadWestvaco stated their predecessor Mead and Harriman Paperboard did not purchase, use, or generate coal tar. They insisted there was no process historically present on the site for coal tar.

Environmental and Regulatory History

Wastes from paper mill operations were disposed of on the CRC Site (TDEC 1991, Shaw 2005). According to TDEC (1991, 2009), multiple waste areas have been identified. These areas include:

- an unlined surface impoundment (black liquor pond) located on the southern portion of the property,
- an unlined surface impoundment (former "coal tar" pond) located on the northeastern side of the property,

- Waste Paper Pile 1 located about 525 feet north of the former pulp and paper mill building,

- Waste Paper Pile 2 located adjacent to the black liquor pond,

- Waste Paper Pile 3 located about 100 feet northwest of the former pulp and paper mill building, and

- Waste Paper Pile 4 located on a concrete slab inside a fenced enclosure on the southern portion of Parcel 002.00.

The impoundments and Waste Paper Piles 1 and 2 remain on the site. Waste Paper Pile 3 was removed in the 1990s. Its former location has been subsequently paved with concrete. The fencing around Waste Paper Pile 4 was removed, and the pile was covered with soil (Shaw 2005).

The Emory River was the source of fresh water for mill operations (TDEC 1991). The receiving streams for site effluent were the Emory and Tennessee Rivers. In 1957, Mead Corporation (Mead) began discharging effluent through the City of Harriman's sewer system. In 1971, Mead maintained Outfall 001 into the Tennessee River. Mead also maintained 12 outfalls into the Emory River. These outfalls included Outfalls 002 to 013. These 12 outfalls discharged into the Emory River (TDEC 1991) from pipes on the west bank of the river:

In June 1974, Mead was issued National Pollutant Discharge Elimination System (NPDES) permit TN0001627 from EPA as well as a temporary discharge permit from the TDEC. The details of this permit are unknown (TDEC 1991). Mead stated its intention to install a primary clarifier on the CRC property by 1976, before the date on which the City of Harriman's secondary treatment system would be completed (TDEC 1991).

The NPDES permit was renewed in 1983 and allowed sanitary and process wastewater from Outfall 001 to be discharged to the City of Harriman sewage treatment plant system (TDEC 1991). In 1988, CRC was issued NPDES permit TN0062383 authorizing discharge of noncontact cooling water and storm water runoff to the Emory River at mile 11.4 (TDEC 1991). This permit required monthly monitoring of effluent, and results were reported to TDEC's Division of Water Pollution Control. The reporting was to include all accidental spills and discharges into the Emory River. A subsequent NPDES permit application, TN0062383, stated that the process wastewater would be recycled. (TDEC 2011).

Several spills, releases, and NPDES permit violations were documented throughout the CRC Site's operational history. Between 1988 and 1989, the facility illegally discharged process water, cooling water, and waste paper wash runoff into the Emory River (TDEC 1991) and to the Harriman Sanitary Sewer (TDEC 2011). Discoloration (black and gray) of the Emory River directly adjacent to and downstream of the CRC Site was also documented during this period (TDEC 1991). Underground piping allowed waste paper and black liquor to be released into the Emory River and the subsurface (TDEC 2011). The CRC Site flooded in 1990, and as a result, waste paper and black liquor wastewater were deposited into the Emory River. During the 1991 TDHE site inspection, TDHE observed (1) black liquor leaching into the Emory River from the

CRC Site below the water line, and (2) the south waste paper impoundment had partially collapsed into the Emory River dumping waste paper and waste paper rolls into the river (TDEC 1991).

Parcel 003.01 contained the site's power plant and a 630,000-gallon AST. The owner of this parcel was convicted of intentionally releasing approximately 500,000 gallons of process liquid containing black liquor and solids from the AST onto the ground, into a site pond, and then into the Emory River on February 14, 1999, during a period of heavy rains (EPA 2012a). The incident was found to violate the Clean Water Act and was investigated by EPA's Criminal Investigation Division and members of the East Tennessee Environmental Crimes Task Force (EPA 2013a). The exact chemicals released into the river were unknown. The AST was removed in 2014. In 2002, the site was closed and has not had any process operations conducted since.

Previous Investigations

Numerous environmental investigations have been conducted at the CRC Site from 1984 to 2015. These are discussed in more detail in the Site Sampling Results section within the Discussion section of this document. Appendix A lists the previous sampling investigations, including the pulp and paper mill-related hazardous substances detected in the samples collected.

Soil impact appears confined to the CRC Site based on the various site environmental investigations conducted. Groundwater flows east toward the Emory River, away from homes, schools, and daycares located near the site.

Land Use and Demographics

Harriman, Tennessee, ZIP Code 37748, has a defined downtown area and several outlying neighborhoods, which include West Hills, South Harriman, Emory Gap, Emory Heights, and Walnut Hill. These neighborhoods have a range of land uses. The downtown Harriman area is bounded on the north by Walden Ridge, a prominent southwest-northeast trending ridge, and on the east, south, and west by a distinct crescent-shape meander of the Emory River.

Harriman's population peaked between 1970 and 1980, and has declined since (East Tennessee Development District 1995; Bureau of the Census 1993, 2000). In 1969, 18 of the 29 manufacturing plants in Roane County were located in the City of Harriman. By 1990, 15 of the 35 manufacturing plants in Roane County were located in Harriman (ETDD 1995) and manufacturing was still the leading source of employment for Harriman residents in 2000. In 2000, the population of Harriman consisted of 6,077 Caucasians, 501 African-Americans, and 166 persons of other races. The majority of residents are between the ages of 45 and 54, with the median age of 40.5 (Bureau of the Census 2000). The population within 1 mile of the CRC Site was estimated to be 1,804 people (TDEC 2011).

According to the 2010 Census, 6,350 people lived in Harriman, a 5.8 % decline since 2000. Of these, 5,677 were Caucasian, 458 were African-Americans, and 61 of other races. Of these residents, 51.1% of people 16 years and older worked as civilians. Of these, 40.6% were employed, and 10.6% were unemployed (Census 2010).

Four schools are located within approximately 2,000 feet of the CRC Site. These schools include Central Elementary, Cumberland Middle, and Harriman High Schools northwest of the site and Emory Heights Elementary School southeast of the site (TopoQuest 2012). The nearest school is 1,300 feet north of the site. The nearest daycare is 2,000 feet to the northwest (TDEC 2009).

Housing near the site includes wood framed and brick single-family homes, subsidized community housing, and apartments. A community center, a retirement center, and churches are located nearby. Additionally, a park with a playground and the above-mentioned schools are within one-half mile of the site (Google Earth 2013).

Community Involvement

Before the site was listed on the NPL and before EEP's involvement, one community meeting took place regarding the site. On October 23, 2012, EPA held an informational public meeting about the CRC Site. The community had "measureable" interest in the CRC Site. Short summaries of the site history and activities conducted to date at the site were presented. Questions from the public involved community involvement activities and dissemination of information regarding the site (E.F. Sutton, TDEC DoR, personal communication, November 5, 2013). Since this initial meeting, additional public meetings were held in 2014 and on January 16, 2016.

In 2013, the City of Harriman proposed to create a recreational area on the former CRC Site. The mayor of Harriman suggested the area be cleaned up through the EPA's Superfund process and transformed into a recreational area with possibly a marina and a waterfront area for public use (Beecken, S. 2013).

Climatology

Summers in Roane County, Tennessee are warm and humid while winters are generally mild. Nearby Lenoir City had an average maximum temperature of 69.1 F and a minimum average temperature of 45.5 F between 1961 and 1990. Average annual precipitation is 52.79 inches with a mean annual lake evaporation of 34 inches. The precipitation rate yields an annual net accumulation of 18.79 inches (USDC 1993). The 2-year/24-hour rainfall probability is approximately 3.3 inches (USDC 1961). The prevailing wind direction is from the southwest (USDC 1968).

Geology and Hydrogeology

Regional Geology and Hydrogeology

Harriman, Tennessee is located in the Valley and Ridge Physiographic Province of the United States. The Valley and Ridge Province has numerous northeast-southeast trending long valleys and ridges that are parallel to one another. They are made up of rocks that are mainly limestones, dolomites, shales, and sandstones. Harder layers of rock such as sandstone form ridges, while the valleys are formed from softer limestone, dolomite, and shale (TDEC 2009). Various lineaments (linear features) were noted on the ridges and slopes near the site. The geology of the area is complicated as geologic structural features such as folds, anticlines, and synclines are also prominent.

The ridges in the Valley and Ridge Province are generally about 1,000 feet above mean sea level (msl) in elevation. Walden Ridge is the highest elevation found near the site, located west and north of downtown Harriman, at an elevation of 1,700 feet mean sea level (msl). The lowest elevation near the site is the Emory River flood plain with an elevation at about 766 feet above msl (TDEC 2012).

Water typically moves through limestones in fractures and bedding planes. Water is usually found at the top of the bedrock where it comes into contact with the soil above. A high number of fractures and solution features are usually in the top portion of bedrock in the Harriman area (DeBuchananne and Richardson 1956).

Site Geology and Hydrogeology

The site is underlain by soils composed of silty clays, and gravelly sandy silts of the Shady-Swafford-Urban Land Complex. These units are typically found on stream terraces and are composed of the alluvium from parent rocks that include limestone, sandstone, and shale. Below these units are thickly-bedded cherty dolomite and interbedded limestone of the Cambrian-Ordovician Knox Group. The Knox Group is approximately 2,500 to 3,500 feet thick.

Based on the latest groundwater investigation performed (TRC 2015), the upper 5.5 to 10 feet of the site is composed primarily of fill material consisting of sandy/silty loam mixed with gravel, wood, and coal fragments (TRC 2015). The silty clays and gravelly, sandy silts forming the soils beneath the fill at the site are the result of weathering or breaking down of the bedrock that underlies these soil types. These soils are well drained and have 2 to 5 percent slopes. Groundwater is found in the pore spaces of these soils (USDA 2012). Native soils at the site have long been disturbed.

The Knox Group is typically a gray, fine to medium crystalline, medium bedded siliceous dolostone interbedded with thin horizons of sandstone. In the humid environment of the Southeastern United States., the dolostone weathers to a thick residuum of reddish-orange soil containing chert nodules (Moore et. al. 1993). The CRC Site also lies between the Chattanooga and Harriman Thrust faults.

The Knox Group carbonate rocks typically exhibit Karst solution features such as springs, sinkholes, and caves. The residual soils and the fractured portion of the Knox Group underlying the site together act as a single unconfined aquifer (Shaw 2005).

Based on a log from an on-site production well, depth to bedrock is about 57 feet below ground surface (bgs). An onsite groundwater investigation conducted in 2015 confirmed that groundwater flows toward the east and the Emory River (TRC 2015). With the Emory River bordering the site, it likely dictates shallow water conditions. Therefore, groundwater flows to the southeast (Figure 5). Groundwater levels at the site rise and fall with river water levels (EPA 2012a).

Only a single permanent groundwater monitoring well was located onsite prior to 2015. Several groundwater monitoring wells were present on the site at one time. Many of these wells may have been covered during site operations over the years. One onsite well was found between the boiler house and the Emory River. The well was in excess of 100 feet deep, and the water level

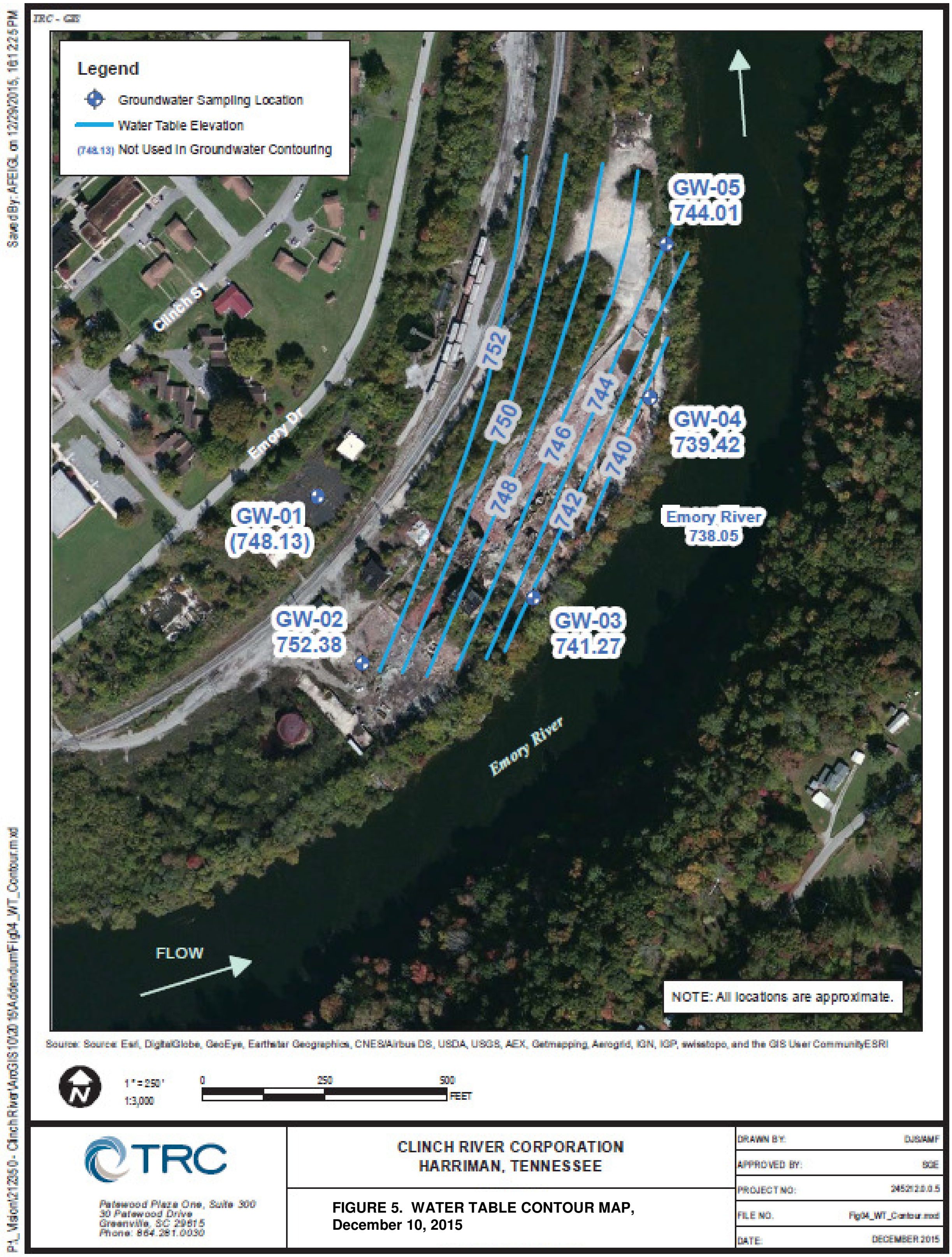


Figure 5. Water table contour map. Source: TRC Addendum for Groundwater Resampling for Engineering Evaluation/Cost Analysis (EE/CA), January 2016.

was measured in June 2009 at 13.77 feet below the top of the well casing. One month later on July 20, 2009, the water level in the well was measured to be 14.47 feet below the top of the well casing. Water levels ranged from 6.08 to 13.53 feet below the top of the well casing in other temporary monitoring wells installed by OTIE in 2012.

The TRC groundwater investigation conducted in 2015 installed six groundwater monitoring wells. TRC found groundwater beneath the site in unconsolidated deposits in unconfined conditions. Depth to groundwater ranged from 6.2 to 16.2 bgs. Depth to groundwater was found by TRC (2015) to be largely dependent on the varying surface elevations, proximity to the Emory River, and seasonal river fluctuations.

Any contamination in site groundwater likely has migrated to the Emory River quickly. If a continuing source for groundwater contamination is found on the site, the Emory River may still be receiving contaminants. Groundwater contamination entering the Emory River is likely diluted based on the volume of water present in the river.

Water Use in Harriman and Near the CRC Site

The Harriman area depends highly on its municipal water supply. No surface water intakes are located within 15 miles downstream of the facility. The Harriman water intake is located approximately 1.4 miles upstream from the CRC Site (TDEC 2009). This intake supplies water to the City of Harriman, the Wolf Branch Utility District, and the Swan Pond Utility District. The Cumberland Utility District withdraws water from the Little Emory River northeast of the site. According to TDEC (2011), the City of Kingston withdraws water at the State Highway 58 Bridge, approximately 17 river miles downstream from the site.

Most residents get their drinking water from the various utility district water intakes that are not close to the CRC Site. Dynamac (1992) found the nearest private water wells were located between 1 and 2 miles south of the site. These private wells were found to serve about seven homes. A spring located between one and two miles south of the site was found to also serve about 13 homes and a mobile home park containing 13 mobile homes located approximately two to three miles from the site. TDEC (1991) suggested that 215 people use groundwater within a 4-mile radius of the site. The lack of targets and presence of municipal water service greatly limits the potential importance of this exposure pathway.

Surface Water

The Emory River, which bounds the CRC site on the east and south, is the closest body of water to the site. Two surface impoundments or ponds are also on the site. Local surface water flows from the hills toward the low valleys. Surface water topographically upgradient likely flows from the north and west directly into the river. Surface water runoff on the site is believed to discharge to the Emory River by storm sewers and sheet flow (TDEC 2012).

The general public uses both the Emory and the Clinch Rivers for fishing and recreation. The Kingston Wildlife Management Area and Refuge is located at the intersection of the Emory and Clinch Rivers, approximately 11.5 miles downstream of the CRC Site. No wetlands are within a 15-mile downstream pathway (USGS 1980, 1989, 1990).

The topography of the Emory River Watershed encourages rapid runoff and flash flooding. The greatest flood occurred in Harriman on March 29, 1929. Numerous other floods occurred in Harriman in 1902, 1939, 1948, 1967, 1977, 1990, and within the late 1990s and early 2000s. The CRC Site was flooded during several of those events (TDEC 2012) mobilizing chemicals from surface soil and shallow groundwater and debris from the site, allowing them to enter the Emory River.

Many open pits, basements of former buildings, a pond, and areas of open water are on the site. Whether these structures contain only precipitation or are connected to the groundwater system at the site is unknown. The water in many of these structures was dark yellow.

Environmental Sampling Phases and Results

Environmental sampling at the CRC Site has been ongoing since at least 1984. Surface soil, subsurface soil, groundwater, surface water, sediment, and fish have been sampled in several sampling events conducted by TDEC, USACE, EPA, and its contractors, and Mead. Appendix A summarizes the environmental sampling events previously conducted at the site.

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates pathways that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. An exposure pathway contains five parts:

- a source of contamination
- contaminant transport through an environmental medium
- a point of exposure
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if evidence shows that all five of these elements have been, are, or will be present at the site. An exposure pathway is considered incomplete if one of the five elements is missing.

The source of contamination is the place where the chemical was released. For the CRC Site, the source was spills and leaks from the Source No. 1 area of the site, the former liquor ponds, the waste paper piles, the drum storage area, and the continuing releases into the Emory River over some 70 years.

The environmental media transports the contaminants. Environmental media are groundwater, surface water, soils, or air. For this site, the chemicals were present in onsite soils at and near the surface or buried beneath the site. The chemicals can be transported through the groundwater.

The point of exposure is the place where people come into contact with the contaminated media. Site soils, surface water, and groundwater; off-site sediment and surface water, off-site groundwater vapor intrusion, and off-site fish consumption are the possible points of exposure for this site. In the past, during site operations, the air at the site might have been a point of exposure.

The route of exposure is the way the contaminant enters the body. Ways a contaminant can enter the body are through ingestion, inhalation, or dermal contact. For this site, all three routes of exposure are present. A person could contact contaminated soil onsite by touching it or ingesting it through hand to mouth behavior. A person could also come into contact with contaminated groundwater by touching it, getting it on their skin, or drinking it. Someone could inhale the vapors of onsite chemicals, either onsite or off-site, and dusts through inhalation or breathing of contaminated indoor air. Someone could also come into contact with contaminants by eating fish caught in the Emory River near the site. Some exposures are only possible if someone is trespassing on the site itself.

When the plant was operating, workers could have been exposed to hazardous chemicals as part of their jobs. Workers may have been protected by occupational safety and health practices and regulations after the Occupational Safety and Health Administration was established in 1971. Activities conducted in the past at the CRC Site were related to cardboard and paper manufacturing. Little is known about past workplace conditions at CRC.

In the past, potentially exposed populations would have included residents near the CRC Site. Residents may have been exposed to chemicals moving from onsite to off-site areas. Potentially completed exposure pathways may have included inhalation of organic compounds, sulfides, mercaptans, and particulates from the air. In addition, contamination in sediment along the river banks and in the surface water of the Emory River may have led to dermal exposure, inhalation, or incidental ingestion of contamination by recreational and subsistence fishermen, boaters, or swimmers.

The chemicals found in the soil, groundwater, sediment, and surface water at the site have accumulated in the biota of the Emory River. Fish samples have shown elevated concentrations of site-related chemicals. For fish to have levels of site-related chemicals, biota the fish feed upon also must have these same chemicals.

TDH EEP believes trespassers such as shore fishermen not in boats have been exposed in the past and are currently being exposed to onsite hazardous chemicals. Both of these exposures are because not all site-related hazardous wastes have been removed. Access roads to the site are gated or blocked but the site is unfenced. There were no posted signs warning of hazards or "No Trespassing." Anyone has access to the site. Exposures also exist to fishermen using boats to harvest fish from the river near the site.

Onsite construction workers, trespassers, and both onsite and off-site recreational and subsistence fishermen could be exposed in the future. Routes of exposure could be incidental ingestion, dermal exposure, and, possibly, inhalation of contaminated particulate matter.

Physical contact with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will develop adverse health effects. A chemical's ability to affect health is controlled by a number of other factors, including:

- the amount of the chemical a person is exposed to (dose)
- the length of time that a person is exposed to the chemical (duration)
- the number of times a person is exposed to the chemical (frequency)

- the person's age and health status, and
- the person's diet and nutritional habits.

Exposure Pathways

The five things to consider when deciding if a person might be exposed to a chemical, are (1) where the chemical is coming from (source), (2) what in a person's environment has been contaminated (environmental medium), (3) the way a person might come into contact with the chemical (exposure point), (4) how a person might come into contact with the chemical (exposure route), and (5) who might be exposed to the chemical (exposed population), An exposure pathway is complete if proof or expectation is present of all five elements. Because the site was a working industry, engineering and institutional controls (such as fencing and security) were in place during its operation to prevent trespassing and exposure to the general public who lived near the site. As such, there likely was no exposure to the general public to site surface or subsurface soil, or groundwater. It is possible the general public would have come into contact with site soil in the past. The exposure pathways at the CRC Site are detailed below and shown in Table 1.

<table>
<tr><td colspan="7">Table 1. Exposure pathways for the public, future onsite workers, and trespassers at the Clinch River Corporation (CRC) Site.</td></tr>
<tr><td>Source</td><td>Environmental Medium</td><td>Exposure Point</td><td>Exposure Route</td><td>Exposed Population</td><td>Time Frame</td><td>Exposure</td></tr>
<tr><td rowspan="6">Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Polycyclic Aromatic Hydrocarbons (PAHs), dioxins, and metals</td><td rowspan="2">Surface soil</td><td rowspan="2">Contact</td><td rowspan="2">Ingestion, Dermal contact</td><td>Trespassers</td><td>Past
Present
Future</td><td>Potential[1]
Potential
Potential</td></tr>
<tr><td>Future recreators</td><td>Future</td><td>Potential</td></tr>
<tr><td rowspan="2">Subsurface soil</td><td>Contact</td><td>Ingestion, Dermal contact</td><td>Trespassers</td><td>Past
Present
Future</td><td>Incomplete[2]
Incomplete
Incomplete</td></tr>
<tr><td>Onsite excavations</td><td>Ingestion, Dermal contact</td><td>Onsite Workers</td><td>Past
Present
Future</td><td>Potential
Potential
Potential</td></tr>
<tr><td rowspan="2">Groundwater</td><td>Private well water</td><td>Ingestion, Dermal contact, Inhalation</td><td>Nearby Residents and Visitors that use private well water</td><td>Past
Present
Future</td><td>Incomplete
Incomplete
Incomplete</td></tr>
<tr><td>Groundwater intrusion into onsite pits and unlined ponds</td><td>Ingestion, Dermal contact</td><td>Trespassers</td><td>Past
Present
Future</td><td>Potential
Potential
Potential</td></tr>
</table>

Table 1. Exposure pathways for the public, future onsite workers, and trespassers at the Clinch River Corporation (CRC) Site.

Source	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Time Frame	Exposure
		Groundwater intrusion into excavations	Ingestion, Dermal contact	Onsite workers	Future	Potential
	Sediment	Contact	Ingestion, Dermal contact	Trespassers	Past Present Future	Potential Potential Potential
	Surface waters (Onsite impoundments and Emory River)	Contact	Ingestion, Dermal contact	Trespassers	Past Present Future	Potential Potential Potential
				Onsite workers	Past Present Future	Potential Potential Potential
	Fish	Eating fish caught from the Emory River	Ingestion	Shore fishermen	Past Present Future	Completed[3] Completed Completed
VOCs, SVOCs, PAHs, dioxins, metals	Fish	Eating fish caught from the Emory River	Ingestion	Boat fishermen	Past Present Future	Completed Completed Completed
VOCs, SVOCs	Air	Emissions from chemicals from site manufacturing	Inhalation	Nearby residents	Past	Potential
	Soil-gas	Vapor Intrusion from chemicals in subsurface soil or groundwater beneath the site	Inhalation	Nearby residents	Past Present Future	Potential Potential Potential
				Trespassers	Past Present Future	Potential Incomplete Incomplete
				Onsite workers	Past Present Future	Potential Potential Potential

[1] = Potential indicates that all five elements of the exposure pathway may have occurred in the past or may occur in the future.
[2] = Incomplete indicates that all five elements of the exposure were or are not present
[3] = Completed indicates that all five elements of the exposure pathway are either expected to occur or are occurring.

Health Comparison Values Used

An evaluation of site-related environmental contamination consists of a two-tiered approach: (1) a screening analysis and (2) a more in-depth analysis to determine public health implications of site-specific exposures (ATSDR 2005). First, maximum concentrations of detected substances are compared to media-specific environmental guideline screening or comparison values (CVs). If concentrations exceed the environmental guideline CVs, these substances, referred to as Contaminants of Potential Concern (COPCs), are selected for further evaluation. If contaminant levels are found above environmental guideline CVs, it does not mean that adverse health effects are likely, but that a health guideline comparison is necessary to evaluate site-specific exposures. Once exposure doses are estimated, they are compared with health guideline CVs to determine the likelihood of adverse health effects.

A number of CVs are available for screening environmental contaminants to identify COPCs (ATSDR 2005). These include ATSDR Environmental Media Evaluation Guides (EMEGs) and Reference Media Evaluation Guides (RMEGs). EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic health effects. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

In the absence of an ATSDR CV, CVs from other sources may be used to evaluate contaminant levels in environmental media. TDEC surface water action levels, USEPA MCLs for drinking water, and USEPA Regional Screening Levels (RSLs) are other comparison values used. RSLs are contaminant concentrations corresponding to a fixed level of risk (i.e., a Hazard Quotient of 1 or lifetime excess cancer risk of one in one million, or 10^{-6}, whichever results in a lower contaminant concentration) in water, air, biota, and soil (USEPA 2013b).

If the substance is a known or a probable carcinogen, ATSDR's Cancer Risk Evaluation Guides (CREGs) were considered as CVs. CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million persons exposed during their lifetimes (78 years). The background lifetime risk of cancer is about one in two for men and one in three for women (ACS 2013). All cancer risk values used express the additional chance of developing cancer above these background occurrences.

Substances exceeding applicable environmental guideline CVs were identified as COPCs and evaluated further to determine whether these contaminants pose a health threat to exposed or potentially exposed receptor populations.

Chemicals of Potential Concern

The various environmental media sampling results from previous site investigations were compared to ATSDR and EPA health screening values as well as TDEC surface water action levels. Chemicals of concern at the CRC Site included VOCs, PAHs, dioxins, metals, and diesel range organic compounds:

VOCs
Naphthalene
2-naphthalene

PAHs
benz(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
naphthalene

Diesel Range Organic Compounds

Dioxin compounds	**Metals**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8-HpCDD)	arsenic
1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)	cadmium
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (2,3,7,8,-TCDD-TEq)	copper
	lead
	mercury

Physical Hazards

On March 11, 2013, TDH EEP representatives conducted a site visit with TDEC's Knoxville Environmental Field Office and TDH's East Region Office. During the visit, EEP staff viewed several piles of discarded debris and materials. Some of the debris piles appeared to be site related whereas others did not. EEP staff also observed an unsecured surface impoundment, numerous pits filled with dark yellow water, numerous dry open vaults containing piping, water-filled pits and former building basements, and cracked concrete flooring above large underground open areas. No sulfur or other odors were noticed during the site visit. There were also several brick buildings in various states of disrepair that were easily accessible by intact stairways and building foundations backfilled with brick and other hard building materials. A long steel walkway appearing to be related to a barge loading and unloading structure that extended out over the Emory River was readily accessible. A concrete roadway/retaining wall in the northern part of the site is being undermined by the Emory River. Appendix B contains photographs of the physical hazards observed during the March 11, 2013 site visit. All of the physical hazards observed were unsecured. On that day there were no obvious signs of trespassing. It had been reported that areas of the riverbank along the site were used by fishermen.

TDH EEP has had two follow-up visits to the site, both in conjunction with public meetings. One site visit was on January 13, 2015 and the second was on January 14, 2016. EEP documented removal activities conducted by the EPA and one of the responsible parties previous to these latest site visits. During these most recent visits, the yellow water has been removed from the basements and many of the basements have been filled with brick and concrete rubble debris. The buildings in disrepair still remain as do two large, tiled, above ground storage tanks and a newly discovered 15,000-gallon former hydraulic oil underground storage tank. The barge loading and unloading structure remains as does the undermined concrete roadway and retaining wall. The wall has been further undermined and a section of the roadway has fallen down into the river. Additional dumping of construction debris and carpeting was observed in some site areas.

Impacted Media

Surface and Subsurface Soil

Most the site was used as a pulp and paper mill operation for more than 70 years. It was decommissioned in 2002. Surface soils on the CRC Site were contaminated with chemicals used and produced as by-products or wastes during industrial activities on the site. These chemicals included VOCs, semivolatile organic compounds (SVOCs), pesticides, herbicides, PAHs, dioxins, furans, and certain metals. Because the site was a working industry, institutional controls (such as fencing and security) were in place during its operation to prevent trespassing and thus exposure to the general public who lived near the site. As such, although possible, exposure to the general public to site surface or subsurface soil was unlikely.

The CRC Site is generally unfenced and unsecured. Only some of the wastes in the various areas of the site have been removed and disposed of properly (TDEC 2012a, OTIE 2012a). Contamination remains in soil at some locations. If a person dug into onsite soil they might become exposed to any chemical contamination below the ground surface. Off-site soil sampling has been limited. Sampling has occurred as part of at least two site investigations to gain knowledge on the background amounts of naturally-occurring chemicals and metals. Background soil samples were collected from a community center and from a community baseball field near the CRC Site. Based on the results of the background soil samples, site soils do appear to have been affected by past site operations.

Potential exposure pathways from incidental ingestion and dermal exposure from onsite surface soil also exist for site trespassers. Trespassers would be walking onto the site or using a motorized recreational vehicle, such as a 4-wheeler or motorcycle. Even though trespassers would only be present on the site for limited periods, they would still have the potential to be exposed if they came into contact with onsite soils.

Potential exposure pathways from inhalation, incidental ingestion, and dermal exposure exist from onsite surface and subsurface soil for future site construction workers. The site could potentially be sold or redeveloped as a recreational area. If redevelopment occurs, we recommend ensuring the safety of site workers and site users. The property parcels comprising the CRC Site are zoned for industrial use (heavy manufacturing) by Roane County.

Sediment

Over the long-term, trespassing has been documented, such as recreational fishermen trespassing onto the CRC Site to gain access to the Emory River. In doing so, they could come into contact with sediments contaminated with site-related chemicals. TDEC (2012a) collected one background and three downgradient sediment samples to understand if there was impact from probable points of entry (PPE) of surface runoff contamination. All sediment samples were analyzed for SVOCs and metals. Many site-related chemicals were found in the sediment samples collected downstream from the site. Concentrations of naphthalene and 2-naphthalene exceeded both short-term and long-term health comparison values.

Groundwater

Contaminants from spills, ponds, container overflows, and flooding can be carried downward to the groundwater beneath the site. Depth to groundwater varies from approximately 6 to 15 feet below ground surface (bgs) across the site. It was unlikely that anyone in the past or at the present would have had access to groundwater beneath the site.

No private water wells exist within a one-mile radius from the site. Therefore, it is unlikely given the depth to groundwater that anyone had access to groundwater off-site within that one-mile radius in the past.

Limited groundwater quality data have been collected from the five temporary onsite monitoring wells installed as part of the OTIE investigation in 2012 (OTIE 2012b) and six permanent wells installed in 2015 by TRC. The onsite permanent and temporary wells were insufficient to characterize the nature and extent of groundwater contamination and therefore, no contaminant plume information exists. Groundwater flow appears to be in an easterly direction toward the Emory River. The flow direction is away from the nearby community. Water for the nearby community is supplied from the Harriman municipal water supply.

Groundwater was not in the past and is not now used as a drinking water source in the vicinity of the CRC Site. No drinking water wells exist in the immediate vicinity (TDEC 2009). The Harriman Utility Board (HUB) has provided drinking water for the City of Harriman for decades. HUB pumps water from the Emory River into its water treatment plant. The Harriman water intake is located approximately 1.4 miles upstream from the CRC Site. At typical water treatment plants, similar to HUB, chlorine is added to kill bacteria and other microorganisms and to oxidize certain chemical compounds for removal. Then the water travels through clarification basins to remove particles. The water is filtered through sand and granular activated carbon to remove odors and any remaining particles. Before the water is pumped through the network of pipes to customers, a small amount of chlorine, fluoride to prevent tooth decay, and a food grade corrosion inhibitor to protect the lines in the customer's home are added to make sure water quality remains good until it comes out of the customers' faucets. HUB is regulated by both the EPA and the TDEC. Connection to the municipal water supply for homes near the CRC Site has eliminated ingestion, inhalation, and dermal pathways for exposure to contaminated groundwater in the past, currently, and in the future.

Groundwater use in Harriman is limited to private wells and wells serving small localities. Dynamac Corporation conducted a reconnaissance survey of the area groundwater use in July 1992 (Dynamac 1992). Dynamac found the nearest private water wells were located between one and two miles south of the site. These private wells were found to serve about seven homes. A spring located between one and two miles south of the site was found to also serve about 13 homes and a mobile home park containing 13 mobile homes located approximately two to three miles from the site. A pumping station pumps the water from the spring to these homes. Another spring that provides water to the community of Kingston Heights and several homes along the Clinch River is located immediately north of the Samuel Rayburn Memorial Bridge on Interstate 40. This spring is located between two and three miles from the site.

Dynamac estimated a total of 86 people located between one to two miles from the site used groundwater as their sole source of household water. They also estimated that 86 people located between two and three miles, and 43 people located between three and four miles from the site also used groundwater as their source of household water (TDEC 2011). Groundwater is not currently monitored at the CRC Site. The single permanent well onsite is not readily accessible to the public.

Soil-Gas

Volatile and semi-volatile contaminants may volatilize (off-gas) from soil and groundwater, migrate through subsurface air spaces and enter buildings where they may be inhaled by occupants. Many variables influence the levels of chemicals entering a building through volatilization from contaminated soil or groundwater. These variables include the chemical's physical and chemical properties, seasonal variations, and building construction. Soil-gas testing has not been completed on the site to understand if this is a potential contaminant pathway.

Vapor intrusion could potentially occur in onsite buildings if redevelopment should occur. If land use on the site changes, soil-gas testing is recommended to ensure the safety of the public and onsite workers, including investigation of potential vapor intrusion issues.

Vapor intrusion could also potentially be occurring in off-site buildings. It would be a prudent public health activity to understand if off-site vapor intrusion could potentially be an issue.

Surface Water

Recent onsite sampling of water accumulated in a pit, building basement, and below the former stock chest did not reveal any contaminants other than diesel range organic (DRO) compounds above applicable screening values. A stock chest is a tank used to agitate and store the pulp slurry before further refining processes. Several chemicals have been found in the Emory River near and downstream from the site thought to be related to the CRC Site. These chemicals were found even though the mean monthly flow rate for the Emory River at Oakdale, Tennessee from July 1, 1927 through September 30, 2012 is reported to be 914 cubic feet per second (USGS 2013). These chemicals included octachlorodibenzodioxin, (m- and/or p-)xylene, 1,2,4-trimethylbenzene, benzene, chloromethane, ethyl benzene, o-xylene, and toluene in the surface water. Amounts of 1,2,4 trimethylbenzene, benzene, and chloromethane were more than three times their respective background concentrations and may be attributable to the site. TDEC believes the CRC Site was likely the source of these chemicals (TDEC 2013).

Fish

Exposure is likely to those who fish and consume the fish caught from the Emory River near the site. TDEC (2011) conducted an investigation into whether game fish in the area of the CRC Site contained site-related chemicals. Several site-related chemicals were found in the game fish tested. Anyone who eats fish caught from the Emory River downstream from the site could be exposed to site-related chemicals.

Outdoor Air

Volatile and semi-volatile chemicals in soil and groundwater may also volatilize to the outdoor air where people may breathe them. Groundwater may be discharged at the surface from springs, or into streams or rivers, providing an exposure point for breathing those chemicals moving from groundwater into the air. EEP is unaware of air samples having been collected at the CRC Site. Approximately 15 residences are located within one quarter-mile from the site. There are no onsite residents. The nearest house is located approximately 100 feet from the northwestern property boundary. The nearest school is approximately 0.4 miles north-northwest. The nearest public park is approximately 100 feet northwest of the property boundary located on Clinch Street in Harriman (TDEC 2012a).

Any current potential hazard from breathing air on the site is unlikely. The site is heavily vegetated, partially paved, and partially graveled. According to TDEC (2012a), there does not appear to be a significant amount of dry soils on the site to create dust in windy conditions. In the past, when the paper and pulp mill was operating, there may have been nearby residents that may have breathed chemicals used onsite or chemicals in the emissions from the mill. In the future, emissions of chemicals from the site are unlikely as chemicals are no longer used onsite, and the sources of the chemicals will have been removed.

Site Sampling Results

Soil

CRC Site soils are contaminated with several chemicals including benzo(a)pyrene (BaP) and 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD)-TEq (Tables C-1 and C-2 [Appendix C]). Table C-1 shows metals results from the one background soil sample and five onsite soil samples collected as part of the USACE investigation conducted in 2005. Table C-2 shows the results of a more extensive site surface soil investigation conducted by TDEC in 2009. A total of one background and two onsite soil samples were collected and analyzed during these investigations. The two onsite soil samples had SVOCs, including PAHs, dioxins, and furans; and metals. In the 2009 TDEC site reassessment investigation, surface soil samples were found to contain dioxins, furans, PAHs, and arsenic. The concentrations of these chemicals exceeded health-based ATSDR and EPA comparison values.

Fourteen onsite surface soil samples were collected in 2012 by EPA's contractor. Specifically samples were collected near Waste Paper Pile 1, north and southeast of the former mill building, near the chipper shed, near the black liquor pond, near Waste Paper Pile 2, and in the wooded area of property parcel 003.01. Two samples had arsenic levels above local background, the Tennessee background value of 10 milligrams per kilogram (mg/kg), the ATSDR chronic EMEG of 15 mg/kg, the ATSDR CREG of 0.47 mg/kg, and the EPA RSL values for both residential and industrial settings. Test results are shown in Appendix C (Table C-3).

Only two subsurface soil samples had arsenic concentrations above the Tennessee background level. A soil boring was advanced through concrete at the former location of the "coal tar" pond. The boring was advanced to a depth of 35 feet bgs. Black liquor was reportedly observed in the boring. Surface and subsurface soils contained PAHs and arsenic. More specifically, benz(a)anthracene was detected at levels up to 2,300 micrograms per kilogram (µg/kg), benzo(a)pyrene was detected at up to 2,000 µg/kg, benzo(b)fluoranthene was detected at levels up to 2,200 µg/kg, dibenzo(a,h)anthracene was detected at levels up to 440 µg/kg, and arsenic was detected at levels of 54 mg/kg.

Additional surface soil samples were collected by TRC in May 2015 (Table C-4). These samples were collected from a municipal park in Harriman and serve as background samples to be used for comparison purposes. The surface soil data collected in 2012 was compared to the results from samples.

Sediment

Results of the sample analysis are in Table C-3 in Appendix C. Tables C-5 and C-6 show the levels of SVOCs and metals measured in one background and three downstream sediment samples near the CRC Site. All samples were collected by TDEC DoR in 2009.

Background and downstream sediment samples were analyzed for SVOCs and metals (TDEC 2009). SVOC analysis was conducted by EPA Region 4 Science and Ecosystem Support Division (SESD), Analytical Support Branch (ASB). Total metals analysis was completed by CompuChem, now known as Liberty. EPA Region 4 SESD ASB reviewed the total metals results.

Measureable levels of several PAHs, and the metals chromium, copper, and manganese were found. As shown in Tables C-5 and C-6, levels are relatively low with many chemicals present in concentrations just above their respective laboratory detection limit. The most abundant SVOCs found in all three samples were chrysene, fluoranthene, 2-methylnaphthalene, naphthalene and phenanthrene. Manganese was the most abundant non-essential nutrient metal in all three samples.

Sediment samples collected in 2015 (TRC 2015) show the same chemicals and metals being found. The most abundant SVOCs found included benzo(a)pyrene, benzo(a)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene. Metals found in the samples included barium, beryllium, chromium, lead, manganese, mercury, nickel, selenium, vanadium, and zinc. The fact that these chemicals are still able to be found in the river sediment, given the flow rate of the river, suggests they bind well to the sediment particles, or a continuing source of leaching of these chemicals remains from onsite soil, groundwater, or surface water.

Fish

The Emory River and Watts Bar Reservoir impoundment, forming the eastern boundary of the site, are used for fishing, recreation, agriculture, and drinking water (USGS 2009). Primary fish species taken from these waterways for human consumption were white bass, largemouth bass, smallmouth bass, black and white crappie, and bluegill. The total annual production of these species in the entire Emory River and Watts Bar Reservoir is approximately 54,750 pounds (TWRA 1993).

TDEC conducted a fish sampling investigation in September 2010. Fish sampling locations were concentrated on the western side of the Emory River immediately downstream from the CRC Site where impacted surface water run-off would likely be entering the surface water pathway. A total of 32 fish were collected as part of TDEC's investigation. The fish were collected at three locations downstream of the site. Fish species collected included four largemouth bass, 25 sunfish, and three carp. Some types of fish commonly consumed were not consumed during TDECs investigation, introducing some uncertainty in the evaluation of exposures from eating fish. Uncertainty is also introduced because there was not evaluation of the migratory zones of these fish and the usual methods for catching the fish were not employed.

Measureable concentrations of pentachlorophenol, benzaldehyde, aroclor 1260, chromium, copper, mercury, mercury, zinc, and 2,3,7,8-tetrachlorodibenzofuran were found in fish sampled. As concentrations of these chemicals were found in fish samples, they are chemicals of potential concern for the site.

Pentachlorophenol was detected at a concentration of 0.0073 mg/kg in one sampled largemouth bass. As stated in the Superfund Chemical Data Matrix (EPA 1994), the Surface Water Food Chain Reference Dose Screen Concentration for pentachlorophenol was 0.026 mg/kg. Levels observed were an order of magnitude lower than the accepted regulatory action level (TDEC 2011).

Estimated levels of benzaldehyde were found in two largemouth bass and one carp. The bass each had a benzaldehyde concentration of 0.042 mg/kg while the carp had a concentration of

0.046 mg/kg, the highest measured. There was not a Surface Water Food Chain Reference Dose Screen Concentration for benzaldehyde.

The polychlorinated biphenyl (PCB) aroclor 1260 was found in all four bass ranging from 0.022 to 0.033 mg/kg and in one of three carp at 0.088 mg/kg. There was not a Surface Water Food Chain Reference Dose Screen Concentration for aroclor 1260.

Chromium was observed in two largemouth bass and one carp at an estimated average concentration of 0.057 mg/kg with a maximum of 0.064 mg/kg in the bass. The background concentration as calculated from TDEC's Water Pollution Control (WPC) database was 0.039 mg/kg, whereas the Surface Water Food Chain Cancer Risk Screen Concentration for chromium was 4.1 mg/kg (EPA 2011). Although total chromium levels in these fish did exceed the historical chromium average background level, they did not exceed the Surface Water Food Chain Cancer Risk Screening Concentration.

Copper was detected in every fish sampled during this study. Copper can be a by-product of the paper making process. Levels of copper ranged from an estimated 0.18 mg/kg in a bass and sunfish to a maximum of 1.2 mg/kg in a carp. The background concentration for copper calculated from the TDEC-WPC database was 0.283 mg/kg. There are no regulatory screening levels for copper in fish but there is an ATSDR intermediate exposure (15 to 364 days exposure) oral MRL of 0.01 mg/kg/day. The maximum level in the carp exceeded three times the TDEC-WPC copper background concentration (TDEC 2011). The copper in fish appears to be site-related.

The highest value of manganese reported in the fish sampled was 2.3 mg/kg. Manganese was detected in every fish sampled with levels ranging from 0.44 to 2.3 mg/kg. The EPA Surface Water Food Chain Reference Dose Screen Concentration for manganese is 180 mg/kg. There is not an EPA Surface Water Food Chain Cancer Risk Screening Concentration for manganese. Zinc was reported in every fish sampled and ranged from 3.8 to 14 mg/kg. The EPA Surface Water Food Chain Reference Dose Screen Concentration for zinc is 400 mg/kg. The ATSDR intermediate and chronic (greater than 365 days) MRL is 0.3 mg/kg/day. There is no EPA Surface Water Food Chain Cancer Risk Screening Concentration for manganese.

Estimated concentrations of 2,3,7,8-dichlorodibenzofuran in one largemouth bass and one carp were 0.64 nanograms per kilogram (ng/kg) and 0.55 ng/kg, respectively. Lab-calculated mammalian toxicity equivalent quantities for TCDD did not exceed their respective method reporting limits. Average background concentrations of TCDD within Watts Bar Reservoir calculated from the TDEC-WPC database was 2.4 ng/kg, while the Surface Water Food Chain Cancer Risk Screen Concentration was 0.021 ng/kg. The TCDD TEq did not exceed the method reporting limits or the average background within the reservoir.

Mercury concentrations were found in all four bass, two of the sunfish, and all three carp samples. Mercury ranged from 0.19 to 0.42 mg/kg in the bass samples, 0.073 to 0.10 mg/kg in the sunfish samples, and 0.14 to 0.25 mg/kg in the carp. The EPA Surface Water Food Chain Reference Dose Screen Concentration for mercury is 0.4 mg/kg. There is no EPA Surface Water Food Chain Cancer Risk Screening Concentration for mercury. EPA and Tennessee have a public consumption screening value of 0.3 parts per million (equivalent to mg/kg). The mercury levels in two bass exceeded this level. Although not a result of the mercury found in fish near the CRC Site, there is a fish tissue advisory on the Emory River from river mile 12.4 to mile 24.8 upstream of the CRC Site.

Two separate fish collection efforts were done after the TVA Kingston Coal Ash Spill. The first was conducted by the Tennessee Wildlife Resource Agency (TWRA). TWRA collected fish samples at Emory River miles 3.0 and 8.0. Mercury levels in six largemouth bass at mile 8.0 averaged 0.19 mg/kg wet weight. Levels in six channel catfish averaged 0.16 mg/kg wet weight. Mercury levels in black crappie averaged 0.05 mg/kg wet weight. At Emory River mile 3.0, the concentration of mercury was 0.09 mg/kg wet weight in whole body analysis of a largemouth bass. Whole body analysis of a red ear sunfish at mile 3.0 yielded a mercury level of 0.04 mg/kg wet weight. These mercury values were below Tennessee's public consumption screening level of 0.3 parts per million (ppm).

The second fish collection was done in the Emory River at miles 0.5, 0.9, and 2.1. Fish collected were also sampled for mercury. Eight largemouth bass, four channel catfish, and five blue catfish were sampled for mercury at river mile 0.5. Average mercury levels in largemouth bass, channel catfish, and blue catfish at mile 0.5 were 0.075 mg/kg wet weight, 0.11 mg/kg wet weight, and 0.09 mg/kg wet weight, respectively. Average mercury levels in five black crappie sampled at mile 0.9 were 0.034 mg/kg wet weight. Average levels of mercury in five black crappie sampled at mile 2.1 were 0.03 mg/kg wet weight.

Average mercury levels in three species of fish in the Emory River at mile 7.0, approximately 4.4 river miles downstream from the CRC Site, were collected in the 1980s at the TVA station upstream from the Little Emory River embayment. The mercury levels measured were 0.22 mg/kg weighted average (wa) of 10 carp, 0.23 mg/kg for 10 largemouth bass, and 0.26 mg/kg wa for 10 channel catfish.

Upstream from the CRC Site, four species of fish were collected and analyzed in the 1980s at the TVA stations at river miles 14.5 through 22.0. The average mercury levels measured were 0.30 mg/kg wa from 5 carp, 0.44 mg/kg wa from 44 largemouth bass, 0.32 mg/kg wa from 35 channel catfish, and 0.63 mg/kg wa from 5 smallmouth bass.

The amount of copper present in site sediment strongly suggests that elevated copper levels in the sediment is in the food chain and may also be affecting other aquatic life in the Emory River/Watts Bar Reservoir. Mercury, although not CRC Site-related, is also found at levels in fish above Tennessee's public consumption screening level of 0.3 ppm.

Surface Water

The surface water exposure pathway may be the most important pathway of concern for the CRC Site. Illegal piping and discharge of waste liquids from the site has been documented and is the most likely route of contamination to the Emory River (TDEC 2011). The entire 15-mile extended surface water pathway is within a wetland (USDI 2007). Emory River surface water was also sampled as part of facility investigations. This water is considered off-site surface water for this report. Historic water analysis results are shown in Table C-7.

Onsite surface water includes water in ponds, surface impoundments, pits, and in building foundations on the site. Surface water from three pits or areas was sampled in February 2014.

For Samples 1 and 2 collected from the mixed liquor pit, all total metals results are below ATSDR comparison values and EPA residential and industrial RSLs, where available. Total petroleum hydrocarbons DRO compound levels in the two samples are above TDEC water quality values (Table C-8). For Samples 3 and 4 collected from the former paper mill basement, all total metals results were below ATSDR and EPA screening values, where available. The toluene level in Sample 3 of 1.02 micrograms per liter (µg/L) was well below its ATSDR intermediate EMEG of 200 µg/L for a child. DRO results were above TDEC's water quality value (Table C-8). For the samples collected from below the former stock chest, all metals were below their respective ATSDR and EPA screening values, where available. DRO ranged from 335 to 920 µg/L and were above TDEC water quality levels (Table C-8).

The amount of DRO found in a sample is useful as a general indicator of heavier petroleum product contamination at that site. However, this DRO measurement or number tells us little about how the particular petroleum hydrocarbons in the sample may affect people, animals, and plants (ATSDR 1999).

Octachlorodibenzodioxin (OCDD) is part of a group of chemicals generally referred to as dioxins that are environmental pollutants. Dioxins occur as by-products of various manufacturing processes including the chlorine bleaching of paper. OCDD was observed in Emory River surface water samples collected in 2009 (TDEC 2009) at an estimated value of 0.018 part per trillion (ppt) at the background location and in the sample furthest downstream. These two values exceeded the TCDD RSL for Tap Water of 0.003 ppt. The absence of this constituent in the upstream sample suggests that OCDD may be site-related (TDEC 2009).

Organic analyses for samples collected in 2009 showed measurable concentrations of (m- and/or p-)xylene, 1,2,4-trimethylbenzene, benzene, chloromethane, ethylbenzene, o-xylene, and toluene in the surface water. Both background and downstream sample locations contained m & p xylene, ethylbenzene, o-xylene, and toluene. Benzene, 1,2,4-trimethylbenzene, and chloromethane were the three chemicals found in downstream surface water samples and not in the background sample (Table C-7). Low levels of 1,2,4-trimethylbenzene, benzene, and chloromethane were more than three times the background concentration and may be attributable to the site (TDEC 2009). 1,2,4-trimethylbenzene does not have an ATSDR or EPA comparison values for water for comparison. The benzene level found was below both its ATSDR EMEG and CREG as well as its EPA RSL comparison values. Chloromethane was below its EPA non-cancer comparison value. ATSDR does not have published comparison values for chloromethane. No organic constituent exceeded the EPA RSL for tap water. Only the metal arsenic was found above its EPA RSL and above the national recommended water quality criteria for the consumption of organisms.

Groundwater

Limited groundwater samples have been collected from the site. Five temporary monitoring wells installed in 2012 and ranging in depth from 20 to 35 feet were sampled once and then properly abandoned. SVOCs and selected metals were found in the groundwater samples collected, as shown in Table C-10 in Appendix C. Six permanent groundwater monitoring wells were installed at the site during 2015. Results of the groundwater sampling are in Table C-10. Six volatile organic chemicals (VOCs) were found in one well, GW-05. Several metals were found in newly installed background wells GW-01 and GW-06, and onsite wells GW-02, GW-03, GW-04, and GW-05. Two of the wells GW-02 and GW-05 were recorded as having high turbidity which led to higher overall levels of metals in samples from those wells. Wells GW-02 and GW-05 were resampled in December 2015. Results are summarized in Table C-10 in Appendix C.

A well thought to be the former site production well was sampled in 2009. The well is reportedly at least 100 feet deep. Metals found included arsenic, barium, cadmium, chromium, cobalt, copper, manganese, nickel, vanadium, and zinc. Only an estimated amount of arsenic at 0.00043 mg/L was found to exceed its EPA RSL of 0.000045 mg/L. An estimated concentration of chloromethane at 0.38 µg/L was the only organic compound found.

Metals found in onsite groundwater samples collected from temporary wells installed in 2012 by OTIE (OTIE 2012) included arsenic, barium, chromium, lead, and selenium. Only arsenic and lead were found at levels above EPA RSLs and ATSDR EMEGs at only one location, temporary well GW-002.

SVOCs found in amounts above their ATSDR comparison values or EPA RSLs in the temporary monitoring well samples included: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and naphthalene. These chemicals are all PAHs. Other PAHs found at levels below their respective ATSDR comparison values and EPA RSLs included: 2-methylnaphthalene, acenaphthalene, anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorine, phenathrene, and pyrene.

VOCs found in the 2015 sampling of six permanently installed monitoring wells included benzene, carbon disulfide, chloroform, methyl ethyl ketone, and methylene chloride (C-11). Levels of benzene, carbon disulfide, methyl ethyl ketone and methylene chloride were estimates and very low, below their respective RSLs. Levels of chloroform were above its EPA carcinogenic RSL but below its non-cancer RSL. Metals identified in the initial June 2015 sampling included arsenic, beryllium, chromium, and lead. Arsenic was present in both GW-02 and GW-05 above its cancer and non-cancer RSLs and lead was found above its non-cancer RSL. Beryllium and chromium and were below their EPA RSLs. Both GW-02 and GW-05 were resampled in December 2015. Levels of arsenic were found to be lower but levels remained above both its EPA cancer and non-cancer RSLs. Other metals detected were below their RSLs.

No one is drinking the water onsite. As outlined in the Dynamac report summarized in TDEC (2011), the homes within a one-mile radius from the site have municipal water as their potable water source.

No known off-site groundwater monitoring wells or residential wells exist within one mile from the site. Whether any of the chemicals in site groundwater are moving off-site is unknown. Whether vapor intrusion could occur offsite from a groundwater contaminant plume is also unknown.

Previous Removal Actions

During a 2005 Phase 1 investigation conducted by Shaw, about 106 damaged, leaking, or open containers (55-gallon drums and two 250-gallon totes) containing various oily liquid wastes were observed in and around the chipper shed. The oily liquid wastes were suspected to contain lubricant oils, white paper and black paper liquor waste, water, and other waste. Notable dark staining was observed in the area near the leaking containers (TDEC 2005). Erosion of the concrete surface near Waste Paper Pile 1 revealed layers of dark staining in the soils underneath the concrete surface. This area of concrete erosion and staining borders the Emory River and is prone to flooding (TDEC 2005). In addition, EEP observed distressed vegetation near Waste Paper Pile 1. These drums and containers were removed as part of the 2011 and 2012 EPA removal actions discussed below. Many of the site buildings were removed between October 2007 and April 2012, based on aerial photographs (Mead 2014) and TDEC (E.F. Sutton, personal communication, 2013).

As mentioned previously, EPA conducted removal activities in August 2011 and February 2012. The removal of all drums and containers plus excavation of an UST containing black liquor occurred in February 2012. The following details of sampling were gleaned from OTIE's (2012a) report. The UST was located southeast of the former pulp and paper mill and contained 38,500 gallons of black liquor and some sludge. Black liquor and sludge were also noted in the UST pit. This material was also removed.

In 2014, the 630,000-gallon above ground former fuel oil storage tank was removed by contractors for the owner of Parcel 3.01 (TRC 2015). Additional removal actions are proposed at the site by WestRock (TRC 2015). These activities are expected to begin in 2016.

Evaluation of Health Effects of Chemicals of Concern

Arsenic

Inorganic arsenic has been recognized as a human poison since ancient times, and large oral doses (above 60,000 ppb in water, which is 10,000 times higher than 80% of U.S. drinking water arsenic levels) can result in death. The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), and EPA have all determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer).

At the CRC Site the most probable pathway for exposure to arsenic would be skin contact. If you have direct skin contact with high concentrations of inorganic arsenic compounds, your skin may become irritated, with some redness and swelling. However, it does not appear that skin contact is likely to lead to any serious internal effects. Almost no information is available on the effects of organic arsenic compounds in humans. Studies in animals show that most simple organic arsenic compounds (such as methyl and dimethyl compounds) are less toxic than the inorganic forms. In animals, ingestion of methyl compounds can result in diarrhea, and lifetime exposure can damage the kidneys. Lifetime exposure to dimethyl compounds can damage the urinary bladder and the kidneys (ATSDR 2007). It is unknown if trespassers may drink from pits or ponds on the site.

Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. Skin cancer may also develop. Swallowing arsenic has also been reported to increase the risk for cancer in the liver, bladder, and lungs (ATSDR 2007).

The metals arsenic, cadmium, copper, and mercury were found above background concentrations in the area. Arsenic is naturally-occurring in Tennessee. Arsenic levels in surface soil samples collected at the site ranged from 2.6 to 54 mg/kg. The average arsenic level for all surface soil samples collected was 23 mg/kg. The state-wide background level for arsenic is 10 mg/kg. Surface soil arsenic levels at the site are both below and above the statewide background level.

The average for all subsurface soil samples collected was 13.2 mg/kg which was slightly above the state-wide average concentration.

BaP and BaP-TEq Health Effects

Benzo(a)pyrene (BaP) is one compound in a class of more than 100 chemicals called PAHs. PAHs are formed during the incomplete combustion of coal, oil, gas, wood, garbage, and other organic substances. PAHs, including BaP, occur naturally in air, water, and soil but are also found in waste products such as those remaining from the paper making process. PAHs were found at the CRC Site in soil near the paper and pulping mill, Waste Paper Piles 1 and 3, and in sediment samples collected from the Emory River. The extent of PAHs has not been totally defined on the site. The following summary of BaP health effects is primarily from the ATSDR Toxicological Profile for Polycyclic Aromatic Hydrocarbons (ATSDR 1995) with other documents as cited.

The BaP toxic equivalent (TEq) is a derived concentration of the seven most common PAHs with their specific concentrations adjusted for their toxicity relative to BaP. Those specific PAHs and relative toxicities (expressed as toxic equivalency factors; TEFs) are as follows (from EPA, 1993):

PAH compound	TEF
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1
Indeno(123-cd)pyrene	0.1

BaP-TEq equals the sum of the individual compound concentrations multiplied by their respective TEF. Concentrations of 14 specific PAHs (including alkylated PAHs) in soil and sediment are included in Tables C-2 and C-4 (Appendix C). Specific PAHs found in site soil and sediment include benzo(a)anthracene, benzo(k)fluoranthene, carbozole, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene. Chart 1 shows the distribution of BaP-TEq in surface soil samples collected at the CRC Site.

PAHs, including BaP, can be harmful to your health. Some PAHs are known to have caused tumors in laboratory animals when they breathed, ate, or had long periods of skin exposure to these substances. Human data specifically linking benzo[a]pyrene (BaP) to carcinogenic effects are lacking.

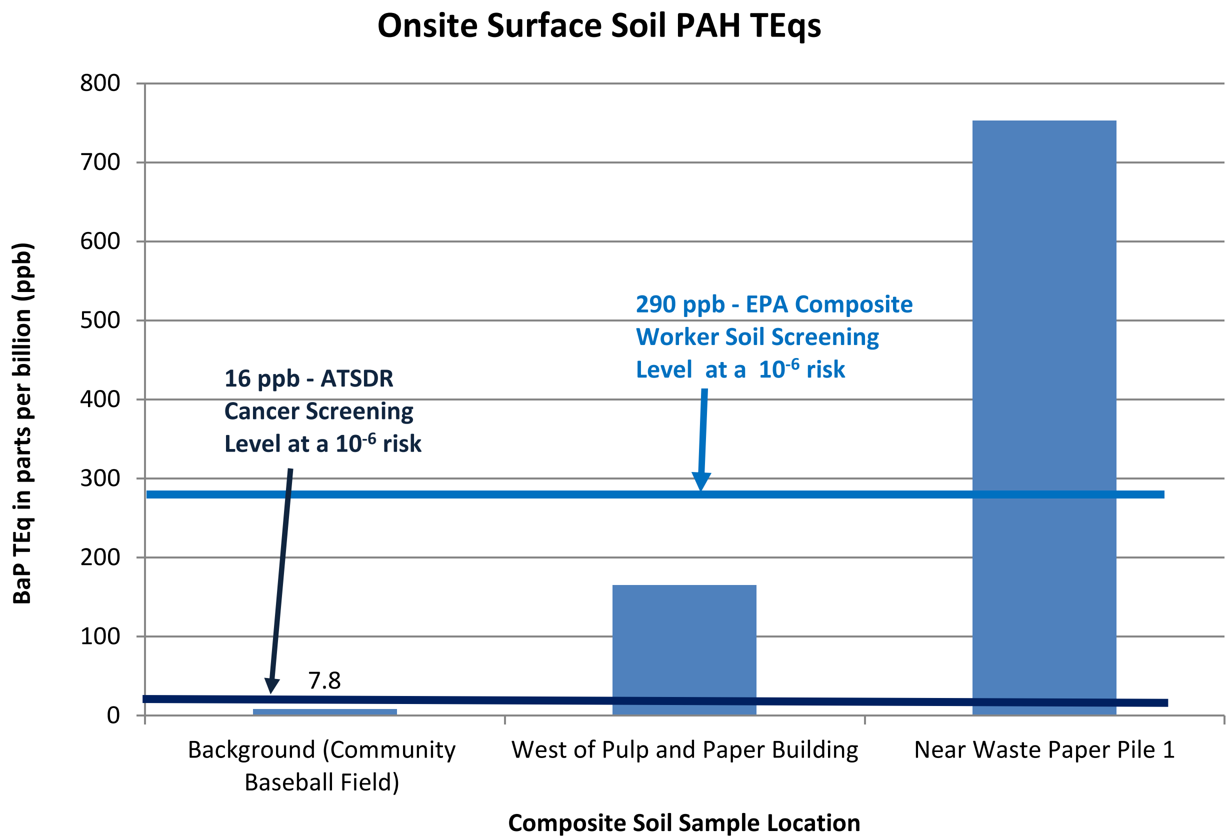


Chart 1. Benzo(a)pyrene – toxic equivalents (BaP-TEq) distribution in samples collected from the CRC Site. BaP-TEqs are reported in parts per billion (ppb).

The cancer risks calculated are based on the most conservative assessment model available (NCRP 2001). The dose-response models used to estimate the cancer slope factor (CSF) assume that there is no threshold below which there is no dose-response and actually ignore data which suggest that such a threshold exists (NCRP 2001; Fitzgerald et.al. 2004). Using BaP and creosote exposures to mice and a benchmark dose-response model for the resulting tumor development, Fitzgerald, et.al. (2004) propose a soil guideline value of 5,000 ppb BaP is safe for human exposure. None of the soil sample results BaP concentrations were above 5,000 ppb.

Some non-cancer dermatological effects could also be associated with exposure to PAH-contaminated soil. However, those effects occur at much higher concentrations than those measured at the CRC Site. In an industrial health survey involving 251 employees at four wood preservative plants where coal tar creosote and coal tar are used or generated, 82 instances of dermal effects were reported, ranging from mild skin irritation, eczema, and folliculitis to benign skin growths such as warts (ATSDR 2002). Skin irritation was described as a redness like a sunburn, lasting two to three days, along with photosensitivity that has been reported by workers who handle coal tar pitch products outdoors (ATSDR 2002).

No acute or chronic Minimal Risk Levels (MRLs) have been derived for BaP because no adequate human or animal dose-response data are available that identify threshold levels for appropriate non-cancer health effects. Although the site is accessible, trespassers are unlikely to spend a great deal of time on the site. The site will not likely be redeveloped into residential housing. Therefore, it appears unlikely that any non-cancerous adverse health effects from PAH (BaP or BaP-TEq) exposure would occur in children or adults that would enter the CRC Site. Examples above are worst case scenarios and overestimate the levels of BaP that would be present on the CRC Site.

All the studies above over-estimate the actual exposure an onsite trespasser would have. Cancer health effects to trespassers are unlikely because of the amount of time they would be on the site. If the trespassers were to be exposed to the waste piles or any other areas containing wastes with elevated BaP levels, a small increased risk for cancer may occur.

TCDD-TEq Health Effects

The term dioxin refers to a family of chlorinated organic chemicals having similar chemical structures. The dioxin molecule can have eight different places where a chlorine atom can attach. Dioxins are formed during the combustion of coal, oil, gas, wood, garbage, and other organic substances. They mostly cannot dissolve in water but have a high attraction for fat. This attraction for fat allows them to be stored in a person's body for a long time. Dioxins also tend to be associated with organic matter such as ash, soil, plant leaves, or any surface having a high organic content.

Dioxins, including 2,3,7,8 Tetrachlorodibenzo-p-dioxin (TCDD), occur naturally in air, water, and soil but are also found as by-products at paper and pulp mill facilities. Similar to where PAHs were found at the CRC Site, dioxins were found in the same surface soil samples near the pulp and paper mill and near Waste Piles 1 and 3. The following summary of TCDD-TEq health effects is primarily from the ATSDR Toxicological Profile for chlorinated dibenzo-p-dioxins (ATSDR 1998) and other documents as cited. TCDD is one compound within a large class of chemicals commonly referred to as polychlorinated dioxins (or dioxins/furans).

The TCDD toxic equivalent (TEq) is a derived concentration of the 17 most common dioxins with their specific concentrations adjusted for their toxicity relative to TCDD. Those specific dioxins and relative toxicities (expressed as toxic equivalency factors; TEFs) are as follows (from Van den Berg et al. 2006):

Dioxin Compound	TEF
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
Octachlorodibenzo-p-dioxin	0.0003
2,3,7,8-Tetrachlorodibenzofuran	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.03
2,3,4,7,8-Pentachlorodibenzofuran	0.3
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1

TCDD-TEq equals the sum of the individual compound concentrations multiplied by their respective TEF. Concentrations of specific dioxins in soil and sediment are included in Tables C-2 and C-3 (Appendix C). Chart 2 shows the distribution of TCDD-TEq in surface soil samples collected at the CRC Site.

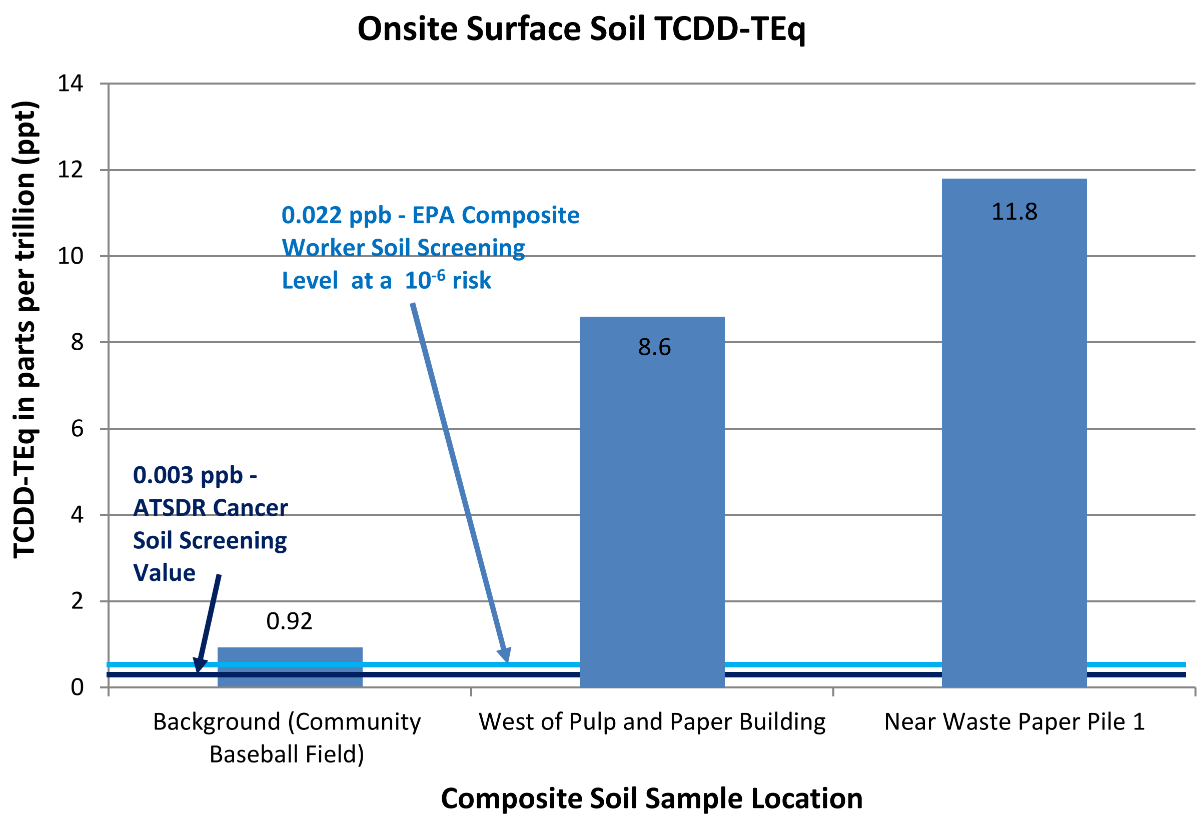


Chart 2. Distribution of dioxin-toxic equivalents (TCDD-TEq) in samples collected at the CRC Site. TCDD-TEq are reported in parts per billion (ppb).

Dioxins, and specifically 2,3,7,8-TCDD, can be harmful to your health. Many studies have looked at how dioxins can affect human health. Most of these studies examined workers exposed during the manufacture of chemicals and pesticides contaminated with 2,3,7,8-TCDD. (ATSDR 1998).

2,3,7,8-TCDD has been the most extensively studied dioxin, shown to cause a significant adverse health effects in animals. Some difficulties will arise in using animal data to quantify health effects in people. In general, the doses used in the animal studies result in body burdens that are at least 10 times higher than human background body burdens; often, the animal studies use doses that are more than 1,000 times higher than human background levels.

The results of the oral animal studies suggest that the most sensitive non-cancer effects (effects that will occur at the lowest doses) are immune, endocrine, and developmental effects. These effects will, reasonably, also be the most sensitive effects in humans. The MRL for TCDD-TEq is $1x10^{-9}$ mg/kg/day and is based on behavioral and developmental effects in rhesus monkeys

(ATSDR 1998). The lowest dose at which these health effects were observed was $1.2x10^{-7}$ mg/kg/day. The MRL is about 100 times lower than the lowest observed dose effect to account for extrapolation of dose effects from animals to humans and other experimental considerations (ATSDR 1998).

Exposure to 2,3,7,8-TCDD can cause reproductive damage and birth defects in animals. Decreases in fertility, altered levels of sex hormones, reduced production of sperm, and increased rates of miscarriages were found in animals exposed to 2,3,7,8-TCDD in food. Rats and mice that were exposed to small amounts of 2,3,7,8-TCDD in food for a long time developed cancer of the liver and thyroid, and other types of cancer. The cancer slope factor for 2,3,7,8-TCDD is currently under review by the EPA. The California Office of Environmental Health Hazard Assessment has established an oral cancer slope factor of 130,000 ($mg/kg/day^{-1}$) for 2,3,7,8-TCDD (http://www.oehha.ca.gov/tcdb/index.asp).

TCDD is classified by EPA as a probable human carcinogen. The World Health Organization (WHO) has determined that TCDD is a human carcinogen (ATSDR 1998). DHHS has determined that TCDD may reasonably be anticipated to cause cancer (ATSDR 1998). Both non-cancer and cancer health effects to trespassers are unlikely because of the amount of time they would be on the site. Based on both the ATSDR comparison values and EPA RSLs, if trespassers were exposed to the waste piles or any other areas containing wastes with elevated TCCD-TEq levels, a small increased risk for both non-cancer and cancer health effects might occur. However, the increased health effects risk depends on the type and length of time of exposure.

Site Health Effects and Calculated Potential Exposure Doses

Soil

As shown in Tables C-1, C-2, and C-3 (Appendix C), CRC Site soils are contaminated with several chemicals, including arsenic, BaP-, and TCDD-TEq. The concentrations of these chemicals exceed local background and respective health-based ATSDR and EPA comparison values. This section of the public health assessment outlines the doses that are the basis for determining whether the levels of these chemicals may harm the health of anyone who would use the site now (e.g., trespassing) or in the future (site redevelopment).

Arsenic

The risk of the onsite arsenic levels was evaluated for ingestion and dermal exposure. The cancer risk was evaluated for both children and adults. The cancer risk was evaluated for a child visiting the site 120 days per year for 21 years. For a dermal exposure, we assumed that the child's torso, hands, arms, and legs would be exposed. The adult cancer risk was evaluated for an adult visiting the site 120 days each year for 57 years. For an adult trespasser, we assumed that their arms, hands, and legs would be exposed.

Table 2 shows the cumulative risk of ingestion and dermal exposure to arsenic in CRC Site soils is within EPA's target risk range of $1x10^{-4}$ (1 excess cancer in 10,000 people) to $1x10^{-6}$ (1 excess cancer in 1 million people). Only slight excess cancer health effects would occur related to ingestion and dermal contact with site surface and subsurface soils containing arsenic at the site. We calculated these cancer risk estimates based on trespassing onto the site for 10 days per month throughout a lifetime. It's unlikely that a person would spend 120 days on the site each year during their entire lifetime. This is a conservative estimation.

Table 2. Calculated excess cancer risk for ingestion and dermal exposure to average Clinch River Corporation (CRC) Site surface and subsurface soil arsenic levels.

	Surface soil exposure		Subsurface soil exposure	
	Ingestion	Dermal	Ingestion	Dermal
Child	$6.0x10^{-5}$	$1.2x10^{-5}$	$3.5x10^{-5}$	$9.9x10^{-6}$
Adult	$3.2x10^{-5}$	$9x10^{-6}$	$1.8x10^{-5}$	$5.2x10^{-6}$
78-year exposure risk	$9.2x10^{-5}$	$2.1x10^{-5}$	$5.3x10^{-5}$	$1.5x10^{-5}$
Cumulative Risk (ingestion plus dermal)	$1.1x10^{-4}$		$6.8x10^{-5}$	

BaP, BaP-TEq and TCDD-TEq

Tables 3a and 3b list the average measured levels of BaP, BaP-TEq and TCDD-TEq in the limited soil sampling completed on the site. The soil sampling was biased toward areas that have been affected by historic manufacturing and disposal activities performed on the site. Thus, the averaged sample concentrations may represent a potential worst-case scenario.

Table 3a lists the estimated child and adult ingestion doses calculated based on the averaged values of BaP, BaP-TEq and TCDD-TEq. The calculated child and adult ingestion exposure doses for these chemicals are small. Table 3b lists the estimated dermal contact doses calculated based on the averaged values of BaP, BaP-TEq and TCDD-TEq. Again, the calculated dermal exposure doses are small.

Table 3c shows the sum of the estimated ingestion and dermal doses. Children and adults trespassing on the site could have an exposure to these soil contaminants through incidental soil ingestion and direct intake through their skin. Appendix D presents exposure parameters and dose calculation procedures used to estimate potential onsite doses. The public health implications of the calculated exposure doses are discussed below. As described previously, soil samples for BaP and dioxins were collected and analyzed from selected onsite areas where previous site activities occurred.

Table 3a. Average soil contaminant of concern concentrations and EEP-calculated ingestion exposure doses. These calculated ingestion doses will be added to the calculated dermal doses to obtain a calculated lifetime doses for these compounds. The lifetime dose will then be compared ATSDR or EPA dose comparison values.

Soil Contaminant	Site Soil Average Concentration	Calculated Exposure Doses[1] Child (mg/kg/day)	Calculated Exposure Doses[1] Adult (mg/kg/day)
BaP	335 ppb	1.8×10^{-5}	1.0×10^{-6}
BaP-TEq	459 ppb	2.4×10^{-5}	1.0×10^{-6}
TCDD-TEq	10.2 ppt	5.3×10^{-9}	1.3×10^{-10}

[1] Doses were calculated using procedures and assumptions described in Appendix D and in units of milligrams (contaminant) per kilogram body weight per day (mg/kg/day).

ATSDR = Agency for Toxic Substances and Disease Registry
BaP = benzo(a)pyrene
BaP-TEq = benzo(a)pyrene toxic equivalents.
EEP = Environmental Epidemiology Program
EPA = Environmental Protection Agency
TCDD-TEq = tetrachlorodibenzo-p-dioxins toxic equivalents.
ppb = parts per billion
ppt = parts per trillion

Table 3b. Average soil contaminant of concern concentrations and EEP-calculated dermal exposure doses. These calculated dermal doses will be added to the calculated ingestion doses to obtain a calculated lifetime doses for these compounds. The lifetime dose will then be compared ATSDR or EPA dose comparison values.

Soil Contaminant	Site Soil Average Concentration	Calculated Exposure Doses[1] Child (mg/kg/day)	Calculated Exposure Doses Adult[1] (mg/kg/day)
BaP	335 ppb	6.8×10^{-7}	1.1×10^{-7}
BaP-TEq	459 ppb	8.7×10^{-7}	1.5×10^{-7}
TCDD-TEq	10.2 ppt	2.0×10^{-11}	3.3×10^{-12}

[1] Doses were calculated using procedures and assumptions described in Appendix D and in units of milligrams (contaminant) per kilogram body weight per day (mg/kg/day).

ATSDR = Agency for Toxic Substances and Disease Registry
BaP = benzo(a)pyrene
BaP-TEq = benzo(a)pyrene toxic equivalents.
EEP = Environmental Epidemiology Program
EPA = Environmental Protection Agency
TCDD-TEq = tetrachlorodibenzo-p-dioxins toxic equivalents.
ppb = parts per billion
ppt = parts per trillion
TCDD MRL for intermediate term exposure (15 to 365 days): 2×10^{-8} mg/kg/day
TCDD MRL for acute term exposure (24 hours to 14 days): 2×10^{-7} mg/kg/day
None of the calculated TCDD-TEq doses are greater than the acute or intermediate MRLs.

Table 3c. Total EEP-calculated soil exposure doses for ingestion and dermal contact. The sum of the ingestion exposure dose and dermal exposure doses for both children and adults was based on average contaminant of concern concentrations. The lifetime dose will then be compared ATSDR or EPA dose comparison values in Table 4.

Soil Contaminant	Site Soil Average Concentration	Sum Total Dose[1] Child (mg/kg/day)	Sum Total Exposure Dose Adult[1] (mg/kg/day)
BaP	335 ppb	1.9×10^{-5}	7.2×10^{-6}
BaP-TEq	459 ppb	2.5×10^{-5}	9.5×10^{-6}
TCDD-TEq	10.2 ppt	5.3×10^{-9}	1.3×10^{-10}

[1] Doses were calculated using procedures and assumptions described in Appendix D and in units of milligrams (contaminant) per kilogram body weight per day (mg/kg/day). Ingestion and dermal doses are added together to estimate total soil exposure dose.

ATSDR = Agency for Toxic Substances and Disease Registry
BaP = benzo(a)pyrene
BaP-TEq = benzo(a)pyrene toxic equivalents
EEP = Environmental Epidemiology Program
EPA = Environmental Protection Agency
TCDD-TEq = tetrachlorodibenzo-p-dioxins toxic equivalents
Procedures and assumptions for calculating TEqs are described in the following section.
ppb = parts per billion
ppt = parts per trillion

Table 4 lists the relevant health comparison values for BaP, Bap-TEq, and TCDD-TEq. Note that BaP and BaP-TEq do not have applicable non-cancer comparison values (MRLs). Because of this, the cancer risk corresponding to a 1 in 10,000 (10^{-4}) risk for developing excess cancer over a 78-year lifetime is used as the benchmark for identifying if BaP or BaP-TEq exposures would correspond to a public health concern (EPA 1991). The comparison value for TCDD-TEq is the chronic or long-term (greater than 365 days) MRL shown in Tables C-2 and C-3 in Appendix C. TCDD also has acute or short-term (24 hours to 14 days) and intermediate (15 days to 365 days) comparison values.

EEP calculated that the estimated excess cancer risks for a 21-year exposure duration as a child and for a 57-year exposure duration as an adult. This was done by summing the exposures for a child and adult over a 78-year period and multiplying by the cancer slope factor for the appropriate compounds. For BaP, the estimated cancer risk is 1.9×10^{-5} over a 78-year lifetime, for coming into contact with soils containing 335 ppb BaP for 120 days per year for a lifetime. For BaP-TEq, the estimated cancer risk is 2.5×10^{-5} for coming into contact with soils containing 459 ppb BaP-TEq over a 78-year lifetime (Table 4). The estimated excess cancer risks for BaP and BaP-TEq are within EPA's target risk level range of 1×10^{-4} to 1×10^{-6} (EPA 1991). Only a slight increased cancer risk would occur for a 78-year, daily constant exposure to soils via trespassing in the areas of the site where the samples were collected. This is a conservative estimation. The real excess cancer risk would likely be much less for children because children would not be trespassing onto the site 120 days each year.

Table 4. Health comparison values for TCDD-TEq and EEP-calculated cancer risks for BaP, BaP-TEq, and TCDD-TEq ingestion and dermal exposures from soil. Cancer risks were calculated based on EEP-calculated soil exposure doses which were multiplied by the chemical-specific cancer slope factor.

	BaP	BaP-TEq	TCDD-TEq
MRL (mg/kg/day)	NA	NA	$1x10^{-9}$ (chronic)
Average soil concentration with dose greater than MRL	NA	NA	10.2 ppt
Cancer slope factor (CSF) in mg/kg/day^{-1}	7.3	7.3	130,000
Maximum cancer risk 21-year ingestion and dermal exposure – child[1] (mg/kg/day)	$1.4x10^{-4}$	$1.8x10^{-4}$	$6.9x10^{-4}$
Maximum cancer risk 57-year ingestion and dermal exposure – adult[2] (mg/kg/day)	$5.3x10^{-5}$	$6.9x10^{-5}$	$1.7x10^{-5}$
Calculated 78-year cancer risk	$1.9x10^{-4}$	$2.5x10^{-4}$	$7.1x10^{-4}$

[1] Child cancer risk was calculated by adding ingestion and dermal doses and multiplying by the specific cancer slope factor.

[2] Adult cancer risk was calculated by adding ingestion and dermal doses and multiplying by the specific cancer slope factor.

ATSDR = Agency for Toxic Substances and Disease Registry
BaP = benzo(a)pyrene
BaP-TEq = benzo(a)pyrene toxic equivalents.
EEP = Environmental Epidemiology Program
EPA = Environmental Protection Agency
TCDD-TEq = tetrachlorodibenzo-p-dioxins toxic equivalents.
mg/kg/day = milligrams per kilogram day
MRL = ATSDR Minimal Risk Level
ppb = parts per billion
ppt = parts per trillion
TCDD MRL for intermediate term exposure (15 to 365 days): $2x10^{-8}$ mg/kg/day
TCDD MRL for acute term exposure (24 hours to 14 days): $2x10^{-7}$ mg/kg/day
None of the calculated TCDD-TEq doses are greater than the acute or intermediate MRLs.
The cancer slope factor for TCDD-TEq is the California Office of Environmental Health Hazard Assessment oral CSF for 2,3,7,8-TCDD
The cancer slope factor for BaP is from the USEPA IRIS Database

For TCDD-TEq, like BaP-TEq, EEP calculated that the estimated excess cancer risks for a 21-year exposure duration as a child and for a 57-year exposure duration as an adult. This was done by summing the exposures for a child and adult over a 78-year period and multiplying by the cancer slope factor for the appropriate compounds. For TCDD-TEq, the estimated cancer risk is $7.1x10^{-4}$, for coming into contact with soils containing 10.2 ppt TCDD-TEq for 120 days over a 78-year lifetime (Table 4). The estimated excess cancer risk for TCDD-TEq is greater than EPA's target risk level range of $1x10^{-4}$ to $1x10^{-6}$ (EPA 1991). A slight increased cancer risk would occur for a 120-day per year, 78-year, exposure to soils via trespassing in the areas of the site where the samples were collected. Again, this is a very conservative estimation. The real excess cancer risk would likely be much less for children because children would not be trespassing onto the site 120 days per year.

Fish

Exposure point concentrations for fish are commonly based on average concentrations (EPA 1995). The maximum concentrations were used because of the limited number of fish analyzed, and maximum concentrations represent a worst-case exposure.

The number of people who consume fish caught from the Emory River in the vicinity of the CRC Site is unknown. For this health assessment, we have assumed that recreational fishermen are those harvesting fish from the vicinity of the CRC Site. The site is unfenced and recreational fishermen trespass across the CRC Site to access the Emory River. Recreational fishermen also can access the areas near the CRC Site from the Emory River in small boats.

For this evaluation, we used a fish consumption report (EPA 2011) to select the fish consumption rates. These rates may be representative of adults and children within the general public who consume average and high amounts of fish. The fish consumption rates reported by EPA are based on data collected from the 2011 edition of EPA's Exposure Factors Handbook. The mean daily average per capita (fish consumers and non-consumers) fish consumption rates of freshwater fish (uncooked) reported for all respondents to a survey conducted on the Clinch River in Tennessee was 38 grams/day. This value was used as the value for adults eating fish caught in the Emory River as both rivers are close to one another. For children, the daily average freshwater per capita fish consumption rate was that reported by EPA of 6 grams/day. These two values were selected to be representative of average fish consumption by the general public. It is unknown if the respondents to the survey ate the fish that are present and available to be consumed in the vicinity of the CRC Site.

An exposure frequency of 350 days per year was assumed for the calculation of the average daily dose. All fish species analyzed may not be caught by recreational fishermen throughout the year. An exposure frequency of 365 days per year was assumed for all fish species because recreational fishermen may catch and freeze fish for later consumption or receive fish for consumption from other recreational fishermen.

The exposure duration is the length of time over which exposure occurs at the measured levels and ingestion rates specified. A specific time over which the general public may be consuming fish from near the CRC Site is unavailable. Therefore, we made estimates of exposure duration for this health assessment.

Child Exposure

A 16-year exposure duration was assumed for calculations of the child average daily intake to assess the potential health risk. We assumed that children ages 0-16 years consumed contaminated fish at the same intake rate. We further assumed that all of the fish consumed were contaminated. Losses of the contaminants by cooking the fish were not assumed in the calculations. Thus, no term denoting the fraction of contaminants lost during cooking was included in the exposure dose calculations. Also, a single value for the contaminant concentration in fish was used to estimate the chronic exposure. The variability in contaminant concentrations in the fish may cause uncertainty in the estimated exposure doses. In addition, some uncertainty exists with exposure duration. Use of an average residence time assumes that children decrease the amount of contaminated fish they eat after 16 years. We also assumed that children would eat one meal of fish each day for 350 days per year. This is likely a very conservative assumption and may overestimate the true exposure and risk.

Adult Exposure

A 62-year exposure duration was assumed for calculations of the adult average daily intake to assess the potential health risk of a lifetime exposure to chemicals detected in fish tissue. The average life expectancy of the general population in the United States is 72 years for males and 79 years for females (USEPA 1997). A value of 78 years was selected as a lifetime exposure duration because this value has been commonly used in other human health assessments throughout the country.

Similar to the child exposure discussed above, we assumed that adults aged 16 to 78 years consumed contaminated fish at the same intake rate. We further assumed that all of the fish consumed were contaminated. Again, losses of the contaminants by cooking the fish were not assumed in the calculations, and no term denoting the fraction of contaminants lost during cooking was included in the exposure dose calculations. Also, a single value for the contaminant concentration in fish was used to estimate the chronic exposure. The variability in contaminant concentrations in the fish may cause uncertainty in the estimated exposure doses. In addition, some uncertainty exists with exposure duration. Adults may move away from the area during the 62-year duration example. To be conservative, we assumed that adults would not move away from the area. We also assumed that adults would eat one meal of fish each day for 350 days per year for 62 years. Again, this may be a conservative assumption and may overestimate the true exposure and risk.

Comparing the estimated exposure doses in Table 5 to ATSDR MRLs, the exposure doses for pentachlorophenol, chromium, copper, and zinc were well below the respective MRLs for these chemicals. The chronic ingestion MRLs for pentachlorophenol is 0.001 mg/kg/day. The chronic ingestion MRL for chromium (as chromium VI) is 0.0009 mg/kg/day. The intermediate ingestion MRL for copper is 0.01 mg/kg/day. Manganese has a chronic reference dose (RfD) of 0.14 mg/kg/day. The chronic ingestion MRL for zinc is 0.3 mg/kg/day. Benzaldehyde has an EPA reference dose (RfD) of 0.1 mg/kg/day. The estimated exposure doses from eating fish with the highest level of benzaldehyde found is much lower than this reference dose. For mercury, ATSDR has a chronic oral MRL of 0.0003 mg/kg/day. The estimated exposure dose from eating fish with the highest level of mercury found is lower than this reference dose. There are no ATSDR ingestion MRLs for aroclor 1260, and 2,3,7,8-dichlorobenzofuran to allow comparison of the estimated exposure doses in Table 5. There is an EPA cancer slope factor for aroclor 1260 of 2.0 mg/kg/day.

TDEC's WPC has a "Precautionary Advisory" level of 0.3 ppm of mercury for consumption of fish by normal healthy people. This advisory suggests that children, pregnant women, or nursing

Table 5. Maximum fish contaminant concentrations in Red ear Sunfish, Largemouth Bass, and Carp (Source: TDEC 2011) and calculated ingestion exposure doses from the concentrations. Table shows exposure doses for child and adult based on child consumption rate of 6 grams per day and adult consumption rate of 38 grams per day. Table also shows EPA or ATSDR health comparison values.

Contaminant	Highest Fish Concentration (mg/kg)	Calculated Exposure Doses[1] Child (mg/kg/day)	Calculated Exposure Doses[2] Adult (mg/kg/day)	Calculated Total Lifetime Dose[3] (mg/kg/day)	EPA Slope Factors
pentachlorophenol	0.0073	1.4×10^{-7}	3.4×10^{-7}	4.8×10^{-7}	1×10^{-3} (mg/kg/day)
benzaldehyde	0.046	9.0×10^{-7}	2.2×10^{-6}	3.1×10^{-6}	1×10^{-1} (mg/kg/day)
aroclor 1260	0.088	1.7×10^{-6}	4.1×10^{-6}	5.8×10^{-6}	2 (mg/kg/day)
chromium	0.064	1.3×10^{-6}	3×10^{-6}	4.3×10^{-6}	9×10^{-4} (mg/kg/day)
copper	1.2	2.4×10^{-5}	5.6×10^{-5}	8×10^{-5}	1×10^{-2} (mg/kg/day)
mercury	0.42	8.3×10^{-6}	2×10^{-5}	2.8×10^{-5}	Precautionary Advisory: 3×10^{-1} ppm; Do Not Consume Advisory: 1 ppm[4]
manganese	2.3	4.5×10^{-5}	1.1×10^{-4}	1.6×10^{-4}	1.4×10^{-1} (mg/kg/day)
zinc	14	2.6×10^{-4}	6.5×10^{-4}	9.1×10^{-4}	$3X10^{-1}$ (mg/kg/day)
2,3,7,8-dichloro-dibenzofuran	6.4×10^{-7}	1.3×10^{-11}	3×10^{-11}	4.3×10^{-11}	EPA cancer screening level of 3.0×10^{-7} mg/kg[5]

[1] Doses are calculated using procedures and assumptions described in Appendix D and in units of milligrams (contaminant) per kilogram body weight per day (mg/kg/day).

[2] Doses are calculated using procedures and assumptions described in Appendix D and in units of milligrams (contaminant) per kilogram body weight per day (mg/kg/day).

[3] Lifetime dose is the sum of the estimated child and adult doses shown in the table.

[4] Mercury Levels in Tennessee Fish, Tennessee Department of Environment and Conservation, Division of Water Pollution Control, May 2007.

[5] EPA screening value for compound.

ATSDR = Agency for Toxic Substances and Disease Registry
EPA = Environmental Protection Agency

CVs = comparison values. These may be ATSDR Minimal Risk Values or EPA Reference Doses, or in the case with mercury, TDEC advisories

mg/kg = milligrams per kilogram
NA = none available

mothers, or persons having previous occupational exposure to mercury should not eat fish containing this amount or more of mercury (TDEC 2007). WPC also has a “Do Not Consume” advisory for fish containing 1.0 ppm of mercury. The advisory states that no persons should eat fish containing 1.0 ppm or more of mercury in any amount (TDEC 2007).

Of these chemicals, only pentachlorophenol and aroclor 1260 have cancer risk comparison values. An explanation of how the cancer risk was calculated for both chemicals follows. The estimated excess cancer risk was calculated for pentachlorophenol using the highest pentachlorophenol measurement in fish. The excess cancer risk over the 16 years was estimated at $1.4x10^{-10}$ for children or about one extra cancer in one billion people. For adults, the excess cancer risk over the 62 years was estimated to be $3.4x10^{-10}$ or about three extra cancers in one billion people. These risk values are much less than EPA’s excess lifetime cancer target risk range of between one extra cancer in 10,000 people to one extra cancer in 1,000,000 people. Therefore, there should not be any risk from eating fish containing these levels of pentachlorophenol.

To calculate the estimated cancer risk from eating fish with the highest amount of aroclor 1260 found, we estimated the excess lifetime cancer risk by multiplying the child and adult doses by the cancer slope factor for aroclor 1260 of 2 mg/kg-day^{-1}. The estimated excess cancer risk was calculated as $3.4x10^{-6}$ for a child or about three extra cancers in 1,000,000. For adults, the calculated excess cancer risk was estimated to be $8.2x10^{-6}$ or about eight extra cancers in 1,000,000. These risk values are within EPA’s target range of risk. However, a slight and very minimal overall excess risk of cancer remains from eating fish with these levels of aroclor 1260.

Groundwater

No one is drinking the water onsite. As outlined in the Dynamac report summarized in TDEC (2011), the homes within a -mile radius from the site have municipal water as their potable water source. There are no known off-site groundwater monitoring wells or residential wells within 1 mile from the site. The site will have institutional controls placed on it outlining groundwater cannot be used. Levels of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene, naphthalene were found above their respective ATSDR comparison values and EPA RSLs.

Other Environmental Considerations

Vapor Intrusion

Although the removal activities recently conducted have been initial steps protective of public health, a land use plan is not adopted for the site. Groundwater has been shown to be impacted at the site by VOCs, SVOCs, and metals. Although the groundwater chemical plume likely travels toward the Emory River and away from nearby homes, groundwater flow direction at the site has not been studied or demonstrated.

No previous soil-gas sampling or indoor air sampling has been done at the site. A soil-gas or indoor air investigation could be done to understand the potential for vapor intrusion fromchemicals off-gassing from the groundwater and migrating into the indoor air of any remaining buildings located on the site that are above any groundwater chemical plume.

Adults and children live in the homes downgradient from the site. Single family and multifamily residences, businesses, and schools are nearby. We recommend that onsite soil-gas or off-site vapor intrusion sampling be conducted to understand if a vapor plume is migrating off-site beneath nearby homes, schools, and businesses.

EEP also determined that vapor intrusion could become an issue onsite if the site were redeveloped. This issue would need careful investigation before any redevelopment occurred. If buildings were constructed on the property, it would be prudent to consider soil-gas sampling prior to construction, and if the potential for vapor intrusion was found, a vapor mitigation system should be incorporated as part of their construction.

Outdoor Air

EEP does not know if community members were harmed in the past by exposure to hazardous air pollutants in outdoor air emitted from the CRC Site or previous site operators. EEP was unaware of any outdoor air testing results available for review.

Off-Site Soil

Whether the CRC Site or other nearby industries have contributed to off-site surface soil contamination is unknown. Contaminants likely were carried from the CRC Site by historic floods and from the intentional release from the 630,000 gallon AST. The only off-site soil sampling done was for establishing background levels of chemicals. EEP recommends further off-site soil sampling to understand if contaminants were carried from the site.

Off-Site Groundwater

No off-site groundwater sampling has been completed in areas surrounding the site.

Onsite Groundwater

Limited onsite groundwater sampling has been completed. To more fully characterize the site, it may be prudent to consider installing and sampling more groundwater sampling points at specific onsite areas. More groundwater monitoring data would allow the potential for vapor intrusion to be assessed.

Asbestos

Most of the buildings remaining onsite were built before 1978 (TDEC 2011). Given the age of the buildings, the buildings likely contain asbestos-containing material in pipe insulation, roofing materials, or sheathing. Only limited testing for removal and waste management purposes has been done before 2014. EPA performed a removal action for asbestos containing material in the former site Turbine building in 2014 (TRC Environmental 2014 and L. Barron, TDEC KFO, personal communication, October 24, 2014). EPA has scheduled additional asbestos-containing material removal for early 2016. Whether the buildings are structurally safe for reuse is unknown. The City of Harriman has expressed interest in retaining some of the onsite historical buildings for reuse if the site were redeveloped into a recreational area.

Lead

Because the buildings are many decades old, they likely contain lead-based paint. No plans are currently underway to survey or remove any potential lead-based paint from existing buildings.

Harriman Land Use Plan

The City of Harriman (Industrial Development Board) and the Harriman Housing Authority have developed a City Center Redevelopment and Urban Renewal Plan for downtown redevelopment and revitalization. The plan's boundaries include most of the city core area along both sides of Roane Street or Highway 27 through Harriman. The redevelopment and revitalization area is bounded on the north by Devonia Street, on the east by Crescent Avenue, on the south by Clinton and Trenton Streets, and on the west by Morgan Avenue (KCDC 2010). The CRC Site is not included in this redevelopment plan as it is approximately 0.4 miles southeast of the redevelopment and revitalization area.

Proposed Future Land Use

The City of Harriman has proposed to create a recreation area on the former CRC Site. The City of Harriman's Mayor suggested the area be cleaned up and transformed into a recreation area (Beecken 2013). This recreation area would possibly have a marina and a waterfront area for public use. Once the area is remediated, the City of Harriman has stated they would like to approach the current owners of the CRC property parcels to see if they will sell the land to the City.

Remediation of the site will likely take several years. EPA and TDEC will jointly oversee and manage any remediation that occurs on the site. We are unaware of what remedial options will be contemplated by EPA for the site. It would be prudent for any remediation plan for the CRC Site result in a property that can be reused in a way that protects the public from health effects of legacy chemicals that may remain in soil, groundwater, surface water, river sediments, and fish, and be in accordance with any long-term land use plan.

Construction of a recreational area with a possible marina and waterfront will likely require the excavation and grading of soils as well as the use of heavy machinery. These actions can affect contaminated soil by digging it up, moving it around, or turning it into breathable dust. The conversion of the site to a recreational area needs to include methods to minimize exposure during construction and then during recreational use thereafter.

It may be prudent to consider the frequent flooding of the Emory River during greenway planning. Materials such as asphalt or concrete pavement that will remain in place are better options. Raised areas such as boardwalks for walking trails are an even better option. This option lifts people above the contaminated soils, effectively eliminating exposure pathways. Also, a raised boardwalk would allow flood waters to flow underneath the decking. The use of handrails, decorative fencing, signs, or landscaping would prevent people from wandering off of any hiking trails into areas where pollution may be left in place. Use of interpretive signage and displays can act as educational materials and warnings to the benefit of future greenway users. All of these concepts will require upkeep. A plan for future maintenance and environmental health oversight may be necessary.

This investigation did not uncover enough evidence to dissuade a recreational area. Yet, lingering pollution will require additional investigation and possible removal before a recreational area, marina, or waterfront area can be recommended from an environmental public health perspective. Caution should be used in assuming what contamination has been measured in the few places tested at the CRC Site and applying the results to other areas of the site that have not been investigated.

Additional environmental investigation and discussion should precede the recreational area construction at the site. Overall, protecting public health and ensuring safety needs to be a priority when considering future recreational uses of properties of the CRC Site.

Child Health Considerations

The TDH EEP recognizes there are unique exposure risks concerning children that do not apply to adults. Children are at a greater risk than are adults to certain kinds of exposures to hazardous substances. Because they play outdoors, children are more likely to be exposed to contaminants in the environment. Children are shorter than adults and as a result, they are more likely to breathe in more dust, soil, and heavy vapors that accumulate near the ground. They are also smaller, resulting in higher doses of chemical exposure per body weight. If toxic exposures occur during critical growth stages, the developing body systems of children can sustain permanent damage. Children depend on adults for risk identification and risk management, housing, and access to medical care. Thus, adults should be aware of public health risks in their community, so they can guide their children accordingly. Although there are no children live at the site, child-specific exposure situations and health effects were considered.

Children typically would not come into contact with any onsite soils, groundwater, or air. Children would only come into contact with the onsite soil or air by trespassing. The three main hazards to children trespassing on the site include 1) the physical hazards present; 2) ingestion of contaminants on site soils by hand to mouth behavior; 3) dermal exposure to soil and sediment, 4) contacting onsite surface water; and 5) eating fish having site-related contaminants. The evaluation done by EEP to understand if the levels of chemicals of concern would lead to harmful effects if children ate fish from the Emory River showed that the chemical levels were below those thought to be harmful to children. Children may find open sites as fun places to wander, explore or play. Trespassing by children is likely given the lack of security controls in place and the proximity of many single-family residences to the site. Therefore, children could be exposed to the many physical hazards present.

Conclusions

EEP reached 10 conclusions in this public health assessment for the CRC Site:

1. Physical hazards such as open pits, ponds, building foundations filled with water, the barge loading and unloading platform, and other hazards at the Clinch River Corporation Site could pose a threat to trespassers. These physical hazards pose a public health hazard to those who trespass on the site. Trespassers use the site as a shortcut and as a fishing location. There are open ponds, open pits, former building basements, debris piles, and scattered debris throughout the former manufacturing area of the site. Former site buildings contained asbestos. Building materials have been used to fill in former basements. These materials are unstable. The site is not securely fenced or guarded.

2. Contact with onsite soil currently and in the future could harm people's health. EEP cannot conclude if past exposure to onsite soil could harm people's health.

3. A small increased risk for cancer exists through touching or accidentally eating contaminated sediment near the Probable Point of Entry of surface runoff from the site into the Emory River.

4. Eating fish contaminated with mercury from the Emory River may harm people's health. Eating fish contaminated with copper, zinc, and chromium is not expected to cause adverse health effects.

5. EEP cannot currently conclude whether there is potential for vapor intrusion at the site for new or reused buildings if the site is redeveloped.

6. EEP cannot conclude whether unsampled soil areas at the site could harm people's health.

7. EEP cannot conclude whether former site workers were harmed by exposure to chemicals previously used or generated as a result of past manufacturing operations.

8. Levels of diesel range organic compounds are above Tennessee Water Quality Values, but it is unknown if these levels could harm people using the site. No metals or volatile organic compounds are present in onsite surface water above health screening values.

9. People do not use groundwater as drinking water at the site so it does not pose harm to people's health. Homes, schools and daycares close to the Site are served by municipal water.

10. Protective health measures are prudent if the site is redeveloped. Residential redevelopment would not be advisable once remediation has been completed.

Recommendations

EEP has the following recommendations to protect public health based on the conclusions:

1. Property owners secure the property and post warning signs to prevent trespassing or injury. This would prevent contact with site physical hazards.

2. TDEC ensure that sufficient contingencies be provided in the final cleanup plan to protect workers on the site should it be redeveloped. We also recommend establishing institutional controls and precautions for future recreator and worker safety, and site redevelopment.

3. Responsible parties post signs along the Emory River to avoid contact with river sediment. It is unknown if remediation of the sediment will be performed.

4. Responsible parties implement engineering controls to prevent trespassing and to discourage fishing in the Emory River from the site.

5. Responsible parties or the EPA conduct soil-gas or vapor intrusion sampling to understand if this pathway could cause exposure if the site were to be redeveloped.

6. More surface soil sampling is recommended to be done by the responsible party or EPA to understand the distribution of chemicals in the surface soils and if there are higher levels in unsampled areas of the site.

7. Responsible parties or EPA implement engineering and institutional controls to prevent trespassing on the site and to prevent the use of groundwater on the site if it is redeveloped.

Public Health Action Plan

The public health action plan for the CRC Site contains a list of actions that have been or will be taken by EEP and other agencies. The public health action plan is designed to mitigate and prevent harmful health effects that result from breathing hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that TDH EEP has taken include the following.

1. Reviewed numerous reports summarizing activities performed and environmental data collected from this site.

2. Prepared this health consultation based on the previous environmental investigations conducted on the CRC Site.

Public health actions that EEP will take include:

1. Attending future public meetings to improve the understanding of the community and other stakeholders in the environmental regulatory process and in the improvements in the environment of the CRC Site as a result of the regulatory process.

2. Providing copies of this Public Health Assessment to federal, state, and local government.

3. Providing health education to all interested parties for the public health hazards associated with the site that may result in increased risks or harmful health effects such as the pervasive physical hazards on the site and with potential sediment contact.

4. Maintaining dialogue with TDEC, ATSDR, EPA, other government agencies, and interested stakeholders to safeguard public health in the community of Harriman near the site.

5. Reviewing additional future environmental data and provide interpretation of the data, as requested.

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Glossary of Terms and Acronyms

acute exposure: Contact with a substance that occurs once or for only a short time (up to 14 days).

adverse health effect: A change in body function or cell structure that might lead to disease or health problems.

AST: above ground storage tank

ATSDR: federal Agency for Toxic Substances and Disease Registry

background level: An average or expected amount of a substance in a specific environment, or typical amounts of substances that occur naturally in an environment.

cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as $1x10^{-6}$ for one excess cancer in 1 million people.

Cancer Risk Evaluation Guide (CREG): CREGs are environmental media (water, soil, air) specific comparison values that are used to identify amounts of cancer-causing substances that are unlikely to result in an increase of cancer rates in people that have been exposed to the media.

chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

comparison value (CV): Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

concentration: The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

contaminant: A substance that is either present in an environment where it does not belong.

CRC: Clinch River Corporation

detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

dioxin: Unwanted chemical byproducts of incineration and some industrial processes that use chlorine. Dioxins can accumulate in fish and wildlife and are suspected human carcinogens. Dioxins are man-made chemical compounds.

discharge: Flow of surface water in a stream or canal or the outflow of ground water from a flowing artesian well, ditch, or spring. A discharge can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

DoR: Tennessee Department of Environment and Conservation's (TDEC) Division of Remediation

DNAPL: A DNAPL is one of a group of organic substances that are relatively insoluble in water and more dense than water. DNAPLs tend to sink vertically through aquifers to an underlying, impenetrable layer.

EEP: Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP)

effluent: A liquid discharged as waste such as contaminated water from a factory or the outflow from a sewage works.

Environmental Media Evaluation Guide (EMEG): EMEGs represent levels of substances in water, soil, and air, to which humans may be exposed during a specified amount of time (acute, intermediate, or chronic) without experiencing adverse health effects.

EPA: United States Environmental Protection Agency

Epidemiology: The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).

exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1. a source of contamination (such as an abandoned business), 2. an environmental media and transport mechanism (such as movement through ground water), 3. a point of exposure (such as a private well), 4. a route of exposure (eating, drinking, breathing, or touching), and 5. a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

groundwater: Water beneath the Earth's surface in the spaces between soil particles and between rock surfaces.

hazard: A source of potential harm from past, current, or future exposures.

health education: Programs designed with a community to help it know about health risks and how to reduce these risks.

inhalation: The act of breathing. A hazardous substance can enter the body this way.

intermediate exposure: Contact with a substance that occurs for more than 14 days and less than one year.

migration: Chemical movement from one location to another.

Minimal Risk Level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

National Pollutant Discharge Elimination System (NPDES): A permit issued by the U.S. EPA or a State regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water. The typical permit also includes a compliance schedule for achieving those limits. NPDES permit program is authorized by the Clean Water Act and works to control water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits for any discharge into waters of the United States.

Polycyclic Aromatic Hydrocarbons (PAHs): PAHs are a group of organic contaminants that form from the incomplete combustion of hydrocarbons, such as coal and gasoline. They are relatively insoluble in water and can be found in potable waters and wastewaters. PAHs are an environmental concern because they are toxic to aquatic life and because several are suspected human carcinogens.

ppb: parts per billion

ppm: parts per million

ppt: parts per trillion

Public Health Assessment (PHA): An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health.

public meeting: A public forum with community members for communication about a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA): This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

release: A release is defined as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing (including the abandonment or discarding of barrels, containers and other closed receptacles containing any hazardous substance, pollutant, or contaminant) into the to the air water or land.

remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site.

Remedial Investigation (RI): The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process of determining the type and extent of hazardous material contamination at a site.

risk: The probability that something will cause injury or harm. For non-carcinogen health effects, it is evaluated by comparing an exposure level over a period to a reference dose derived from experiments on animals. For carcinogenic health effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime (70 years) as a result of exposure to a potential carcinogen.

route of exposure: The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

sample: A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population. An environmental sample, such as a small amount of soil or water, might be collected to measure contamination in the environment at a specific location.

Semivolatile Organic Compound (SVOCs): A general term for organic compounds that volatilize relatively slowly at a standard temperature (20^{o}C or 68^{o}F) and normal atmospheric pressure (1 atmosphere).

soil-gas: Gaseous elements and compounds in the small spaces between particles of earth and soil. Such gases can be moved or driven out under pressure.

solvent: A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

source area: The location of or the zone of highest soil or ground water concentrations, or both, of the chemical of concern. The source of contamination is the first part of an exposure pathway.

surface water: Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs.

TDEC: Tennessee Department of Environment and Conservation

TDH: Tennessee Department of Health

TDHE: Tennessee Department of Health and Environment (before the establishment of separate agencies for the environment [TDEC] and health [TDH])

TEq: Toxicity Equivalency factor: The TEq expresses the toxicity of dioxins, furans and polychlorinated biphenyls (PCBs) in terms of the most toxic form of dioxin, 2,3,7,8-TCDD. The toxicity of the individual congeners of dioxins, furans, and PCBs may vary by orders of magnitude

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

volatile organic compounds (VOCs): Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, dichloroethylene, toluene, trichloroethylene, methylene chloride, methyl chloroform, and vinyl chloride.

Appendix A. Environmental Investigation History of the CRC Site

Environmental Sampling Phases and Results

Environmental sampling at the CRC Site has been ongoing since at least 1984. Surface soil, subsurface soil, groundwater, surface water, sediment, and fish have been sampled in several sampling events conducted by TDEC, USACE, and EPA contractors. The environmental sampling events are summarized below.

TDHE 1984 Investigation

In 1984, the Tennessee Department of Health and the Environment (TDHE) performed a toxicity study to understand if contaminants in the process discharge water could be acutely harmful to aquatic life. Process water discharge samples were collected and phenols were found in the discharged water at levels that could harm aquatic life.

TDHE 1991 Site Inspection

In 1991, TDHE sampled surface soil, surface water, and sediment during a Site Inspection. Metals were found in site soil and sediment and included chromium, copper, lead, manganese, mercury, nickel, and zinc.

Halliburton NUS 1993 Investigation

In 1993, Halliburton NUS sampled surface soil, subsurface soil, and sediment for the EPA as part of an Expanded Site Investigation. Various polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds, and the metals, cadmium, chromium, copper, lead, manganese, mercury, nickel, and zinc, were found in the samples.

TDEC 1994 Field Investigation

In 1994, TDEC's Division of Superfund initiated a Preliminary Assessment, Site Inspection and Expanded Site Investigation. The investigation included installation and sampling of shallow groundwater wells. Onsite soil and river sediment was sampled. Some metals such as arsenic, beryllium, cadmium, copper, lead, nickel, selenium, and cyanide were found in elevated concentrations. It is unknown in what media the metals were found. SVOCs found in site media included elevated levels of 2-chlorophenol, 4-nitrophenol, p-chloro-m-cresol, phenol, and pentachlorophenol. The black liquor ponds were sampled during these investigations. Organic chemicals identified in the sampling of the ponds included aldrin, benzene, cyanide, methylene chloride, methyl ethyl ketone, naphthalene, and toluene. These investigations documented the onsite contamination. Off-site migration could not be determined at the time (TDEC 2012a). Since the measured concentrations of onsite chemicals was excessive, the site was recommended for further consideration and placed on the CERCLIS - No Further Remedial Action Planned (NFRAP) list (Halliburton NUS 1994).

Shaw 2005 Phase 1 Environmental Site Assessment

In 2005, Shaw Environmental performed a Phase 1 Environmental Site Assessment (ESA) for the CRC Site. No samples of site media were collected or analyzed. During site reconnaissance activities, 106 damaged, leaking, or open containers including 104 55-gallon drums and two 250-gallon totes containing various oily liquids were observed in and around the chipper shed. The oily liquids were suspected to contain lubricant oils, white paper and black paper liquor waste, water, and other waste. Notable dark staining was observed in the area near the leaking containers (Shaw 2005). Erosion of the concrete surface near Waste Paper Pile 1 revealed layers of dark staining in the soils underneath the concrete surface. This area of concrete erosion and staining borders the Emory River and is prone to flooding. In addition, distressed vegetation was observed near Waste Paper Pile 1, a sign of chemicals being released to the ground. Shaw recommended a Phase 2 ESA.

USACE 2005 Targeted Brownfield Assessment (TBA) Phase 2 Field Investigation

In 2005, the USACE collected a background surface soil composite sample, three composite surface soil samples adjacent to Waste Paper Pile 3, and two composite surface soil samples near the western wall of the steam generation and turbine building. All composite surface soil samples were collected at a depth of 0 to 1 foot below ground surface (bgs).

In addition, a grab, near-shore sediment sample was collected from the Emory River. Numerous PAHs and other semi-volatiles were detected (USACE 2005). Benzo(a)pyrene (BaP) was the only analyte detected exceeding EPA's residential soil Preliminary Remedial Goals (PRGs). BaP was detected at an estimated concentration of 130 micrograms per kilogram (µg/kg) compared to EPA's industrial soil Regional Screening Level (RSL) of 210 µg/kg.

TDEC 2009 Field Investigation

In 2009, TDEC sampled a total of 13 locations. These samples consisted of: one groundwater sample obtained from a production well onsite; two surface water and five sediment samples from the shoreline adjacent to the site; and five surface soil samples from other locations on the site. Additionally, a background sample was collected for each media (TDEC 2009). Sample locations are shown on Figure A-1.

<u>Groundwater</u>
Measurable concentrations of chloromethane and several metals were found within the single onsite groundwater well. Chloromethane was estimated to be 0.38 parts per billion (ppb), well below the EPA tap water regional screening level of 19 ppb. Comparison to tap water screening levels is a very conservative comparison since this site will likely not be developed into a residential development. Metals found within the well included arsenic, barium, cadmium, chromium, cobalt, copper, manganese, nickel, vanadium, and zinc. Arsenic was estimated at 0.43 ppb exceeding the 0.045 ppb EPA regional screening level. It should be noted the pH and conductivity were elevated at 10.18 pH units and 1,251 µS/cm, respectively (TDEC 2009). It is unknown why the pH of the well water was elevated. The elevated pH may be related to the spent black liquor that has been found in groundwater across the site. Spent black liquor reportedly is corrosive, having a pH that ranges from 11.5 to 13.5 (EPA 2003).

<u>Surface Water</u>
Octachlorodibenzodioxin (OCDD) was observed in two of three surface water samples collected at an estimated value of 0.018 parts per trillion (ppt). The two samples where OCDD was noted were the background location 3,000 feet upstream in the Emory River near a community baseball

Figure A-1. TDEC 2009 Sample Locations. Source: TDEC 2009 field and in the sample furthest downstream, collected downstream of the CRC Site loading dock terminal on the Emory River. The levels and locations of the detections suggest OCDD may be site-related (TDEC 2009).

Organic analyses showed measurable concentrations of (m- and/or p-)xylene, 1,2,4-trimethylbenzene, benzene, chloromethane, ethylbenzene, o-xylene, and toluene in the surface water. Low levels of 1,2,4-trimethylbenzene, benzene, and chloromethane were more than three times their respective background concentration and may be attributable to the site. No organic constituent exceeded its respective EPA tap water regional screening level (TDEC 2009).

Sediment

Most congeners of dioxins and furans were observed in all sediment samples taken in the Emory River. Many were three times the background concentrations. Lab analysis (Appendix A - Table 1) showed the majority of the constituents were qualified. 1,2,3,4,6,7,8-heptachlorodibenzodioxin, 1,2,3,4,6,7,8-heptachlorodibenzofuran, octachlorodibenzodioxin, and octachlorodibenzofuran results were not qualified for one sample, a pipe sediment sample. Toxicity Equivalence Factors (TEF) for these congeners are 0.1, 0.01, 0.001, and 0.0001, respectively.

Based on the elevated concentration and high TEF for 1,2,3,4,6,7,8-heptachlorodibenzodioxin, TDEC (2009) assumed the estimated TEq for TCDD in mammals of 1.5 ppt for this pipe sediment sample is acceptable. The TEq for this sample exceeds EPA's Mid-Atlantic Sediment Screening Level of 0.85 ppt (EPA 2013c).

Multiple organic compounds were found in every sediment sample collected. Site samples contained acetone, carbon disulfide, methyl ethyl ketone, methylcyclohexane, toluene, pisopropyltoluene, DDE, DDD, DDT, 1,1-biphenyl, dibenzofuran, 2,4-dimethylphenol, 2-methylnaphthalene, 3- and 4-methylphenol, and naphthalene. The levels of these chemicals all exceeded three times their background concentrations. DDE, DDT, 2-methylnaphthalene, and naphthalene were found at concentrations exceeding their respective EPA soil screening levels. Naphthalene and 2-methylnaphthalene were found at levels above ATSDR screening levels. These four chemicals are likely attributable to site activities.

Several metals were found within the sediment samples. Arsenic, cadmium, calcium, chromium, copper, manganese, and vanadium were found at concentrations exceeding three times their respective background sample levels. The background sediment sample was collected along the Emory River approximately 3,000-feet upgradient of the CRC Site at a community baseball field. According to TDEC (2009), no metals were found to exceed EPA's Mid-Atlantic screening levels.

Surface Soil

Similar to the sediment results, multiple dioxins and furans were observed in the surface soil samples at the background location and onsite. All onsite samples exceeded three times their respective background levels. Lab-calculated mammalian toxicity equivalent quantities for TCDD ranged from 1 ppt at the northern waste paper collection area to 130 ppt at the drum storage area. Background soil TCDD TEq was reported as 2.0 ppt. All onsite surface soil samples, except one, exceeded EPA's industrial regional screening level of 18 ppt. Numerous organic compounds were detected in all of the surface soil samples and included 1,2,4-trimethylbenzene, acetone, methyl butyl ketone, methyl ethyl ketone, tetrachloroethylene, aroclor 1254, aroclor 1242, and several PAH's. Some of these compounds were observed in the background sample; however, concentrations measured in onsite soils were more than three times background concentrations. Aroclor 1252, aroclor 1242, benzo(a)pyrene, and bis(2-ethyl hexyl)phthalate exceeded their EPA regional screening levels for industrial soils in the sample collected inside the mill. Aroclor 1254 was found to exceed its EPA regional screening level in the sample collected at the drum storage area.

Metal analysis of the surface soils show elevated concentrations of several metals. Antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, iron, lead, magnesium, nickel, silver, sodium, and zinc were three times higher than their respective background concentrations. Arsenic was the only metal found at levels exceeding its EPA regional screening level of 1.6 parts per million (ppm). Arsenic ranged from 0.16 ppm at the western waste pile area to 45 ppm inside the mill. Regional levels of arsenic in the surface soil are elevated and typically average 10 ppm (Kopp, 2001).

TDEC 2010 Field Investigation

The TDEC 2010 field investigation focused on sampling game fish from the adjacent Emory River. The Emory River (Watts Bar Reservoir) is used for recreational and subsistence fishing, and recreational activities such as boating and swimming (ETRVG 2012, EPA 2012a).

A separate fish consumption advisory for mercury is currently in effect for the Emory River. However, this advisory is for upstream of river mile 12.4 which is located upstream from the CRC property at approximately river mile 11.5 (TWRA 2012). There are no advisories at the CRC Site.

There are active, observed hazardous substance releases continuing from the CRC Site to the Emory River (TDEC 2011). According to the U.S. Fish and Wildlife Service (USFWS), TDEC, and TWRA, the Emory River is fished in the vicinity of the CRC property, which receives runoff from Source No. 1. The fish are consumed (TDEC 2011, EPA 2012a). During the 2009 and 2010 TDEC sampling events, several fishermen were observed fishing on the Emory River (TDEC 2011). The types of fish caught and consumed from the Emory River include catfish, crappie (black, blacknose, and white), and bass (largemouth, rock, smallmouth, striped, spotted, white, and yellow), bluegill, red ear, and redbreast (TDEC 2011).

During the field investigation, the Tennessee Wildlife Resources Agency (TWRA) collected a total of 32 fish at three locations downstream of the site. TWRA employed a pulsed DC electrofishing boat using 5 amps at 120 pulses per second for a total of 3,400 seconds of effort to obtain the species. The fish were weighed, measured, and filleted prior to being frozen and sent to the lab for analysis. The fish were four largemouth bass, 25 sunfish, and three carp. Sampling efforts were concentrated primarily on the western side of the Emory River immediately downstream of the facility where impacted surface water run-off would likely be entering the surface water pathway. The sampling was done to understand the potential for exposure to recreational fishermen who fish near the site and their families who may consume the fish caught.

A fish tissue sample was not collected upstream of the CRC property. Analytical data from the fish tissue samples were compared to average concentrations from the Watts Bar Reservoir, obtained from a biological database maintained by TDEC's Division of Water Pollution Control (TDEC 2011).

Fish fillet samples were frozen overnight and packed on ice in coolers for shipment. The fillets were shipped to Mitkem Corporation of Warwick, Rhode Island. Both flanks from each of the four largemouth bass were sent and were treated as four separate samples. Fillets were homogenized by Mitkem for each sample. The 25 sunfish that were collected were divided into three composite samples. Fillets from each fish were grouped into the three samples. The fillets from each group were then homogenized by Mitkem. Both flanks from each of the three carp were sent to the lab and treated as three separate samples. Similar to what was done for the largemouth bass, the carp fillets were homogenized by Mitkem for each sample. Mitkem analyzed the homogenized fillet samples for semivolatiles, pesticides, PCBs, metals, dioxins/furans, and percent moisture/lipids. The USEPA Region IV SESD Laboratory Analytical Support Branch in Athens, Georgia completed a final quality assurance and quality control procedure before releasing the data in November and December 2010.

The fish tissue samples contained polychlorinated biphenyls (aroclor 1260), dioxins (e.g. 2,3,7,8-tetrachlorodibenzofuran), pentachlorophenol, benzaldehyde, chromium, copper, and zinc.

EPA Contractor 2011 Field Investigation

In August 2011, Oneida Total Integrated Enterprises (OTIE), a contractor for EPA, conducted an assessment of the leaking drums in the drum storage area and of the 630,000-gallon AST located on parcel 003.01 (EPA 2012a). Field testing indicated that the drums contained liquid acids, liquid and solid bases, flammable liquids, and natural liquids (EPA 2011, OTIE 2012). Approximately 20 cubic yards of spilled material were observed in the drum storage area. In September 2011, EPA initiated an emergency removal action to stabilize the leaking drums located in the drum storage area. The drums were stabilized and disposed of in February 2012 (Tetra Tech 2012a, OTIE 2012). Stained surface soil directly surrounding the drums located in the drum storage area was reportedly removed. No other areas on the CRC Site were excavated (Tetra Tech 2012c). It is unknown what if any impact the leaking drums may have had on site groundwater.

EPA Contractor 2012 Field Investigation

In February 2012, OTIE managed removal activities, including removing all drums and containers, excavating an underground storage tank (UST), collecting surface and subsurface soil samples, and advancing borings to install temporary monitoring wells (OTIE 2012b). The UST, located southeast of the former paper and pulp mill building, contained approximately 38,500 gallons of black liquor. Once the UST was removed, black liquor and associated sludge were observed in the tank pit. This material was also removed. During removal of the black liquid and sludge in the tank pit, about six inches of water containing black liquor was noted seeping into the excavated tank pit. This suggests groundwater in the vicinity of the pit contains black liquor and is a possible indicator of remaining acute hazards.

OTIE performed additional surface soil, subsurface soil, and groundwater sampling activities in February 2012. Surface soil samples were collected from 14 locations throughout the CRC Site. Specifically, samples were collected near Waste Paper Pile 1, north and southeast of the former mill building, near the chipper shed, near the black liquor pond, near Waste Paper Pile 2, and in the wooded area of parcel 003.01 (Tetra Tech 2012d). Samples were collected using both direct-push drilling and hand auger methods. Samples were collected from various depths from ground surface to five feet bgs. Samples were analyzed for VOCs, SVOCs, and total metals. Five of the fourteen samples were analyzed for dioxins.

Subsurface soil samples were collected from nine soil borings. The soil borings were installed using direct-push drilling methods. Fourteen soil samples from depths ranging from 2 to 25 feet bgs were collected from these borings. The soil samples were analyzed for VOCs, SVOCs, and total metals. Only one subsurface soil sample was analyzed for dioxins.

A soil boring was advanced through the concrete at the former location of the "coal tar" pond to a depth of 35 feet bgs. Black liquor was observed in the boring.

Temporary groundwater monitoring wells were installed in five of the nine soil borings. The monitoring wells were constructed of one-inch diameter polyvinyl chloride (PVC). The temporary wells were used to evaluate groundwater quality below the site. After collecting groundwater samples from the wells, they were properly abandoned according to State well abandonment regulations. Samples from the wells were tested for VOCs, SVOCs, and total metals. Groundwater samples had exceedances above their maximum contaminant level (MCL) screening values for arsenic, barium, and lead. No VOCs or SVOCs were measured in concentrations above MCLs.

EPA Contractor 2012 Field Investigation

OTIE oversaw drum and liquids removal activities, collection of surface and subsurface soil samples, and the installation of temporary groundwater monitoring wells in February 2012 (Figure A-2). A total of 63 drums containing unknown liquids were sampled, profiled, and consolidated into totes. The consolidated liquids were properly disposed. Samples of both solid and liquid wastes were taken. An underground storage tank (UST) containing black liquor was also excavated and removed.

Results indicated the presence of several VOCs, SVOCs, metals, and dioxins in surface and subsurface soil samples. No VOC or dioxin compounds were detected above comparison values. SVOCs detected above comparison values in surface soil samples included benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene. Arsenic was the only metal present at levels above comparison values in surface soil samples. Benzo(a)pyrene was found in one subsurface soil sample above its comparison values. The surface and subsurface soil samples contained PAHs and arsenic. More specifically, benz(a)anthracene was detected up to 2,300 micrograms per kilogram (µg/kg); benzo(a)pyrene was detected up to 2,000 µg/kg; benzo(b)fluoranthene was detected at 2,200 µg/kg; dibenzo(a,h)anthracene was detected up to 440 µg/kg; and arsenic was detected at 54 mg/kg (OTIE 2012b).

Temporary groundwater monitoring well results showed that the depth to water was approximately 6 to 15 bgs. Several chemicals were found in groundwater, including the metals arsenic, barium, and lead. SVOCs found in groundwater included sporadic detections of 2-methylnaphthalene, benzo(g,h,i)perylene, and naphthalene. One temporary monitoring well had detections of all SVOC parameters analyzed. This temporary monitoring well was located between the large 630,000-gallon AST and the Emory River. Benzo(a)pyrene was measured at a concentration of 0.17 milligrams per liter (µg/L), just below its industrial RSL of 0.2 µg/L. The detections of PAHs in this temporary well suggest contamination migrating in groundwater from the AST. Arsenic, barium, and lead were measured above their comparison values at only one temporary groundwater monitoring well.

Site Surface Water Sampling – February 2014

A total of seven samples of water were collected onsite from three separate pits or areas where precipitation and potentially groundwater had accumulated. Samples 1 and 2 were collected from the mixed liquor pit. Samples 3 and 4 were collected from the former paper mill building basement. Samples 5 and 6 were collected below the former stock chest area. Sample R-1 was a mixed liquor pit resample.

Samples 1 through 6 were analyzed for conventional pollutants (ammonia, phosphorus, chemical and biological oxygen demand, total dissolved solids, total suspended solids, chloride, nitrate and nitrite), total and dissolved metals, VOCs, SVOCs, PCBs, pesticides, herbicides, and both gasoline and DRO petroleum hydrocarbons . Sample R-1 was analyzed for only SVOCs.

Samples 1 and 2 from the mixed liquor pit had levels of the metals barium, calcium, iron, magnesium, manganese, and sodium. The only organic compounds identified in the two samples were C12-C40 (diesel range) petroleum hydrocarbons.

Samples 3 and 4 from the former paper mill basement contained the metals barium, copper, iron, magnesium, manganese, sodium, and zinc. Low levels of toluene were found. Diesel range petroleum hydrocarbons were also found in the two samples.

Samples 5 and 6 from below the former stock chest had the metals barium, copper, iron, magnesium, manganese, sodium, and zinc. The only organic compounds identified in the two samples were C12-C40 DRO.

TRC Engineering Evaluation and Cost Analysis (EE/CA) – 2015

Based on previous results, additional sediment and groundwater samples were collected in May and June 2015, respectively. Three surface soil samples were also collected off-site in May 2015 to augment information on background constituent levels. Following the NTCRA, up to eight confirmatory surface soil samples were collected and analyzed.

On March 10, 2015, a pipe reconnaissance was conducted of the left bank of the Emory River near the site (TRC, 2015a). The purpose of this reconnaissance was to identify the location of pipes on the riverbank related to former mill operations (*i.e.,* those related to Parcel 003.00, Figure 2). The pipes were described and locations noted. Also, an evaluation was completed to

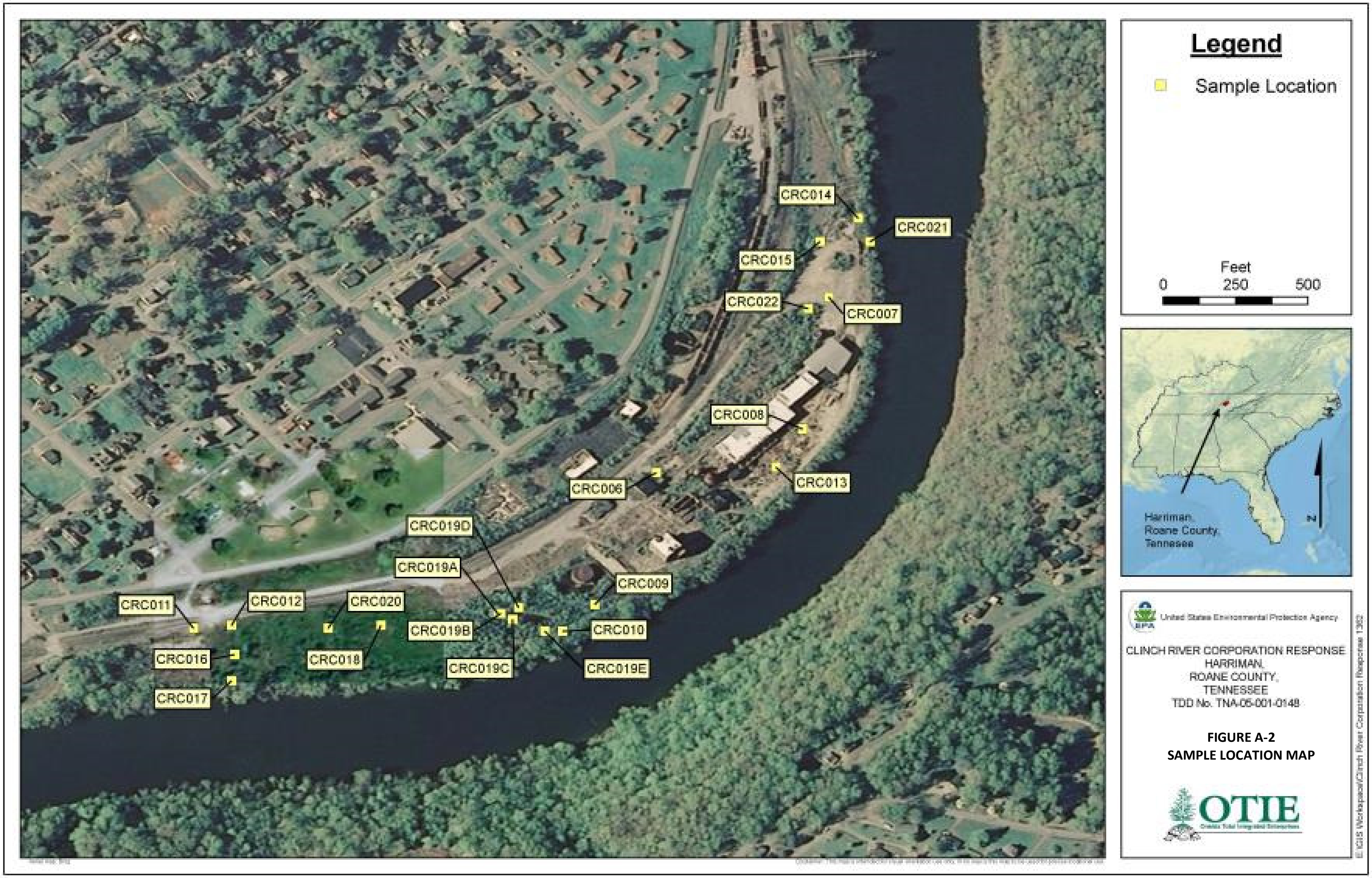

Figure A-2. Surface, subsurface, and groundwater sampling locations for OTIE (EPA) 2012 site investigation. Source: OTIE 2012.

determine if any of the pipes were active and if collecting sediment samples adjacent to these pipes was needed.

During the 2015 survey, five areas were noted where pipes were present on the riverbank near the Site (TRC, 2015). Five sediment samples were collected near the site. On May 20, 2015, USEPA (2015) requested that an additional sixth sediment sample (*i.e.,* SD-07) be collected near the downstream end of the site. This additional sample was added to the May 27, 2015 field work.

On May 27, 2015, TRC collected sediment samples from seven locations with a petite ponar dredge (6-inch by 6-inch sampling area) lowered from a boat. The recovered sediment was gently mixed on a clean aluminum cookie sheet. This homogenized sediment was then transferred into the sampling containers with a clean metal spoon. The filled sampling containers were placed into a cooler containing ice.

TRC collected background surface soil samples in May 2015 west of the site at a riverside park and the nearby soccer complex. These samples are intended to represent background conditions for the Site.

Based on the recently completed soil borings, the upper 5.5 to 10 feet of material at the site consists of gravel, wood fragments, and soil apparently buried by sand following a historical high-flow event in the Emory River. In the southern portion of the site the soil borings for Monitoring Wells GW-02 and GW-03 are underlain by clay or silty clay. In the northern portion of the Site, alluvial sands are present in the soil borings for Monitoring Wells GW-04 and GW-05. The occurrence of sand deposits in the northern portion of the site is consistent with previous descriptions for work completed in 1990. TDHE (1991) indicated that this sand was deposited on the site during high flow in the Emory River.

Groundwater samples were collected from four monitoring wells installed on site and two background wells installed off-site. Geologic information was obtained from soil boings used to install the monitoring wells. Samples were collected from 5 of the wells using low-flow purging and sampling techniques. For monitoring well GW-05, only a small amount of turbid groundwater could be developed and purged from this well, and may be the result of the drilling process. With EPA's concurrence, the first recovered groundwater in the well was sampled using a disposable bailer. Results from Monitoring Well GW-02 indicated that arsenic in the groundwater sample was slightly above the Maximum Contaminant Level (MCL) for public water supply.

Following installation, development, and purging of Monitoring Well GW-05, the June 2015 groundwater sample continued to exhibit elevated turbidity. An unfiltered sample of this groundwater was collected using a disposable bailer and submitted to the WRK Laboratory for analysis. With USEPA's concurrence, a filtered sample of this groundwater was also collected and submitted to the WRK Laboratory for analysis of inorganic constituents. Four inorganic constituents (*i.e.,* arsenic, beryllium, chromium, and lead) in the unfiltered sample from Monitoring Well GW-05 were above their respective MCLs. The inorganic constituents in the filtered samples were all less than MCLs. Five volatile organic compounds (VOCs) (*i.e.,* benzene, carbon disulfide, chloroform, methyl ethyl ketone [MEK], and methylene chloride) were below their respective MCLs (TRC 2015).

Wells GW-02 and GW-05 were resampled in December 2015 using a low-flow sampling method approved by EPA. The goal was to gently purge the wells until the turbidity was less than 10 nephelometric turbidity units (NTUs). Final turbidities at the time of sampling were 8.5 NTU for well GW-02 and 13 NTU for well GW-05. Arsenic levels decreased in both wells for the event. All other metals and VOCs detected in the June sampling event were non-detect for the December sampling event (TRC 2016).

Appendix B. Site Photographs ─ March 11, 2013

Photo 1 - Clinch River Corporation (CRC) Site conditions, March 2013. Photo shows the former 630,000 gallon AST and remaining buildings at the site. View looking northeast. (Photo credit: Brad Parman, 03/11/13).

Photo 2 - Another view of site looking to the northeast. Note dilapidated former site buildings and piles of material in the distance. (Photo credit: Brad Parman, 03/11/13).

Photo 3 – Closer view of 630,000-gallon AST at the site. The landowner removed this tank in September 2014. Concrete retaining wall and drive at the left center of photo is being undermined by the Emory River. (Photo credit: Brad Parman, 03/11/13).

Photo 4 - Debris from demolished buildings in the northeastern portion of the site. (Photo credit: Brad Parman, 03/11/13).

Photo 5 - Unused piping and valve with former spent liquor pond; some of the physical hazards present. The pond is unfenced. Debris is also located in the pond. (Photo credit: Brad Parman, 03/11/13).

Photo 6 - Unknown structure with void adjacent to Emory River at site. Another physical hazard, which is unfenced along the river's edge. (Photo credit: Brad Parman, 03/11/13).

Photo 7 – Former walkway for a barge loading and unloading structure extending out over the Emory River. This physical hazard is unfenced and is open for trespassing. (Photo credit: Brad Parman, 03/11/13).

Photo 8 - Open former hydraulic oil underground storage tank (UST), one of the several open pits across the former manufacturing area of the site. Note the extensive piping and valves within the UST. The UST access is uncovered. (Photo credit: Brad Parman, 03/11/13).

Photo 9 – One of several waste paper rolls that are present across the site. (Photo credit: Brad Parman, 03/11/13).

Photo 10 - Abandoned site building and scattered debris. (Photo credit: Brad Parman, 03/11/13).

Photo 11 - Open former building basement filled with dark colored water. Note debris from demolished site buildings. Concrete retaining wall for site and trees on riverbank can be seen in background. This area is easy to access. (Photo credit: Brad Parman, 03/11/13).

Photo 12 - Site of former soil removal. Note former building basement at edge of concrete cover in background. (Photo credit: Brad Parman, 03/11/13).

Appendix C. Media Sampling Results ─ Onsite and Off-Site

Table C-1. Chemicals found in surface soil during the U.S. Army Corps of Engineers (USACE) investigation of Source No. 1. All units are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 1 foot depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Off-Site Background Surface Soil Sample								
Composite surface soil sample from the community center								
SS-CECB-A9-39-00-01	chromium	34.7	630*	ngv	350*	6.3*	23*	0.3*
	copper	22.2	7,000i	nc	4,700	nc	310	nc
	manganese	836	35,000+	nc	2,600	nc	180	nc
	mercury	0.37	1,400@	nc	35	nc	2.3	nc
	silver	<1.2	3,500+	nc	580	nc	39	nc
Onsite Surface Soil Samples								
Composite surface soil samples collected next to Waste Paper Pile 3								
SS-CRCB-A2-03-00-01	chromium	988	630*	ngv	350*	6.3*	23*	0.3*
	copper	131	7,000i	nc	4,700	nc	310	nc
	manganese	9,400	35,000+	nc	2,600	nc	180	nc
	silver	18.6	3,500+	nc	580	nc	39	nc
SS-CRCB-A2-05-00-01	silver	9.3	3,500+	nc	580	nc	39	nc
SS-CRCB-A2-34-00-01	copper	122	7,000i	nc	4,700	nc	310	nc

Table C-1 continued. Chemicals found in surface soil during the U.S. Army Corps of Engineers (USACE) investigation of Source No. 1. All units are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 1 foot depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Composite surface soil samples near the western wall of steam generation and turbine building								
SS-CRCB-A4-26-00-01	copper	126	7,000i	nc	4,700	nc	310	nc
	mercury	1.4	1,400@	nc	35	nc	2.3	nc
SS-CRCB-A4-27-00-01	copper	131	7,000i	nc	4,700	nc	310	nc

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

mg/kg – milligrams per kilogram, equivalent to parts per million in soil

SS = surface soil sample, A# = area number, 00-01 = 0 to 1 foot below ground surface

<1.2 = chemical not found in sample above its method detection limit

ngv = no guidance value available

nc = chemical has not been classified as to human carcinogenicity

+ = ATSDR RMEG used as there was no Chronic EMEG available for the chemical

i = ATSDR intermediate exposure duration (15 to 364 days) EMEG used; Chronic EMEG unavailable

* = ATSDR EMEG and EPA RSLs for Hexavalent Chromium used; ATSDR Chronic EMEG and EPA RSL for Cr^{+4} unavailable

@ = ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

Table C-2. Chemicals found in surface soil during the Tennessee Department of Environment and Conservation's (TDEC) site reassessment in 2009. All semi-volatile organic compounds, dioxin compounds, and metals are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 2 inch depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: TDEC 2009.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Off-Site Background Surface Soil Samples								
Composite surface soil sample from a community baseball field								
CR08 0709SF	Semi-volatile organic compounds							
	anthracene	<0.0038	15,000+	nc	23,000	nc	1,700	nc
	benz(a)anthracene	0.0073	ngv	ngv	ngv	2.9	ngv	0.15
	benzo(a)pyrene	0.0066	ngv	0.096	ngv	0.29	ngv	0.015
	benzo(k)fluoranthene	0.0042	ngv	ngv	ngv	29	ngv	1.5
	carbozole	<0.0038	ngv	ngv	ngv	ngv	ngv	ngv
	chrysene	0.0089	ngv	ngv	ngv	290	ngv	15
	dibenzo(a,h)anthracene	<0.0038	ngv	ngv	ngv	0.29	ngv	0.015
	fluoranthene	0.012	2,000+	nc	3,000	nc	230	nc
	flourene	<0.0038	2,000+	nc	3,000	nc	230	nc
	indeno(1,2,3-cd)pyrene	<0.0038	ngv	ngv	ngv	2.9	ngv	0.15
	2-methylnaphthalene	0.017	2,000	nc	300	nc	23	nc
	naphthalene	0.011	1,000+	nc	17	59	13	3.8
	phenanthrene	0.011	ngv	nc	ngv	nc	ngv	nc
	pyrene	0.011	1,500+	nc	2,300	nc	170	nc
	Dioxin compounds							
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	$5.2x10^{-5}$	ngv	ngv	ngv	$4.7x10^{-4\#}$	ngv	$1.0x10^{-4\#}$

Table C-2. Chemicals found in surface soil during the Tennessee Department of Environment and Conservation's (TDEC) site reassessment in 2009. All semi-volatile organic compounds, dioxin compounds, and metals are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 2 inch depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: TDEC 2009.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
CR08 0709SF	1,2,3,4,6,7,8-heptachlorodibenzofuran	$6.6x10^{-6}$	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	$5.7x10^{-7}$ J	ngv	ngv	ngv	$4.7x10^{-4\#}$	ngv	$1.0x10^{-4\#}$
	1,2,3,6,7,8-hexachlorodibenzodioxin	$1.4x10^{-6}$ J	ngv	ngv	ngv	$4.7x10^{-4\#}$	ngv	$1.0x10^{-4\#}$
	1,2,3,7,8,9-hexachlorodibenzodioxin	$1.4x10^{-6}$ J	ngv	ngv	ngv	$4.7x10^{-4\#}$	ngv	$1.0x10^{-4\#}$
	Metals							
	cadmium	0.052 J	70	ngv	80	9,300	7	2,100
	chromium	15	630*	ngv	350*	6.3*	23*	0.3*
	copper	12	7,000i	nc	4,700	nc	310	nc
	lead	30	ngv	ngv	800	ngv	400	ngv
	mercury	<0.11	1,400@	nc	35	nc	2.3	nc
	nickel	8.7	1,000+	ngv	1,100^	69,000^	82	16,000^
	zinc	50	210,000	nc	35,000	nc	2,300	nc
Onsite Surface Soil Samples								
Composite surface soil sample west of former pulp and paper mill building near Waste Paper Pile 3								
CR09 0709SF	Semi-volatile organic compounds							
	benz(a)anthracene	0.100	ngv	ngv	ngv	2.9	ngv	0.15
	benzo(a)pyrene	0.110	ngv	0.096	ngv	0.29	ngv	0.015

Table C-2. Chemicals found in surface soil during the Tennessee Department of Environment and Conservation's (TDEC) site reassessment in 2009. All semi-volatile organic compounds, dioxin compounds, and metals are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 2 inch depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: TDEC 2009.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
	benzo(k)fluoranthene	0.110	ngv	ngv	ngv	29	ngv	1.5
	carbozole	0.037	ngv	ngv	ngv	ngv	ngv	ngv
	chrysene	0.140	ngv	ngv	ngv	290	ngv	15
	dibenzo(a,h)anthracene	0.026J	ngv	ngv	ngv	0.29	ngv	0.015
	fluoranthene	0.140	2,000[+]	nc	3,000	nc	230	nc
	flourene	0.0052	2,000[+]	nc	3,000	nc	230	nc
	indeno(1,2,3-cd)pyrene	0.083	ngv	ngv	ngv	2.9	ngv	0.15
	2-methylnaphthalene	0.110	200	nc	220	nc	23	nc
	naphthalene	0.084	1,000[+]	nc	17	59	13	3.8
	phenanthrene	0.094	ngv	nc	ngv	nc	ngv	nc
	pyrene	0.150	1,500[+]	nc	1,700	nc	170	nc
CR09 0709SF	Dioxin compounds							
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	7.1×10^{-4}	ngv	ngv	ngv	4.7×10^{-4}[#]	ngv	1.0×10^{-4}[#]
	1,2,3,4,6,7,8-heptachlorodibenzofuran	1.5×10^{-4}	ngv	ngv	ngv	ngv	ngv	ngv
	Metals							
	copper	45	7,000i	nc	4,700	nc	310	nc
	lead	290	ngv	ngv	800	ngv	400	ngv
	mercury	0.37	1,400[@]	nc	35	nc	2.3	nc

Table C-2. Chemicals found in surface soil during the Tennessee Department of Environment and Conservation's (TDEC) site reassessment in 2009. All semi-volatile organic compounds, dioxin compounds, and metals are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 2 inch depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: TDEC 2009.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
	zinc	760	210,000	nc	35,000	nc	2,300	nc
Composite surface soil sample near Waste Paper Pile 1								
CR13 0709SF	Semi-volatile organic compounds							
	anthracene	0.290J	15,000+	ngv	23,000	nc	1,700	nc
	benz(a)anthracene	0.530	ngv	ngv	ngv	2.9	ngv	0.15
	benzo(a)pyrene	0.560	ngv	0.096	ngv	0.29	ngv	0.015
	benzo(k)fluoranthene	0.780	ngv	ngv	ngv	29	ngv	1.5
	carbozole	0.068	ngv	ngv	ngv	Ngv	ngv	ngv
	chrysene	0.800	ngv	ngv	ngv	290	ngv	15
	dibenzo(a,h)anthracene	0.098	ngv	ngv	ngv	0.29	ngv	0.015
	fluoranthene	0.730	2,000+	nc	3,000	nc	230	nc
	flourene	0.025	2,000+	nc	3,000	nc	230	nc
	indeno(1,2,3-cd)pyrene	0.330	ngv	ngv	ngv	2.9	ngv	0.15
	2-methylnaphthalene	0.520	200	nc	220	nc	23	nc
	naphthalene	0.270	1,000+	nc	17	59	13	3.8
	phenanthrene	0.210	ngv	nc	ngv	nc	ngv	nc
	pyrene	0.780	1,500+	nc	1,700	nc	170	nc
	Dioxin compounds							
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	$1x10^{-3}$	ngv	ngv	ngv	$4.7x10^{-4\#}$	ngv	$1.0x10^{-4\#}$

Table C-2. Chemicals found in surface soil during the Tennessee Department of Environment and Conservation's (TDEC) site reassessment in 2009. All semi-volatile organic compounds, dioxin compounds, and metals are reported in milligrams per kilogram (mg/kg). All samples were collected from the 0 to 2 inch depth interval and were composite samples. Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: TDEC 2009.

Sample ID	Chemical	Concentration (mg/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
	1,2,3,4,6,7,8-heptachlorodibenzofuran	1.8×10^{-4}	ngv	ngv	ngv	ngv	ngv	ngv
	Metals							
	copper	57	7,000i	nc	4,700	nc	310	nc
	zinc	160	210,000	nc	35,000	nc	2,300	nc

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2012). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2012. Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs are for exposure to an onsite worker. Residential RSLs are for a lifetime exposure to a resident

mg/kg – milligrams per kilogram, equivalent to parts per million in soil

SF = surface soil sample, A# = area number, 00-01 = 0 to 1 foot below ground surface (Ref. 11, p. 13)

J = estimated concentration. Chemical was found at concentrations below the reported method detection level.

ngv = No guidance value available

nc = chemical has not been classified as to human carcinogenicity

$^{+}$ = ATSDR RMEG for child used as there was no Chronic EMEG available for the chemical

i = ATSDR intermediate exposure duration (15 to 364 days) EMEG used; Chronic EMEG unavailable

* = ATSDR EMEG for Hexavalent Chromium used; ATSDR Chronic EMEG for Cr^{+4} unavailable

$^{\wedge}$ = EPA comparison values for nickel are nickel refinery dust screening levels

$^{\#}$ = EPA hexachlorobenzo-p-dioxin mixture RSL used as surrogate for various hexachlorobenzo-p-dioxin isomers

$^{@}$ = ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EME unavailable.

Table C-3. Dioxins and furans found in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil								
CRC-SB-002A	tetrachlorodibenzodioxin (T)	1 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	1.4 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	3 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	2.4 J	240,000	ngv	ngv	ngv	ngv	ngv
	2,3,4,6,7,8-hexachlorodibenzofuran	0.63 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8,9-hexachlorodibenzodioxin	1.3 J	6	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzofuran	0.39 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzodioxin	2.1 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzofuran	0.39 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	0.75 J	ngv	ngv	ngv	ngv	ngv	ngv
	hexachlorodibenzodioxin (T)	18 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	14 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	96	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8,9-heptachlorodibenzofuran	1.7 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	18 J	ngv	ngv	ngv	ngv	ngv	ngv
	heptachlorodibenzodioxin (T)	180 J	ngv	ngv	1,600	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-002A	heptachlorodibenzofuran (T)	73 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	1900	ngv	ngv	53,000	ngv	ngv	ngv
	octachlorodibenzofuran	110	ngv	ngv	38,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	1.7 J	ngv	ngv	ngv	ngv	ngv	ngv
CRC-SB-005A	2,3,7,8,-tetrachlorodibenzofuran	0.48 J	ngv	ngv	110	ngv	ngv	ngv
	tetrachlorodibenzodioxin (T)	6.4 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	6.5 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	8.3 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	5.4 J	240,000	ngv	ngv	ngv	ngv	ngv
	2,3,4,6,7,8-hexachlorodibenzofuran	0.64 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8,9-hexachlorodibenzodioxin	1.2 J	6	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzofuran	0.46 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzodioxin	1.4 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzofuran	0.58 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	0.84 J	ngv	ngv	ngv	ngv	ngv	ngv
	hexachlorodibenzodioxin (T)	20 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	9.5 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	41	ngv	ngv	ngv	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-005A	1,2,3,4,6,7,8-heptachlorodibenzofuran	8 J	ngv	ngv	ngv	ngv	ngv	ngv
	heptachlorodibenzodioxin (T)	82 J	ngv	ngv	1,600	ngv	ngv	ngv
	heptachlorodibenzofuran (T)	25 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	410	ngv	ngv	53,000	ngv	ngv	ngv
	octachlorodibenzofuran	28	ngv	ngv	38,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	1.6 J	ngv	ngv	ngv	ngv	ngv	ngv
CRC-SB-013	2,3,7,8,-tetrachlorodibenzofuran	0.89 J	ngv	ngv	110	ngv	ngv	ngv
	tetrachlorodibenzodioxin (T)	7.8 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	9.6 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8-pentachlorodibenzodioxin	0.48 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	6.7 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	8.2 J	240,000	ngv	ngv	ngv	ngv	ngv
	2,3,4,6,7,8-hexachlorodibenzofuran	1.2 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8,9-hexachlorodibenzodioxin	1.6 J	6	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzofuran	1.2 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzodioxin	3 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzofuran	1.5 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	0.69 J	ngv	ngv	ngv	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-013	hexachlorodibenzodioxin (T)	23 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	18 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	78	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	1.9 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	17 J	ngv	ngv	ngv	ngv	ngv	ngv
	heptachlorodibenzodioxin (T)	150 J	ngv	ngv	1,600	ngv	ngv	ngv
	heptachlorodibenzofuran (T)	63 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	800	ngv	ngv	53,000	ngv	ngv	ngv
	octachlorodibenzofuran	94	ngv	ngv	38,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	2.3 J	ngv	ngv	ngv	ngv	ngv	ngv
CRC-SB-014	2,3,7,8,-tetrachlorodibenzofuran	0.62 J	ngv	ngv	110	ngv	ngv	ngv
	2,3,7,8,-tetrachlorodibenzodioxin	0.3 J	ngv	ngv	18	ngv	ngv	ngv
	tetrachlorodibenzodioxin (T)	4.4 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	9 J	ngv	ngv	ngv	ngv	ngv	ngv
	2,3,4,7,8-pentachlorodibenzofuran	0.75 J	ngv	ngv	38	ngv	ngv	ngv
	1,2,3,7,8-pentachlorodibenzodioxin	2.1 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	12 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	17 J	240,000	ngv	Ngv	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-014	2,3,4,6,7,8-hexachlorodibenzofuran	3.2 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8,9-hexachlorodibenzodioxin	6.4	6	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzofuran	2 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzodioxin	9.4	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzofuran	1.6 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	3.3 J	ngv	ngv	ngv	ngv	ngv	ngv
	hexachlorodibenzodioxin (T)	72 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	75 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,7,8,9-heptachlorodibenzodioxin	280	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	4.7 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	70 J	ngv	ngv	ngv	ngv	ngv	ngv
	heptachlorodibenzodioxin (T)	510 J	ngv	ngv	1,600	ngv	ngv	ngv
	heptachlorodibenzofuran (T)	240 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	2,300	ngv	ngv	53,000	ngv	ngv	ngv
	octachlorodibenzofuran	330	ngv	ngv	38,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	6.6 J	ngv	ngv	ngv	ngv	ngv	ngv
CRC-SB-014D	2,3,7,8,-tetrachlorodibenzofuran	0.62 J	ngv	ngv	110	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-014D	2,3,7,8,-tetrachlorodibenzodioxin	0.26 J	ngv	ngv	18	ngv	ngv	ngv
	tetrachlorodibenzodioxin (T)	4.7 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	8.5 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8-pentachlorodibenzofuran	1.6 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	10 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	14 J	240,000	ngv	ngv	ngv	ngv	ngv
	2,3,4,6,7,8-hexachlorodibenzofuran	2.4 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,7,8,9-hexachlorodibenzodioxin	4.1 J	6	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzofuran	1.6 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,6,7,8-hexachlorodibenzodioxin	6.5	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzofuran	1.5 J	ngv	ngv	ngv	ngv	ngv	ngv
	1,2,3,4,7,8-hexachlorodibenzodioxin	2.4 J	ngv	ngv	Ngv	ngv	ngv	ngv
	hexachlorodibenzodioxin (T)	52 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	55 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	210	ngv	ngv	Ngv	ngv	ngv	ngv
	1,2,3,4,7,8,9-heptachlorodibenzofuran	3.3	ngv	ngv	Ngv	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzofuran	56 J	ngv	ngv	Ngv	ngv	ngv	ngv

Table C-3 continued. Dioxins and furans found in surface soil in surface soil during the 2012 OTIE Removal Assessment. All units are reported in nanograms per kilogram (ng/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), and EPA industrial soil cancer regional screening levels (RSLs). Source: USACE 2006.

Sample ID	Chemical	Concentration (ng/kg)	ATSDR Adult EMEG (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA Industrial RSL (non-cancer)	EPA Industrial RSL (cancer)	EPA Residential RSL (non-cancer)	EPA Residential RSL (cancer)
Surface Soil continued								
CRC-SB-014D	heptachlorodibenzodioxin (T)	400 J	ngv	ngv	1,600	ngv	ngv	ngv
	heptachlorodibenzofuran (T)	190 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	2,000	ngv	ngv	53,000	ngv	ngv	ngv
	octachlorodibenzofuran	260	ngv	ngv	38,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	5.1 J	ngv	ngv	ngv	ngv	ngv	ngv
Subsurface Soil								
CRC-SB-013	tetrachlorodibenzodioxin (T)	0.24 J	ngv	ngv	ngv	ngv	ngv	ngv
	tetrachlorodibenzofuran (T)	0.87 J	ngv	ngv	ngv	ngv	ngv	ngv
	pentachlorodibenzodioxin (T)	0.43 J	ngv	ngv	16	ngv	ngv	ngv
	pentachlorodibenzofuran (T)	0.055 J	240,000	ngv	ngv	ngv	ngv	ngv
	hexachlorodibenzodioxin (T)	4.1 J	ngv	ngv	160	ngv	ngv	ngv
	hexachlorodibenzofuran (T)	0.046 J	ngv	ngv	110	ngv	ngv	ngv
	1,2,3,4,6,7,8-heptachlorodibenzodioxin	5 J	ngv	ngv	ngv	ngv	ngv	ngv
	heptachlorodibenzodioxin (T)	18 J	ngv	ngv	1,600	ngv	ngv	ngv
	heptachlorodibenzofuran (T)	0.26 J	ngv	ngv	1,100	ngv	ngv	ngv
	octachlorodibenzodioxin	210	ngv	ngv	53,000	ngv	ngv	ngv
	TEQ (Fish, WHO TEQ-98	0.33 J	ngv	ngv	ngv	ngv	ngv	ngv

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

ng/kg = nanograms per kilogram, equivalent to parts per trillion in soil

(T) = total

ngv = no guidance value available

J = estimated concentration of chemical

Table C-4. Semivolatile Organic Compounds (SVOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-001A Surface Soil	CRC-SB-001B Subsurface Soil	CRC-SB-002A Surface Soil	CRC-SB-002A Subsurface Soil	CRC-SB-002BD Subsurface Soil	CRC-SB-003A Subsurface Soil
2-methylnaphthalene	32,000,000	2,300,000	ngv	4,100,000	94	<3.9	7.5	<4	<4	39
acenaphthene	48,000,000	3,400,000	ngv	33,000,000	<3.7	<3.9	<3.9	<4	<4	<3.9
acenaphthylene	ngv	ngv	ngv	ngv	12	<3.9	5.6	<4	<4	5.8
anthracene	240,000,000	17,000,000	ngv	170,000,000	14	<3.9	3.6 J	<4	<4	<3.9
benzo(a)anthracene	ngv	ngv	ngv	2,100	62	<3.9	11	<4	<4	8.5
benzo(a)pyrene	ngv	ngv	16	210	39	5.7	11	<4	<4	16
benzo(b)fluoranthene	ngv	ngv	ngv	2,100	48	<3.9 J	12 J	<4 J	<4 J	15 J
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	37	<3.9	11	8.2	4.2	23
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	45	<3.9 J	5.3 J	<4 J	<4 J	5.2 J
chrysene	ngv	ngv	ngv	210,000	110	<3.9	8.9	<4	<4	13
dibenzo(a,h)anthracene	ngv	ngv	ngv	210	27	4.8	5	4.5	<4	10
fluoranthene	32,000,000	2,300,000	ngv	22,000,000	91	4.8	11	<4	<4	4.6
fluorine	48,000,000	3,400,000	ngv	22,000,000	6.6	<3.9	<3.9	<4	<4	<3.9
indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	37	6.4	10	6.9	<4	18
naphthalene	16,000,000	1,100,000	ngv	20,000	43	<3.9	5.3	<4	<4	21
phenanthrene	ngv	ngv	ngv	ngv	130	<3.9	5.5	<4	<4	14
pyrene	24,000,000	1,700,000	ngv	17,000,000	100	<3.9	15	<4	<4	12

Table C-4 continued. Semivolatile Organic Compounds (SVOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-004A Surface Soil	CRC-SB-004B Subsurface Soil	CRC-SB-005A Surface Soil	CRC-SB-005B Subsurface Soil	CRC-SB-006A Surface Soil	CRC-SB-006B Subsurface Soil
2-methylnaphthalene	32,000,000	2,300,000	ngv	4,100,000	250	22	36	50	45	<3.9
acenaphthene	48,000,000	3,400,000	ngv	33,000,000	22	13	<3.8	<3.5	4.4 J	<3.9
acenaphthylene	ngv	ngv	ngv	ngv	61	20	34	6.2	15	9.1
anthracene	240,000,000	17,000,000	ngv	170,000,000	54	69	59	9.1	18	<3.9
benzo(a)anthracene	ngv	ngv	ngv	2,100	95	160	280	43	58	6
benzo(a)pyrene	ngv	ngv	16	210	90	110	230	36	36	23
benzo(b)fluoranthene	ngv	ngv	ngv	2,100	73	98	230 J	39	39	19 J
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	72	82	100	30	30	39
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	83	110	280	33 J	41 J	7.9 J
chrysene	ngv	ngv	ngv	210,000	150	200	370	55	73	7.3
dibenzo(a,h)anthracene	ngv	ngv	ngv	210	38	39	45	19	28	9.9
fluoranthene	32,000,000	2,300,000	ngv	22,000,000	140	440	530	74	100	<3.9
fluorine	48,000,000	3,400,000	ngv	22,000,000	23	19	<3.8	4	4.8	<3.9
indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	56	73	93	25	25	22
naphthalene	16,000,000	1,100,000	ngv	20,000	450	15	20	21	25	<3.9
phenanthrene	ngv	ngv	ngv	ngv	170	310	190	49	73	<3.9
pyrene	24,000,000	1,700,000	ngv	17,000,000	220	340	380	69	93	7.4

Table C-4 continued. Semivolatile Organic Compounds (SVOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-006BD Subsurface Soil	CRC-SB-007A Surface Soil	CRC-SB-008A Subsurface Soil	CRC-SB-008B Subsurface Soil	CRC-SB-009A Surface Soil	CRC-SB-009B Subsurface Soil
2-methylnaphthalene	32,000,000	2,300,000	ngv	4,100,000	<4	<4.3	31	38	270	55
acenaphthene	48,000,000	3,400,000	ngv	33,000,000	<4	<4.3	<4.3	<3.9	7.3	<4.1
acenaphthylene	ngv	ngv	ngv	ngv	<4	<4.3	4.7	5.3	160	3.9 J
anthracene	240,000,000	17,000,000	ngv	170,000,000	<4	<4.3	4 J	4	100	5.3
benzo(a)anthracene	ngv	ngv	ngv	2,100	<4	12	31	26	250	18
benzo(a)pyrene	ngv	ngv	16	210	140 J	11	27	24	260	19
benzo(b)fluoranthene	ngv	ngv	ngv	2,100	120 J	19	29	33 J	260	19
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	190 J	15	26	27	130	19
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	120 J	7.9 J	28	15 J	260	16
chrysene	ngv	ngv	ngv	210,000	<4	9.9	69	26	260	24
dibenzo(a,h)anthracene	ngv	ngv	ngv	210	<4	6.7	13	9.1	48	5.4
fluoranthene	32,000,000	2,300,000	ngv	22,000,000	<4	7.6	120	56	270	35
fluorine	48,000,000	3,400,000	ngv	22,000,000	<4	<4.3	<4.3	<3.9	5.5	<4.1
indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	180 J	14	35	23	110	14
naphthalene	16,000,000	1,100,000	ngv	20,000	<4	<4.3	15	22	230	32
phenanthrene	ngv	ngv	ngv	ngv	<4	<4.3	95	57	210	34
pyrene	24,000,000	1,700,000	ngv	17,000,000	<4	8.7	120	52	430	36

Table C-4 continued. Semivolatile Organic Compounds (SVOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-010A Subsurface Soil	CRC-SB-011 Surface Soil	CRC-SB-012 Surface Soil	CRC-SB-013 Surface Soil	CRC-SB-014 Surface Soil	CRC-SB-014D Surface Soil
2-methylnaphthalene	32,000,000	2,300,000	ngv	4,100,000	5.9	17	200	26	6	<5.1
acenaphthene	48,000,000	3,400,000	ngv	33,000,000	<4	<6.5	570	<5.1	<4.6	<5.1
acenaphthylene	ngv	ngv	ngv	ngv	<4	<6.5	350	<5.1	19	12
anthracene	240,000,000	17,000,000	ngv	170,000,000	<4	<6.5	1,300	<5.1	9.4	6.1
benzo(a)anthracene	ngv	ngv	ngv	2,100	3.3 J	6 J	2,300	17	100	42
benzo(a)pyrene	ngv	ngv	16	210	<4	6.8	2,000	12	120	46
benzo(b)fluoranthene	ngv	ngv	ngv	2,100	<4	6 J	2,200	12	140	78
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	5.5	10	1,300	16 J	77 J	32
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	<4	<6.5	1,600	10	110	46
chrysene	ngv	ngv	ngv	210,000	4.3	7.2	2,200	16	100	43
dibenzo(a,h)anthracene	ngv	ngv	ngv	210	<4	<6.5	440	<5.3	27 J	12 J
fluoranthene	32,000,000	2,300,000	ngv	22,000,000	<4	9.9	6,300	8.7	120	49
fluorine	48,000,000	3,400,000	ngv	22,000,000	<4	<6.5	640	<5.1	<4.6	<5.1
indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	3.7 J	<6.5	1,300	13 J	77 J	30
naphthalene	16,000,000	1,100,000	ngv	20,000	3.8 J	12	150	15	<4.6	<5.1
phenanthrene	ngv	ngv	ngv	ngv	3.6 J	13	7,100	11	7.3	5.4
pyrene	24,000,000	1,700,000	ngv	17,000,000	5.8	15	5,600	12	150	82

Table C-4 continued. Semivolatile Organic Compounds (SVOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs). Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-015 Subsurface Soil	CRC-SB-016 Surface Soil	CRC-SB-017 Surface Soil
2-methylnaphthalene	32,000,000	2,300,000	ngv	4,100,000	10	7.5	16
acenaphthene	48,000,000	3,400,000	ngv	33,000,000	<5.5	<4.2	<4.3
acenaphthylene	ngv	ngv	ngv	ngv	120	5.6	5
anthracene	240,000,000	17,000,000	ngv	170,000,000	120	5.1	5.7
benzo(a)anthracene	ngv	ngv	ngv	2,100	320	33	20
benzo(a)pyrene	ngv	ngv	16	210	250	31	21
benzo(b)fluoranthene	ngv	ngv	ngv	2,100	220	29	27
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	180 J	21	24 J
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	260	29	22
chrysene	ngv	ngv	ngv	210,000	330	34	26
dibenzo(a,h)anthracene	ngv	ngv	ngv	210	65 J	8.1	8.2 J
fluoranthene	32,000,000	2,300,000	ngv	22,000,000	170	69	30
fluorine	48,000,000	3,400,000	ngv	22,000,000	<5.5	<4.2	<4.3
indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	160 J	20	18 J
naphthalene	16,000,000	1,100,000	ngv	20,000	6.7	4.5	10
phenanthrene	ngv	ngv	ngv	ngv	29	16	17
pyrene	24,000,000	1,700,000	ngv	17,000,000	260	55	32

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

µg/kg = micrograms per kilogram, equivalent to parts per billion in soil

ngv = no guidance value available

j = estimated concentration of chemical

Table C-5. Total metals found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-001A Surface Soil	CRC-SB-001B Subsurface Soil	CRC-SB-002A Surface Soil	CRC-SB-002B Subsurface Soil	CRC-SB-002BD Subsurface Soil	CRC-SB-003A Subsurface Soil
mercury	24	1.7	ngv	28	0.22	<0.12	0.02 J	0.036 J	0.24 J	<0.12
arsenic	240	17	0.25	1.6	36	3.4	2.6	5	3.7	2.7
barium	160,000	11,000	ngv	190,000	260	19 J	97	130	160	84
cadmium	80	5.7	ngv	ngv	0.75 J	<0.58	<0.58	<0.61	<0.61	<0.57
cadmium	80	5.7	ngv	810	0.75 J	<0.58	<0.58	<0.61	<0.61	<0.57
chromium	720	51	ngv	ngv	12	7.6	21	7.6	7.4	4.7
lead	ngv	ngv	ngv	ngv	34	5.2	8.9	9	9.9	7.6
selenium	4,000	290	ngv	5,100	2.5 J	<4.1	<4	<4.2	<4.2	<4

Table C-5 continued. Total metals found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in milligrams per kilogram (mg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-004A Surface Soil	CRC-SB-004B Subsurface Soil	CRC-SB-005A Surface Soil	CRC-SB-005B Subsurface Soil	CRC-SB-006A Surface Soil	CRC-SB-006B Subsurface Soil
mercury	24	1.7	ngv	28	<0.12	<0.11	0.39	0.25	0.06 J	0.036 J
arsenic	240	17	0.25	1.6	19	2.6	22	13	9.8	4.6
barium	160,000	11,000	ngv	190,000	110	26	200	220	180	110
cadmium	80	5.7	ngv	ngv	0.41 J	<0.58	0.63 J	1.9 J	0.37 J	<0.6
cadmium	80	5.7	ngv	810	0.41 J	<0.58	0.63 J	1.9 J	0.37 J	<0.6
chromium	720	51	ngv	ngv	5.3	2.6	17	18	8.4	13
lead	ngv	ngv	ngv	ngv	36	8.6	26	120	30	11
selenium	4,000	290	ngv	5,100	<4.1	<4.1	4.1 J	1.6 J	<4.6	<4.2

Table C-5 continued. Total metals found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-006BD Subsurface Soil	CRC-SB-007A Surface Soil	CRC-SB-008A Subsurface Soil	CRC-SB-008B Subsurface Soil	CRC-SB-009A Subsurface Soil	CRC-SB-009B Subsurface Soil
mercury	24	1.7	ngv	28	0.028 J	0.028 J	<0.12	0.02 J	0.04 J	0.034 J
arsenic	240	17	0.25	1.6	3.4	4.9	<1.5	<1.6	13	3.3
barium	160,000	11,000	ngv	190,000	44	230	110	38	73	230
cadmium	80	5.7	ngv	ngv	<0.59	<6.2	<0.59	<0.58	0.22 J	<6.2
cadmium	80	5.7	ngv	810	<0.59	<6.2	<0.59	<0.58	0.22 J	<6.2
chromium	720	51	ngv	Ngv	7.9	9.3	4.4	5.9	11	8.3
lead	ngv	ngv	ngv	Ngv	6.7	36	10	5.3	15	14
selenium	4,000	290	ngv	5,100	<4.1	<4.3	<4.1	<4	<4	<4.3

Table C-5 continued. Total metals found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in milligrams per kilogram (mg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-010A Subsurface Soil	CRC-SB-011 Surface Soil	CRC-SB-012 Surface Soil	CRC-SB-013 Surface Soil	CRC-SB-014 Surface Soil	CRC-SB-014D Surface Soil
mercury	24	1.7	ngv	28	<0.12	0.87	0.041 J	0.73	0.41	0.48
arsenic	240	17	0.25	1.6	5	35	8.9	54	26	47
barium	160,000	11,000	ngv	190,000	77	320	110	320	130	190
cadmium	80	5.7	ngv	ngv	<0.61	1 J	0.31 J	1.6 J	0.87 J	2.1 J
cadmium	80	5.7	ngv	810	<0.61	1 J	0.31 J	1.6 J	0.87 J	2.1 J
chromium	720	51	ngv	Ngv	9.4	22	11	18	28	24
lead	ngv	ngv	ngv	Ngv	7.2	30	87	35	23	32
selenium	4,000	290	ngv	5,100	<4.2	5.2	1.8 J	9.3	6.7	12

Table C-5 continued. Total metals found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in milligrams per kilogram (mg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-015 Subsurface Soil	CRC-SB-016 Surface Soil	CRC-SB-017 Surface Soil
mercury	24	1.7	ngv	28	0.86	0.039 J	0.28
arsenic	240	17	0.25	1.6	18	<1.6	21
barium	160,000	11,000	ngv	190,000	180	36	160
cadmium	80	5.7	ngv	ngv	0.78 J	<0.59	0.9 J
cadmium	80	5.7	ngv	810	0.78 J	<0.59	0.9 J
chromium	720	51	ngv	ngv	14	4.5	22
lead	ngv	ngv	ngv	ngv	34	5.1	34
selenium	4,000	290	ngv	5,100	8	<4.1	7.4

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

mg/kg = milligrams per kilogram, equivalent to parts per billion in soil

ngv = no guidance value available

J = estimated concentration of chemical

Table C-6. Volatile Organic Compounds (VOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-001A Surface Soil	CRC-SB-001B Subsurface Soil	CRC-SB-002A Surface Soil	CRC-SB-002B Subsurface Soil	CRC-SB-002BD Subsurface Soil	CRC-SB-003A Subsurface Soil
carbon disulfide	80,000	5,700	ngv	3,000,000	45	20	<12	<5.8	14	<6.3
cyclohexane	ngv	ngv	ngv	30,000,000	<7.2	<5	<12	<5.8	<4.4	<6.3
methylcyclohexane	ngv	ngv	ngv	14,000,000	<7.2	<5	<12	<5.8	<4.4	<6.3

Table C-6 continued. Volatile Organic Compounds (VOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-004A Surface Soil	CRC-SB-004B Subsurface Soil	CRC-SB-005A Surface Soil	CRC-SB-005B Subsurface Soil	CRC-SB-006A Surface Soil	CRC-SB-006B Subsurface Soil
carbon disulfide	80,000	5,700	ngv	3,000,000	86	<7.1	<6.6	<5.3	<7.4	<5.7
cyclohexane	ngv	ngv	ngv	30,000,000	<8.7	<7.1	<6.6 J	<5.3	<7.4	<5.7
methylcyclohexane	ngv	ngv	ngv	14,000,000	<8.7	<7.1	<6.6 J	2.7 J	<7.4	<5.7

Table C-6 continued. Volatile Organic Compounds (VOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-006BD Subsurface Soil	CRC-SB-007A Surface Soil	CRC-SB-008A Subsurface Soil	CRC-SB-008B Subsurface Soil	CRC-SB-009A Subsurface Soil	CRC-SB-009B Subsurface Soil
carbon disulfide	80,000	5,700	ngv	3,000,000	<4.9	<8.8	<7.4	<5.3	<6.5	<7
cyclohexane	ngv	ngv	ngv	30,000,000	<4.9	4 J	<7.4	<5.3	<6.5	<7
methylcyclohexane	ngv	ngv	ngv	14,000,000	<4.9	7.4 J	<7.4	<5.3	2.9 J	<7

Table C-6 continued. Volatile Organic Compounds (VOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-010A Subsurface Soil	CRC-SB-011 Surface Soil	CRC-SB-012 Surface Soil	CRC-SB-013 Surface Soil	CRC-SB-014 Surface Soil	CRC-SB-014D Surface Soil
carbon disulfide	80,000	5,700	ngv	3,000,000	<5.6	<10	<6.9	<15	<7.8	<13
cyclohexane	ngv	ngv	ngv	30,000,000	<5.6	<10 J	<6.9	<15	<7.8 J	<13 J
methylcyclohexane	ngv	ngv	ngv	14,000,000	<5.6	<10 J	<6.9	<15	<7.8 J	<13 J

Table C-6 continued. Volatile Organic Compounds (VOCs) found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in micrograms per kilogram (µg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	CRC-SB-015 Subsurface Soil	CRC-SB-016 Surface Soil	CRC-SB-017 Surface Soil
carbon disulfide	80,000	5,700	ngv	3,000,000	<12	<10	<11
cyclohexane	ngv	ngv	ngv	30,000,000	<12	<10	<11
methylcyclohexane	ngv	ngv	ngv	14,000,000	<12	<10	<11

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

mg/kg = milligrams per kilogram, equivalent to parts per billion in soil

ngv = no guidance value available

<5.3 = Not detected with detection limit shown

J = estimated concentration of chemical

Table C-7. Total metals and organics found in surface soil background samples during the 2012 OTIE Removal Assessment. All units are reported in milligrams per kilogram (mg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	Background SS-01	Background SS-01D	Background SS-02	Background SS-03
Inorganics (mg/kg)								
aluminum	800,000	57,000	ngv	ngv	9,020	8,650	19,000	20,400
arsenic	240	17	0.25	1.6	9	8	12	11
barium	160,000	11,000	ngv	190,000	85	86	83	94
beryllium	1,600	110	ngv	ngv	0.5	0.4	0.4	0.6
calcium	ngv	ngv	ngv	ngv	1,200	1,100	,3,900	11,100
cobalt	8,000	570	ngv	ngv	7	5	13	11
chromium (total)	720	51	ngv	ngv	11	9	23	17
chromium +6	720	51	ngv	ngv	0.43	0.61	0.48	0.61
copper	8,000	570	ngv	ngv	11	11	10	17
iron	ngv	ngv	ngv	ngv	15,300	14,500	25,700	24,800
mercury	24	1.7	ngv	28	0.07	0.06	0.08	0.11
potassium	ngv	ngv	ngv	ngv	300	300	500	500
magnesium	ngv	ngv	ngv	ngv	500	400	1,000	1,600
manganese	40,000	2,900	ngv	ngv	660	550	1,740	1,120
nickel	16,000	1,100	ngv	ngv	8	7	9	11
lead	ngv	ngv	ngv	ngv	25	24	38	41
selenium	4,000	290	ngv	5,100	1.2	1.2	1.4	1.6
vanadium	8,000	570	ngv	ngv	21	18	39	37
zinc	240,000	17,000	ngv	ngv	34	38	37	59
Organics (µg/kg)								
VOCs					ND	ND	ND	ND
SVOCs								
benzo(a)anthracene	ngv	ngv	ngv	2,100	<10	7	<10	<10
benzo(a)pyrene	ngv	ngv	0.016	210	9	11	6	9
benzo(g,h,i)perylene	ngv	ngv	ngv	ngv	<10	9	<10	<10

Table C-7 continued. Total metals and organics found in surface and subsurface soil during the 2012 OTIE Removal Assessment. All units are reported in milligrams per kilogram (mg/kg). Screening values shown are ATSDR residential soil non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR residential soil cancer risk evaluation guides (CREGs), EPA industrial soil non-cancer regional screening levels (RSLs), Source: OTIE 2012.

Sample ID /Chemical	ATSDR Adult Chronic (non-cancer)	ATSDR Child Chronic (non-cancer)	ATSDR CREG (10^{-6} excess cancer risk)	EPA RSL Industrial Soil	Background SS-01	Background SS-01D	Background SS-02	Background SS-03
benzo(k)fluoranthene	ngv	ngv	ngv	21,000	26	15	16	19
Chrysene	ngv	ngv	ngv	210,000	15	9	11	14
fluoranthene	320,000	23,000	ngv	22,000,000	12	19	7	15
Indeno(1,2,3-cd)pyrene	ngv	ngv	ngv	2,100	5	10	<10	5
phenanthrene	ngv	ngv	ngv	ngv	42	18	13	24

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, February 2013. Cancer risk comparison values - cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels (EPA 2015). Industrial RSLs for non-cancer and cancer health effects are for exposure to an onsite worker. Residential RSLs for non-cancer and cancer health effects are for a lifetime exposure to a resident

mg/kg = milligrams per kilogram, equivalent to parts per billion in soil

ngv = no guidance value available

ND = Not detected

VOCs = volatile organic compounds

SVOCs = semivolatile organic compounds

Table C-8. Summary of February 2012 OTIE temporary groundwater monitoring well sampling detections at the CRC Site and ATSDR and EPA comparison values. Screening values shown are ATSDR tap water non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR cancer risk evaluation guides (CREGs), EPA non-cancer regional screening levels (RSLs), and EPA cancer regional screening levels (RSLs). All results are reported in micrograms per liter (µg/L). Sampling of temporary wells was conducted by OTIE on February 17, 2012.

Sample ID	GW-001	GW-002	GW-002 Duplicate	GW-003	GW-004	GW-005	ATSDR EMEG (µg/L)	ATSDR CREG (µg/L)	EPA non-cancer RSL (µg/L)	EPA cancer RSL (µg/L)	EPA MCL (µg/L)
Location	CRC011	CRC008		CRC007	CRC009	CRC006					
Collection Date	2/17/12	2/17/12		2/17/12	2/17/12	2/17/12					
Semivolatile Organic Compounds (µg/L)											
2-methylnaphthalene	<0.1	0.14	0.15	<0.1	0.68	<0.1	700[1]	nc	27	nc	ngv
acenaphthalene	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	600[2]	nc	53	nc	ngv
anthracene	<0.1	<0.1	<0.1	<0.1	0.12	<0.1	3,000[2]	nc	180	nc	ngv
benz(a)anthracene	<0.1	<0.1	<0.1	<0.1	0.17	<0.1	ngv	ngv	ngv	0.034	ngv
benzo(a)pyrene	<0.1	<0.1	<0.1	<0.1	0.17	<0.1	ngv	0.0048	ngv	0.0034	0.2
benzo(b)fluoranthene	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	ngv	ngv	ngv	0.034	ngv
benzo(g,h,i)perylene	<0.1	<0.1	0.14	<0.1	0.16	<0.1	ngv	ngv	ngv	ngv	ngv
benzo(k)fluoranthene	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	ngv	ngv	ngv	0.34	ngv
chrysene	<0.1	<0.1	<0.1	<0.1	0.21	<0.1	ngv	ngv	ngv	3.4	ngv
fluoranthene	<0.1	<0.1	<0.1	<0.1	0.57	<0.1	400[2]	ngv	80	ngv	ngv
fluorene	<0.1	<0.1	<0.1	<0.1	0.15	<0.1	600[2]	nc	29	ngv	ngv
indeno(1,2,3-cd)pyrene	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	ngv	nc	ngv	0.034	ngv
naphthalene	<0.1	0.19	0.21	<0.1	0.89	0.1	200[2]	ngv	0.61	0.17	ngv
phenanthrene	<0.1	<0.1	<0.1	<0.1	0.63	<0.1	ngv	nc	ngv	nc	ngv
pyrene	<0.1	<0.1	<0.1	<0.1	0.66	<0.1	300[2]	nc	12	nc	ngv
Total Metals (µg/L)											
arsenic	<10	14	16	<10	<10	<10	3[1]	0.023	0.6	0.052	10
barium	93 J	2,700	2,500	1,100	1,700	96 J	2,000[1]	nc	380	nc	2,000
chromium	<10	32	42	3.5 J	22	2.5 J	ngv	nc	ngv	nc	100
lead	4.1 J	19	26	12	6.6 J	<10	ngv	ngv	15	ngv	15
selenium	<35	14 J	12 J	<35	17 J	<35	50	nc	10	nc	50

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, March 2013. Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels with cancer risk of $1x10^{-6}$ and hazard quotient of 0.1 (EPA 2014).

µg/L = micrograms per liter

ngv = no guidance value available nc = chemical has not been classified as to human carcinogenicity

J = estimated concentration. Chemical was found at concentrations below the reported method detection level.

<0.1 = Chemical concentration reported below the method detection level.

Table C-9. Summary of February 2014 groundwater monitoring well sampling detections at the CRC Site and ATSDR and EPA comparison values. Screening values shown are ATSDR tap water non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR cancer risk evaluation guides (CREGs), EPA non-cancer regional screening levels (RSLs), and EPA cancer regional screening levels (RSLs). All results are reported in micrograms per liter (µg/L).

Sample ID	GW-001	GW-002	GW-003	GW-004	GW-005	GW-006	ATSDR Adult EMEG (µg/L)	ATSDR Child EMEG (µg/L)	EPA non-cancer RSL (µg/L)	EPA cancer RSL (µg/L)	EPA MCL (µg/L)
Collection Date	2/2012	2/2012	2/2012	2/2012	2/2012	2/2012					
Inorganics (µg/L)											
barium (total)	17.1	13.4	34.1	29.1	32.8	29.3	5,200	1,400	3,800	ngv	2,000
barium (dissolved)	17.2	13.7	35.6	30.1	35	30.4	5,200	1,400	3,800	ngv	2,000
calcium (total)	34,000	31,300	49,600	34,600	46,900	34,800	ngv	ngv	ngv	ngv	ngv
calcium (dissolved)	35,600	32,200	53,600	37,200	52,200	38,400	ngv	ngv	ngv	ngv	ngv
copper (total)	<10	<10	32.8	22.6	32	23.7	260	70	800	ngv	1,300
copper (dissolved)	<10	<10	23.9	18.7	23	19.9	260	70	800	ngv	1,300
iron (total)	373	364	460	231	461	281	ngv	ngv	14,000	ngv	ngv
iron (dissolved)	158	405	203	116	192	124	ngv	ngv	14,000	ngv	ngv
magnesium (total)	5,340	4,380	5,040	3,440	4,720	3,450	ngv	ngv	ngv	ngv	ngv
magnesium (dissolved)	4,940	4,000	4,710	3,310	4,630	3,360	ngv	ngv	ngv	ngv	ngv
manganese (total)	31.8	<15	25.1	<15	25	<15	1,300	350	430	ngv	ngv
manganese (dissolved)	15	<15	16.2	<15	17	<15	1,300	350	430	ngv	ngv
sodium (total)	166,000	129,000	26,800	17,800	24,600	18,100	ngv	ngv	ngv	ngv	ngv
sodium (dissolved)	167,000	128,000	27,300	16,600	27,000	17,500	ngv	ngv	ngv	ngv	ngv
zinc (total)	<50	<50	279	144	239	151	7,800	2,100	6,000	ngv	ngv
zinc (dissolved)	<50	<50	272	145	245	152	7,800	2,100	6,000	ngv	ngv
Organics (µg/L)											
toluene	<1.00	<1.00	1.02	<1.00	<1.00	<1.00	2,100	560	1,100	ngv	1,000
total petroleum hydrocarbons C12-C40	564	335	770	786	824	920	ngv	ngv	100	ngv	ngv

Notes: ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, March 2013. Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels with cancer risk of $1x10^{-6}$ and hazard quotient of 0.1 (EPA 2014).

µg/L = micrograms per liter

ngv = no guidance value available nc = chemical has not been classified as to human carcinogenicity

J = estimated concentration. Chemical was found at concentrations below the reported method detection level.

<0.1 = Chemical concentration reported below the method detection level.

Table C-9 continued. Summary of February 2014 groundwater monitoring well sampling results at the CRC Site and ATSDR and EPA comparison values. Screening values shown are ATSDR tap water non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR cancer risk evaluation guides (CREGs), EPA non-cancer regional screening levels (RSLs), and EPA cancer regional screening levels (RSLs). All results are reported in micrograms per liter (µg/L).

Sample ID	GW-001 Back-ground	GW-002	GW-003	GW-004	GW-005 unfiltered	GW-006 Back-ground	ATSDR Adult Chronic (µg/L)	ATSDR Child Chronic (µg/L)	EPA non-cancer RSL (µg/L)	EPA cancer RSL (µg/L)	EPA MCL (µg/L)
Collection Date	2/2012	2/2012	2/2012	2/2012	2/2012	2/2012					
Inorganics (µg/L)											
aluminum	110	20/30	<20	90	160,000	200	26,000	7,000	2,000	nc	ngv
antimony	<1	<1/<1	<1	<1	<1	<1	10	2.8	0.78	nc	6
arsenic	<1	17/17	2	<1	41	<1	7.8	2.1	0.052	0.052	10
barium	73	360/360	620	150	1,400	160	5,200	1,400	380	nc	2,000
beryllium	<1	<1/<1	<1	<1	10	<1	52	14	2.5	ngv	4
cadmium	<1	<1/<1	<1	<1	1	<1	2.6	0.7	0.92	ngv	5
calcium	19,000	140,000/140,000	110,000	96,000	51,000	8,100	ngv	ngv	ngv	nc	ngv
chromium +6	<1.8	<0.44/<0.25	<0.30	<0.34	<0.45	3.0	23	6.3	44	0.035	ngv
chromium (total)	1	<1/<1	<1	<1	140	3	ngv	ngv	ngv	nc	100
cobalt	1	<1/<1	17	2	49	2	260	70	0.6	nc	ngv
copper	<2	<2/<2	<2	<2	110	<2	260	70	80	nc	1,300
iron	<20	19,000/19,000	36,000	440	230,000	170	ngv	ngv	1,400	nc	ngv
lead	<1	<1/<1	<1	<1	210	<1	ngv	ngv	15	nc	15
magnesium	2,900	8,900/8,800	16,000	15,000	18,000	2,500	ngv	ngv	ngv	nc	ngv
manganese	1,400	1,500/1,500	10,000	1,600	5,500	57	1,300	350	43	nc	ngv
mercury	0.3	<0.2/<0.2	<0.2	<0.2	<0.3	<0.2	ngv	ngv	0.063	nc	2
nickel	8	<1/<1	6	1	120	5	520	140	39	ngv	ngv
potassium	3,400	7,800/7,900	25,000	9,300	14,000	300	ngv	ngv	ngv	nc	ngv
selenium	<2	<2/<2	<2	<2	18	<2	130	35	10	nc	50
sodium	3,400	5,700/5,700	80,000	44,000	180,000	1,400	ngv	ngv	ngv	nc	ngv
thallium	<1	<1/<1	<1	<1	1	<1	ngv	ngv	0.02	ngv	2
vanadium	<1	2/2	<1	<1	200	<1	260	70	1.1	nc	ngv
zinc	8	<20/<20	8	10	1,000	11	7,800	2,100	600	nc	ngv

Table C-9 continued. Summary of February 2014 groundwater monitoring well sampling detections at the CRC Site and ATSDR and EPA comparison values. Screening values shown are ATSDR tap water non-cancer environmental media evaluation guides (EMEGs) for chronic exposure duration (>364 days exposure), ATSDR cancer risk evaluation guides (CREGs), EPA non-cancer regional screening levels (RSLs), and EPA cancer regional screening levels (RSLs). All results are reported in micrograms per liter (µg/L).

Sample ID	GW-001	GW-002	GW-003	GW-004	GW-005	GW-006	ATSDR Adult EMEG (µg/L)	ATSDR Child EMEG (µg/L)	EPA non-cancer RSL (µg/L)	EPA cancer RSL (µg/L)	EPA MCL (µg/L)
Collection Date	2/2012	2/2012	2/2012	2/2012	2/2012	2/2012					
Organics (µg/L)											
Benzene	<0.5	<0.5/<0.5	<0.5	<0.5	0.3 J	<0.5	13	3.5	3.3	0.46	5
Carbon disulfide	<1	<1/<1	<1	<1	0.7 J	<1	2,600	700	81	ngv	ngv
Chloroform	<0.5	<0.5/<0.5	<0.5	<0.5	4.2	<0.5	260	70	9.7	0.22	80
Methyl ethyl ketone	<10	<10/<10	<10	<10	2.2 J	<10	16,000	4,200	560	ngv	ngv
Methylene chloride	<2	<2/<2	<2	<2	0.4 J	<2	1,600	420	11	11	5

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2013). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR CREG = Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, March 2013. Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.

EPA RSL = Environmental Protection Agency Regional Screening Levels with cancer risk of $1x10^{-6}$ and hazard quotient of 0.1 (EPA 2014).

µg/L = micrograms per liter

ngv = no guidance value available

nc = not classifiable as to carcinogenicity

J = estimated concentration. Chemical was found at concentrations below the reported method detection level.

<0.1 = Chemical concentration reported below the method detection level.

20/30 = original sample concentration/duplicate sample concentration

Table C-10. 2015 sediment sampling results. Source: TRC Engineering Evaluation and Cost Analysis, September 2015.

Summary of Detected May 2015 Sediment Sampling Results

Inorganics (mg/kg)	Bkgd	RSL_{Res}	COPC	Eco. Screen. Values NOAA Max.	USEPA	Eco COPC	Smpl Date: Smpl ID:	Bkgd May-15 SD-01	May-15 SD-02	May-15 SD-03	May-15 SD-04	May-15 SD-04/Dup	May-15 SD-05	May-15 SD-06	May-15 SD-07
Aluminum	6,353	7,700	●	25,500		- - -		4,030	2,840	3,440	11,400	10,100	10,200	4,630	11,600
Arsenic	- - -	0.68	●	33	9.8	- - -		2.1	1.5	1.4	4.2	3.4	4.2	2.3	4.0
Barium	71	1,500	- - -	- - -	- - -	- - -		48	37	38	110	120	120	58	140
Beryllium	- - -	16	- - -	- - -	- - -	- - -		0.5	0.4	0.4	1.1	1.2	1.3	0.6	1.3
Cadmium	- - -	7.1	- - -	10	0.99	- - -		0.2 U	0.2	0.2	0.4	0.4	0.4	0.2	0.4
Calcium		Essential Nutrient						830	650	780	1,530	1,600	2,090	1,300	1,800
$Chromium_{Total}$	9.1	12,000	- - -	111	43.4	- - -		5.8	3.7	3.9	12	12	11	6	13
Cobalt	8.7	2.3	●	50	50	- - -		4.3	4.9	4.7	17	17	17	9	18
Copper	- - -	310	- - -	197	31.6	- - -		5.2	3.8	3.9	11	8.2	11	5.4	9.5
Iron	13,927	5,500	●	188,400	20,000	- - -		7,190	5,550	6,440	16,300	16,400	17,000	8,960	18,400
Lead	15	400	- - -	250	35.8	- - -		7.8	5.4	6.0	13	15	14	8.5	15
Magnesium		Essential Nutrient						380	390	450	1,090	1,080	1,050	500	1,100
Manganese	139	180	●	1,100	460	●		51	130	150	770	700	700	240	820
Mercury	- - -	0.94	- - -	2	0.18	- - -		0.03 J	0.02 J	0.02 J	0.05	0.05	0.05	0.03 J	0.07
Nickel	- - -	150	- - -	75	22.7	●		7.4	8.0	8.4	24	25	26	11	28
Potassium		Essential Nutrient						270	170	190	600	560	550	300	660
Selenium	- - -	39	- - -	- - -	2	●		0.9	0.6	0.7	2.1	1.9	2.4	0.9	1.9
Sodium		Essential Nutrient						200 U	50	50	200	200	200	200	200
Vanadium	*13*	39	- - -	- - -	- - -	- - -		8.7	3.9	4.4	15	15	11	8	16
Zinc	*45*	2,300	- - -	820	- - -	- - -		23	26	27	84	64	87	35	67
Organics (ug/kg)															
Benzo(a)anthracene	- - -	160	- - -	14,800	108	- - -		49	18	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	- - -	16	●	14,400	150	- - -		71	30	6 J	7 J	20	9 J	11	9 J
Benzo(b)fluoranthene	- - -	160	- - -	- - -	27.2	- - -		67	33 j	11	10 U	45	10 U	10 U	27
Benzo(ghi)perylene	- - -	- - -	- - -	3,200	170	- - -		53	24	5 J	5 J	9	8 J	6 J	6 J
Benzo(k)fluoranthene	- - -	1,600	- - -	13,400	27.2	- - -		30	14	10 U	10 U	10 U	9 J	8 J	10 U
Chrysene	- - -	16,000	- - -	4,600	166	- - -		55	19	8 J	5 J	30	20	20	17
Dibenzo(a,h)anthracene	- - -	16	- - -	1,300	33	- - -		9 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	- - -	240,000	- - -	10,200	423	- - -		129	28 j	17	15	28	22	16	17
Fluorene	- - -	240,000	- - -	1,600	77.4	- - -		10 U	10 U	10 U	10 U	10 U	11	10 U	9 J
Indeno(1,2,3-cd)pyrene	- - -	160.0	- - -	3,200	17	- - -		57	24	10 U	6 J	11	9 J	6 J	6 J
Naphthalene	- - -	3,800.0	- - -	600	176	- - -		7 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	- - -	- - -	- - -	9,500	204	- - -		140	32 j	28	19	85	40	40	40
Pyrene	- - -	180,000	- - -	8,500	195	- - -		115	40 j	15	10 U	44	10 U	10 U	23
Other Constiteunts															
Solids (%)	- - -	- - -	- - -	- - -	- - -	- - -		69	69.0	65.2	39.5	37.4	34.6	56.8	35.8
TOC (mg/kg)	- - -	- - -	- - -	- - -	- - -	- - -		8,500	8,500	12,000	30,000	37,000	49,000	23,000	45,000

Notes/Comments

U Less than value provided by laboratory

J Estimated value provided by laboratory

j Estimated value provided by TRC data validator

USEPA USEPA (2008)

NOAA Max. Maximum value from Buchman (2008)

RSL_{Res} USEPA Regional Sreening Level (RSL) for residential soil using using TR = 10^{-6} and THQ = 0.1; dated June 2015. Only used to select COPCs.

Bkgd Two-times average background conc., see Table 13. Detected background sampling results for Sediment Sample SD-01 are also provided in this table.

Table C-11. River Water Sampling Results ‒ dates are as shown. Source: TRC Engineering Evaluation and Cost Analysis (EE/CA), Sept. 2015.

Table 10
Summary of Detected River Water Sampling Results

Inorganics (ug/L)	Bkgd.	RSL_{Tap}	COPC	Eco. Screen Values Tox	CCC	Eco COPC	Smpl. Date: Smpl. ID:	Feb-91 SW-2		Mar-91 SW-2		Jul-09 CR02		Jul-09 CR02Dup		Jul-09 CR03	
Aluminum	- - -	2,000	- - -	- - -	- - -	- - -		210		- - -		- - -		- - -		- - -	
Arsenic	1.1	0.052	- - -	10	150	- - -		- - -		2	U	0.85		0.80		0.73	
Barium	30	380	- - -	2,000	- - -	- - -		100	U	- - -		30		31		31	
Cobalt	0.20	0.6	- - -	- - -	- - -	- - -		10	U	- - -		0.16		0.17		0.18	
Copper	7	80	- - -	- - -	9.0	- - -		5	U	- - -		1.3	U	0.56	U	0.73	
Iron	111	1,400	- - -	- - -	- - -	- - -		148		- - -		- - -		- - -		- - -	
Manganese	56	43	- - -	- - -	- - -	- - -		83		- - -		20		20		24	
Nickel	1.3	39	- - -	100	52	- - -		20	U	- - -		1.2		1.3		1.2	
Selenium	0.37	10	- - -	50	5	- - -		- - -		- - -		0.24		0.19		0.23	
Thallium	0.029	0.02	- - -	2	- - -	- - -		- - -		- - -		0.0090		0.0090	R	0.010	
Vanadium	0.49	8.6	- - -	- - -	- - -	- - -		- - -		- - -		0.40		0.45		0.48	
Zinc	8	600	- - -	- - -	120	- - -		6		- - -		1.5		2.1		1.7	
Organics (ug/L)																	
1,2,4-Trimethylbenzene	- - -		- - -	- - -	- - -	- - -		- - -		- - -		0.50	U	0.50	U	0.1	J
Acetone	8	1,400	- - -	- - -	- - -	- - -		2		- - -		4.0	U	4.0	U	4.0	U
Aldrin	0.224	0.0046	- - -	- - -	- - -	- - -		- - -		0.220		0.10	U	0.10	U	0.10	U
Benzene	- - -	0.45	- - -	5	- - -	- - -		- - -		- - -		0.50	U	0.50	U	0.24	U
Chloromethane	- - -	19	- - -	- - -	- - -	- - -		- - -		- - -		0.16		0.17		0.50	U
Ethyl benzene	- - -	1.5	- - -	700	- - -	- - -		- - -		- - -		0.50	U	0.50	U	0.19	
OCDD	0.000018	0.006	- - -	- - -	- - -	- - -		- - -		- - -		0.015	U	0.016	U	0.000018	
Toluene	4	110	- - -	1,000	- - -	- - -		- - -		- - -		0.27		0.24		1.1	
Xylene, m/p-	7	19	- - -	10,000	- - -	- - -		- - -		- - -		1.0	U	1.0	U	0.63	
Xylene, o-	3	19	- - -	10,000	- - -	- - -		- - -		- - -		0.090		0.09		0.27	

Notes/Comments

Bkgd — Two-times average background conc., see Table 13

CCC — Criterion Continuous Concentration [TDEC Rule 0400-40-03-.03(3)(g)]

COPC — Constituent of potential concern (*i.e.*, max. value above RSL_{Res})

None of the detected constituents exceeded the RSL_{Tap} and therefore were not conisder COPCs; however, human/ecological screening values provided for informational purposes only

OCCD — Octachlorodibenzodioxin

RSL_{Tap} — USEPA regional screening level to tap water consumption, June 2015 at TR 10^{-6} and THQ 0.1. Only used to select COPCs.

Tox — Toxic subatances [TDEC Rule 0400-40-03-.03(1)(j)]

U — Less than value provided by laboratory

Appendix D. Exposure Parameters and Dose Calculation Procedures

People are not always exposed to hazardous substances released into the environment. Exposure happens when people breathe, eat, drink, or make skin contact with a contaminant. Factors that determine the type and severity of health effects associated with contaminant exposure include exposure concentration, frequency and duration of exposure, route of exposure, and cumulative exposures, (i.e., the combination of contaminants and routes). Following exposure, individual characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status influence how the person absorbs, distributes, metabolizes, and excretes the contaminant. These characteristics, the exposure factors discussed above, and the specific toxicological effects of the substance, determine the health effects that might result. The following summary of the ATSDR procedure for developing health comparison values and calculating exposure doses comes from the ATSDR Public Health Assessment Guidance Manual (ATSDR 2005) and the ATSDR Division of Community Health Investigations Exposure Dose Guidance (EDG) (November 2014).

ATSDR considers these physical and biological characteristics when developing health guidelines. Health guidelines provide a basis for evaluating exposures estimated from concentrations of contaminants in different environmental media–soil, air, water, and food– depending on the characteristics of the people who may be exposed and the length of exposure. Health guideline values are in units of dose such as milligrams of contaminant per kilogram of body weight per day (mg/kg/day).

ATSDR reviews health and chemical information in *Toxicological Profiles*. Each toxicological profile covers a particular substance: it summarizes toxicological and adverse health effects information about that substance and includes health guidelines such as ATSDR’s minimal risk level (MRL), EPA reference dose (RfD) and reference concentration (RfC), and EPA’s cancer slope factor (CSF). ATSDR uses these guidelines to determine a person’s potential for developing adverse non-cancer health effects or cancer from exposure to a hazardous substance.

Health comparison values such as environmental media evaluation guides (EMEGs), cancer risk evaluation guides (CREGs), and maximum contaminant levels (MCLs) are derived using standard intake rates for inhalation of air and ingestion of water, soil, and biota. These intake rates are derived from the ATSDR Public Health Assessment Guidance Manual (ATSDR 2005) or from the EPA Exposure Factors Handbook (EPA 2011). We consider doses calculated using health protective exposure factors and environmental concentrations as “health protective doses” because any real community exposures are unlikely to be greater than the calculated doses and are more likely to be less than the health protective doses.

After estimating the potential exposure at a site, ATSDR identifies the site’s “contaminants of concern” by comparing the exposures of interest with health guidelines or contaminant concentrations with comparison values. As a general rule, if the guideline or value is exceeded, ATSDR evaluates exposure to determine potential health concerns. Sometimes additional medical and toxicological information may indicate that these exposures are not of health concern. In other cases, exposures below the guidelines or values could be of health concern because of interactive effects with other chemicals or because of potential health effects to sensitive populations. Thus, additional analysis is necessary to determine whether health effects are likely to occur.

Soil

Soil exposure doses via ingestion are calculated on the basis of the following equation:

Soil Dose (Ingestion) = (Chemical Conc. x IR x EF x ED x ABS) / (BW x AT)

Where:

Chemical Conc.	= concentration of each contaminant (in mg/g, µg/g, µg/kg, mg/L or µg/L; with appropriate unit conversion factors)
IR	= ingestion rate (in grams/day)
EF	= exposure frequency (in days per year)
ED	= exposure duration (in years)
ABS	= a chemical-specific absorption or bioavailability factor (unitless)
BW	= body weight (in kilograms)
AT	= averaging time (in days)

For soil and sediment doses, we take an additional step to determine the exposure via dermal absorption, with the total dose being the sum of the ingestion dose and the dermal dose.

Soil Dose (Dermal) = Chemical Conc. x ABS x TSA x EF x ED) / (BW x AT)

Where all factors are as above except:

TSA	= total soil adhered in milligrams (skin surface area x soil adherence value)

The total soil exposure dose = ingestion dose + dermal dose

Table D-1 lists the specific exposure factors used to calculate doses for the CRC Site soil exposures. Doses to those who trespass on the site to contaminants found are for both incidental ingestion and direct absorption though the skin. The calculation of the 70 year estimated cancer risk from BaP-TEq and TCDD-TEq exposure includes 16 years of exposure as a child and 54 years of exposure as an adult.

The dose calculations form both BaP-TEq and for TCDD-TEq include relative absorption factors (listed as ABS in the above equations). These absorption factors account for the difference in contaminant bioavailability for the doses administered to laboratory animals in their feed or corn oil vs. absorption from soil. Note that the ABS values used here are the same (Table D-1) for uptake via ingestion and dermal exposure. Dermal absorption of strongly particle-bound contaminants such as PAHs and dioxins has been shown to be limited (ATSDR 1995, 1998; NAS 2006). However, no site-specific studies have been done to date to understand the specific absorption percentages.

Numerous studies have determined that the relative oral bioavailabilities of BaP and 2,3,7,8-TCDD from soil are less than 100% (as reviewed in ATSDR 1995, 1998; NAS 2006; Kirwan, et. al. 2010). BaP-TEq and TCDD-TEq represent the toxicity adjusted concentration of numerous PAH and dioxin/furan species; the relative bioavailabilities of the specific compounds may vary (NAS 2006; Ounnas, et. al., 2009). Consequently, the ABS values listed in Table D-1 represent average ABS values across the suite of individual compounds comprising these toxicity–adjusted contaminant concentrations.

Table D-1. Exposure Parameters Used to Calculate Soil Exposure Doses		
Exposure Parameters (units)	Child	Adult
Soil Ingestion (IR: grams/day)	200	100
Exposure Factor (EF: unitless) = [frequency in days/year x duration in years] / AT [days]	0.96	0.96
Exposure Duration (ED: years)	21	57
BaP Absorption – Ingestion (ABS: unitless)	1	1
TCDD Absorption – Ingestion (ABS: unitless)	1	1
BaP Absorption – Dermal (ABS: unitless)	1	1
TCDD Absorption – Dermal (ABS: unitless)	1	1
Body Weight (BW: kilograms)	35	80
Averaging Time (AT: days)	365	365
Total Soil Adhered (TSA: mg/day) Area skin surf. [cm^2] x adherence factor $mg/cm^2/day$]	8,750 cm^2 x 0.2 $mg/cm^2/day$	19,400 cm^2 x 0.07 $mg/cm^2/day$
TSA (milligrams/day; see above)	1751	1358
Frequency (days/year)	120	120
ABS = chemical-specific absorption factor (unitless)		
BaP = benzo(a)pyrene equivalents		
TCDD = trichlorodibenzodioxin equivalents		

Fish

Fish exposure doses via ingestion are calculated on the basis of the following equation:

Fish Dose (Ingestion) = (Chemical Conc. x IR x EF x AF) / (BW x AT)

Where:

Chemical Conc.	= concentration of each contaminant (in mg/g, µg/g, µg/kg, mg/L or µg/L; with appropriate unit conversion factors)
IR	= ingestion rate (in grams/meal)
EF	= exposure frequency (in meals/year)
AF	= a chemical-specific bioavailability factor (unitless)
BW	= body weight (in kilograms)
AT	= averaging time (in days)

Table D-2 lists the specific exposure factors used to calculate doses for the CRC Site soil exposures. Doses to those who trespass on the site to contaminants found are for both incidental ingestion and direct absorption though the skin. The calculation of the 78- year estimated cancer risk from BaP-TEq and TCDD-TEq exposure includes 16 years of exposure as a child and 62 years of exposure as an adult.

Numerous studies have determined that the relative oral bioavailabilities of BaP and 2,3,7,8-TCDD from soil are less than 100% (as reviewed in ATSDR 1995, 1998; NAS 2006; Kirwan, et. al. 2010). BaP-TEq and TCDD-TEq represent the toxicity adjusted concentration of numerous PAH and dioxin or furan species. The relative bioavailabilities of the specific compounds may vary (NAS 2006; Ounnas, et. al., 2009).

Table D-2. Exposure Parameters Used to Calculate Fish Exposure Doses		
Exposure Parameters (units)	Child	Adult
Fish Ingestion (IR: grams/day)	6	38
Exposure Factor (EF: unitless) = [frequency in days/year x duration in years] / AT [days]	0.98	0.98
Exposure Duration (ED: years)	16	62
BaP Absorption – Ingestion (ABS: unitless)	1	1
TCDD Absorption – Ingestion (ABS: unitless)	1	1
Body Weight (BW: kilograms)	30	80
Averaging Time (AT: days)	365	365
Frequency (days/year)	350	350
ABS = chemical-specific absorption factor (unitless)		
BaP = benzo(a)pyrene equivalents		
TCDD = trichlorodibenzodioxin equivalents		

REPORT PREPARATION

This Public Health Assessment for the Clinch River Corporation Site was prepared by the Tennessee Department of Health's Environmental Epidemiology Program under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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Certification

This Public Health Assessment: *Evaluation of Environmental Health Concerns Related to the Clinch River Corporation Site, 728 Emory Drive, Harriman, Roane County, Tennessee,* was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the Public Health Assessment was prepared.