Memorandum For: **Rachael Thompson, Executive Director**
Glynn Environmental Coalition
Brunswick, Georgia

From: **Frank Anastasi, P.G., Community Technical Advisor**
Brunswick GA Superfund Sites
Glynn County, Georgia Frank Anastasi

Date: **December 15, 2023**

Subject: **Review of Focused Feasibility Study for The Cell Building Area Portion of Operable Unit 2, LCP Chemicals Site, Brunswick GA**

This Final memorandum replaces an earlier Draft version dated November 30, 2023.

This memorandum summarizes the Montrose Environmental September 27, 2023 *Focused Feasibility Study for The Cell Building Area Portion of Operable Unit 2, LCP Chemicals Site, Brunswick* Georgia. This review highlights key considerations and technical details that will factor into the future selection of a preferred alternative for treating mercury in the subsurface beneath this part of the LCP Chemicals Superfund Site (referred to as the cell buildings area, or CBA). The study (FFS) was performed after the U.S. Environmental Protection Agency (EPA) determined that an interim remedy to treat the mercury there was appropriate as an "early action" to address risks posed by the mercury in the subsurface. Site-wide ground water contamination by numerous contaminants of concern, including mercury, will be addressed later in a separate action.

At the LCP Chemicals Site, cleanup of marsh and creek sediments is nearing completion, and deed restrictions and controls on future use of the Uplands portion of the site have been established.

GEC and its community partners met with members of EPA's National Remedy Review Board at the LCP site in the summer of 2022, and made a formal presentation to that board on June 22, 2022 regarding desires for remediation of the LCP site CBA and ground water. GEC also facilitated and participated in public availability sessions held by EPA in Brunswick on October 27, 2022 and on February 16, 2023 to keep the community informed about the FFS as well as future activities at the other Brunswick Superfund Sites.

Background

The 813-acre LCP site is located between the Turtle River and New Jesup Highway, just northwest of the Brunswick city limits. The northern boundary of the site runs along Blythe Island Highway and the southern boundary meets with the property line of the active Georgia Pacific Pulp and Paper Mill. The lead Responsible Party (PRP) for this site, Honeywell, maintains a website at http://www.lcpbrunswickcleanup.com/index.cfm.

A long history of industrial activity at the site dates from the 1920s through 1994, including oil refining, coal-fired power plant, and chemical and paint/varnish manufacturing plants. Past activities contaminated soil, ground water, surface waters/creeks, and marshlands until operations ceased in 1994. These industries polluted the site with polychlorinated biphenyls (PCBs), mercury, lead, dioxins, and polycyclic aromatic hydrocarbons (PAHs).

LCP Site Cleanup to Date

The cleanup is being managed by EPA in three parts: Operable Unit 1 - Marsh and Estuary; Operable Unit 2 - Cell Buildings Area and Ground Water; and Operable Unit 3 - Upland Soils and Sediments (at old industrial areas). EPA's website contains details the cleanup projects at https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.docdata&id=0401634.

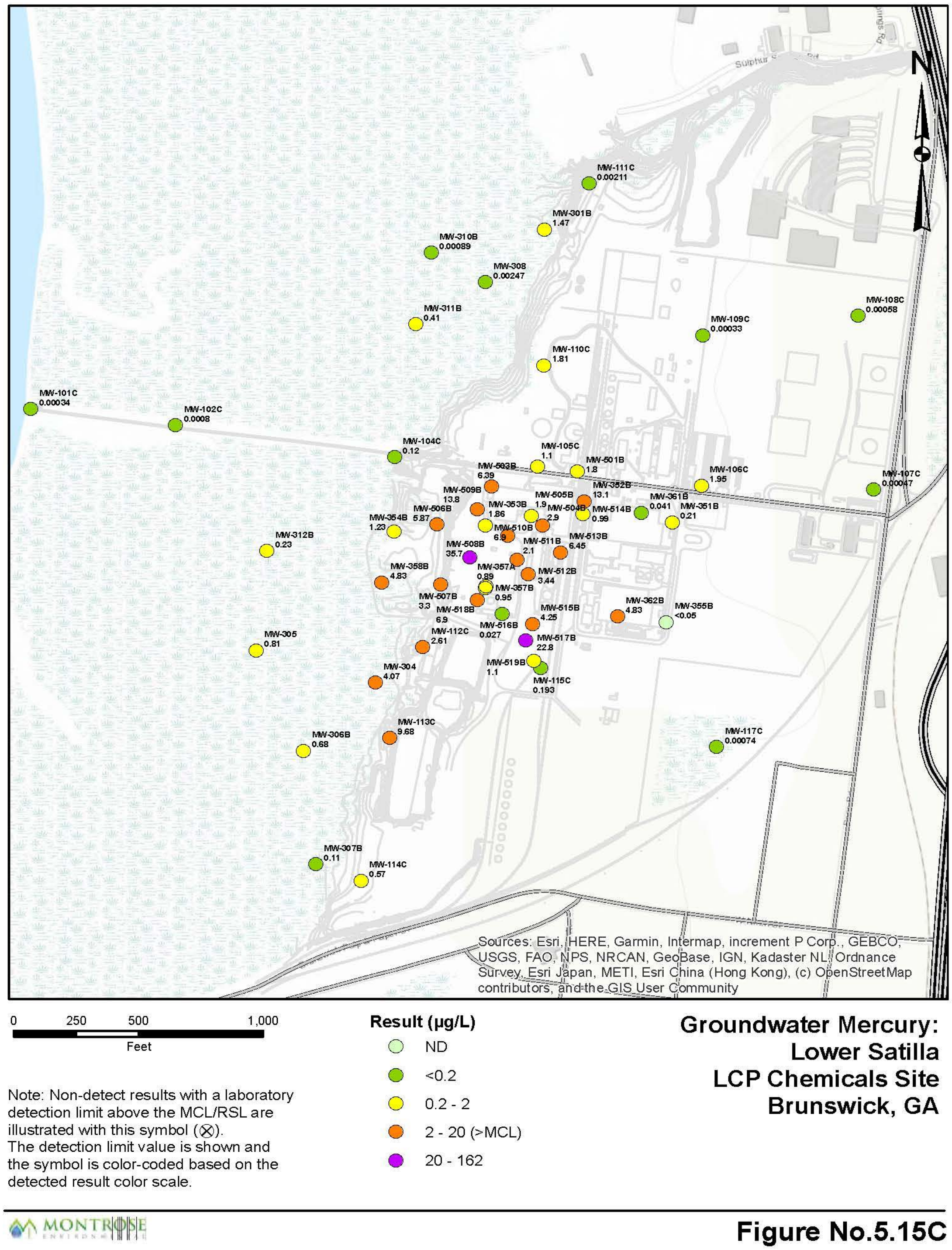
Between 1994 and 1998, approximately 130,000 cubic yards of contaminated soil and wastes were removed from the site. Industrial buildings and facilities were demolished. EPA in 2020 determined that no further action would be required for the Uplands soil and sediment after the above actions were completed, as long as the site is not used for residential purposes in the future. Contaminants in the marshlands and creeks are being addressed by dredging and covering sediments (and nearing completion at this time).

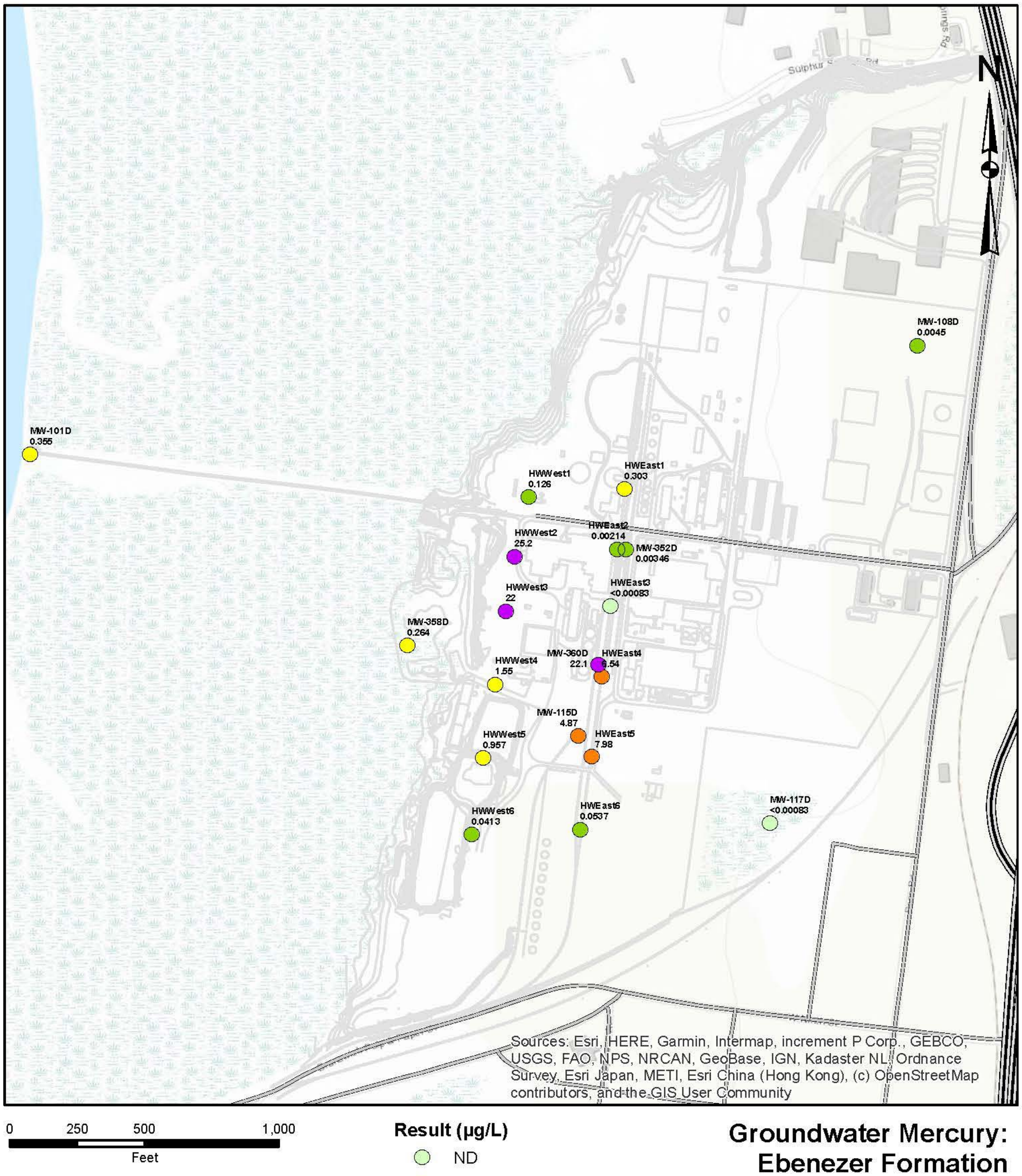
The Remedial Investigation (RI) for site-wide ground water and soil at the CBA was completed in 2022. The early action for mercury at the CBA is a major element of addressing risks from site-wide ground water contamination. The RI Report is at chrome-extension//efaidnbmnnnibpcajpcglclefindmkaj/https://semspub.epa.gov/work/04/11173841.pdf

Mercury in Ground Water at the Site

The RI Report presents information about mercury in ground water in Section 5.5.2.5 (beginning on p. 64), including Figures 5.15A – 5.15D, which show dissolved mercury in ground water in the shallow Satilla and deeper Ebenezer aquifers. A cemented sandstone leis between these two water bearing strata. The following excerpt from that section of the RI report details that contamination.

"Mercury spatial distribution mirrors that of metals such as arsenic and chromium across all portions of the Satilla with increasing concentration and extent vertically in the Middle and Lower Satilla. Exceedances of the mercury MCL are centered in the area of the former CBA and overall the condition is essentially fully bounded in the downgradient direction (one marsh well, MW-313B, exhibits a concentration slightly above the MCL). Beneath the sandstone layer, mercury detection above the MCL occurs in six wells (highest concentration is 25.2 µg/L in HWWest2) with the recent 2020 showing mercury concentrations consistent with historical concentrations. The condition is bounded horizontally within the Ebenezer Formation by well MW-101D." Additional RI Report figures reproduced below and on the following page depict the observations of mercury at monitor wells in the Lower Satilla and in the Ebenezer.





Result (µg/L)

- ND
- <0.2
- 0.2 - 2
- 2 - 20 (>MCL)
- 20 - 162

Note: Non-detect results with a laboratory detection limit above the MCL/RSL are illustrated with this symbol (⊗). The detection limit value is shown and the symbol is color-coded based on the detected result color scale.

Groundwater Mercury: Ebenezer Formation LCP Chemicals Site Brunswick, GA

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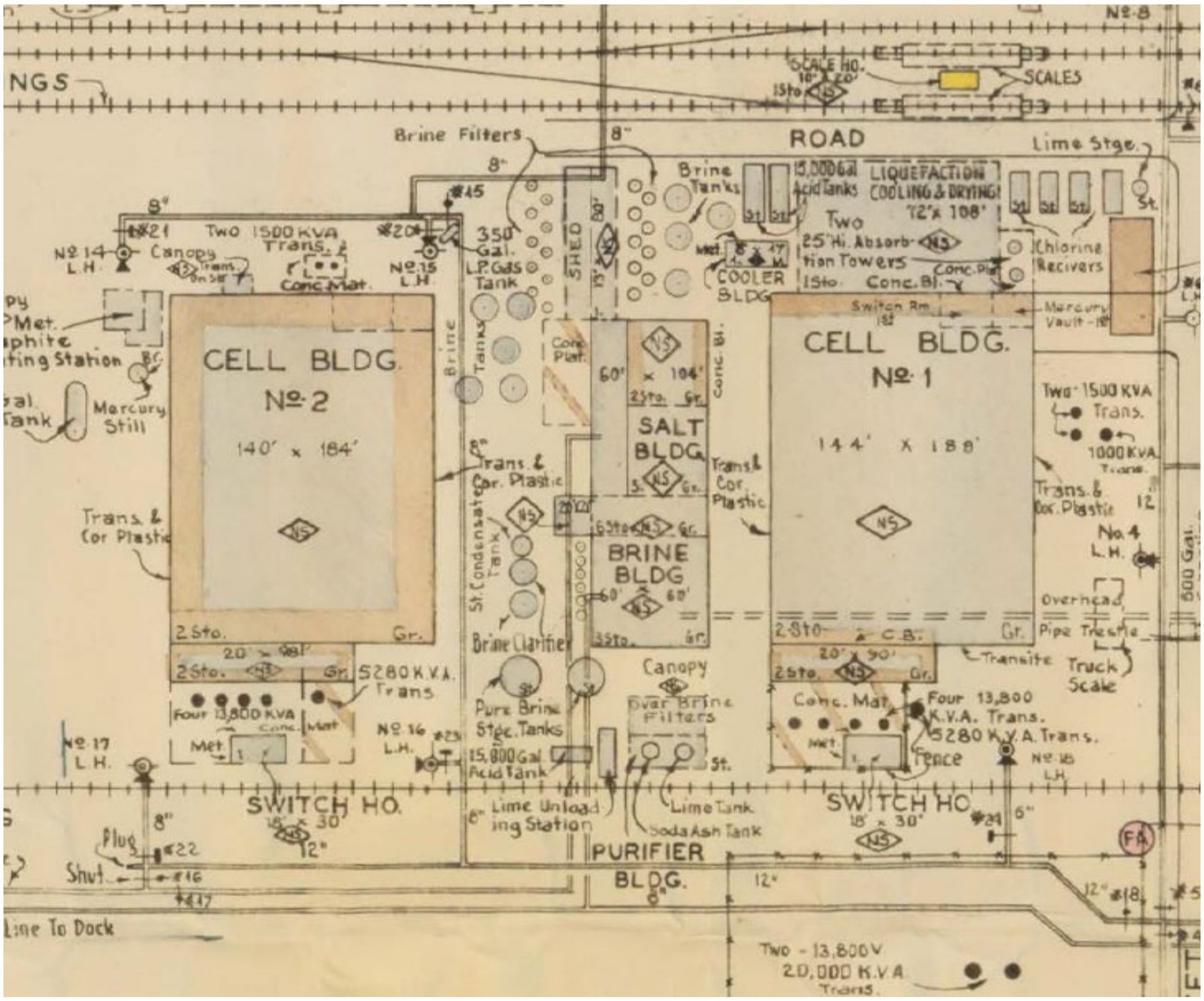
Figure No.5.15D

Mercury at the CBA

From 1944 to 1994, the "mercury cell process" was used to make sodium hydroxide (caustic), hypochlorite (bleach), chlorine gas, and hydrogen gas by immersing graphite and mercury in salty solutions at two "cell buildings". From 1979 to 1994, hydrochloric acid was also made by reacting chlorine and hydrogen. Mercury, which is liquid under ambient conditions, was lost to the environment during operations. An historical diagram showing the layout of the processing facilities at the CBA is shown below.

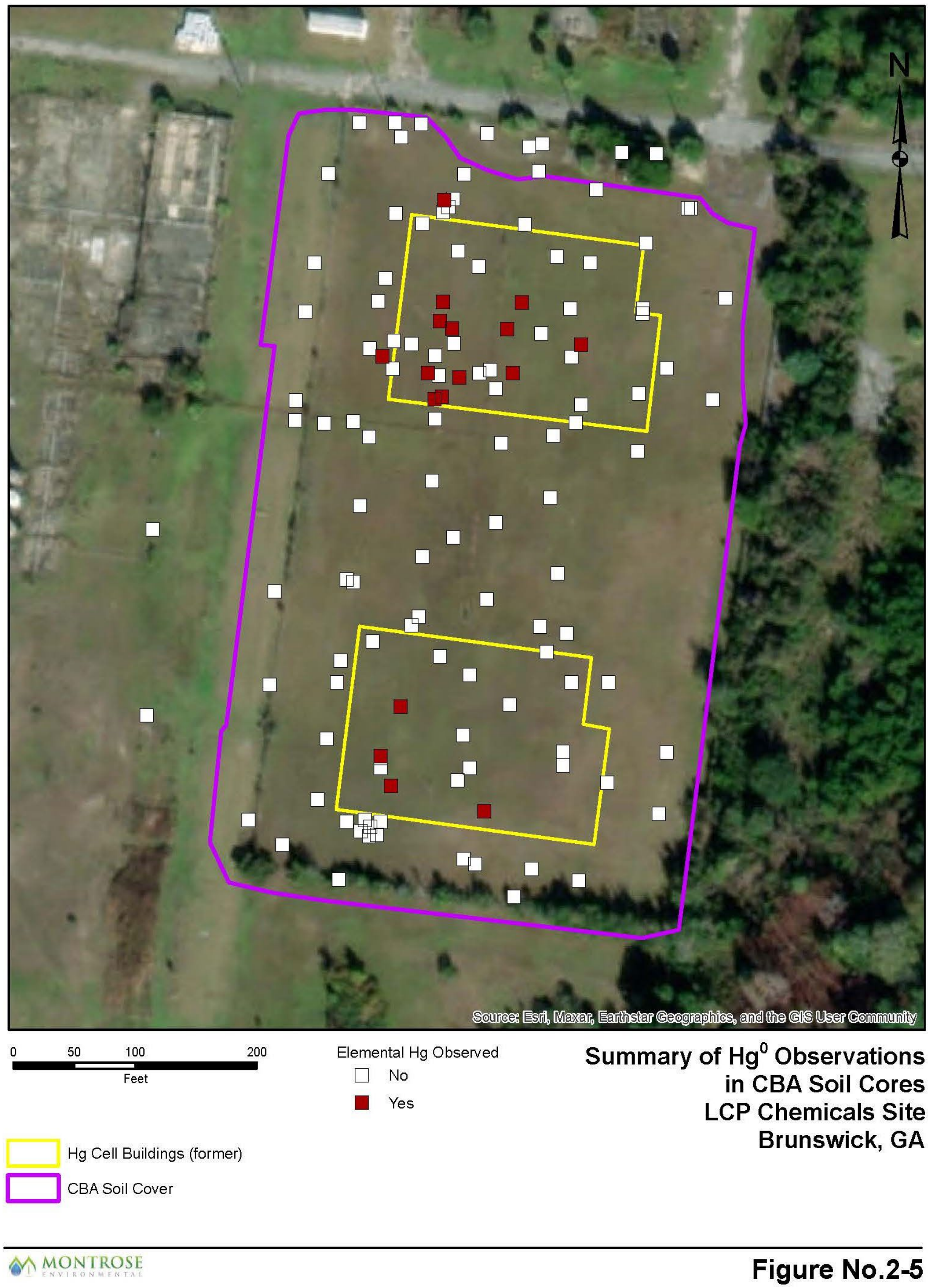


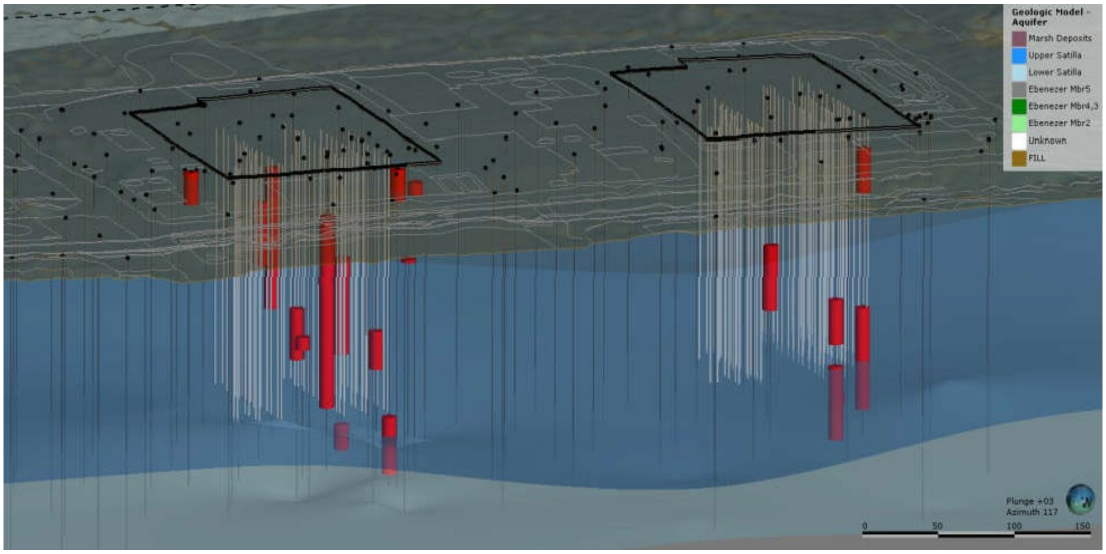
Leaks and spills of caustic solutions containing mercury, sodium hydroxide, sodium chloride brine, and bleach contaminated the sediments and ground water surrounding the cell buildings. Some liquid mercury was removed from the process equipment and from spaces beneath and between the building slabs after the cell buildings were demolished, and a soil cover was placed over the footprint of the buildings. A photograph taken during contaminated soil sampling/removal appears on the following page.

The contaminated ground water around the cell buildings had an extremely high pH - the measure of how acidic or basic (or caustic) a solution is. A pH of 14, the most-caustic limit of the scale, was observed in some places. Ground water also contained large amounts of salts and dissolved solids. This dense and highly caustic ground water sunk through the sands of the Satilla (approx. 15 to 50 feet deep). The pool spread out laterally and settled on top of a 10-foot-thick cemented sandstone that lies about 50 feet deep below the ground surface. Contamination then migrated through the sandstone into the underlying water-bearing sands of the Ebenezer.

Carbon dioxide injected into the Satilla sands lowered the pH and removed dissolved contaminants from the ground water, causing mercury and other metals to precipitate and be deposited in the sediments. Elemental mercury is not thought to have migrated through the cemented sandstone layer beneath the Satilla, however test borings did not penetrate into the sandstone out of precaution to not promote potential mercury migration through it. Ground water in the Ebenezer does contain dissolved mercury at levels above natural background (up to 25.2 micrograms per liter (ug/L, or ppb).

Elemental mercury remains present underground in certain locations. Small discrete droplets or beads of mercury were observed in the sands up to 50 feet below ground. The beads of mercury were very small, ranging up to 2 millimeters in size. Some small, localized deposits of mercury beads, ranging from less than 1 to 3 inches thick, were found in circular to elliptical shaped deposits resting upon clay layers. Areas where mercury was found beneath the cell buildings are shown in the following FFS figure; the depths of mercury occurrence are shown in the next figure from the RI report.





Focused Feasibility Study for CBA Mercury Cleanup

After the RI defined the extent of elementary mercury contamination, EPA and Georgia Environmental Protection Division (GA EPD) encouraged the PRPs to study potential early actions to reduce risks posed by mercury at the CBA. In the Superfund process, an early action, or interim remedy, may be taken to address specific high-risk situations before the ultimate site remedy is chosen. The process for early actions is a Focused Feasibility Study (FFS). In the CBA FFS, technologies for mercury removal and/or treatment specifically at the CBA were evaluated. In-situ chemical sequestration (ICS) appears to be the most promising alternative; in-situ biological treatment is the other alternative considered potentially viable.

<u>Remedial Action Objectives</u>

The established remedial action objectives for the interim remedy are:

- Prevent human exposure by direct contact to the surficial and subsurface soil across the CBA to mercury through ingestion and dermal contact above levels protective of commercial, industrial, and recreational use of the area;

- Reduce through treatment, to the maximum extent practicable, the elemental mercury present within the aquifer matrix of the surficial aquifer and mercury in soil, to minimize any continuing source of contamination to groundwater; and

- Prevent mercury vapor emissions potentially emanating from the CBA from resulting in air concentrations that would pose unacceptable risk to human health.

Screening Potential Technologies

The first step of evaluating potential remedies was to assemble a variety of potential technologies and screen them for chances of success. Technologies that were judged to be ineffective or impractical were "screened out"; the others were "retained" for development into remedial alternatives and thorough evaluation. The technologies that were considered are listed below; those that were retained are indicated by bold-face type. Table 5-1 in the FFS summarizes the technology evaluations and screening.

- **No Further Action (NFA)** - to serve as a baseline for comparing others;
- **Institutional Controls (ICs)** - record a deed restriction(s) to prevent future exposures;
- **Monitored Natural Attenuation (MNA)** - ground water monitoring to document long-term reduction in contamination via natural processes;
- **Soil Cover** - to prevent dermal contact;
- Low-permeability Cap with Perimeter Slurry Wall - physical containment;
- **In-situ Biological Treatment** - use of bacterial action to destroy mercury;
- **In-situ Chemical Sequestration (ICS)** - injection of sulfur-based material to chemically bind with mercury, forming insoluble compounds;
- In-situ Solidification (ISS) - injecting and mixing cement to encapsulate mercury in a mass of insoluble concrete-like material;
- Vitrification -using high temperature to render the sand (and mercury) into insoluble glass;
- Thermal Desorption/Retorting - heating the subsurface to vaporize the mercury with vapor recovery; and
- Comprehensive removal with off-site disposal - excavate the affected area and transport to an approved hazardous waste management facility.

MNA, ICs, and Soil Cover were judged to be inadequate on their own, but could be combined with other technologies to make up an acceptable remedy.

Rejected Technologies

A major reason for rejecting the screened-out technologies is the EPA's requirement that a remedy include *treatment* of mercury which has been determined to be a Principal Threat (a Superfund rule). Another primary reason for not retaining a technology is impracticability, due to subsurface conditions such as: unstable saturated soils down to the 50-foot depth of treatment; presence of steel piles; and very large volumes of ground water from dewatering that would have to be treated (estimated to be about two million gallons per day). The biological treatment approach was considered innovative, and would need extensive laboratory and field experimentation to determine if an effective biological agent could be found and how effective it would be in treating the mercury. The lack of experience in applying biological treatment for mercury in ground water reduces the confidence that this approach would effectively destroy or isolate mercury at the CBA.

Environmental and social impacts of the technologies were evaluated as well as the technological issues. Adverse impacts of pollutant and greenhouse-gas emissions, safety risks, and nuisance to the community, were addressed. Appendix A of the FFS presents the evaluation of the impacts. Comprehensive removal produced far greater impacts than the other alternatives; ICS caused the least impacts.

<u>Issues with Two Popular and Frequently Community-preferred Alternatives</u>

Issues with two alternatives are worth noting. Although they are traditional and common approaches to remedial actions at hazardous waste sites with subsurface soil and ground water contamination, site-specific factors render them probably inappropriate for the CBA.

Comprehensive Removal (Excavation and Off-site Disposal)

- Comprehensive removal of mercury-containing soil at the CBA would involve excavating the Satilla soils down to the top of the cemented sandstone (a depth of about 50 feet). The presence of steel pilings beneath the building slabs would complicate such excavation.

- Excavating through nearly 50-feet of saturated soils would require special precautions to keep the excavation open, such as dewatering, driving sheet piling and/or laying back excavation slopes to low angles. Such a removal approach would generate vast quantities of soil and ground water which would require treatment, management and disposal.

- The FFS states that these factors push the estimated cost of removal to far exceed the costs of the other potential approaches, although no cost estimate for this alternative was provided.

- Also as shown in Appendix A, comprehensive removal would have far greater social and community impacts than any other alternative. Emissions of pollutants and greenhouse gasses with removal would be from about three to six times more than the other alternatives; traffic and safety impacts would be up to ten times higher with removal; and public nuisance impacts would be from about three to six times worse with removal.

Low-permeability Cap with Perimeter Slurry Wall (physical containment)

- Construction of a slurry wall involves excavating native soils in a trench surrounding the wastes to be contained, and mixing/emplacing a slurry of bentonite clay/amendment material in the trench to create an impermeable barrier. This would generate significant volumes of soil that would require treatment and off-site disposal.

- Successful containment via slurry wall requires that the base of the wall is keyed into an impermeable soil layer that runs beneath the waste, completing the containment cell on the bottom and preventing downward leakage of contaminated ground water. At the CBA, a dense clayey soil layer is present at the base of the Satilla in some locations but not everywhere. A slurry wall would have to be keyed into that clay layer where present, and into the underlying cemented sandstone where the clay is absent. The sandstone is permeable, so ground water could leak through it and into the underlying Ebenezer aquifer. This would limit the degree of containment that could be achieved.

- An impermeable cap would be required over the CBA to prevent infiltration of precipitation into the waste containment cell and complete the containment on the top. An appropriate cap for such a Superfund containment remedy would be multi-layered with clay and geotechnical liner material. This type of cap over the six-acre CBA area would add significant cost to the remedy.

- Subsurface hydraulic control would be necessary for long-term stability and performance. The FFS notes that outside the wall, this would involve collecting ground water on the up-gradient side, and routing collected ground water around the containment cell to down-gradient areas. Dewatering could be required inside the wall as well, and any collected ground water would have to be treated and managed in the future. Pumping, treating, and disposal of contaminated water from within the CBA containment cell over the long-term would likely require significant maintenance.

- The FSS notes that these factors would significantly increase the cost of the remedy, although no cost estimate was provided.

<u>Retained Remedial Alternatives</u>

The retained technologies were developed into two active Remedial Alternatives, which include MNA and soil cover; these active remedial approaches were compared to No Further Action as required by the Superfund process.

- No Further Action;

- In-situ Biological Treatment with MNA and Soil Cover;

- In-situ Chemical Sequestration with MNA and Soil Cover.

No Further Action is not an option for the mercury contamination, and Biological Treatment was judged to be innovative, with little real-world experience, and as such would require much study. ICS appears to be the most-promising alternative.

<u>Apparent Best Alternative – In-situ Chemical Sequestration</u>

The FFS indicates that ICS is the leading contender for selection as the preferred remedial alternative (with MNA and soil cover). It would address two of the three remedial action objectives – treating the mercury source and protecting against potential subsurface mercury vapor formation – while an improved soil cover would address the objective of preventing dermal contact with the mercury. Compared to biological treatment, ICS appears to have better chances for success and could be implemented more quickly. Important elements of ICS, as explained in the FFS, are summarized as follows.

- This is a chemical treatment approach that will "fix" (or *sequester*) dissolved and elemental mercury in the saturated zone.

- ICS for mercury would use sulfur-based chemical amendments. Sulfides are known to directly convert mercury to mercury sulfide (the mercury and sulfur combine to form the minerals cinnabar and metacinnabar). These minerals are essentially insoluble.

- ICS would result in conversion of mercury to mercury sulfide, and encapsulation of the elemental mercury beads within a layer of the mercury sulfide, thus inhibiting further solubilization of elemental mercury into ground water.

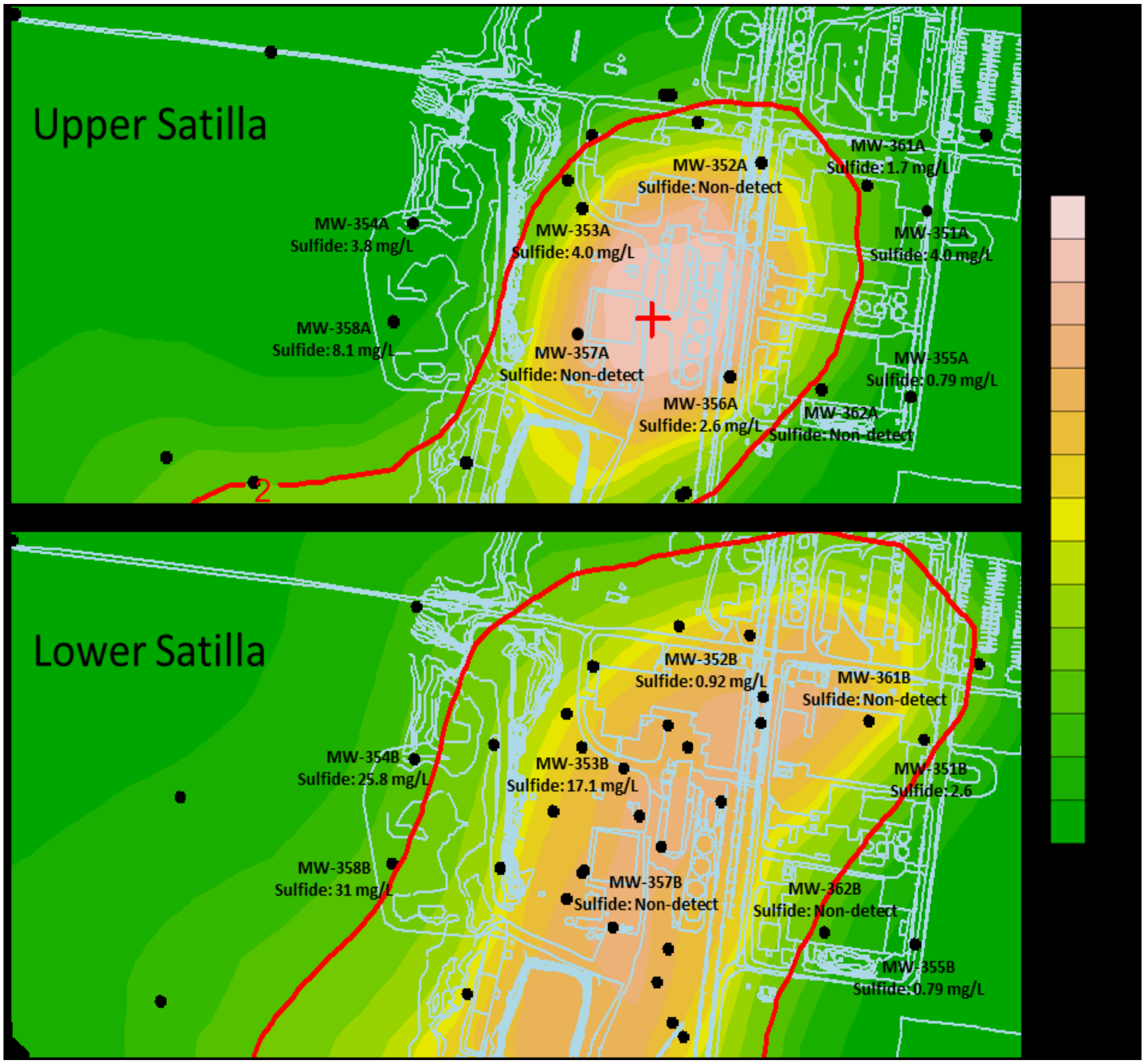
- A primary advantage is that ICS is implemented with widely available mobile, direct injection technology, or temporary injection wells can be installed, such that the subsurface obstructions like pilings can be easily avoided.

- Injection points and treatment-chemical volumes can be readily modified as the technique is implemented to ensure adequate distribution throughout the target areas.

- The cost of the ICS remedy is estimated to be about $4.7 million, including 30 years of operations and maintenance (maintaining the soil cap and monitoring for MNA). FFS Appendix E contains the details of the cost estimate.

- The entire process for pilot testing, designing, and completing this remedy is tentatively estimated to take about 18 months (as noted in the cost estimate - see Appendix E). The FFS does not indicate, however, how long it would take after injection is completed before the mercury would be rendered insoluble.

The FFS presents information from historical ground water monitoring that demonstrates that some degree of natural in-situ mercury sequestration is occurring at the CBA (Section 6.3.4.4.2 beginning at p. 32). Mercury and sulfide concentrations and other geochemical evidence indicates some natural formation of mercury-sulfide compounds. This increases confidence that ICS would be successful at the CBA. The graphical depiction of the underlying data and explanatory discussion contained on FFS p. 34 is reproduced on the following page.



This series of figures depicts the last dissolved mercury concentration profile in the Upper and Lower Satilla in 2012 prior to commencing CO_2sparging and the most recent data set for dissolved sulfide. Note the historical concentration drop in dissolved mercury occurred near the marsh-upland border west of the CBA (see Section 5.4). Corresponding to the marsh-upland boundary is a historical increase in the dissolved sulfide typically increasing from a few mg/L or less to greater than 20 mg/L in the Lower Satilla. Sulfide concentration is provided in the well label. The intersection of high sulfide and the dissolved mercury front is interpreted to be one pathway for the attenuation of mercury with potential formation of HgS. Mercury MCL of 2 µg/L shown as red line.

Pilot Testing for ICS

Appendix C of the FFS presents an outline of the pilot testing that will be performed to determine the appropriate chemical amendment make-up and the volumes of chemical amendment that will need to be injected into the subsurface to effectively treat the mercury.

Pilot testing will follow four sequential steps:

- Detailed assessment of CBA groundwater;

- Refinement of CBA geochemical model;
- Bench-scale studies of ICS amendments; and
- ICS design.

A detailed chemical profile will be developed for CBA ground water. Sampling and laboratory analysis will determine major ions, dissolved mercury other metals, natural organic matter, and geochemical parameters such as pH, oxygen reducing potential, temperature, alkalinity.

Geochemical modeling was performed in the FFS to predict the stability of mercury in the aquifer. The information gained by the detailed chemical profiling will be used to model mercury stability more thoroughly. Also, variations of amendments and amendment doses will be assessed to support the bench-scale pilot testing design.

Laboratory bench testing of chemical amendments will be performed to evaluate reactivity and suitable concentrations in the presence of site-specific geochemical conditions present in the CBA treatment zones. Tested amendments will include sodium polysulfide, colloidal sulfur, iron sulfide, and potentially one or more non-sulfur-based amendments. Soil cores from the CBA containing elemental mercury will be subjected to the various amendments to observe how well each amendment converts mercury into mercury sulfide.

The ICS process will be designed after bench testing demonstrates adequate formation of mercury sulfide. The process for implementing ICS at the CBA will be tailored to the specific ICS treatment zones, and a final design will be prepared and submitted in the overall CBA Remedial Design package for EPA and GAEPD review and approval.

November 30, 2023 EPA Presentation and Public Meeting

EPA explained the FFS and discussed citizens' concerns at a public meeting held in Brunswick on November 30, 2023. This meeting was held to give community stakeholders an opportunity to learn about what EPA is considering for the CBA, and to discuss their concerns about the site and the potential interim action. This meeting was not the required public meeting for a Proposed Plan, which would announce EPA's preferred alternative once that is determined. The Proposed Plan is the next step in the Superfund process toward selecting a remedy. A public comment period would follow release of the Proposed Plan (30 days is required, but extensions are typically granted when requested).

The community stakeholders' primary concerns raised in the meeting are summarized below.

- Uncertainty about the mercury that must still be out there beyond the CBA in the soil, marsh and estuary sediments, and ground water – it is causing health and environmental impacts. What is EPA going to do to protect the community and the environment from this contamination (beyond the marsh sediment remedial action that is just being completed and the future CBA interim action)?

- Doubts that either ICS or biological treatment will provide the level of protection the community desires and produce meaningful ground water cleanup in a timely manner.

- Disappointment that it has taken decades to reach this point in the cleanup process, and that EPA's procedural requirements will delay implementing the interim remedy further.

- Concern about potential health and environmental risks of introducing the chemicals or biological agents to be used in ICS or biological treatment into the local environment.

- Requests that EPA provide additional information, that lay persons can understand, about the biological treatment approach so stakeholders will be able to compare it to ICS and make better-informed comments about the two alternatives.

- Frustration that in the past, while the community has commented on EPA proposals for remedial actions at LCP (as well as the other Brunswick Superfund sites) expressing strong desires for other solutions, EPA has not taken actions that the community preferred.

- Concern about inability to get answers to questions that relate to some of the other Superfund site issues at meeting such as this, when only one EPA project manager holds a meeting on that person's area of responsibility (for example, Mr. Pope could not answer questions about marsh remediation because he oversees the ground water issues at LCP, and the person responsible for marsh remediation was not present).

Future Activities

Following the November 30 meeting, EPA is soliciting early input from the community stakeholders about alternatives for the interim action. Mr. Pope committed to considering stakeholders' comments and their position on these issues. He may hold additional informative sessions as the process moves forward if needed. Also, in response to requests, he agreed to provide additional information about the alternatives, especially biological treatment, so that community members can better compare that to ICS, evaluate the alternatives, and comment on them to EPA.

The EPA's next official step toward implementing the CBA interim action will be formal issue of the Proposed Plan, which will state EPA's preferred alternative and request public comment in 2024. When the Proposed Plan is issued, EPA will schedule a formal public meeting and hold the public comment period (30 days minimum).

After reviewing comments from the public and any other stakeholders, EPA would release an interim Record of Decision for the selected remedial action for the CBA. GEC has been coordinating with EPA to facilitate this outreach.

Closing

I trust that this memorandum will serve as a useful and timely reference for GEC and the community on the upcoming cleanup at the CBA. I enjoyed supporting GEC and the community at the November 30 meeting and helping to keep community stakeholders informed on this aspect of the LCP Site cleanup. I look forward to continuing this support through 2024 (and likely in 2025) as the process moves to actual remedial design for the selected remedy. If you have any questions, feel free to contact me at (301) 309-0061.