Public Health Assessment for

LCP CHEMICALS SUPERFUND SITE
and Adjacent Areas
BRUNSWICK, GEORGIA

EPA FACILITY ID: GAD099303182

APRIL 16, 2014

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. The revised document was released for a 90-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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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PUBLIC HEALTH ASSESSMENT

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Prepared by:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

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Summary

Introduction

The Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia has evaluated environmental data from the LCP Chemicals Superfund Site in Brunswick, Georgia. The LCP Chemicals Superfund Site (LCP Chemicals Site) is located on Ross Road and occupies approximately 813 acres immediately northwest of the city of Brunswick. Tidal marshland covers more than 670 acres of the property. Former manufacturing operations at the LCP Chemicals Site are located on about 133 acres of dry land (upland), east of the marsh.

The current LCP Chemicals Site has been associated with industrial-related activities since at least 1919 (EPS 2007a). An oil refinery, a paint manufacturing company, a power plant, and a chlor-alkali plant have all operated at this site over the years. During various manufacturing activities by several companies, site soils in the dry-land portion of the site, groundwater beneath the site, and the tidal marsh adjacent to the site became contaminated with waste products from these operations (EPA 2011).

In September 2010, ATSDR released this public health assessment as a draft for public comment. The 2010 public health assessment focused on the evaluation of contaminants in soil in the 133 acres of dry-land area because this area is being redeveloped and could be used for either commercial or residential purposes. We received comments on the 2010 report, which are presented in Appendix F.

In addition, EPA collected environmental data since 2010, in part based on recommendations in the 2010 report. New data are available for soils, sediment, and pond water from the dry-land area and for sediment and seafood samples from a portion of the Altamaha Canal, just south of the site.

This final Public Health Assessment for the LCP Site presents the findings, conclusions, and recommendations that were part of the 2010 report as well as new findings, conclusions, and recommendations based on new environmental data.

ATSDR has conducted numerous activities at the site since it was added in 1996 to the National Priorities List of hazardous waste sites. These activities include the following:

- The 2010 public release of this public health assessment focused on the dry-land area. This public release made numerous recommendations to other agencies to collect additional environmental data, which now are part of this final release of the same report.

- A 2005 health consultation for the Arco neighborhood, which evaluated soil samples from the former Arco neighborhood adjacent to the LCP Site.

- A 1999 report about the consumption of seafood and wild game contaminated with mercury to evaluate self-reported symptoms and illnesses for persons who ate locally caught seafood. The report also assesses person's exposure to mercury and provided information that was used to develop recommendations for a seafood consumption advisory.

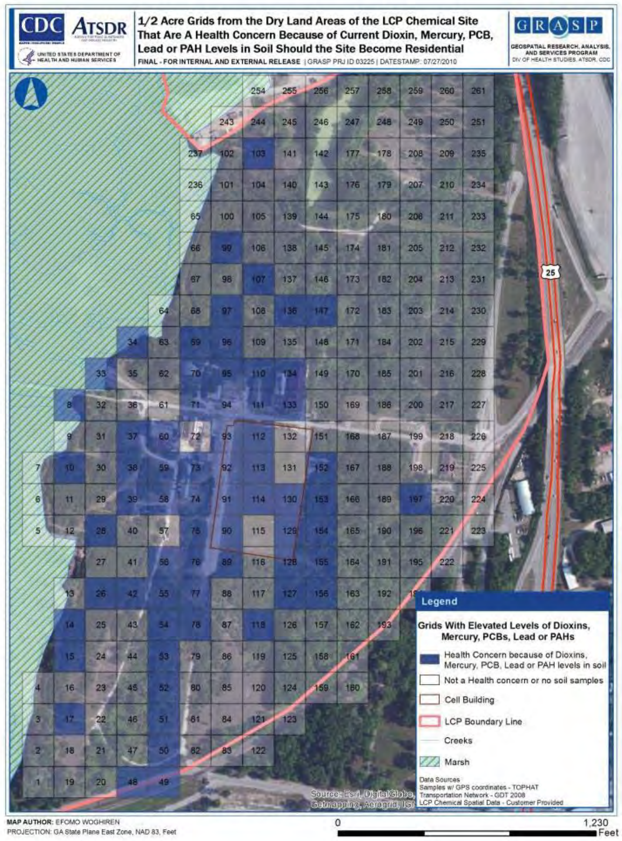
- A series of health consultations from 1994 to 1996 that evaluated the risk of harmful effects from consuming locally caught seafood from the Turtle River System contaminated with hazardous waste from the LCP site. These evaluations were used to develop the initial fish consumption advisory.

Throughout ATSDR's activities at the LCP site, we worked closely with federal, state, and local officials and most importantly with the community to assess the impact that the LCP site may have had on the residents of Brunswick and Glynn County. ATSDR has strived to serve the public by using the best science, take responsive public health actions, and provide trusted health information to prevent people from coming into contact with harmful toxic substances.

Overall Conclusion

ATSDR divided the 133 acres into half-acre grids to determine whether a grid would be a concern for future residential or commercial development. Some of these grids were found to contain harmful soil levels of mercury, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, lead, and dioxins should certain portions of the site be developed.

If the LCP Chemicals Site becomes residential, 66 half-acre grids have at least one chemical in soil that could harm the health of children and adults. If the site becomes commercial or industrial, 9 half-acre grids have at least one chemical in soil that could harm the health of workers (see figures below). Some uncertainty exists in this overall conclusion because uncertainty exists in the amount of chemical exposure that will occur after the site is developed and some dry-land areas were inadequately sampled.



This figure shows the 66 half-acre grids that are a health concern if the LCP Chemicals Site becomes residential.

This figure shows the 9 half-acre grids that are a health concern if the LCP Chemicals Site becomes commercial or industrial.

Conclusions 1–5

Conclusions 1–5 were presented in the September 2010 release of this report for public comment. The basis for these conclusions is environmental soil samples collected by the U.S. Environmental Protection Agency (EPA) predominantly in the 1990s, although a few samples were collected in the early 2000s. These conclusions focus on soil contamination in the dry-land area of the LCP site. During the 1990s, EPA also removed much of the contaminated soils from the site.

Conclusion 1 PCBs in Dry-land Area+

If certain dry-land areas of the LCP Chemicals Site become residential, polychlorinated biphenyls (PCBs) in soil at 41 half-acre grids on the site could harm the health of children and adult.

If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, PCBs in soil in six half-acre grids on the site pose a health risk for commercial and industrial workers.

Basis for Decision (Conclusion 1)

Children and adults who come in contact with high PCBs in soil might experience harmful effects to the immune, dermal, nervous, developmental, and reproductive systems (ATSDR 2000). Specific health effects include

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession,
- Learning and performance problems,
- Problems with attention and impulse control,
- Fewer male births,
- Lower birth weight,
- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women,
- An increase in deaths from Parkinson disease in women,
- An increase in deaths from dementia in women, and
- An increase in diabetes in women.

Children and especially preschool children, with their nervous systems still developing, may be a particularly susceptible group if they come in contact with high PCBs levels in soil in some areas.

Commercial and industrial workers also are at risk of harmful effects if they have contact with soil in six half-acre grids of the site with the highest PCB levels. Their estimated exposure to PCBs could cause the same health effects as listed previously.

Daily contact with PCBs in soil over many years poses a high cancer risk for children and adults should the site become residential. PCBs in soil pose a moderate cancer risk for workers if the site becomes commercial or industrial. Such exposure could put residents and workers at increased risk for several cancers, including cancers of the liver, thyroid, biliary tract, intestines and skin.

Some uncertainty exists when deciding if harmful effects might be expected because very little health information is available on the most common type of PCBs found in LCP soils. Therefore, ATSDR relied upon health information from other types of PCBs. Uncertainty also exists in estimating how much PCBs people will contact once the site is developed and from using results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site. In addition, some dry-land areas were insufficiently sampled.

Six half-acre grids on the site exceed the U.S. Environmental Protection Agency's (EPA) 1994 clean-up level for PCBs of 25 parts per million (ppm) while 41 grids have average PCB concentrations greater than 1 ppm. In the text of this report, see Table 4 for a list of grids that are a concern because of residual PCB contamination and see Figure 34 for their location.

Conclusion 2 Mercury in Dry-Land Area

If certain dry-land areas of the LCP Chemicals Site become residential, mercury in soil in 10 half-acre grids on the site could harm the health of children and the developing fetus if women are pregnant.

If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, mercury in soil in four half-acre grids on the site could harm the health of the developing fetus if a female worker is pregnant. One of these half-acre grids also could harm the health of women who are not pregnant and the health of men.

Basis for Decision (Conclusion 2)

For women who live in the 10 half-acre grids on the site with high mercury concentrations in soil, the estimated intake of mercury from soil approaches or exceeds levels that cause harmful neurological effects to the fetus during pregnancy. Children born to these women might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions. The estimated exposure levels in preschool children who live in these areas also approach or exceed levels that could harm their health. They are at risk of the same neurological effects.

Mercury in soil in four half-acre grids on the site also poses a risk for commercial and industrial workers if the site is developed. Pregnant workers who have contact with mercury in soil in these areas are at risk of exposing their developing fetus to mercury levels that might cause harmful effects after birth. Some children born to women exposed to these levels might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions.

Male and female workers who have prolonged contact with soil from the one half-acre grid with the highest remaining mercury contamination also are at risk of harmful effects. Their estimated exposure level might result in damage to their neurological system, such as diminished sensitivity to pain, diminished touch, decreased fine motor performance, impaired vision, and impaired hearing.

Some uncertainty exists concerning the risk of harmful effects from mercury in soil. The chemical form of mercury in soil at the LCP Chemicals Site has not been well-established, although scientific studies from marsh sediment show that almost half the mercury is organic mercury. Therefore, ATSDR assumed that most of the mercury in soil at the LCP Chemicals Site was organic mercury. There's some uncertainty about whether the organic mercury bound to soil would cause harmful effects. In addition, uncertainty exists in the mercury concentrations in surface soil following development of the site and uncertainty exists from using the results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

Ten half-acre grids exceed EPA's 1994 clean-up level of 20 ppm mercury in soil. See Table 29 for a list of the 10 grids that are a concern because of residual mercury contamination and see Figure 37 for their location.

Conclusion 3 Lead in Dry-land Area

If certain dry-land areas of the LCP Chemicals Site become residential, lead in soil in 28 half-acre grids on the site could harm the health of children.

Basis for Decision (Conclusion 3)

If the site becomes residential, exposure to lead in soil at these 28 half-acre grids could increase children's blood lead levels and result in the following harmful effects:

- Small decreases in IQ,
- An increase in attention deficit hyperactivity disorder,
- Reduced attention span,
- Lack of concentration,
- Decreased fine muscle skills,
- Withdrawn behavior,

- Decreased height,
- Small delays in puberty, and
- Small changes in kidney function.

Some uncertainty exists in this conclusion because uncertainty exists in estimating children's exposure to lead in soil if the site becomes residential. Uncertainty also exists from using the results of soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

See Table 31 for a list of the 28 half-acre grids that are a concern because of residual lead contamination and see Figure 40 for their location.

Conclusion 4 PAH in Dry-land Area

If certain dry-land areas of the LCP Chemicals Site become residential, polycyclic aromatic hydrocarbons (PAHs) in soil in six half-acre grids on the site could harm the health of children and adults.

If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, PAHs in soil in two half-acre grids on the site could harm the health of workers.

Basis for Decision (Conclusion 4)

Daily contact with PAHs in residential soil over many years poses a moderate risk of certain cancers for children and adults. Similarly, workers also have a moderate risk of certain cancers should some areas become commercial or industrial. Such exposure could put residents and workers at increased risk for lung and skin cancers.

Some uncertainty exists in these conclusions because uncertainty exists in estimating how much PAHs people will contact once the site is developed. Uncertainty also exists from using the results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

See Table 35 for the list of half-acre grids that are a concern because of residual PAH contamination and see Figure 41 for their location.

Conclusion 5 Mixtures of PCB, Mercury, and Lead in Dry-Land Area

If certain dry-land areas of the LCP Chemicals Site become residential, contact with soil containing a mixture of PCBs, mercury, and lead (or a combination of these) could harm the health of children.

Basis for Decision (Conclusion 5)	Studies have shown that children exposed to low levels of PCBs, mercury, and lead showed impaired learning of a performance task, resulting in problems with attention and impulse control. Three grids have elevated levels of PCBs, lead, and mercury; eight grids have elevated levels of PCB and lead; and, five grids have elevated levels of PCBs and mercury. See Figure 42 for the location of these grids.
Conclusions 6–12	Conclusions 6–12 are based on new environmental samples collected by EPA after 2010. Many of these samples were collected in response to recommendations from ATSDR in the December 2010 public release version of this report. The new environmental samples consist of soil samples from the dry-land area with a focus on the former drive-in theater and the pond in the northwest corner of the site. EPA also collected sediment and seafood samples from the Altamaha Canal just south of the LCP Site.
Conclusion 6 Dioxin in Dry-land Area	In 2011, EPA collected soil samples from eight, dry-land areas and measured dioxin levels. These dry-land area varied in size and thus consisted of varying numbers of half-acre plots. One sampling area consisting of 30 half-acre plots contained dioxins in soil that could harm the health of children and adults should this area become residential.
Basis for Decision (Conclusion 6)	Daily contact with dioxins in soil in this one area over many years poses a high risk of cancer for children and adults. Human studies have shown that dioxin can cause liver cancer and might be associated with cancers of the lung, colon, prostrate, breast, blood, and lymphatic system. Rodent studies have confirmed that dioxin can cause cancer at multiple sites, including the liver, lung, mouth, and thyroid. In addition, preschool male children who have daily contact with these soils could be at risk of reproductive effects once they reach adulthood. As adults, they might experience problems with (1) decreased number of sperm, (2) decreased number of motile sperm, and (3) fewer male offspring The location of this 30 half-acre area contaminated with dioxin is shown in Figure 43 and is labeled as sampling area 8.
Conclusion 7 Former Theater	In 2010, EPA collected soil samples from the former theater area in the northeast section of the site. Glynn County plans to build a detention center in this area so ATSDR evaluated the risk for adult workers and inmates who might come in contact with chemicals in soil. Mercury, lead, and PCBs in soil from the former drive-in theater area is not expected to harm people’s health.

Basis for Decision (Conclusion 7)	The mercury and lead levels in soil in the former theater area were either below ATSDR's screening levels or the levels were at or near background levels in soils. Therefore, harmful effects from mercury and lead in soil are not likely. The exposure of prison inmates and adult workers to PCBs in soil would be at levels far below ATSDR's health guideline for PCBs. Therefore, PCBs in soil are not likely to cause harmful, non-cancerous effects. The risk of cancer from daily exposure to PCBs in soil is insignificant.
Conclusion 8 On-site Pond	In 2010, EPA collected surface water and sediment samples from the on-site pond in the northwest corner of the dry-land area. The levels of PCBs, mercury, PAHs, and lead in surface water and sediment from the on-site pond are not expected to harm people's health.
Basis for Decision (Conclusion 8)	Levels of PCBs, mercury, PAHs and lead in the on-site pond were either below ATSDR's comparison values or at background levels. In addition, the pond does not serve as a source of drinking water nor does the pond support fish.
Conclusion 9 Sampling Sufficiency for Dry-land Area	Some dry-land areas do not have adequate sampling data; therefore, it is difficult to draw conclusions about whether these unsampled soils could harm people's health. Most of the insufficiently sampled areas are in the southeastern portion of the site (including the cell building area) and in the western dry-land area closest to the marsh. For other areas that have been sufficiently sampled, we are able to draw conclusions about potential health impacts.
Basis for Decision (Conclusion 9)	One reason for the limited sampling in some areas is that EPA decided that some environmental data were unusable because of data quality issues. In addition, some areas were not sampled because LCP Chemicals did not perform industrial activities on certain portions of the site. However, numerous industries occupied the site before LCP's chlor-alkali facility, and those industries could have disposed of waste throughout the property. Approximately half of the grids are considered sufficiently sampled for making a health conclusion for the chemicals PCBs, mercury, and lead. That means that half of the grids require additional sampling in order to be sure that those areas are not contaminated. See Figures 22 through 25 for the dry-land areas considered to have adequate sampling data.

Conclusion 10 Altamaha Canal

In 2011, EPA collected sediment samples from a portion of the Altamaha Canal that exists south of the LCP Site. ATSDR evaluated the risk of harmful effects from exposure to PCBs, mercury, PAHs, and dioxins in sediment along the Altamaha Canal. Adults and children who visit or play along the canal would not be exposed to contaminants in sediment at levels that could cause harmful, non-cancerous effects. It is unlikely that contact with these chemicals in sediment could cause cancer.

Basis for Decision (Conclusion 10)

These chemicals are not a health concern in Altamaha Canal sediment because:

- The concentration of lead in sediment from the canal is at or near background lead levels in soils and is unlikely to cause harmful health effects from direct contact,
- The concentration of mercury is below ATSDR's comparison value; therefore, mercury in sediment is unlikely to cause harmful health effects from direct contact,
- The estimated exposure to dioxins and PCBs for adults and children who visit or play along the canal is well below ATSDR's and EPA's health guidelines. Therefore, harmful non-cancerous effects are not likely. The estimated exposure to PCBs, PAHs, and dioxins for adults and children who visit or play along the canal results in insignificant cancer risks.

Conclusion 11 Mercury in Seafood from Altamaha Canal

In 2011, EPA collected fish and shellfish samples from the canal. ATSDR estimated exposure to mercury from eating various fish and shellfish from the Altamaha Canal and reached the following conclusions about adults and children with typical and high fish consumption:

- Mercury levels in mullet and shrimp from the Altamaha Canal is not expected to harm people's health.
- Mercury levels in blue crab, red drum, and sea trout is not expected to harm the health of typical fish consumers but could harm the health of high fish consumers.

Basis for Decision (Conclusion 11)

Depending upon age and race, high fish consumers eat about 2 to 7 ounces of fish and shellfish daily. Typical fish consumers eat about a half to 2 ounces of fish daily. These daily fish consumption rates do not necessarily mean that people eat fish every day. Their fish consumption averages out to the rates previously described. For example, someone with a daily fish consumption rate of 2 ounces might eat one 14 ounce fish meal a week or two 7 ounces fish meals a week. This frequency and amount of fish consumption averages out to two ounces of fish eaten daily.

- Typical and high fish consumers of mullet and shrimp from the Altamaha Canal have estimated exposures to mercury that are well below levels that cause harmful effects. Typical fish consumers of blue crab, red drum, and sea trout from the Altamaha Canal have estimated exposures to mercury that are well below levels that cause harmful effects.
- High fish consumers of blue crab, red drum, and sea trout from the Altamaha Canal have estimated exposures to mercury that approach levels that can cause harmful effects in young children and in children born to pregnant women who are high consumers. These children might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions.

Some uncertainty exists in the conclusions for sea trout and red drum because only one fish of each species was collected from the Altamaha Canal.

Conclusion 12 PCBs in Seafood from Altamaha Canal

Fish and shellfish from the Altamaha Canal were also found to contain PCBs. ATSDR estimated exposure to PCBs from eating various fish and shellfish from the Altamaha Canal and reached the following conclusions about adults and children with typical and high fish consumption:

- PCB levels in red drum, blue crab, and shrimp is not expected to cause harmful, non-cancerous effects.
- PCB levels in sea trout is not expected to harm the health of typical fish consumers, but could harm the health of high fish consumers.
- PCB levels in mullet could harm the health of typical and high fish consumers.

The results of the fish and shellfish sampling from the Altamaha Canal support the current fish advisory for the Turtle River system issued by the Georgia Department of Natural Resources (GDNR). The Altamaha Canal is tidally connected to the lower Turtle River through several waterways and GDNR has fish and shellfish consumption advice specifically for the lower Turtle River. See Table 46 for more information about the state’s fish and shellfish consumption recommendations for the lower Turtle River.

Basis for Decision (Conclusion 12)

The basis for this decision are:

- Typical and high fish consumers of red drum, blue crab, and shrimp have estimated exposures to PCBs that are well below levels that can cause harmful, non-cancerous effects. Typical fish consumers of sea trout have estimated exposures to PCBs are well below levels that can cause harmful, non-cancerous effects.
- High fish consumers of sea trout and typical and high fish consumers of mullet have estimated exposure to PCBs that approach levels that can cause harmful, non-cancerous effects.

High consumers of sea trout and typical and high consumers of mullet might experience the following harmful effects to the immune, dermal, nervous, developmental, and reproductive systems. Specific health effects include:

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession,
- Learning and performance problems,
- Problems with attention and impulse control,
- Fewer male births,
- Lower birth weight,
- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women,
- An increase in deaths from Parkinson disease in women,
- An increase in deaths from dementia in women, and
- An increase in diabetes in women (ATSDR 2000).

Children and especially preschool children, with their nervous systems still developing, may be a particularly susceptible group.

Children and adults who frequently eat mullet from the Altamaha Canal for many years also have a high increased risk for several cancers, including cancers of the liver, thyroid, biliary tract, intestines and skin.

Next Steps

ATSDR recommends

1. Restricting some LCP Chemicals Site areas from residential development unless further steps are taken to prevent contact with PCB, mercury, lead, PAH, and dioxin contamination that remains in soil on the property.

2. Restricting some LCP Chemicals Site areas from commercial or industrial use unless further steps are taken to prevent contact with PCB, mercury, and PAH contamination that remains in soil on the property.

3. Additional soil sampling in and around the former cell building’s footprint because of residual soil contamination if future plans include development of this area.

4. Additional sampling in areas where sampling data are limited. In general, the western portion of the site has been sampled more than the eastern portion. Particular attention should be given to the former cell building area should the land use change and to future enclosed structures built above the caustic brine pool area.

5. Continued monitoring of fish and shellfish in the Turtle River and in the marsh near the LCP Chemicals Site. The Georgia DNR continues to monitor seafood in the area and to maintain the fishing advisory for the Turtle River System.

6. Continuation of the GDNR's fish advisory for the Turtle River System. The major components of this advisory are provided in Tables 43-46 of this health assessment. GDNR's recommendations for the lower Turtle River (see Table 46) apply for fish obtained from the Altamaha Canal. The 2013 GDNR fish advisories for rivers, lakes, and estuaries in Georgia, including the Turtle River system, can be found at this website: http://www.gaepd.org/Documents/fish_guide.html. To view their brochure, click on "Guidelines for Eating Fish from Georgia's Waters, 2013".
   In addition, GDNR has a brochure, 'A woman's guide for eating fish and seafood from coastal Georgia'. This brochure is available at http://health.state.ga.us/pdfs/environmental/chemhazard/fish%20consumpti n/wfcg_coastal.pdf.

For More Information

ATSDR's Public Health Assessment for the LCP Chemicals Superfund Site is available at this internet address: http://www.atsdr.cdc.gov/sites/lcp/.

For more information about ATSDR's work at the LCP Chemicals Superfund Site, you should contact ATSDR at 1-800-CDC-INFO (1-800-232-4636) and ask to be transferred to Dr. David Mellard or you can dial Dr. Mellard direct at 770-488-0727.

I. PURPOSE AND PUBLIC HEALTH ISSUES

The purpose of this document is to describe ATSDR's public health assessment activities at the LCP Chemicals Superfund Site (aka LCP Chemicals Site) and to provide the Agency's opinion about the public health significance of exposure to chemicals at the site. A public health assessment (PHA) is a document prepared after an evaluation of pertinent environmental data, community concerns, and, when appropriate, health outcome data, to determine whether people have been, are being, or will be exposed to hazardous substances; and, if so, whether those exposures are harmful. If the exposure is harmful, ATSDR will recommend actions to prevent or reduce those exposures.

The LCP Chemicals Site was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL) in June 1996. In the 1990s, ATSDR prepared several health consultations (HC) for the site, most of which focused on potential health impacts from eating local fish and seafood. However, the community remained concerned because ATSDR had not prepared a PHA for the LCP Chemicals Site. A local environmental group, the Glynn Environmental Coalition, requested that ATSDR conduct a PHA for the LCP Chemicals Site. ATSDR reviewed its activities at the site and in 2004 agreed that a PHA was warranted. Staff members from ATSDR were assigned and conducted additional site visits to learn about community concerns. During these initial meetings, residents expressed concern about whether site-related contaminants might have migrated into the nearby Arco neighborhood, and whether these potential exposures could result in adverse health effects. ATSDR worked with EPA, Honeywell, [one of the parties responsible for the contamination], and the Glynn Environmental Coalition to create a neighborhood soil sampling plan. These efforts resulted in another HC focused specifically on neighborhood soil issues; this HC was released in 2005.

Since that time, ATSDR staff has worked to understand the extensive environmental data that exist for the LCP Chemicals Site. Because the LCP Chemical property is scheduled for redevelopment, ATSDR focused on potential exposures to future populations once the site is redeveloped.

ATSDR prepared this PHA using available data. At the time of publication of this document, a full evaluation of the nature and extent of groundwater contamination (defined by EPA as Operable Unit 2) had not been completed. Therefore, ATSDR will focus this PHA on the dry-land soils region of the LCP Chemicals Site, with some information about the pond and marsh areas that also are part of the site, and the off-site Altamaha Canal area. EPA documents refer to the dry-land areas as upland soils; EPA's investigations of these areas are part of Operable Unit 3.

The public comment version of this document was released in September 2010. ATSDR received comments on the document from the general public and other third party entities. ATSDR's responses to the comments are in Appendix F of this document. ATSDR has added to this document an evaluation of new environmental data received since the public comment release in September 2010. The evaluation of new data is discussed separately.

II. BACKGROUND

II.A. Site Description

The LCP Chemicals Site is located on Ross Road in Brunswick, Glynn County, Georgia. It occupies approximately 813 acres immediately northwest of the city of Brunswick. The site is bordered by a county land disposal facility and a pistol firing range on the north, Ross Road on the east, the Turtle River and associated marshes on the west, and Georgia-Pacific Cellulose to the south. (See Figure A1 in Appendix A). Tidal marshland comprises more than 670 acres of the property. Former manufacturing operations at the LCP Chemicals Site were located on approximately 133 acres of dry-land area, east of the marsh (EPS 2007a).

II.B. Site History

The current LCP Chemicals Site has been associated with industrial-related activities since at least 1919 (EPS 2007a). An oil refinery, a paint manufacturing company, a power plant, and a chlor-alkali plant have all operated at this site over the years. During various manufacturing activities by several companies, site soils, groundwater, and the tidal marsh became contaminated. The contamination resulted from past manufacturing operations at the site (EPA 2011).

Past industrial operators and activities include:

- ARCO Petroleum (1919–1935), a successor of the Atlantic Refining Company, operated the site as a petroleum refinery that refined crude oil into fuel and oils. At one time, over 100 process and storage tanks were present on site. ARCO may have released petroleum products and wastes onto the ground.

- Georgia Power (1937–1950s) purchased portions of the site at various times between 1937 and 1950. The property purchased by Georgia Power included two parcels of land, two 750 kilowatt (kW) electric generators, and an additional 4.0 megawatts of electric generation capacity. Georgia Power may have released polychlorinated biphenyls (PCBs) onto the ground.

- The Dixie Paint and Varnish Company (later known as the Dixie O'Brien Corporation) (1941-1955) operated a paint and varnish manufacturing facility on a portion of the site south of the Georgia Power parcel. The Dixie Paint and Varnish Company is reported to have generated lead- and mercury-containing wastes at the site. These wastes may have been released by the O'Brien Paint Company operations at the site from 1942 to 1955.

- Allied Chemical and Dye Corporation (aka, AlliedSignal; Honeywell) (1950s–1979) acquired most of the land constituting what is now known as the LCP Chemicals Site. Allied Chemical operated a chlor-alkali facility at the site, principally for the production of chlorine gas, hydrogen gas, and caustic solution. The plant operated using the mercury cell process, which involves passing a concentrated brine solution between a stationary graphite or metal anode and a flowing mercury cathode to produce chlorine gas, sodium hydroxide (caustic) solution, and hydrogen gas, as a by-product. Sodium hypochlorite (bleach) was also produced in a secondary reaction.

Allied Chemical may have released mercury, mercury-containing wastes, and other chemicals onto the ground.

- LCP Chemicals (1979–1994) purchased the property and chlor-alkali plant in 1979. The chlor-alkali process continued with modification following the purchase. Part of the modification included the production of hydrochloric acid by reacting chlorine and hydrogen. LCP Chemicals is reported to have released mercury, mercury-containing wastes, and other chemicals onto the ground at the site before ceasing operations in 1994.

Upon the plant's closing in February 1994, the State of Georgia asked EPA to take immediate action at the site to address the threat of releases of chlorine gas and the flow of contamination into the adjacent saltwater tidal marsh containing endangered species. In 1994, EPA issued a Unilateral Administrative Order for Removal (UAO) which directed cleanup operations at the site. The LCP Chemicals Site was proposed for listing on the National Priorities List (NPL) in October 1995. The site was finalized on the NPL in June 1996 (EPA 2002).

The LCP Chemicals Site is currently divided into operable units to address the different contaminated media at the site. Operable Unit 1 (OU1) previously represented the marsh and dry-land soils and OU2 represented groundwater. In 2005, EPA redefined the operable units as follows: OU1 represents the marsh, OU2 represents groundwater, and OU3 represents the dry-land (upland) soils. OU3, dry-land soils, is the focus of this public health assessment ATSDR also reviewed data from the on-site pond, the marsh, the Altamaha Canal and other off-site areas. Other OUs may be examined when the data are available for review.

II.C. Summary of Removal Response Actions

Between 1994 and 1997, a removal action was performed on the dry-land portion of the Site. The removal action included the excavation of contaminated soils and industrial process waste from 26 discrete areas. A total of approximately 167,000 cubic yards of soil, sediment, and waste was removed during these actions. The removal areas contained material contaminated with constituents including petroleum hydrocarbons (volatile and semi-volatile organic compounds), mercury, alkaline sludge, polychlorinated biphenyls (PCBs), and lead. Between 1998 and 1999, the removal response action was extended to approximately 13 acres within the marsh and 2,650 linear feet of tidal channels (EPA 2011).

During the removal response action, the petroleum process buildings and the mercury cell buildings were among the structures dismantled onsite. The mercury cell buildings were demolished to the slab at grade and the area capped and fenced.

As stated above, the LCP Chemicals Site is comprised of 3 operable units: OU1 represents the marsh, OU2 represents groundwater, and OU3 represents the dry-land soils. The cleanup/removal activities for each operable unit are summarized below.

II.C.1. Marsh (OU1)

A large dispersion of mercury and polychlorinated biphenyls (PCBs) occurred throughout the marshlands as a result of the chemical manufacturing processes undertaken at the site between

1955 and 1979. EPA estimates that more than 380,000 pounds of mercury were "lost" in the area during this period. In addition to mercury and PCBs, lead, other metals, and volatile organic compounds contaminated the marshlands area, a 1-mile portion of the Turtle River, and the entirety of Purvis Creek (EPA 2011).

Mercury and PCBs were detected in aquatic life at levels sufficient to produce a ban on commercial fishing in these areas and a seafood consumption advisory for parts of the river and all of the creek. In 1992, the Georgia Environmental Protection Division (GEPD) issued a seafood consumption advisory for fish, crabs, oysters and other seafood harvested in the Turtle River estuary after mercury and PCBs were found in seafood samples. The seafood consumption advisory remains in effect at the time of the publication of this document and is available at this State of Georgia website: http://www.gaepd.org/Documents/fish_guide.html (GDNR 2012).

Between 1998 and 1999, a removal response action was conducted on approximately 13 acres within the marsh and 2,650 linear feet of tidal marshes. Removal activities included the excavation and off-site disposal of contaminated sediment and waste materials as a part of EPA's Remedial Investigation/Feasibility Study (RI/FS), additional ecological (biota and sediment) sampling was conducted.

II.C.2. Groundwater (OU2)

Groundwater monitoring has occurred periodically at the site since 2001. Leakage of mercury contamination was discovered beneath a sandstone layer. As a result, horizontal wells were installed in 2002 (approximately 75 feet below ground surface). In addition, a caustic brine pool which has a high pH was discovered beneath the site. A phytoremediation project was approved by EPA during November 2003. The purpose was to locally suppress the groundwater table to prevent seepage of groundwater to the marsh and staining of marsh sediments from occurring (EPA 2009). The phytoremediation project is reported to have failed because all of the poplars and many of the pine trees died (GDNR 2010).

EPA negotiated an Administrative Order of Consent (AOC) with Honeywell on April 18, 2007. According to the AOC, the caustic brine pool (CBP) will be extracted to meet the following removal action objectives: 1) reduce the pH of the CBP to less than 10.5, and 2) reduce the density of the CBP. The removal action began on September 25, 2007.

As of 2012, a total of 138 monitoring wells and 12 horizontal wells are on the site (EPS 2012). In 2012, Honeywell tested the feasibility of using CO_2 sparging to remediate the subsurface CBP. The results of the test show that CO_2 sparging is an effective technology for full-scale implementation at the site, and should be conducted over a multiple-year, sequential effort (Mutch Associates 2013). The results of the sparging effort were not available at the time of publication of this document.

II.C.3. Upland Soils (OU3)

A removal response action was performed on the dry-land (upland) portion of the LCP Chemicals Site from 1994 to 1997. The removal action included the excavation of contaminated soils and industrial process waste from 26 geographical areas on the site. A total of approximately 167,000 cubic yards of soil and waste was removed during these actions. The removal areas contained material contaminated with constituents including petroleum hydrocarbons (volatile and semi-volatile organic compounds), mercury, alkaline sludges, polychlorinated biphenyls (PCBs), and lead. (EPA 2009)

During the removal response action, the petroleum process buildings and the former mercury cell buildings were among the structures dismantled. The mercury cell buildings were demolished to slab and the area capped and fenced.

II.D. Site Features

A dominant physical feature of the site is the approximately 670 acres of tidal marsh located in the western areas of the site. The salt marsh is characterized by a flat, heavily vegetated surface dissected by numerous channels and larger creeks under tidal influence from nearby Turtle River. The dry-land area to the east of the marshland is characterized by gently sloping terrain ranging from approximately 5 feet above mean sea level along the marsh/dry-land border to an elevation of approximately 15 feet along Ross Road. This area of the site is roughly divided in half by the east-west entrance road (EPS, 2007a) (See Figure A2 in Appendix A). Other notable features include an onsite pond and a former drive-in theater in the northern portion of the site (See Figure A3 in Appendix A).

The locations of the site's past industrial operations and staging areas are depicted in Figure A4 in Appendix A. A total of 26 discrete removal areas were delineated on the site. Operations related to the chlor-alkali process were primarily located in the areas south of the entrance road and the area of the boiler house, along with smaller isolated waste disposal areas dispersed over the northern half of the site. Refinery operations were present over most of the dry-land areas (EPA 2009).

II.E. Site Visit

Staff members from ATSDR visited the LCP Chemicals Site on several occasions to conduct activities as part of the PHA process. Beginning in September 2004, ATSDR conducted a public availability session to speak with the community to gather community concerns and to assess site conditions. ATSDR conducted additional visits in October 2006, March 2007, and July 2009. ATSDR also met with state, local, or Honeywell representatives on numerous other occasions from 2004 until present.

During our March 2007 visit, staff members from ATSDR, Honeywell, EPA, and the Glynn County Health Department toured the site by land and car. At the time of the visit, all industrial operations at the site had ceased. Many of the industrial buildings and structures had been removed from the site. An office building and a guard house stood at the entrance of the site. The footprint of several demolished buildings could be observed only by the above ground concrete pads.

The LCP Chemicals Site is currently surrounded by barbed-wired fencing on all sides except for the back of the site which faces Purvis Creek and the Turtle River. Purvis Creek is accessible from the Turtle River. Vehicle entry to the site is controlled by a guard at the main gate. During site operations, residences were located just outside the fence on the southeastern boundary of the site. Recently, a portion of the Arco neighborhood southeast of the site was torn down. Currently, the closest residential areas are approximately 300 yards north of the site and about 600 yards southeast of the site.

There are no full-time production workers at the facility. However, there are full-time and/or part-time employees who work in the administration and security buildings. Remedial workers occasionally access the site to conduct site-related remedial activities.

II.F. Demographics

Demographic information characterizes the populations potentially affected by the site and the current population trends. Identifying the presence of potentially sensitive populations, such as young children (aged 6 and under), the elderly (aged 65 and older), and women of childbearing age (ages 15 to 44), is particularly important because these sub-groups could be more sensitive to environmental exposures than the general population.

According to the 2010 U.S. census, approximately 4,202 people live within a 1-mile radius of the site. Of this total population, approximately 451 are children aged 6 and younger, 519 are adults aged 65 and older, and 827 are women of childbearing age. See Figure A5 in Appendix A for more detailed demographic information.

II.G. Past ATSDR Health Evaluations

At various times throughout the history of this site, ATSDR has evaluated potential risks for humans near the LCP Chemicals Site, including the Arco neighborhood. A summary of ATSDR's past activities and reports is included below to highlight the progression of events and activities at the site. Full reports may be obtained by contacting any of the contacts listed at the end of this report, by calling ATSDR's toll-free hotline at 1-800-CDCINFO, or by visiting ATSDR's website for the LCP Chemicals Site at this URL: http://www.atsdr.cdc.gov/sites/lcp/.

II.G.1. Health Consultation, Arco Neighborhood 2004 Soil Samples – June 2005

ATSDR prepared a report in June 2005 titled, Health Consultation, Arco Neighborhood 2004 Soil Samples, LCP Chemicals Site (ATSDR 2005a). This health consultation (HC) evaluated the public health significance of certain chemicals in soil in the Arco neighborhood. The HC was prepared in response to residents' concern about soil contamination in their neighborhood because of past industrial activities related to the LCP Chemicals Site. EPA collected soil samples from residential yards and measured for mercury, lead, arsenic, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs), which included Aroclor 1268.

ATSDR concluded that:

- The concentration of lead at all but one of the properties in the Arco neighborhood is not a public health hazard. The lead contamination at one property in the Arco neighborhood was a public health hazard for children aged 6 and younger who might frequently play there.

- The levels of other chemicals (arsenic, mercury, PAHs, and PCBs) in soil from the Arco neighborhood are not a public health hazard.

II.G.2. Final Report, Consumption of Seafood and Wild Game Contaminated with Mercury – July 1999

In July 1999, the Glynn County Health Department (GCHD), in cooperation with ATSDR, conducted a study that evaluated the potential health effects associated with consuming seafood and wild game from the Turtle River and its tributaries (GCHD 1999). The study was in response to concerns regarding the consumption of mercury-contaminated seafood and wild game from these areas. The GCHD conducted a community-based study which compared 211 residents who may have been exposed to mercury by consuming seafood and wild game from the waters of the Turtle River (target group) to 105 residents who reported that they had not consumed seafood and wild game from those areas (comparison group).

The objectives of the study were: 1) to compare the prevalence of self-reported symptoms and illnesses between target and comparison group participants; 2) to determine seafood and wild game consumption levels among study participants and to assess the accuracy of the self-reported consumption levels; 3) to provide a basis for developing sound recommendations for seafood consumption advisories to the community; and 4) to assess individuals for evidence of mercury exposure using biological evidence (24-hour urine mercury test).

GCDH concluded that:

- Participants in the target group reported a statistically higher number of symptoms compared with participants in the comparison group. The symptoms were lightheadedness, difficulty concentrating, trouble remembering, problems retaining reading/conversations, irritability, and sleep changes.
- Respondents generally underestimated their amount of seafood consumption as reported in the questionnaire when compared to the amount they reported actually consuming as measured by the two-week dietary diary.
- Seafood comprised a smaller proportion of protein in study participants' diets than anticipated.
- The current seafood consumption guidelines are protective for the general public because individuals are not consuming more seafood per meal than values used in calculating the consumption guidelines.
- The majority of study participants do not fish in the restricted area; the few that do, however, state that they are aware of the advisory.
- All study participants had urine mercury concentrations levels below the reference level of 20 µg mercury/g creatinine.
- There is evidence that the target group consumed seafood from the restricted area, without evidence of high mercury burden.

Additionally, the GCDH recommended continued public education about the hazards of consuming contaminated seafood and continued monitoring of mercury levels in seafood and wild game.

One of the study objectives was to assess mercury exposure in recreational, commercial, and subsistence fishers. Of the 101 (65%) target group participants who self-reported which type of fisher they were:

- 97 (96%) classified themselves as recreational fishers,
- 3 (3%) identified as commercial, and
- 1 (1%) identified as subsistence fisher.

Therefore, the study results reflect characteristics of recreational fishers and do not necessarily apply to commercial or subsistence fishers.

In addition, urine mercury results might have been influenced by prior knowledge of the risks associated with mercury in fish. Participants might have reduced their fish intake following the dietary recall survey as they realized that they might be consuming too much mercury-contaminated fish. A more appropriate test of mercury exposure would have been hair mercury levels because it is a better indicator of long-term methylmercury exposure than urinary mercury levels. A more appropriate reference level to determine whether excessive urinary mercury levels were present would have been 2 micrograms per gram creatinine (μg/g) instead of 20 μg/g.

And finally, it should be noted that African-Americans made up only 4% (9 out of 211) of the people who participated in the study. African-Americans make up 26% of the population of Glynn County and nearly 40% of the population within four miles of the LCP Chemicals Site. Therefore, African-Americans are underrepresented in the Brunswick fish study.

A study of fishers along the Savannah River showed that African-Americans

- Eat more fish meals per month than whites (average, 5.4 vs. 2.9),
- Eat slightly larger portions than whites (average, 13.7 oz. vs. 13.1), and
- Eat higher amounts of fish per month than whites (average, 75 ounces vs. 41 ounces).

It is reasonable to assume that the fish-eating habits of African-Americans in Brunswick, Georgia, are similar to African-Americans along the Savannah River. Therefore, African-Americans who fish along the Turtle River are likely to have higher exposure to mercury from eating fish than whites. The results of the Brunswick fish study should not be applied to African-Americans in the Brunswick area for those reasons.

II.G.3. Health Consultation, LCP Chemical – October 1996

ATSDR prepared a HC in October 1996 to evaluate post-removal conditions at the LCP Chemicals Site. The HC was prepared in response to concerns about conditions after on-site removal and containment actions had been completed, and whether contaminant levels in seafood were a public health hazard. [ATSDR had previously identified the site as a public health hazard in August 1994 because the uncontrolled release of mercury into the environment posed an imminent threat to human health (ATSDR 1994)]. From 1994 to 1996, extensive seafood sampling took place and several studies were in progress, including the Emory University Former LCP Workers Health Study and the Brunswick Area Fish Consumption Study. However, at the time of the release of the 1994 health consultation, ATSDR did not have sufficient information to determine whether exposures to contaminants were occurring at levels that could be a health concern.

Therefore, ATSDR concluded in 1996 that:

- The LCP Chemicals Site is an indeterminate public health hazard because there is insufficient exposure information to support any other public health classification. However, this classification may change when additional pending data are evaluated. (e.g., results from the seafood consumption survey).
- The food chain in the LCP marsh, the Turtle River, and Purvis Creek and its tributaries is contaminated with mercury and PCBs because of past disposal practices.
- On-site removal and containment have stopped the movement of contaminants into the marsh.
- Marsh sediments are contaminated because of past disposal practices due to migration from the LCP Chemical Site.
- The nature and extent of groundwater contamination in the shallow aquifer is unknown. The water that people use for drinking is not contaminated.
- On-site surface and subsurface soils are contaminated but do not pose a health threat to people off-site because they have no contact with on-site soils.
- Off-site soils are not contaminated from past disposal practices.
- Several data gaps are yet to be filled (e.g., fish consumption and health studies).

II.G.4. Health Consultation, LCP Chemical – August 1994

In 1994, ATSDR prepared its first HC for the LCP Chemicals Site that evaluated the public health implications of exposure to mercury and PCB-contaminated seafood along areas of Purvis Creek and the Turtle River. Seafood samples collected in 1991, 1992 and 1993, revealed the presence of elevated levels of mercury and PCBs.

After evaluating the data, ATSDR concluded in 1994 that:

- Residents who have consumed fish and shellfish from Purvis Creek and other restricted fishing areas nearby may have been exposed to unsafe levels of PCB and mercury prior to the fish advisory.
- Exposures to contaminated fish may be ongoing due to noncompliance or lack of awareness of the existing fishing advisory.
- Fish and shellfish may continue to bioaccumulate mercury and PCBs until the source of contamination is removed.
- There is no evidence of residents being exposed to on-site or off-site surface water and sediment contamination.
- Since off-site private wells are upgradient from the site, it is unlikely that offsite wells are contaminated.

III. EVALUATION OF EXPOSURE PATHWAYS

To determine whether nearby residents or on-site workers could be exposed to contaminants on the site, ATSDR will now describe the environmental and human components that could result in exposure to remaining contaminants on the site or to contaminants that have migrated off site.

III.A. What is an exposure pathway?

> An exposure pathway has five elements: (1) a source of contamination, (2) an environmental media, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population.
>
> The source is the place where the chemical was released. The environmental media (such as groundwater, soil, surface water, or air) transport the contaminants. The point of exposure is the place where people come into contact with the contaminated media. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people actually exposed are the receptor population.

ATSDR's PHAs are driven by exposure to, or contact with, environmental contaminants. Contaminants 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 in contact with that contaminant—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant. If no one comes in contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come in contact with the contaminants.

The route of a contaminant's movement is the *pathway*. ATSDR identifies and evaluates exposure pathways by considering how people might come in contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing (inhaling), eating (ingesting), drinking (ingesting), or by skin (dermal) contact with a substance containing the chemical contaminant. ATSDR identifies an exposure pathway as completed or potential, or in some cases eliminates the pathway from further evaluation.

III.A.1. Completed Exposure Pathways

Completed exposure pathways exist for a past, current, or future exposure if contaminant sources can be linked to a human receptor population. All five elements of the exposure pathway must be present. In other words, people have contact or are likely to come in contact with site-related contamination at a particular exposure point via an identified exposure route. As stated above, a release of a chemical into the environment does not always result in human exposure. For an exposure to occur, a completed exposure pathway must exist. Completed exposure pathways require further evaluation to determine whether exposures are sufficient in magnitude, duration, and frequency to result in adverse health effects.

IIIA.2. Potential Exposure Pathways

Potential exposure pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. It exists when one or more of the elements are missing or uncertain, but available information indicates possible human exposure.

A potential exposure pathway is one which ATSDR cannot rule out, even though not all of the five elements are identifiable.

III.A.3. Eliminated Exposure Pathway

An eliminated exposure pathway exists when one or more of the elements are missing. Exposure pathways can be ruled out if the site characteristics make past, current, and future human exposures extremely unlikely. If people do not have access to contaminated areas, the pathway is eliminated from further evaluation. Also, an exposure pathway is eliminated if site monitoring reveals that media in accessible areas are not contaminated.

Site-specific characteristics are used to determine whether completed, potential, or eliminated exposure pathways exist at a site. The completed, potential, and eliminated exposure pathways for the LCP Chemicals Site are listed in the Table 1. Each of the identified exposure pathways is explained further in the following section.

III.B. Exposure Pathways at the LCP Chemicals Site

This section identifies and discusses completed and potential exposure pathways associated with past, present and future use of the LCP Chemicals Site.

III.B.1. Completed Exposure Pathways

III.B.1.a. On-site Soils

Pre- and post-remedial soil sampling data confirm the presence of contaminants in on-site soils. However, access to the site property is restricted and there are no on-site workers or residents (except for limited security staff and occasionally remedial workers). Thus, current exposure to contaminants in on-site soil is limited to the occasional trespasser who might access the site by breaching security measures or by arriving onsite via the river. The trespasser is assumed to engage in general recreational activities such as walking, hiking, riding a bike, or riding an all-terrain vehicle (ATV). The trespasser may be exposed to soil by accidentally swallowing it (ingestion), inhaling it (inhalation), and touching it (dermal contact). The typical trespasser is assumed to be an older child (7 through 18 years of age) or an adult (19 years and older). However, because trespassing events would occur infrequently, if at all, ATSDR concluded that trespassers are not likely to be exposed to high enough levels of contaminants in soil to cause adverse health effects.

When industrial activities were taking place on the site, workers were likely exposed to contaminants in soil as they performed their job-related duties or otherwise accessed outdoor areas (e.g., outdoor lunches, traveling to and from other buildings, etc.). The frequency, duration, and magnitude of exposure would vary depending on the type of job performed and the area in which it was performed. The typical worker exposure scenario includes incidental swallowing of and dermal contact with soil.

Table 1. Completed and Potential Exposure Pathways Identified at the LCP Chemicals Site, Brunswick, GA (All OUs)							
Exposure Pathway	***Exposure Pathway Elements***					***Time Frame***	***Comments***
	Sources of Contamination	***Fate and Transport***	***Point of Exposure***	***Exposed Population***	***Route of Exposure***		
Completed Exposure Pathways							
On-site Soil							
Surface and subsurface soils on the facility property	Wastes from previous industrial operations at the site	Improper disposal or spillage onto ground	On-site property	Former facility workers, remedial workers, future residents/property owners	Ingestion Dermal Inhalation	Past Present Future	Currently, the facility is not operational. Most of the property is fenced and access is restricted. Therefore, contact with on-site soil is limited except to the occasional trespasser. However, the site may be developed in the future for any use (residential, commercial, etc.).
Seafood							
Seafood from nearby rivers and waterways	Wastes from previous industrial operations at the site	Surface water runoff, waste seeps into the Turtle River; uptake and bioaccumulation of contaminants in aquatic organisms	Entire Turtle River system	People eating contaminated seafood from affected areas	Ingestion	Past	Seafood consumption advisories have been issued for the Turtle River system. This advisory should reduce people's exposure to contaminated seafood. Therefore, consumption of contaminated seafood prior to the issuance of the advisory was a past, completed exposure pathway.

Table 1. Completed and Potential Exposure Pathways Identified at the LCP Chemicals Site, Brunswick, GA (All OUs)							
Exposure Pathway	***Exposure Pathway Elements***					***Time Frame***	***Comments***
	Sources of Contamination	***Fate and Transport***	***Point of Exposure***	***Exposed Population***	***Route of Exposure***		
Potential Exposure Pathways							
Groundwater							
Private groundwater wells	Wastes from previous industrial operations at the site	Migration of contaminated groundwater into areas with private wells, municipal supply wells	Residential tap water; other potable water taps	People with nearby private wells and others not connected to public water supply	Ingestion Dermal Inhalation	Past Future	The extent to which private wells are used in the area is uncertain. The groundwater investigation is completed; only groundwater monitoring and treatment (CBP) are ongoing. This pathway remains a potential future pathway in case the plume migrates to areas with private wells. Groundwater is not evaluated in this document.
Off-site Soil							
Off-site Soil	Wastes from previous industrial operations at the site	Surface water runoff ; air deposition; off-site dumping	Residential yards and public places near the site or off-site dumping areas	People in nearby neighborhoods, communities, schools	Ingestion Dermal Inhalation	Past Current Future	Residents report the existence of off-site dumping areas. Also, the nearby Arco neighborhood was previously sampled and did not contain unsafe levels of contaminants, except for lead. These potential off-site areas should be revisited if planned for re-development.
Surface water and Sediment							
Surface water and Sediment	Wastes from previous industrial operations at the site	Surface water runoff; marsh seeps	Turtle River estuaries and tributaries; Altamaha Canal	People recreating in or near the Turtle River or the Altamaha Canal	Ingestion Dermal Inhalation	Past Current Future	Sediment in the marsh was found to contain elevated levels of contaminants. Therefore, contact with sediment or surface water is a potential exposure pathway.

Table 1. Completed and Potential Exposure Pathways Identified at the LCP Chemicals Site, Brunswick, GA (All OUs)							
Exposure Pathway	***Exposure Pathway Elements***					***Time Frame***	***Comments***
	Sources of Contamination	***Fate and Transport***	***Point of Exposure***	***Exposed Population***	***Route of Exposure***		
Soil Gas							
Indoor Air	Wastes from previous industrial operations at the site	Migration of subsurface waste vapors into indoor air	Enclosed structures over contaminated soil or groundwater	People living or working in homes or buildings built over contaminated subsurfaces (e.g., caustic brine pool)	Inhalation	Future	The potential for migration of vapors into indoor structures should be examined if the site is re-developed. Mercury vapors are of particular concern for this potential pathway.

ATSDR's evaluation included residential development as a future use because residential development was considered in EPA's assessment of the property (e.g., EPA's draft Human Health Risk Assessment considers a future on-site resident in the exposure assessment) and because residential use has not been ruled out. Although Honeywell claims in some reports that the site is intended to remain industrial, they acknowledge the potential for some mixed land use of the property and/or the possibility that some portion of the site might be used as residential property in the future. Therefore, ATSDR believes it prudent to evaluate all possible future scenarios to be protective of public health.

In the future, the site property can be developed for any use, including commercial, industrial, or residential use. While the property is zoned for industrial use, land use can change with time; therefore, ATSDR will assume that the intended future land use is mixed-use residential, commercial, or industrial. The exposures in these settings would occur by incidental swallowing, dermal contact, and inhalation of contaminants from contaminated soil. It should be noted that EPA's risk assessment for the LCP Chemicals Site also includes a residential exposure scenario.

III.B.1.b. Fish and Shellfish

Site-related wastes have entered nearby marshes and aquatic areas. These wastes are present in the water column and/or are attached to bottom sediment or particles in the water. PCBs and other contaminants are taken up into the bodies of small organisms and fish in water. They are also taken up by other animals, including humans that eat these aquatic animals as food. Previous data have shown that some species of fish from the Turtle River contain elevated levels of mercury, PCBs, and other contaminants. The GCHD has determined that the levels of these contaminants in some fish are high enough to cause health problems (see discussion above in *Past ATSDR Health Evaluations* section). The GDNR currently monitors contaminant levels in fish and shellfish from the Turtle River system and has issued fish consumption guidelines (*Guidelines for Eating Fish from Georgia Waters*) designed to protect consumers from experiencing health problems associated with eating contaminated fish from the Turtle River system. These guidelines are available on the internet at http://www.georgiawildlife.com/node/705.

A local environmental group, the GEC, published a "Seafood Consumption Advisory for Turtle River" which sets out in plain language the recommended limits on the consumption of fish and seafood from the Turtle River system (see Appendix D.) Along with the GDNR's fish advisory, these public health actions are believed to have reduced the amount of contaminated fish and seafood from the Turtle River system eaten by residents, although it is possible that some contaminated fish are still eaten by people who are not aware of the advisory or who disregard it.

Although the biota pathway is completed, ATSDR will not re-evaluate the data in this document because the agency has released two health consultations on the topic. In addition, the GCHD and the GDNR have already done extensive work evaluating fish and seafood in the Turtle River and have issued consumption advisories for residents to follow. However, in 2011, EPA collected fish and shellfish samples from the Altamaha

Canal. Neither ATSDR nor any other agency had evaluated these data. ATSDR did evaluate in this document the fish and shellfish data for samples collected from the Altamaha Canal in 2011.

III.C. Potential Exposure Pathways

III.C.1. Groundwater

The drinking water supply for the area is composed of private wells and the Brunswick municipal wells. The municipal wells draw water from the Upper Floridan Aquifer while the private wells are drilled at a wide range of depths. Within a 4-mile radius of the site, the municipal system serves approximately 28,000 residents and private wells serve approximately 5,000 residents (EPS 2007a).

A 1995 well inventory report indicated that private wells in the vicinity had not been impacted by site-related contaminants because they are located upgradient of the site (EPS 2007a). More recent sampling efforts have found no site-related contaminants in private or municipal wells. According to local officials, to date, no private or municipal wells in the area have been impacted by site-related contaminants (EPS 2007a). However, given that contaminants in groundwater move over time, it might be possible in the future that contaminants from the site can migrate to previously uncontaminated wells. Although highly unlikely, future developers/residents may drill new wells into the contaminated groundwater. If this happens, future workers/residents would be exposed via ingestion, inhalation, and dermal contact with contaminated water.

III.C.2. Off-Site Soil

The off-site areas are comprised of the current and former Arco community located southeast of the site and the off-site areas along New Jesup Hwy/Newcastle Street that were former tank farms. Portions of the Arco community are currently owned by Georgia-Pacific Cellulose, while other parts of the Arco community remain industrial and residential. The areas formerly occupying the off-site tanks along New Jesup Hwy/Newcastle Street Road have been transitioned to other commercial or industrial uses. One of the former off-site tanks is currently covered by US Highway 341/25 and was not accessible for sampling.

III.C.3. Surface Water & Sediments

Sediment sampling data from the 1990s confirm the presence of contaminants in surface water and sediments near the LCP Chemicals Site. Sediments that contain some contaminants can also release the chemicals into the surrounding water. Impacts to the Turtle River surface water and river sediment have been documented through laboratory testing. Wastes containing contaminants seeped into the marsh at several locations (EPS 2007b). To date, actions have been taken to address the release of contaminants from the site to the surface water pathway.

People who recreated (swim, wade, boat, canoe, etc.) in the Turtle River near the site or downstream of the site in the past could have been exposed to contaminants in surface water and sediment. Exposure would have occurred by swallowing small amounts of water or sediment, or by absorbing some of the chemicals in the water or sediments through bare skin.

III.C.4. Soil Gas

Some of the contaminants currently remaining beneath the ground surface of the site have the potential to evaporate into the air spaces between soil grains ("soil gas") and gradually work their way to the surface. Mercury, in particular, has the potential to evaporate into the air and be carried long distances. If mercury or volatile organic compounds (VOCs) volatilize between soil grains and enter an enclosed structure, these contaminants can accumulate in the air of the structure and be breathed in (inhaled) by humans. This potential pathway is not a current pathway because most on-site buildings have been removed. However, this pathway should be evaluated if the site is re-developed for either residential or commercial uses.

IV. ENVIRONMENTAL CONTAMINATION

An important component of the exposure assessment process is the evaluation of environmental contamination using available environmental sampling data collected on or near the site. Environmental data indicate the levels of chemicals in water, soil, air or the food chain (biota). ATSDR relies on environmental data collected from EPA, Honeywell, other governmental agencies, or other third party sources. ATSDR determines whether the available data for a site accurately and sufficiently reflect past, current, and future exposure conditions, and requests additional data to fill critical data gaps, if necessary.

After evaluating site conditions and determining that people could have been, are being, or could be exposed in the future (i.e., via a past, current, or future exposure pathway) to site-related contaminants, ATSDR must then consider whether chemicals were/are present at levels that might affect people's health. The health effects evaluation consists of two pieces: 1) a screening analysis and 2) based on the results of the screening analysis (and community concerns), a more in-depth analysis to determine possible health implications of site-specific exposures (detailed in Section V).

IV.A. The Screening Analysis – How ATSDR Selects Chemicals to Evaluate

During the screening analysis, ATSDR sorts through the environmental data in a consistent manner to identify substances within completed and potential exposure pathways that may need to be evaluated more closely. ATSDR selects the chemicals for further evaluation by comparing them to health-based *comparison values*.

> ***What are comparison values?***
>
> *Comparison values are chemical concentrations in soil, water, or air that are set well below levels known or anticipated to result in adverse health effects. ATSDR and other governmental agencies develop these values to make consistent decisions about what substance concentrations might require a closer look.*
>
> *Comparison values* ***are not*** *thresholds of toxicity and therefore should not be used to predict adverse health effects. Although concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Additional toxicological evaluation is needed to determine if harmful effects might be expected when a comparison value is exceeded.*

These are developed by ATSDR and other governmental agencies from available scientific literature related to exposure and health effects. Comparison values are derived for each of the different media and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

ATSDR has developed comparison values for substances in drinking water, soil, and air. ATSDR's comparison values include environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs). Comparison values are developed in a uniform way using health guidelines and standard default exposure assumptions that protect children and adults. ATSDR uses comparison values as a screening tool to compare to the contaminant levels found at the site. This screening process is a way to select contaminants that require further evaluation at the site. When no comparison value is available, the contaminant is generally retained for further evaluation. Other factors that become important in deciding which chemicals to evaluate further include the frequency of detection and a chemical's inherent toxicity.

Analytical data that characterize the post-removal conditions of the site were evaluated by ATSDR. The screening analysis revealed the presence of many chemicals, but most were eliminated because they were below applicable comparison values.

On the basis of the initial screening analysis, site history, and results from previous published assessments of soil (the dry-land soil portion) at the site, ATSDR selected Aroclors (PCBs), polycyclic aromatic hydrocarbons (PAHs), lead, mercury, and dioxins for further evaluation.

IV.B. The Exposure Analysis – How ATSDR Evaluated the Environmental Data

Although completed pathways for past exposure to site contaminants were identified for onsite and offsite receptors, this document focuses on risks to future populations from exposure to soil after the LCP Chemicals Site is redeveloped. Therefore, ATSDR focused the health evaluation on the chemicals left in the soil after clean-up activities (post-removal action) was completed. Most of these clean-up activities were completed in the mid-1990s. The residual contaminants in soil represent current contaminant levels and pose the greatest likelihood for future exposure and therefore, the greatest potential risk for future populations when the site is redeveloped.

ATSDR made the following assumptions when evaluating the post-removal environmental data.

IV.B.1. Subdivided the Property into Half-acre Exposure Units

Most often, an average chemical concentration is used as a single quantitative measure to determine the risks posed by a particular chemical for a contaminated area. Because the site is so large, ATSDR divided the site into smaller geographic (or exposure) units, which we believe will more accurately reflect whether a particular exposure area contains elevated concentrations of contaminants if the site becomes residential, commercial, or industrial.

ATSDR defined the exposure units as 1/2 acre parcels, or 150 x 150 foot lots. This area is about half the size of the American football field. In the absence of a defined redevelopment plan for the site, ATSDR concluded that each future home or commercial lot would occupy approximately this much space, particularly in a mixed-use community. ATSDR believes that this subdivision produces reasonably sized parcels with which to evaluate risks to potential future residential and commercial populations.

In order to evaluate these ½ acre exposure areas, ATSDR randomly overlaid ½ acre-sized grids onto a map of the site. This produced a series of equal-sized parcels, but with varying amounts of environmental sampling data for each lot. Potential health risks for each parcel were assessed separately. Where possible, ATSDR calculated the concentration of contaminants in each parcel to determine if the level was high enough to cause adverse health effects. In some cases, if the parcel contained too few samples to derive a health conclusion, ATSDR recommended additional sampling for that grid.

ATSDR's exposure unit approach is different than the approach chosen by EPA. Rather than dividing the site into ½ acre parcels, EPA divided the site into 4 large exposure units called quadrants. Each quadrant is roughly equal in size and is based on the location of B-Street and the north-south fence line located by the former guard house on B-Street (See Figure A13 in Appendix A). EPA Quadrant 1 and Quadrant 2 are in the eastern parcel of the site; EPA Quadrant 3 and Quadrant 4 (including the salt dock area) comprise the western parcel of the site. EPA's quadrants range from approximately 20 to 50 acres in size. The quadrants used by EPA are considerably larger than the ½ parcels used by ATSDR. Therefore, it is possible for ATSDR and EPA to reach different conclusions regarding assessing exposure and making health determinations.

IV.B.2. Evaluated Contaminants to Depth of 0-5 and 0-2 Feet

The process for determining which soil samples to include in our evaluation was driven by the groundwater field investigations and our assumptions regarding potential soil exposures of future populations. Previous investigative documents reveal that the depth to groundwater in the area is approximately 5 feet. Also, because the site is slated for redevelopment, we assumed that various earth-moving activities will occur during the redevelopment process. These earth-moving activities increase the probability that soil that is currently subsurface (and therefore not accessible for human contact) will become surface soil (and vice versa) as it is being moved around. Therefore, ATSDR assumed that a person may be exposed to any soil above the water table (5 ft.). Where the soil sample was collected at less than 5 ft., ATSDR included that sample result in the evaluation. Where the soil sample was collected at 6 ft. or greater, ATSDR eliminated that sample from further consideration. This process was conducted to account for the uncertainty in identifying surface versus subsurface soil. The EPA used a similar evaluation method in their human health risk assessment for the site, although their focus was the top 1 or 2 foot of soil (EPS 2007b).

In addition to estimating descriptive statistics for contamination at the 0-5 ft. depth, ATSDR also determined descriptive statistics for contamination at 0-2 ft. depth as well. The reasons for looking at this depth are that contaminant concentrations might be different in the top few feet, and the possibility that construction activity might be limited to a more shallow depth than 0-5 ft.

IV.C. Previous Sampling – Dry-land Soils

Site dry-land soils were investigated as part of a removal response action and during four phases of a remedial investigation. Removal action sampling was performed on the dry-land soil portion of the site from 1994 to 1997. Remedial investigation sampling was conducted from 1995 to 2004.

IV.C.1. Removal Action

The objective of the removal response action was to mitigate conditions deemed by the EPA to pose an imminent and substantial threat to human life, health or the environment. The dry-land removal response activities included the following components: (i) characterization of the dry-land area of the site; (ii) delineation of removal areas; (iii) removal and off-site disposal of impacted materials; (iv) post-excavation confirmational sampling to verify compliance with the removal action goals; (v) containment and treatment of contaminated water; (vi) permanent abandonment of water-supply wells; (vii) backfilling and grading of removal areas; and (viii) closure of the site sewer system. Decommissioning and removal activities at the Cell Building Area began immediately following the chlor-alkali plant closure in February 1994. The onsite mercury cell buildings were demolished and the area was capped and fenced. Other dry-land removal activities commenced in July 1994 and were completed in June 1997 (Geosyntec 1996, 1997, 1998).

Surface and subsurface soil samples were collected during the removal action using the following methods: 1) hand augering, 2) test trenching, 3) direct push drilling, 4) hollow stem auger drilling, and 5) mud rotary drilling. Lateral and vertical dimensions of each excavation grid were surveyed during the removal action.

Characterization and delineation sampling was performed concurrently with waste removal activities. Analytical results were compared to EPA removal criteria to determine areas requiring cleanup from those areas that did not. Contaminated soil was excavated and disposed off-site. The depth of excavation at the dry-land portion of the site ranged from less than 1 ft. (0.3 m) to approximately 13 ft. (4 m).

The removal response action also included a confirmational (post-excavation) sampling program. Confirmational soil samples were collected to verify attainment of the following removal target action goals identified by EPA (Geosyntec, June 1998). EPA target action levels for the LCP Chemicals Site are shown in Table 2.

Table 2. EPA Target Action Levels used between 1994 and 1997 at the LCP Chemicals Site

Contaminant	***Cleanup Goal***
Total Mercury	20 ppm*
Total Lead	500 ppm**
Total PCBs	25 ppm
Total carcinogenic PAHs	50 ppm

* ppm = parts per million
**When removal actions were taking place between 1994 and 1997, the total lead target action level was 500 ppm. Since that time, the EPA has set 400 ppm as the target action level for lead.

One composite sample was generally collected from the subgrade of each grid excavated to verify that the vertical extent of excavation was sufficient to meet site clean-up goals. The number of points in a subgrade composite sample depended on the size of the excavation grid, and varied from two to five points. An excavation grid comprised an area of approximately 2,500 ft^2-- nominally 50 ft. by 50 ft. To verify the horizontal limit of excavation, a three-point vertical composite sample was collected approximately every 100 linear ft. (30 m) around the perimeter sidewall of the excavations. If confirmational sampling results did not meet cleanup goals, additional excavation and re-sampling was conducted in the corresponding subgrade or sidewall. However, in some deep excavation areas where ground water infiltration and possible unstable slopes were a concern, grids were backfilled before confirmational samples were analyzed. The decision to backfill was based on visual examination of the subgrade and analytical results from nearby excavation grids. Once the confirmational sampling showed that the cleanup goal had been met, the area was backfilled with clean fill from off-site sources to restore the natural grade and promote positive drainage.

Confirmational samples were collected from the dry-land area of the site. Removal performance goals were not met at numerous sampling locations, prompting additional soil excavations. These sampling locations were removed during the additional soil excavations. Final confirmational samples represent the current (i.e., post-removal) conditions of the dry-land soils at the site. ATSDR noted that no samples were collected from the onsite pond; some samples were collected from the on-site theater.

Soil samples that were excavated during the removal action can be used to define past exposures. Soil samples that were not excavated, along with confirmational samples, represent existing conditions at the site, and were used to define present and future exposures.

IV.C.2. Exclusion of Sampling Data Collected during Removal Action

ATSDR was informed by EPA that data generated by Transglobal Environmental Geochemistry (TEG), which analyzed soil and water samples between April 1995 and June 1996, had data quality problems (EPA 2010a). TEG was the onsite laboratory used at the LCP Chemicals site during the removal action. The TEG data produced from approximately April 1995 to June 1996 has been deemed to be of poor quality because of quality control issues with the on-site laboratory. EPA has informed ATSDR that they did not include the TEG data in their baseline Human Health Risk Assessment for the site. However, EPA will use the TEG data in their Remedial Investigation.

Because of the concerns regarding the TEG data quality, ATSDR decided not to include TEG data in this evaluation. ATSDR recommends additional sampling in areas where sampling data are limited due to the exclusion of the TEG data. For example, the following highly contaminated areas were identified by ATSDR as having limited (confirmational) sampling data once the TEG data were removed:

- The scrap yard,
- The former facility disposal area,
- The cell parts area,
- The north and south dredge spoils area, and
- The outfall pond.

These areas are located between the former cell building and the marsh (see Figure 1). With the removal of the TEG data, it is uncertain whether these areas met EPA's target action levels.

IV.C.3. Remedial Investigation

Four separate soil sampling programs were conducted as part of the remedial investigation for dry-land soils.

IV.C.3.a. Phase I investigation

The purpose of the Phase I investigation was to assess the degree of preferential vertical distribution of chemical contaminants in the upper 2 ft. of soil. A set of 9 test trenches were located at two different areas of the site – one in the eastern portion in an area that had little industrial activity; the second in the southern portion in an area suspected to be more heavily contaminated. Each test trench was excavated approximately 5 ft. long and 2 ft. deep; samples were collected from each test trench at typical discrete depths of 0 ft., 0.5 ft., 1.25 ft. and 2.0 ft.

IV.C.3.b. Phase II investigation

The Phase II investigation was focused on verifying removal action characterization previously performed on the eastern portion of the site. Nine random sampling points were identified and collected. Each sampling point consisted of a square with an approximate side length of 25 ft. from which 2 five-point composite samples were collected. The samples were collected from depth ranges of 0 to 1 ft. and 2 to 3 ft.

IV.C.3.c. Phase III investigation

The Phase III investigation was focused on off-site tank farm sampling to characterize surface and subsurface soils at the locations of former refinery tanks east of Ross Road. Fourteen sample points at 3 former tank locations were identified and sampled. Sample points were located in the approximate center and corners or the former tank enclosures. Grab samples were collected from each sample point at typical depth increments of 0 to 1 ft. and 2 to 3 ft.

IV.C.3.d. Phase IV investigation

Soil sampling was conducted in a portion of the nearby ARCO neighborhood in 1995 and 2004. The portion of the ARCO community was southeast of the LCP property and consisted of residential homes. In 1995, the EPA collected two composite samples from the front and back yards of 5 residences in the ARCO community. Each composite sample was comprised of a 5-point sample of the upper 3 inches of soil. ATSDR evaluated the analytical results from the ARCO neighborhood sampling and determined that no contaminants were found at levels that would represent a public health threat [ATSDR 2005].

In 2004, a second sampling event was performed in this portion of the ARCO neighborhood and surrounding areas. City blocks were divided into quadrants to create 36 sampling grids. Samples were collected from each grid as 5-point composites. Composite sampling was conducted from a 0 to 3 inch and 0 to 12 inch depth. Samples for the two depth increments were collected immediately adjacent to each other.

IV.D. Contaminants of Potential Concern

As discussed above, ATSDR selected PCBs, PAHs, lead, and mercury as contaminants of potential concern because of their noted predominance at the site and because of the concerns raised by community members. Therefore, the focus of the health discussion will be on these contaminants. The section below discusses the distribution of these contaminants in and around the LCP Chemicals Site. The discussion will reference specific locations on the LCP property; therefore, the use of the Figure A4 in Appendix A (site map) may be helpful to identify the areas being discussed.

IV.D.1. Polychlorinated biphenyls (PCBs)

IV.D.1.a. What are PCBs?

Polychlorinated biphenyls (PCBs) are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs, yet they are found all over the world. With few exceptions, PCBs were manufactured as a mixture of various PCB congeners (EPA 2008b). In general, commercial mixtures with higher percentages of chlorine contained higher proportions of the more heavily chlorinated congeners, but all congeners could be expected to be present at some level in all mixtures (EPA 2008b). While PCBs were manufactured and sold under many names, the most common trade name was the Aroclor series. There are several types of Aroclors and each has a distinguishing suffix number, which usually indicates the degree of chlorination. The numbering standard for the different Aroclors is as follows: The first two digits generally refer to the number of carbon atoms in the phenyl rings (for PCBs this is 12), the second two numbers indicate the percentage of chlorine by mass in the mixture. For example, the name Aroclor 1254 means that the mixture contains approximately 54% chlorine by weight (EPA 2008b). The exception is Aroclor 1016, which has 12 carbons and 42% chlorine by weight. Once in the environment, PCBs do not readily break down and may remain for very long periods of time.

IV.D.1.b. Combined PCB congeners (except Aroclor1016)

For the purposes of this health assessment, ATSDR added all Aroclors (except Aroclor 1016) to arrive at a "total PCB" concentration for a given sample. The Aroclors detected at the site include Aroclor 1016, Aroclor 1221, Aroclor 1248, Aroclor 1254, Aroclor 1260, and Aroclor 1268. Aroclors 1232, 1242, and 1262 were not detected at the site. Aroclor 1016 has its own cancer toxicity values; therefore, it was not included in the Total PCB concentration. Table 3 lists the frequency with which the various Aroclors were detected in soil at the site.

EPA recommends that Aroclors be summed to give "total PCBs" when evaluating cancer (EPA 2009b). The derived cancer slope factor, therefore, applies to total PCBs. ATSDR used the same summing method when assessing non-cancer risk.

Table 3. Frequency of detection for various Aroclors in soil.

Substance	***# Detections***	***# Samples***	***Frequency***
Aroclor 1016	2	891	0.2
Aroclor 1221	1	902	0.1
Aroclor 1232	0	902	0.0
Aroclor 1242	0	902	0.0
Aroclor 1248	2	902	0.2
Aroclor 1254	81	902	9.0
Aroclor 1260	37	902	4.1
Aroclor 1262	0	0	0.0
Aroclor 1268	171	852	20.1

IV.D.1.c. Residual PCB Levels in Soil

Prior to clean-up (removal) actions, elevated concentrations of PCBs were detected in the former facility disposal area, the outfall pond and canal, the anode loading area, the north and south dredge spoils area, the scrap yard, northwest field, the material staging area, the south rail yard, and portions of the marsh, including tidal channels. After clean-up (removal) actions, residual PCB contamination exists in the some of the same areas.

Figure 1 shows the location of each sample collected and tested for PCBs that represents PCB levels in soil following clean-up activities. The figure also depicts where residual PCB concentrations are higher in some areas than in others by using a color scheme. Generally, the western portion of the site contains the most samples; the southwestern portion of the site contains the most residual PCB contamination. The eastern portion of the site contains fewer samples and less residual contamination.

The distribution of total PCBs remaining in soil is shown in Figure 1. Generally, residual PCB concentrations are highest in the north and south dredge spoils area, the scrap yard, the material staging and retort area, and the cell building area.

The exposure units for the site are defined as ½ acre-sized parcels. Figure 2 shows the overlay of the ½ acre grids to reflect residual PCB contamination and distribution at the site. Average PCB concentrations were calculated for each ½ acre grid. Non-detects were assumed to be zero because of irregularities in reporting laboratory detection limits.

0-5 Ft Depth

For the 0 to 5 foot soil depth, six grids have average total PCB levels that exceed EPA's 1994 LCP target action level of 25 parts per million (ppm); 35 grids have average total PCB levels between 1 and 24 ppm (see Table 4). Fifty-five grids have average total PCB concentrations less than 1 ppm, but not including non-detects. The maximum PCB concentration from a single sample remaining at the site is 826 ppm (Grid #93) and is located in the northwest corner of the former cell building area. The highest average PCB concentration for any grid (Grid #93) is 139 ppm.

0-2 Ft Depth

Soil samples with a depth of 0-2 ft. showed similar results as the 0-5 ft. depth. In the 0-2 ft. samples, 6 grids have average total PCB levels that exceed EPA's LCP target action level of 25 ppm; 35 grids have average total PCB levels between 1 and 24 ppm. The highest average PCB concentration for any grid is 240 ppm; however, more uncertainty exists in the average concentration because fewer soil samples are available from the 0-2 ft. depth.

Table 4. Average Total PCB concentration in soil by grid number, all depths								
ATSDR Grid #	***Average Total PCB in ppm***	***Maximum Total PCB in ppm***	***# Soil Samples***		***ATSDR Grid #***	***Average Total PCB in ppm***	***Maximum Total PCB in ppm***	***# Soil Samples***
93	138.6	826	6		75	2.6	23	17
58	122.0	122	1		94	2.4	16.8	22
114	53.0	53	1		38	2.4	4.9	2
53	42.3	167	7		70	2.3	9	9
90	40.9	350	13		92	2.2	11	8
60	34.0	34	1		39	2.1	2.1	1
89	20.6	240	13		42	1.9	10	12
111	15.8	37	3		8	1.6	3	2
37	11.9	28.5	4		69	1.5	28.3	21
128	10.5	19	2		154	1.4	4.3	6
55	9.0	27	3		112	1.4	7.3	8
76	7.3	53	10		74	1.4	10.9	8
10	7.0	13	2		152	1.4	2.7	2
91	6.2	24	6		153	1.4	2.7	2
56	5.6	11	3		71	1.3	7.5	9
155	5.6	10	2		77	1.3	3.3	7
110	4.0	22	12		133	1.3	8.8	17
95	3.5	16	12		197	1.1	3.5	6
59	3.3	12	6		17	1.1	9.5	12
73	2.6	4.3	4		134	1.0	12	12
118	2.6	10	4					

Figure 1. Sampling Locations Showing Residual PCB Levels in Soil, 0-5 ft.

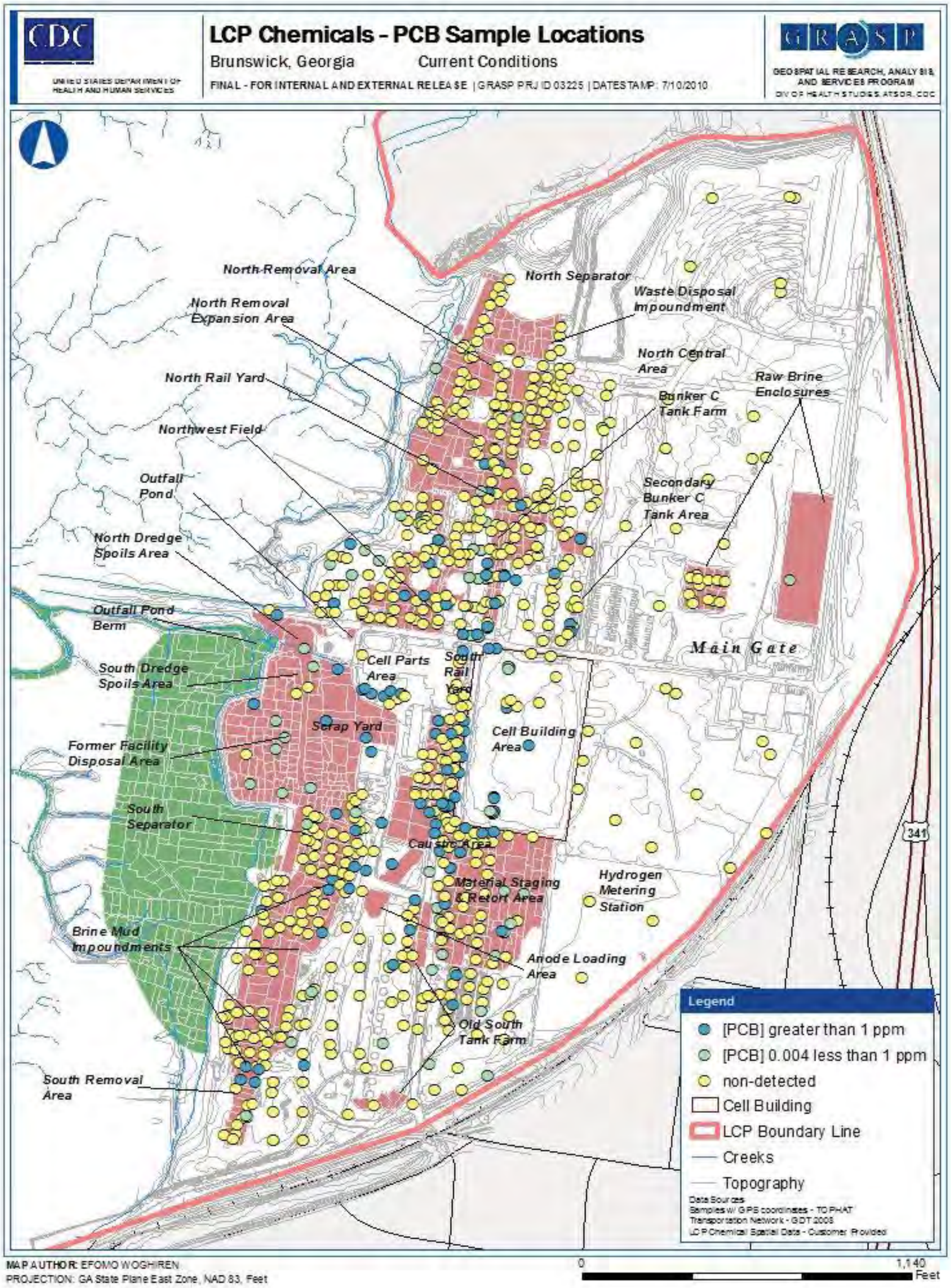
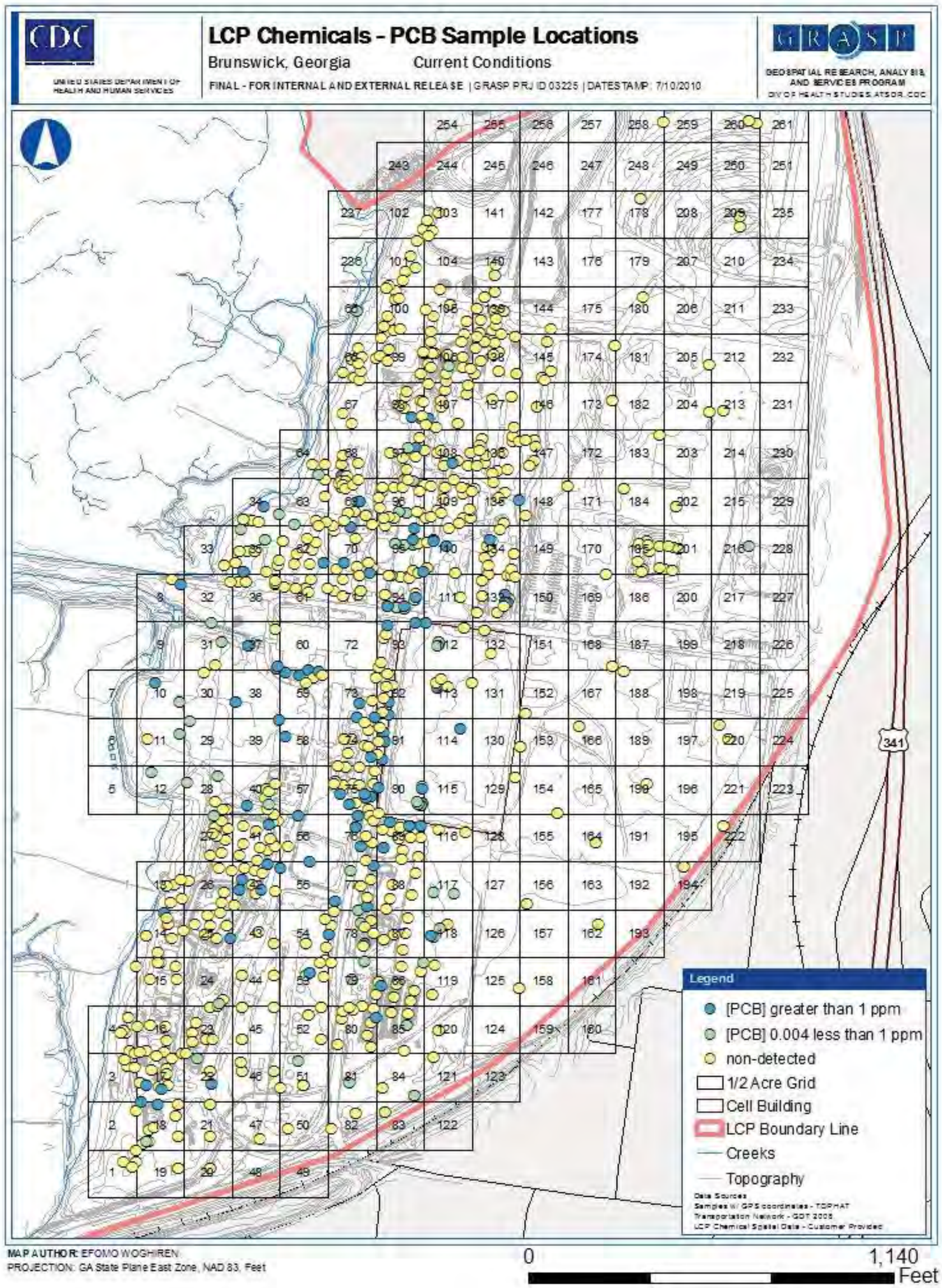


Figure 2. Exposure Units: ½ Acre Grids
PCB Samples and Residual Levels, 0-5 ft.



IV.D.2. Mercury

Prior to removal actions, mercury and mercury-contaminated alkaline sludges were detected in the cell building area, the mercury retort area, the caustic tanks area, the bleach mud at the north removal area, the lime softening mud at the waste disposal impoundment, the brine mud impoundments, the former facility disposal area, and portions of the marsh, including tidal channels. After EPA's clean-up actions, residual mercury still exists in some of the same areas. Figure 3 shows the location of each sample collected and tested for mercury that represents current mercury levels. The figure also depicts where residual mercury concentrations are higher in some areas than in others by using a color scheme. Generally, the western portion of the site contains more samples and more residual mercury contamination.

IV.D.2.a. The Chemistry of Mercury in Soil

Chlor-alkali plants such as LCP use mercury as electrodes in the electrolysis process that liberates dichlorine from a brine solution (Rule *et al*. 1998). The original form of mercury that is discharged into the environment in many cases is elemental mercury (Renneberg and Dudas 2001). Over time, the mercury-containing waste in soil may undergo chemical transformations into new forms. Elemental mercury is likely to be transformed into divalent mercury salts, such as mercuric chloride, mercuric hydroxide, mercuric sulfide, and to organic mercury. In soil, most of the mercuric salts become bound to the organic matter in soil, by reacting with sulfur- and oxygen-containing areas in aromatic and aliphatic chemicals. Some mercuric salts also can be bound to soil minerals, while a small portion can remain as elemental mercury or dissolved mercury (Schuster 1991, Stevenson 1994, Renneberg and Dudas 2001).

When the soil is co-contaminated with industrial hydrocarbons, some of the mercuric salts can react with sulfur- and oxygen-containing areas of these hydrocarbons, much like it does with organic matter in soil (CCME 1997, Renneberg and Dudas 2001). Renneberg and Dudas have analyzed soil that was contaminated with mercury several decades ago. They found 62% to 85% of the mercury in the soil samples was associated with organic matter. Several soil samples, however, showed small amounts of mercury bound to hydrocarbons (i.e., less than 5%), although one sample showed almost 30%. The percentage of mercury bound to minerals ranged from 5% to 10% for some samples and 20% to 30% in other samples. One soil sample showed that elemental mercury made up 30% of the remaining mercury in soil. The authors were not able to identify the specific chemical form of mercury in each sample (Renneberg and Dudas 2001).

In 2003, EPA collected 10 sediment samples from the nearby marsh and performed laboratory tests to determine which form of mercury was present. The organic mercury typically was 45% with individual marsh sediment samples ranging from 3% to 86% organic mercury. The other major components consisted of mercury in a mineral lattice, mercuric chloride, or elemental mercury. The mineral or elemental component typically was 41% with individual marsh sediment samples ranging from 0% to 72% (EPA 2010). These results are consistent with the previously cited studies. It is important to remember that these are marsh sediment samples and may or may not accurately represent the speciation of mercury in soils.

These results show that a large proportion of mercury in soil at the LCP Chemicals Site is likely to be organic mercury and this mercury is now bound to the organic humic content of soil. However, other forms, such as inorganic mercuric salts, and possibly elemental mercury, might also be present.

IV.D.2.b. Residual Mercury Levels in Soil

The distribution of mercury remaining in soil is shown in Figure 3. Residual mercury concentrations are highest in the footprint of the cell building area and in the areas immediately north and south of the cell building area. Soils beneath the footprint of the cell building area are poorly characterized and were not a significant part of the removal effort. It is likely that significant mercury contamination remains in these soils.

The exposure units for the site are defined as ½ acre-sized parcels. Figure 4 contains the overlay of the ½ acre grids to show residual mercury contamination and distribution at the site. Average mercury concentrations were calculated for each ½ acre grid.

0-5 Ft Depth

In the 0-5 ft. depth, 10 grids have average mercury levels that exceed EPA's LCP target action level of 20 ppm (see Table 5). Approximately 114 grids have average total mercury levels between 0.5 ppm and 19 ppm. Approximately 49 grids have average mercury concentrations less than 0.5 ppm, or levels which are considered background for mercury. The maximum mercury concentration at the site from a single soil sample is 10,400 ppm and is located in the footprint of the cell building area (Grid #113). The highest average mercury concentration for any grid (Grid #113) is 1,470 ppm and is also located in the former cell building area.

Table 5 (0-5 ft. Depth). Grids with average mercury levels in soil above EPA's LCP target action level of 20 ppm

Grid #	***Average Concentration***	***Maximum Concentration***	***Minimum Concentration***	***# Samples***
113	1470	10400	2	13
93	296	3510	0.32	12
112	271	3700	0.55	17
90	184.4	840	0.30	26
60	85	85	85	1
128	81	150	12	2
114	41	260	1.8	8
118	29.8	86	0.03	6
53	23.5	82.0	0.29	5
55	23.4	23.4	23.4	1

0-2 ft. Depth

In the 0-2 ft. samples, 5 grids have average mercury levels that exceed EPA's LCP target action level of 20 ppm (see Table 6). Approximately 103 grids have average total mercury levels between 0.5 ppm and 19 ppm. The remaining 42 grids have average mercury concentrations less than 0.5 ppm, or levels which are considered background for mercury. The maximum mercury concentration at the site from a single soil sample is 280 ppm for grid #90. The maximum average mercury concentration for any grid is 250 ppm, also in grid #90. Many of the grids in the 0-2 ft. depth contained only a single to a few samples. More uncertainty exists in these average concentrations because so few samples are available.

Table 6 (0-2 ft. Depth). Grids with average mercury levels in soil above EPA's LCP target action level of 20 ppm

Grid #	*Average Concentration*	*Maximum Concentration*	*Minimum Concentration*	*# Samples*
90	250	280	220	2
89	142	142	142	1
60	85	85	85	1
53	27.7	82	0.00	3
55	23.4	23.4	23.4	1

Figure 3. Sampling Locations Showing Current Mercury Levels in Soil (0 -5 ft.)

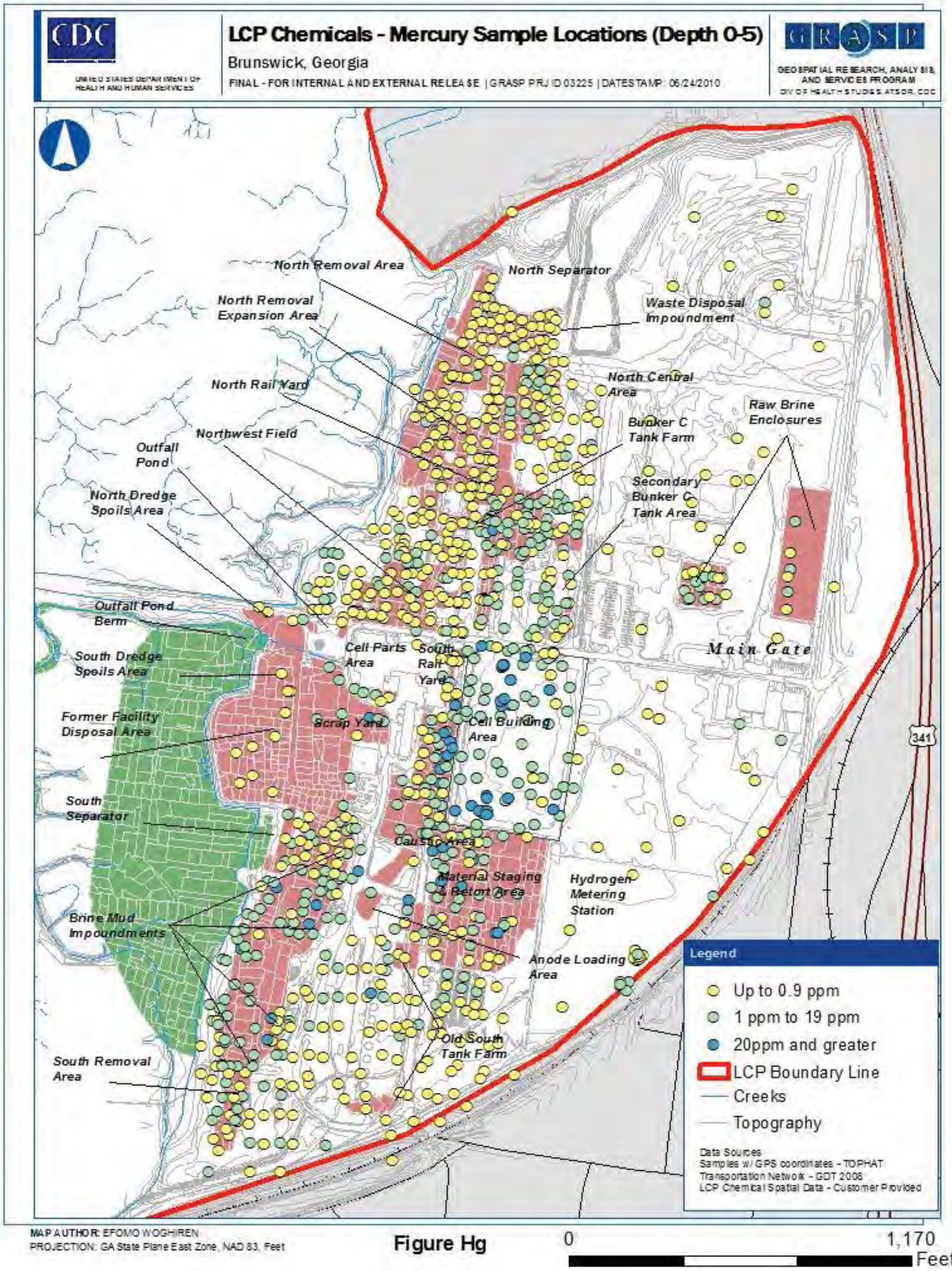
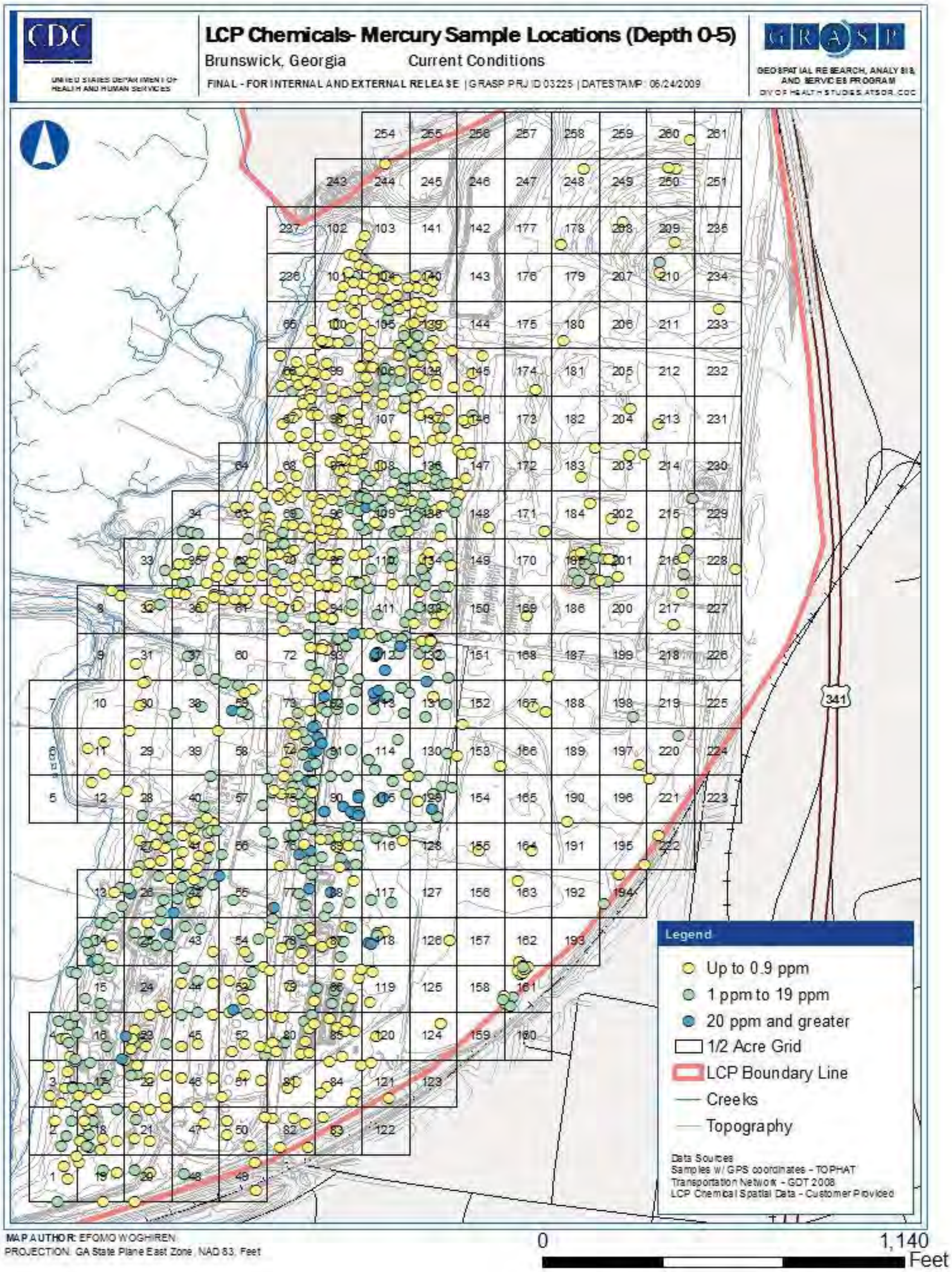


Figure 4. Exposure Units: ½ Acre Grids
Mercury Sampling Locations and Residual Levels, 0-5 ft.



IV.D.3. Polycyclic Aromatic Hydrocarbons (PAHs)

Prior to clean-up actions, PAHs were detected in the north and south removal areas, the north and south separators, and the bunker "C" tank area. Figure 5 shows the location of each sample collected and tested for PAHs. The figure also depicts where residual PAH concentrations are higher in some areas than in others by using a color scheme. Generally, the western portion of the site contains more samples and more residual PAH contamination.

IV.D.3.a. What are PAHs?

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs may occur naturally or be manufactured. Many products contain PAHs including creosote wood preservatives, roofing tar, certain medicines, dyes, and pesticides. PAHs enter the atmosphere from vehicle exhaust, emissions from residential and industrial furnaces, tobacco smoke, volcanoes, and forest fires (ATSDR 1996b). The PAHs at the LCP Chemicals Site are residues from the distillation of crude oil.

IV.D.3.b. How are Carcinogenic PAHs Evaluated?

PAHs are composed of carcinogenic and non-carcinogenic PAHs. To evaluate the risk of cancer, an approach is used from the California Environmental Protection Agency (Cal EPA) that converts the total PAH concentration in a sample to a total carcinogenic PAH concentration (CalEPA 2005). On the basis of benzo(a)pyrene toxicity, this approach uses potency factors specific for each carcinogenic PAH to change the concentration of that PAH to a benzo(a)pyrene equivalent concentration. Thus, the benzo(a)pyrene equivalent concentration of various individual carcinogenic PAHs in a soil sample are summed to give the total carcinogenic PAHs (cPAH) for that sample. Therefore, in this document benzo(a)pyrene equivalents will be referred to as cPAHs.

More information about this approach can be found at these websites:

- http://oehha.ca.gov/air/hot_spots/pdf/May2005Hotspots.pdf
- http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584
- http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html

*IV.D.3.c. Current c*PAH *Levels in Soil*

The exposure units for the site are defined as ½ acre-sized parcels. Figure 6 contains the overlay of the ½ acre grids to show residual carcinogenic PAH (cPAH) contamination and distribution at the site. Average cPAH concentrations were calculated for each ½ acre grid. The highest average cPAH in any grid was 29 ppm. No grids had average cPAH levels that exceeded EPA's LCP target action level of 50 ppm in soil at either the 0-5 or 0-2 ft. depths. The highest cPAH concentration for any grid (#93) is 59 ppm in the 0-5 ft. depth.

Figure 5. Sampling Locations and Current cPAH Levels in Soil, 0-5 ft.

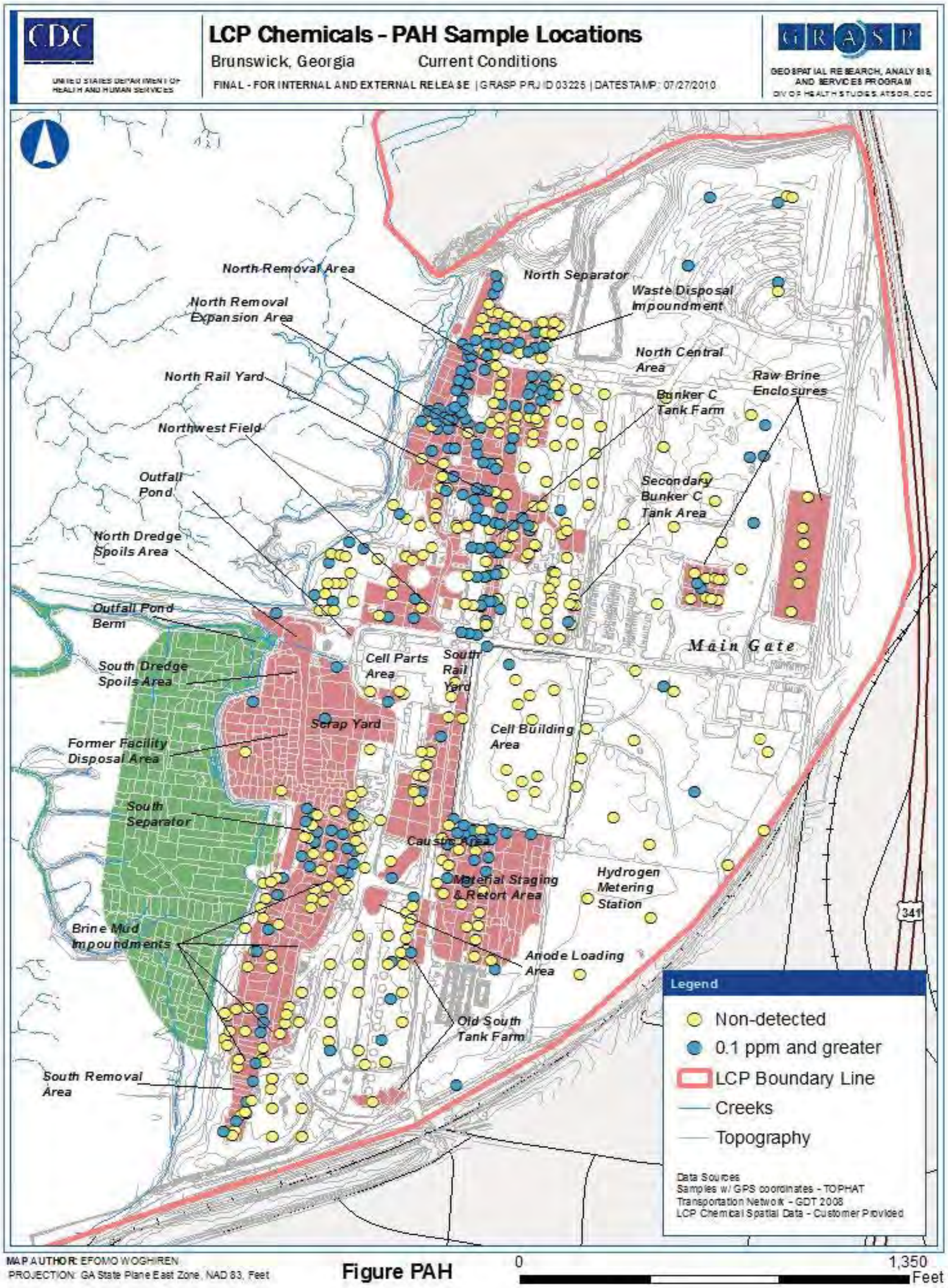
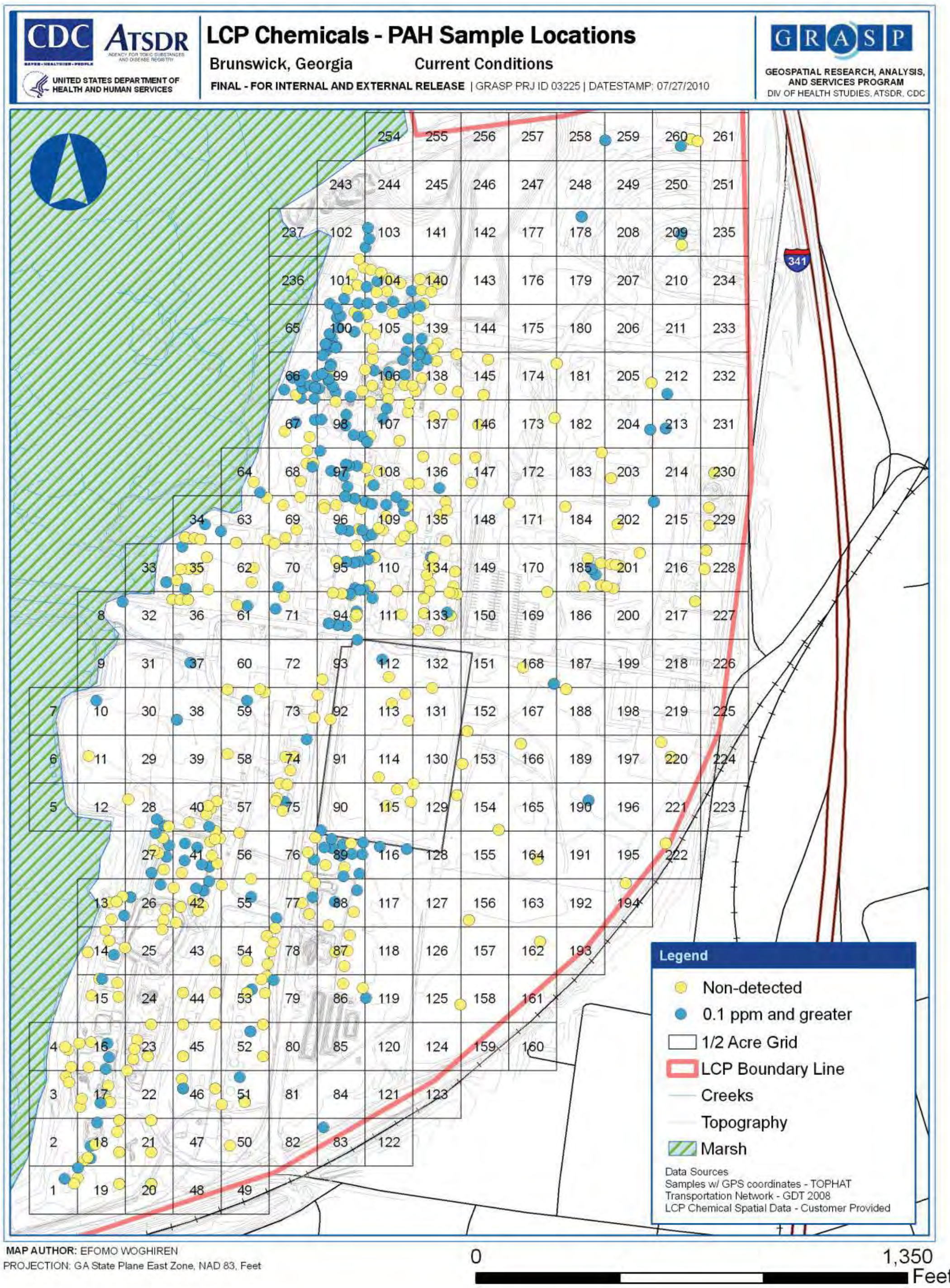


Figure 6. Exposure Units: ½ Acre Grids
cPAH Sampling Locations and Residual Levels in Soil, 0-5 ft.



IV.D.4. Lead

Prior to EPA's clean-up actions, lead was detected in the north removal expansion area, the north central area, the north rail yard, and the old south tank farm. After removal actions, residual lead still exists in some areas. Figure 7 shows the location of each sample collected and tested for lead that represents current lead levels in soil. The figure also depicts where residual lead concentrations are higher in some areas than in others by using a color scheme. Generally, more samples were collected from the western portion of the site. Residual lead levels appear to be evenly dispersed throughout the site.

IV.D.4.a. Current Lead Levels in Soil

The exposure units for the site are defined as ½ acre-sized parcels. Figure 8 contains the overlay of the ½ acre grids to show lead contamination and distribution at the site. Average lead concentrations were calculated for each ½ acre grid.

0-5 Ft Depth

Using samples with any depth between 0 and 5 foot, six grids have average lead levels that exceed EPA's 1994 LCP target action level for this site of 500 ppm (see Table 7); 21 grids have average lead levels between 154 and 499 ppm. (See more discussion in section "*V.F.3.b. Estimating children's lead dose from soil lead levels"* about how 154 ppm was derived). The maximum lead concentration at the site from a single soil sample is 4,430 ppm (Grid #136) and is located slightly northeast of the Bunker C Tank Farm. The highest average lead concentration for any grid (Grid #136) is 745 ppm.

Table 7 (0-5 ft. Depth). Grids with average lead levels in soil above EPA's 1994 site-specific target action level of 500 ppm

Grid #	***Average Concentration***	***Maximum Concentration***	***Minimum Concentration***	***# Samples***
136	745	4,430	52	18
48	728	820	635	2
103	692	1,580	14	6
26	660	3,680	6	7
93	590	3,040	46	6
59	513	1,040	66	6

0-2 Ft Depth

Using samples with any depth between 0 and 2 foot, five grids have average lead levels that exceed EPA's 1994 target action level for this site of 500 ppm (see Table 8); 36 grids have average lead levels between 154 and 499 ppm. (See more discussion in section "*V.F.3.b. Estimating children's lead dose from soil lead levels"* about how 154 ppm was derived). When comparing the 0-2 ft. averages with the 0-5 ft. averages, the maximum lead concentration at the site from a single soil sample is still 4,430 ppm (Grid #136). The highest average lead concentration for any grid (Grid #103) is 1,111 ppm compared to 745 for the 0-5 ft. samples. It is also worth noting that the number of samples per grid decreases, as expected, in the 0-2 ft. depth range.

Table 8 (0-2 ft. Depth). Grids with average lead levels in soil above EPA's 1994 LCP target action level of 500 ppm

Grid #	*Average Concentration*	*Maximum Concentration*	*Minimum Concentration*	*# Samples*
136	745	4,430	52	18
48	728	820	635	2
103	1111	1,580	832	3
26	638	638	638	1
59	513	1,040	66	6

Figure 7. Sampling Locations Showing Current Lead Levels in Soil, 0-5 ft

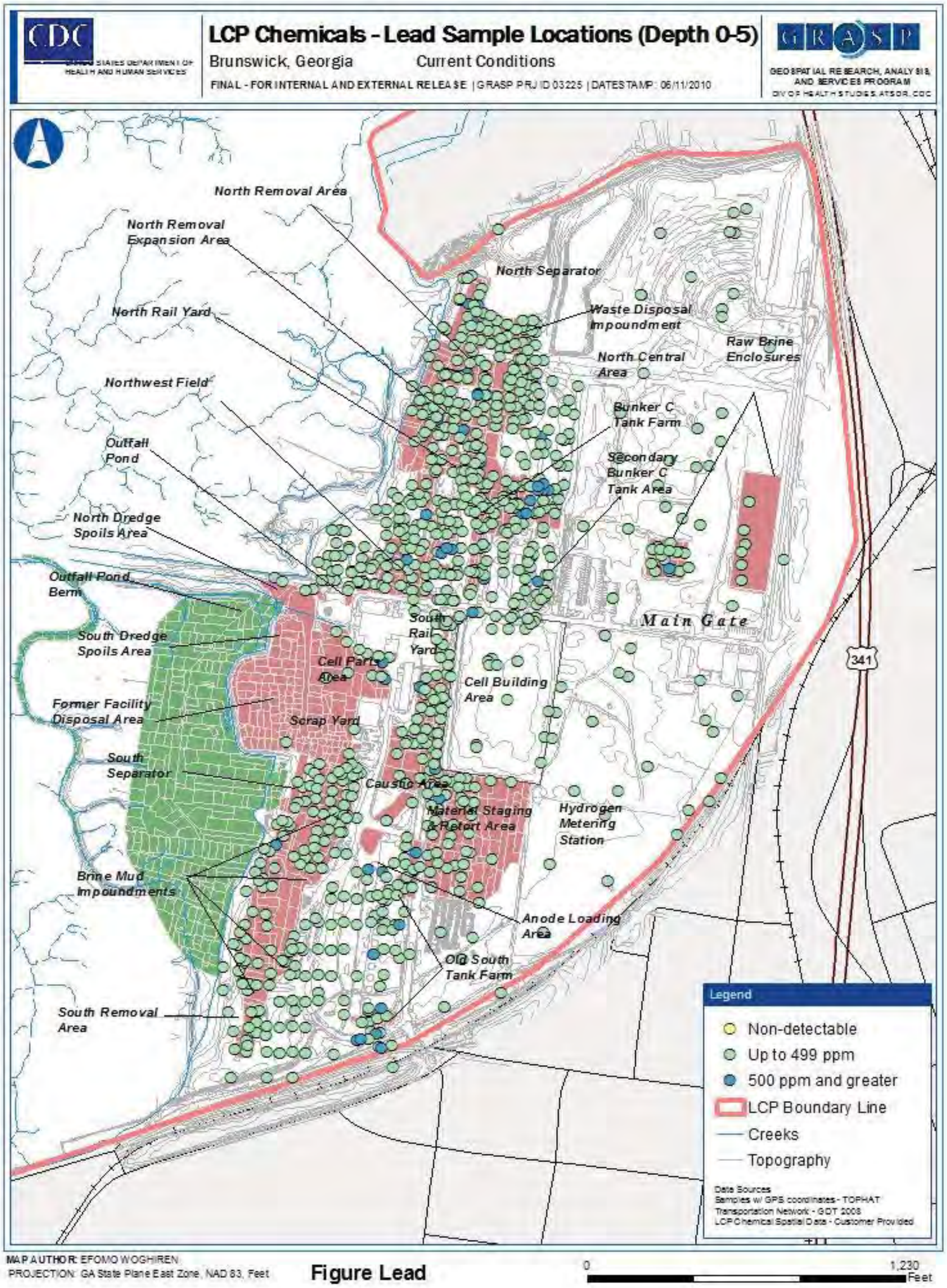
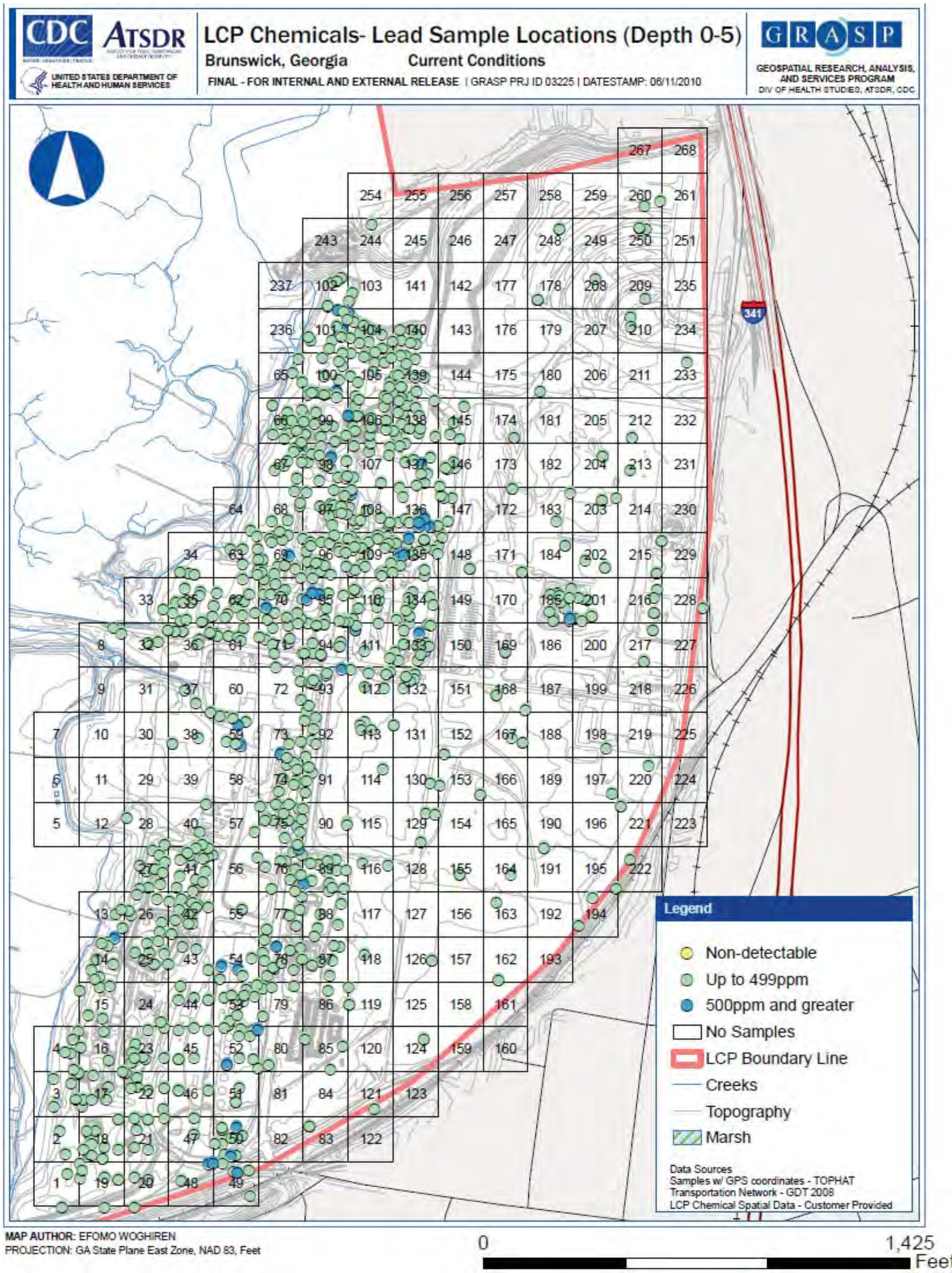


Figure 8. Exposure Units: ½ Acre Grids Lead Sampling Locations and Residual Levels, 0-5 ft.



IV.E. Potential Off-site Disposal Areas

During our assessment of the off-site areas surrounding the LCP Chemicals Site, ATSDR was informed of the existence of four potential historically contaminated areas. These off-site locations are alleged to have been the disposal grounds for various industries in the past. ATSDR has not confirmed, and is not suggesting, that these alleged disposal areas are associated with the LCP Chemicals Site. However, in some instances, historical photos suggest that these off-site locations may be linked to past industrial enterprises, including industries at the (former) LCP Chemicals property. Using historical aerial photos, this link is indicated by the presence of worn paths/roads extending from the LCP industrial facility to a potentially contaminated area.

Because it was raised by the community as a concern, and because some evidence exists to suggest a plausible connection to past industrial activities, ATSDR examined four potential disposal areas. We determined whether environmental samples had been collected in a given area and, when possible, evaluated the results. Below is a list of these potentially contaminated disposal areas:

IV.E.1. Former Tank Areas

Historical photos show the presence of three off-site tanks approximately one-quarter mile from the LCP Chemical property, east of Newcastle Street. The use or content of these former tanks is not known. In the presented historical photo, Figure A6 in Appendix A, the tanks appear as large white circles inside a square enclosure at the rightmost edge of the page. A present-day image of this area shows that the northernmost tank coincides with an area located between Knight Street and Ross Road extension (Former Tank Area 1); the middle tank lies at the western end of Cedar Street and Newcastle (Former Tank Area 2); and the southernmost tank lies at the corner of Cedar and Whitlock Streets (Former Tank Area 3).

EPA conducted limited soil sampling at each of the identified former tank locations (See Figures A7 through A11 in Appendix A).

ATSDR visited each location in July 2009 and made the following observations:

IV.E.1.a. Former Tank Area 1

Former tank area 1 is overgrown in some areas, including thick vegetation covering several mounds of soil currently located on the site. The site also contains piles of rock. Earthmoving equipment (e.g., bulldozers, dump trucks, etc.) was stored on the property. A mobile trailer which appeared to be the office for a car maintenance shop was located on the property. Many vehicles in various stages of disrepair were near the office trailer. A well pump was found on the property and is apparently used to wash trucks.

Limited sampling of the area conducted by EPA revealed the presence of up to 88 ppm of lead and 0.1 ppm of mercury in soil. These levels are not a health concern because they are below ATSDR’s comparison values.

IV.E.1.b. Former Tank Area 2

Former tank area 2 contains an abandoned industrial building. The site was posted against trespassing or dumping, so we walked only the public access road along the perimeter of the site. A repair shop appeared to be located approximately 100 yards east of the site.

Ten soil samples were collected from former tank area 2. While the highest lead level was 3,155 ppm, the average lead level from all the samples was 347 ppm. This average lead level is not a health concern for a commercial area but would be a concern for a residential area.

IV.E.1.c. Former Tank Area 3

Former tank area 3 is currently occupied by a business and is fenced; therefore, we could not observe current conditions at the location. Samples collected from former tank area 3 contained lead up to 232 ppm in soil. PCBs were not detected in any of the soil samples. The level of lead detected is not a health concern for a commercial location.

IV.E.2. Clairmont Lane

The Clairmont Lane area is a residential street that intersects Habersham Street and is surrounded by a densely wooded area. Previous community interest arose regarding this area when it was selected by the Glynn County Board of Education for the location of a new elementary school (GEC, undated). The GDNR, Environmental Protection Division, performed environmental sampling at the site to determine if the site was contaminated by historical waste dumping (GDNR 2004a). A total of 35 investigative soils borings were taken across the site in December 2003. Each boring was taken to a depth of 16 feet below existing grade, and sample composites were taken at one foot intervals (GDNR 2004b).

Clinker material, a type of waste product believed to be associated with past industrial activities at the LCP property, and the surrounding soils were analyzed to determine the chemical composition of the clinker for proper disposal, and whether the clinker had caused the immediate surrounding soils to become contaminated (GDNR 2004b). Detectable but low levels of metals were found in the soil. Carbon disulfide was detected in the clinker material at a concentration which exceeded the regulatory level for the chemical. Calcite, a naturally occurring carbonate mineral, was also found in the clinker material. Analytical results found no substances above regulatory limits in the soil samples tested; carbon disulfide was detected above detection limits in the clinker material itself (GDNR 2004b).

In January 2004, approximately 8.8 tons of clinker material were removed from the Clairmont Lane site (GDNR 2004b). Despite the cleanup in 2004, ATSDR staff members observed what appeared to be an area of waste material (i.e. clinker) near the backyard of a home on Clairmont Lane during our visit in July 2009. The material was a black deposit that had been removed from an area that contained loose clinker rocks. The material was near shrubbery and covered by pine needles, but was easily accessible by walking along the edge of the back yard.

IV.F. Residual Contamination in the Marsh

The marsh near the LCP Chemicals Site contains residual concentrations of PCBs, mercury and dioxins in sediment.

IV.F.1. Residual PCB Levels in the Marsh

Approximately 1,400 sediment samples were collected from the marsh, the Turtle River, off-site areas, and the salt dock area and were tested for PCBs. Total PCB concentrations ranged from non-detect to 570 ppm. The distribution of total PCBs remaining in these areas is shown in Figure 9. Generally, more PCB samples were collected in the marsh areas near the facility; therefore, these areas are more characterized. Samples were also collected from the salt dock area located southwest of the site, along the Turtle River (See Figure 9). Approximately 252 samples had concentrations above 10 ppm total PCBs; approximately 477 samples had concentrations between 1 and 9.9 ppm. The remaining 737 samples had total PCB concentrations less than 1 ppm, including some non-detects.

IV.F.2. Residual Mercury Levels in the Marsh

Approximately 1,500 sediment samples were collected from the marsh, the Turtle River, off-site areas, and the salt dock area and were tested for mercury. Mercury concentrations ranged from non-detect to 450 ppm. The distribution of mercury remaining in these areas is shown in Figure 10. Approximately 110 samples had concentrations above 20 ppm; approximately 693 samples had concentrations between 1 and 19 ppm. The remaining 727 samples had mercury concentrations less than 1 ppm, including some non-detects.

IV.F.3. Residual Dioxin Levels in the Marsh

Dioxins, or chlorinated dibenzo-*p*-dioxins (CDDs), are a class of structurally similar chlorinated hydrocarbons. The basic structure is comprised of two benzene rings joined via two oxygen bridges at adjacent carbons on each of the benzene rings. Dioxins is a term used interchangeably with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCCD or TCDD). TCDD is the most toxic form of the numerous dioxin compounds. Dioxins are not intentionally produced and have no known use. They are the by-products of various industrial processes (i.e., bleaching paper pulp, and chemical and pesticide manufacture) and combustion activities (i.e., burning household trash, forest fires, and waste incineration) (ATSDR 2006).

Not all dioxins have the same toxicity or ability to cause illness and adverse health effects. The most toxic chemical in the group is 2,3,7,8-TCDD. It is the chemical to which other dioxins are compared. The levels of other dioxins measured in the environment are converted to a TCDD-equivalent concentration on the basis of how toxic they are compared to 2,3,7,8-TCDD. These converted dioxin levels are then added together to determine the total equivalent (TEQ) concentration of the dioxins in a sample (ATSDR 2006). Hereafter, TCDD equivalents will be referred to as dioxins.

A total of 45 samples were tested for dioxins. Of the 45 samples tested, 6 were surface water samples and 1 was a groundwater sample. Two sediment samples were collected to determine background concentrations. The 36 remaining samples were sediment samples collected from the marsh and from selected off-site locations. Figure 11 shows the sample locations and concentration of dioxins at the site using a color scheme.

Dioxin concentrations in sediment ranged from non-detect to 0.003 ppm. ATSDR's current comparison value for dioxin is 35 parts per trillion (ppt), or 0.000035 ppm. Nine samples exceeded had dioxin levels that exceeded 35 ppt. No samples for dioxins were collected from the dry-land area during this round of sampling. Samples from the dry-land area were collected in 2011 and are discussed in Section IV.G. of this document.

Figure 9. Sampling Locations Showing Residual PCB Levels in Sediment
in the Marsh and Off-Site Locations

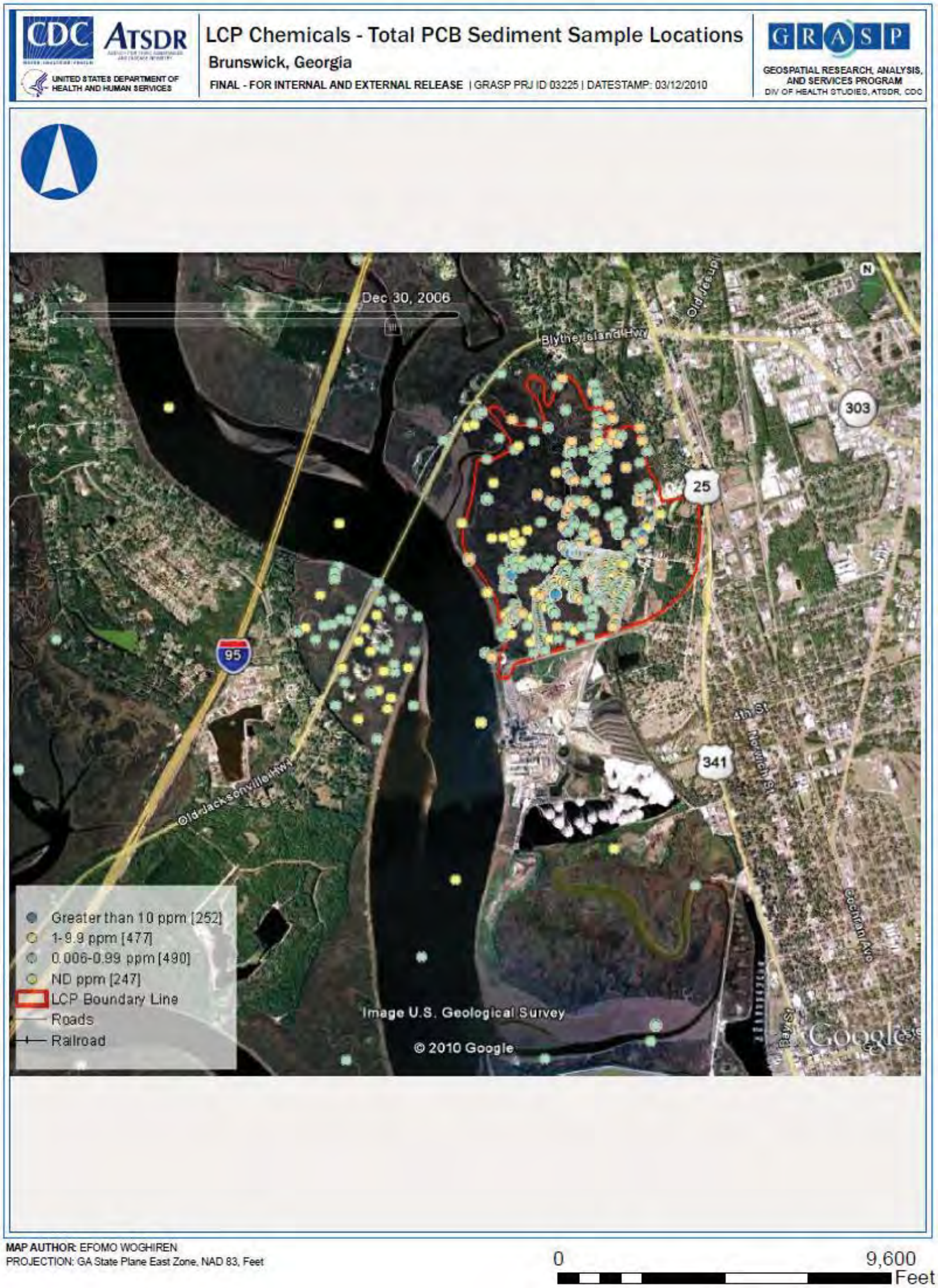


Figure 10. Sampling Locations Showing Residual Mercury Levels in Sediment in the Marsh and Off-site Locations

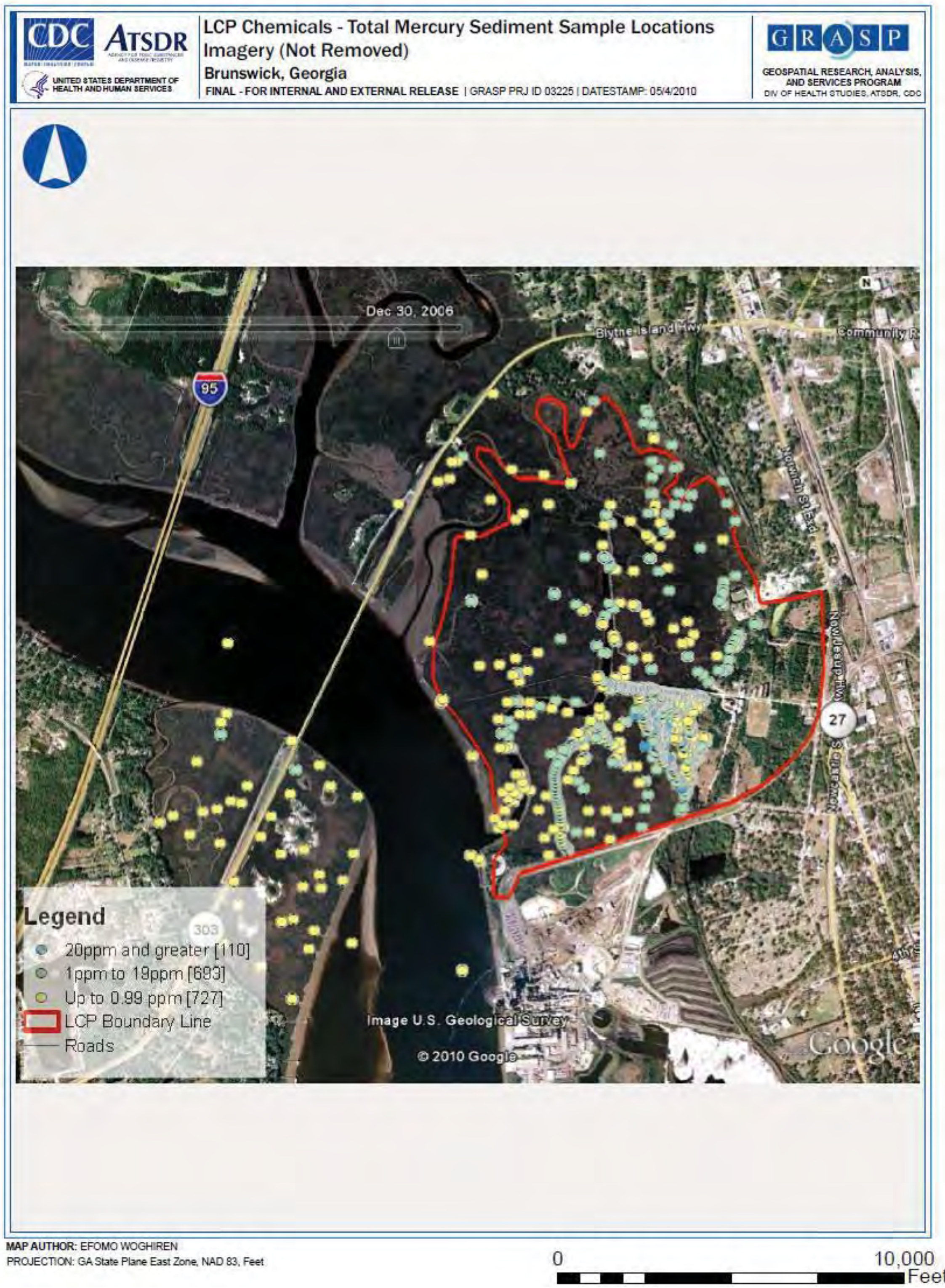
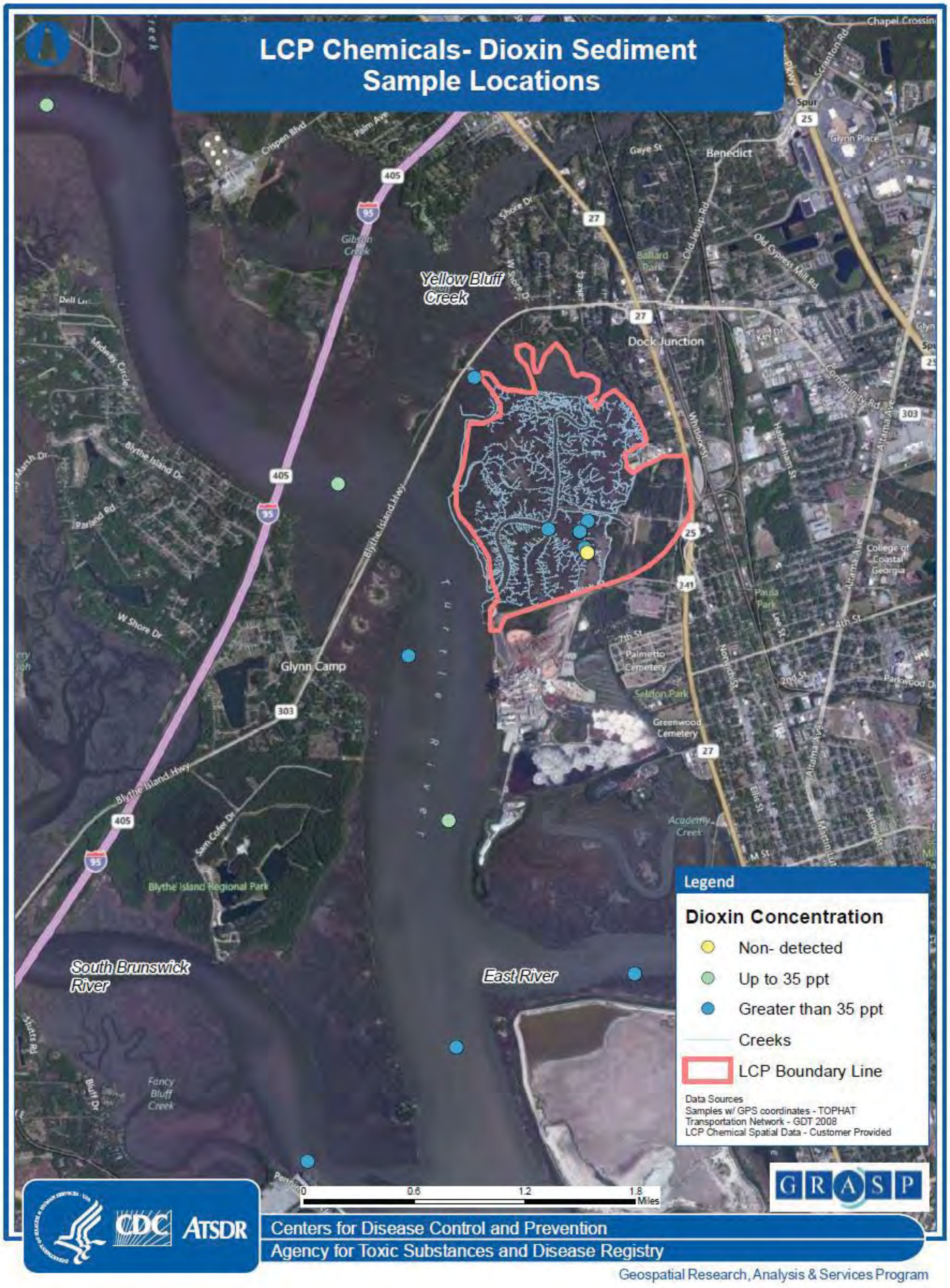


Figure 11. Sampling Locations Showing Residual Dioxin Levels in Sediment in the Marsh and Off-site Locations



IV.G. New Data Collected Since the Public Release of the LCP PHA in 2010

This section presents the results of environmental samples collected in 2010 and 2011. These data were not part of the data evaluated during the previous public release of this document in fall 2010. Some of the new environmental sampling was conducted in response to recommendations by ATSDR in the public release document. The new sampling was focused in the following areas: 1) the dry-land area (dioxins), 2) the on-site former theater area, 3) the on-site pond, and 4) the Altamaha Canal.

IV.G.1. The Dry-land Area (Operable Unit 3)

In April 2011, Honeywell, with the concurrence of EPA and the Georgia Environmental Protection Division (GEPD), sampled soil from the dry-land area for dioxins. The purpose of the sampling was to determine the concentrations of dioxin in the dry-land area (also referred to by EPA as the upland soil area) of the site. The dry-land area also includes the former theater area and on-site pond, which are discussed separately below. The sampling protocol used Incremental Sampling Methodology (ISM), which is a structured composite sampling method that uses "sampling units" as a way to determine contaminant concentrations in a specified geographical area.

Honeywell divided the site into 4 separate quadrants, which is consistent with the sampling design used in EPA's upland soils Human Health Risk Assessment for the site. Each quadrant identified by EPA contained from 1 to 3 sampling units. The size of the sampling units varied. ATSDR renumbered the sampling units in each quadrant from left to right, top to bottom, for easy referencing (see Figure 12 in Appendix E). Appendix E discusses in detail the use of EPA's quadrants and ATSDR's numbering method.

The new data for the dry-land area included sampling results for dioxins only. The dioxin data were converted to TCDD-equivalent concentrations based on how toxic the congeners are compared to 2,3,7,8-TCDD. These converted dioxin/furan concentrations are then added together to determine the total equivalent (TEQ) TCDD concentration in a sample. Hereafter, TCDD equivalents will be referred to as dioxins.

Table 9 below contains the sampling results for total dioxins for the dry-land area. Two dioxin concentrations were reported for most sampling areas; three dioxin concentrations were reported for sampling area 4. For purposes of this assessment, the highest dioxin value was selected to determine health risks.

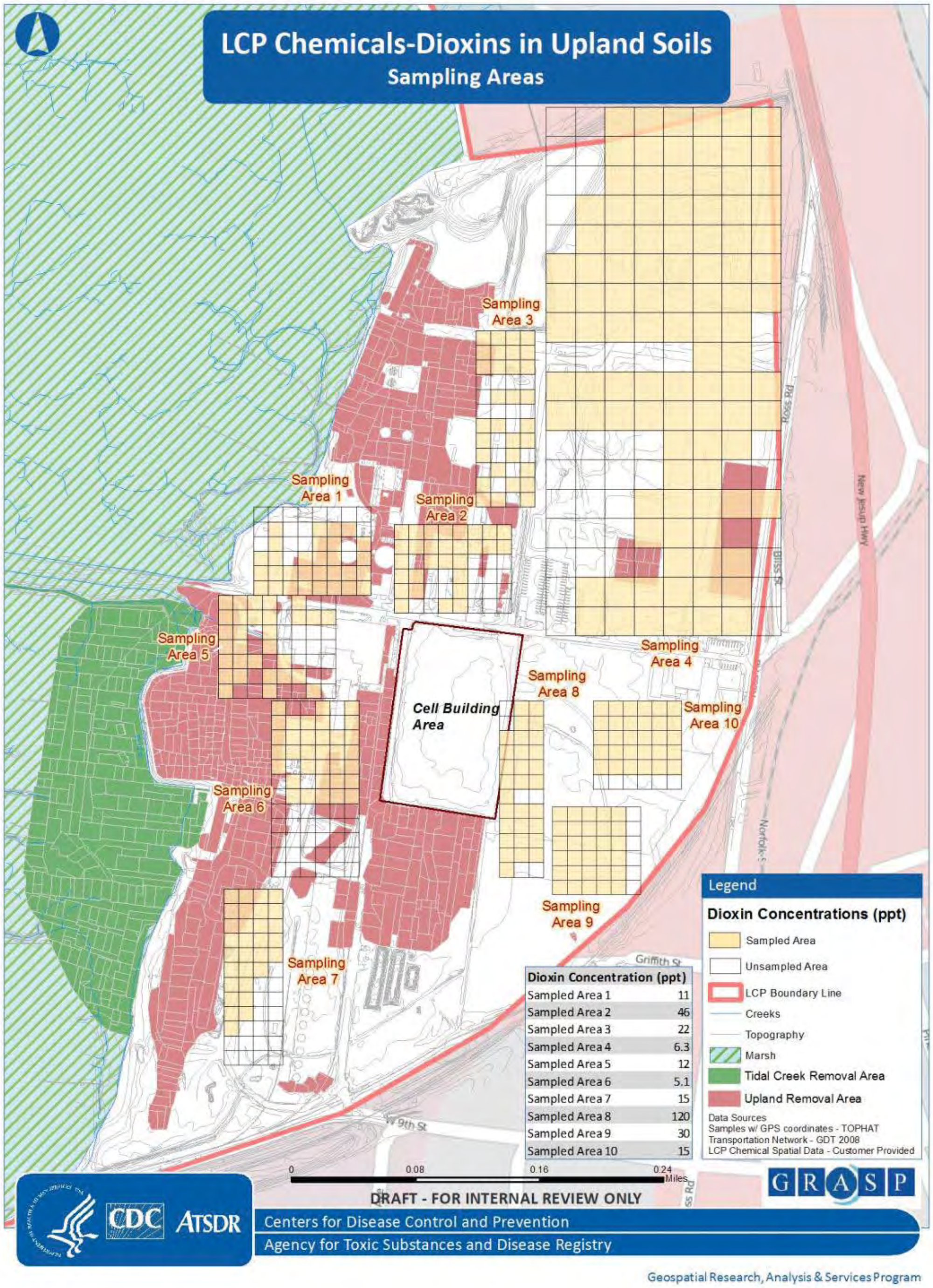
Figure 13 shows the location of the sampled dry-land areas and the dioxin concentration for each sampled area. In some cases, no samples were taken from a smaller block within the larger sampling unit. Where this occurred, ATSDR deleted the smaller block from the sampling unit to show that no sample was taken. The areas not sampled appear as a blank block on the map in Figure 13.

Table 9. List of Sampling Areas and Dioxin Levels in Soil for the Dry-Land Area (See Figure 13)				
Sampled Area	***Dioxin Conc. (ppt)***		***Sampled Area***	***Dioxin Conc. (ppt)***
4	6.2		**2**	**38**
4	5.5		**2**	**46**
4	6.3		3	14
10	13		3	22
10	15		5	12
8	**81**		5	8
8	**120**		6	5.1
9	30		6	1.2
9	30		7	15
1	9.3		7	14
1	11			

Four samples exceed ATSDR's current comparison value of 35 parts per trillion (ppt) for dioxins in soil. The four samples are from two sampling areas – sampling area 8 and sampling area 2 (See Figure 13). Seventeen samples have dioxins concentrations below the comparison value of 35 ppt.

The distribution of dioxins in the dry-land area is shown in Figure 13. Sampling areas 2 and 8 contain the highest concentrations of dioxins. Sampling area 2 is located north of the former cell building area and sampling area 8 is located immediately east of the former cell building area.

Figure 13. Sampling Locations Showing Concentration of Dioxins
for Dry-Land Area (2011)



In some cases, no samples were taken from a smaller section within the larger sampling area. Where this occurred, ATSDR deleted the smaller block from the sampling area to show that no sample was taken. The areas not sampled appear as a blank block on the map.

IV.G.1.a. Former Theater Area

In December 2010, Honeywell sampled the soil at five locations along an arc in the middle of the theater area. Soil samples were collected at two depths: 0 to 1 ft. (surface soil) and 2 to 3 ft. (subsurface soil). Figures 14 through 17 show soil sample locations and sampling results for PCBs, mercury, cPAHs and lead from the December 2010 sampling event.

The soil sampling results from the December 2010 sampling event are summarized in Table 10.

Table 10. Recent Sampling Results, December 2010, for Soil in the Theater Area (ppm)

Contaminant	***Comparison Value (ppm)***	***Concentration Range in Surface Soil (ppm) (0-1 f.t depth)***		***Concentration Range in Subsurface Soil (ppm) (2-3 ft. depth)***	
		Min	***Max***	***Min***	***Max***
PCBs	0.35	0.005	0.13	ND	0.01
Mercury	5*	0.04	0.20	0.01	0.03
cPAHs	0.096	0.003	**0.14**	ND	0.02
Lead	None	8	63	4	43

*indicates comparison value for methylmercury

As shown in the table, only cPAHs in surface soil exceeded its comparison value. None of the other sampling results that had a comparison value exceeded their applicable soil comparison value. Lead does not have a comparison value. The level of PAH exceed the comparison value and therefore will be evaluated further in the public health implications section of this report.

Figure 14. Sampling Locations Showing Concentration of PCBs in Soil
In Theater Area, 2010

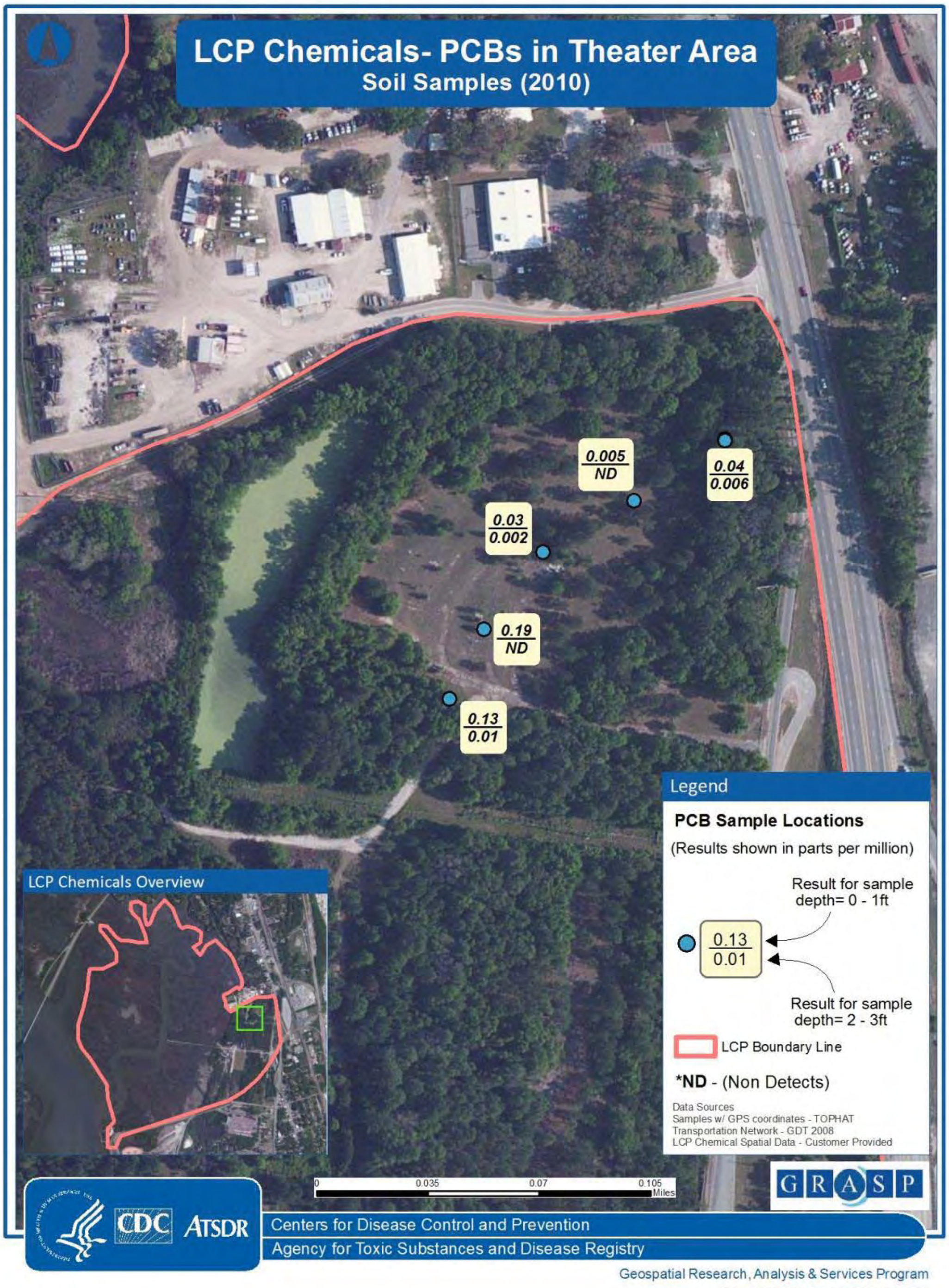


Figure 15. Sampling Locations Showing Concentration of Mercury in Soil
In Theater Area, 2010

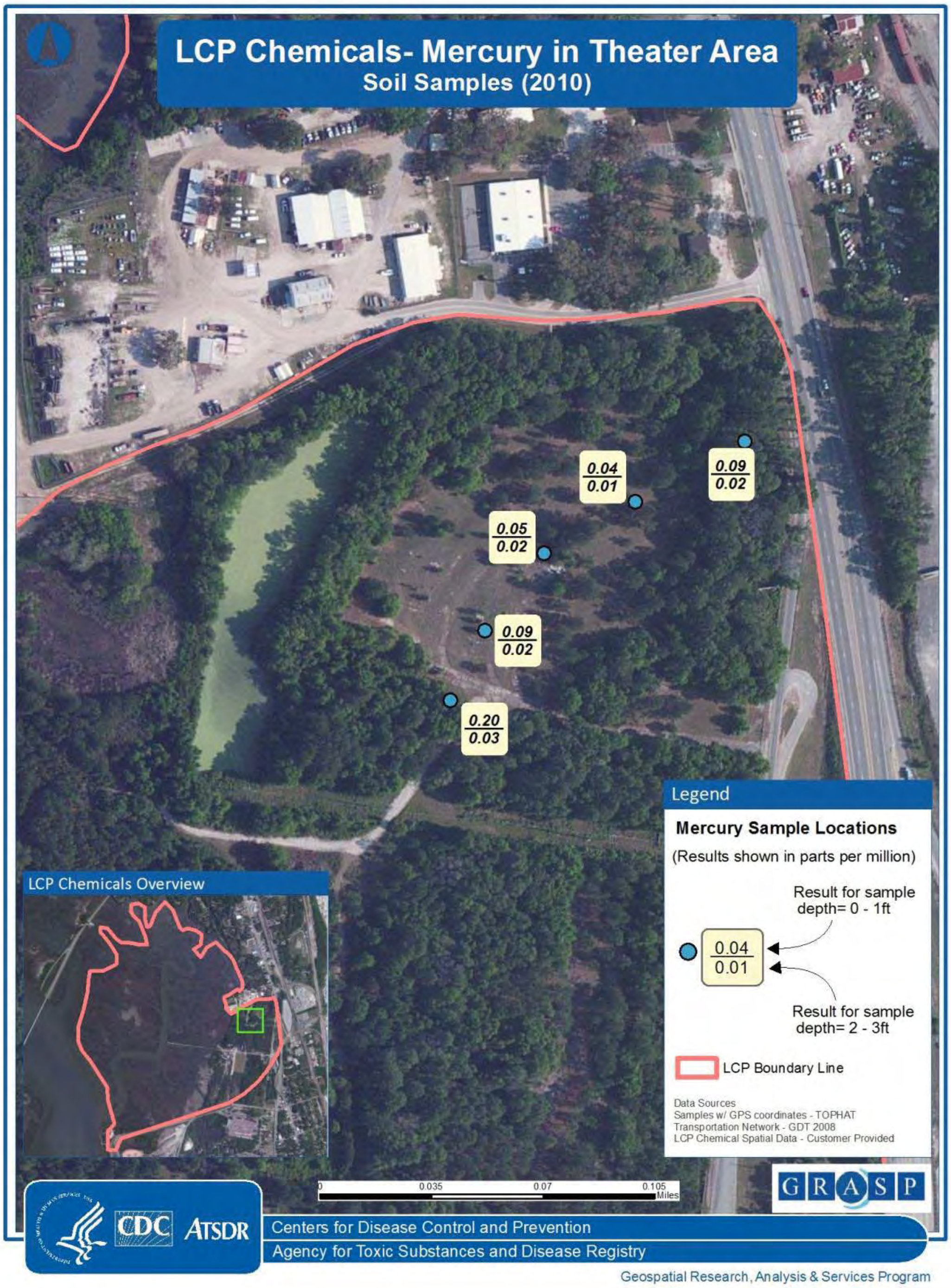


Figure 16. Sampling Locations Showing Concentration of cPAHs in Soil
In Theater Area, 2010

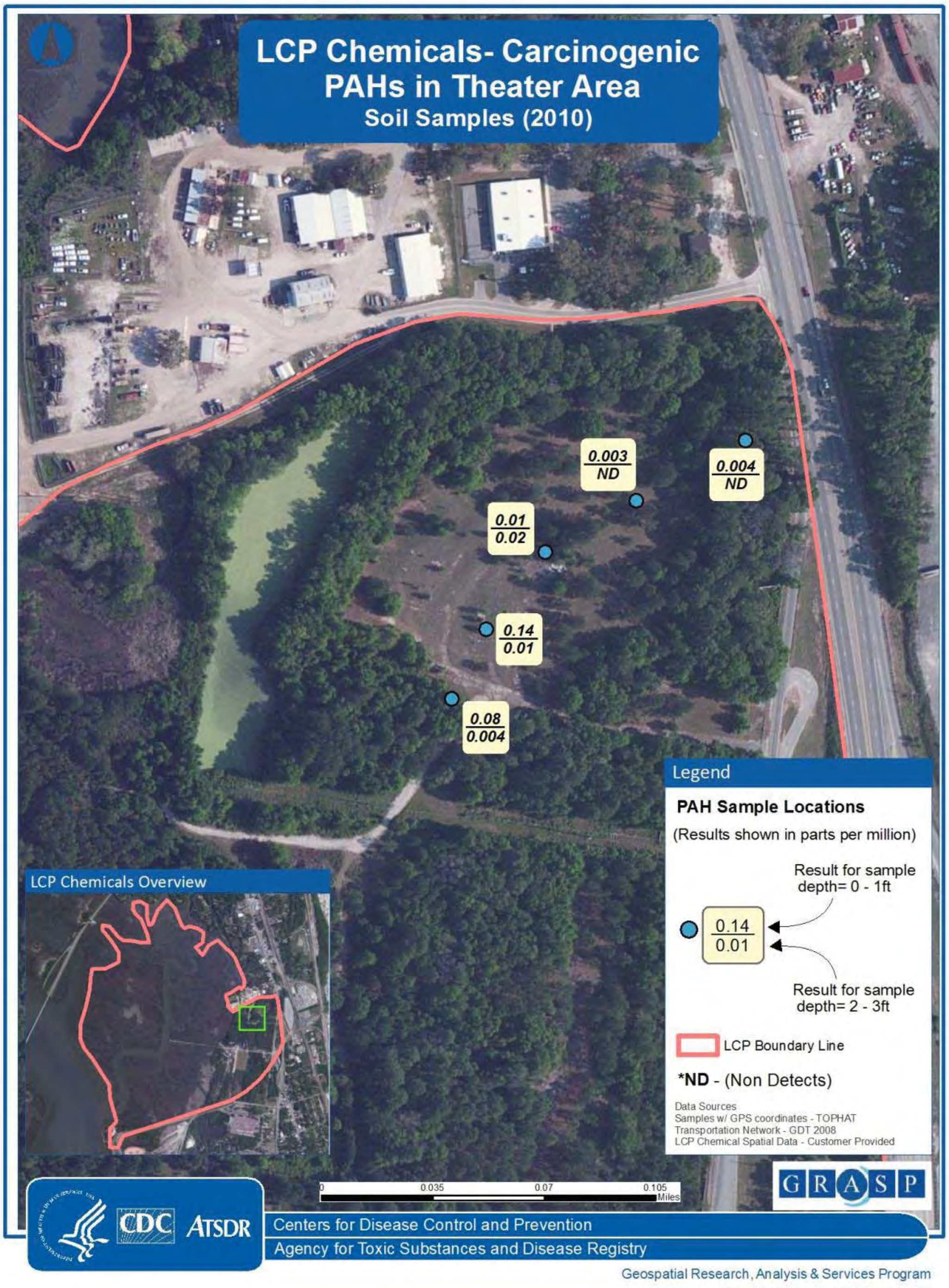
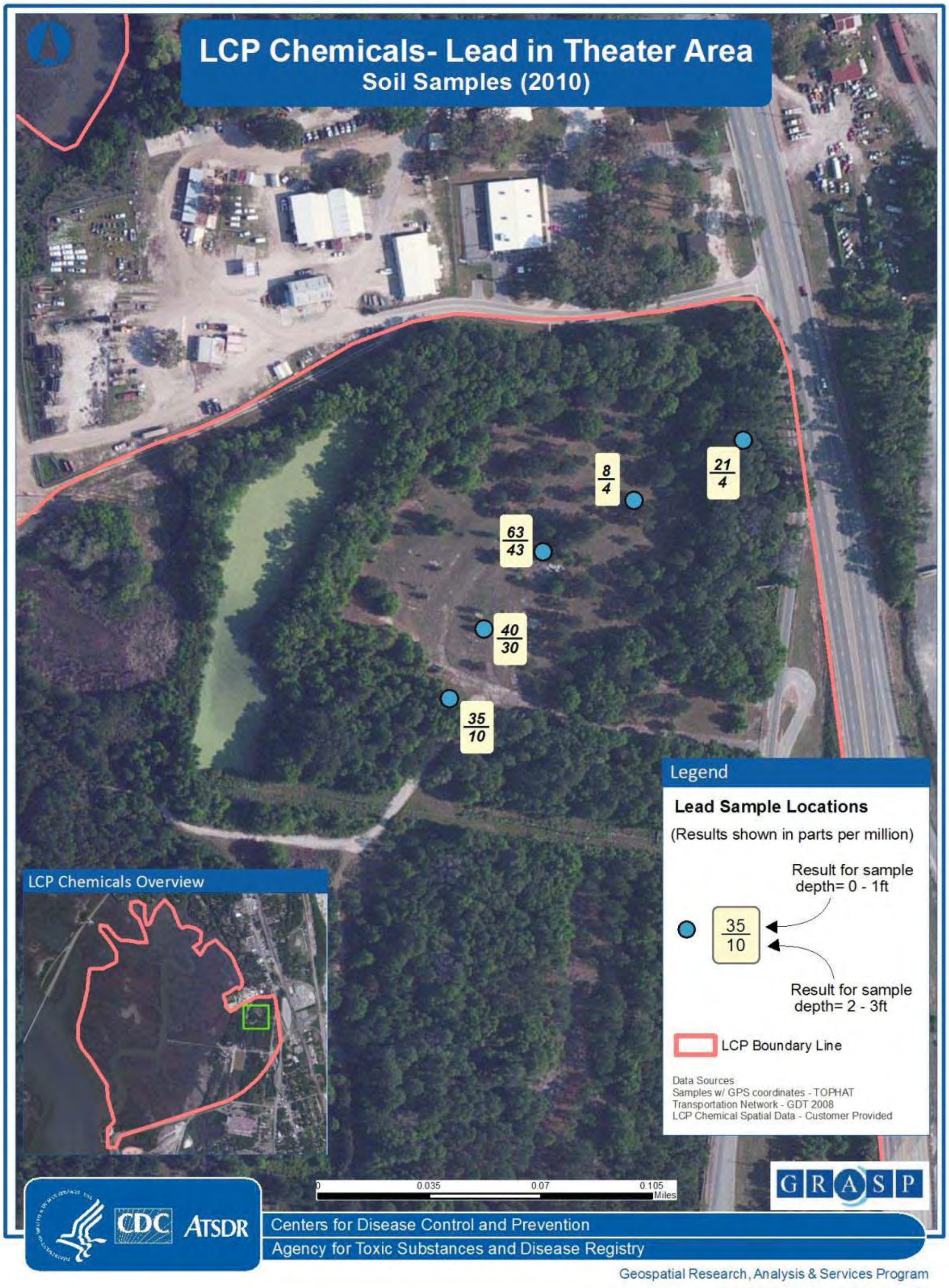


Figure 17. Sampling Locations Showing Concentration of Lead in Soil
In Theater Area, 2010



IV.G.1.b. The On-site Pond

During three different sampling events between 1989 and 2008, a total of 4 surface water and 3 sediment samples were collected from the freshwater pond located in the theater area. The three sampling events are summarized below:

- One surface water sample was collected in 1989;
- One surface water and one sediment sample were collected in 2007; and
- Two surface water and two sediment samples were collected in 2008.

In December 2010, Honeywell collected surface water and sediment samples from three locations in the on-site pond. The three locations were selected to be evenly spaced along the longitudinal axis of the pond near the former drive-in theater. One surface water sample and one sediment sample (0 to 1/2 ft.) were collected from each location. Fish collection was attempted but no fish were caught in the on-site pond.

The location of the surface water and sediment samples and the analytical results are illustrated in Figures 18 through 21 and summarized in Tables 11 and 12.

Table 11. Recent Sampling Results, December 2010, for Surface Water in On-site Pond (ppm)				
	Contaminant	***Comparison Value***	***Min Conc.***	***Max Conc.***
Surface Water	PCBs	0.000018	ND	ND
	Mercury	None	0.000002	0.000002
	cPAHs	0.0000048	ND	ND
	Lead	0.015*	0.0002	0.0002

Table 12. Recent Sampling Results, December 2010, for Sediment in On-site Pond (ppm)				
	Contaminant	***Comparison Value***	***Min Conc.***	***Max Conc.***
Sediment	PCBs	0.35	0.01	0.14
	Mercury	None	0.03	0.1
	cPAHs	0.096	0.004	0.01
	Lead	None	3	4

*indicates the MCL action level

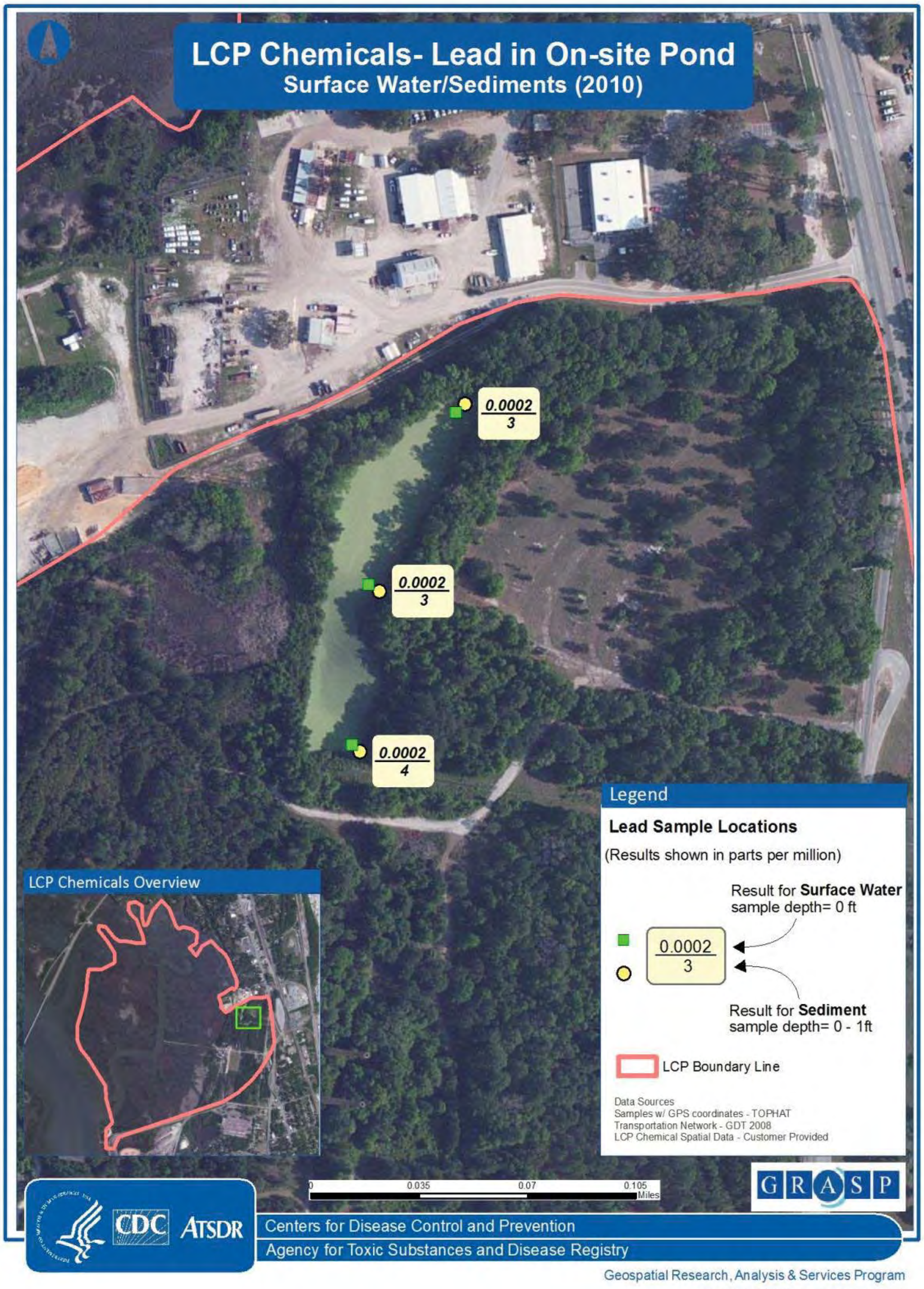
None of the surface water or sediment concentrations exceeds their applicable comparison value. (Surface water concentrations were compared to drinking water comparison values for conservatism.) Therefore, PCBs and cPAHs in the pond's surface water and sediment will not be evaluated further. The concentrations of mercury (0.004 to 0.01 ppm vs. a background of 0.12 ppm) and lead (3 to 4 ppm vs. a background of 17 ppm) are well below background soil levels (ATSDR 1992); therefore, mercury and lead in sediment will not be evaluated further. Because pond water does not serve as a drinking water source and because the mercury levels are very low, mercury in pond water is not a health concern.

Figure 18. Sampling Locations Showing Concentration of PCBs in
Surface Water and Sediment in On-site Pond, 2010

Figure 19. Sampling Locations Showing Concentration of Mercury in Surface Water and Sediment in On-site Pond, 2010

Figure 20. Sampling Locations Showing Concentration of cPAHs in Surface Water and Sediment in On-site Pond, 2010

Figure 21. Sampling Locations Showing Concentration of Lead in
Surface Water and Sediment in On-site Pond, 2010



IV.G.2. Adequacy of the sampling in the dry-land area

ATSDR evaluated the adequacy of sampling in the dry-land area of the site. The goal of our evaluation was to determine if the collection of soil samples was adequate for making public health decisions. Our public health decision-making considers all available or proposed uses for the site - residential, commercial and industrial uses.

ATSDR now understands that approximately 32 acres of the dry-land area have been purchased by Glynn County to build a detention center (The Florida Times-Union, 2012) According to the report, a 610-bed detention center will be built on the grounds of the former theater area, which also includes the on-site pond. Using publicly available files, ATSDR was able to approximate the location of the 32 acre detention center facility on the site. The (approximate) prison boundaries are shown in Figures 22 through 25. The area of the detention center will not be evaluated for sampling adequacy because the future land use has already been determined.

Figures 22 through 25 illustrate the areas of the site ATSDR considers to have enough samples to draw health conclusion and which areas do not. Grids shaded in blue are considered to have enough samples to draw a health conclusion. Grids that are not shaded are considered to be under-sampled (i.e., not enough samples taken to make a health conclusion). Generally, ATSDR considered a grid with 3 or more samples to have an adequate amount of samples to make a health call. There are separate sampling adequacy figures for the contaminants of concern - PCBs, cPAHs, mercury and lead.

IV.G.2.a. Dioxin

Generally, the dioxin sampling appears to be adequate to evaluate surface soil (top 3 inches) for the site. However, we do not have adequate sampling from soil below 3 inches. Soils below 3 inches are important because we expect soil at all depths to be moved during future on-site construction activities. Because no samples were collected at depth, it is not possible to evaluate whether dioxin contamination might exist below the surface. The lack of depth samples seems inconsistent with all the other sample designs for the LCP Chemicals Site. For example, recent soil samples collected from the theater area consisted of sample depths 0 to 1 ft. and 2 to 3 ft.

IV.G.2.b. PCBs, Mercury, cPAHs and Lead

Approximately half of the grids are considered sufficiently sampled for making a health conclusion for the chemicals PCBs, mercury, and lead. That means that half of the grids require additional sampling in order to have an adequate amount of samples to make a health determination. For cPAHs, approximately one-third of the grids are sufficiently sampled for ATSDR to make a health conclusion. Most of the insufficiently sampled areas (excluding the area of the proposed detention center) for each chemical of concern is in the southeastern portion of the site. Another area frequently identified as not having adequate sampling is the western dry-land area closest to the marsh. A possible reason for this is that the TEG data were deemed unusable because of data quality issues.

One reason certain areas may not have been sampled is that LCP Chemicals did not perform industrial activities on that portion of the site. However, LCP Chemicals may have disposed industrial waste anywhere on the property. In addition, numerous other industries existed at this location before LCP Chemicals and those industries may have disposed of waste throughout the property.

Figure 22. Adequacy of Sampling for PCBs in the Dry-land Area

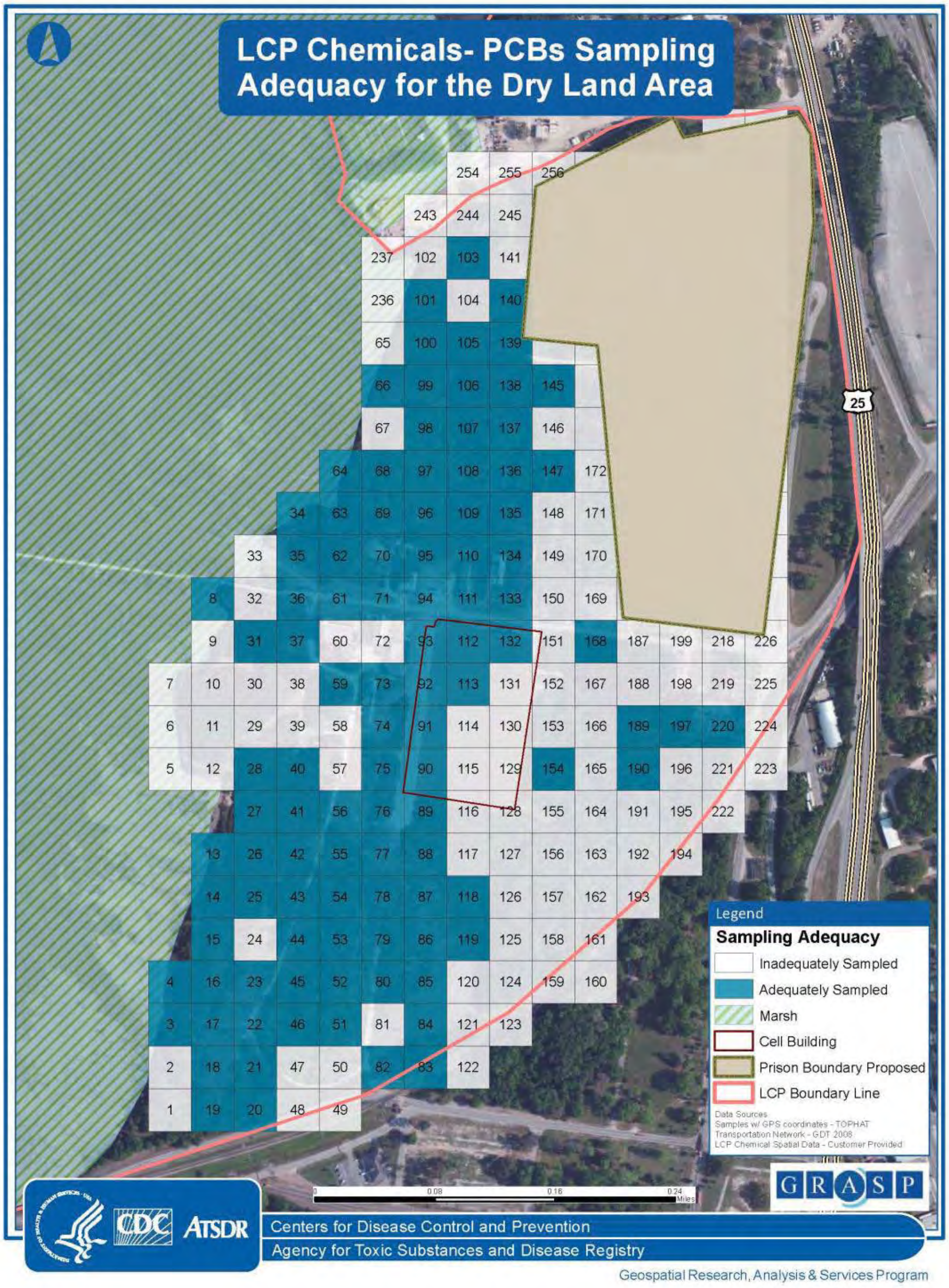


Figure 23. Adequacy of Sampling for Mercury in the Dry-land Area

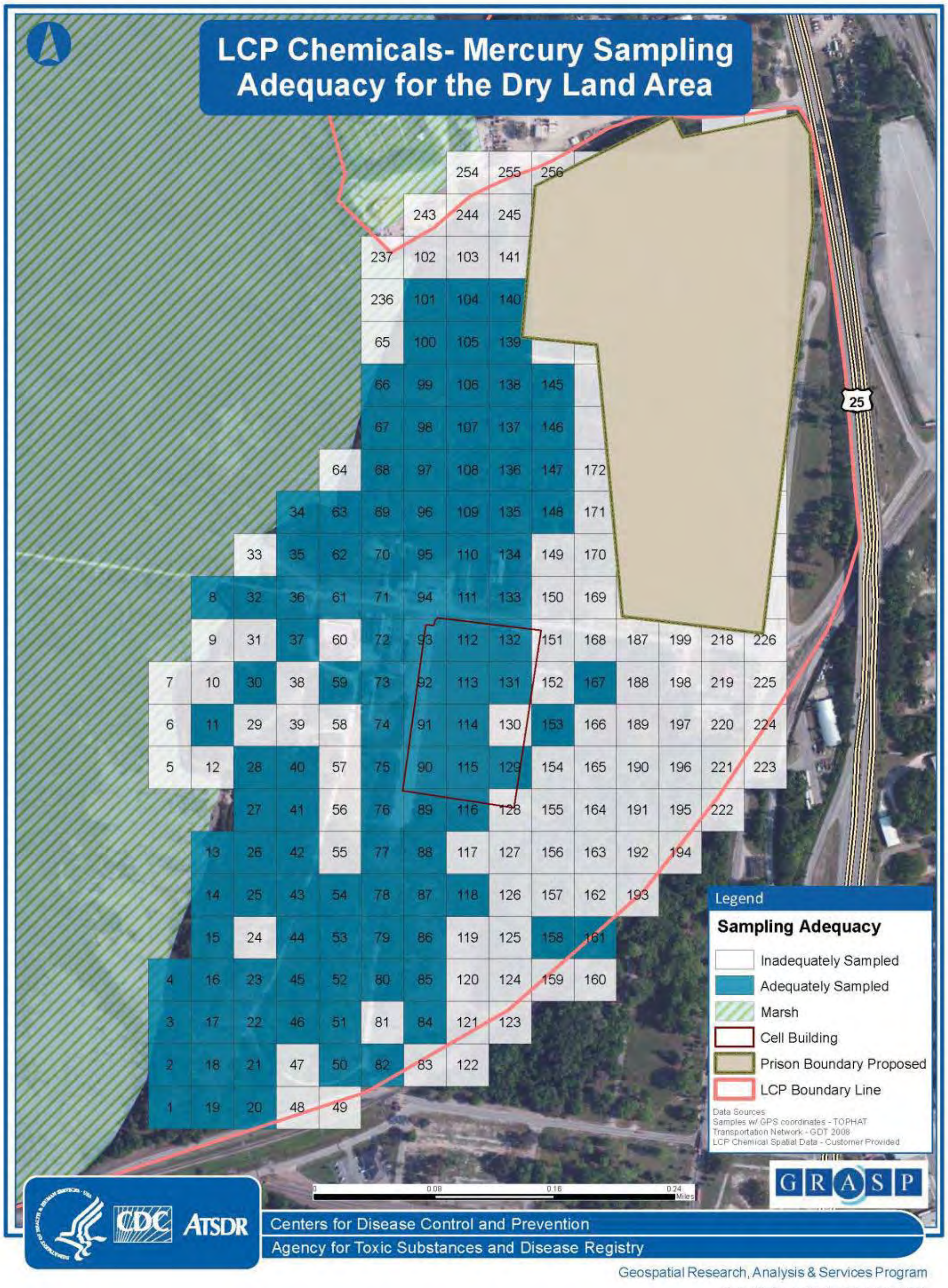


Figure 24. Adequacy of Sampling for PAHs in the Dry-land Area

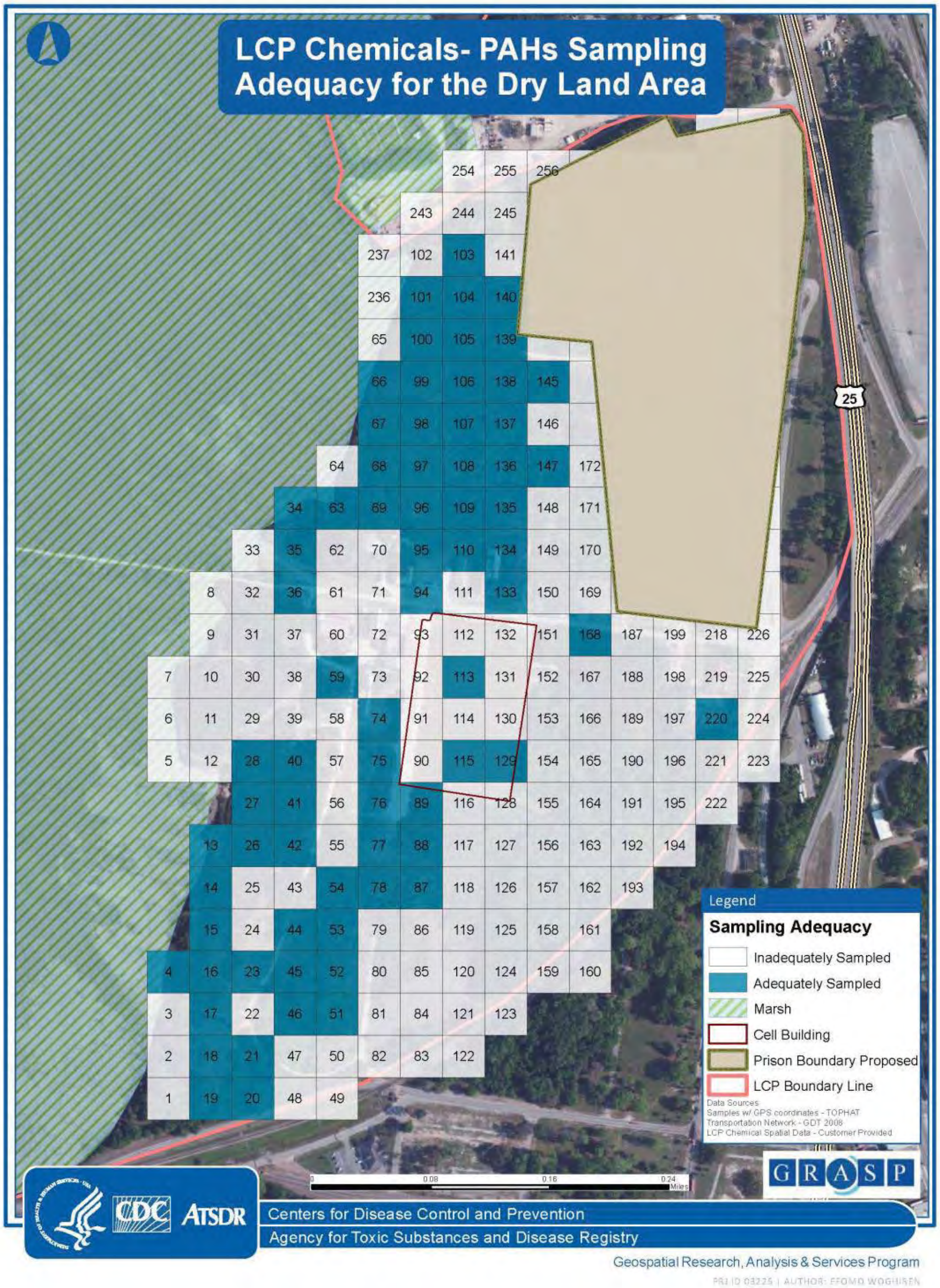
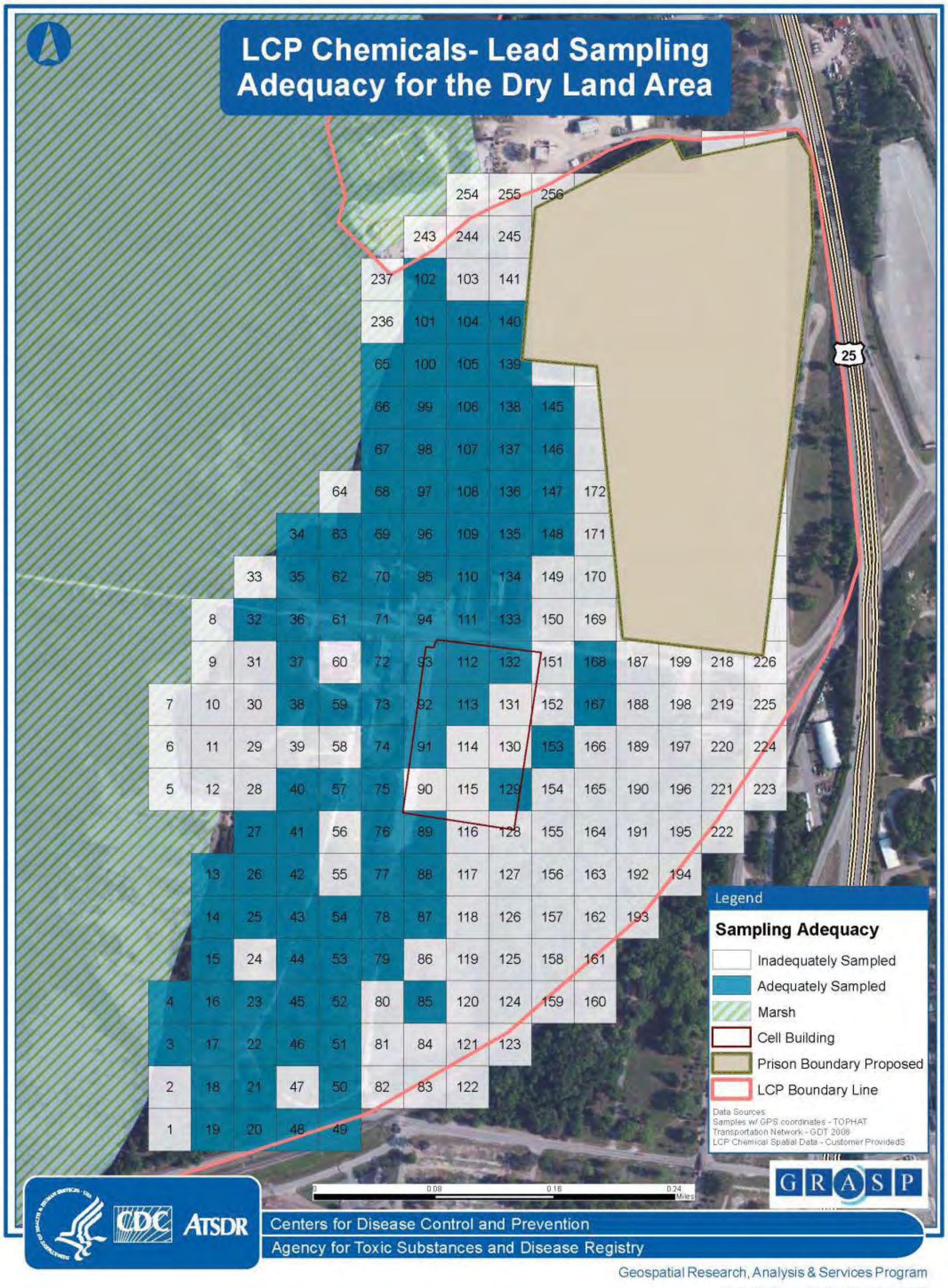


Figure 25. Adequacy of Sampling for Lead in the Dry-land Area



IV.G.3. The Altamaha Canal

In July 2011, Honeywell collected sediment and fish tissue samples from a segment of the former Brunswick-Altamaha Canal ("the Altamaha Canal") south of the LCP Chemical Site (EPS 2011). Honeywell conducted the sampling in response to a recommendation by ATSDR to further characterize the sediment and fish tissue in the Altamaha Canal that lies south of the LCP Chemical site. This section of the canal was identified by ATSDR as a potential pathway for onsite contaminant migration. The sampling was conducted to provide information on the potential for human exposure due to (1) direct contact with contaminants in surface sediments and (2) consumption of contaminated fish or shellfish from the canal.

When the canal was constructed in the mid-1800s, it served as a transportation point between harbors in Brunswick and the Altamaha River, which lies approximately 12 miles to the north (EPS 2011). A portion of the canal once traversed the shoreline area along the western edge of the LCP property but has since been filled in. Today there is no visible presence of the canal on the LCP property. According to Honeywell, there is no direct surface water communication between the LCP marsh and the canal (EPS 2011).

IV.G.3.a. Sediment Sampling

Surficial sediment samples (upper 6 inches) were collected from twenty locations within the canal section between the West 9th Street (northern limit) and the T Street (southern limit). Each sample is comprised of a five-point composite taken along an approximate 1000-ft stretch of the canal. The sampling locations and analytical results are shown in Figures 29 through 33. The sediment sampling results are summarized in Table 13.

Table 13. Recent Sampling Results, July 2011, for Sediment in an Offsite Portion of the Altamaha Canal (ppm)

	Contaminant	*Comparison Value*	*Min Conc.*	*Max Conc.*
Sediment	PCBs	0.35	0.01	**2.3**
	Mercury	5*	0.04	4.96
	cPAHs	0.096†	0.07	**0.69**
	Lead	None	5.82	45.2
	Dioxin	0.000035±	0.000021	**0.000127**

*indicates comparison value for methylmercury
† indicates comparison value for benzo(a)pyrene
±indicates ATSDR's comparison value of 35 ppt for soil

The concentration of lead in sediment from the canal is at or near background lead levels in soils (i.e., 7 ppm) (ATSDR 1992) and the concentration of mercury is below ATSDR's comparison value; therefore, lead and mercury in sediment will not be evaluated further. The levels of PCBs, cPAHs, and dioxin exceed ATSDR's comparison values and therefore will be evaluated further in the public health implications section of this report.

It should be noted that PCBs, specifically Aroclor 1268,were detected in every sediment sample.

It should also be noted that the concentrations of all contaminants (PCBs, mercury, PAHs and lead) except dioxin are higher at the northernmost sampling location, which is also closest to the LCP Chemical site. The general trend is for higher concentrations to be closer to the site (north) and to decrease as the canal flows south. This spatial trend suggests that contaminants might have migrated from the site into the Altamaha Canal.

IV.G.3.b. Fish Tissue Sampling

Fish and shellfish were collected from areas near the southern terminus of the canal (Figure 31) using gill nets, cast nets, and crab traps. Nets were place approximately every 1000 linear feet of canal. The following types and numbers of finfish and shellfish were collected:

- 1 spotted sea trout
- 1 red drum
- 7 striped mullet
- 15 blue crabs
- 108 white shrimp

Three replicate samples from each finfish and shellfish species were tested (except for red drum and spotted sea trout where only one fish of each was caught). Finfish were scaled and filleted; only the edible portion was collected for testing. Shellfish were also processed to remove only edible tissue for testing. Fish tissue samples were analyzed for metals (including mercury and lead), PCBs and PAHs. The results for PCBs and mercury are summarized in Table 14.

It should be noted that Aroclor 1268 was the only PCB congener detected in fish tissue, which suggests that the LCP Chemicals Site is the likely source.

Table 14. Results of Fish and Shellfish Tissue Sampling Altamaha Canal, 2011			
FINFISH	***Contaminant***	***Concentration (µg/kg-ww)****	***No. Fish in Sample***
Red Drum	PCBs (1268)	21	1
	Mercury	88.3	
Striped Mullet	PCBs (1268)	290	3
	Mercury	12.3	
Striped Mullet	PCBs (1268)	260	2
	Mercury	14.9	
Striped Mullet	PCBs (1268)	200	2
	Mercury	12.8	
Spotted Sea trout	PCBs (1268)	81	1
	Mercury	117	
SHELLFISH	***Contaminant***	***Concentration (µg/kg-ww)****	***No. Fish in Sample***
Blue Crab	PCBs (1268)	14	4
	Mercury	67.2	
Blue Crab	PCBs (1268)	21	6
	Mercury	69.2	
Blue Crab	PCBs (1268)	9.4	5
	Mercury	107	
Shrimp	PCBs (1268)	14	36
	Mercury	18.7	
Shrimp	PCBs (1268)	16	36
	Mercury	22.3	
Shrimp	PCBs (1268)	16	36
	Mercury	21.2	

*µg/kg-ww = microgram per kilogram wet weight; dry weight will likely be higher when accounting for the moisture content

Figure 26. Sampling Locations Showing Concentration of PCBs in Sediment in Altamaha Canal, 2011 Just South of the LCP Chemicals Site.

Figure 27. Sampling Locations Showing Concentration of Mercury in Sediment in Altamaha Canal, 2011 Just South of the LCP Chemicals Site.

Figure 28. Sampling Locations Showing Concentration of PAHs in Sediment in Altamaha Canal, 2011 Just South of the LCP Chemicals Site.

Figure 29. Sampling Locations Showing Concentration of Lead in Sediment in Altamaha Canal, 2011 Just South of the LCP Chemicals Site.

Figure 30. Sampling Locations Showing Concentration of Dioxins in Sediment in Altamaha Canal, 2011 Just South of the LCP Chemicals Site.

Figure 31. Sampling Locations for Finfish and Shellfish Collection, Altamaha Canal South of the LCP Chemicals Site.

V. PUBLIC HEALTH IMPLICATIONS

The public health implication section evaluates whether people's health could be affected should the site become residential or commercial. We know that contact with soil results in soil ingestion that could lead to exposure to contaminants in soil. If that exposure is high enough, it could cause harmful effects in people. This section describes the harmful effects that might be possible from exposure to contaminants in soil. This evaluation was a major component of the public release of the report in September 2010.

Since that time, EPA has collected more soil samples, particularly around the former theater and the pond in the northwest corner of the site. These new data are evaluated for the first time in this report. In addition, EPA collected sediment and fish samples from the Altamaha Canal that exists just south of the LCP site. This section evaluates whether eating fish from the Altamaha Canal might cause harmful effects.

V.A. Soil Ingestion

Children and adults can come in contact with chemicals in soil by accidentally swallowing small amounts of soil that cling to their hands when they put their hands in or near their mouths. This exposure is greatest for preschool children because of their frequent hand-to-mouth activity. When chemically contaminated soil is tracked indoors, people also can be exposed to chemicals by swallowing contaminated dust that clings to their hands. Preschool children, on average, swallow more soil and dust than people in any other age group. This is because some preschoolers often have close contact with soil and dust when they play, and because they tend to engage frequently in hand-to-mouth activity. The amount of soil that people ingest daily is typically somewhere between 30 milligrams to 200 milligrams (ATSDR 2005b; EPA 1997; Calabrese 1997). To put this amount in perspective, it is approximately equal to a pinch (or less than $^{1}/_{32}$ teaspoon) to $^{1}/_{8}$ teaspoon of soil.

V.B. Soil Pica Behavior

Pica behavior, or the eating of non-food items, is well known in children. Children have been observed eating paint chips, matches, paper, clay, soil, and numerous other non-food items. Children who eat large amounts of soil have a behavior called "soil-pica." Soil pica behavior is most likely to occur in preschool children as part of their normal exploratory behavior. Children between the ages of 1 and 2 years have the greatest tendency for soil-pica behavior, and this tendency diminishes as they become older. The exact percentage of children who eat soil is not known. Studies have reported that soil pica behavior occurs in as few as 4 out of every 100 children (i.e., 4%) or in as many as 21 out of every 100 children (i.e., 21%) (Barltrop 1966; Robischon 1971; Shellshear 1975; Vermeer and Frate 1979). A study by ATSDR and the Colorado Department of Health and Environment found 21% of preschool children with soil pica behavior in a predominantly Hispanic population. About 10% of preschool children ate soil within 2 weeks of their parents being interviewed (ATSDR 2005b). Studies on children with soil pica behavior have shown that they can eat up to a teaspoon of dirt (or 5,000 milligrams) (Stanek and Calabrese 2000; Calabrese and Stanek 1993; Calabrese *et al*. 1989; Wong 1988).

Limited information is available concerning how often and how long soil pica behavior occurs in children. Some preschool children might eat soil once during their preschool years, while others might go through a stage of eating soil several times during a week, or even over several months. Soil-pica behavior might occur for several days in a row, or a child might skip days between eating soil (Calabrese and Stanek 1998; Calabrese and Stanek 1993; Wong 1988; ATSDR 2001).

When estimating the intake of chemicals from soil pica behavior, ATSDR estimates a dose assuming that some children eat soil 3 times a week. Because soil pica behavior is habitual, it is reasonable to assume that this behavior can occur for several weeks to several months, especially during late spring, summer and early fall when preschool children might spend more time outdoors (ATSDR 2001).

V.C. Estimating Contact with Chemicals in Soil

As described previously, one way contact with chemicals in soil occurs is from swallowing contaminated soil that clings to a person's hands. The amount of chemical that is swallowed is called a dose. Factors that are important in estimating the dose of chemicals include the following:

- the average concentration of chemicals in soil,
- how much soil is ingested,
- how frequently someone ingests soil, and
- a person's weight.

The following equation is used to estimate chemical dose in people from swallowing soil:

Chemical dose =

$$\frac{\text{(chemical concentration in soil, mg/kg)} \times \text{(mg soil swallowed)} \times \text{(exposure frequency)} \times \text{(0.000001 kg/mg)}}{\text{person's weight in kg}}$$

The resulting chemical dose is milligrams of chemicals per kilogram body weight per day or milligram per kilogram per day (mg/kg/day). A range of chemical doses are possible because different values can be used for various parameters in the equation. For example, the amount of soil ingested varies from about 100 mg for a typical child, to 200 mg for some children, and to 5,000 mg for children with soil pica behavior (ATSDR 2005b; ATSDR 2001; Calabrese 1997). Weight can also vary from 10 kg for a 1-year-old child to 35 kg for elementary age children, and 60 kg for women to 70 kg for men. Since site-specific information is usually not available, we assume that all of the chemical that is swallowed will cross the gut into the body. Therefore, because of differences in weight and differences in soil intake, the estimated dose of a chemical can vary within an age group and between age groups.

The resulting dose is milligram chemicals per kilogram body weight per day (mg/kg/day). When very small doses are calculated it is often easier to view the doses as micrograms chemicals per kilogram body weight per day (µg/kg/day). A microgram is one-thousandth of a milligram. Therefore, an estimated dose of 0.005 mg/kg/day is the same as 5 µg/kg/day. Most of the doses in this report are presented as µg/kg/day.

To determine whether harmful effects might be possible from ingesting contaminated soil, ATSDR compares the estimated chemical dose to the Agency's "health guideline" dose for that chemical. ATSDR's health guidelines are called Minimal Risk Levels (MRLs) and they are developed for three exposure periods: acute (less than 2 weeks), intermediate (2 weeks to 1 year), and chronic (1 year or more). MRLs are available for oral exposure and for inhalation exposure. We will use the chronic, oral MRL as a guide because the principle route of exposure at the LCP Chemicals site is from swallowing soil and because residential exposures are likely to occur for many years. When appropriate, we may use the acute and intermediate MRLs as a guide, for instance, when evaluating worker exposures that take place for periods less than a year.

An MRL is a chemical dose below which noncancerous harmful effects are not expected. It is important to remember that MRLs cannot be used to evaluate cancer. Cancer risk is evaluated using another method, which will be explained later in the public health assessment. MRLs are derived by reviewing animal and human studies to identify either the lowest level known to cause harmful effects or identifying a level that will not cause harmful effects. Most MRLs are set anywhere from 3 to 1000 times below these effect or no effect levels. Therefore, when an MRL is exceeded, it does not mean that harmful effects will occur but rather that more toxicological evaluation is needed to determine if harmful effects might be expected. This additional toxicological evaluation involves comparing the estimated chemical dose to effect and no effect levels and reviewing additional toxicological information to decide if harmful effects might be expected.

A useful tool in deciding if the estimated dose exceeds an oral MRL or some other health guideline is the use of hazard quotients (HQ). An HQ is a number that shows whether the MRL has been exceeded. If the HQ is greater than 1, then the estimated dose for a chemical exceeds the MRL and further toxicological evaluation is needed. If the HQ is less than one, the estimated dose for a chemical is below the MRL and non-cancerous harmful effects are not expected. Using the HQ allows the reader to look at a table showing multiple dose estimates for various age groups and to easily see if the estimated doses are greater than or lower than the MRL.

The formula for determining the HQ follows:

$$HQ = \frac{\text{estimated dose of a chemical in mg/kg/day}}{\text{MRL in mg/kg/day.}}$$

The same HQ can be calculated by using the estimated dose in µg/kg/day and converting the MRL to µg/kg/day.

V.D. Uncertainty in Deciding Harmful Effects

Some uncertainty exists in deciding whether harmful effects are expected because uncertainty exists in estimating the chemical dose in people. This uncertainty exists because we are not sure exactly how much soil people ingest daily, although we have a fairly good idea. As mentioned previously, most children swallow about 100 milligrams of soil and dust daily while some children may swallow up to 200 mg daily. Similarly, adults may swallow only a few milligrams of soil and dust daily or they may swallow 100 mg or more, for instance, if they have frequent contact with soil from yard work or gardening. Uncertainty also comes from deciding the body weight to use for various age groups. In addition to these factors, uncertainty comes from deciding the chemical concentration in soil to use in estimating dose. These uncertainties result in a range of doses that can be estimated for various age groups. One way to encompass this uncertainty is to use average values to estimate the dose to get an estimated dose that represents exposure for most people. For example, to estimate the chemical dose for most children, ATSDR uses 100 milligrams of soil and dust ingested daily. Because ATSDR wants to protect all people from harmful chemicals, it is possible to estimate the highest dose that might be expected in a population. For example, ATSDR uses 200 milligrams of soil and dust ingested daily to represent the chemical dose in the small percentage of children with high soil intake. This dose is presented in the tables.

In addition to the uncertainty that comes from estimating a chemical dose, uncertainty could exist in the human and animal studies that identify the doses that cause harmful effects or the doses that cause no harmful effects. This uncertainty varies with each chemical. When an MRL is exceeded or if an MRL is not available, the estimated chemical dose in people is compared to the doses from human and animal studies that cause harmful effects and to doses that show no effect. This comparison along with a review of other information in ATSDR's chemical-specific toxicological profile is used to decide what harmful effects might be expected.

Uncertainty also exists that is specific to the LCP Chemicals Site. First, uncertainty exists from using soil samples that were collected 15 years ago. These soil samples may not represent current conditions at the site. Second, uncertainty also comes from not knowing how much chemical contamination below the surface will actually become surface soil during construction activity. And lastly, some 1990's data were not useable because of data quality issues, thus not only were fewer samples available but also this made some areas of the site inadequately sampled.

V.E. Background Information About Cancer

Cancer is a complex subject and some background information is provided before discussing cancer evaluations of specific chemicals. The probability that residents of the

United States will develop cancer at some point in their lifetime is 1 in 2 for men (44.9 %) and 1 in 3 (38.5%) for women. Stated another way, half of all men and one-third of all women will develop cancer in their lifetime (ACS 2009). This probability is based on medical data collected on all types of cancer, regardless of whether the cause was identified, the case was successfully treated, or the patient died (directly or indirectly) from the cancer.

Factors that play major roles in cancer development include:

- Lifestyle (what we eat, drink, smoke; where we live);
- Natural (including sunlight) and medical radiation;
- Workplace exposures;
- Drugs;
- Socio-economic factors; and
- Chemicals in our air, water, soil, or food.

Infectious diseases, aging, and individual susceptibility, such as genetic predisposition, are also important factors in cancer development (ATSDR 2000, ACS 2009, NTP 2005).

We rarely know environmental factors or conditions responsible for the onset and development of cancer. For some occupational exposures or for the use of specific drugs, we do have some understanding of cancer development (Tomatis *et al*. 1997). Overall cancer risks can be reduced by eating a balanced diet, getting regular exercise, having regular medical exams, and avoiding high risk behaviors, such as tobacco use and excessive alcohol consumption. Proper safety procedures, appropriate personal protective equipment, and medical monitoring programs can decrease cancer risks in the workplace (ACS 2009).

V.E.1. How to estimate and interpret cancer risk

The EPA has a method for estimating the cancer risk from chemical exposure. The cancer risk is estimated by multiplying the estimated dose for a population by what is called a cancer slope factor. The resulting number is an estimate of the number of cancers in a population over a lifetime that might result from the chemical exposure. The equation for estimating cancer risk follows:

Cancer risk = estimated lifetime dose x cancer slope factor

The resulting risk of cancer is called an excess cancer risk because it is the risk of cancer above the already existing background risk of cancer discussed above.

This additional cancer risk estimate from chemical exposures is often stated as 1×10^{-4}, 1×10^{-5}, or 1×10^{-6} (or 1E-4, 1E-5, or 1E-6). Using 1×10^{-6} (or 1E-6) as an example, it means that a population of one million people exposed to a carcinogen over a lifetime (70 years) at a specific dose may have one additional case of cancer because of the exposure. This estimated cancer risk is in addition to the 412,000 cases expected in this population of 1 million men and women over a lifetime. The "one-in-a-million" risk level is generally regarded as a low risk. If the exposed population is small, it is difficult to prove that cancer cases in a community are the result of chemical exposures, especially given the large number of people that get cancer from other causes.

An estimated additional cancer risk of 1×10^{-4} means that a population of 10,000 people exposed for a lifetime (70 years) at a certain chemical dose may have one additional cancer case. This one case is in addition to the 4,120 cases expected in this population of 10,000 men and women over a lifetime. This risk is 100 times higher than the one in a million risk described in the previous paragraph. Although a "one-in-ten thousand" risk level may be viewed as a high increased risk, it is good to understand the exposure assumptions that went into estimating this risk.

Mathematically, the excess cancer risk is an estimate of the 95% upper confidence limit of additional cancer risk for adults or children with similar exposures. For this reason, the risk is presented as the number of cancers that might occur in a large number of people (e.g., 10,000, 100,000 or 1,000,000) with similar exposures. The true risk is not known, but will likely be lower. When we talk about the additional or excess cancer risk, we mean the risk above and beyond what is considered background or normal. It is important to remember that we cannot determine an individual's cancer risk but rather the estimated cancer risk refers to the risk for a population of people with similar chemical exposure.

V.F. Chemical-specific evaluations

As mentioned previously, ATSDR is concerned about people's contact with soil if land on the LCP Chemicals Site is developed in the future as residences or as commercial or industrial businesses. If a home or business is built on certain grids, contaminated soil from various depths could be moved so that contaminants are now at the surface. It is not possible to predict the concentration of contaminants at the surface from future soil movement. Therefore, ATSDR used the current contaminant soil concentration from samples up to 5 feet below the surface to estimate an average contaminant concentration for a grid. The groundwater at the site is approximately 5 ft. below ground surface. In addition to looking at contamination from 0 to 5 ft. in depth, ATSDR estimated contaminant concentration from 0 to 2 ft. in depth. The reasons for looking at this depth are (1) contaminant concentrations might be different in the top few feet, and (2) construction activity might be limited to a more shallow depth. The following chemical-specific subsections describe ATSDR's evaluation of each chemical of concern for these two scenarios, residences and businesses.

V.F.1. Polychlorinated Biphyenls

V.F.1.a. ATSDR's Health Guideline for PCBs

ATSDR has a chronic oral MRL of 0.00002 milligram per kilogram per day (mg/kg/day), which is the same as 0.02 microgram per kilogram per day (µg/kg/day). When deriving an MRL, ATSDR scientists review the toxicological literature to identify the lowest doses in either animals or humans that cause harmful effect. These doses are referred to as the lowest observed adverse effect level (LOAEL). When appropriate, ATSDR scientists select one of these LOAELs to derive the MRL. For some chemicals, the MRL is derived from a dose that does not cause harmful effects. This dose is referred to as the no observed adverse effect level (NOAEL). For PCBs, ATSDR derived the chronic oral MRL from a LOAEL identified in a monkey study. The lowest dose identified to cause harmful effects in monkeys' immune system is 0.005 mg/kg/day (or 5 µg/kg/day). Monkeys who were exposed daily to this PCB dose for 23 months showed reduced antibody response when the monkeys were injected with sheep red blood cells. To derive the chronic MRL, ATSDR divided the LOAEL of 5 µg/kg/day by an uncertainty factor of 300, which resulted in 0.016 µg/kg/day. This dose was rounded to 0.02 µg/kg/day and became the chronic oral MRL.

For now, it is important to know that estimated PCB doses in people who come in contact with LCP soils will be compared to ATSDR's chronic oral MRL for PCBs of 0.02 µg/kg/day.

V.F.1.b. Estimating Human Doses of PCBs and PCB Hazard Quotients

As mentioned previously, doses were estimated using a range of soil ingestion rates for various age groups. Preschool children were assumed to swallow 200 milligrams of soil daily, while elementary-age children, teenagers, and adults were assumed to swallow 100 milligrams of soil daily. Average body weights were selected for each age group. These and other parameters used to estimate PCB doses in people are shown in Appendix B, Table B1.

The estimated dose of total PCBs for each age group is shown in Table 15 for various PCB average concentrations ranging from 1 ppm to 139 ppm. The resulting estimated dose is presented as micrograms total PCBs per kilogram body weight per day (or µg/kg/day). The estimated dose of total PCBs ranges from 0.001 µg/kg/day in adult men who have daily contact with 1 ppm total PCBs in soil to 2.78 µg/kg/day in 1-year-old children who have daily contact with 139 ppm total PCBs in soil.

As mentioned previously, the PCB HQ is an easier way to determine if the estimated dose is less than or greater than the chronic MRL. The PCB HQ was derived by dividing the estimated PCB dose by the chronic oral MRL of 0.02 micrograms/kg/day. The PCB HQs for various age groups are shown in Table 16 for average soil concentrations of 1, 5, 10, 25, 50 and 139 ppm total PCBs. These PCB HQs are for the people in each age group with high soil intake who might live in a grid having the specified average PCB concentration. People in each group with average or typical soil intake have PCB HQs that are about 2 to 4 times lower than people with high soil intake.

Table 15. Chronic estimated doses for total PCBs by age group for total PCB concentrations ranging from 1 ppm to 139 ppm.						
Age Group	***Average Total PCB Concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Chronic estimated dose in µg/kg/day					
Preschool children (1 yr.)	0.020	0.10	0.20	0.50	1.0	2.78
Preschool children (3 yr.)	0.01250	0.0625	0.125	0.3125	0.625	1.7375
Elementary school children	0.00286	0.01429	0.02857	0.07143	0.14286	0.39714
Teenagers	0.00182	0.00909	0.01818	0.04545	0.09091	0.25273
Adult men	0.00143	0.00714	0.01429	0.03571	0.07143	0.19857
Adult women	0.00167	0.00833	0.01667	0.04167	0.08333	0.26806
Chronic oral MRL in µg/kg/day	0.02	0.02	0.02	0.02	0.02	0.02

Table 16. PCB HQs for total PCB soil concentrations ranging from 1 ppm to 139 ppm.						
Age Group	***PCB Concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Chronic PCB HQ					
Preschool children (1 yr.)	1	5	10	25	50	139
Preschool children (3 yr.)	0.6	3	6	16	31	87
Elementary school children	0.10	0.7	1	4	7	20
Teenagers	0.10	0.5	0.9	2	5	13
Adult men	0.07	0.4	0.7	2	4	10
Adult women	0.08	0.4	0.8	2	4	12

The resulting PCB HQs shown in Table 16 vary by age group and by PCB soil concentration. Whenever the PCB HQ is below 1, then the estimated dose is below the chronic oral MRL and non-cancerous harmful effects are not expected. When the PCB HQ exceeds 1, then the estimated dose exceeds the chronic oral MRL. What follows is brief summary of the PCB HQs shown in Table 16:

- For one-year-old children with high soil intake, the PCB HQ is 1 when PCB concentrations are 1 ppm. For grids that have an average concentration of 5, 10, 25, 50, or 139 ppm, the PCB HQ for 1-year-old children with high soil intake is 5, 10, 25, 50, or 139, respectively.
- For 3-year-old children with high soil intake, the PCB HQ is below 1 when average PCB soil concentrations are 1 ppm. The PCB HQ is 3, 6, 16, 31, and 87 when average soil concentrations are 5, 10, 25, 50, and 139, respectively.
- For elementary age children with high soil intake, the PCB HQ is below 1 for average PCB concentrations of 1 and 5 ppm. The PCB HQ is 4, 7, and 20 when average soil concentrations are 25, 50, and 139 ppm, respectively.
- For adults, the PCB HQ is below 1 for average PCB concentrations of 1, 5, and 10 ppm. The PCB HQ is 2, 4, and 12 when average soil concentrations are 25, 50, and 139 ppm, respectively.

The PCB HQs described previously are shown graphically in Figure 32. The PCB HQs show that as average total PCB concentrations for a grid exceed about 5 ppm in soil, the PCB HQs for preschool children exceed ATSDR's chronic oral MRL. As average total PCB concentrations exceed about 25 ppm, the PCB HQs for older children and adults exceed ATSDR's chronic oral MRL. Depending on the average total PCB concentration for a grid, the PCB HQ for various age groups exceeds ATSDR's oral MRL for PCBs, thus prompting a more thorough toxicological evaluation to determine if harmful effects are expected.

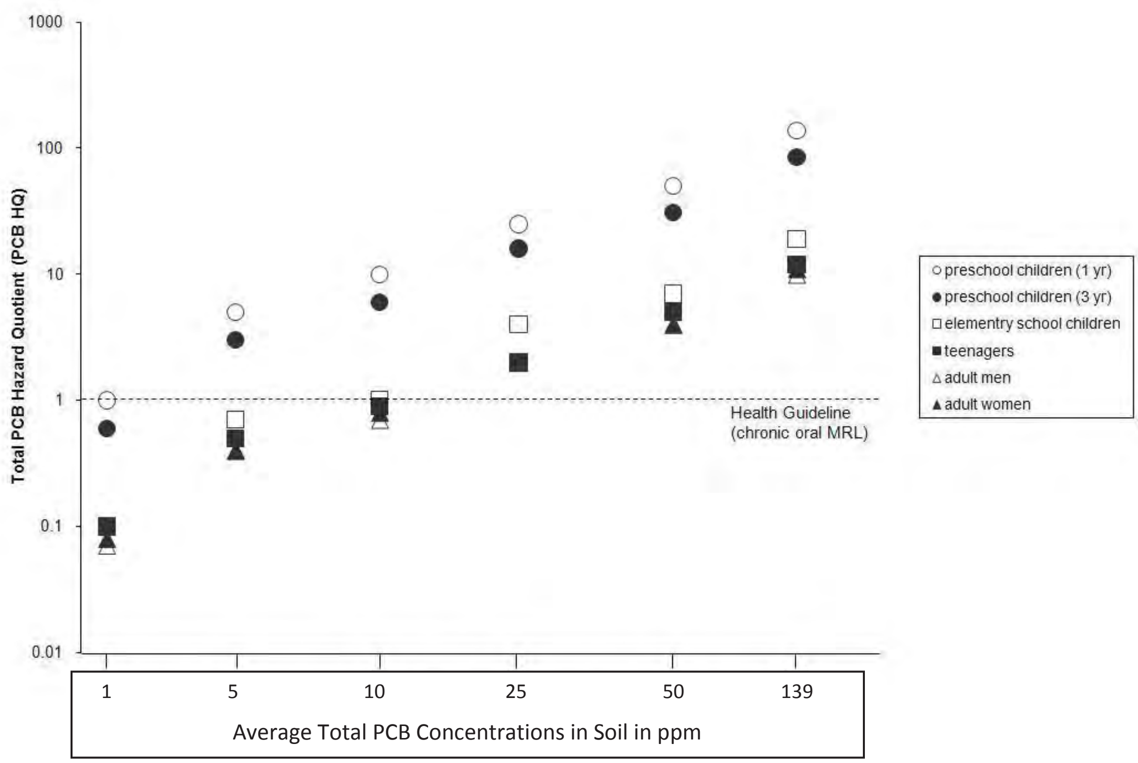


Figure 32. The Total PCB hazard quotient (PCB HQ) for various age groups are shown for average soil concentrations ranging from 1 ppm to 139 ppm. The hazard quotient is an indicator of where the estimated dose is in relation to ATSDR's health guideline for PCBs (i.e., the chronic MRL). When the HQ is below 1, the estimated dose is below ATSDR's chronic oral MRL for PCBs and harmful effects are not expected. Whenever the HQ is greater than one, which is the case for preschool children when average PCB levels exceed 5 ppm in soil, then a more thorough toxicological evaluation is needed to decide if harmful effects might be expected. As average PCB soil concentrations exceed 25 ppm, all age groups have PCB HQs that exceed one.

V.F.1.c. Human Studies and PCBs

As part of a more thorough toxicological evaluation, ATSDR will describe the human and later the animal studies that show the harmful effects of PCBs. This review is not an exhaustive review of the known harmful effects of PCBs but rather focuses on the lowest PCBs doses that cause harmful effects. These studies are more relevant to deciding what harmful effects might be expected in a human population exposed to low levels of PCBs from the environment.

Recent human studies have shown that small increases in serum PCBs are associated with harmful effects in people involving the reproductive, immune, cardiovascular, and neurological systems. Table B2 in Appendix B summarizes these studies. Specific information about each study follows.

1. The results of a prospective health study showed a 33% reduction in male births for women at the 90th percentile compared to women at the 10th percentile for serum PCB levels. Thus, women with higher PCB levels are more likely to have female children. The authors concluded that each 1 part per billion (ppb) increase in serum PCBs was associated with a 7% decrease in the number of male births. Mean serum (whole-weight) PCB levels were 5.4 ppb with a range of 3.1 ppb to 8.7 ppb for the 10th and 90th percentile, respectively. The authors caution that the findings could be due to other contaminants, metabolites, or PCBs (Hertz-Picciotto 2008).

2. Increasing serum (whole-weight) PCB levels were associated with slightly longer menstrual cycles, increasing the cycle by about a day. The authors stated weaker associations were found for serum PCB levels and irregular menstrual cycles. Serum PCB levels ranged from less than 1 ppb to greater than 5 ppb, and the effect appears in the groups with PCB levels greater than 3.75 ppb. The authors point out that an important limitation to the study is recall bias since women had to answer questions about their menstrual cycles (Cooper 2005).

3. Other human studies have shown lower birth weight for infants exposed during pregnancy via maternal body burdens of PCBs. In one study, this effect persisted to age 4 for children with the highest PCB exposure. Reduced weight persisted in another study in infants at 3 months of age. The consistency with which this finding has been demonstrated strengthens the position that PCBs cause developmental effects. It should be pointed out that birth weight is a sound indicator of newborn development and health (ATSDR 2000).

4. Cord blood PCB levels at birth was associated with impaired learning of a performance task in nine-year-old children. Low-level PCB exposure results in an inability to withhold or delay inappropriate responses, which is a measure of attention and impulse control. Mean cord PCBs levels were 1 ppb. Similar effects were seen in children with lead exposure (mean blood lead level = 4.6 µg/dL) and methyl mercury exposure (mean hair = 0.56 ppm) (Stewart 2006).

5. Serum (lipid-standardized) PCBs were associated with prevalence of cardiovascular disease in women (but not men). Lipid-standardized serum PCB levels ranged from less than 141 ppb to greater than 651 ppb (Ha 2007).

6. Using job characteristics as an indicator of PCB exposure, women (but not men) with the highest suspected PCB exposure had excess mortality from Parkinson disease (SMR = 2.96, CI = 1.08-6.42) and dementia (SMR = 2.04, CI = 1.12-3.42) (Steenland 2006).

7. A two-fold increased incidence of adult-onset diabetes in women (but not men) was associated with higher serum (whole-weight) PCB levels ranging from 5 ppb to greater than 10 ppb. The increased incidence of diabetes was observed in the people with serum PCB levels greater than 5.1 ppb compared to people with serum PCB levels below 5 ppb (Vasiliu 2006).

8. Diabetes

   About 1 out of every 12 Americans (or 23 million) has diabetes, a disease in which the body does not produce or properly use insulin. Insulin is a hormone that is needed to convert sugar, starches and other food into energy the body needs to function properly. About 1 in 5 Americans (or 57 million) have pre-diabetes, a condition that occurs when a person's blood sugar levels are higher than normal but not high enough for a diagnosis of diabetes.

   The cause of diabetes continues to be a mystery, although both genetics and environmental factors appear to play roles. Certain risk factors have been shown to be associated with diabetes. People who are overweight or obese or who are physically inactive are more likely to develop diabetes. Diabetes also leads to unhealthy cholesterol levels, which can affect people's cardiovascular health, leading to hardening of the arteries and heart disease. People also have inherent risk factors that might increase their risk of diabetes. These factors include age, race, gender, and family history (American Diabetes Association 2009).

   In addition to these risk factors, some chemicals, such as PCBs, have been associated with diabetes. As mentioned previously, a two-fold increased incidence of adult-onset diabetes in women (but not men) was associated with higher serum (whole-weight) PCB levels ranging from 5 ppb to greater than 10 ppb. The increased incidence of diabetes was observed in people with serum PCB levels greater than 5.1 ppb compared to people with serum PCB levels below 5 ppb (Vasiliu 2006).

   People with diabetes also are sensitive to air pollution found both indoors and outdoors. Breathing in harmful particles from air pollutants (for example, vehicle exhaust, industrial emissions, and haze from burning fossil fuels) may increase their risk of heart attack and stroke. A recent study found that in adults living with diabetes the ability of their blood vessels to control blood flow was decreased on days with high particulate matter pollution in the air. Decreased blood flow has been associated with an increased risk of heart attack, stroke, and other heart problems. Other studies have shown that when air pollution levels are high, people with diabetes have higher rates of hospitalization and death related to cardiovascular problems (EPA 2009d, Goldberg 2001, Zanobetti 2002).

Numerous other human studies have shown an association with PCB exposure and adverse effects, including effects on fertility, growth and development, the immune system and the nervous systems. These studies are described in ATSDR's Toxicological Profile for Polychlorinated Biphenyls and the World Health Organization's (WHO)Concise International Chemical Assessment 55, Polychlorinated Biphyenyls (ATSDR 2000, WHO 2003).

V.F.1.d. Animal Studies and PCBs

Numerous studies have demonstrated that PCBs will cause harmful effects in monkeys at low levels (ATSDR 2000). These studies, many of which are described in ATSDR's Toxicological Profile for PCBs, are summarized in Table B3 in Appendix B.

The most sensitive endpoints identified in animal studies showed developmental, immunological, and dermal effects in monkeys at daily doses of 5 µg/kg/day to 7.5 µg/kg/day. The exposure duration for most of these monkey studies was 23 to 72 months, although one study showed neurological effects in infant monkeys after 5 months exposure. At slightly higher daily doses (i.e., 20 to 40 µg/kg/day), PCBs caused fetal and post-partum deaths in pregnant monkeys along with significantly reduced conception rate and decreased serum cholesterol (ATSDR 2000). The specific effects are described below.

V.F.1.d.1. Immune System Effects in Animals

Low-level PCB exposure in monkeys showed reduced IgM and IgG antibody and a temporary reduction in B lymphocytes in response to sheep red blood cells. While this effect was observed at a daily dose of 5 µg/kg/day Aroclor 1254[1] in monkeys, this and other immunological effects are observed at higher doses. For example, at a daily dose of 200 µg/kg/day Aroclor 1248 for 11 months, monkeys showed decreased anti-SRBC hemolysin titers. At a daily dose of 800 µg/kg/day in guinea pigs for 8 weeks, guinea pigs showed decreased gamma globulin-containing cells in lymph nodes. At very high doses (500 to 1,300 µg/kg/day) ranging from 1 to 6 months, mice showed increased susceptibility to leukemia virus and increased sensitivity to bacterial endotoxin (ATSDR 2000).

V.F.1.d.2. Skin Effects in Animals

Low-level PCB exposure in monkeys at 5 µg/kg/day exposed for 72 months has been shown to damage fingernails and toenails. At slightly higher doses (e.g., 100 µg/kg/day for 2 months), harmful effects in monkeys included facial edema, acne, inflammation of

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[1] Aroclor 1254 is a commercial mix of various PCB compounds with an average chlorine content of 54%.

hair follicles, and hair loss. Longer exposure at 100 µg/kg/day in monkeys also caused fingernail loss and cellular changes in the gums (ATSDR 2000).

V.F.1.d.3. Developmental Effects During and After Pregnancy in Animals

Developmental effects refer to effects that occur during gestation and following birth as the infant grows. In animals, lower birth weight and hyperpigmentation of the skin was reported in offspring of monkeys treated before mating and during gestation with 30 µg/kg/day Aroclor 1016. Similarly, monkeys exposed during pregnancy to 5 µg/kg/day (Aroclor 1254) and via breast milk after birth for 22 weeks resulted in offspring with inflamed and enlarged tarsal glands[2], as well as nail and gum lesions (ATSDR 2000).

V.F.1.d.4. Neurological Effects in Animals

PCB exposure in juvenile monkeys for 20 weeks at a daily dose of 7.5 µg/kg/day showed changes in behavioral performance in non-spatial and spatial discrimination reversal tasks. Specifically, treated monkeys showed decreases or variable increases in response latencies across three tasks of non-spatial discrimination reversal as well as retarded acquisition of a delayed alternation task and increased errors at short delay task responses. The study investigators interpreted these findings as a learning and performance decrements. Interestingly, the resulting serum PCB levels after 20 weeks of exposure was 1.8 ppb to 2.8 ppb, levels similar to what is found in the general US population (ATSDR 2000).

V.F.1.d.5. Summary of Health Effects in Humans and Animals

In summary, low-level PCB exposure at 5 to 7.5 µg/kg/day in animals can be expected to cause the following harmful effects:

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession, and
- Learning and performance decrements.

In addition, recent human studies have shown that small increases in serum PCB levels are associated with the following:

- Fewer male births,
- Problems with attention and impulse control in children
- Lower birth weight in children,

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[2] The tarsal glands (or meibomian glands) are a special kind of sebaceous glands at the rim of the eyelids. They supply sebum, an oily substance that stops evaporation of the eye's tear film, prevents tear spillage onto the cheek, and makes the closed lids airtight. Glands are located on the upper and lower eyelids.

- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women (but not men),
- Increased death from Parkinson disease and dementia in women (but not men), and
- An increase in diabetes in women (but not men).

Unfortunately, it is not possible to assign daily PCB doses to these human studies. Some insight into daily doses might be gleaned from Rice's and Hayward's monkey studies. In a 20 week exposure study, infant monkeys were dosed daily at 7 µg/kg/day. The PCB mixture consisted of congeners that are commonly found in human breast milk. After 20 weeks exposure, PCB levels were 1.7-3.5 ppm in fat and 1.8–2.8 ppb in blood. These levels (1.8–2.8 ppb) are very similar to blood levels (0.8–1.5 ppb) that are typically found in the US general population who do not frequently eat fish (ATSDR 2000). Therefore, the dose of 7 µg/kg/day can be considered an environmentally relevant dose for humans.

V.F.1.e. Groups with Increased Sensitivity to PCBs

Other subpopulations that are potentially more susceptible to PCBs include people with incompletely developed glucuronide conjugation mechanisms (Calabrese and Sorenson 1977; Lester and Schmid 1964), such as people with Gilbert's Syndrome. Gilbert's Syndrome is a relatively common and benign congenital liver disorder that is characterized by mild, fluctuating increase in serum bilirubin, and is estimated to occur in 3–7% of the adult population (American Liver Foundation 2000). Persons with hepatic infections may have decreased glucuronide synthesis, making them more sensitive because of their decreased capacity to detoxify and excrete PCBs (Calabrese and Sorenson 1977). People with compromised liver function, such as in the case of liver cirrhosis or hepatitis B, also could be considered to be more susceptible to PCB toxicity (ATSDR 2000).

V.F.1.f. Uncertainty About the Toxic Effects of PCBs

Some uncertainty exists when deciding whether PCBs are harmful to humans because commercial mixtures of PCBs are made of different combinations of the 209 PCB chemicals. The basic structure of PCBs is a biphenyl ring, which can have from 1 to 10 chlorine molecules attached, thus the name polychlorinated biphenyl. Commercial mixtures of PCBs are classified into several groups depending upon the percent chlorination of the biphenyl compound. One common commercial name used in the U.S. is Aroclor, which is followed by a four digit number that represents the percent chlorine by weight. Examples of commonly produced Aroclors and the average chlorine content are as follows:

Aroclor 1016	42% chlorine
Aroclor 1232	32% chlorine
Aroclor 1242	42% chlorine
Aroclor 1248	48% chlorine
Aroclor 1254	54% chlorine
Aroclor 1268	68% chlorine.

Many of the animal studies use one of these commercial Aroclor mixtures to assess PCB toxicity. For chronic exposures greater than 1 year, the lowest level known to cause harmful effects in monkeys (i.e., 5 µg/kg/day) used Aroclor 1254; therefore, some uncertainty exists when using this value to assess the harmful effects of other Aroclor mixtures. A slightly different situation exists for intermediate exposures of two weeks to one year. The basis for the lowest dose known to cause harmful effects in monkeys (7.5 µg/kg/day) used a mixture of PCBs that simulated breast milk. The next lowest intermediate dose known to cause harmful effects is 100 µg/kg/day. Aroclor 1242, Aroclor 1248, and Aroclor 1254 cause harmful effects at this dose.

Additional uncertainty exists when deciding if harmful effects might be expected because very little toxicological information is available on Aroclor 1268; therefore, ATSDR relied upon toxicological information available on the other Aroclors, particularly Aroclor 1254.

V.F.1.g. Possible Health Effects from PCBs If the Site Becomes Residential

The estimated doses in various age groups with high soil ingestion have already been presented in Table 15, which is repeated here. Because the doses are small, the table shows estimated PCB doses in micrograms/kg body weight/day or µg/kg/day. For comparison, ATSDR's chronic oral MRL for PCBs also is shown in µg/kg/day.

Table 15. Chronic estimated doses for total PCBs by age group for total PCB concentrations ranging from 1 ppm to 139 ppm.

Age Group	***PCB concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Chronic estimated dose in ug/kg/day					
Preschool children (1 yr.)	0.02	0.1	0.2	0.5	1.0	2.78
Preschool children (3 yr.)	0.013	0.063	0.13	0.31	0.62	1.74
Elementary school children	0.003	0.014	0.029	0.071	0.14	0.4
Teenagers	0.002	0.009	0.018	0.045	0.091	0.25
adult men	0.001	0.007	0.014	0.036	0.071	0.2
adult women	0.002	0.008	0.017	0.042	0.083	0.23
Chronic oral MRL in µg/kg/day	0.02	0.02	0.02	0.02	0.02	0.02

Depending on the age group and the average PCB concentration in a grid, estimated doses range from well below 0.02 µg/kg/day (i.e., the chronic MRL) to the highest dose of 2.78 µg/kg/day in one-year-old children who live on soil containing 139 ppm total PCBs.

Because some estimated doses exceed ATSDR's chronic oral MRL of 0.02 µg/kg/day, it is necessary now to compare those doses to doses that cause harmful effects to decide if harmful effects might be expected.

Figure 33 shows the estimated doses in various age groups that exceed the chronic oral MRL. These doses are shown in relation to doses in monkey studies that are known to cause harmful effects. The highest estimated dose is 2.8 µg/kg/day in one-year-old children and this dose is roughly 2 times below 5 µg/kg/day, the lowest level known to cause harmful effects in monkeys.

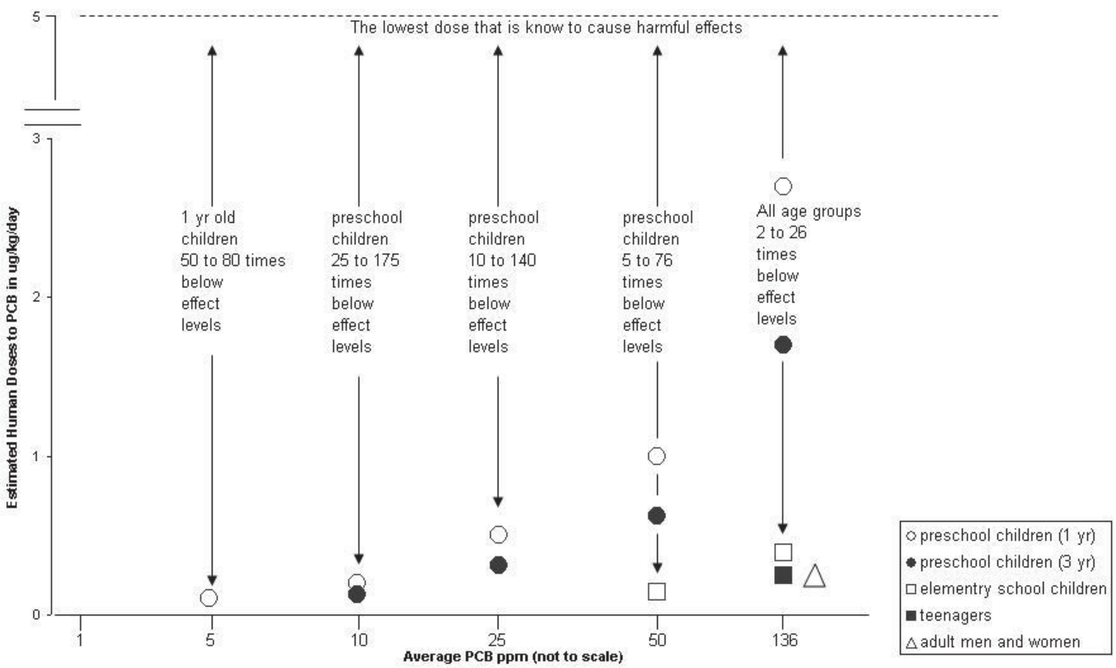

Figure 33. This graph shows the relationship between the estimated PCB doses in various groups in comparison to the lowest dose in monkeys known to cause harmful effects (i.e., 5 µg/kg/day). For example, at 139 ppm PCBs in soil, the estimated dose in 1-year old preschool children (as shown by the open circle on the far right side of the graph) is about 2 times below the lowest dose known to cause harmful effects. The estimated dose in adults (as shown by the open triangle on the far right side of the graph) is 26 times below levels known to cause harmful effects in monkeys..

The other estimated doses can be described as follows:

- At 5 ppm PCBs in soil, the estimated doses in one- and three-year-old preschool children are 50 to 80 times below the lowest effect level,
- At 10 ppm PCBs in soil, the estimated doses in preschool and elementary-age children are 25 to 175 times below the lowest effect level,
- At 25 ppm, the estimated doses in preschool, elementary-age, teenagers, and adults are 10 to 140 times below the lowest effect level,
- At 50 ppm, the estimated doses in preschool, elementary-age, teenagers, and adults are 5 to 70 times below the lowest effect level, and
- At 139 ppm, the estimated doses in preschool, elementary-age, teenagers, and adults are 2 to 25 times below the lowest effect level.

A useful concept in evaluating risk is the margin of exposure. The margin of exposure is the difference between the estimated dose and the dose that causes harmful effects and derived using the following formula:

$$\text{Margin of Exposure} = \frac{\text{Lowest Effect Level from a Study}}{\text{Estimated dose}}$$

The margin of exposure for various age groups at different average PCB soil concentrations is described in the previous bullets. The margin of exposure provides insight into how close an estimated dose is to the doses that cause harmful effects. For example, a margin of exposure of five means that the estimated dose is five times below levels that have been shown to cause harmful effects. The margin of exposure for various age groups is shown in Table 17. It should be noted that ATSDR's chronic oral MRL is 250 times below the lowest level known to cause harmful effects in monkeys. ATSDR provided margin of exposures down to 1 ppm, which is the level that corresponds to the chronic, oral MRL.

Table 17. Chronic margin of exposure to PCBs for various age groups

Age Group	***PCB Concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***136***
	Chronic Margin of Exposure					
Preschool children (1 yr.)	250	50	25	10	5	2
Preschool children (3 yr.)	400	80	40	16	8	3
Elementary school children	1,750	350	175	70	35	13
Teenagers	2,750	550	275	110	55	20
Adult men	3,500	700	350	140	70	25
Adult women	3,000	600	300	120	60	22
Commercial workers	5,096	1,019	510	204	102	37

Children have the greatest risk of experiencing harmful effects from exposure to PCBs that remain in LCP soils because their estimated doses are close to the effect level of 5 μg/kg/day, particularly at the higher PCB concentrations. Children exposed to average PCB concentrations that exceed about 1 to 5 ppm and adults exposed to average PCB concentrations that exceed about 10 to 25 ppm might experience the following harmful effects from PCBs:

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession,
- Learning and performance decrements,

- Fewer male births,
- Problems with attention and impulse control
- Lower birth weight,
- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women (but not men),
- An increase in deaths from Parkinson disease and dementia in women (but not men), and
- An increase in diabetes in women (but not men) (ATSDR 2000).

Six grids exceed EPA's 1994 target action level of 25 ppm total PCBs, while 41 grids have average total PCB concentrations greater than 1 ppm (see Table 18). The location of these grids is shown in Figure 34.

The previous results were derived using soil samples with a depth of 0 to 5 ft. The justification for using 0 to 5 ft. is that future site development might bring soil to the surface that was previously up to 5 feet below the surface. One concern is that more contaminated soil is nearer the surface, and this more contaminated soil might have a greater chance of becoming surface soil in the future because of construction activity. Therefore, ATSDR calculated statistics using soil samples with a depth of 0 to 2 ft.

Using soil samples with a depth of 0 to 2 ft. showed similar results as using 0 to 5 ft. At 0 to 2 ft., 6 grids exceed EPA's 1994 target action level of 25 ppm and 41 grids exceed 1 ppm total PCBs. More uncertainty exists in these average concentrations because fewer soil samples are available from the 0 to 2 ft. depth.

Table 18. Grids That Have Average PCB Concentrations Greater than 1 ppm

Grid #	***Average PCB Concentration in ppm***		***Grid #***	***Average PCB Concentration in ppm***
93	138.6		75	2.6
58	122.0		94	2.4
114	53.0		38	2.4
53	42.3		70	2.3
90	40.9		92	2.2
60	34.0		39	2.1
89	20.6		42	1.9
111	15.8		8	1.6
37	11.9		69	1.5
128	10.5		154	1.4
55	9.0		112	1.4
76	7.3		74	1.4
10	7.0		152	1.4
91	6.2		153	1.4
56	5.6		71	1.3
155	5.6		77	1.3

Table 18. Grids That Have Average PCB Concentrations Greater than 1 ppm				
Grid #	**Average PCB Concentration in ppm**		**Grid #**	**Average PCB Concentration in ppm**
110	4.0		133	1.3
95	3.5		197	1.1
59	3.3		17	1.1
73	2.6		134	1.0
118	2.6			

V.F.1.h. Possible Health Effects in Children with Soil Pica Behavior

As mentioned previously, somewhere between 4% and 21% of preschool children could have soil-pica behavior. Preschool children with soil-pica behavior swallow much more soil than children typically do from putting their hands in their mouth. Therefore, preschool children with soil-pica behavior will have a much greater intake of PCBs in soil.

Using PCB concentrations ranging from 1 ppm to 139 ppm, the estimated doses for 1 year-old and 3 year-old preschool children are shown in Table 19 for soil-pica behavior that occurs 3 days a week. The intermediate MRL for PCBs is shown because soil pica behavior is intermittent (ATSDR 2001).

Table 19. Estimated PCB doses in preschool children with soil-pica behavior at various total PCB concentrations. Doses are estimated for soil-pica occurring three times a week						
Age Group	**PCB Concentrations in ppm**					
	1	**5**	**10**	**25**	**50**	**139**
	Dose in ug/kg/day					
Preschool children, 1 year old, soil pica 3/week	0.21	1.1	2.1	5.4	11	30
Preschool children, 3 years old, soil pica 3/week	0.13	0.7	1.3	3.3	7	19
Intermediate oral MRL	0.03	0.03	0.03	0.03	0.03	0.03

All of the estimated doses in preschool children with soil-pica behavior shown in Table 19 exceed ATSDR's intermediate oral MRL of 0.03 µg/kg/day. For example, the estimated doses in children with soil-pica behavior who swallow soil containing 139 ppm total PCBs range from 19 to 30 µg/kg/day. These doses are significantly greater than the intermediate oral MRL of 0.03 µg/kg/day.

The PCB HQs for children with soil-pica behavior are shown in Table 20. As mentioned previously, whenever an HQ exceeds 1, the estimated dose exceeds the intermediate oral MRL. The HQ exceeds 1 for all PCB concentrations shown in Table 20. Because the estimated PCB doses exceed the intermediate oral MRL, further toxicological evaluation is needed.

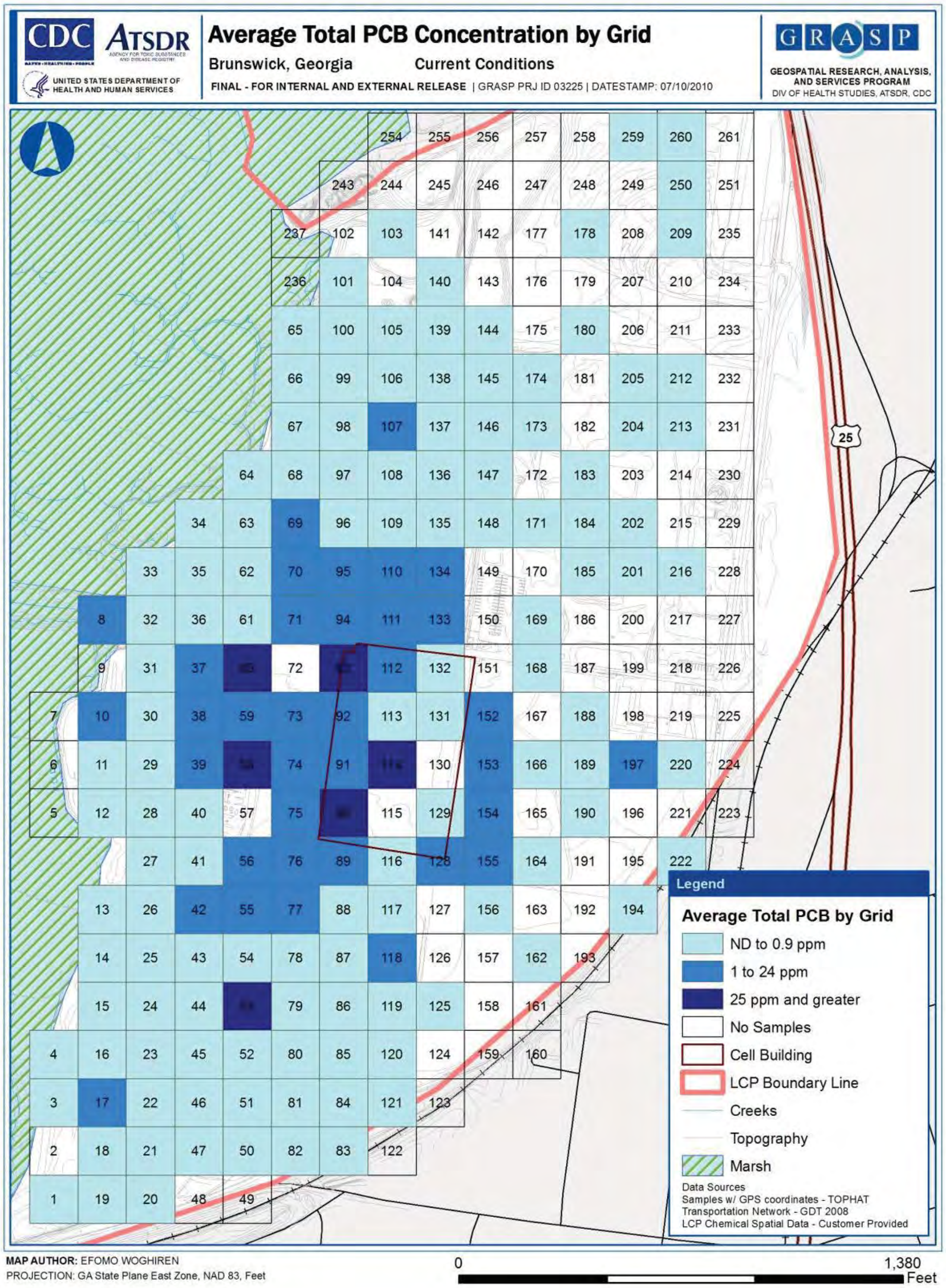

Figure 34. As indicated by the dark blue, six grids exceed EPA's 1994 target action level of 25 ppm PCBs. As indicated by medium blue, 41 grids have average PCB levels between 1 and 24 ppm. Children exposed to average PCB concentrations that exceed about 1 to 5 ppm and adults exposed to average PCB concentrations that exceed about 10 to 25 ppm might experience harmful effects from PCBs.

The lowest PCB dose known to cause harmful effects in monkeys from intermediate exposures (i.e., 2 weeks to 1 year) is 7.5 µg/kg/day, which is the same study as previously described for chronic exposure. This study showed that young monkeys were impaired in their ability organize their behavior temporally and to learn from the consequences of previous actions (Rice 2000)

Table 20. Hazard quotient (HQ) for children with soil-pica behavior						
Age Group	***PCB Concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Intermediate HQ					
Preschool children, 1 year old, soil pica 3 times/week	7	36	71	179	357	992
Preschool children, 3 years old, soil pica 3 times/week	4	22	45	112	223	620

The following comparisons can be made from the estimated doses in children with soil-pica behavior (see Table 20).

- At 139 ppm PCBs in soil, the estimated doses range from 19 to 30 µg/kg/day. These doses exceed the lowest level known to cause harmful effects in monkeys (i.e., 5 µg/kg/day).
- At 25 ppm PCBs in soil, the estimated doses range from 3 to 5 µg/kg/day. These doses are just below the lowest level known to cause harmful effects in monkeys.
- At 5 ppm PCBs in soil, the estimated doses range from 0.7 to 1.1 µg/kg/day. These doses are about seven times below the levels known to cause harmful effects in monkeys.
- At 1 ppm PCBs in soil, the estimated doses range from 0.1 to 0.2 µg/kg/day. These doses are 35 to 75 times below levels known to cause harmful effects in monkeys.

Because their brains are still developing, children with soil-pica behavior at the doses described previously are at risk of impaired learning and performance. Children could be impaired in their ability organize their behavior and to learn from mistakes.

The next lowest dose known to cause harmful effects in monkeys is 100 µg/kg/day. Numerous monkey studies have shown that PCBs can cause harmful effects to the immune system, endocrine system, liver, stomach, skin, and eye. These studies are summarized in ATSDR's Toxicological Profile for PCBs (ATSDR 2000).

The following harmful effects have been demonstrated in monkeys dosed with 100 µg/kg/day for periods ranging from 2 months to 8 months:

- Lipid accumulation in the liver, small areas of dead cells in the liver, and increased liver enzyme in the blood (Barsotti 1976),
- Decreased antibody response to sheep red blood cells (Truelove 1982),

- Decreased thyroid (T_3 and T_4) hormones (Andrews 1989),
- Cyst formation in cells lining the stomach (Becker 1979),
- Facial swelling (Becker 1979)
- Skin acne (Barsotti 1976)
- Hair loss (Barsotti 1976)
- Red eyes (Becker 1979)
- Swelling of eyelids (Gray 1993),
- Increased bone density (Andrews 1989), and
- Lack of weight gain (Becker 1979).

One-year-old children with soil-pica behavior might be expected to experience these harmful effects if they had frequent contact with soil containing 10 ppm or more total PCBs. Their estimated doses are about 50 times below the 100 µg/kg/day effect level (see Table 20). Three-year-old children with soil-pica behavior might be expected to experience these harmful effects if they exhibit soil-pica behavior 3 times a week on soil containing 25 ppm or more total PCBs. Their estimated dose is 30 times below the 100 µg/kg/day effect level. Contact with soil containing 139 ppm total PCBs yields estimated doses in three-year-old children with soil-pica behavior that are 3 to 5 times below the 100 µg/kg/day effect level.

V.F.1.i. Possible Health Effects in Workers

Since specific plans have not been identified as to the eventual use of the property, ATSDR evaluated the possibility of harmful effects for two categories of workers: commercial/industrial workers, and excavation workers.

Once the property is developed, commercial workers and industrial workers might come in contact with contaminated soil. The contact is assumed to be long-term, chronic exposure occurring for many years. Therefore, ATSDR compared estimated doses in these workers to its chronic oral MRL for PCBs. Excavation workers are likely to be exposed for periods less than a year as they move soil during construction activity. Therefore, their estimated doses are compared to ATSDR's intermediate oral MRL for PCBs.

The estimated doses for commercial and industrial workers are shown in Table 21 should these workers ingest 100 mg soil daily, 5 days a week. Estimated doses also are provided for excavation workers should these workers ingest 330 mg soil daily, 5 days a week.

Table 21. Estimated doses of PCBs for commercial and industrial workers						
Age Group	***PCB Concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Estimated dose in µg/kg/day					
Commercial/Industrial workers	0.00098	0.0049	0.0098	0.025	0.049	0.13
Chronic oral MRL in µg/kg/day	0.02	0.02	0.02	0.02	0.02	0.02
Excavation workers	0.0034	0.017	0.034	0.084	0.168	0.47
Intermediate oral MRL in µg/kg/day	0.03	0.03	0.03	0.03	0.03	0.03

As shown in Table 21, the estimated doses in commercial and industrial workers exceed the chronic oral MRL of 0.02 µg/kg/day when average PCB levels exceed about 25 ppm. Six grids have average PCB levels that exceed 25 ppm (see Table 18). At 25, 50, and 139 ppm PCBs in soil, commercial and industrial workers have estimated doses of 0.025, 0.049, and 0.13 µg/kg/day, respectively. The estimated dose of 0.1 µg/kg/day exceeds the chronic oral MRL of 0.02 µg/kg/day and is about 50 times below the lowest dose known to cause harmful effects in monkeys (i.e., 5 µg/kg/day). Workers exposed to 0.1 µg/kg/day PCBs might experience the following harmful effects from PCBs:

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession,
- Learning and performance decrements,
- Fewer male births,
- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women (but not men),
- An increase in deaths from Parkinson disease and dementia in women (but not men), and
- An increase in diabetes in women (but not men) (ATSDR 2000).

ATSDR assumed that excavation workers might conduct excavation activities for 6 months while developing the site. Therefore, the most appropriate health guideline to use is ATSDR's intermediate oral MRL for PCBs, which is developed for exposure periods of 2 weeks to 1 year. ATSDR's intermediate oral MRL for PCBs is 0.03 µg/kg/day. For excavation workers, estimated doses exceed the intermediate oral MRL when average PCB concentrations in soil exceed 10 ppm. Because the intermediate oral MRL is exceeded, a more detailed toxicological evaluation is warranted to decide if harmful effects are expected.

The basis for the intermediate MRL is a study involving infant monkeys, which is not appropriate to use when evaluating the risk for adults. More appropriate studies involve older monkeys and rats. These studies show that harmful effects in animals result from exposure to 100 µg/kg/day for periods of 2 to 8 months (Barsotti 1976, Becker 1979, Andrew 1989, ATSDR 2000). The following harmful effects were observed in older monkeys and rats at 100 µg/kg/day :

- Skin acne
- Hair loss
- Swelling and reddening of the eyelids and facial edema,
- Liver damage (e.g., lipid accumulation, localized cell death, liver enzyme in the blood),
- Cysts in the stomach lining,
- No weight gain,
- Increased bone density in the femur

At 10 and 25 ppm PCBs, the estimated doses in excavation workers are 0.03 and 0.08 µg/kg/day, which are at or below the intermediate MRL. Therefore, non-cancerous harmful effects are not expected. At 50 and 139 ppm total PCBs in soil, the estimated doses in excavation workers are 0.17 to 0.47 µg/kg/day. These estimated doses in excavation workers are 200 to 600 times below doses that cause harmful effects in animals. Non-cancerous harmful effects in excavation workers are not expected.

In summary, workers who have contact with PCBs in some areas on the site could be at risk of small changes in immune function, mild damage to fingernails and toenails, and damage to oil glands around the eyes. In addition, excavation workers who have contact with PCBs in some areas on the site could be at risk of skin problems (e.g., acne, hair loss), damage to the eyes, face, stomach, liver, and bones.

V.F.1.j. PCBs and Cancer

The carcinogenicity of PCBs in humans has been investigated in retrospective, cohort, mortality studies that investigated cancer in exposed workers, and in case-control studies of environmental exposure that examined associations between serum or adipose tissue levels of PCBs and the occurrence of cancer. Some of the mortality studies suggest that occupational exposures to PCBs were associated with cancer at several sites, particularly the liver, biliary tract, intestines, and skin (melanoma). A report of liver cancer in Japanese victims who were poisoned by PCBs appears to support the occupational liver cancer data. There is no clear association between occupational exposures to PCBs and cancer in other tissues, including the brain, hematopoietic, and lymphatic systems. Case-control studies of the general population are inconclusive with respect to associations between environmental exposures to PCBs and risk of breast cancer or non-Hodgkin's lymphoma, although there are preliminary indications that particular subgroups of women may be at increased risk for breast cancer. Overall, the human studies provide some evidence that PCBs are carcinogenic. There is conclusive evidence, however, that commercial PCB mixtures are carcinogenic in animals on the basis of induced tumors in the liver and thyroid (ATSDR 2000).

The human studies examining the cancer causing effect of PCBs often have methodological limitations. However, the evidence, taken in totality, indicates a potential cancer causing effect from PCBs. EPA determined that the human data are inadequate, but suggestive, of carcinogenicity. Using animal data, EPA classifies PCBs as a probable human carcinogen (TOXNET 2009). The U.S. Department of Health of Human Services through its National Toxicology Program has designated PCBs as a probable human carcinogen; and, the International Agency for Research on Cancer (IARC) designates PCBs as probably carcinogenic in humans (ATSDR 2000, IARC 2009).

It should be pointed out that the EPA recommends using total PCBs to estimate cancer risk rather than the commercial designations of PCBs into the various Aroclor groups (EPA 2009b).

V.F.1.k. Estimated Cancer Risk If the LCP Chemicals Site Becomes Residential

Numerous studies have shown that several commercial mixtures of PCBs (i.e., Aroclors 1016, 1242, 1254, and 1260) have caused liver and thyroid cancer in rats at doses ranging from 1 mg/kg/day to 5.4 mg/kg/day (or 1,000 µg/kg/day to 5,400 µg/kg/day). The EPA used these studies to generate a cancer slope factor that can be used to estimate an increase in the number of cancers if people come in contact with PCBs in soil for long periods. Because we are looking at future residential development, two cancer risks will be estimated, one for children who live at a house for 18 years and another for adults who live at the same house for 52 years. The estimated cancer risk is for children and adults with high soil intake. The estimated cancer risk for children and adults with typical soil intake is about half of the risk estimated for children and adults with high soil intake.

Table 22 shows the estimated cancer risk at various PCB soil concentrations for children and adults with high soil intake if the LCP Chemicals Site becomes residential. For example, if children with high soil intake live at a property with 139 ppm PCBs in soil for 18 years, their estimated cancer risk is 6 in 10,000. Stated another way, if 10,000 children lived at properties with 139 ppm PCB in soil, one might expect 6 extra cases of cancer. Adults who live at properties for 52 years with 139 ppm PCB in soil have an estimated cancer risk of 3 in 10,000. A lifetime cancer risk is not provided since it is unlikely that children will continue to live in the house as adults for an additional 52 years. It should be pointed out that the cancer risk is greater for children with 18 years of exposure than it is for adults with 52 years of exposure. The estimated cancer risk at 5 ppm PCBs in soil is 2 in 100,000 for children and 1 in 100,000 for adults.

So the public can understand the estimated cancer risk and scientific notation presented in Table 22, the same risks are presented in Table 23 as extra cases of cancers if a million people are exposed to PCBs in soil. For example, if one million children have daily contact with soil containing 139 ppm PCBs, about 600 extra cases of cancers might occur from 18 years of exposure.

In summary, if the site becomes residential, children might have an increased risk of cancer if they have contact with PCB in soil above 5 ppm. Adults might have an increased risk of cancer at PCB soil levels above 10 ppm.

V.F.1.l. Estimated Cancer Risk in Workers If the LCP Chemicals Site Is Developed

If the site is developed in the future, workers doing excavation work and commercial or industrial workers might come in contact with PCBs in soils. The estimated cancer risks for outdoor commercial or industrial workers are shown in Table 24 should these workers ingest 100 mg soil daily, 5 days a week for 20 years. The estimated cancer risk also is provided for excavation workers should these workers ingest 330 mg soil daily for half a year.

The estimated cancer risk for commercial/industrial workers who have contact with soil containing 139 ppm PCBs for 20 years is 8E-5 (or 8×10^{-5}). This means that if 100,000 workers had contact with soil containing 139 ppm PCBs for 20 years, 8 additional cases of cancers might occur. The estimated cancer risk for excavation workers who have contact with soil containing 139 ppm PCBs for 6 months is 7E-6 (or 7×10^{-6}). This means that if 1,000,000 workers had contact with soil containing 139 ppm PCBs for 20 years, 7 additional cases of cancers might occur. The cancer risk in workers at various PCB concentrations in soil are shown in Table 24. So the public can understand the estimated cancer risk and scientific notation presented in Table 24, the same risks are presented in Table 25 as extra cases of cancers if a million workers are exposed to PCBs in soil at 1, 5, 10, 25, 50 or 139 ppm.

In summary, an increased risk of cancer might exist for commercial and industrial workers who have daily contact with PCBs in soil above 25 ppm. The estimated cancer risk for excavation workers is low.

Table 22. Estimated cancer risk at various PCB soil concentrations for children and adults with high soil intake if the LCP Chemicals Site becomes residential in the future. The estimated cancer risk is for children and adults with high soil intake. The estimated cancer risk for children and adults with typical soil intake is about half the risk shown this table.

Age Group	*PCB soil concentrations in ppm*					
	1	*5*	*10*	*25*	*50*	*139*
	*Increase in Cancer Risk**					
Children's cancer risk, 18 years	4 E-6	2 E-5	4 E-5	1 E-4	2 E-4	6 E-4
Adult cancer risk (av. for men and women), 52 yrs.	2 E-6	1 E-5	2 E-5	6 E-5	1 E-4	3 E-4

* Cancer risk estimates are rounded to one significant figure.

Table 23. Estimated cancer risk at various PCB soil concentrations for children and adults if one million people are exposed. Cancer numbers are rounded to one significant figure.						
Age Group	***PCB soil concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Estimated number of cancers if one million people are exposed					
The estimated number of cancers if a million children are exposed to PCBs in soil for 18 years at various PCB concentrations.	4	20	40	100	200	600
The estimated number of cancers if a million adults are exposed to PCBs in soil for 52 years	2	10	20	60	100	300

Table 24. Estimated cancer risk at various PCB soil concentrations for commercial/industrial and excavation workers on the basis of future site development.						
Age Group	***PCB soil concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Increase in Cancer Risk*					
Outdoor commercial/industrial worker cancer risk, 20 yrs.	6 E-7	3 E-6	6 E-6	1 E-5	3 E-5	8 E-5
Excavation worker, 1/2 yr.	5 E-8	2 E-7	5 E-7	1 E-6	2 E-6	7 E-6

* Estimated cancer risks are rounded to one significant figure.

Table 25. Estimated cancer risk at various PCB soil concentrations for commercial/industrial and excavation workers on the basis of future site development. Cancer risks are rounded to one significant figure.						
Age Group	***PCB soil concentrations in ppm***					
	1	***5***	***10***	***25***	***50***	***139***
	Estimated number of cancers if one million workers are exposed					
The estimated number of cancers if one million commercial/industrial workers are exposed to PCBs in soil for 20 years	0.6	3	6	10	30	80
The estimated number of cancers if one million excavation workers are exposed to PCBs in soil for 6 months	0.05	0.2	0.5	1	2	7

V.F.1.m. Uncertainty in Cancer Risk Estimates

Some uncertainty exists in these cancer risk estimates. It is important to remember the assumptions that went into estimating these cancer risks. These assumptions are as follows:

- The PCB-contaminated areas of the site will become residential,
- PCB contamination that is below the surface will be moved to the surface during construction thus allowing human contact,
- The average PCB concentration calculated using the current contaminant levels represents the level of future exposure,
- For the residential scenario, children will live on the property for 18 years or adults will live on the property for 52 years,
- For the commercial/industrial scenario, adults will have contact with the soil for 20 years,
- Children and adults will have high soil intake from hand-to-mouth activity, and
- The carcinogenicity of the various groups of PCBs are similar.

V.F.2 Mercury

V.F.2.a. The Chemistry of Mercury in Soil

During operations at the LCP facility, elemental mercury was used as part of the chemical reactions to produce chlorine. These processes resulted in mercury-containing waste that was discharged to soil and to the nearby marsh, as well as off-gassing of elemental mercury from the cell buildings to ambient air. Over the years, elemental mercury in soil and sediment is likely to be transformed into divalent mercury salts, such as mercuric chloride, mercuric hydroxide, and mercuric sulfide and to organic mercury. In soil, most of the mercuric salts become bound to the organic matter in soil by reacting with sulfur- and oxygen-containing areas in aromatic and aliphatic chemicals. These aromatic and aliphatic chemicals are part of the organic humic component of soil. Some mercuric salts also can be bound to soil minerals, while a small portion can remain as elemental mercury or dissolved mercury (Schuster 1991, Stevenson 1994, Renneberg and Dudas 2001, Biester 2002).

When soil is contaminated with industrial hydrocarbons, some of the mercuric salts can react with sulfur- and oxygen-containing areas of these hydrocarbons, much like it does with organic matter in soil (CCME 1997, Renneberg and Dudas 2001). Renneberg and Dudas have analyzed soil that was contaminated with mercury 20 to 30 years ago. They found 62% to 85% of the mercury in the soil samples was associated with organic matter. Several soil samples showed small amounts of mercury bound to hydrocarbons (i.e., less than 5%), although one sample showed almost 30%. The percentage of mercury bound to minerals ranged from 5% to 10% for some samples and 20% to 30% in other samples. One soil sample showed that elemental mercury made up 30% of the remaining mercury in soil. The authors were not able to identify the specific chemical form of mercury in each sample (Renneberg and Dudas 2001).

In 2003, EPA collected 10 sediment samples from the nearby marsh and performed laboratory tests to speciate the mercury. The organic mercury typically was 45% with individual marsh sediment samples ranging from 3% to 86% organic mercury. The other major component consisted of mercury in a mineral lattice, mercuric chloride, or elemental mercury. The mineral or elemental component typically was 41% with individual marsh sediment samples ranging from 0% to 72% (EPA 2010). These results are consistent with the previously cited studies. It is important to remember that these are marsh sediment samples and may or may not accurately represent the speciation of mercury in soils.

These results show that a large proportion of mercury in soil at the LCP Chemicals Site is likely to be organic mercury and this mercury is now bound to the organic humic content of soil. However, other forms, such as inorganic mercuric salts, and possibly elemental mercury, might also be present. Because mercury in soil becomes bound to organic molecules, ATSDR will use health guidelines developed for organic mercury, specifically methylmercury.

V.F.2.b. Health Guideline for Mercury

Several health guidelines exist for mercury and they vary depending upon its chemical form. EPA has an oral Reference Doses (RfD) for organic mercury (i.e., methylmercury) and ATSDR will use this health guideline to evaluate exposure to mercury in soil should the site be developed (see Table 26). The EPA defines RfDs as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure in the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious [non-cancerous] effects during a lifetime.

Table 26. Oral health guideline for mercury used to evaluate exposure to mercury in soil should the site be developed.

Chemical	***Exposure Period***	***Type***	***Agency***	***Value in mg/kg/day***	***Value in µg/kg/day***
Methyl Mercury*	Lifetime	Chronic RfD	EPA	0.0001	0.1

*Methylmercury is an organic form of mercury.

V.F.2.c. Estimating Human Doses to Mercury and Mercury Hazard Quotients

The parameters used to estimate mercury doses in children and adults if the site becomes residential are shown in Appendix B, Table B1. As mentioned previously, preschool children were assumed to swallow 200 milligrams of soil daily, while older children and adults were assumed to swallow 100 milligrams of soil daily. These soil intake rates represent the group of children and adults with high soil intake.

The estimated mercury doses for each age group for average mercury soil concentrations ranging from 1 to 1,470 ppm are shown in Table 27. Because the doses are small, the table shows estimated mercury doses in µg/kg/day. Depending on the age group and the average mercury concentration in a grid, estimated doses range from well below the health guideline for organic mercury of 0.1 µg/kg/day to the highest estimated dose of 29 µg/kg/day in 1-year-old children who live on soils containing an average of 1,470 ppm mercury in soil.

The mercury HQ for various average mercury concentrations was derived by dividing the estimated mercury dose in µg/kg/day by the chronic, oral RfD for organic mercury, which is 0.1 µg/kg/day. The resulting mercury HQs shown in Table 28 vary by age group and by the average mercury concentration in soil. What follows is a brief summary of these mercury HQs:

- For one-year-old children, the mercury HQ is 1 when average mercury soil concentrations are 5 ppm. The mercury HQs are 3, 4, 17, 59, and 294 when average mercury soil concentrations are 15, 20, 85, 296, and 1,470, respectively.
- For 3-year-old children, the mercury HQs are 1.9, 2.5, 11, 37 and 184 when average mercury soil concentrations are 15, 20, 85, 296, and 1,470 ppm.
- For elementary-age children, the mercury HQs are 2.4, 8.5, and 42 when average mercury soil concentrations are 85, 296, and 1,470 ppm, respectively.
- For teenagers, the mercury HQs are 1.5, 5.4, and 27 when average mercury soil concentrations are 85, 296 and 1,470 ppm, respectively.
- For adults, the mercury HQs range from 1.4, 4.9, and 25 when average mercury soil concentrations are 85, 296 and 1,470 ppm, respectively.

These mercury HQs are shown graphically in Figure 35. The HQs show that as a grid's average mercury concentration in soil exceeds 15 to 20 ppm, the HQ exceeds 1. Whenever the HQ of 1 is exceeded, further toxicological evaluation is necessary to determine if harmful effects might be expected.

Organic Mercury Studies

As part of a more thorough toxicological evaluation, ATSDR will describe the human and animal studies that show the harmful effects of mercury. This review is not an exhaustive review of the known harmful effects of mercury but rather it focuses on the lowest organic mercury doses that cause harmful effects since these studies are more relevant to deciding what harmful effects might be expected in a human population exposed to low levels of organic mercury from the environment.

Table 27. The estimated doses of mercury at various mercury concentrations in soil						
Age Group	***Mercury concentrations in ppm***					
	1	***15***	***20***	***85***	***296***	***1470***
	Chronic estimated dose in µg/kg/day					
Preschool children (1 yr.)	0.02	0.3	0.4	1.7	5.92	29.4
Preschool children (3 yr.)	0.012	0.19	0.25	1.06	3.7	18.38
Elementary school children	0.003	0.04	0.06	0.24	0.85	4.2
Teenagers	0.002	0.03	0.04	0.16	0.54	2.67
Adult men	0.001	0.02	0.03	0.12	0.42	2.1
Adult women	0.002	0.02	0.03	0.14	0.49	2.45
EPA's RfD for organic mercury in µg/kg/day	0.1	0.1	0.1	0.1	0.1	0.1

Table 28. Mercury HQs for various age groups and mercury soil concentrations.						
Age Group	***Mercury concentrations in ppm***					
	1	***15***	***20***	***85***	***296***	***1470***
	Chronic Methylmercury HQ					
Preschool children (1 yr.)	0.20	3.0	4.0	17.0	59.2	294
Preschool children (3 yr.)	0.13	1.9	2.5	10.6	37	184
Elementary school children	0.03	0.4	0.6	2.4	8.5	42
Teenagers	0.02	0.3	0.4	1.5	5.4	27
adult men	0.01	0.2	0.3	1.2	4.2	21
adult women	0.02	0.3	0.3	1.4	4.9	25

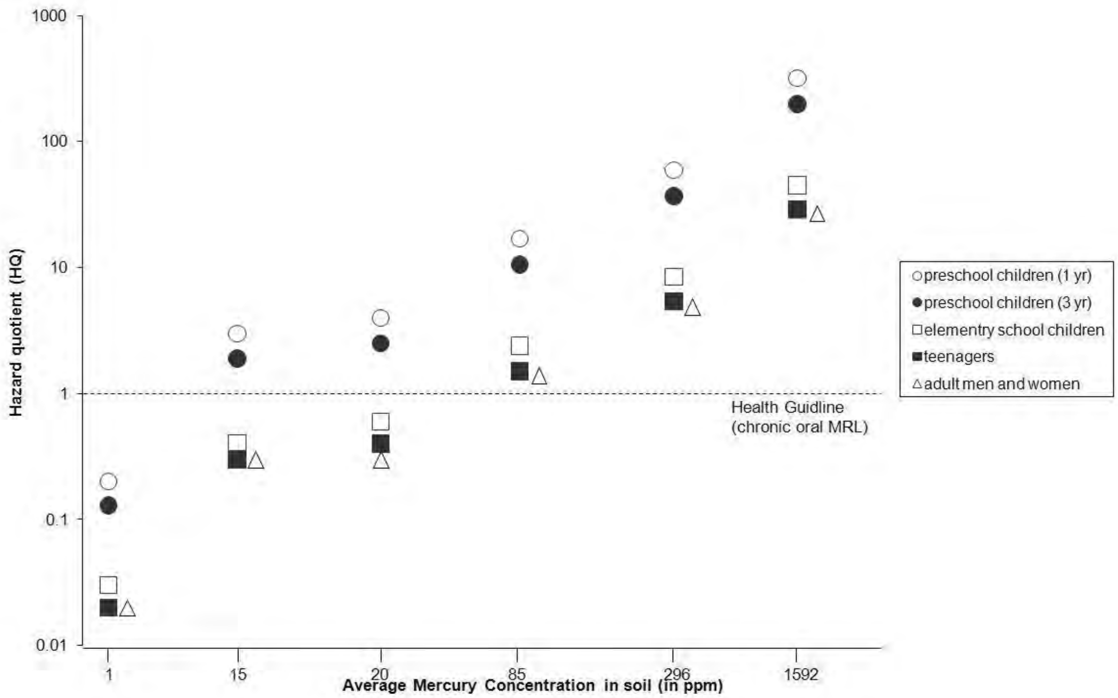

Figure 35. This graph shows the mercury HQ for various age groups at average mercury soil concentrations ranging from 1 to 1,470 ppm. At 1 ppm mercury in soil, the HQs are less than 1 indicating that the estimated doses are below health guideline; therefore, harmful effects are not expected. At 15 to 20 ppm mercury in soil, the HQ for 1-year-old children ranges from 3 to 4. At 85 ppm mercury in soil, all age groups exceed the HQ of 1. At average mercury soil concentrations of 15 or higher, the mercury HQ exceeds 1; therefore, additional toxicological evaluation is needed to determine if harmful effects might be expected.

Several environmental pollution episodes brought to light that contamination of the environment with organic mercury can cause serious harmful effects in humans. In Japan, a local chemical company dumped organic mercury-containing waste into a bay and river that ended up as high levels in fish and shellfish eaten by local residents. Another poisoning episode occurred in Iraq where adults and children ate grain treated with a methylmercury-containing fungicide. These initial human poisoning episodes prompted much research into understanding the harmful effects of organic mercury with the goal of identifying the lowest human doses that might be expected to cause harmful effects.

Several human studies have been conducted that have evaluated the neurological effects of methylmercury exposure in children. A long-term human study of children from the Faroe Islands, a small group of islands in the North Atlantic Ocean, which is affiliated with Denmark, began in 1986 and focused on children born to women who lived on the islands. This population relies heavily on seafood and whales as a source of protein. The investigators used various tests that monitor child development. They concluded that cord blood mercury levels in the mother at birth were associated with harmful effects in children at age 7 years involving language, attention and memory, and to a lesser extent visual/spatial and motor functions (Grandjean *et al* 1997). Follow-up studies at age 14 years showed similar findings (Debes *et al* 2006). Another human study was conducted in New Zealand in 1978. This study focused on 61 children who were exposed *in utero* to high mercury levels that resulted from their mother's consumption of 4 or more fish meals a week. The authors showed a decrease in children's intelligence quotient (IQ) at age 6 with increasing exposure to methylmercury as measured by their mother's hair mercury levels at birth (Kjellstrom 1991, Crump 1998). The third study came from the Republic of Seychelles, where 85% of the population relies on local seafood for protein. Average ocean fish consumption in this population is 12 meals a week (Davidson 1998). The Seychelles study initially did not find harmful effects in children as they grew older. The investigators report that they occasionally found adverse effects in children but attributed these effects to chance because of the large number of tests being performed (Myers 2003, Davidson 2006, Myers 2009). Much more information about the harmful effects of methylmercury is available in ATSDR's Toxicological Profile for Mercury (ATSDR 1999).

The EPA developed a RfD using a mathematical model that estimates a 5% response in children for neurological effects[3]. Using the Faroe Islands study, EPA determined that the mercury concentration in maternal blood that causes a 5% adverse response in children ranged from 46 to 79 ppb. This mercury concentration in blood equates to a range of 0.8 to 1.5 µg mercury per kilogram per day (µg /kg/day) as a dietary intake. This dose was divided by an uncertainty factor of 10 to arrive at the Reference Dose of 0.1 µg/kg/day. This approach is supported by the U.S. National Academy of Science, which recommended that EPA use the Faroe Islands Study and 58 ppb mercury in cord blood as a LOAEL for deriving their health guideline (NRC 2000).

V.F.2.d. Uncertainty About the Harmful Effects of Methylmercury

It is well-established that high doses of methylmercury will cause neurological effects and will damage other organ systems within the human body. The debate about methylmercury toxicity centers on the lowest dose at which harmful effects might be expected. The Faroe Islands study clearly shows harmful neurological effects in a population that obtains most of its methylmercury exposure from eating whale meat and blubber, although some exposure also comes from other seafood. Similarly, the New Zealand study shows harmful neurological effects in a population that obtains most of its methylmercury exposure from eating seafood. The debate exists because the Seychelles study could not identify consistent harmful effects in a population that relied heavily on seafood. It should be noted that the Seychelles study occasionally identifies an adverse association with methylmercury exposure but the authors conclude that the associations are due to chance because so many tests were administered.

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[3] More precisely, EPA estimated the lower 95th concentration of mercury in maternal blood that gave a 5% response for neurological effects in offspring at 7 years of age.

As described previously, the U.S. National Academy of Science through its National Research Council reviewed all three studies and in 2000 recommended that a dose response model be used to estimate the dose at which a 5% adverse response might be expected in children who were exposed *in utero,* that is, during fetal development in the womb. They used the Faroe Islands study to identify a lower 95th percentile of the dose that causes a 5% adverse neurological response. They also conducted an additional mathematical analysis using data from the New Zealand and Seychelles studies and stated that those studies support the results of the Faroe Islands study (NRC 2000).

The investigators of the Seychelles study also conducted a similar dose response analysis. Their conclusion supports in part the conclusion of the National Academy of Science. The Seychelles investigators concluded that they could not exclude a low risk of adverse effects at the upper range of mercury levels in the Seychelles study because of the limited number of data points in the upper ranges (Davidson *et al*. 2004).

Therefore, some uncertainty might exist about the precise lowest dose of methylmercury that might be expected to cause harmful effects. The National Academy of Sciences has recommended that it is reasonable to assume that some risk of harmful effects might be expected in children who were exposed *in utero* to methylmercury at 58 ppb methylmercury in cord blood. This concentration in cord blood equates to 12 ppm mercury in maternal hair (NRC 2000). A cord blood concentration of 58 ppb methylmercury and 12 ppm maternal hair equates to about 1 µg/kg/day methylmercury as a dietary dose, the LOAEL that served as the basis for EPA's derivation of its RfD (EPA 2009a).

V.F.2.e. Possible Health Effects from Methylmercury If the Site Becomes Residential

The estimated doses in various age groups with high soil ingestion have already been presented in Table 27. Because the doses are small, the table shows estimated methylmercury doses in µg/kg/day. For comparison, EPA's Reference Dose for methylmercury also is shown in µg/kg/day.

Depending on the age group and the average methylmercury concentration in a grid, estimated doses range from well below the EPA's RfD of 0.1 µg/kg/day to the highest dose of 29 µg/kg/day in one-year-old children who live on soil containing 1,470 ppm mercury. The estimated doses can be described as follows:

- At 1 ppm methylmercury in soil, all the estimated doses are below EPA's RfD,
- At 15 and 20 ppm methylmercury in soil, the estimated doses in one- and three-year-old children exceeds EPA's RfD,
- At concentrations greater than 85 ppm PCBs in soil, the estimated doses in all age groups exceed EPA's RfD.

Because the estimated doses exceed EPA's RfD for methylmercury of 0.1 µg/kg/day, it is necessary now to compare the estimated doses in various age groups to doses that can cause harmful effects to decide if harmful effects might be expected.

Figure 36 shows the estimated doses in various age groups that exceed EPA's RfD for methylmercury. These doses are shown in relation to the RfD of 0.1 µg/kg/day and in relation to the lowest dose in humans (i.e., 1 µg/kg/day) that might be expected to cause harmful effects to the neurological system in 5% of children.

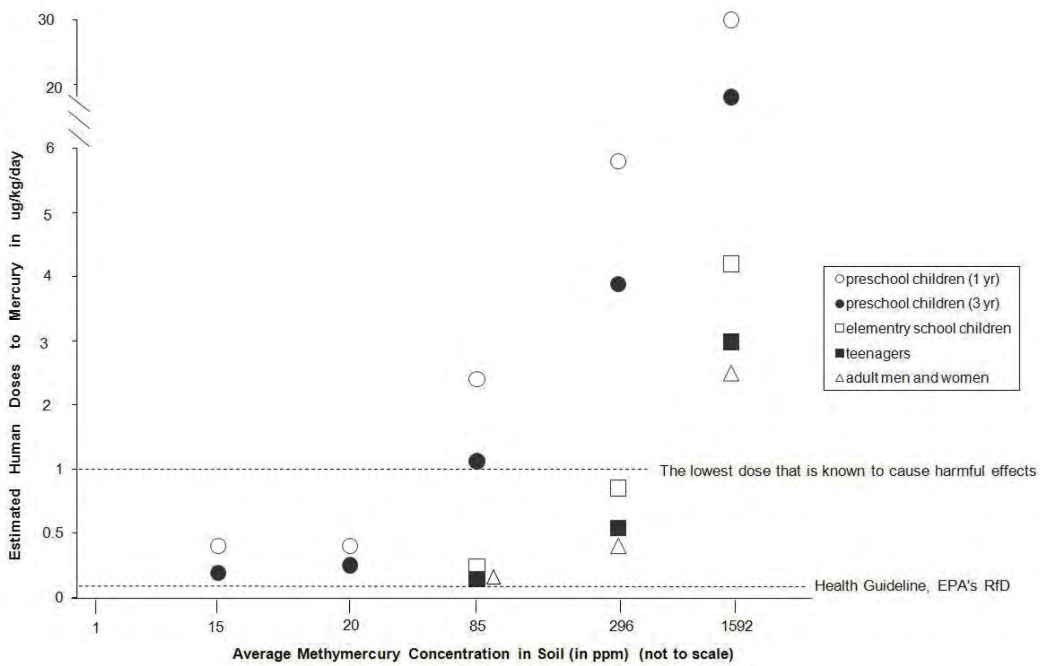

Figure 36. This figure shows the estimated dose in various age groups for various average mercury concentration in soil ranging from 15 ppm to 1,470 ppm. The estimated doses at 1 ppm are below the health guideline for methylmercury of 0.1 µg/kg/day and are not shown. At average soil concentrations of 15 ppm and 20 ppm, the estimated doses in preschool children exceed EPA's RfD. At an average concentration of 85 ppm and 296 ppm in soil, the estimated doses in all age groups exceed the RfD; and, the estimated doses in preschool children exceed the lowest dose known to cause harmful effects in humans. At an average concentration of 1,470 ppm, the estimated doses in all age groups exceeds the lowest dose known to cause harmful effects in humans.

The highest estimated dose in women is 2.5 µg/kg/day for women who live on soil containing 1,470 ppm mercury. This estimated dose is twice the dose that is expected to cause harmful neurological effects to the fetus during pregnancy. Some children born to women exposed to this dose while pregnant might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions. Preschool children who live on properties containing 1,470 ppm mercury have estimated doses of 20 to 32 µg/kg/day and are at risk of similar harmful effects. Preschool children who live on soil containing 85 ppm mercury have estimated doses of 1 µg/kg/day and also are at risk of harmful effects. At 20 ppm mercury in soil, estimated mercury doses in preschool children range from 0.2 to 0.4 µg/kg/day. They have a small risk of harmful effects from mercury in soil.

Some uncertainty exists in these conclusions. First, uncertainty exists in estimating how much mercury people will contact in surface soil if the site becomes residential. This uncertainty comes from assuming that soil below the surface (e.g., several feet down) could become the surface soil (e.g., the top few inches) that people contact during their daily activities. Uncertainty also exists from using soil samples that were collected 15 years ago. These soil samples may not represent current conditions at the site.

Second, some uncertainty exists concerning the risk of harmful effects from mercury in soil. The chemical form of mercury in soil at the LCP Chemicals Site has not been well-established, although analytical studies have been conducted on marsh sediment. Studies by EPA in 2003 showed that almost half the mercury in marsh sediment was bound to organic molecules. Other scientific studies evaluated the weathering of elemental mercury in soil over time. These studies showed that most of the mercury was bound to organic molecules (Renneberg and Dudas 2001). Therefore, ATSDR assumed that the mercury in soil at the LCP Chemicals Site was organic mercury. There's some uncertainty whether the mercury bound to organic molecules in soil would have the same or similar toxicity as methylmercury. Nevertheless, it seems reasonable to assume that grids with average mercury concentrations as high as 1,470 ppm mercury in soil pose some risk to women and children if the site becomes residential.

Ten grids exceed EPA's 1994 target action level of 20 ppm mercury in soil. The location of these grids is shown in Figure 37 and the average mercury concentration in each grid is shown in Table 29. The half-acre grids on the site that are a concern if the site becomes residential are grids 53, 55, 60, 90, 93, 112, 113, 114, 118, and 128.

The previous results were derived using 1990s soil samples with a depth of 0 to 5 ft. The justification for using 0 to 5 ft. is that future site development might bring soil to the surface that was previously up to 5 feet below the surface. One concern is that more contaminated soil is nearer the surface, and this more contaminated soil might have a greater chance of becoming surface soil in the future because of construction activity. Therefore, ATSDR calculated statistics using 1990s soil samples with a depth of 0 to 2 ft. Using soil samples with a depth of 0 to 2 ft. showed overall somewhat similar results as using 0 to 5 ft. At 0 to 2 ft., 5 grids exceed EPA's 1994 target action level of 20 ppm and four of these grids are found in Table 29. More uncertainty exists in these five concentrations because fewer soil samples are available from the 0 to 2 ft. depth.

Table 29. Grid number and average mercury concentrations greater than 20 ppm in soil	
Grid #	***Average Mercury Concentration in Soil (ppm)***
113	1,470
93	296
112	271
90	184
60	85
128	81
114	41
118	30
53	24
55	23

V.F.2.f. Possible Health Effects for Workers

Since specific plans have not been identified as to the eventual use of the property, ATSDR evaluated the possibility of harmful effects for two categories of workers: commercial/industrial workers, and excavation workers.

Once the property is developed, commercial and industrial workers might come in contact with contaminated soil for extended periods. The contact is assumed to be long-term, chronic exposure occurring for many years. Therefore, ATSDR compared estimated doses in these workers to EPA's RfD for organic mercury. Excavation workers are likely to be exposed for periods less than a year as they move soil during construction activity. No health guidelines are available for organic mercury for exposure periods of less than one year; therefore, the estimated doses will be compared directly to doses from human and animal studies to decide if harmful effects might be expected.

The estimated doses for commercial and industrial workers are shown in Table 30 should these workers ingest 100 mg soil daily, 5 days a week. Estimated doses also are provided for excavation workers should these workers ingest 330 mg soil daily, 5 days a week.

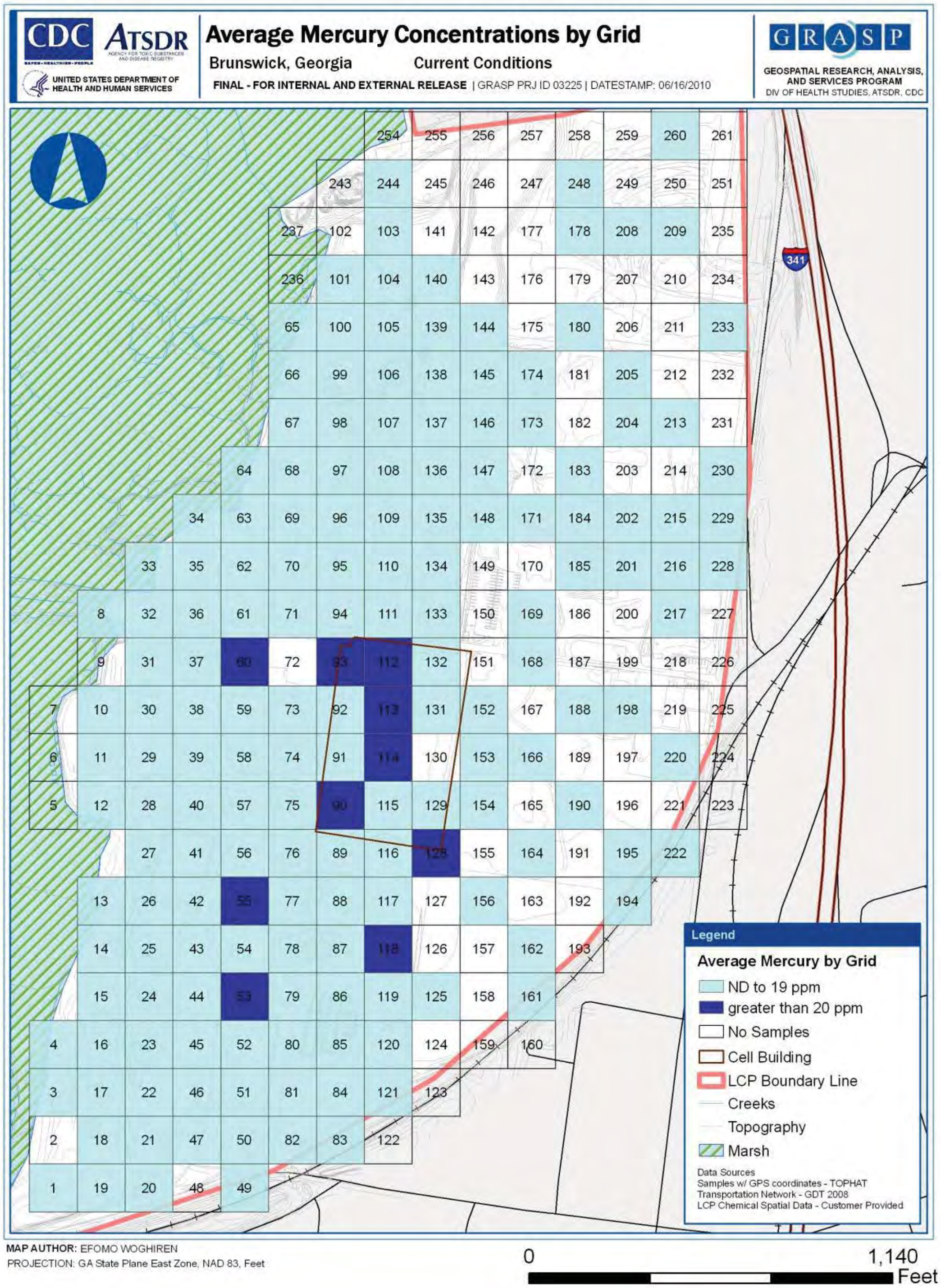

Figure 37. This figure shows the ten grids in dark blue where average mercury levels in soil 0 to 5 ft. exceed EPA's 1994 target action level of 20 ppm. If these grids become residential, mercury in soil is a health concern. Most of the dark blue grids are associated with the former mercury cell building, indicating these soils are still highly contaminated with mercury (see Table 29).

For grids with average mercury concentrations ranging from 184 ppm to 1,470 ppm, the estimated doses for commercial/industrial workers range from 0.2 to 1.4 µg/kg/day. These estimated doses exceed EPA's chronic RfD of 0.1 µg/kg/day. Four grids have estimated doses that exceed EPA's chronic RfD. The average mercury concentration for these grids is 184 ppm (grid 90), 271 ppm (grid 112), 296 ppm (grid 93), and 1,470 ppm (grid 113) (see Table 29).

Table 30. Estimated mercury doses in commercial/industrial workers and in excavation workers if the site is developed.

Age Group	***Mercury Concentrations in ppm***					
	1	***15***	***20***	***100***	***296***	***1470***
	Estimated dose in ug/kg/day					
commercial workers	0.0010	0.015	0.020	0.1	0.29	1.44
excavation workers	0.0034	0.051	0.067	0.34	1.00	4.95

As mentioned previously, the EPA used a mathematical model to estimate a 5% response for neurological effects in children who were exposed *in utero*[4]. Using the Faroe Islands study, EPA determined that an intake of 0.8 to 1.5 µg /kg/day is expected to cause a 5% adverse response in children exposed *in utero*. This intake is supported by the U.S. National Academy of Science, which estimated a mercury intake of 1 µg/kg/day to be associated with a 5% response (NRC 2000). Therefore, an intake of about 1 µg/kg/day in female workers can be considered a LOAEL for adverse effects to the developing fetus from exposure to organic mercury.

Pregnant commercial or industrial workers who have contact with mercury in soil in grids 90, 93, 112, and 113 are at risk of exposing their developing fetus to mercury at doses that are expected to cause harmful effects. Some children born to women exposed to these doses might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions. The mercury soil levels in these grids range from 184–1,470 ppm.

Male and female workers who have contact with soil from grid 113, which has an average of 1,470 ppm mercury, also are at risk of harmful effects. Their estimated dose of 1.4 µg /kg/day is roughly 35 times below levels known to cause harmful effects in monkeys and cats. Male and female workers who have prolonged contact with soil mercury at this grid might experience damage to their neurological system, such as diminished sensitivity to pain, diminished touch, decreased fine motor performance, impaired vision, and impaired hearing, (Charbonneau 1976, Rice and Gilbert 1982, Rice 1989, ATSDR 1999).

Excavation workers exposed to mercury in soil at 1,470 ppm have an estimated dose of about 5 µg /kg/day. It seems unlikely, however, that this dose would be sustained for

[4] More precisely, EPA estimated the lower 95th concentration of mercury in maternal blood that gave a 5% response for neurological effects in offspring at 7 years of age.

more than a few weeks or maybe a month or so before they move on to other grids with lower mercury contaminant levels. If they moved on to the grid containing 296 ppm mercury, their estimated dose would be 1 µg /kg/day. These doses would average out to be about 2 or 3 µg /kg/day over the course of a few weeks or a few months. Exposure at these doses for a few months might cause an increase in a certain type of brain cell called reactive glia cells (Charleston 1994, ATSDR 1999). This increase is a mild adverse response to mercury exposure; however, it does not result in any symptoms of mercury poisoning.

It should be noted that soil beneath the cell building area is likely to have high levels of mercury since this area was not excavated to remove highly contaminated mercury in soil below the surface. Any future excavations in this area could result in mercury exposure for workers who have direct contact with soil and groundwater, or who breathe mercury vapors. Therefore, appropriate worker protection guidelines should be used to prevent exposure and to ensure that mercury in air is not a public health concern.

V.F.3. Lead

V.F.3.a. Levels in Soil at the LCP Chemicals Site

Using half-acre grids, average lead levels in soil (0-5 ft.) exceeded EPA's target action level of 400 ppm in seven grids. Average lead levels in these grids are 745 ppm (grid 136), 728 ppm (grid 48), 692 ppm (grid 103), 590 ppm (grid 93), 513 ppm (grid 59), 422 ppm (grid 60), and 411 ppm (grid 411). The distribution of average lead levels in grids can be described as follows:

- 7 grids have average lead levels above 400 ppm
- 6 grids have average lead levels in the 300 ppm range,
- 10 grids have average lead levels in the 200 ppm range,
- 29 grids have average lead levels in the 100 ppm range,
- 110 grids have average lead levels below 99 ppm.

V.F.3.b. CDC's Reference Level for Lead and Recent Human Studies on the Effects of Lead

Using data from the National Health and Nutrition Examination Survey (NHANES), the Centers for Disease Control and Prevention (CDC) has established a reference value for lead in children aged 1 to 5 years. This new reference value is based on the U.S. population of children aged 1-5 years and was selected based on the blood lead level in the top 2.5% of children. Currently, the reference value is 5 micrograms lead per deciliter (µg/dL) of blood. This reference value replaces CDC's historical value of 10 µg/dL.

More information about CDC's new reference value as well as CDC's recommendations concerning elevated blood lead in children can be found at these CDC websites:

- http://www.cdc.gov/nceh/lead/ACCLPP/activities.htm, and
- http://www.cdc.gov/nceh/lead/tips.htm.

CDC replaced its blood lead 'level of concern' with a reference value following recommendations in January 2012 from CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP 2012). As the advisory committee and CDC pointed out, scientific research has clearly shown that blood lead levels below 10 µg/dL cause serious harmful effects in children. Table C1 in Appendix C summarizes some of these studies.

Blood lead levels below 10 µg/dL have been shown to cause neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with the following harmful effects:

- Decreases in intelligent quotient (IQ),
- Attention deficit hyperactivity disorder (ADHD),
- Deficits in reaction time,
- Problems with visual-motor integration and fine motor skills,
- Withdrawn behavior,
- Lack of concentration,
- Issues with sociability,
- Decreased height,
- Changes in kidney function, and
- Delays in puberty, such as breast and pubic hair development, and delays in menarche.

V.F.3.c. Estimating Children's Lead Exposure from Soil Lead Levels

The EPA has developed a model to estimate the contribution of soil lead to children's blood lead level. The model is called the Integrated Exposure Uptake Biokinetic (IEUBK) model and the current version is IEUBKwin version 1.1 build 11. More information about the IEUBK model can be found at this EPA web address: http://www.epa.gov/superfund/lead/products.htm#guid. After identifying a set of exposure parameters (e.g., lead concentrations in soil, water, air), the model estimates the percentage of children up to 7 years old that exceed a specified blood lead level. In most situations, the EPA's goal is to limit exposure to lead in soil such that a typical child exposed for 7 years (0 to 84 months) would have an estimated risk of no more than 5% of exceeding a specified blood lead level. When EPA ran the model in the mid-1990s for the LCP Chemicals Site, the standard practice was to set the target blood lead level to 10 µg/dL, CDC's historical level of concern at the time (EPA 1998). For the LCP Chemicals Site, the EPA used the model to select their initial soil lead action level of 500 ppm. They have since lowered the action level to 400 ppm. See this web address for a listing of EPA's recommended default parameters for the IEUBK model: http://www.epa.gov/superfund/lead/guidance.htm#training.

Because CDC has a new reference value for lead in children, ATSDR ran the IEUBK model using 5 µg/dL (instead of 10 µg/dL) as the target blood lead level and using the following default parameters recommended by EPA:

- Lead in air (0.1µg/m^3),
- Lead in drinking water (4 µg/L),
- Soil/dust ingestion (0.085 to 0.135 g/day),
- Drinking water (0.2 to 0.59 L/day),
- Maternal blood lead (1 µg/dL),
- Dietary lead intake (1.95 to 2.26 ug/day),
- Geometric standard deviation of blood lead levels (1.6), and
- Bioavailability (30%).

The results show that if a child lives on soil for 7 years containing 400 ppm lead, the child has a 40% risk of exceeding a blood lead level of 5 µg/dL (see Figure 38). Stated another way, if 100 children lived for 7 years on soil containing an average of 400 ppm lead, 40 children out of 100 would be expected to have blood lead levels that exceed 5 µg/dL, the current CDC reference level.

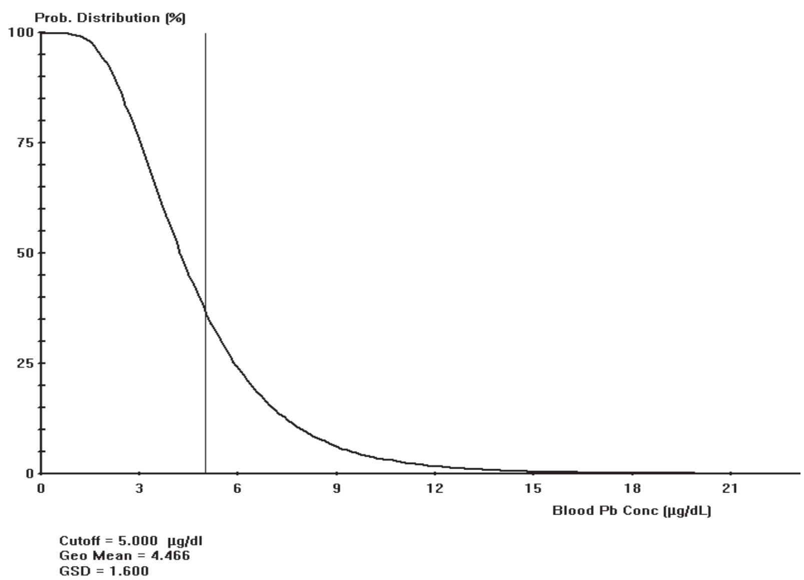

Figure 38. This figure shows the expected distribution of blood lead levels in children using EPA's target action level for lead (i.e., 400 ppm) and CDC reference level for blood lead (i.e., 5 µg/dL). At 400 ppm lead in soil and at a target blood lead level of 5 µg/dL, 40% of children who live there for 7 years (0 to 84 months) might be expected to exceed 5 µg/dL. The geometric mean blood lead level in this population of children would be 4.5 µg/dL.

The IEUBK model also can be run to identify the soil lead concentration that would result in no more than a 5% risk that children's blood lead levels would exceed 5 µg/dL after 7 years of exposure (see Figure 39). The IEUBK model shows that at 154 ppm lead in residential soil, children have a 5% risk of exceeding CDC's reference level of 5 µg/dL. It should be noted that EPA is currently reviewing the IEUBK model in light of CDC's new reference level for lead.

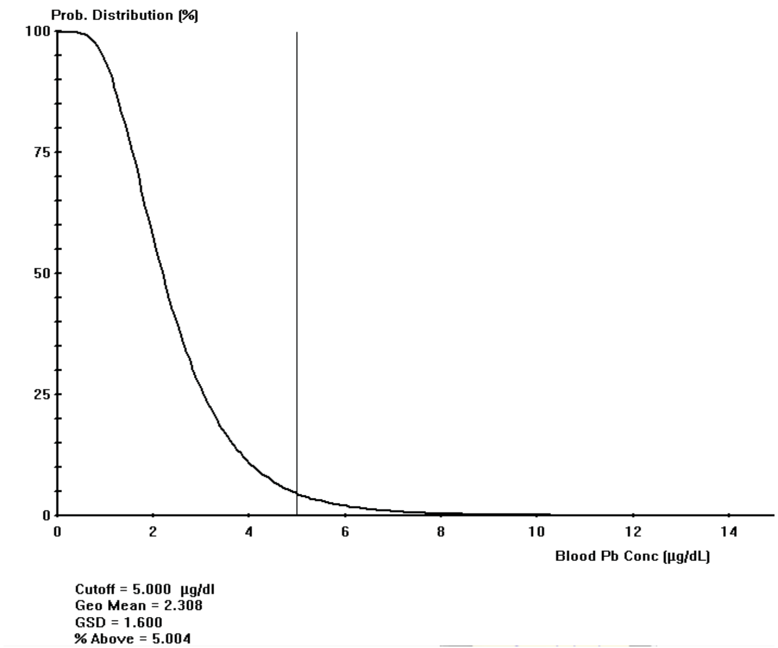

Figure 39. This figure shows the expected distribution of blood lead levels in children after 7 years of exposure (0 to 84 months) if the target blood lead level is set at 5 µg/dL and the average soil lead level is set at 154 ppm. The IEUBK model shows that at 154 ppm lead in residential soil, children have a 5% risk of exceeding CDC's reference level of 5 µg/dL.

V.F.3.d. Possible Health Effects from Lead If the Site Becomes Residential

Most grids on the LCP property have low levels of lead in soil and do not present a health concern for future residential, commercial, or industrial development. However, seven grids have average lead levels that exceed EPA's target action level of 400 ppm and the average lead level in soil at these grids are a health concern if residential properties are built on them. An additional 21 grids have average soil lead levels between 154 ppm and 399 ppm; these grids also are a health concern if residential properties are built on them.

If the site becomes residential, exposure to lead in soil at these levels could increase children's blood lead levels and result in the following harmful effects:

- Small decreases in IQ,
- An increase in attention deficit hyperactivity disorder,
- Reduced attention span,
- Lack of concentration,

- Decreased fine muscle skills,
- Withdrawn behavior,
- Decreased height,
- Small delays in puberty, and
- Small changes in kidney function (Braun 2006, Lanphear 2000, Lanphear 2005, Bellinger 1992, Bellinger 2003, Selevan 2003, Walkowiak 1998, and Burbure 2006, ATSDR 2007).

The location of the grids that are a health concern for lead is shown in Figure 40. Table 31 shows the average lead concentration in soil for each of these grids.

Table 31. Grid Number and Average Lead Concentration in Soil for Those Grids That Are a Health Concern if the Site Becomes Residential

ATSDR Grid #	*Average Soil Lead in ppm*		*ATSDR Grid #*	*Average Soil Lead in ppm*
136	745		96	280
48	728		34	272
103	692		147	250
93	590		37	245
59	513		8	245
60	422		51	237
54	411		73	214
33	394		78	214
58	390		107	208
99	376		97	190
50	371		76	175
111	354		89	170
49	341		53	169
52	292		26	157

The previous results were derived using soil samples with a depth of 0 to 5 ft. Using soil samples with a depth of 0 to 2 ft. showed somewhat similar results as using 0 to 5 ft. At 0 to 2 ft., nine grids have average lead levels that exceed 500 ppm and 36 grids have average lead levels between 154 ppm and 499 ppm. For comparisons, these data are presented in Table 32.

Table 32. Comparison of number of grids that exceed 500 ppm or 154 ppm using soil samples of various depths		
	Greater than 400 ppm average lead	***154 to 399 ppm average lead***
# Grids (0-5 ft.)	7	21
# Grids (0-2 ft.)	9	36

V.F.3.e. Estimating Blood Lead Levels in Workers

The EPA also has an adult lead model that can be used to estimate blood lead levels in the developing fetus. The model is often used for women of child-bearing age to estimate blood lead levels in the developing fetus because the developing fetus is likely to be more sensitive than adult women. More information about EPA's adult lead model can be found at this EPA web address: http://www.epa.gov/superfund/lead/products.htm (EPA 2009c).

Using 5 µg/dL as the target blood lead level, the adult lead model estimates a 5% risk that fetal blood lead levels will exceed 5 µg/dL when average soil lead levels are 773 ppm. No grids exceed the average lead level of 773 ppm, although two grids with averages of 745 ppm and 728 ppm (grids 136 and 48) approach this concentration (see Table 31). The parameters used in the adult lead model are shown in Table 33. The adult lead model assumes that the typical worker is exposed for 219 days a year (approximately 44 weeks). Should women work longer (e.g., 50 weeks a year), their blood lead levels would exceed 5 µg/dL at three grids (grids 136, 48, and 103). Should they be pregnant, their exposure to lead in soil would put their unborn fetus at risk of the harmful effects previously mentioned.

V.F.3.f. Uncertainty About Lead in Soil

Some uncertainty exists in these conclusions about the risk of harmful effects from lead in soil. Uncertainty exists in estimating children's exposure to lead in soil if the site becomes residential because of uncertainties in the model and because construction activity is likely to alter the concentration of lead in soil that children contact. Uncertainty also exists in estimating adult's exposure to lead in soil for the same reason. In addition, uncertainty exists from using soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

Table 33. Parameters used in EPA's adult lead model to generate the soil concentration that is expected to result in a 5% risk that a fetus will have blood lead levels that exceed 5 µg/dL.			
Variable	***Description of Variable***	***Units***	***Model Parameters***
$PbB_{fetal, 0.95}$	95^{th} percentile PbB in fetus	µg/dL	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
Soil Lead Concentration	The soil lead concentration that results in a 5% risk that the fetus will have blood lead levels that exceed 5 µg/dL	ppm	773

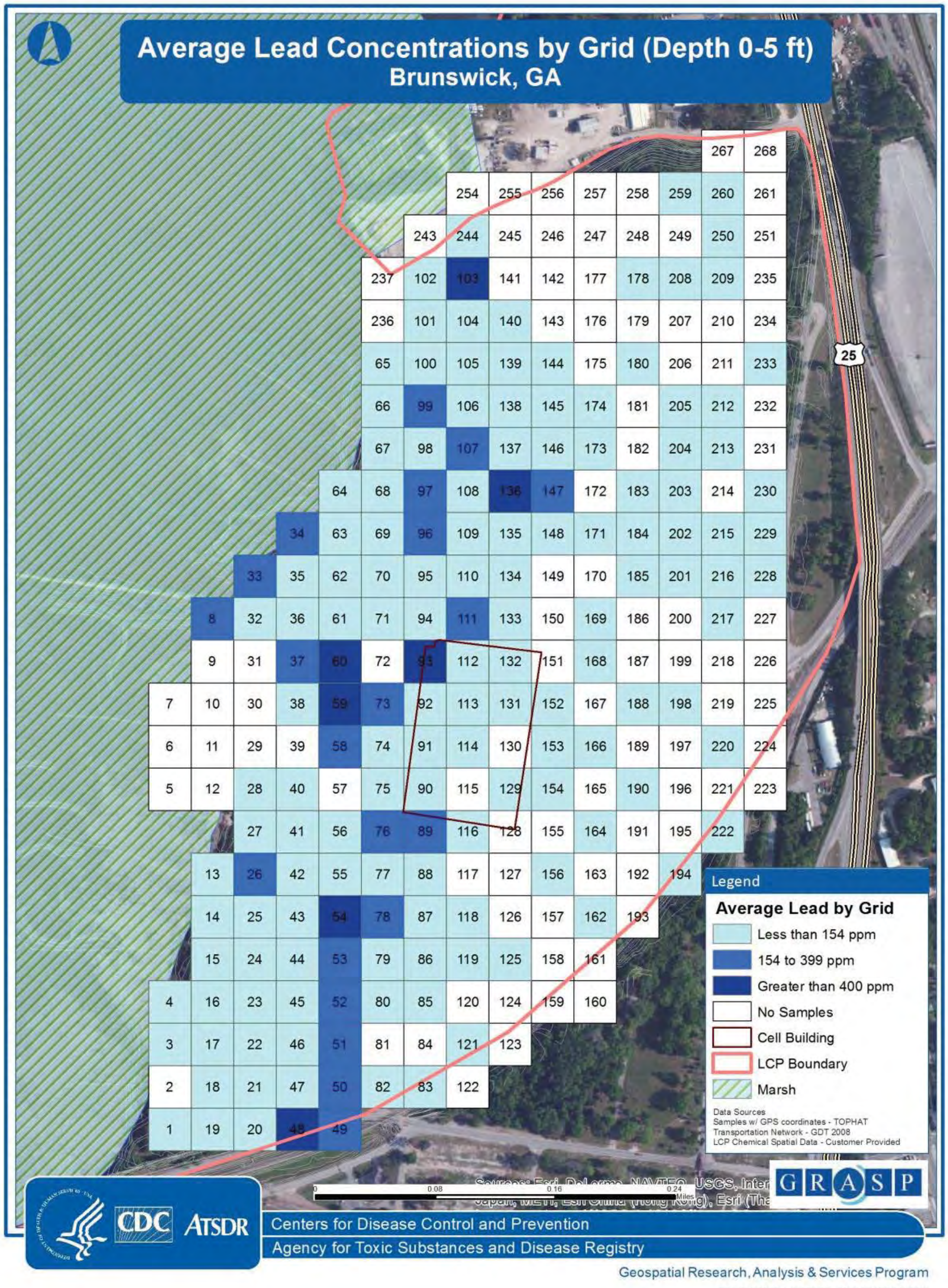

Figure 40. This figure shows the seven grids in dark blue that exceed EPA's target action level for lead of 400 ppm. An additional 21 grids have average lead levels between 154 ppm and 399 ppm. If these half-acre grids become residential in the future, they are a health concern for children.

V.F.4. Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals with a similar chemical structure and are formed during the incomplete burning of coal, oil, gas, wood, or other organic substances. The PAHs detected in soils from the LCP Chemicals Site are most likely residues from distillation of crude oil that occurred during historical site operations (McNamara 2010). There are more than 100 different PAHs, which occur as complex mixtures in the environment. PAHs can be grouped into the non-carcinogenic PAHs and the carcinogenic (cancer-causing) PAHs (or cPAHs). Table 34 shows the PAHs that were most frequently detected in soils from the LCP Chemicals Site and indicates whether the specific PAH is in the non-carcinogenic or carcinogenic group.

PAHs are composed of carcinogenic and non-carcinogenic PAHs. To evaluate the risk of cancer, an approach is used from the California Environmental Protection Agency (Cal EPA) that converts the total PAH concentration to a total carcinogenic PAH concentration in a sample (CalEPA 2005). Based on the toxicity of benzo(a)pyrene, this approach uses potency factors specific for each carcinogenic PAH to change the concentration of that PAH to a benzo(a)pyrene equivalent concentration. Thus, the benzo(a)pyrene equivalent concentration of various individual carcinogenic PAHs in a soil sample are summed to give the total carcinogenic PAHs (cPAH) for that sample.

The CalEPA PEFs for each cPAH are shown in Table 34. This concentration is used to estimate the dose in BaP equivalents and the cancer slope factor for BaP along with the duration of exposure is used to estimate the risk of cancer from ingesting soil with cPAHs. The exception to this approach is samples with dibenz(a,h)anthracene. This cPAH has its own cancer slope factor; therefore, a separate cancer risk is estimated for this cPAH and combined with the cancer risk estimated using the BaP equivalent concentration.

More information about how to estimate cancer risk from PAHs can be found at these websites:

- http://oehha.ca.gov/air/hot_spots/pdf/May2005Hotspots.pdf
- http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584
- http://www.health.state.mn.us/divs/eh/risk/guidance/pahmemo.html

Table 34. The carcinogenic and non-carcinogenic PAHs that were detected most frequently in soils from the site are shown along with descriptive information about the PAHs. This information is described further in the text and is used to evaluate the risk of harmful effects

Substance Name	*Cancer Slope Factor* *(mg/kg/day)$^{-1}$*	*Potency Equivalency Factor*	*# Samples > ND*	*Total # Samples*	*% Detection*
Carcinogenic PAHs (cPAH)					
Benzo(a)pyrene	7	1	72	651	11.1
Benzo(a)anthracene		0.1	90	651	13.8
Benzo(b)fluoranthene		0.1	56	568	9.9
Benzo(k)fluoranthene		0.1	44	567	7.8

Table 34. The carcinogenic and non-carcinogenic PAHs that were detected most frequently in soils from the site are shown along with descriptive information about the PAHs. This information is described further in the text and is used to evaluate the risk of harmful effects					
Substance Name	***Cancer Slope Factor*** *(mg/kg/day)$^{-1}$*	***Potency Equivalency Factor***	***# Samples > ND***	***Total # Samples***	***% Detection***
Benzo(b and/or k)fluoranthene		0.1	17	84	20.2
Indeno(1,2,3-cd)pyrene		0.1	43	651	6.6
Chrysene		0.01	116	651	17.8
Dibenz(a,h)anthracene	4		18	650	2.8
Naphthalene	None	None	90	650	13.8
Non-carcinogenic PAHs (PAH)					
Pyrene			139	651	21.4
Phenanthrene			143	651	22
2-Methylnaphthalene			126	631	20
Fluoranthene			69	651	10.6
Benzo(g,h,i)perylene			70	651	10.8
Anthracene			72	650	11.1
1-Methylnaphthalene			107	462	23.2
Acenaphthene			15	649	2.3
Fluorene			14	650	2.2
Acenaphthylene			18	650	2.8

V.F.4.a. Estimating Human Doses of PAHs

The parameters used to estimate doses in children and adults if the site becomes residential are shown in Appendix B, Table B1. As mentioned previously, preschool children were assumed to swallow 200 milligrams of soil daily, while older children and adults were assumed to swallow 100 milligrams of soil daily. These soil intake rates represent the group of children and adults with high soil intake.

Two cancer risks were estimated and then combined to get a total cancer risk. The first cancer risk was estimated using cPAH concentrations and represents the cancer risk from ingesting benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene. A separate cancer risk was estimated from ingesting dibenz(a,h)anthracene because this PAH has its own cancer slope factor. The two cancer risks were combined to represent the total cancer risk from all cPAHs in soil.

The average cPAH concentration and the dibenz(a,h)anthracene concentration are shown in Table 35 for the grids with the highest average concentrations. The grids with the highest average cPAH concentration was grid 93 with an average concentration of 29 ppm on the basis of two soil samples. The low number of samples increases the uncertainty about the average cPAH concentration for this grid. Five other grids have average cPAH concentrations ranging from 1.6 ppm to 9.6 ppm.

Table 35. The grids are listed with the highest average cPAH concentration and dibenz(a,h)anthracene concentration.			
Grid Number	***Average cPAH Concentration in ppm***	***Average dibenz(a,h)anthracene in ppm***	***# samples***
93	29.4	0	2
15	9.6	1.9	5
28	2.6	0	4
26	2	0.3	5
14	2	0.3	6
33	1.6	1.4	2

The estimated cPAH doses for various age groups exposed to an average of 1.6 or 29.4 ppm cPAHs in soil are shown in Table 36. Because the doses are small, they are shown as µg/kg/day. These doses are used to estimate cancer risk for the cPAHs in soils. Depending on the age group, estimated doses range from 0.002 µg/kg/day in adults to 0.58 µg/kg/day in 1 yr old preschool children.

In addition to cPAH doses, estimated doses were also calculated for dibenz(a,h)anthracene. Those doses ranged from 0 µg/kg/day for those grids with no dibenz(a,h)anthracene to 0.038 µg/kg/day for preschool children who live on soil containing 1.9 ppm dibenz(a,h)anthracene.

Table 36. Estimated cPAH doses in various age groups exposed to an average concentration of 1.6 or 29.4 ppm cPAHs in soil		
Age Group	***1.6 ppm cPAHs***	***29.4 ppm cPAHs***
	cPAH Dose µg/kg/day	
Preschool children (1 yr)	0.0320	0.5880
Preschool children (3 yr)	0.0200	0.3675
Elementary age children	0.0046	0.0840
Teenagers	0.0029	0.0535
Adult men	0.0023	0.0420
Adult women	0.0027	0.0490
Commercial/Industrial workers (20 years)	0.0016	0.0288
Excavation workers (6 months)	0.0054	0.099

V.F.4.b. Possible Health Effects From PAHs If the Site Becomes Residential

The greatest concern from PAH exposure is the potential for cPAHs to cause cancer. The concern is for cancer because non-cancerous effects are not expected at the soil levels found at the LCP site. Human studies has shown that exposure to PAHs is associated with lung and skin cancers in humans. The estimated dose of cPAHs can be multiplied by EPA's cancer slope factor for benzo(a)pyrene and the number of years of exposure to estimate the cancer risk from exposure to cPAHs in soil. The formula for estimating cancer risk follows:

Estimated Cancer Risk =

(cPAH Dose x Cancer Slope Factor) x (# years / 70 years)

The estimated dose for each age group can be used to estimate a cancer risk for that age group. The cancer risks for the 3 age groups that represent children can be added to give the estimated cancer risk for children who live on a property for 18 years. The estimated cancer risk for adults is the average of cancer risk for men and women assuming 52 years of exposure.

A similar procedure is followed to estimate the cancer risk from exposure to dibenz(a,h)anthracene. This approach uses the estimated dose of dibenz(a,h)anthracene and the cancer slope factor that is specific to dibenz(a,h)anthracene. The cancer risks estimated from both cPAHs and dibenz(a,h)anthracene are added to arrive at a total cancer risk from carcinogenic PAHs.

The estimated cancer risks in children and adults who live on soil containing the highest cPAH levels are shown in Table 37. So that the reader can understand the scientific notation, the same cancer risks are presented in Table 38. The grids with elevated levels of carcinogenic PAHs are shown in Figure 41.

Grids 15 and 93 have the highest estimated cancer risks ranging up to 1E-4 (grid 15) and 3.2E-4 (grid 93) for children if they live within these grids for 18 years. The cancer risk for adults is slightly lower. The highest cancer risk estimate is 3.2E-4. This means that should 100,000 children live for 18 years on soil containing 29.4 ppm cPAHs (grid 93), about 30 extra cancer cases might be expected. For adults who live for 52 years on grid 93, their estimated cancer risk is 2.5E-4. This means that should 100,000 adults live for 52 years on soil with 29.4 ppm cPAHs, about 25 extra cases of cancer might be expected. In summary, if the site becomes residential, children and adults might have an increased risk of cancer if they have contact with cPAHs in soil above 2 ppm.

The estimated cancer risks shown in Tables 37 and 38 likely underestimate the cancer risk from carcinogenic PAHs. The EPA is reviewing and updating the potency factors for cPAHs and will be adding more CSFs for various PAHs. These changes will result in a higher cancer risk estimate once EPA makes them final. More information about EPA's potency estimates for cPAHs can be found at http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=66193&utm_medium=email&utm_source=govdelivery and http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584.

Table 37. Estimated cancer risks in children and adults who live on certain grids with elevated levels of carcinogenic PAHs in soil (using scientific notation). The estimated cancer risk is for children and adults with high soil intake. The estimated cancer risk for children and adults with typical soil intake is about half the risk shown this table

Grid Number	*Cancer Risk*		*# samples*
	Children	*Adults*	
93	3.2E-4	2.5E-4	2
15	1.1E-4	9E-5	5
28	2.8E-5	2.2E-5	4
26	2.5E-5	1.9E-5	5
14	2.5E-5	1.9E-5	6
33	2.6E-5	2.0E-5	2

Table 38. Estimated number of cancer cases if 100,000 children or 100,000 adults were exposed to carcinogenic PAHs in soil in certain grids. The estimated cancer risk is for children and adults with high soil intake. The estimated cancer risk for children and adults with typical soil intake is about half the risk shown this table

Grid Number	*Estimated Number of Cancers if 100,000 Children or 100,000 Adults Are Exposed to Carcinogenic PAHs in Soil**		*# samples*
	Children	*Adults*	
93	30	25	2
15	10	9	5
28	3	2	4
26	3	2	5
14	3	2	6
33	3	2	2

*Estimated cancer risks are rounded to whole numbers.

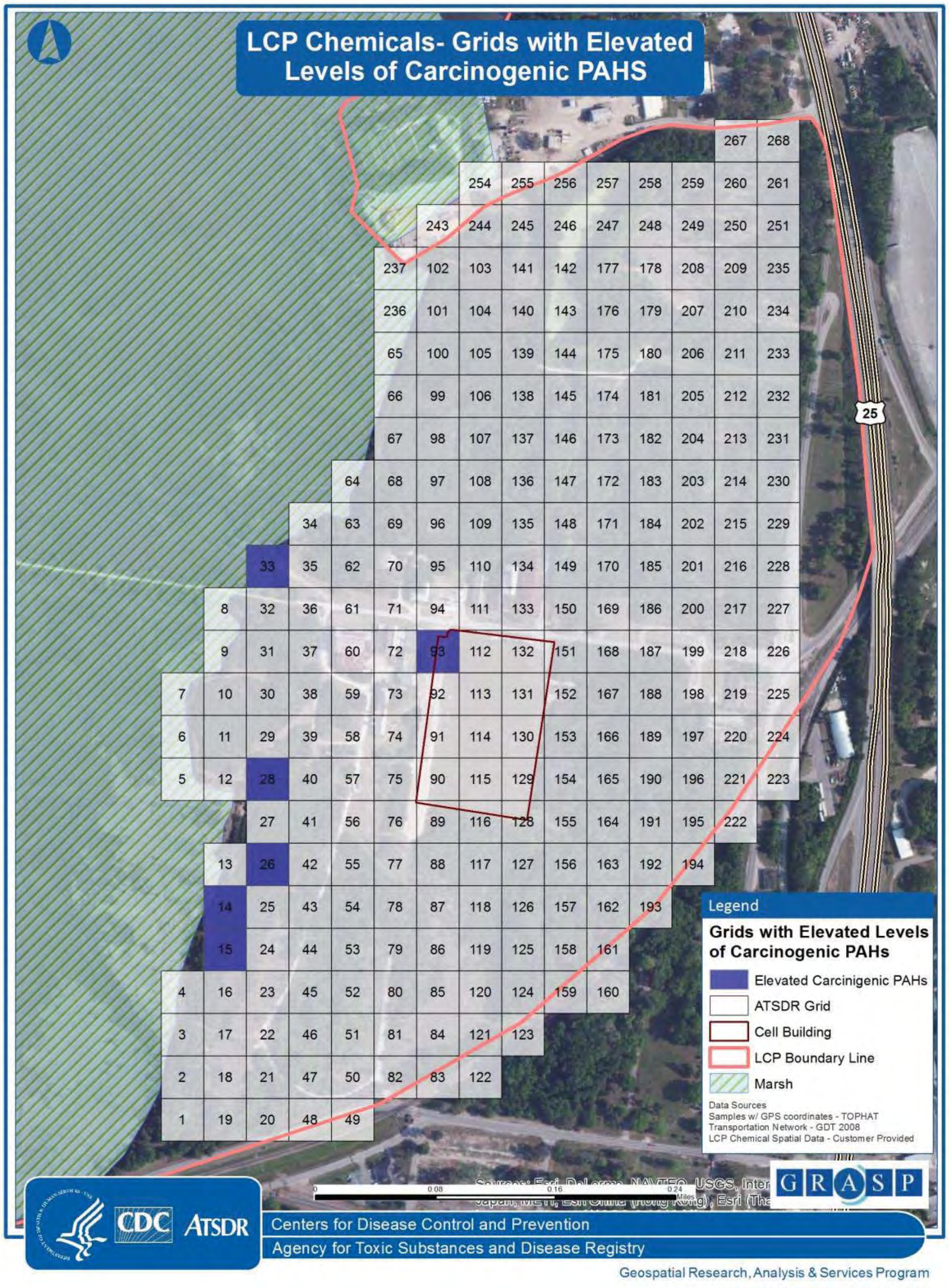

Figure 41. This figure shows the six grids in dark blue where residents might be at elevated risk of cancer from PAHs in soil if the site becomes residential in the future.

V.F.4.c. Possible Health Effects in Workers

Excavation workers who have contact with soil containing cPAHs have negligible risk of harmful effects because their exposure is very low and because their exposures last only a few months. Commercial or industrial workers who have contact with cPAHs in soil have a moderate increased risk of cancer if they have contact with soil in grids 15 and 93. Their estimated cancer risk is 2 (grid 15) or 6 (grid 93) extra cases of cancer for 100,000 workers exposed.

V.F.4.d. Uncertainty in Cancer Risk Estimates

It is important to remember the assumptions that went into estimating these cancer risks. The assumptions are as follows:

- The PAH-contaminated areas of the site will become residential or commercial/industrial,
- PAH contamination that is below the surface will be moved to the surface during construction thus allowing human contact,
- The average cPAH and dibenz(a,h)anthracene concentrations calculated using the current contaminant levels represent the level of future exposure,
- For the residential scenario, children will live on the property for 18 years or adults will live on the property for 52 years,
- For the commercial/industrial scenario, adults will have contact with the soil for 20 years, and
- Children and adults will have high soil intake from hand-to-mouth activity.

In addition, uncertainty exists for grids 33 and 93 because only 2 soil samples were collected. Also, uncertainty exists from using soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site. Nevertheless, the soil samples show that some residual cPAH contamination may still exist at the LCP dry-land area.

V.G. Mixture Effects from PCB, Methylmercury, and Lead

Several studies have shown that PCB, methylmercury, and lead have a mixture effect. Children exposed to low levels of PCBs, methylmercury, and lead showed impaired learning of a performance task. Specifically, children prenatally exposed to PCBs (as well as methylmercury and lead) responded excessively, with significantly lower inter-response times and fewer re-enforcers earned across the test session. In other words, low-level PCB, methylmercury, and lead exposure results in an inability to withhold or delay inappropriate responses, which are measures of attention and impulse control. Mean cord serum PCB level was 0.96 ppb. Maternal hair mercury levels averaged 0.56 ppm, while postnatal blood lead levels averaged 4.6 µg/dL in children aged 2 to 4 years, which are similar to levels found in the US population (Stewart 2006). The impairments of each chemical were statistically independent of the other chemical. While these tests do not prove the chemicals acted synergistically (i.e., greater than just additive), the author concluded that it is reasonable to assume that the chemicals act in an additive manner (Stewart 2006).

Three grids (53, 60, and 93) have elevated levels of PCBs, lead, and mercury. Eight grids have elevated levels of PCB and lead (8, 58, 59, 73, 76, 89 and 111); and, five grids have elevated levels of PCBs and mercury (55, 112, 114, 118, and 128). Should these grids be developed for residential purposes, children could be at risk for problems with attention and impulse control. See Figure 42 for the location of these grids. Table 39 shows the concentrations of each chemical.

Table 39. Grids with either two or three chemicals above levels of concern				
Grid # Residential	***Combination***	***PCB***	***Lead***	***Mercury***
		Average Concentration in ppm		
93	PCBs, Lead, Mercury	139	590	296
53	PCBs, Lead, Mercury	42	169	24
60	PCBs, Lead, Mercury	34	422	85
8	PCBs, lead	1.6	245	0.5
37	PCBs, Lead	12	245	6
58	PCBS, Lead	122	390	18
59	PCBs, Lead	3	513	7
73	PCBs, Lead	3	214	16
76	PCBs, Lead	7	175	13
89	PCBs, Lead	21	170	13
111	PCBs, Lead	16	354	10
90	PCBs, Mercury	41	146	184
55	PCBs, Mercury	9	9	23
112	PCBs, Mercury	1.4	119	271
114	PCBs, Mercury	53	15	41
118	PCBs, Mercury	3	4	30
128	PCBs, Mercury	11	--	81

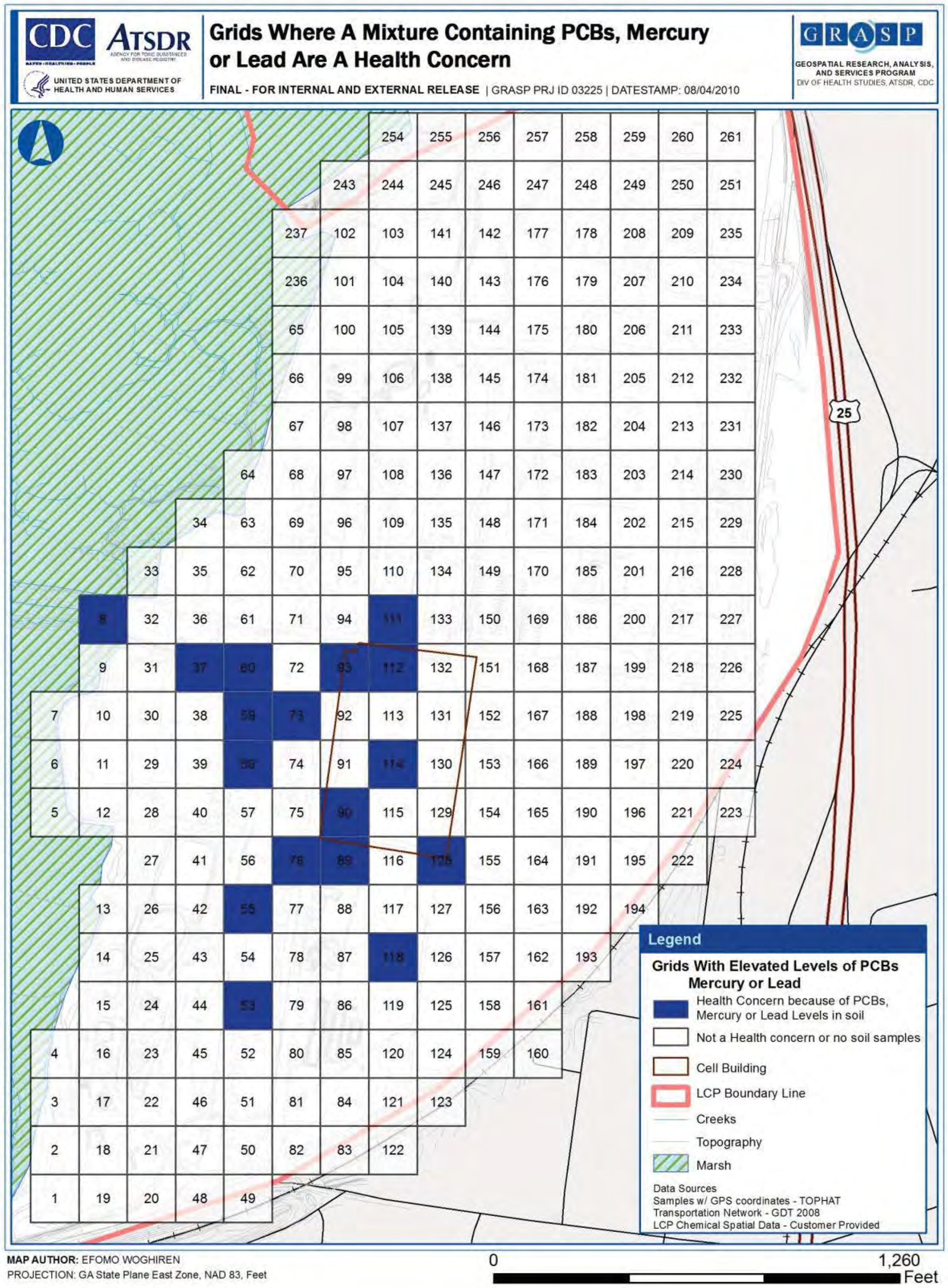

Figure 42 shows those grids that are a health concern because of a possible mixture effect from a combination of PCBs, mercury, or lead in soil. The combination of chemicals in these grids could act together to cause harmful effects.

V.H. Public Health Implications of New LCP Data Collected in 2010-2011

This section describes the public health implications of environmental samples collected from the LCP Chemicals Site in 2010 and 2011. This evaluation was not part of the evaluation presented in the fall 2010 public release document. This new evaluation focuses on several areas:

- Dioxin in soil from the dry-land area,
- PCBs and PAHs in soil from the former drive-in theater,
- PCBs, mercury, and PAHs in sediment and surface water from the on-site pond, and
- PCBs, mercury, and PAHs in sediment and PCBs and mercury in fish from the Altamaha Canal, south of the LCP Chemicals Site.

V.H.1. The Dry-land Area

As stated previously, composite soil samples for dioxins reported as TCDD-equivalent concentrations exceeded ATSDR's comparison level for soil (35 ppt) in two sampling areas (SA). The maximum TCDD-equivalent concentration from SA 8 is 120 ppt and from SA 2 is 46 ppt (See Figure 13). This section will evaluate whether a health concern exists should a home or business be built on SA 8 or SA 2.

V.H.1.a. Health Guidelines for Dioxins

The EPA has an RfD for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). As a reminder, an RfD is an estimate of a daily oral exposure in the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Because TCDD is so toxic, very small doses can cause harmful effects. The RfD for TCDD is 7×10^{-10} mg/kg/day (or 0.0000000007 mg/kg/day or 0.0007 ng/kg/day). A nanogram (ng) is one millionth of a milligram (mg).

Two human epidemiologic studies were chosen as the basis for deriving the RfD (Baccarelli *et al*., 2008; Mocarelli *et al*., 2008). Both of these studies evaluated a human population exposed to TCDD from a 1976 industrial accident in Seveso, Italy. Baccarelli *et al*. reported increased levels of thyroid stimulating hormone (TSH) in newborns exposed to TCDD *in utero.* An increase in TSH in humans indicates a possible dysregulation of thyroid hormone metabolism. The study authors related TCDD concentrations in maternal plasma to newborn TSH levels using a linear regression model. Based on this regression modeling, EPA defined the LOAEL to be a neonatal TSH level of 5 microunits/milliliter (µU/mL). Using the Emond human PBPK model, the corresponding daily oral intake at the LOAEL is calculated to be 0.020 nanogram (ng)/kg day. Adequate levels of thyroid hormone are essential in the newborn and young infant because this is a period of active brain development. Thyroid hormone disruption during pregnancy and in newborns can lead to neurological deficiencies in newborns, particularly in attention and memory (EPA 2012).

In another study, Mocarelli *et al*. (2008) reported decreased sperm concentrations and decreased motile sperm counts in men who were exposed as boys (1–9 years of age) at the time of the Seveso accident in 1976. The lowest exposure group in the Mocarelli *et al*. study (68 ppt serum TCDD) is designated as a LOAEL. Using the Emond PBPK model, EPA calculated the LOAEL over the 10 year period to be 0.02 ng/kg/day (EPA 2012). Mocarelli *et al*. (2000) also reported a lower male to female sex ratio in offspring of men exposed to TCDD less than 20 ng/kg, which supports the findings of reproductive effects involving sperm (EPA 2012, ATSDR 2012). EPA divided the LOAEL of 0.02 ng/kg/day from the Baccarelli and Mocarelli studies by an uncertainty factor of 30 to arrive at the RfD of 0.0007 ng/kg/day (or 7×10^{-10} mg/kg/day).

In summary, exposure to TCDD *in utero* can cause neurological problems in newborns, such as problems with memory and attention. In addition, exposure to TCDD *in utero* or as young boys can cause health effects later in life, such as:

- Decreased number of sperm,
- Decreased counts of motile sperm, and
- Fewer male offspring as adults.

More information about the effects of TCDD and other dioxins can be found at EPA's IRIS website (http://www.epa.gov/iris/subst/1024.htm) and at ATSDR's Addendum for chlorinated dibenzo dioxins (http://www.atsdr.cdc.gov/toxprofiles/cdds_addendum.pdf).

V.H.1.b Estimating Human Doses of Dioxins and Dioxin Hazard Quotients

As mentioned previously, TCDD-equivalent doses were estimated using a range of soil ingestion rates for various age groups. Hereafter, TCDD equivalents will be referred to as dioxins. Preschool children were assumed to swallow 200 milligrams of soil daily, while elementary-age children, teenagers, and adults were assumed to swallow 100 milligrams of soil daily. Average body weights were selected for each age group. These and other parameters used to estimate dioxin doses in people are shown in Appendix B, Table B1.

Figure 43 shows the location of SA 8, which covers portions of grids 127 to 130 and 152 to 156. EPA's composite soil sample contained dioxins at 120 ppt. The estimated dose (in ng/kg/day) of dioxins for each age group is shown in Table 40 for exposure to 120 ppt dioxins in residential soil. As shown by the HQs of 2.1 and 3.4, the estimated doses in preschool children (0.0015 and 0.0024 ng/kg/day) are two to three times higher than the RfD of 0.0007 ng/kg/day. The doses for preschool children require further evaluation to determine the risk of harmful effects from exposure to dioxins in soil should SA 8 within the site become residential. As shown by HQs ranging from 0.2 to 0.5, the doses in older children and adults are below the RfD. Older children and adults are not at risk of harmful, non-cancerous effects.

Table 40. Estimated doses and hazard quotients (HQ) in children and adults exposed to 120 ppt dioxin in residential soil. The estimated doses in preschool children exceed the RfD (HQ = 2.1 and 3.4), while the estimated doses in older children and adults are below the RfD		
	Dose	**HQ**
Age Groups	**ng/kg/day**	
Preschool children (1 yr old)	0.0024	3.4
Preschool children (3 yr old)	0.0015	2.1
Elementary school children	0.00034	0.5
Teenagers	0.00022	0.3
Adult men	0.00017	0.2
Adult women	0.0002	0.3
RfD	0.0007	

The estimated doses for preschool children (0.0015 and 0.0024 ng/kg/day) exceed the RfD (0.0007 ng/kg/day) by two to three fold. The doses for preschool children range from 8 to 13 times below the levels that are thought to cause harmful effects in humans. Because their doses approach those that might cause harmful effects, preschool male children who have contact with soil containing 120 ppt dioxins could be at risk of the following harmful effects after puberty:

- Decreased number of sperm,
- Decreased counts of motile sperm, and
- Fewer male offspring as adults.

The estimated dose for pregnant women is below the RfD; therefore, they and their developing fetus are not at risk of harmful effects.

Another area on site (SA 2) also contained dioxin but at lower levels (i.e., 46 ppt). Should this area become residential, children and adult would not be at risk of harmful effects because their estimated exposures are at or below the RfD.

V.H.1.c. Estimated Cancer Risk from Dioxins If the LCP Chemicals Site Becomes Residential

Several agencies have evaluated the cancer-causing ability of dioxins. The Department of Health and Human Services (DHHS) has determined that it is reasonable to expect that TCDD may cause cancer in humans. The International Agency for Research on Cancer (IARC) also has determined that TCDD can cause cancer in people. Previously, the EPA had determined that TCDD and a mixture of TCDD is a probable human carcinogen; however, EPA is currently reviewing their opinion about the carcinogenic effects of dioxins (ATSDR 1998, EPA 2012).

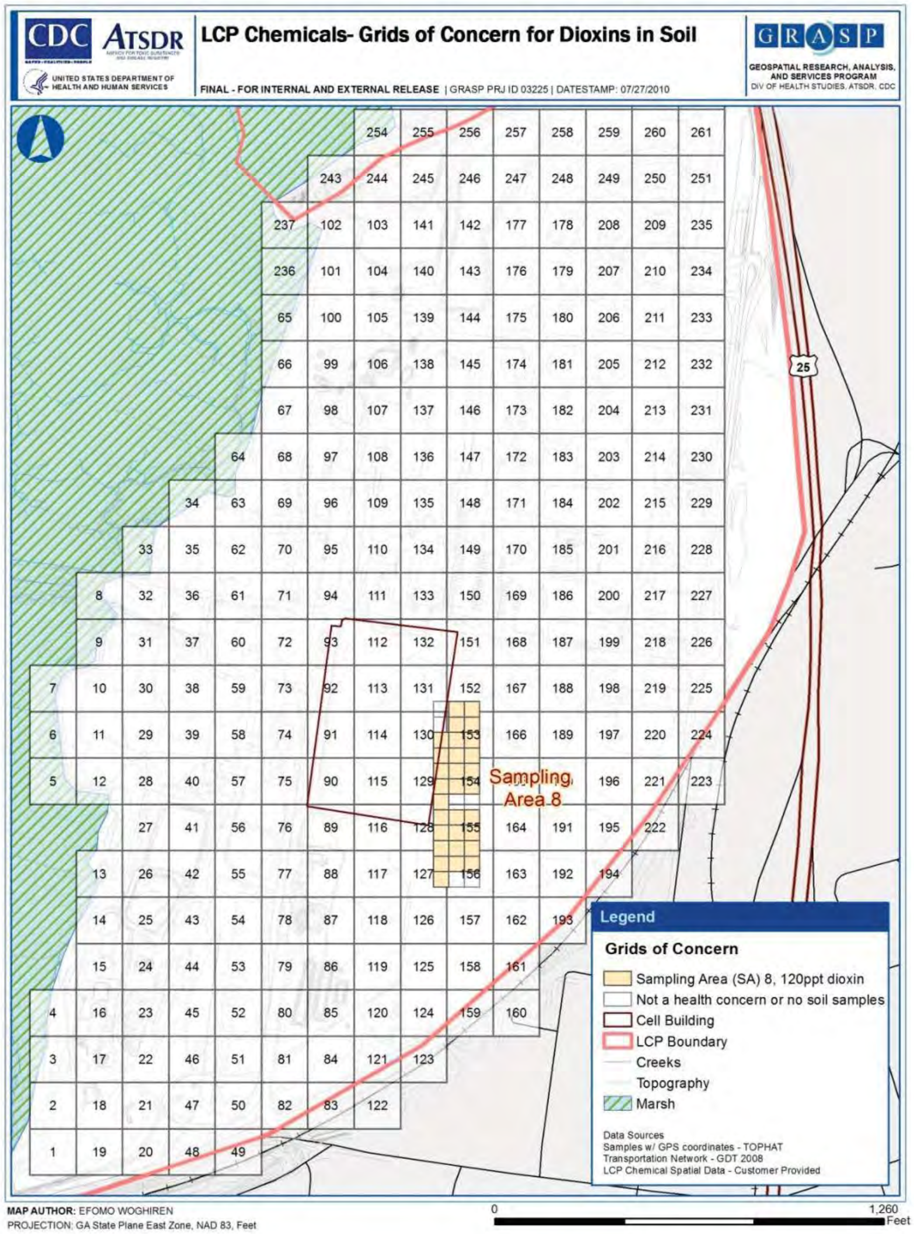

Figure 43. This figure shows the location of sampling area 8 (SA 8), which has dioxins in soil at 120 ppt.

Human studies have shown that TCDD can cause liver cancer and might be associated with lung, colon, prostrate, breast, lymphatic, and hematopoietic cancers (ATSDR 2012). Rodent studies have confirmed that TCDD can cause cancer at multiple sites, including the liver, lung, mouth, and thyroid (ATSDR 1998, 2012).

As mentioned previously, a cancer slope factor (CSF) method can be used to estimate cancer risk using the following formula:

Cancer risk = estimated lifetime dose x cancer slope factor

The California Environmental Protection Agency (CalEPA) has developed a CSF for dioxins, specifically 1.3E5 $(mg/kg/day)^{-1}$. Using CalEPA's CSF, the cancer risk for children exposed to 120 ppt in soil for 18 years is 2 extra cases of cancer for every 10,000 children exposed. The cancer risk for adults exposed to 120 ppt in soil for 50 years is 2 extra cases of cancer for every 10,000 adults exposed. Therefore, a high risk of cancer could exist for children and adults should SA 8 be developed for residential use (see Figure 43).

The EPA is re-evaluating the cancer risk for dioxins and has a draft CSF under review. The estimated cancer risks at LCP could be higher or lower depending on the final CSF that EPA chooses.

In conclusion, should SA 8 be developed as a residential neighborhood, a high risk of cancer exists for children and adults, and preschool children could be at risk of reproductive effects once they reach adulthood.

V.H.1.d. PCBs and cPAHs in Soils from the Former Drive-in Theater

From 1994 to 2010, EPA collected surface and subsurface soil samples from the former drive-in theater area. The results of these sampling events were previously presented in Table 10. PCBs and cPAHs exceeded ATSDR's screening values for residential soils; therefore, those two chemicals will be evaluated further in this section.

It should be noted that Glynn County purchased approximately 32 acres from the northeastern portion of the site, which includes the theater area and an on-site pond. The county plans to build a detention center on this property. Therefore, this portion of the site will not be residential and will be evaluated only for future adult exposures for workers and prisoners at the prison. Appendix B, Table B1 shows the parameters used to estimate adult doses from soil ingestion. Prison inmates were assumed to ingest soil daily and guards were assumed to ingest soil 5 days a week. Insufficient data exist to estimate a reliable average for the theater area; therefore, ATSDR used the maximum concentration of PCBs and cPAHs (see Table 41).

The estimated PCB doses in prison inmates and guards are far below ATSDR's chronic, oral MRL for PCBs. Therefore, non-cancerous harmful effects are unlikely. The risk of cancer in prison inmates and guards is well below one in a million. The estimated dose of cPAHs in prison inmates and guards results in a cancer risk of three in a million.

Table 41. Maximum soil concentrations of PCBs and cPAHs in the theater area.	
Contaminant	**Soil Concentration in ppm**
PCBs	0.57
cPAHs	1.3

V.H.1.e. The On-Site Pond

As previously mentioned, the levels of PCBs, mercury, cPAHs, and lead in surface water and sediment from the on-site pond are not a health concern.

V.H.2. Altamaha Canal

V.H.2.a. Sediment

The Altamaha Canal once traversed the LCP Chemicals Site and a portion of the canal, which is influenced by the tides, still exists south of the LCP Chemicals Site. Sediment samples (upper 6 inches) were collected from twenty locations along the canal from its northern limit at West 9th Street to its southern outflow at T Street. The canal flows into the adjoining marsh where the outflow drains to Academy Creek and eventually to the East River and to the lower portion of the Turtle River. Each sample is comprised of a five-point composite taken along an approximate 1000-ft stretch of the canal. The sampling locations and individual results are shown in Figures 29 through 33. The average concentration of PCBs, cPAHs, and dioxin are presented in Table 42.

When adults or children visit or play along the banks of the Altamaha Canal, they could ingest small amounts of sediments from hand to mouth activity. ATSDR assumed that adults visit the canal once a week to fish and that elementary-age children and teenagers play along the canal three times a week. Because of their age, preschool children are unlikely to play along the canal. It should be noted that even if adults and children visit or play along the canal every day, the same conclusions are reached.

ATSDR evaluated the risk of harmful effects from exposure to PCBs, cPAHs, and dioxins and reached the following conclusions.

- The estimated dose of PCBs for adults and children who visit or play along the canal is well below ATSDR's chronic, oral MRL for PCBs. Therefore, harmful non-cancerous effects are not likely. The estimated cancer risk is less than one in 10 million.

- The estimated dose of cPAHs for adults and children who visit or play along the canal results in a cancer risk well below one in a million.

- The estimated dose of dioxins for adults and children who visit or play along the canal is well below EPA's RfD for dioxin. Therefore, harmful, non-cancerous effects are not likely. The estimated cancer risk for children and adults is 1 in a million.

In summary, the estimated exposure to PCBs, cPAHs, and dioxins in sediment is below health guidelines and the risk of cancer is insignificant.

Table 42. Average concentration of PCBs, cPAHs, and dioxin in sediment collected from the Altamaha Canal south of the LCP Chemicals Site	
Contaminant	***Average Concentration in ppm***
PCBs	0.17
cPAHs	0.24
Dioxin	0.00007*

*0.00007 = 70 ppt

V.H.2.b. Fish and Shellfish from the Altamaha Canal

V.H.2.b.1. GDNR Fish and Shellfish Advisory

The Georgia Department of Natural Resources (GDNR) has issued a fish advisory for the Buffalo, Turtle, South Brunswick, and Brunswick Rivers as well as their tributary creeks, such as Purvis and Gibson Creeks, the closest creeks to the LCP Chemicals Site. Figure 44 shows these rivers and creeks in relation to the LCP Chemicals Site, which borders the Turtle River. In Tables 43, 44, 45, and 46, GDNR describes the fish advisory for several sections of the Turtle River system, which includes:

- Purvis and Gibson Creeks,
- Buffalo River and upper Turtle River upstream of Georgia Highway 303,
- Middle Turtle River between Georgia Highway 303 and channel marker 9, and
- South Brunswick River and lower Turtle River from channel marker 9 downstream to channel marker 27 at DuBignon's and Parsons Creek (channel marker 27) (GDNR 2012).

Depending upon mercury and PCB levels in the edible portion of various fish and shellfish from the areas listed in the previous bullets, GDNR recommends one of four consumption guidelines:

- No restrictions,
- One meal per week,
- One meal per month, and
- Do not eat.

This approach allows the greatest flexibility in informing residents about fish consumption. For example, GDNR recommends that residents not eat Atlantic croaker taken from Purvis or Gibson Creeks because the edible portion is highly contaminated with PCB 1268–the PCB most commonly found at the LCP Chemicals Site (see Table 43). GDNR recommends that residents limit consumption of red drum and flounder taken from these creeks to one meal per week because of PCB and mercury levels in the edible portion of those fish. Similar recommendations exist for the upper, middle, and lower Turtle River and adjoining rivers and creeks.

Table 43. GDNR's fish consumption recommendations for Purvis and Gibson Creeks (see Figure 44).

Turtle River System: ***Satilla River Basin***
Purvis and Gibson Creeks , (St. Simons Estuary)

Species	Site Tested	Recommendation	Chemical
Atlantic Croaker	Purvis & Gibson Creeks	Do Not Eat	PCBs
Southern Kingfish (whiting), Black Drum, Spot, Spotted Seatrout		1 meal/month	PCBs
Sheepshead		1 meal/month	PCBs, Mercury
Striped Mullet		1 meal/week	PCBs
Red Drum, Flounder		1 meal/week	PCBs, Mercury
Blue Crab		1 meal/week	Mercury
Shrimp		No Restrictions	
Clams, Mussels, Oysters	Not applicable	Do Not Eat	Shellfish Ban *
* Shellfish Ban: National Shellfish Sanitation Program. For information see Coastal Resources Division website: http://crd.dnr.state.ga.us			

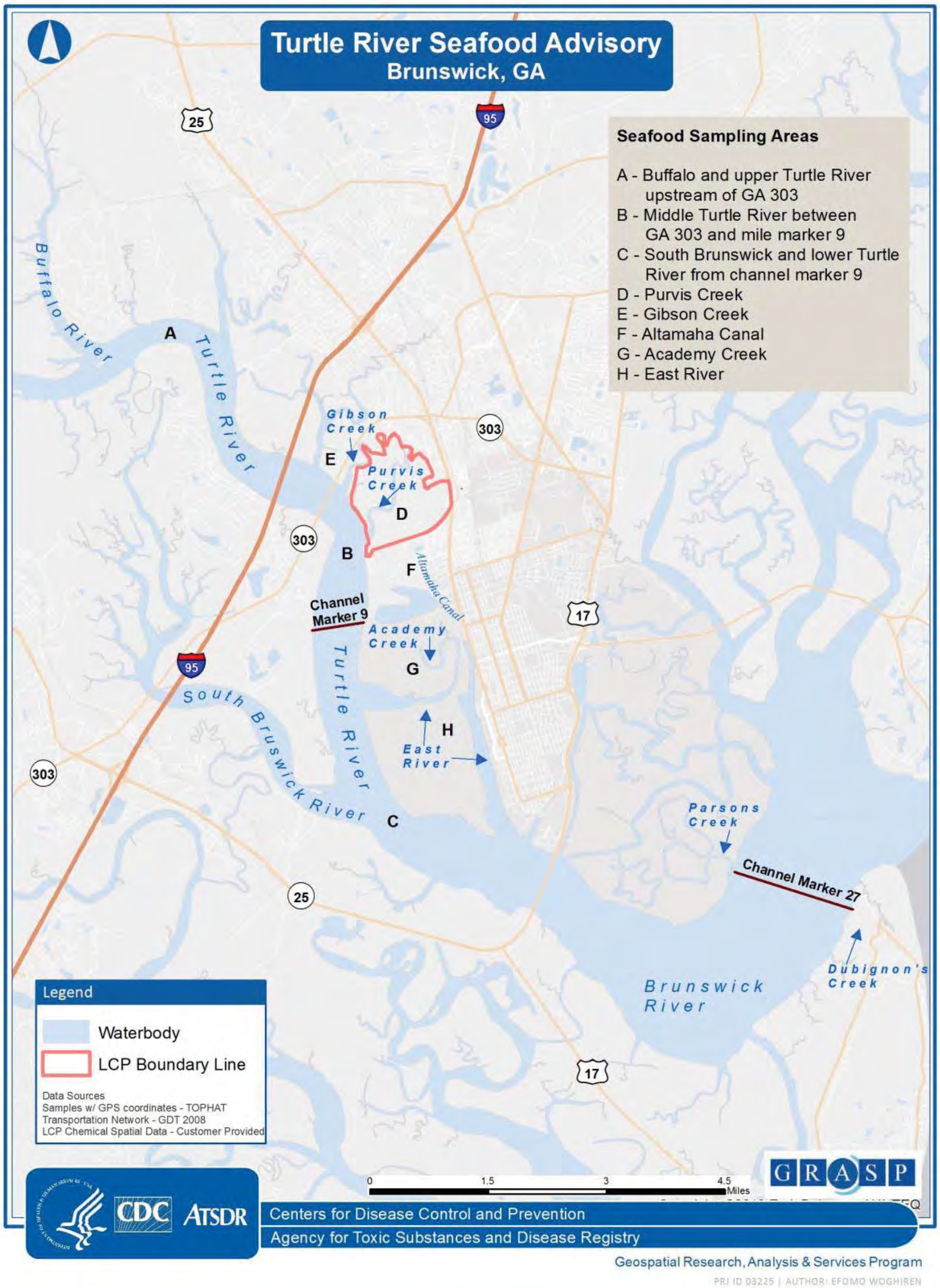

Figure 44. This figure shows the Turtle River system and highlights portions of the river system (see A, B, C, D and E) that are pertinent to GA DNR's fish advisory. The Altamaha Canal (see F) is located just south of the LCP Chemicals Site and connects to Academy Creek, the East River, and lower portion of the Turtle River (See G, H, and C).

Table 44. GDNR's fish consumption recommendations for the Buffalo and Turtle Rivers upriver of Georgia Highway 303 (see Figure 44).

Upper Turtle & Buffalo Rivers (St. Simons Estuary) ***Satilla River Basin***

Species	Site Tested	Recommendation	Chemical
Spotted Seatrout, Spot, Southern Kingfish (whiting), Atlantic Croaker	Turtle and Buffalo Rivers, Upriver of Georgia Hwy 303	1 meal/month	PCBs
Red Drum, Black Drum, Striped Mullet		1 meal/week	PCBs
Sheepshead		1 meal/week	PCBs, Mercury
Blue Crab		1 meal/week	Mercury
Shrimp, Flounder		No Restrictions	
Clams, Mussels, Oysters	Not applicable	Do Not Eat	Shellfish Ban *
* Shellfish Ban: National Shellfish Sanitation Program			

Table 45. GDNR's fish consumption recommendations for the middle Turtle River between Georgia Highway 303 and channel marker 9 (see Figure 44)

Middle Turtle River (St. Simons Estuary) ***Satilla River Basin***

Species	Site Tested	Recommendation	Chemical
Spot	State Hwy 303 to Channel Marker 9	Do Not Eat	PCBs
Spotted Seatrout, Sheepshead, Striped Mullet, Southern Kingfish (whiting)		1 meal/month	PCBs
Black Drum		1 meal/week	PCBs
Red Drum, Flounder		1 meal/week	PCBs, Mercury
Blue Crab		1 meal/week	Mercury
Shrimp		No Restrictions	
Clams, Mussels, Oysters	Not applicable	Do Not Eat	Shellfish Ban *
* Shellfish Ban: National Shellfish Sanitation Program			

Table 46. GDNR's fish consumption recommendations for the South Brunswick and lower Turtle Rivers from channel marker 9 downstream to Dubignon's and Parsons Creeks (See Figure 44).

Lower Turtle & South Brunswick Rivers (St. Simons Estuary) ***Satilla River Basin***

Species	Site Tested	Recommendation	Chemical
Atlantic Croaker, Spot	Turtle River (From Channel Marker 9) and South Brunswick River (Downstream to Dubignon and Parsons Creeks)	1 meal/month	PCBs
Spotted Seatrout, Black Drum, Southern Kingfish (whiting)		1 meal/week	PCBs
Red Drum, Sheepshead, Striped Mullet, Blue Crab, Shrimp, Flounder		No Restrictions	
Clams, Mussels, Oysters	Not applicable	Do Not Eat	Shellfish Ban *

* Shellfish Ban: National Shellfish Sanitation Program

The 2013 GDNR fish advisories for rivers, lakes, and estuaries in Georgia, including the Turtle River system, can be found at this website: http://www.gaepd.org/Documents/fish_guide.html. To view their brochure, click on "Guidelines for Eating Fish from Georgia's Waters, 2012".

GDNR also has brochures that provide information and recommendations specifically on women who eat fish and shellfish. These brochures cover specific geographic regions within Georgia, and the one for Brunswick, Georgia, states:

> Extensive studies have been performed on the Turtle River System, and Terry and Dupree Creeks. Assessment of contaminants in the species sampled suggests striped mullet and bivalves (oysters, clams, etc.) from this area should not be eaten. Consumption of all other finfish and blue crabs should be limited to once a month for women of childbearing age. However, in most areas there is no restriction on the amount of shrimp that can be eaten from these waters (GDNR 2012).

The brochure "A Woman's Guide to Eating Fish and Seafood in Coastal Georgia" can be downloaded from http://www.gaepd.org/Files_PDF/gaenviron/fish_advisory/wfcg_coastal.pdf.

V.H.2.b.2. Mercury in Fish and Shellfish from the Altamaha Canal

As mentioned previously, EPA collected fish and shellfish samples in 2011 from the tidally influenced Altamaha Canal that flows south of the LCP Chemicals Site. Table 47 shows the average mercury levels in fish and shellfish collected from the canal in 2011. These levels can be compared to fish and shellfish collected from the Turtle River System in 2002. This comparison shows that mercury levels in red drum, mullet, blue crab, and shrimp from the Altamaha Canal are similar to or below the levels found in the same fish and shellfish groups from the Turtle River. Mercury levels are closest to levels in fish and shellfish from the lower Turtle River south of the site. This similarity is probably due to the fact that the Altamaha Canal is connected to the lower Turtle River via Academy Creek and the East River (see Figure 44). Thus, influence by tidal cycles, fish and shellfish move from the lower Turtle River via the East River and Academy Creek to the Altamaha Canal. Comparison data for sea trout from the Turtle River were not available. However, the concentration of mercury in the one sea trout from the Altamaha Canal (0.117 ppm) is lower than average levels reported by the U.S. Food and Drug Administration in a national survey (0.235 ppm) (http://www.fda.gov/food/foodsafety/product-specificinformation/seafood/foodbornepathogenscontaminants/methylmercury/ucm115644.htm).

It should be noted that the red drum and sea trout samples consisted of one fish of each species; therefore, the actual levels in other fish of these species that might be caught in the Altamaha Canal is highly uncertain.

Table 47. Average mercury levels in edible fish and shell fish tissue are provided for Altamaha Canal as well as for various sections of the Turtle River system north of, adjacent to, and south of the LCP Chemicals Site. Data are not available for sea trout from the Turtle River System for 2011 so average mercury levels are reported from an FDA survey.

Date and Location	***Mercury concentrations in mg/kg-wet weight (ppm-ww)***				
	Red Drum	***Mullet***	***Sea Trout***	***Blue Crab***	***Shrimp***
2011 Altamaha Canal	0.09	0.013	0.117	0.081	0.02
2002 Upper Turtle and Buffalo Rivers (north of LCP)	0.27	0.02	NA	0.51	0.05
2002 Middle Turtle River, including Purvis and Gibson Creeks (adjacent to LCP)	0.32	0.02	NA	0.68	0.09
2002 Lower Turtle River south of the site, including South Brunswick and Brunswick River (south of LCP)	0.15	0.01	NA	0.31	0.04
FDA national survey			0.235		

NA = not available

V.H.2.b.3. Mercury Dose Estimates in Fishers

Information about fish intake rates is provided in Table 48. The basis for these rates comes from Burger *et al*., who reported fish consumption rates for adult fishers along the Savannah River between Georgia and South Carolina (Burger *et al*. 2001; Burger *et al*. 1999).[5] Burger also estimated the rates for women at 68% of male intake rates (Burger 2000). The rates for children were estimated using the ratio of adult to children portion sizes reported by EPA (EPA 2011).

[5] The Savannah River is about 80 miles from Brunswick, Georgia.

Table 48. Daily fish consumption rates (95th percentile and median) reported by Burger et al. (2001) for fishers along the Savannah River between Georgia and South Carolina.

Population	***95th %***		***Median***
	oz./day		***oz./day***
Black male	6.6		1.8
White male	4.8		0.7
Black female	4.5		1.2
White female	3.2		0.5
Children 3 to 5 years	1.8		0.5
Children 6 to 10 years	2.5		0.7
Children 11 to 15 years	3.6		1
Children 16 to 17 years	4.1		1.1

The daily fish consumption rates shown in Table 48 do not mean that people eat fish every day. The rates were derived by taking the survey results and reporting them as a daily intake and using those rates to derive daily rates for women and children as previously explained. For example, for children 3 to 5 years old who are typical (median) fish consumers (0.5 oz./day), they could have fish consumption patterns that might look like this:

- One 3.5 oz. fish meal a week,
- Two 1.8 oz. fish meals a week, or
- Three 1 oz. fish meals a week.

These combinations of weekly fish meals represent a daily rate of 0.5 oz./day. For children 3 to 5 years who are high (95%) fish consumers (1.8 oz./day), their consumption pattern might look like this:

- Three 4.2 oz. fish meals a week,
- Four 3.2 oz. fish meals a week, or
- Five 2.5 oz. fish meals a week.

What follows is a sample dose calculation for children 3 to 5 years old who are high consumers of sea trout from the Altamaha Canal, which contain 0.117 ppm (or mg/kg) mercury.

Dose =

$$\frac{\text{Mercury Concentration in Fish x Daily Fish Consumption Rate x Conversion Factor}}{\text{Body Weight}}$$

Dose =

$$\frac{[[0.117\ \text{mg/kg} \times 1000\ \mu\text{g/mg}] \times [1.8\ \text{oz/day} \times 28.35\ \text{gm/oz} \div 1000\ \text{gm/kg}]]}{17\ \text{kg}^{6}}$$

Dose = 0.35 µg/kg/day

This dose exceeds the RfD of 0.1 µg/kg/day and approaches the effect level of 1 µg/kg/day.

As mentioned previously, children and the fetus are particularly sensitive to the effects of mercury. ATSDR reached the following conclusions about adults and children with typical (i.e., median) and high (i.e., 95th percentile) fish consumption:

- Typical and high fish consumers of mullet and shrimp have estimated exposures to mercury that are below EPA's RfD for mercury. The levels of mercury in mullet and shrimp from the Altamaha Canal are not a health concern.
- Typical fish consumers of blue crab, red drum, and sea trout have estimated exposures to mercury that are below EPA's RfD for mercury. The levels of mercury in blue crab, red drum, and sea trout are not a health concern for typical fish consumers.
- High fish consumers of blue crab, red drum, and sea trout have estimated exposures to mercury that exceed EPA's RfD for mercury. Their mercury exposure approaches the level that causes harmful effects. Young children and children born to pregnant women who are high consumers of blue crab, red drum, and sea trout might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions. The levels of mercury in blue crab, red drum, and sea trout are a health concern for high fish consumers.

Some uncertainty exists in the conclusions for sea trout and red drum because only one fish of each species was collected from the Altamaha Canal.

These findings support the fish advisory issued by the GDNR for the lower Turtle River, which is based in part on mercury levels in blue crabs, sea trout, and king fish. Residents should follow GDNR's fish advisory for the lower Turtle River by restricting their

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[6] µg = micrograms; mg = milligrams; oz = ounces; gm = grams; kg = kilograms

consumption of certain fish species from the Altamaha Canal and from the lower Turtle River. See Table 46 for more information about the state's fish consumption recommendation for the lower Turtle River.

V.H.2.b.4. PCBs in Fish and Shellfish from the Altamaha Canal

Table 49 shows the average PCB levels in fish and shellfish collected in 2011 from the Altamaha Canal. These levels can be compared to fish and shellfish collected in 2002 from the Turtle River system. This comparison shows that PCB levels in red drum, mullet, sea trout, blue crab, and shrimp from the Altamaha Canal are below the levels found in the same fish and shellfish groups from the Turtle River. It should be noted that the red drum and sea trout samples from the Altamaha Canal consisted of one fish of each species; therefore, the actual levels in other fish of these species that might be caught in the Altamaha Canal is highly uncertain.

ATSDR estimated the dose of PCBs from eating various fish and shellfish from the Altamaha Canal and reached the following conclusions about adults and children with typical (i.e., median) and high (i.e., 95^{th} percentile) fish consumption:

- Typical and high fish consumers of red drum, blue crab, and shrimp have estimated exposures to PCBs that are at or below ATSDR's chronic oral MRL. PCB levels in red drum, blue crab, and shrimp are not a health concern for harmful, non-cancerous effects.
- Typical fish consumers of sea trout have estimated exposure to PCBs that are at ATSDR's chronic oral MRL. High fish consumers of sea trout have estimated exposure to PCBs that exceed the chronic oral MRL and approach levels that put them at risk of harmful, non-cancerous effects.
- Typical and high fish consumers of mullet have estimated exposure to PCBs that exceed ATSDR's chronic oral MRL and approach levels that put them at risk of harmful, non-cancerous effects.

High consumers of sea trout and typical and high consumers of mullet might experience the following harmful effects:

- Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
- Mild damage to fingernails and toenails,
- Inflamed oil-producing glands associated with the eyes
- Gum recession,
- Learning and performance decrements,
- Fewer male births,
- Problems with attention and impulse control
- Lower birth weight,
- Longer menstrual cycles in women,
- An increase in cardiovascular disease in women (but not men),

- An increase in deaths from Parkinson disease and dementia in women (but not men), and
- An increase in diabetes in women (but not men) (ATSDR 2000).

In addition to these harmful effects, monkey studies have shown that 4 year old monkeys experience learning and performance decrements when exposed to 7.5 µg/kg/day PCBs from birth to 20 weeks. These studies showed that young monkeys exposed during early life were impaired in their ability to organize behavior temporally, and monkeys were impaired in their ability to learn from the consequences of previous actions. Stated another way, monkeys showed an inability to change an already established response strategy and were unable to prevent inappropriate responses (ATSDR 2000). According to the author, these impairments are consistent with features demonstrated by children with attention deficient hyperactivity disorder (Rice 2000). Therefore, children and especially preschool children, with their nervous systems still developing, may be a particularly susceptible group. These conclusions are supported by human studies that show small changes in serum PCB concentrations are associated with harmful effects to the neurological systems.

Children and adults who frequently eat mullet from the Altamaha Canal also have an increased risk of liver and thyroid cancers. Should 10,000 children eat mullet frequently for 18 years, 3 extra cases of cancer might be expected. Should 10,000 adults eat mullet frequently during their adult life, 10 extra cases of cancers might be expected.

The GDNR has issued a fish advisory for the lower Turtle River, which tidally influences the Altamaha Canal. The advisory is based in part on PCB levels in mullet, red drum, sea trout, and blue crab. For fish and shellfish taken from the Altamaha Canal, residents should follow GDNR's fish advisory for the lower Turtle River. According to GDRN's advisory, residents should restrict their consumption of mullet to one meal per month and their consumption of red drum, sea trout, and blue crab to one meal per week. See Table 46 for more information about the state's fish consumption recommendation for the lower Turtle River and Tables 43-45 for other parts of the Turtle River system.

Table 49. Average PCB levels in edible fish and shell fish tissue are provided for the Altamaha Canal as well as for various sections of the Turtle River system north of, adjacent to, and south of the LCP Chemicals Site. Data are not available for sea trout from the Turtle River System for 2011 so average mercury levels are reported from an FDA survey.					
Date and Location	***PCB concentrations in mg/kg-wet weight (ppm-ww)****				
	Red Drum	***Mullet***	***Sea Trout***	***Blue Crab***	***Shrimp***
2011 Altamaha Canal	0.02	0.25	0.08	0.015	0.015
2002 Upper Turtle and Buffalo Rivers (north of LCP)	0.25	1.4	NA	0.16	0.1
2002 Middle Turtle River, including Purvis and Gibson Creeks (adjacent to LCP)	0.14	2.6	NA	0.02	0.23
2002 Lower Turtle River south of the site, including South Brunswick and Brunswick River (south of LCP)	0.11	0.36	NA	0.1	0.1

*The only PCB detected in fish and shellfish was Aroclor 1268, the most predominant Aroclor at the LCP Chemicals Site.
NA = not available

V.I. Summary of Grids That Are a Health Concern

In summary, numerous grids have elevated levels of mercury, PCBs, lead, PAHs, or dioxins that are a public health concern if the site becomes residential in the future. Figure 45 shows 66 grids that have at least one contaminant that is a health concern if the site becomes residential in the future. Figure 46 shows the nine grids that are a public health concern if the site becomes commercial or industrial in the future. Stated another way, 33 acres are a health concern should the site become residential, and about 5 acres are a health concern should the site become commercial or industrial.

The previous discussions about PCBs, mercury, lead, PAHs, and dioxins provide the justifications for these conclusions. Some uncertainty exists in these conclusions. The reasons for this uncertainty are described previously in the PHA.

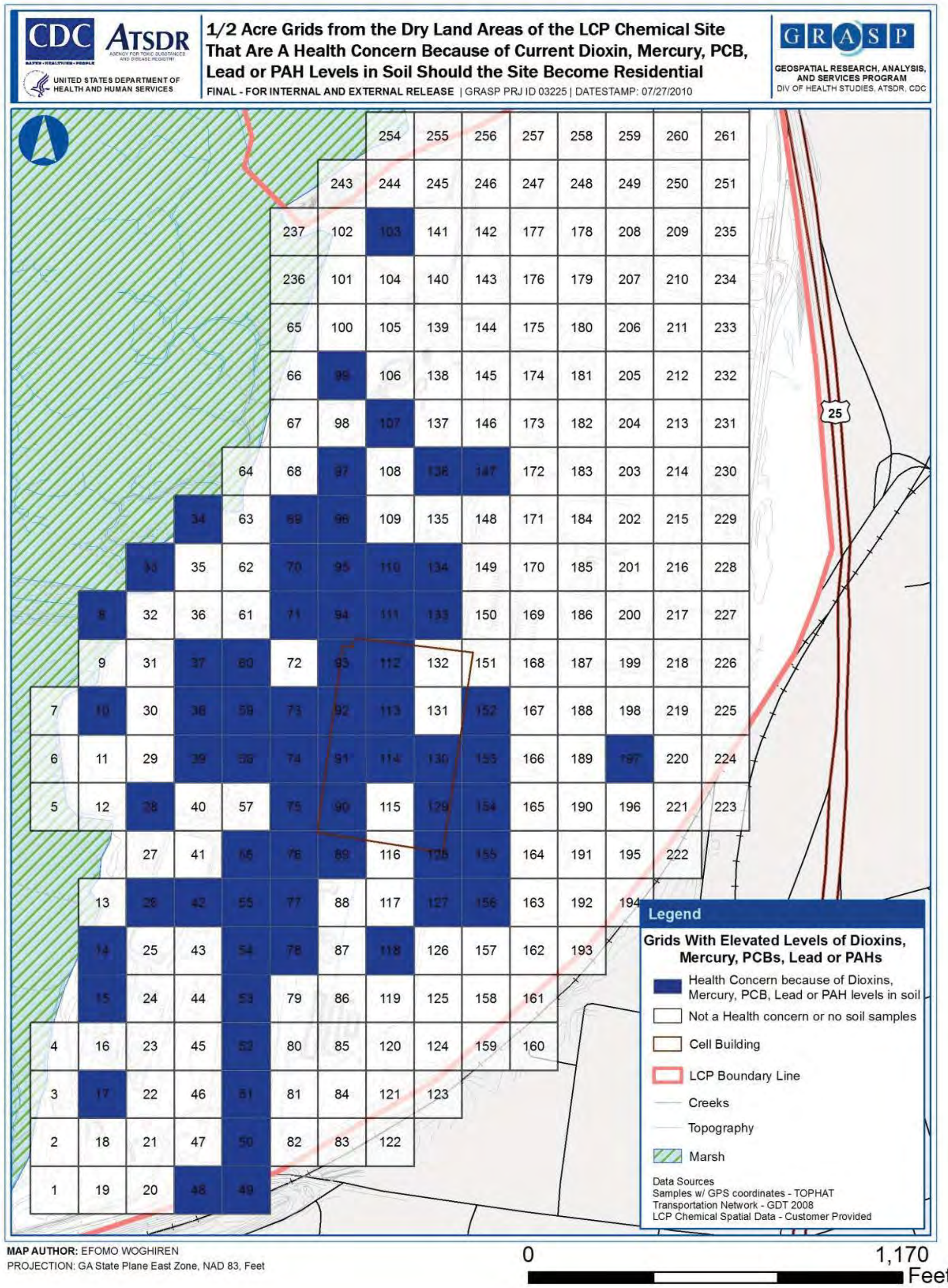

Figure 45. This figure shows the 65 grids that are a health concern if the site becomes residential in the future.

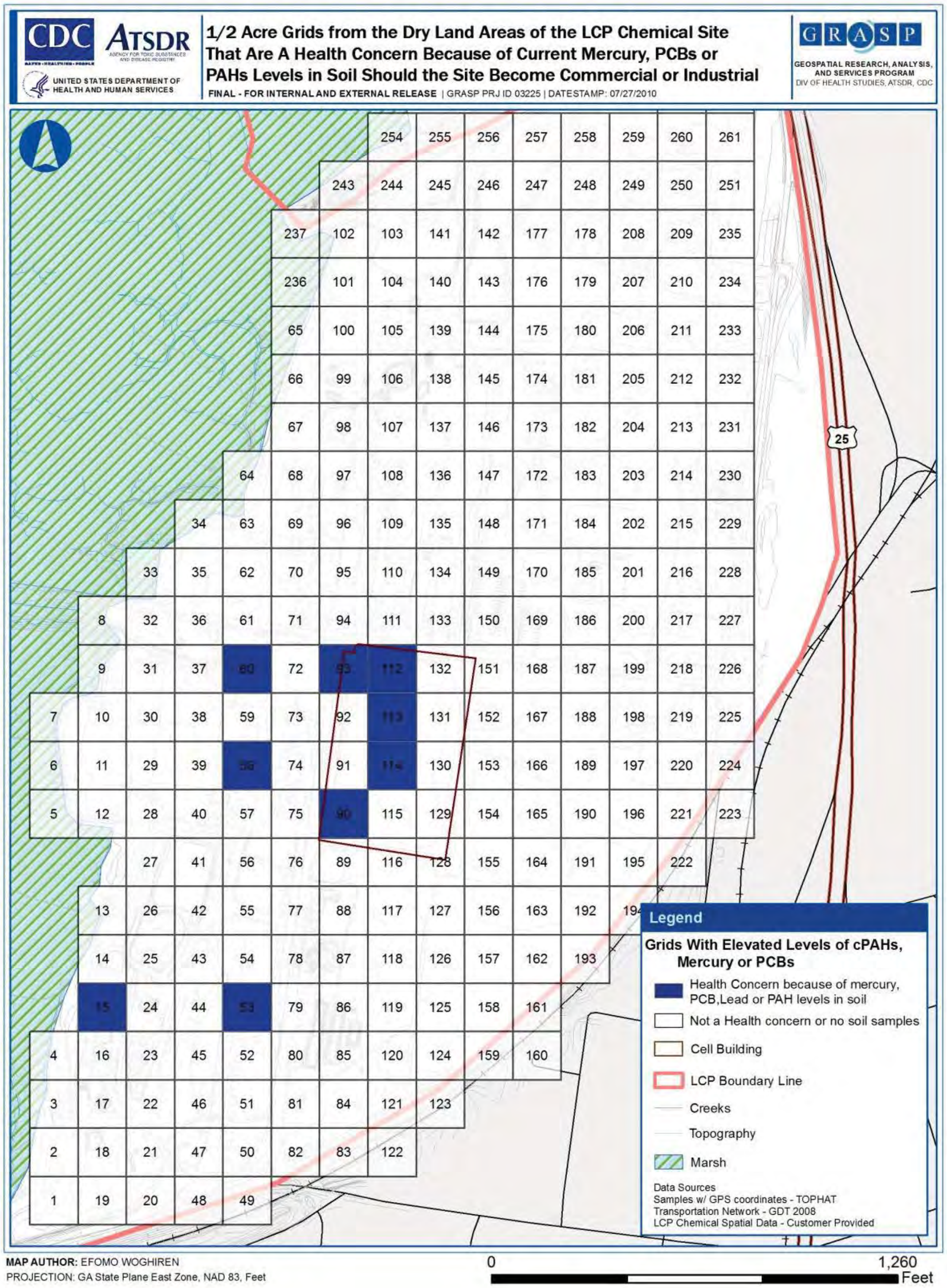

Figure 46. This figure shows nine grids that are a health concern if the site becomes commercial or industrial in the future.

VI. COMMUNITY HEALTH CONCERNS

When performing a public health assessment, ATSDR gathers health concerns from people living in the community. The health concerns that people express help direct the focus of the evaluation. For the LCP Chemicals Site, ATSDR gathered concerns from the community on several occasions dating from October 2004 until present. ATSDR received numerous health concerns from residents who live near the LCP Chemicals site or who worked for LCP Chemicals when it was operating. Below is a list of the health concerns expressed by community members:

1. Community Concern: Residents reported numerous health concerns that they thought might be related to living near the LCP Chemicals Site. Their health concerns fall into these general categories: respiratory, skin, muscular, metabolic, neurological, cardiovascular, and reproductive. A list of their specific health concerns follows:

chronic sinus infections	allergies	hay fever
eczema	arthritis	diabetes
high cholesterol	hives	fatigue
shortness of breath	hypertension	ear infection
poor circulation	sinus infection	hysterectomy
low birth weight	hearing problems	speech problems
glaucoma	low potassium	bones ache
rash	heart trouble	cataracts
stroke	brain tumor	liver disease
breathing problem	nose bleeds	stomach cancer
hardening of the arteries	lung cancer	fibroid tumors
bone deterioration	cancer	fertility problems
poor vision	birth defect	nausea
migraines	bronchitis	poor memory
iron deficiency	bruise easily	heart attack
skin conditions	hair loss	dizziness
balance problems	shortness of breath	heart murmur
visual problems	light headedness	agitation
joint pain	congestive heart failure	slow learning
heart racing	blackouts	confusion
forgetfulness	poor eyesight	prostate cancer
sores on arms and legs	ringing sound in ears	difficulty concentrating
breakout of bumps on skin	getting oxygen to the brain	
sensitive to temperature changes	long and short term memory loss	
difficulty with blood flow to the brain	sarcoidosis (immune disease)	

ATSDR Response: Many of the people with the health conditions or symptoms listed previously report that they lived in the Arco neighborhood for many years or they had family members that worked at the LCP Chemicals facility. Unfortunately, it is not possible to know if these health conditions or symptoms are related to the LCP Chemicals Site. Some residents report smelling chemicals that they believe were coming from the LCP Chemicals facility when it was operating; however, we could not confirm that the smell was coming from the facility because it happened so many years ago and because, to our knowledge, no air monitoring data are available in nearby neighborhoods.

2. Community Concern: Residents are concerned about contaminated water.

ATSDR Response: ATSDR is currently unsure if any private wells are impacted by site-related contaminants. During our site visit in July 2009, we noticed numerous private wells in a neighborhood immediately north of the LCP Chemicals Site on the following roadways: Manning Street, Deloach Street, Fader Lane, Roadway Street, Cedar Avenue, Robarts Road, and Lakeside Circle. We also noticed private wells in a neighborhood immediately south of the LCP Chemicals Site on the following roadways: Sycamore Street and Baines Bluff Road. Groundwater flow at the site is westward toward the marsh; therefore, it is unlikely that private wells north, south, and east of the site could be contaminated.

If you currently receive your household water from a municipal source (e.g., city water), then your water should be safe to drink.

3. Community Concern: Another resident is concerned about historical air contamination when the LCP Chemical Plant was operating.

ATSDR Response: ATSDR believes that it is likely that past operations at the site created conditions where contaminants were dispersed in the air to nearby, off-site locations. A review of past soil sampling conducted in the Arco neighborhood suggests that mercury levels were elevated in some soil samples well above background levels. It seems reasonable to assume that mercury may have been deposited as a result of aerial releases from LCP operations when the facility was actively making chlorine.

However, we have no emissions data from the facility to review and no air samples in the Arco neighborhood during that time period. Therefore, it is not possible for us to state with certainty that aerial releases occurred in the past, or for us to quantify the exposures from these releases if they did occur. Therefore, ATSDR cannot reach a conclusion about whether historical air releases could have exposed nearby residents and caused adverse health effects.

4. Community Concern: Residents are concerned about soil contamination.

ATSDR Response: On-site soil contamination is addressed in this document. Off-site soil contamination, such as in the Arco neighborhood, has been addressed in previous evaluations done by this agency. A summary of those reports can be found in Section II.G above. Generally, off-site soils do not contain contamination levels high enough to result in adverse health effects.

5. Community Concern: Several residents are concerned about having eaten seafood (shrimp, fish, and crabs) from the Turtle River. Some residents report eating seafood for many decades (e.g., 1960s, 1970s, and 1980s). They report the following signs and symptoms:

Resident #1: This person has experienced hypertension, diabetes, dizziness, memory loss, balance problems, numbness around the fingers and toes, shortness of breath, heart murmur, sudden headaches, and visual problems.

Resident #2: This person is now experiencing light-headedness, headaches, agitation, diabetes, join pain, and vision problems.

Resident #3: This person is now experiencing memory loss, diabetes, high blood pressure, dizziness, loss of equilibrium, agitation, no feeling in lower extremities, pain around neck and shoulder, congestive heart failure, numbness in fingers, poor vision, heart racing, blackouts, confusion, and forgetfulness.

Resident #4: This person is experiencing diabetes, hypertension, lightheaded, dizziness, loss of equilibrium, stroke, heart attack, long and short-term memory loss, numbness in right side, and difficulty breathing.

ATSDR Response: It is not possible to know if the health conditions, signs, or symptoms described previously are the result of having eaten fish from the Turtle River or from the creeks closest to the LCP Chemicals site (i.e., Purvis and Gibson Creeks).

Residents who caught and ate fish and blue crab frequently from Purvis and Gibson Creeks and from the Turtle River were at greater risk of harmful effects from mercury and PCBs. Pregnant women and their unborn child as well as young children were at greatest risk of harmful effects. It is difficult to be precise because the amount of mercury and PCB intake from eating fish varies with the portion size, the type of fish eaten, and the location the fish came from. In general, pregnant women who ate several fish meals a month were at risk of having children with neurological effects from mercury. Children born to women and young children who ate fish and blue crab frequently from Purvis and Gibson Creeks and from the Turtle River might experience neurological effects involving problems with language, attention and memory, and to a lesser extent visual/spatial and motor functions.

Residents who ate several fish meals a month for several decades were also at greater risk of liver and thyroid cancers because of PCBs in fish and blue crabs. It is important to remember that someone who ate fish or blue crabs from the Purvis and Gibson Creeks or the Turtle River only a few times are not likely to experience harmful effects from mercury and PCBs. The risk of harmful effects is for those people who for several decades regularly ate several fish and blue crab meals a month from these areas.

The Georgia Department of Natural Resources has issued a fish advisory for the Buffalo, Turtle, and Brunswick Rivers and their tributary creeks. This fish advisory provides advice about the number of fish meals that are safe to eat from these rivers. An example of the fish advisory for Purvis and Gibson Creeks is shown below. The fish advisory for other areas along these rivers are provided elsewhere in this report and at the GDNR website: http://www.gaepd.org/Documents/fish_guide.html.

Turtle River System: ***Satilla River Basin***
Purvis and Gibson Creeks , (St. Simons Estuary)

Species	Site Tested	Recommendation	Chemical
Atlantic Croaker	Purvis & Gibson Creeks	Do Not Eat	PCBs
Southern Kingfish (whiting), Black Drum, Spot, Spotted Seatrout		1 meal/month	PCBs
Sheepshead		1 meal/month	PCBs, Mercury
Striped Mullet		1 meal/week	PCBs
Red Drum, Flounder		1 meal/week	PCBs, Mercury
Blue Crab		1 meal/week	Mercury
Shrimp		No Restrictions	
Clams, Mussels, Oysters	Not applicable	Do Not Eat	Shellfish Ban *
* Shellfish Ban: National Shellfish Sanitation Program. For information see Coastal Resources Division website: http://crd.dnr.state.ga.us			

6. Community Concern: Residents are concerned that the Altamaha canal remains contaminated.

ATSDR Response: Figure A12 (Appendix A) shows the Altamaha Canal as it exists today. This tidal canal begins just south of W. 9th Street and flows to the marsh at T Street. A portion of the Altamaha canal was also located on the LCP Chemical property when it was operating (Figure A13 in Appendix A). During EPA's cleanup activities, contamination was detected in the on-site portion of the Altamaha canal. These on-site portions of the canal have been excavated and filled. However, it is possible that contamination could have been transported to off-site portions of the canal while the LCP facility was operating and before the on-site portions were filled in. The tidal nature of Altamaha Canal most likely facilitated the off-site migration of contaminants from the LCP property along with surface water runoff during heavy rains.

This off-site transport of site-related contaminants is supported by the recent fish samples that were collected from the Arco Quarry Pond (ATSDR 2008). Fish samples from the pond showed elevated levels of mercury and Aroclor 1268. The presence of Aroclor 1268 in fish tissue from the Arco Quarry Pond is significant because Aroclor 1268 is the predominant Aroclor associated with LCP Chemical waste. The Arco Quarry Pond is located approximately 700 feet south of the southern boundary of the LCP Chemicals Site. During ATSDR's site visit in July 2009, the wooded area around the pond had been cleared and a fence erected to prevent access to pond and surrounding land. The Altamaha Canal currently ends at the Arco Quarry Pond, although it is unclear at this time if the canal and pond are connected.

ATSDR does not currently have sampling data from the existing portion of the Altamaha Canal to support or rule out the possibility of off-site migration of contamination in the canal. Therefore, we will recommend that sediment and fish sampling be conducted to address this data gap. On the basis of this recommendation, EPA collected fish and shellfish samples from the Altamaha Canal in 2011.

VII. CONCLUSIONS

ATSDR has evaluated environmental data from the LCP Chemicals Superfund Site in Brunswick, Georgia, which is located off of Ross Road. The focus of this public health assessment is the 133 acres of dry-land between Ross Road and the marsh. ATSDR divided the 133 acres into half-acre grids to determine whether a grid would be a concern for future residential or commercial development. Some of these grids were found to contain elevated soil levels of mercury, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), lead, and dioxins.

ATSDR's overall conclusion is that if the LCP Chemicals Site becomes residential, 66 half-acre grids have at least one chemical in soil that poses a health risk for children and adults. If the site becomes commercial or industrial, 9 half-acre grids have at least one chemical in soil that poses a health risk for workers. See Figures 45 and 46 for the location of these grids. Some uncertainty exists in this overall conclusion because uncertainty exists in the amount of chemical exposure that will occur after the site is developed and some dry-land areas were inadequately sampled.

ATSDR has more detailed conclusions about the LCP Chemicals Site that fall into two categories: (1) conclusions presented in the 2010 Public Health Assessment for the LCP Chemicals Site that was released for public comment, and (2) new conclusions based upon recent environmental data that was not available for the 2010 PHA.

VII.A. Conclusions from the 2010 Public Health Assessment for the LCP Chemicals Superfund Site

The basis for conclusions presented in the 2010 public health assessment for the LCP Chemicals Site comes from environmental samples collected by EPA predominantly in the 1990s, although a few samples were collected in the early 2000s.

1. Conclusions about PCBs in dry-land soils

   If certain dry-land areas of the LCP Chemicals Site become residential, polychlorinated biphenyls (PCBs) in soil in 41 half-acre grids on the site pose a health risk for children and adult. If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, PCBs in soil in six half-acre grids on the site pose a health risk for commercial and industrial workers.

   Children and adults who come in contact with high PCBs in soil might experience harmful effects to the immune, dermal, nervous, developmental, and reproductive systems. Specific health effects include:

   - Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
   - Mild damage to fingernails and toenails,
   - Inflamed oil-producing glands associated with the eyes
   - Gum recession,
   - Learning and performance problems,
   - Problems with attention and impulse control,
   - Fewer male births,
   - Lower birth weight,
   - Longer menstrual cycles in women,
   - An increase in cardiovascular disease in women,
   - An increase in deaths from Parkinson disease in women,
   - An increase in deaths from dementia in women, and
   - An increase in diabetes in women (ATSDR 2000).

   Children and especially preschool children, with their nervous systems still developing, may be a particularly susceptible group if they come in contact with high PCBs levels in soil in some areas.

   Commercial and industrial workers also are at risk of harmful effects if they have contact with soil in six half-acre grids of the site with the highest PCB levels. Their estimated exposure to PCBs could cause the same health effects as listed previously.

   Daily contact with PCBs in soil over many years poses a high cancer risk for children and adults should the site become residential. PCBs in soil pose a moderate cancer risk for workers if the site becomes commercial or industrial. Such exposure could put residents and workers at increased risk for several cancers, including cancers of the liver, thyroid, biliary tract, intestines and skin.

Some uncertainty exists when deciding if harmful effects might be expected because very little health information is available on the most common type of PCBs found in LCP soils. Therefore, ATSDR relied upon health information from other types of PCBs. Uncertainty also exists in estimating how much PCBs people will contact once the site is developed and from using results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site. In addition, some dry-land areas were insufficiently sampled.

Six half-acre grids on the site exceed the EPA's 1994 clean-up level for PCBs of 25 parts per million (ppm) while 41 grids have average PCB concentrations greater than 1 ppm. In the text of this report, see Table 4 for a list of grids that are a concern because of residual PCB contamination and see Figure 34 for their location.

2. Conclusions about mercury in dry-land soils

   If certain dry-land areas of the LCP Chemicals Site become residential, mercury in soil in 10 half-acre grids on the site poses a health risk for children and for the developing fetus if women are pregnant.

   If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, mercury in soil in four half-acre grids on the site poses a health risk for the developing fetus if a female worker is pregnant. One of these half-acre grids also poses a health risk for women who are not pregnant and for men.

   For women who live in the 10 half-acre grids on the site with high mercury concentrations in soil, the estimated intake of mercury from soil approaches or exceeds levels that cause harmful neurological effects to the fetus during pregnancy. Children born to these women might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions. The estimated exposure levels in preschool children who live in these areas also approach or exceed levels that could harm their health. They are at risk of the same neurological effects.

   Mercury in soil in four half-acre grids on the site also poses a risk for commercial and industrial workers if the site is developed. Pregnant workers who have contact with mercury in soil in these areas are at risk of exposing their developing fetus to mercury levels that might cause harmful effects after birth. Some children born to women exposed to these levels might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions.

   Male and female workers who have prolonged contact with soil from the one half-acre grid with the highest remaining mercury contamination also are at risk of harmful effects. Their estimated exposure level might result in damage to their neurological system, such as diminished sensitivity to pain, diminished touch, decreased fine motor performance, impaired vision, and impaired hearing.

Some uncertainty exists concerning the risk of harmful effects from mercury in soil. The chemical form of mercury in soil at the LCP Chemicals Site has not been well-established, although scientific studies from marsh sediment show that almost half the mercury is organic mercury. Therefore, ATSDR assumed that most of the mercury in soil at the LCP Chemicals Site was organic mercury. There's some uncertainty about whether the organic mercury bound to soil would cause harmful effects. In addition, uncertainty exists in the mercury concentrations in surface soil following development of the site and uncertainty exists from using the results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

Ten half-acre grids exceed EPA's 1994 clean-up level of 20 ppm mercury in soil. See Table 29 for a list of the 10 grids that are a concern because of residual mercury contamination and see Figure 37 for their location.

3. Conclusions about lead in dry-land soils

If certain dry-land areas of the LCP Chemicals Site become residential, lead in soil in 28 half-acre grids on the site poses a health risk for children.

If the site becomes residential, exposure to lead in soil at these 28 half-acre grids could increase children's blood lead levels and result in the following harmful effects:

- small decreases in IQ,
- an increase in attention deficit hyperactivity disorder,
- reduced attention span,
- lack of concentration,
- decreased fine muscle skills,
- withdrawn behavior,
- decreased height,
- small delays in puberty, and
- small changes in kidney function.

Some uncertainty exists in this conclusion because uncertainty exists in estimating children's exposure to lead in soil if the site becomes residential. Uncertainty also exists from using the results of soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

See Table 31 for a list of the 28 half-acre grids that are a concern because of residual lead contamination and see Figure 40 for their location.

4. Conclusions about PAHs in dry-land soils

   If certain dry-land areas of the LCP Chemicals Site become residential, polycyclic aromatic hydrocarbons (PAHs) in soil in six half-acre grids on the site pose a health risk for children and adults. If certain dry-land areas of the LCP Chemicals Site become commercial or industrial, PAHs in soil in two half-acre grids on the site pose a health risk for workers.

   Daily contact with PAHs in residential soil over many years poses a moderate risk of certain cancers for children and adults. Similarly, workers also have a moderate risk of certain cancers should some areas become commercial or industrial. Such exposure could put residents and workers at increased risk for lung and skin cancers.

   Some uncertainty exists in these conclusions because uncertainty exists in estimating how much PAHs people will contact once the site is developed. Uncertainty also exists from using the results from soil samples that were collected 15 years ago. These soil samples may not represent current or future conditions at the site.

   See Table 35 for the list of half-acre grids that are a concern because of residual PAH contamination and see Figure 41 for their location.

5. If certain dry-land areas of the LCP site become residential, exposure to a mixture of PCBs, methylmercury, or lead in soil could harm the health of children.

   If the site becomes residential, exposure to a mixture of PCBs, mercury, or lead in soil could impair learning and lead to an inability to withhold or delay inappropriate responses. These impairments are a measure of attention and impulse control.

   Three grids have elevated levels of PCBs, lead, and mercury. Eight grids have elevated levels of PCB and lead; and, five grids have elevated levels of PCBs and mercury. Should these grids be developed for residential purposes, children could be at risk for problems with attention and impulse control. See Figure 42 for the location of these grids.

6. If certain dry-land areas of the LCP Chemicals Site become residential, contact with soil containing a mixture of PCBs, mercury, and lead (or a combination of these) could harm the health of children.

   Studies have shown that children exposed to low levels of PCBs, mercury, and lead showed impaired learning of a performance task, resulting in problems with attention and impulse control.

   Three grids have elevated levels of PCBs, lead, and mercury; eight grids have elevated levels of PCB and lead; and, five grids have elevated levels of PCBs and mercury. See Figure 42 for the location of these grids.

VII.B. New Conclusions Based Upon Recent Environmental Data

The basis for these conclusions comes from environmental samples collected by EPA after 2010. Many of these samples were collected in response to recommendations from ATSDR in the December 2010 public release version of this report.

1. Conclusions about Dioxins in the Dry-land Area

   In 2011, EPA collected soil samples from eight, dry-land areas and measured dioxin levels. One 30 half-acre area contained dioxins in soil that is a public health concern for children and adults should this area become residential.

   Daily contact with dioxins in soil in this one area over many years poses a high risk of cancer for children and adults. Human studies have shown that dioxin can cause liver cancer and might be associated with cancers of the lung, colon, prostrate, breast, blood, and lymphatic system. Rodent studies have confirmed that dioxin can cause cancer at multiple sites, including the liver, lung, mouth, and thyroid.

   In addition, preschool male children who have daily contact with these soils could be at risk of reproductive effects once they reach adulthood. As adults, they might experience problems with (1) decreased number of sperm, (2) decreased number of motile sperm, and (3) fewer male offspring

   The location of this 30 half-acre area contaminated with dioxin is shown in Figure 43 and is labeled as sampling area 8.

2. Conclusions about the Former Theater Area

   In 2010, EPA collected soil samples from the former theater area in the northeast section of the site. Glynn County plans to build a detention center in this area so ATSDR evaluated the risk for adult workers and inmates who might come in contact with chemicals in soil. Mercury, lead, and PCBs in soil from the former drive-in theater area are not a health concern.

   The mercury and lead levels in soil in the former theater area were either below ATSDR's screening levels or the levels were at or near background levels in soils. Therefore, harmful effects from mercury and lead in soil are not likely.

   The exposure of prison inmates and adult workers to PCBs in soil would be at levels far below ATSDR's health guideline for PCBs. Therefore, PCBs in soil are not likely to cause harmful, non-cancerous effects. The risk of cancer from daily exposure to PCBs in soil is insignificant.

3. Conclusions about the On-Site Pond

   In 2010, EPA collected surface water and sediment samples from the on-site pond in the northwest corner of the dry-land area. The levels of PCBs, mercury, PAHs, and lead in surface water and sediment from the on-site pond are not a health concern.

   Levels of PCBs, mercury, PAHs and lead in the on-site pond were either below ATSDR's comparison values or at background levels. In addition, the pond does not serve as a source of drinking water nor does the pond support fish.

4. Conclusions about Sampling Sufficiency for the Dry-land Area

   Some dry-land areas do not have adequate sampling data; therefore, it is difficult to draw conclusions regarding potential health impacts from soils in these areas. Most of the insufficiently sampled areas are in the southeastern portion of the site (including the cell building area) and in the western dry-land area closest to the marsh. For other areas that have been sufficiently sampled, we are able to draw conclusions about potential health impacts.

   One reason for the limited sampling in some areas is that EPA decided that some environmental data were unusable because of data quality issues. In addition, some areas were not sampled because LCP Chemicals did not perform industrial activities on certain portions of the site. However, numerous industries occupied the site before LCP's chlor-alkali facility, and those industries could have disposed of waste throughout the property.

   Approximately half of the grids are considered sufficiently sampled for making a health conclusion for the chemicals PCBs, mercury, and lead. That means that half of the grids require additional sampling in order to be sure that those areas are not contaminated.

   See Figures 22 through 25 for the dry-land areas considered to have adequate sampling data.

5. Conclusions about Sediment from the Altamaha Canal South of the LCP Chemicals Site

   In 2011, EPA collected sediment samples from a portion of the Altamaha Canal that exists south of the LCP Site. ATSDR evaluated the risk of harmful effects from exposure to PCBs, mercury, PAHs, and dioxins in sediment along the Altamaha Canal. Adults and children who visit or play along the canal would not be exposed to contaminants in sediment at levels that would cause harmful, non-cancerous effects. It is unlikely that contact with these chemicals in sediment would cause cancer.

These chemicals are not a health concern in Altamaha Canal sediment because:

- The concentration of lead in sediment from the canal is at or near background lead levels in soils and is unlikely to cause harmful health effects from direct contact,
- The concentration of mercury is below ATSDR's comparison value; therefore, mercury in sediment is unlikely to cause harmful health effects from direct contact,
- The estimated exposure to dioxins and PCBs for adults and children who visit or play along the canal is well below ATSDR's and EPA's health guidelines. Therefore, harmful non-cancerous effects are not likely. The estimated exposure to PCBs, PAHs, and dioxins for adults and children who visit or play along the canal results in insignificant cancer risks.

6. Conclusions about Mercury in Fish and Shellfish from the Altamaha Canal South of the LCP Chemicals Site

   In 2011, EPA collected fish and shellfish samples from the canal. ATSDR estimated exposure to mercury from eating various fish and shellfish from the Altamaha Canal and reached the following conclusions about adults and children with typical and high fish consumption:

- Mercury levels in mullet and shrimp from the Altamaha Canal are not a health concern.
- Mercury levels in blue crab, red drum, and sea trout are not a health concern for typical fish consumers but are a health concern for high fish consumers.

Depending upon age and race, high fish consumers eat about 2 to 7 ounces of fish and shellfish daily. Typical fish consumers eat about a half to 2 ounces of fish daily. These daily fish consumption rates do not necessarily mean that people eat fish every day. Their fish consumption averages out to the rates previously described. For example, someone with a daily fish consumption rate of 2 ounces might eat one 14 ounce fish meal a week or two 7 ounces fish meals a week. This frequency and amount of fish consumption averages out to two ounces of fish eaten daily.

- Typical and high fish consumers of mullet and shrimp from the Altamaha Canal have estimated exposures to mercury that are well below levels that cause harmful effects. Typical fish consumers of blue crab, red drum, and sea trout from the Altamaha Canal have estimated exposures to mercury that are well below levels that cause harmful effects.
- High fish consumers of blue crab, red drum, and sea trout from the Altamaha Canal have estimated exposures to mercury that approach levels that can cause harmful effects in young children and in children born to pregnant women who are high consumers. These children might experience neurological effects involving language, attention and memory, and to a lesser extent visual/spatial and motor functions.

Some uncertainty exists in the conclusions for sea trout and red drum because only one fish of each species was collected from the Altamaha Canal.

7. Conclusions about PCBs in Fish and Shellfish from the Altamaha Canal South of the LCP Chemicals Site

   Fish and shellfish from the Altamaha Canal were also found to contain PCBs. ATSDR estimated exposure to PCBs from eating various fish and shellfish from the Altamaha Canal and reached the following conclusions about adults and children with typical and high fish consumption:

   - PCB levels in red drum, blue crab, and shrimp are not a health concern for harmful, non-cancerous effects.
   - PCB levels in sea trout are not a health concern for typical fish consumers, but are a health concern for high fish consumers.
   - PCB levels in mullet are a health concern for typical and high fish consumers.

   The basis for these decisions is:

   - Typical and high fish consumers of red drum, blue crab, and shrimp have estimated exposures to PCBs that are well below levels that can cause harmful, non-cancerous effects. Typical fish consumers of sea trout have estimated exposures to PCBs are well below levels that can cause harmful, non-cancerous effects.
   - High fish consumers of sea trout and typical and high fish consumers of mullet have estimated exposure to PCBs that approach levels that can cause harmful, non-cancerous effects.

   High consumers of sea trout and typical and high consumers of mullet might experience the following harmful effects to the immune, dermal, nervous, developmental, and reproductive systems. Specific health effects include:

   - Small changes in immune function as evidenced by a weakened response to an antigenic challenge,
   - Mild damage to fingernails and toenails,
   - Inflamed oil-producing glands associated with the eyes
   - Gum recession,
   - Learning and performance problems,
   - Problems with attention and impulse control,
   - Fewer male births,
   - Lower birth weight,
   - Longer menstrual cycles in women,
   - An increase in cardiovascular disease in women,
   - An increase in deaths from Parkinson disease in women,
   - An increase in deaths from dementia in women, and
   - An increase in diabetes in women (ATSDR 2000).

Children and especially preschool children, with their nervous systems still developing, may be a particularly susceptible group.

Children and adults who frequently eat mullet from the Altamaha Canal for many years also have a high increased risk for several cancers, including cancers of the liver, thyroid, biliary tract, intestines and skin.

The results of the fish and shellfish sampling from the Altamaha Canal support the current fish advisory for the Turtle River system issued by the Georgia Department of Natural Resources (GDNR). The Altamaha Canal is tidally connected to the lower Turtle River through several waterways and GDNR has fish and shellfish consumption advice specifically for the lower Turtle River. See Table 46 for more information about the state's fish and shellfish consumption recommendations for the lower Turtle River.

VIII. RECOMMENDATIONS

VIII.A. Recommendations for the 2013 Public Health Assessment for the LCP Chemicals Site

ATSR recommends

1. Restricting some LCP Chemicals Site areas from residential development unless further steps are taken to prevent contact with PCB, mercury, lead, PAH, and dioxin contamination that remains in soil on the property.

2. Restricting some LCP Chemicals Site areas from commercial or industrial use unless further steps are taken to prevent contact with PCB, mercury, and PAH contamination that remains in soil on the property.

3. Additional soil sampling in and around the former cell building's footprint if future plans include development of this area because of residual soil contamination.

4. Additional sampling in areas where sampling data are limited. In general, the western portion of the site has been sampled more than the eastern portion. Particular attention should be given to the former cell building area should the land use change and to future enclosed structures built above the caustic brine pool area.

5. Continued monitoring of fish and shellfish in the Turtle River and in the marsh near the LCP Chemicals Site. The Georgia DNR continues to monitor seafood in the area and to maintain the fishing advisory for the Turtle River System.

6. Continuation of the GDNR's fish advisory for the Turtle River System. The major components of this advisory are provided in Tables 43-46 of this health assessment.

GDNR’s recommendations for the lower Turtle River (see Table 46) apply for fish obtained from the Altamaha Canal.

The 2013 GDNR fish advisories for rivers, lakes, and estuaries in Georgia, including the Turtle River system, can be found at this website: http://www.gaepd.org/Documents/fish_guide.html. To view their brochure, click on “Guidelines for Eating Fish from Georgia’s Waters, 2013”.

In addition, GDNR has a brochure, ‘A woman’s guide for eating fish and seafood from coastal Georgia’. This brochure is available at http://health.state.ga.us/pdfs/environmental/chemhazard/fish%20consumption/wfcg_coastal.pdf

VIII.B. Recommendations for the 2010 Public Health Assessment for the LCP Chemicals Site

ATSDR made these recommendations in the 2010 Public Health Assessment for the LCP Chemicals Site when the assessment was released for public comment.

ATSDR recommended

1. Collecting sediment and fish samples from the existing portion of the Altamaha Canal that flows south of the LCP Chemicals Site to determine whether mercury and PCBs have migrated to and contaminated portions of the canal. In response to this recommendation, EPA collected sediment and fish samples in 2011 from the Altamaha Canal.

2. Collecting sediment, water, and fish samples from the on-site pond to determine whether site-related contaminants are present. In response to this recommendation, EPA collected sediment samples in 2010 from the on-site pond. Fish samples could not be collected from the on-site pond because the pond does not support fish.

3. Collecting soil samples from the on-site theater area. In response to this recommendation, EPA collected soil samples from the theater area in 2010.

4. Continued monitoring of fish and shellfish in the Turtle River and in the marsh near the LCP Chemicals Site. The Georgia DNR continues to monitor seafood in the area and to maintain the fishing advisory for the Turtle River System.

5. Developing health education and community involvement activities to ensure that the findings of this public health assessment are presented to the community, which includes residents who live in the area, elected government officials, and ATSDR’s government partners. In September 2010, ATSDR met with elected officials and the agency’s government partners and held public meetings to educate and involve the community.

IX. PUBLIC HEALTH ACTION PLAN

1. As part of its health education and community involvement activities at the LCP Chemicals Site, ATSDR met with elected officials and held public meetings in September 2010 as part of the public release of this health assessment. These meetings informed the public and government agencies about the risk from future development at the LCP Chemicals Site in Brunswick, Georgia. As part of these meetings, we also answered questions from elected officials and from concerned residents.

2. During the development of the public health assessment, ATSDR met with US EPA, Honeywell (the principle responsible party), and Glynn Environmental Coalition (a local environmental group) to inform them of our progress and initial findings. One outcome of these meetings was that EPA and Honeywell collected soil, sediment, and seafood samples that are now part of the final release of this public health assessment.

3. ATSDR will inform news outlets, elected officials, and the Glynn Environmental Coalition of the findings in this final release of the LCP Chemicals Public Health Assessment.

4. ATSDR will correspond with staff members from the U.S. Environmental Protection Agency, Region IV to inform officials about our findings and recommendations in this public health assessment.

X. PREPARERS OF REPORT

David Mellard, Ph.D.
Toxicologist
Division of Community Health Investigations
ATSDR, Atlanta

Teresa Foster, M.P.H.
Environmental Health Scientist
Division of Community Health Investigations
ATSDR, Atlanta

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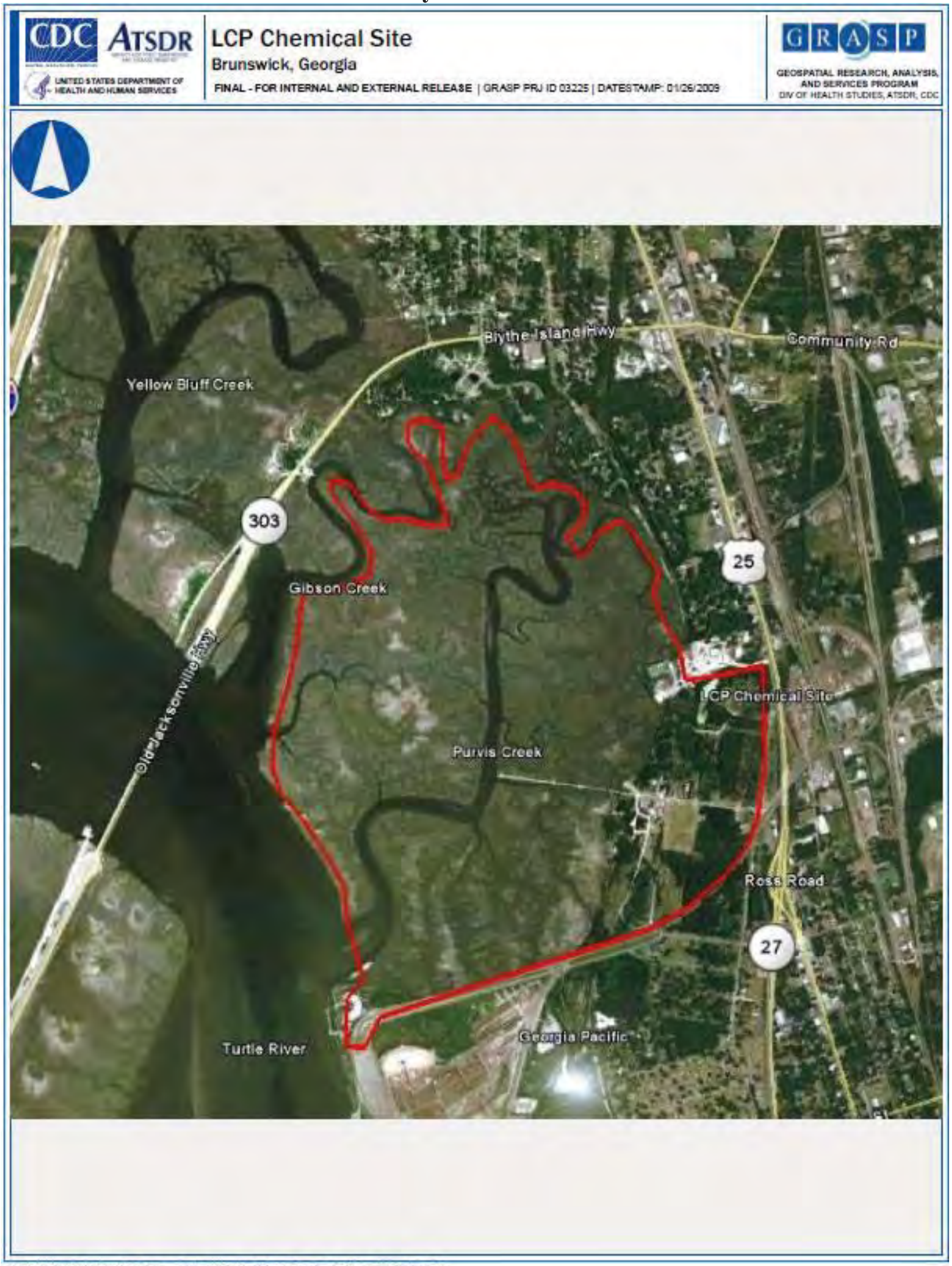
APPENDIX A

Site Maps

Figure A1. LCP Chemicals Site Boundary Map Showing Marsh, Purvis Creek, and Dry-land Area



MAP AUTHOR: Efomo Woghiren PROJECTION: GA State Plane East Zone, NAD 83, Feet

Figure A2. Site Map Showing Current Onsite Structures on Dry-land Area with Marsh in Background (March 2004)

Figure A3. Site Map Showing Onsite Pond and Theater –Current View 2010

Figure A4. Site Map of Dry-land Area Showing Location of Various Activities and Buildings When LCP Was Operational

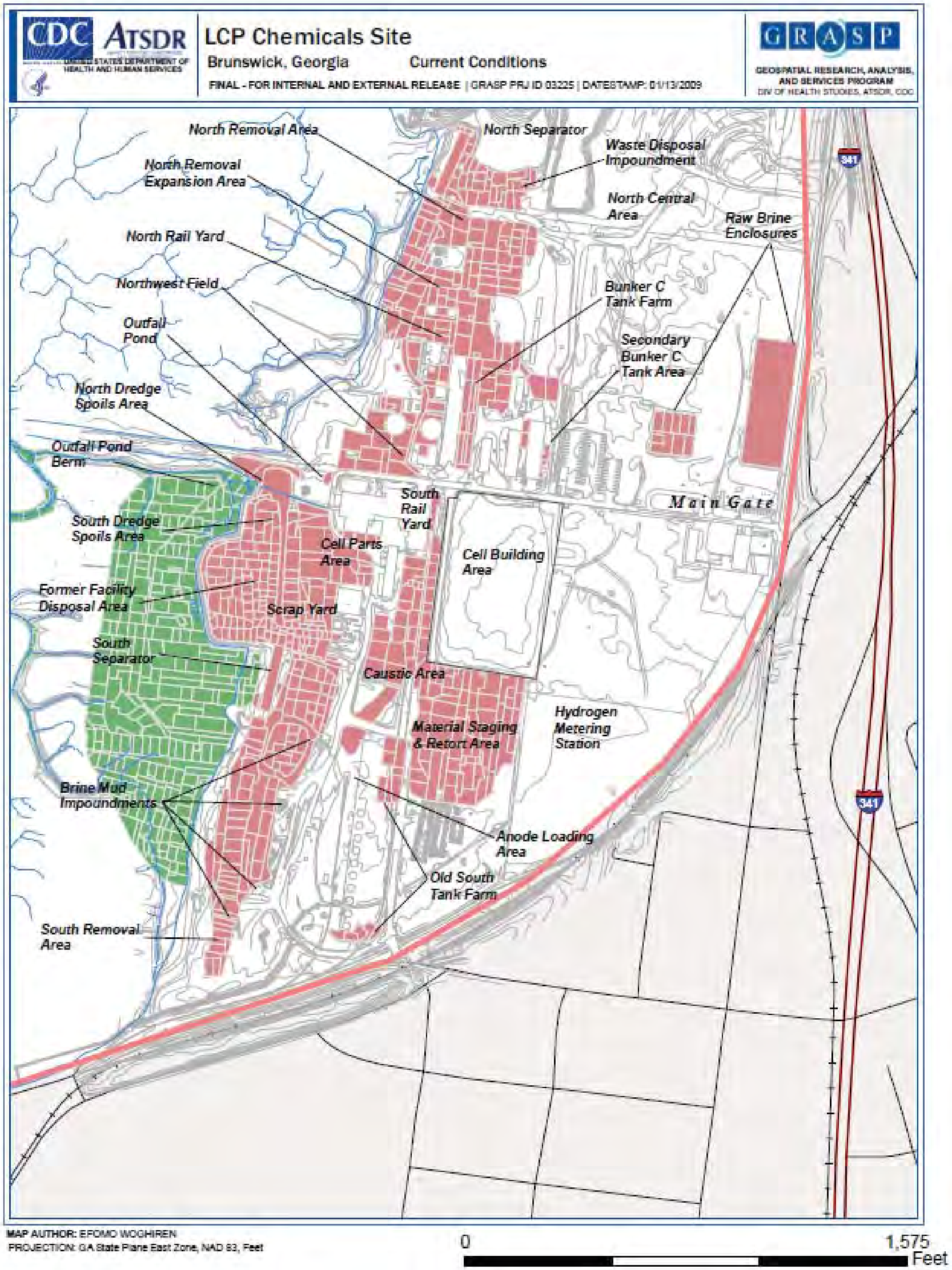
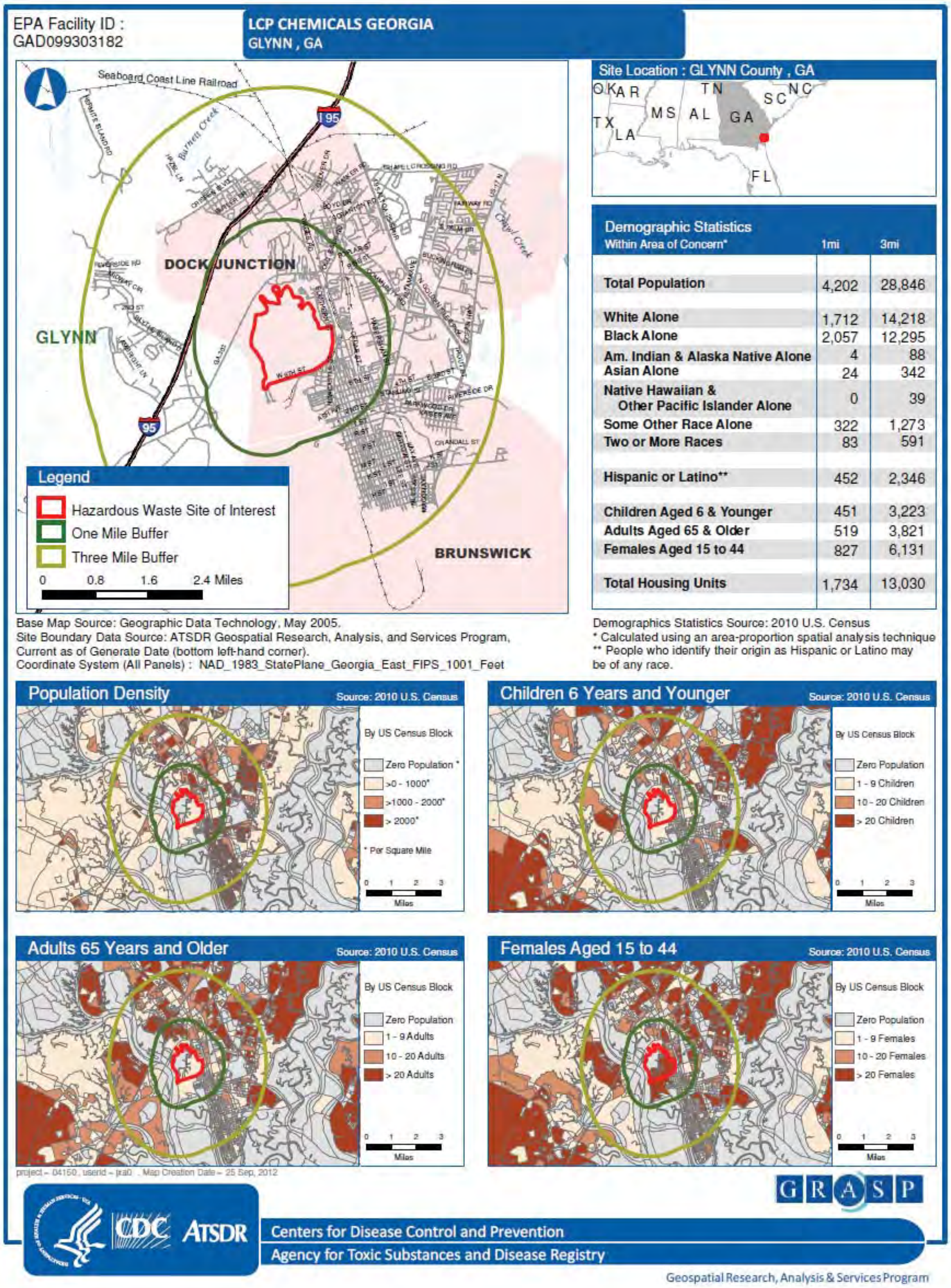


Figure A5. LCP Chemical and Surrounding Area 2010 Demographic Map



Demographic Statistics Within Area of Concern*	1mi	3mi
Total Population	4,202	28,846
White Alone	1,712	14,218
Black Alone	2,057	12,295
Am. Indian & Alaska Native Alone	4	88
Asian Alone	24	342
Native Hawaiian & Other Pacific Islander Alone	0	39
Some Other Race Alone	322	1,273
Two or More Races	83	591
Hispanic or Latino**	452	2,346
Children Aged 6 & Younger	451	3,223
Adults Aged 65 & Older	519	3,821
Females Aged 15 to 44	827	6,131
Total Housing Units	1,734	13,030

Figure A6. Historical Photo Showing Off-site Tank Farms

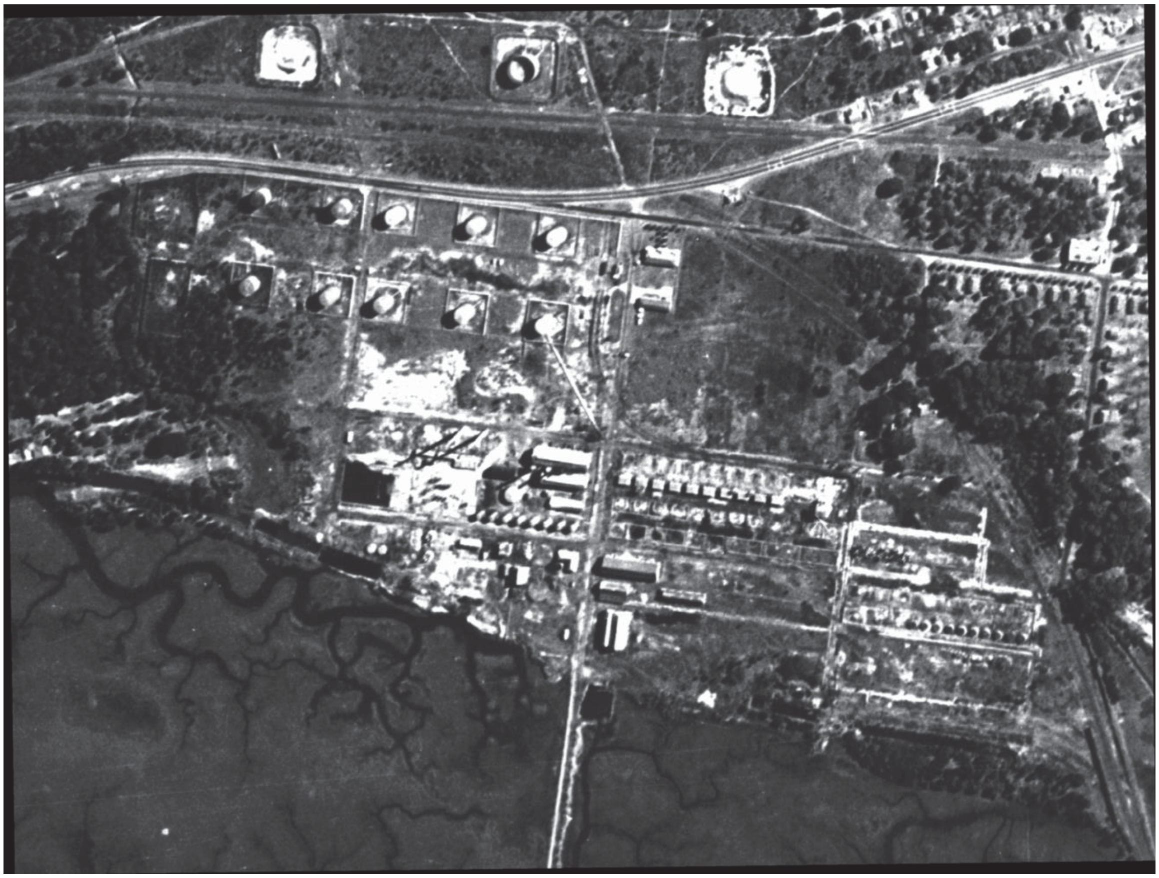


Figure A7. Off-Site Former Tank Farm Area
Mercury Sampling Locations and Concentrations

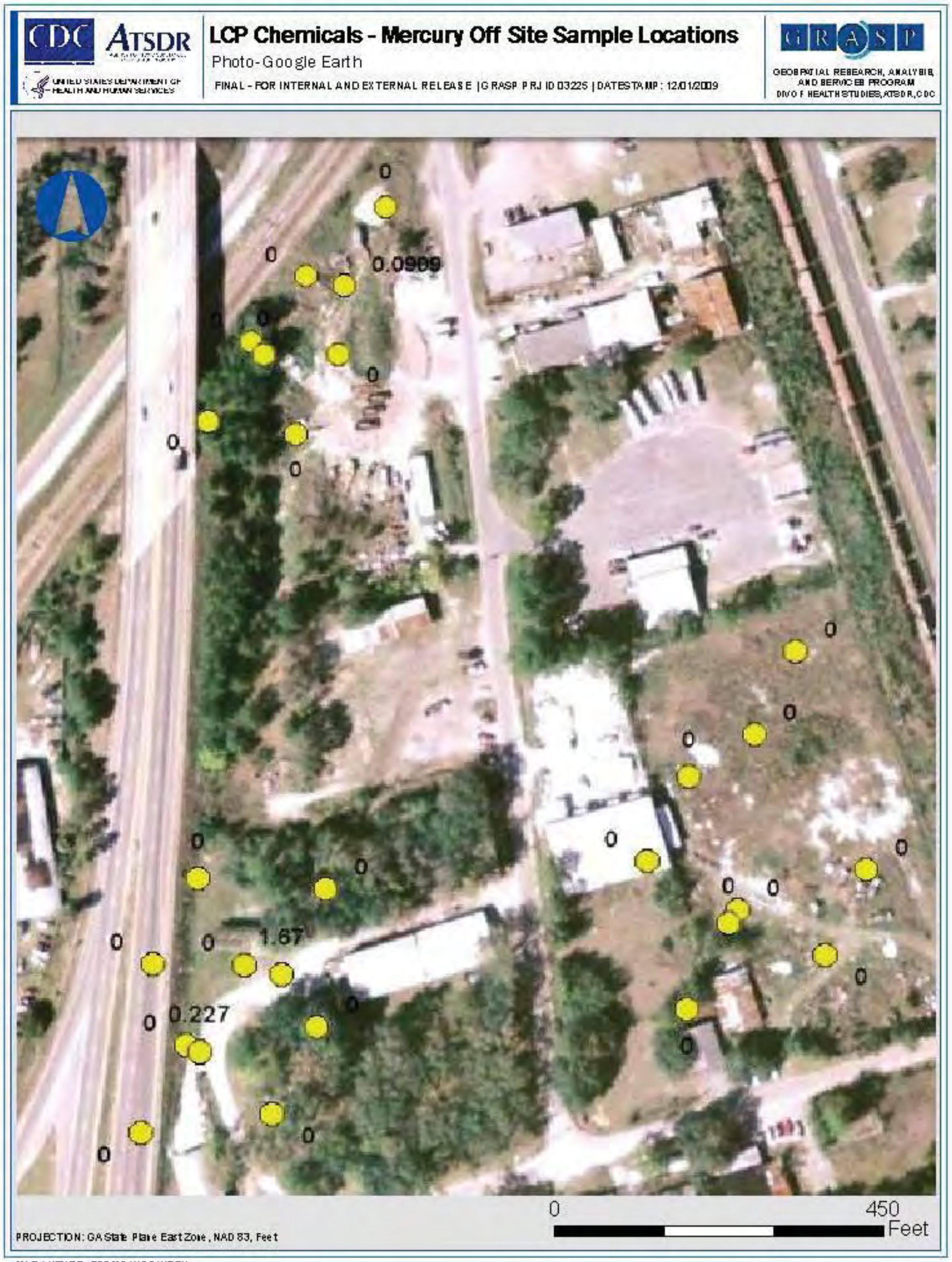


Figure A8. Off-Site Former Tank Farm Area – Historical Photo Underlay Mercury Sampling Locations and Concentrations

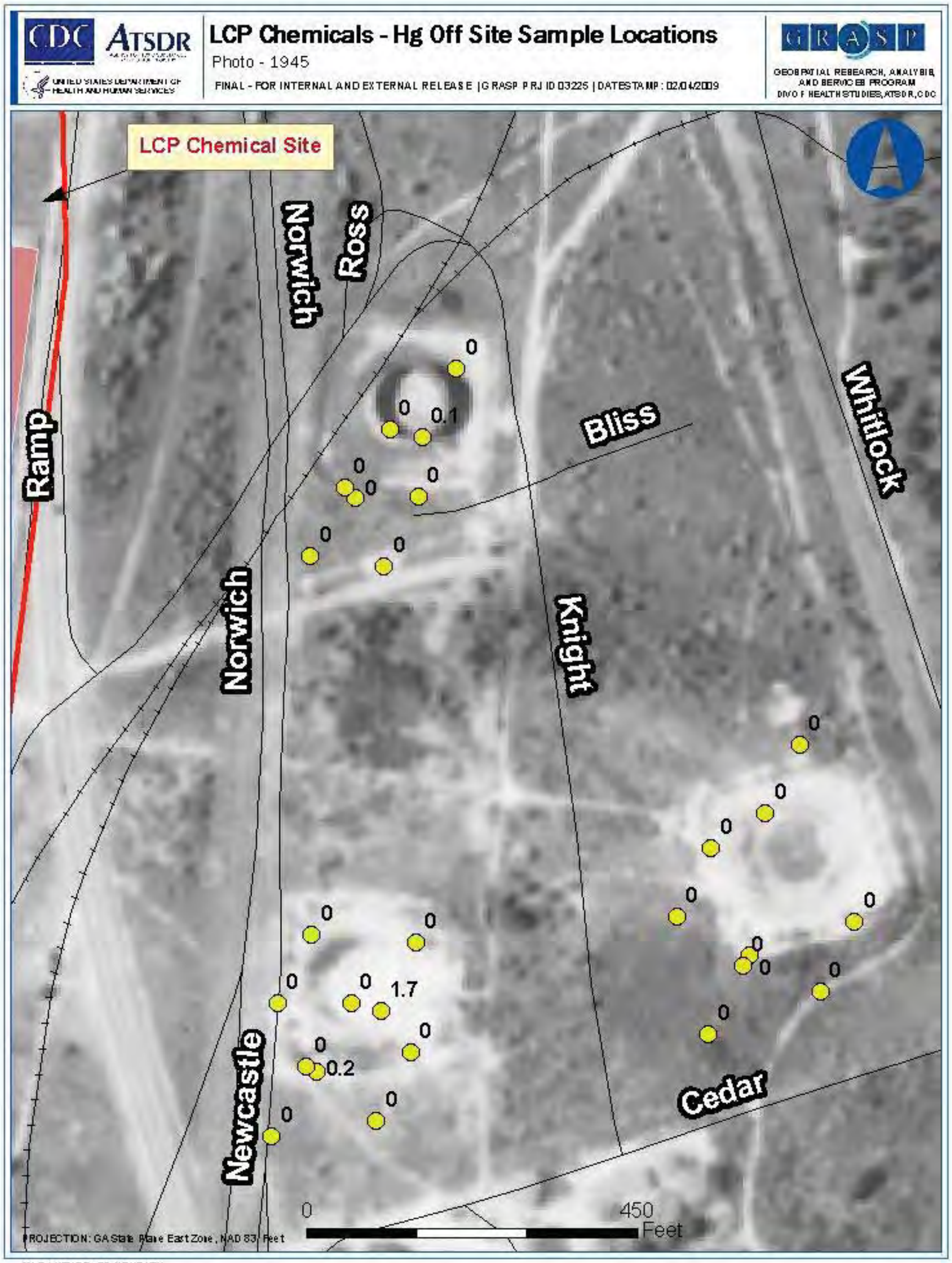


Figure A9. Off-Site PCB Sampling Locations

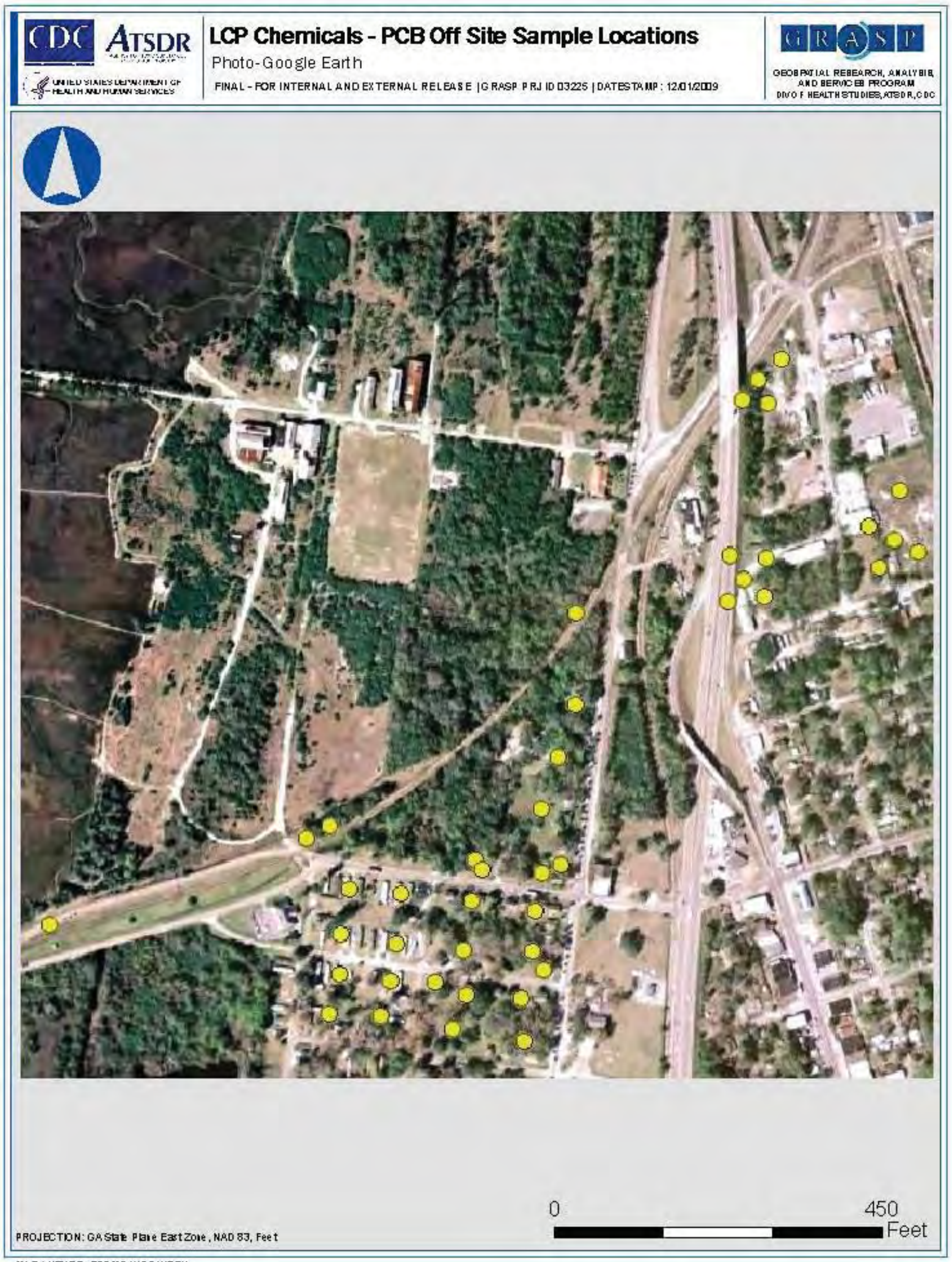


Figure A10. Former Tank Farm Areas PCB Sampling Locations and Concentrations

Figure A11. Former Tank Farm Areas
Lead Sampling Locations and Concentrations

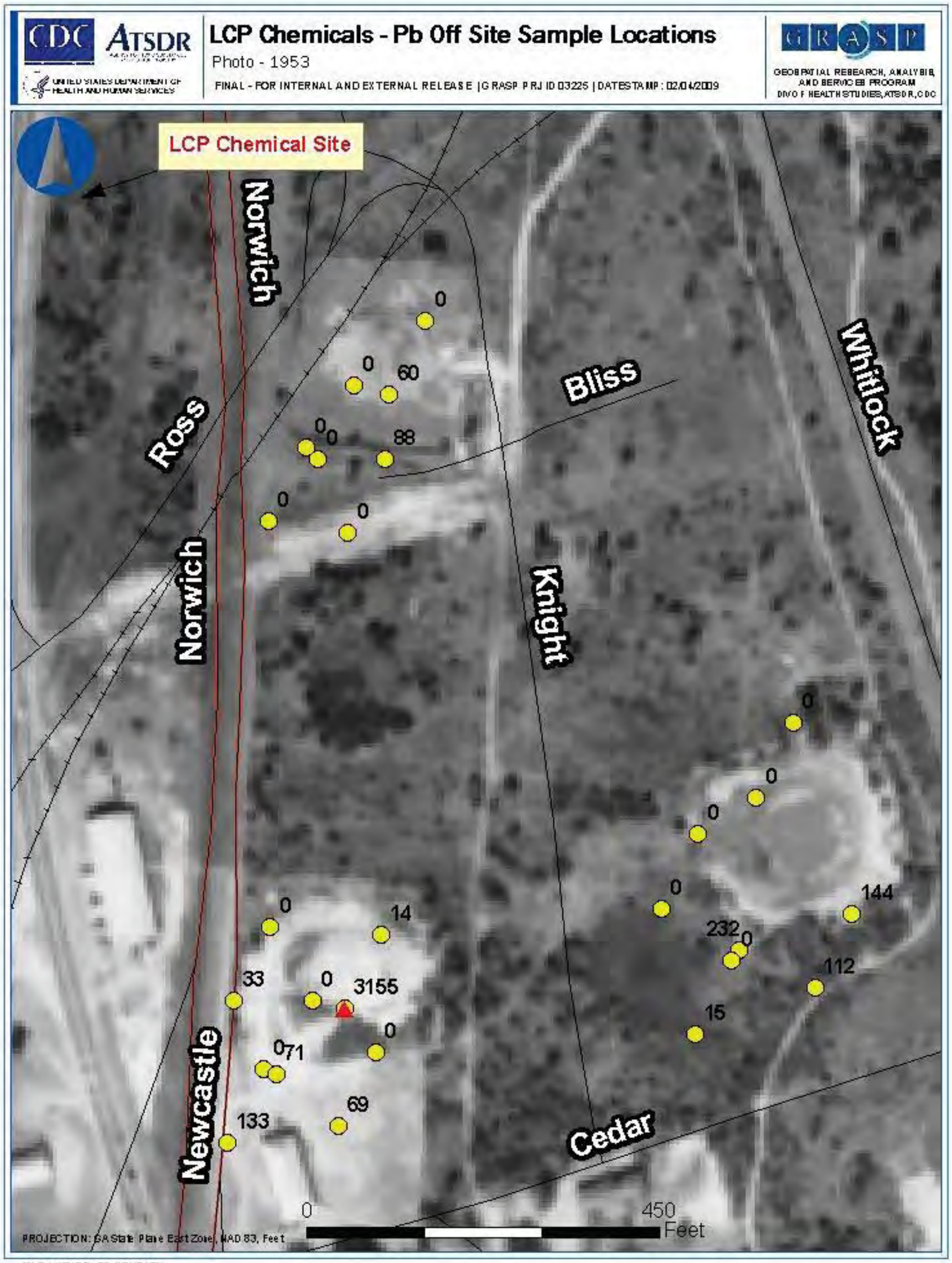


Figure A12. The Altamaha Canal 2010

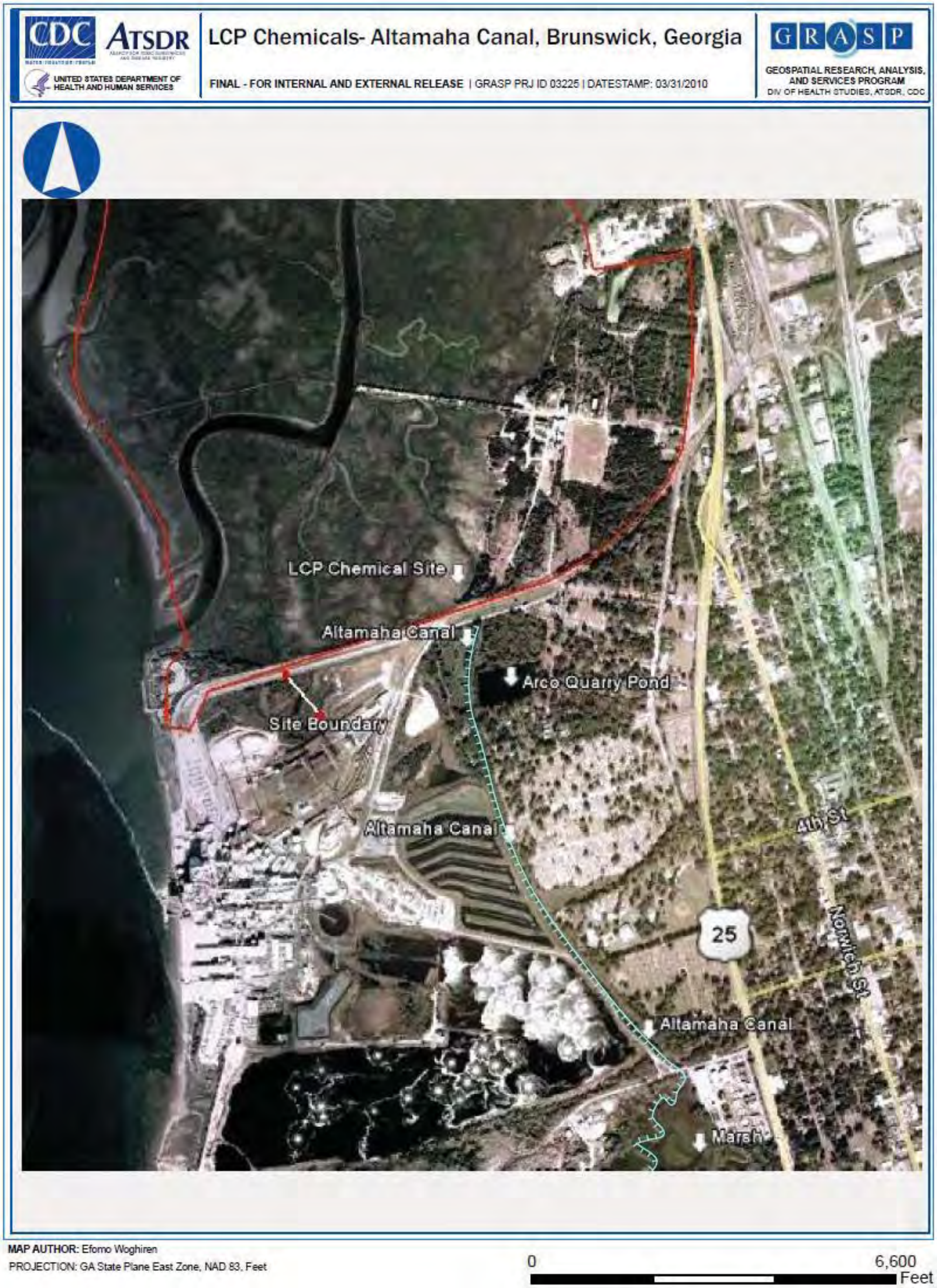


Figure A13. Altamaha Canal (1945) Showing Historical On-site Location

APPENDIX B

Parameters Used to Estimate Chemical Dose in Various Age Groups
and
Summary of Human and Animal Studies Demonstrating the Harmful Effects of PCBs at Low Levels

Table B1. Parameters used to estimate chemical dose in various age groups		
Parameter	***Quantity***	***unit***
Body weight--preschool children 1 yr	10	kg
Body weight--preschool children 3 yr	16	kg
Body weight--elementary school children	35	kg
Body weight--teenagers	55	kg
Body weight--pica children	10	kg
Body weight--adults men	70	kg
Body weight--adult women	60	kg
Soil intake--preschool children	200	mg/day
Soil intake--elementary school children	100	mg/day
Soil intake--teenagers	100	mg/day
Soil intake--pica children	5000	mg/day
Soil intake--adults	100	mg/day
Soil intake-- outdoor commercial workers	100	mg/day
Soil intake--excavation workers	330	mg/day
Exposure factor, residents	1	---
Exposure factor, workers	0.687	--
Exposure factor, excavation workers	0.714	--
Exposure factor for pica behavior (3 days a week)	0.429	--

Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.						
Target	***Study duration***	***Effect Level***	***System***	***Harmful Effects***	***Chemical Form***	***Reference***
Human	Follow-up at 25 years	>5.1 ppb serum PCB (whole weight, not standardized for lipids)	Immunological (endocrine disruptors)	2-fold increased incidence of adult-onset diabetes in women (but not men) with higher serum PCB levels compared to non-detect group. Serum PCBs ranged 5 ppb to 10 ppb.	Not specified	Vasiliu 2006
Human	Prospective cohort study (5 year follow-up)	Serum PCB whole weight (not standardized for lipids) Mean = 5.4 ppb Median = 4.7 ppb 10^{th} = 3.1 ppb 90^{th} = 8.7 ppb	Reproductive	33% reduction in male births for women at the 90^{th} % compared to women at the 10^{th} % Each 1 ppb increase in serum PCB associated with 7% decrease in # male births. Maternal exposure to PCBs may be detrimental to the success of male sperm or to the survival of male embryos. Findings could be due to contaminants, metabolites or PCBs themselves.	Total PCBs and PCB congeners #105 #110 #117 #137 #138 #153 #170 #187	Hertz-Picciotto 2008
Human	Prospective cohort study (recruitment 1959-1965)	Serum PCB whole weight <1 to > 5 ppb Effect observed in 3.75-	Reproductive	Increasing serum PCB levels associated with slightly longer menstrual cycles, increasing by about 1 day.	Total PCBs PCB congeners # 28 # 138 # 52 # 153 # 74 # 170	Cooper 2005

Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.						
Target	***Study duration***	***Effect Level***	***System***	***Harmful Effects***	***Chemical Form***	***Reference***
		4.99 ppb group Effect not statistically significant for serum PCB standardized to lipid (but samples were not fasting)		Weaker evidence for an association with irregular cycles No association with bleeding duration and volume, or dysmenorrhea. Important limitation is recall bias when answering questions about menstrual cycle.	# 105 # 180 # 118 # 194	
Human	NHANES cross-sectional study 1999-2002	Congener concentrations reported Calculated total serum PCBs standardized for lipids $<25\% = 141$ ppb 25^{th} to $<50^{th} = 243$ ppb 50^{th} to $<75^{th} = 370$ ppb $\geq 75^{th} = 651$ ppb	Cardiovascular	PCBs positively associated with prevalence of CVD among women (but not men). Odds ratio for dioxin-like PCBs $50\text{-}<75^{th}\ \% = 2$ $\geq 75^{th}\% = 5$ Odds ratio for non-dioxin like PCBs 25^{th} to $<50^{th}\ \% = 1.2$ 50^{th} to $< 75^{th}\ \% = 1.2$ $\geq 75^{th}\ \% = 3.8$	Dioxin-like PCB congeners: 74, 118, 126 156 169 Non-dioxin like PCB congeners: 99, 138, 153, 170, 180, 187	Ha M-H 2007
Human	9.5 years	Total PCBs At birth:	Neurological/ Developmental	Impaired learning of a performance task in children exposed to PCBs,	Total PCBs via sum of all congeners	Stewart 2006

Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.						
Target	***Study duration***	***Effect Level***	***System***	***Harmful Effects***	***Chemical Form***	***Reference***
		Mean cord PCB = 0.96 ppb Maternal hair, Mercury Prenatal = 0.56 ppm Prenatal cord Pb = 1.81 µg/dL Postnatal Pb = 4.6 µg/dL (at 2 to 4 years)		methylmercury, and lead. Children prenatally exposed to PCBs responded excessively, with significant lower inter-response times and fewer re-enforcers earned across the session. (In other words, low-level PCB exposure results in an inability to withhold or delay inappropriate responding, which are measures of attention and impulse control) Exposure to either methylmercury or lead (postnatal only) predicted statistically significant impairments of a similar magnitude to those for PCBs. The associated impairments of all three chemicals were statistically independent of one another.		
Human	Occupational,	> 90 days employment	Neurological	No overall (men/women	Not specified	Steenland

Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.						
Target	***Study duration***	***Effect Level***	***System***	***Harmful Effects***	***Chemical Form***	***Reference***
	Retrospective mortality study	Mean = 5.3 years PCB levels not specified Groups classified into low exposure and high exposure		combined) excess of Parkinson disease, amyotrophic lateral sclerosis, or dementia. Women had an excess mortality from amyotrophic lateral sclerosis, ALS (SMR = 2.26, CI = 1.08-4.15) (SMR = standardize mortality ratio) Among the highest exposed women (based on job-exposure matrix), women had an excess mortality from Parkinson disease (SMR = 2.96, CI = 1.08-6.42) and dementia (SMR = 2.04, CI = 1.12-3.42). Loss of dopaminergic cells in the brain is the hallmark pathologic sign of Parkinson disease. Studies indicate that exposure to PCBs decreases dopamine levels in rats and monkeys.		2006

<table>
<tr><th colspan="7">Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.</th></tr>
<tr><th>Target</th><th>Study duration</th><th>Effect Level</th><th>System</th><th>Harmful Effects</th><th>Chemical Form</th><th>Reference</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Conclusion: suggestive data of an effect of PCBs on neurodegenerative disease for women</td><td></td><td></td></tr>
<tr><td>Human</td><td>NHANES Cross-sectional study 2003-2004</td><td>Not applicable</td><td>Blood</td><td>Serum background levels of PCBs in US population.

Note: serum PCB levels change with year of sample and with age, making it difficult to compare these levels with human studies reported above.

<table><tr><td colspan="2">Total PCBs</td></tr><tr><td>Serum whole weight</td><td>Serum lipid standardized</td></tr><tr><td>GM= 0.8 ppb</td><td>GM = 134.4 ppb</td></tr><tr><td>95%= 3.53 ppb</td><td>95%= 530.7 ppb</td></tr></table>GM = geometric mean</td><td>Total PCBs
Congener-specific PCBs</td><td>Patterson 2009</td></tr>
</table>

<table>
<tr><th colspan="7">Table B2. Human Studies Demonstrating the Harmful Effects of PCBs at Low Levels.</th></tr>
<tr><th>Target</th><th>Study duration</th><th>Effect Level</th><th>System</th><th>Harmful Effects</th><th>Chemical Form</th><th>Reference</th></tr>
<tr><td></td><td></td><td></td><td></td><td><table>
<tr><td colspan="3">Serum whole weight PCBs in ppb</td></tr>
<tr><td>Age-group</td><td>Geometric mean</td><td>95th percentile</td></tr>
<tr><td>12-29</td><td>0.3</td><td>0.7</td></tr>
<tr><td>20-39</td><td>0.5</td><td>1.5</td></tr>
<tr><td>40-59</td><td>1.2</td><td>3.2</td></tr>
<tr><td>60+</td><td>2.3</td><td>5.9</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>Human</td><td>9 months</td><td>< 1,04 to > 2.17 pg TEQ/g lipid</td><td>Developmental/ Immunological</td><td>Multivariate analyses showed independently and significantly decreased free T4 (FT4) × thyroid stimulating hormone with increasing non-ortho PCBs (r = –0.2; p < 0.05). This suggests that significant FT4 feedback alterations to the hypothalamus result from in utero exposure to non-ortho PCBs.</td><td>Non-ortho PCBs</td><td>Wang 2005</td></tr>
</table>

Table B3. Animal Studies Demonstrating the Harmful Effects of PCBs at Low Levels.							
Target	***Study duration***	***Effect Level in µg/kg/day***	***System***	***Harmful Effects***	***Chemical Form***	***ATSDR Study #****	***Reference***
Monkey	23 months Daily	5	Immunological	Reduced IgM and IgG antibody response to sheep red blood cells	1254	148	Tryphonas 1989
Monkey	37 months Daily	5	Dermal	Elevated and separated toenails	1254	136	Arnold 1993a, 1993b
Monkey (female)	48 months ppm 37; ppw 22 daily	5	Developmental	Inflammation of tarsal glands, nail lesions, gum recession, reduced IgM antibody levels to sheep red blood cell in infant offspring	1254	160	Arnold 1995
Monkey	72 months	5	Developmental	Inflammation of tarsal glands, nails and nail beds in infants	1254	160	Arnold 1995
Monkey	20 weeks Daily, starting at birth	7.5	Neurological	Changes in behavioral performance in non-spatial and spatial discrimination reversal tasks at 3, 4.5, and 5 years of age. Treated monkeys showed decreases and variable increases in response latencies across three tasks of nonspatial discrimination reversal as well as retarded acquisition of a delayed	15 PCBs similar to breast milk	87	Rice 1997, 1998 Rice and Hayward 1997, 1999a

Table B3. Animal Studies Demonstrating the Harmful Effects of PCBs at Low Levels.							
Target	***Study duration***	***Effect Level in µg/kg/day***	***System***	***Harmful Effects***	***Chemical Form***	***ATSDR Study #****	***Reference***
				alternation task and increased errors at short delay task responses. Rice interpreted the findings as a learning/performance decrement.			
Monkey	20 weeks Daily, starting at birth	7.5	Developmental	Lowered IgM and IgG antibodies to sheep red blood cell, temporary decrease in B lymphocytes	15 PCBs similar to breast milk	113	Arnold 1999
Monkey (female)	48 months ppm 37; ppw 22 Daily	20	Developmental	Fetal and post-partum deaths in 4 of 4 impregnated monkeys	1254	160	Arnold 1995
Monkey	37 months Daily	20	Blood	Decreased mean platelet volume	1254	136	Arnold 1993a, 1993b
Monkey	37 months Daily	20 LOAEL 5 NOAEL	Reproductive	42% reduced conception rate	1254	152	Arnold 1995
Monkey	37 months Daily	40	Hepatic	Decreased serum cholesterol	1254	136	Arnold 1993a, 1993b
Monkey	72 months	40	Dermal	Nail and nail bed changes	1254	137	Arnold 1997

* The ATSDR study number can be found in Table 3-2 in ATSDR's Toxicological Profile for PCBs and is provided as a reference to the study being described. Additional description of the study can be found in ATSDR's profile at this internet address; . http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=142&tid=26

** ppm = post partum month; ppw = post partum week

Appendix C

Summary of Scientific Studies
Evaluating the Effects of Lead Below 10 µg/dL

Table C1. Summary of scientific studies evaluating the effects of lead below 10 µg/dL.			
Blood Lead Level µg/dL	*Effect*	*Results/Conclusions*	*Author*
2.1	IQ	1. Peak (lifetime) blood lead concentration down to 2.1 µg/dL showed an inverse relationship with IQ for children at 6 years. 2. Lifetime average blood lead levels in children up to 6 years old, showed a 4.9 pt. decrease in IQ in children with average lifetime blood with blood lead level between 5 and 9.9 compared to children below 5 µg/dL.	Jusko 2007
< 10 µg/dL	Immune System	Pre- and post-natal blood lead levels below 10 µg/dL can alter children's adrenocorticol responses to acute stress. The behavioral and health consequences yet to be determined	Gump 2007
> 2	ADHD	Children (4 to 15 years) with blood lead levels between 2 - 5 µg/dL had a 4.5 fold higher risk of ADHD	Braun 2006
< 7.5	IQ	Children with blood lead levels up to 7.5 µg/dL have a greater decrease in IQ scores compared to children with higher blood lead levels. IQ decreases 3.9 points for children with blood lead levels between 2.4 - 10 µg/dL	Lanphear 2005
5 to 10	IQ	Data shows IQ decreased 3 to 5 pts. when blood lead levels increase from 5 to 10 µg/dL. IQ at 5 and 7 yrs. not related to peak lead levels of 20-44 µg/dL at 2 years of age	Chen 2005
1 to 10	IQ	An increase from 1 to 10 µg/dL blood lead is associated with 7.4 point decrease in IQ in children 3 to 5 years. From 10 to 20 µg/dL, IQ declines 2 points. Greater decrease in IQ from 1 to 10 when compared to higher blood lead levels	Canfield 2003
< 5	IQ	Blood lead levels below 5 µg/dL associated with deficits in cognitive and academic skills. Every 1 µg/dL increase in blood lead associated with • 0.7 pt. decrease in math scores • 1 pt. decrease in reading scores • 0.1 pt. decrease in nonverbal reasoning • 0.5 pt. decrease in short-term memory	Lanphear 2000

Table C1. Summary of scientific studies evaluating the effects of lead below 10 µg/dL.			
Blood Lead Level µg/dL	*Effect*	*Results/Conclusions*	*Author*
10.4	IQ	Lead at low levels of exposure probably has a small harmful effect on the performance of children in ability and attainment tests. Authors remark no evidence of a threshold	Fulton 1987
< 5	IQ	IQ at 10 years inversely related to blood lead levels at 2 years. Data suggest that inverse relationship persisted at blood lead levels < 5 µg/dL. Slope of dose response is greater at levels below 10 µg/dL	Bellinger 2006
3	Neurobehavior	3 µg/dL blood lead associated with deficits in attention, including executive function	Selevan 2003
5	Neurobehavior	5 µg/dL blood lead associated with deficits in reaction time, visual-motor integration, fine motor skills, off-task behaviors, and withdrawn behaviors	Selevan 2003
<10	Behavior	Blood Pb levels below 10 in 3 yr old children associated with small effects on behavior (e.g., cannot concentrate, quickly shifts from one thing to another) as measured by the destructive subscale. Between 10 and 20 µg/dL, blood lead causes a very small increase effect on behavior.	Wasserman 1998
1.86 all < 10	Behavior	Lead was significantly inversely related to teacher ratings of girls' sociability and classroom social competence.	Hubbs-Tait 2007
4.2 to 9	Attention	In a population with mean blood lead level of 4.2 µg/dL and 90% blood lead of 9 µg/dL, sustained attention negatively affected by lead levels	Walkowiak 1998
3	Height	Compared to 1 µg/dL, lead at 3 µg/dL associated with decreased height	Selevan 2003
3	Development	3 µg/dL associated with delays in breast and public hair development in African-American and Mexican-American girls. Also delayed menarche by 3.6 months. White girls showed non-statistically significant delays. Conclusion: 3 µg/dL causes delays in puberty	Selevan 2003

Table C1. Summary of scientific studies evaluating the effects of lead below 10 µg/dL.			
Blood Lead Level µg/dL	*Effect*	*Results/Conclusions*	*Author*
3.4	Behavior	Data suggest that social and emotional dysfunctions may be expressions of increased lead exposure. 3.4 µg/dL (SD 2.4) associated with total problem behavior scores Increases in tooth lead associated with internalizing and externalizing scores. Weaker association between tooth lead and extreme problem behavior. Cord blood not associated with later behavioral problems	Bellinger 1994
>5.5	Renal	Inverse relationship between serum levels of creatinine, B2-microglobulin, cystatin C and blood lead, suggesting renal hyperfiltration (i.e., increased glomerular filtration rate (x = 7.8 µg/dL)	Burbure 2006
> 1.5 to 10 µg/dL	Behavior	Children 8 to 15 years of age have an increased likelihood of conduct disorder (persistent behavioral patterns that violate social rules and the rights of individuals). Children with CD display aggression towards other people and animals and intentionally destroy others= property and chronically steal and deceive.	Braun 2008
4.8 µg/dL (cord)	Behavior in infants	Prenatal lead exposure was related to increased frenetic movement in neonates at 11 months. Frenetic movement is associated with hyperactivity and thus consistent with primate studies that have identified agitation as an early behavioral effect of lead and increased hyperactivity in childhood. This impaired ability to maintain attention and regulate one's behavior could be one of the earliest signs of lead neurotoxicity and a possible basis for later cognitive dysfunction. After removing children with blood lead levels greater than 10 µg/dL, authors still observed decrements in sustained attention.	Plusquellec 2007

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Appendix D

Glynn Environmental Coalition
Seafood Advisory Brochure

Reduce Risk from Fish You Catch and Eat

Fish Age & Size

Generally, older and larger fish may be more contaminated than younger, smaller fish.

Cooking Methods to Reduce Risk

GOOD
Broiling
Baking
Grilling

OKAY
Deep-fat frying
(do not reuse oil)

POOR
Pan frying

Fish Cleaning to Reduce Risk

Remove all skin
Remove the fat along the back
Remove guts
Remove the belly fat
Remove the fatty dark meat along the length of the fillet

Removing skin and fatty areas reduces some contaminants by 25 to 50% but does not remove mercury.

Women and Small Children

Children under seven and women who are pregnant, nursing, or may become pregnant should:

- **not eat mullet from advisory areas**
- **limit meals of fish and blue crabs to one per month from advisory areas**

Don't stop eating fish and seafood. They provide one of the best sources of protein and Omega-3 fatty acids. Get seafood from other sources than advisory areas.

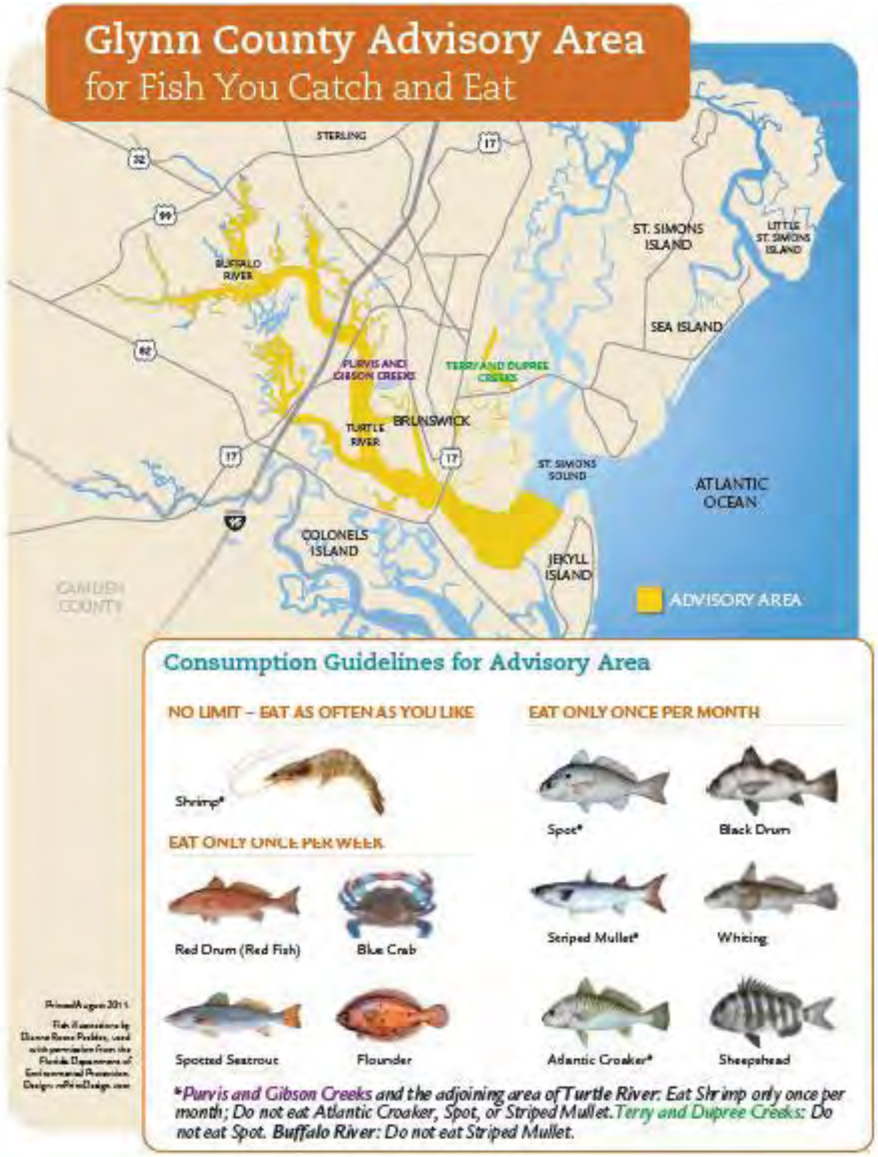
For More Information

Glynn Environmental Coalition
P.O. Box 2443
Brunswick, GA 31521
(912) 466-0934

Glynn County Health Department
150 Scranton Connector
Brunswick, GA 31525
(912) 262-2300

Georgia Department of Natural Resources
One Conservation Way
Brunswick, GA 31520
(912) 262-7218

Program support provided by:


Glynn County Advisory Area
for Fish You Catch and Eat
STERLING
BUFFALO RIVER
PURVIS AND GIBSON CREEKS
TERRY AND DUPREE CREEKS
TURTLE RIVER
BRUNSWICK
ST. SIMONS ISLAND
LITTLE ST. SIMONS ISLAND
SEA ISLAND
ST. SIMONS SOUND
ATLANTIC OCEAN
COLONELS ISLAND
JEKYLL ISLAND
CAMDEN COUNTY
ADVISORY AREA
Consumption Guidelines for Advisory Area
NO LIMIT – EAT AS OFTEN AS YOU LIKE
Shrimp*
EAT ONLY ONCE PER WEEK
Red Drum (Red Fish)
Blue Crab
Spotted Seatrout
Flounder
EAT ONLY ONCE PER MONTH
Spot*
Black Drum
Striped Mullet*
Whiting
Atlantic Croaker*
Sheepshead
*Purvis and Gibson Creeks and the adjoining area of Turtle River: Eat Shrimp only once per month; Do not eat Atlantic Croaker, Spot, or Striped Mullet. Terry and Dupree Creeks: Do not eat Spot. Buffalo River: Do not eat Striped Mullet.

APPENDIX E

EPA's Quadrant Mapping/Sampling Unit Method for Dioxins Collected in 2011 and ATSDR's Sampling Area Designations

Honeywell divided the site into 4 separate quadrants, which is consistent with the sampling design used in the Human Health Risk Assessment for the site (EPS 2010). Each quadrant contained 1 to 3 different sampling units. Incremental Sampling Methodology (ISM) samples were collected from each sampling unit within each quadrant. Each ISM sample was comprised of multiple equal-mass aliquots of soil collected from 0 to 3 inches below ground surface. For each sampling unit, a replicate sample was taken; two replicates were taken in sampling unit 1. A total of three (2 of which were replicates) ISM samples were collected from Quadrant 1. A total of six (3 of which are replicates) ISM samples, two per sampling unit, were collected from Quadrants 2, 3 and 4 (EPS 2011). ATSDR selected the higher of the two replicate sampling results in our evaluation.

Figure 12 illustrates the quadrants and sampling units established by Honeywell for the site.

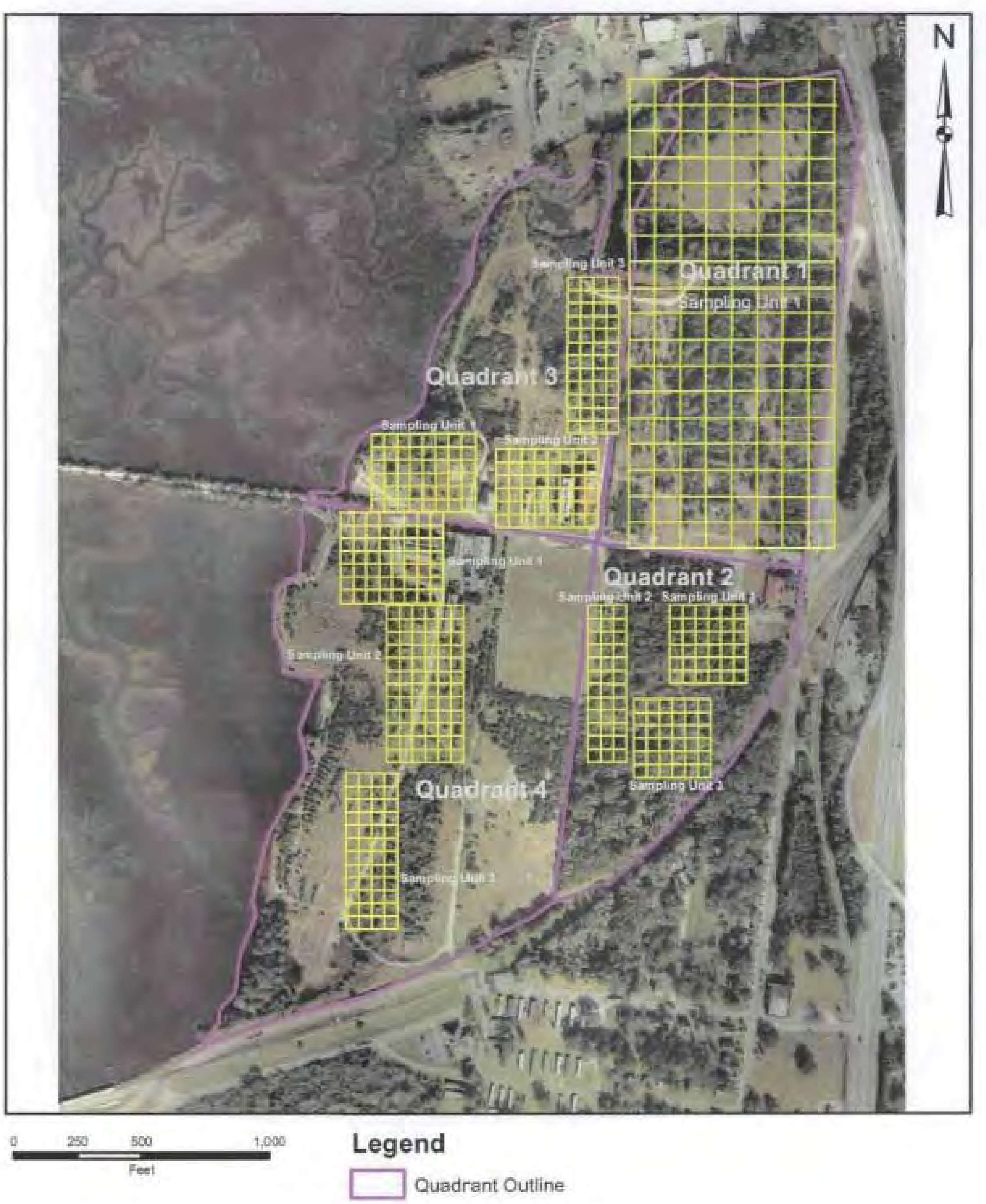
ATSDR consecutively numbered the sampling units (1 through 10) for ease of description. ATSDR's numbering system goes from left to right, top to bottom.

For comparison purposes, the table below shows Honeywell's sampling units and the corresponding numbered sampling area used by ATSDR:

Table 9. Honeywell's sampling units and ATSDR's sampling areas

Honeywell's Quadrant	***Equals***	***ATSDR's Sampling Area Designation***
Quadrant 3, Sampling Unit 1	=	1
Quadrant 3, Sampling Unit 2	=	2
Quadrant 3, Sampling Unit 3	=	3
Quadrant 1, Sampling Unit 1	=	4
Quadrant 4, Sampling Unit 1	=	5
Quadrant 4, Sampling Unit 2	=	6
Quadrant 4, Sampling Unit 3	=	7
Quadrant 2, Sampling Unit 2	=	8
Quadrant 2, Sampling Unit 3	=	9
Quadrant 2, Sampling Unit 1	=	10

Figure 12. LCP Chemicals Site Showing EPA Quadrants and Sampling Units



Environmental Planning Specialists, Inc.

APPENDIX F
RESPONSE TO COMMENTS

ATSDR released this public health assessment in September 2010 for public comment. We received and responded to comments (shown below) and made changes to the public assessment, as appropriate. The page numbers cited in the responses that follow are to the 2010 public comment release of this public health assessment.

1. **Comment**: The PHA places undue emphasis on a hypothetical future use of the LCP property as a residential development. The PHA fails to acknowledge that the LCP Chemicals Site has been used in an industrial capacity for the last 100 years and that the property remains zoned for commercial/industrial use. The current property owner (Honeywell) has no intention of developing the property for residential use and will be placing institutional controls on the property, restricting future use of the property for commercial use only.

   <u>ATSDR Response</u>: ATSDR's evaluation included residential development as a future use because residential development was considered in EPA's assessment of the property (e.g., EPA's draft Human Health Risk Assessment considers a future on-site resident in the exposure assessment) and because residential use has not been ruled out. Although Honeywell claims in some reports that the site is intended to remain industrial, they acknowledge the potential for some mixed land use of the property and/or the possibility that some portion of the site might be used as residential property in the future. Therefore, ATSDR believes it prudent to evaluate all possible future scenarios to be protective of public health.

2. **Comment**: There are a number of statements in Section II.B. (Site History) for which the Draft Remedial Investigation/Feasibility Study (RI/FS) Report for Operable Unit 3 (OU3) (i.e., "EPS 2007b") is cited. Most of the statements attributed to that reference misrepresent information and/or specific statements presented therein[7]. The PHA should be revised in a manner that either removes all such "EPS 2007b" citations in Section II.B. Alternatively, the wording in Section II.B should be altered in a manner to accurately reflect the wording from the cited documents[8].

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[7] Some examples of improper citations occurs on page 2 of the PHA, bullets 1, 2, 4, and 5 with respect to "releases" and references to "large quantities". EPS 2007b is also mis-referenced on page 16 of the PHA where the statement begins "Wastes laced with contaminants…".

[8] Please also note that there appear to be several instances of improper citation references in the document. For example, the first citation of an "EPS 2007" reference appears on page 2; however it is listed with a "b" suffix. The citation of "EPS 2007a" does not appear until page 15. The "a" and "b" suffixes on these references should be reversed. In Section II.B (page 2), there is a citation of "EPA 2007b." There is no "EPA 2007b" in the reference list and given its proximity to the other "EPS 2007b" citations, it is likely that the ATSDR intended to cite "EPS 2007b." There are also numerous citations of "EPA 2009" within Section II. There are four EPA 2009 references in the reference list (each labeled with a, b, c, or d suffix). However, none of these references seem likely to support the statements attributed to the "EPA 2009"

<u>ATSDR Response</u>: This section has been revised.

3. **Comment**: There are a number of statements in the PHA that describe residual contaminated soil within the footprint of the former cell building (e.g., pages 24, 28, 29, 85, 86, 105). None of these statements acknowledge that the cell buildings were razed and the entire area capped and enclosed with a chain link fence as part of the EPA Removal Action in 1994-97. This cap and chain link fence surrounding the area is an effective barrier to human exposure to conditions in the underlying soil (that were also characterized as part of the site investigation). By ignoring the cap and fence, ATSDR's conclusion that there is "a health concern if the site becomes commercial or industrial in the future" (page 105, Figure 22) overstates the risk in at least five of the nine grids. Section IV.C.1, which describes the decommissioning and removal actions in the cell building area, should describe the construction of the soil cap over the razed structures and the chain link fence surrounding this area. The PHA figures should also be modified accordingly.

<u>ATSDR Response</u>: Several sections were revised to acknowledge the construction of the soil cap over the razed cell building structures and the installation of the chain link fence.

Also, we did consider the soil cap and fence in our evaluation of the site. Although we believe that exposures may be mitigated by the presence of the cap and fence in the short term, we think it important to acknowledge the presence of significant residual contamination in case land use changes are considered for the future. The cell building area should be carefully re-evaluated and further characterized if structures are to be built on or near the capped area in the future.

4. **Comment**: The PHA correctly identifies Aroclor 1268 as the primary form of polychlorinated biphenyl (PCB) present in site soils. Neither EPA nor ATSDR, however, have developed default toxicity criteria for Aroclor 1268. The PHA evaluates the Aroclor 1268 using the toxicity criteria developed by those agencies for Aroclor 1254 and goes on to generically characterize the "uncertainty" associated with the toxicological evaluation of Aroclor 1268. There is evidence in the scientific literature to support the conclusion that Aroclor 1268 is considerably less toxic than Aroclor 1254.[9,10] The PHA should be revised to acknowledge that

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citation in Section II. The March 31, 2009 Addendum to the Human Health Baseline Risk Assessment appears in the reference list as "EPS 2009", but is never cited in the document.

[9] Warren, D. A., Kerger, B. D., Britt, J. K. and James, R. C. (2004). Development of an oral cancer slope factor for Aroclor 1268. *Regulatory Toxicology and Pharmacology,* 40: 42-53.

the "uncertainty" associated with the use of the Aroclor 1254 toxicity criteria to evaluate Aroclor 1268 results in a more conservative assessment of potential toxicity.

<u>ATSDR Response</u>: **In the absence of substantial toxicity data on Aroclor 1268, it is prudent public health practice to use health guidelines and toxicity information from other mixtures of Aroclor. This approach is commonly used by public health agencies to evaluate Aroclor mixtures. The articles cited by the commenter also have considerable uncertainty so it is not certain that Aroclor 1268 is less toxic than Aroclor 1254. ATSDR has appropriately acknowledged the uncertainty in using health guidelines and toxicity information for Aroclor 1254. ATSDR did not make the suggested change.**

5. **Comment**: Section IV.E.2 discusses the presence of "clinker material" at a residential property on Clairmont Lane and suggests that this area be investigated (see page 115). As described in the PHA, the presence of clinker material was the subject of an investigation and removal action conducted by Georgia Environmental Protection Division in 2004. Neither that investigation nor this PHA present demonstrable evidence linking the clinker material to the LCP Chemicals Site. In fact, the material is common to many industrial operations and is known to be associated with other industrial sites in Brunswick. Given that its relevance to this PHA has not been established, it should be removed from the PHA.

<u>ATSDR Response</u>: **In the PHA, ATSDR maintains that the alleged disposal sites may not be associated with the LCP Chemicals site. We elected to include the suspected disposal areas in this document because community members raised concerns regarding these areas and because some evidence exists to suggest a connection with past industrial activities in the area, not limited to activity by LCP Chemicals.**

6. **Comment**: ATSDR created half-acre grids as "exposure units" that were used to segregate and evaluate the site sampling data. The use of a small exposure unit grid results in the conclusion that many of the grids lack sufficient data to characterize the condition of each grid. This analysis fails to acknowledge that many areas of the site, however, did not warrant the same density of site characterization as did other areas of the site, because of a lack of historical industrial activity in those areas. ATSDR should consider using a more appropriate grid size such as one-acre grids so that there would be fewer instances where ATSDR concludes that there was a "lack of sufficient data".

<u>ATSDR Response</u>: **While it is known that industrial activity occurred predominantly in the western portion of the LCP property, on-site disposal of**

[10] Simon, T., Britt, J. K. and James, R. C. (2007). Development of a neurotoxic equivalence scheme of relative potency for assessing the risk of PCB mixtures. *Regulatory Toxicology and Pharmacology,* 48: 148-170.

industrial waste could have occurred anywhere on the property during the 83 years that industrial operations took place. The disposal locations are uncertain for the first half of the 20th century when petroleum refining (1919-1935), electric generation (1937-1950s), and paint and varnish manufacturing (1941-1955) took place. The chlor-alkali operations clearly took place in the western portion of the site, although disposal of waste could have occurred anywhere on the property even during these operations. This information is described in more detail the background section of the PHA.

In addition, increasing the grid size to one acre will not change substantially the conclusion that eastern portions of the site are poorly characterized. The basis for half-acre grids is the assumption that the site could be developed for residential, commercial, or industrial activity. Without specific information on future land use, the most prudent grid size to evaluate human exposure is a half-acre. ATSDR did not make the suggested change.

7. Comment: In this PHA the evaluation of potential health effects associated with lead exposure in site soil includes the derivation of a soil lead comparison level of 141 ppm based on the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model, using the model's default input parameters and a target of 5% of children's blood lead levels exceeding 5 µg/dL. The use of this blood lead target for this purpose is not consistent with Centers for Disease Control (CDC), EPA guidance, and standard practice. The CDC established 10 µg/dL as its "blood lead level of concern" in 1991, and a revision of the 10 µg/dL level of concern was considered and rejected by CDC's Advisory Committee on Childhood Lead Poisoning and Prevention (ACCLP) in 2005. The ACCLP revisited this issue at a recent meeting,[11] without reaching consensus. The committee voted to form a working group to study the issue further. The EPA has long relied on the 10 µg/dL level of concern for establishing cleanup levels for lead in soils and there is no evidence that these levels are not protective of public health. In fact, one of the primary issues confronting the CDC as it considers revisions to the [sic] its level of concern is that no effective interventions have been demonstrated to further reduce blood lead levels in children who already have levels at or below 10 µg/dL.[12] Given this set of circumstances, the ATSDR's use of a 5 µg/dL target blood lead level to draw conclusions about the need for remedial actions to protect the health of hypothetical future residents is arbitrary and out of step with current policy and guidance from the EPA and CDC

<u>ATSDR Response</u>: **On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile for children 1 to 5 years old as the reference value for designating elevated blood lead levels in children. The 97.5% currently is 5**

[11] The ACCLP meeting was held in Atlanta, Georgia on November 16-18, 2010.

[12] Brown, MJ and Rhodes, GG. (2008). Guest Editorial: Responding to Blood Lead Levels <10 µg/dL, Environmental Health Perspectives, 116: A60-A61

µg/dL. This came about because of the numerous studies that show health effects at levels below 10 µg/dL. Furthermore, the advisory committee recommended that CDC stop using the phrase 'blood lead level of concern.' (ACCLPP 2012)[13]. The advisory committee's report to CDC and CDC's response is available at http://www.cdc.gov/nceh/lead/acclpp/acclpp_main.htm.

CDC has accepted the advisory committee's recommendation, has dropped the use of the term, 'level of concern', and has adopted the 97.5th percentile as CDC's reference value for lead.

In addition, in a letter dated January 16, 2008 from Dr. Henry Falk (Director, Coordinating Center for Environmental Health and Injury Prevention, CDC) to Mr. Robert Meyers, (Principal Deputy Assistant Administrator, EPA), CDC comments on EPA's use of 10 µg/dL in the IEUBK model to derive the national ambient air quality standard for lead[14]. CDC points out that CDC has developed several blood lead levels (BLL) where CDC recommends public health action (e.g., > 70 µg/dL, > 45 µg/dL, > 15 µg/dL, and 10 µg/dL). Thus, CDC states, "there is no single CDC level of concern". CDC further states that 10 µg/dL should not be used as a safe level, and that 10 µg/dL has frequently been misinterpreted as a toxicological threshold. CDC cautions that using 10 µg/dL as a target for deriving lead standards (and by inference soil clean up level) is an inappropriate interpretation of CDC's historical 10 µg/dL. CDC states that the use of 10 µg/dL in EPA's IEUBK model could needlessly expose children to levels of lead known to adversely affect academic performance and success later in life.

Because CDC's current reference level for lead in children is 5 µg/dL, ATSDR did not make the suggested change.

8. **Comment**: Excerpt from LCP PHA, Site History, Page 2 –

   "ARCO Petroleum (1919-1935), a successor of the Atlantic Refining Company, operated the site as a petroleum refinery that refined crude oil into fuel and oils. At one time, over 100 process and storage tanks were present on site. ARCO is reported to have released large amounts of petroleum products and wastes onto the ground (EPS 2007b)."

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[13] [ACCLPP] Advisory Committee for Childhood Lead Poisoning Prevention. 2012. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention, Report of the Advisory Committee on Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention, January 4. Available at http://www.cdc.gov/nceh/lead/acclpp/acclpp_main.htm.
[accessed 5 May 2013].

[14] Falk H. 2008. Letter from Henry Falk, Coordinating Center for Environmental Health and Injury Prevention, CDC, to Robert J. Meyers, Principal Deputy Assistant Administrator, US EPA, Washington DC. January 16.

The boundaries of operations on the site during the 1919 to 1935 period have not been described. Areas that are now considered to be off-site are actually part of the original ARCO Petroleum operations area. The boundaries of the site for each operational period described in the Site History section of the Public Health Assessment (PHA) should be described and figures produced and included. Figure A4 should also be accompanied by figures of the land boundaries for all operational periods in the Site History section.

ATSDR Response: It is beyond the scope of the PHA to define and describe all historical site boundaries and it is not needed to perform the evaluation of current on-site and off-site locations. Therefore, this suggestion was not implemented. For example, the current boundaries of the Superfund site, as described by EPA Region 4, do not encompass all the areas where tanks were historically located. However, we still evaluated soil sample results available for these off-site areas. See Figure A6.

9. **Comment**: The commenter served on the seafood consumption advisory group formed to consult and review the results of a seafood consumption study in Brunswick conducted by the state health department.[15] The Principal Investigator of the study was taken to the subsistence fishing areas on the Brunswick peninsula and an effort was made to introduce her to the subsistence fishers. The study design was changed to select only those that owned boats and fished from boats, even though the advisory group objected. The commenter is concerned that the participants in the study do not represent the African-American community and subsistence fishers in the area.

ATSDR Response: The study was conducted by the Glynn County Health Department through a cooperative agreement and funding from ATSDR. The study design targeted three groups: commercial, recreational, and subsistence fishers. The target groups had to meet three criteria:

1. **Consumed or caught seafood from the Turtle River or its tributaries in Glynn County;**
2. **Lived in Glynn County for at least the last two consecutive years prior to the study; and**
3. **Had not been employed at the LCP Chemicals Site since 1956, in order to exclude individuals who may have had occupational exposure to mercury.**

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[15] Final Report, Consumption of Seafood and Wild Game Contaminated with Mercury – July 1999.

Much effort went into finding local fishers using multiple methods to identify the target groups. The various methods include:

- **6,200 surveys were distributed to local schools, businesses, agencies, industries, community groups, churches, and professional and civic organizations.**
- **Residents in private homes in the target geographical areas were contacted by door-to-door canvassing**
- **Screening surveys were left at homes of those who could not be contacted during the door-to-door canvassing.**
- **Surveys were distributed at fishing piers, bridges, boat ramps, businesses, and homes adjacent to affects waterways, fish camps, bait and tackle shops, and to the local commercial seafood industry.**
- **The survey was published several times in the local newspapers and the GCHD Hazardous Waste Site Newsletter with instructions on submitting the completed survey for enrollment.**
- **Television and radio coverage was used extensively throughout the recruitment period.**

Of the 282 eligible residents in the target group of recreational, commercial, or subsistence fishers

- **214 (76%) were interviewed,**
- **156 (55%) completed a dietary diary, and**
- **139 (49%) provided urine samples.**

Of the 101 (65%) target group participants who self-reported which type of fisher they were

- **97 (96%) classified themselves as recreational fishers,**
- **3 (3%) identified as commercial, and**
- **1 (1%) identified as subsistence fisher.**

It's important to note that the study results reflect characteristics of recreational white fishers and do not necessarily apply to commercial or subsistence fishers.

No effort was made to select residents who only owned boats or who fished from boats. It should be pointed out, though, that portions of the Turtle River and its tributaries under the advisory are only accessible by boat. Several fishing areas along the shore or from a bridge are possible but the survey did not attempt to distinguish which method was used to catch fish nor was any effort made to not select persons who fish from the shore. The text already explains that the study results do not necessarily apply to the African-American community, who were underrepresented in the target study group.

10. **Comment:** This study design overlooks people of color, who are the predominant population on the Brunswick peninsula bordering the most contaminated areas and the subsistence fishing locations. The PHA correctly states, "It should be noted that African-Americans made up only 4% (9 out of 197) of the people who participated in the study; therefore, the findings of this study may not apply to the African-American community in the Brunswick area." But, the statement should be strengthened to reflect that the most likely to consume contaminated seafood and be the impacted subpopulation – the subsistence fisher population – was not included in the study. Furthermore, the study participants were aware of the advisories and by virtue of having boats could fish outside the advisory areas when obtaining seafood for consumption.

ATSDR Response: ATSDR agrees with the comment that African-Americans are underrepresented in the Brunswick fish study and has already stated this in the main text. According to the 2010 U.S. census, African-Americans make up 26% of the population of Glynn County. Within four miles of the LCP Chemicals site, African-Americans make up almost 40% of the population.

For this reason, we have used information about fish consumption from an African-American population to evaluate fish contaminant levels from the Altamaha Canal. A study of fishers along the Savannah River showed that African-Americans

- **eat more fish meals per month than whites (average, 5.4 vs. 2.9),**
- **eat larger portions than whites (average, 13.7 oz vs . 13.1), and**
- **eat more fish per month than whites (average, 75 ounces vs. 41 ounces).[16]**

It is reasonable to assume that African-Americans in Brunswick, Georgia, are similar to African-Americans along the Savannah River when it comes to fish-eating habits. Therefore, African-Americans who fish along the Turtle River are likely to have higher exposure to mercury from eating fish than whites.
The commenter states that the study participants were aware of the advisories and by virtue of having boats could fish outside the advisory areas when obtaining seafood for consumption. This statement is consistent with one of the conclusions of the Brunswick fish study, which states that most study participants do not fish in the restricted area and the few that do are aware of the advisory.

ATSDR has added several of these points to the main text of the PHA.

11. **Comment:** Regarding the Brunswick fish study, the conclusions of the Glynn County Health Department are of little value and might mislead the public and lead to underestimating the risks from consuming contaminated seafood.

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[16] Burger J, Stephens WL, Boring CS, et al. 1999. Factors in exposure assessment: ethnic and socioeconomic differences in fishing and consumption of fish caught along the Savannah River.

Therefore, ATSDR should consider clarifying language in this section to fully reveal the significant flaws in the study methods.

<u>ATSDR Response</u>: The conclusions in the Brunswick fish study apply to persons who responded to the survey and to some extent to non-responders with similar demographic variables. It should not be applied to African-Americans who may fish in restricted areas of the Turtle River and its tributaries. ATSDR has modified the text to make this point more clear.

12. **Comment**: There were other significant flaws in the study, such as educating the study participants to the risk from contaminated seafood prior to the 24 hour urine collection.

<u>ATSDR Response</u>: Awareness of the fish advisory was present long before the Brunswick fish study was conducted. It is not possible to avoid some of the bias that comes with knowing about the dangers of mercury in fish and the effect that knowledge may have had on someone's fish-eating habits. The timeline of events for the study included the following in this order:

- **Administer a screening survey to identify target and control groups,**
- **Administer a detailed survey to identify signs/symptoms and diseases as well as details of fish catching and eating habits,**
- **Complete a dietary diary over a two-week period,**
- **Collect a 24-hr urine sample.**

Additional bias could have been introduced because persons may have changed their fish-eating habits during the two week dietary period when study participants monitored their own fish intake. Even so, the dietary diary showed that residents tended to underestimate their fish intake when filling out those parts of the detailed survey that dealt with their fish consumption. Additional information has been added to the main text of the PHA.

13. **Comment**: Hair testing would have provided a history of exposure and interjected less bias into the study methods and design.

<u>ATSDR Response</u>: Blood and hair testing are more appropriate methods for identifying exposure to methylmercury from fish consumption. The Brunswick fish study decided to use urine to monitor mercury levels for two reasons. First, 10% to 30% of organic (e.g., methyl) mercury may be excreted in the urine. Therefore, the investigators thought that the large amounts of mercury in fish would still show up in fish consumers as elevated mercury urine levels. Secondly, the investigators thought that participation would be higher if non-invasive urine samples were required rather than invasive blood samples. In addition, there could have been problems with collecting hair samples in some older men because of insufficient hair for a sample.

Unfortunately, collecting urine samples diminishes the ability to identify low to moderately exposed individuals. In addition, the selection of 20 ug/L as a reference value was too high. Although not available at the time of the 1999 Brunswick fish study, the 4th National Report on Human Exposure to Environmental Chemicals shows that 2 or 3 ug/L (or 2 ug/g creatinine) would be a more appropriate reference level to identify excessively exposed individuals. The following levels are reported by the 4th National Report for the three 2-year reporting periods covering 2003 to 2008:

	Geo Mean	**95th percentile**
Urinary Mercury µg/L	**0.44-0.47**	**2.6-3.2 µg/L**
Urinary Mercury µg/g creatinine	**0.44-0.46**	**2.3 µg/g**

The 4th National Report is available at this web address: http://www.cdc.gov/exposurereport.

Additional information has been added to the main text of the LCP PHA.

14. Comment: The section on page 22 of the PHA concerning PCBs should include a section "How PCBs Were Used at the Site". The graphite anodes impregnated with PCBs were used in the chlor-alkali cells. Electricity was passed through the anode to crack the salt brine solution into chlorine, and caustic soda. The electric current created great heat and produced byproducts such as hydrogen and dioxin/furan. Within the chlor-alkali cells, the PCBs were exposed to heat and chlorine as the graphite anode was consumed. Further clarification about how dioxin/furans are produced during the chlor-alkali process, and why dioxin/furans can be presumed to be co-located with PCBs should be included in the PHA. Furthermore, a clear statement that testing for dioxin/furans is needed on the uplands before further residential or commercial development should be included in the section concerning PCBs, dioxin, and in the conclusions and recommendations.

ATSDR Response: **Generally, specific comments regarding chemical production and/or use at a site are determined by the regulatory agency conducting the environmental investigation. Although we can include general information about the chlor-alkali process, we do not have specific information about how the chemicals were produced or used at *this* site. Therefore, we would refer the commenter to EPA documents for a more specific explanation of the chlor-alkali process.**

We were able to use third party studies and professional experiences to make the case for why dioxins/furans are presumed to be co-located with PCBs. We cite the evidence we used to support our conclusion.

Honeywell conducted further sampling for dioxins in upland soils in 2011. ATSDR evaluated that data and provided recommendations and conclusions based on our evaluation of the data.

15. **Comment**: The discussion of the dioxin/furan group of chemicals should be included in the PCB section. Since PCBs and dioxin/furan were co-located, the removal action was premised upon dioxin/furan being removed with the PCBs. Therefore, the presence of PCBs is presumptive evidence of dioxin/furan. The lack of dioxin/furan data for the uplands is not "data" indicating the chemicals are not present.

<u>ATSDR Response</u>**: Honeywell conducted further sampling for dioxins in upland soils in 2011. ATSDR evaluated that data and provided recommendations and conclusions based on our evaluation of the data**.

16. Comment: Excerpt from page 43 of the PHA:

"A total of 45 samples were tested for dioxins. Of the 45 samples tested, 6 were surface water samples and 1 was a groundwater sample. Two sediment samples were collected to determine background concentrations. The 36 remaining samples were sediment samples collected from the marsh and from selected off-site locations. " "…Dioxin concentrations in sediment ranged from non-detect to 0.003 ppm. ATSDR's comparison value for dioxin in soil is 0.00005 ppm. Eight samples exceeded ATSDR's comparison value of 0.00005 ppm. No samples for dioxins were collected from the dry-land area."

The source areas for the dioxin found in sediment and surface water can reasonably be expected to be on the upland portions of the site, and these areas should be identified prior to any commercial or residential use of the site.

<u>ATSDR Response</u>**: Honeywell conducted further sampling for dioxins in upland soils in 2011. ATSDR evaluated that data and provided recommendations and conclusions based on our evaluation of the data.**

17. **Comment**: Excerpt from LCP PHA, Residual Mercury Levels in Soil, Page 29

"The maximum mercury concentration at the site from a single soil sample is 10,400 ppm and is located in the footprint of the cell building area (Grid #113). The highest average mercury concentration for any grid (Grid #113) is 1,470 ppm and is also located in the former cell building area."

The PHA authors have correctly noted that the Cell Building area is poorly characterized. Still, the testing conducted found 10,400 ppm, or 1.4% mercury in the soils. Considering that the mercury leaked to a cement floor and then flowed through cracks in the concrete, even higher levels could be present in the soil below the Cell Building area. The sampling did not extend further than 5 feet (also around the groundwater table), which means the potential for significant amounts of mercury below the groundwater table exists. More vertical and horizontal characterization is needed in the Cell Building area and should be recommended in the PHA.

ATSDR Response: We acknowledge the lack of proper characterization of the cell building area and recommend additional sampling should the area be considered for future development.

18. **Comment**: The PHA should note that excavation activities in the Cell Building area have the potential to expose workers and the general public. Any work in the Cell Building area should be scheduled for times of the year with the coolest temperatures.

ATSDR Response: ATSDR acknowledges that significant contamination remains beneath the cell building. EPA and/or its contractors will be responsible for developing a plan that is protective of workers and the general public during excavation activities at the site. If requested, ATSDR staff are available to review worker protection plans.

19. **Comment**: The cell building area was not analyzed as thoroughly as the other areas of the LCP Chemicals Site during the EPA Emergency Response and Removal Action since it was assumed extensive remediation would be needed in this area, which has been delayed at this point for 14 years. With soil mercury levels in excess of 1% reported and limited data, the PHA should strongly recommend another timely assessment when the data are obtained.

ATSDR Response: We acknowledge the lack of proper characterization of the cell building area and recommend additional sampling should the area ever be considered for future development.

20. **Comment**: The huge quantity of mercury in the cell building area and the very limited delineation of the vertical and horizontal extent continue to be a concern, as is the continued contaminated groundwater discharge from the uplands to the marsh. The upland contamination, groundwater, and marsh cannot be independently analyzed for risk since they are so interconnected. What happens in one unit directly affects the others.

ATSDR Response: ATSDR agrees that significant mercury contamination is likely to exist in soils beneath and adjoining the footprint of the former cell building. This soil contamination is likely still contributing to groundwater contamination beneath the footprint and is likely still migrating towards and entering the nearby marsh. Several types of risk can exist from this contamination in the environment. There could be risk from direct contact or from breathing air should the soils be disturbed or the area developed for

commercial or residential use. This risk is described in the PHA. In addition, the remaining mercury that contaminates the soil and groundwater is migrating into the marsh and continues to contribute to mercury levels in fish and shellfish from the marsh.

21. **Comment**: Excerpt from LCP PHA, Residual Dioxin Levels in the Marsh (page 42)

    "Dioxins, or chlorinated dibenzo-p-dioxins (CDDs), are a class of structurally similar chlorinated hydrocarbons. The basic structure is comprised of two benzene rings joined via two oxygen bridges at adjacent carbons on each of the benzene rings. Dioxins is a term used interchangeably with 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCCD or TCDD). TCDD is the most toxic form of the numerous dioxin compounds."

    The similarity between the structures of PCBs and Dioxin/furans should be included in this discussion. Also, a TEQ that includes the dioxin, furans, and PCBs at the site should be incorporated into the PHA.

ATSDR Response: The discussion now includes more information about the structures of PCBs and dioxins/furans. WHO TEQs have been included for dioxins/furans for upland soils sampled in 2011.

22. **Comment**: Excerpt from the LCP PHA.

    "Dioxins are not intentionally produced and have no known use. They are the by-products of various industrial processes (i.e., bleaching paper pulp, and chemical and pesticide manufacture) and combustion activities (i.e., burning household trash, forest fires, and waste incineration) (ATSDR 2006)."

    The production of dioxin/furans in the chlor-alkali process should be discussed in this section. At a minimum, how PCBs would react in the presence of heat, pressure, chlorine, oxygen, and hydrogen should be discussed.

<u>ATSDR Response</u>: Generally, specific comments regarding chemical production and use at a site are detailed in reports by the investigative/regulatory agency. We have included general information regarding the formation and fate of dioxins and PCBs in the environment.

23. **Comment**: The figures and tables identifying the grids of concern are a helpful tool in describing where the areas of concern are located, and where additional remedial activities are needed. The PHA is organized in a manner to present the information in an easy to understand and use format.

<u>ATSDR Response</u>: Thank you for the comment.

24. **Comment**: The figures with grids in the PHA are great. If you could use a color to designate the grids where there was no data to make a determination about risk, I think this would strengthen the PHA and would not infer contamination was not present. Currently, the way the PHA is written, it makes it appear the grids identified as contaminated and having risk are the only ones that need be of concern.

ATSDR Response: We have added a map that shows grids that are not adequately sampled.

25. **Comment:** The Salt Dock area is mentioned in the PHA but not discussed. PCB contaminated anodes were removed from this area. The sampling in the salt dock location was minimal and did not sample at depths over 1 foot. The PHA should note that sampling at deeper levels is needed in the Salt Dock area to determine risk from subsurface soils.

ATSDR Response: The Salt Dock area was not considered a significant potential source for exposures because the land use is industrial and the contamination, if any, is at deeper levels. Additional sampling should be considered if the land use changes.

26. **Comment**: Since significant areas of the Site have been allowed to be re-forested, significant soil disturbance should be expected with any future development activity. The PHA should note that potential for exposure and elevated surface soil contaminant levels may occur as a result of soil disturbance.

ATSDR Response: The PHA includes language which acknowledges the potential for surface and subsurface soils to be disturbed during future development. We consider all upland soils (surface and subsurface) to contribute to any potential exposures.

27. **Comment**: The lack of PCB data for the cell building area should be noted. Several more of the grids could contain elevated PCB levels since the cell building area is where the PCB impregnated anodes were used. The lack of PCB data for the cell building area, and other areas, are not data that PCBs are not present or a risk does not exist in these areas. The PHA should note this lack of data and that the adjoining grids do have elevated levels of PCBs. The grids where there is a lack of data are 72, 57, 115, 126, 127, 128, 129, 130, 150, 151, and 165. The number of grids identified as having elevated levels of PCBs (and therefore dioxin/furan) in Figure 14 on Page 66 could be much higher if the PCB data was available. The same comment applies to areas where mercury, lead, and PAH data was not present for a grid due to the lack of data.

ATSDR Response: The commenter makes a valid point. The number of grids of concern could be higher if we had adequate data to analyze for each grid.

We have now included new figures (Figures 22-26) to show the grids/areas where there is inadequate sampling data to make a health call. There are separate figures for each contaminant of concern. These figures should be considered in conjunction with the grids that are determined to be a health concern.

28. **Comment**: ATSDR was asked to consider these references concerning dioxin production and the chlor-alkali process.

    http://www.americanchemistry.com/chlorine/sec_content.asp?CID=1131&DID=5124&CTYPEID=107

    http://yosemite.epa.gov/R1/npl_pad.nsf/148bf278d6a49a3f85256aef005e1bff/94dd5df1d9c0ab95852570c20063f11a!OpenDocument

    "From the late 1800s to the 1960s, chlorine and other chemicals (e.g., caustic soda, hydrogen, chloroform) were produced using electrolytic cells in "cell houses" at the former facility. Diaphragm cells, and also possibly mercury cells, produced chlorine for use in the manufacture of paper at the adjacent pulp mill. The mercury and other contaminants associated with that process, including dioxin and PCBs, were disposed on-site."

    Env Sci Pollut Res 15 (2) 96 – 100 (2008). Dioxin – Contemporary and Future Challenges of Historical Legacies Dedicated to Prof. Dr. Otto Hutzinger, the founder of the DIOXIN Conference Series Roland Weber, Mats Tysklind and Caroline Gaus, POPs Environmental Consulting, Ulmenstrasse 3, 73035 Goeppingen, Germany, Department of Chemistry, Umeå University, 901 87 Umeå, Sweden, National Research Centre for Environmental Toxicology (EnTox), The University of Queensland, 39 Kessels Road, Coopers Plains 4108, Australia

    "The beginning of the chlorine industry and Dioxin history. It has long been recognized that significant CDDs/PCDFs (Dioxins) formation during industrial processes commenced in the early twentieth century with the chloro alkali process and the subsequent high volume production of organochlorines."

    http://www.gcmonitor.org/downloads/Dioxins_India_Study.pdf
    http://www.portaec.net/library/pollution/dioxins/dioxfaq.html "Dioxin has even been identified at the root of chlorine chemistry: in the sludges and residues from the chlor-alkali process, in which chlorine gas is produced by passing a powerful electric current through salt-water.

    http://abstracts.co.allenpress.com/pweb/setac2005/document/56870
    http://abstracts.co.allenpress.com/pweb/setac2005/document/56870

The LCP Chemicals Site is mentioned in this article (site in southeast Georgia).

ATSDR Response: Thank you for the references; they were considered.

29. **Comment**: If you could obtain the Glynn County data concerning diabetes, thyroid function and growth hormone disruption, and hepatic function, this information should be in the PHA. Also, the intelligence quotient (IQ) data for the schools serving the population within the contaminated seafood advisory area. The IQ data should be broken down by grade and school. I believe you can do this without identifying the individual schools. Socio-economic data can be used to reduce the statistical deviation of the target population.

ATSDR Response: It is not possible to link county level data for health conditions (e.g., diabetes, thyroid function, etc.) to chemical exposure from the LCP Chemicals Site (e.g., mercury, PCBs, etc.). Therefore, providing descriptive statistics about health conditions has no ability to determine whether contamination of the environment has increased rates of various health conditions (e.g., diabetes) in Glynn County. The same situation applies to descriptive data about IQ. It is not possible to identify children who were exposed to chemicals from the LCP Chemicals Site; therefore, it is not possible to determine whether contamination of the environment has decreased IQ scores in the area.

30. **Comment**: Glynn County established a tumor registry several years back. You might want to look at the data to see if there are any unusual patterns. Since the tumor registry has been recording data for several years now, there might be enough information to avoid the dreaded "Insufficient number of persons to be statistically significant".

ATSDR Response: When evaluating cancer rates for specific geographic regions (e.g., a county), it is likely that some cancer rates will be higher than expected and this will be useful information for the community. However, it would not be possible to link any increased cancer rates with possible exposure to cancer-causing chemicals from the LCP Chemicals Site. The reason for this is that we cannot identify a sufficient number of persons in the county who were exposed to cancer-causing chemicals from the LCP Chemicals Site. For this reason, ATSDR will not evaluate cancer rates at the county level.

31. **Comment**: Has there been any mercury air monitoring at the LCP Chemicals Site in the last 10 years? The information would be helpful to have in the PHA.

ATSDR Response: ATSDR is not aware of any mercury air monitoring at the LCP Chemical site.

32. **Comment**: Also, a recommendation to do monitoring during any land disturbance activities. This would support the intent to have the ROD and Consent Decree explicitly state the minimum number and placement of air monitors at the site during any remedial activity or land disturbance.

<u>ATSDR Response</u>: A determination regarding what monitoring, if any, is needed is made by the Agency supervising the cleanup. The details of any air monitoring plan should be made on a case-by-case basis.

33. **Comment**: Please add these studies to the PHA.

Yang CY, Wang YJ, Tsai PC, Chen PC, Tsai SJ, Guo YL *. Exposure to a mixture of polychlorinated biphenyls and polychlorinated dibenzofurans resulted in a prolonged time to pregnancy in women. Environ Health Perspect 2008;116:599-604.

Wang SL, Tsai PC, Yang CY, Guo YL*. Increased risk of diabetes and polychlorinated biphenyls and dioxins: A 24-year follow-up study of the Yucheng cohort. Diabetes Care 2008;31:1574-1579.

Hsu PC, Pan MH, Li LA, Chen CJ, Tsai SS, Guo YL*. Exposure in utero to 2,2',3,3',4,6'-hexachlorobiphenyl (PCB 132) impairs sperm function and alters testicular apoptosis-related gene expression in rat offspring. Toxicol Appl Pharmacol 2007;221:68-75.

Hsu JF, Guo YL, Liu CH, Hu SC, Wang JN, Liao PC. A comparison of PCDD/PCDFs exposure in infants via formula milk or breast milk feeding. Chemosphere 2007;66:311–319.

Chen HL, Su HJ, Wang YJ, Guo YL, Liao PC, Chen CH, Lee CC. Interactive effects between CYP1A1 genotypes and environmental polychlorinated dibenzo-p-dioxins and dibenzofurans exposures on liver function profile. J Toxicol Environ Health 2006;69:269-281.

Lambert GH, Needham LL, Turner W, Patterson DG, Lai TJ, Guo YL*. Induced CYP1A2 activity as a phenotypic biomarker in humans highly exposed to certain PCBs/PCDFs. Environ Sci Technol 2006;40:6176-6180.

Chen HL, Su HJ, Guo YL, Liao PC, Hung CF, Lee CC. Biochemistry examinations and health disorder evaluation of Taiwanese living near incinerators and with low serum PCDD/Fs levels. Sci Total Environ 2006;366:538-548.

Tsai PC, Huang WY, Lee YC, Chan SH, Guo YL*. Genetic polymorphisms in CYP1A1 and GSTM1 predispose humans to PCBs/PCDFs-induced skin lesions. Chemosphere 2006;63:1410-1418.

Lee CC, Yao YJ, Chen HL, Guo YL, Su HJ. Fatty liver and hepatic function for residents with markedly high serum PCDD/Fs levels in Taiwan. J Toxicol Environ Health 2006;69:367-380.

Yang CY, Yu ML, Guo HR, Lai TJ, Hsu CC, Lambert GH, Guo YL*. The endocrine and reproductive function of the female Yucheng adolescents prenatally exposed to PCBs/PCDFs. Chemosphere 2005;61:355-360.

Wang SL, Su PH, Jong SB, Guo YL, Chou WL, Päpke O. In utero exposure to dioxins and polychlorinated biphenyls and its relations to thyroid function and growth hormone in newborns. Environ Health Perspect 2005;113;1645-1650.

Hsu PC, Lai TJ, Guo NW, Lambert GH, Guo YL*. Serum hormones in boys prenatally exposed to polychlorinated biphenyls and dibenzofurans. J Toxicol Environ Health A 2005;68:1447-1456.

Guo YL, Lambert GH, Hsu CC, Hsu MML. Yucheng: Health effects of prenatal exposure to polychlorinated biphenyls and dibenzofurans. Int Arch Occup Env Health 2004;77:153-158.

Hsu PC, Huang WY, Yao WJ, Wu MH, Guo YL*, Lambert GH. Sperm changes in men exposed to polychlorinated biphenyls and dibenzofurans. JAMA 2003;289:2943-2944.

Lai TJ, Liu XC, Guo YL*, Guo NW, Yu ML, Hsu CC, Rogan WJ. A cohort study of behavioral problems and intelligence in children with high prenatal polychlorinated biphenyls exposure. Arch General Psychiat, 2002;59:1061-1066.

ATSDR Response: When deciding what PCB-induced harmful effects that residents might experience should the site become residential, ATSDR estimated the amount of their PCB exposure (or dose) from soil ingestion. A toxicologist from ATSDR then reviewed the literature to identify harmful effects that might be possible based on these site-specific, estimated doses from future exposure. The discussion of possible harmful effects was limited to those effects that might occur at or near the site-specific estimated doses. The possible health effects are described in the text and a summary of the human and animal studies that served as a basis for the described health effects are provided in Appendix B in Table B2 and Table B3. If appropriate, these articles will be added to the public health assessment.

34. **Comment**: At a minimum, the PHA should identify all areas where there is insufficient data for one or more chemicals, metals, or other hazards (all on one map, and in the text). A section for just data deficiencies would be desirable and helpful for the RI/FS and post removal sampling.

ATSDR Response: **The PHA now includes a discussion regarding areas where sampling is inadequate to make public health decisions. The PHA also includes maps that identify those areas of sufficient and insufficient sampling.**