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Date: **June 15, 2022**

Subject: **Summary of December 2021 Draft Remedial Investigation Report**
Operable Unit 2 – Site-wide Groundwater and Cell Building Area
LCP Chemicals Superfund Site, Brunswick, GA

Introduction

Montrose Environmental prepared the December 2021 Draft *Remedial Investigation Report, Operable Unit 2 – Site-wide Groundwater and Cell Building Area* of the LCP Chemicals Superfund Site, Brunswick, GA for the LCP Site Steering Committee. OU2 encompasses all ground water beneath the entire 813-acre LCP site and includes the subsurface within the former chlor-alkali cell building area (CBA).

The Remedial Investigation (RI) report is a preliminary or "draft' version of what will become a Final RI Report after remaining issues between Honeywell and the regulators are resolved. This version builds upon several preceding reports on contamination of ground water and the subsurface at the CBA. It summarizes the history of investigations and findings of the work performed over 25 years, and integrates the historical data with more-recently acquired information to refine the conceptual site model (CSM), which is the current understanding of the nature and extent of the site-wide ground water contamination and contamination beneath the CBA.

The knowledge of contamination conditions presented in the report forms the basis of the included Human Health Risk Assessment (RA) for site-wide ground water and for the soils at the CBA. Assessment of the origin, fate, and transport for the primary constituents of concern (COCs) is also included in the RI report. The RA and fate and transport assessment will support evaluations of potential remedial alternatives in the next step of the remedial process, the OU2 Feasibility Study (FS, planned for 2022-2023).

This memorandum focuses on summarizing the findings of the RI and the RA. I will perform a complete technical review of the final RI report once it is published (expected in the third quarter of 2022). The reader is referred to GEC's May 2020 Technical Assistance Report on the final phase of site characterization activities for OU2 *Subsurface Contamination Defined at LCP Chemicals Superfund Site* for details about the nature and extent of contamination in OU2.

Background

The LCP site is located between the Turtle River and New Jesup Highway, just northwest of the Brunswick city limits. It is owned by Honeywell, who along with Georgia Power Company are the responsible parties that have cooperated with EPA to investigate and clean up the site.

Various industries have operated at the site. ARCO operated an oil refinery from 1918 to the early 1930s; a power plant was operated by Georgia Power from the 1930s to the 1950s; Dixie Paint and Varnish Company ran a paint and varnish manufacturing facility operated by from 1941 to 1955; and a "chlor-alkali" facility that produced chlorine gas, hydrogen gas, and caustic solution was operated by Allied (now Honeywell) from 1955 to 1979 and by LCP Chemicals from 1979 to 1994. The following page shows a site map from the RI report showing the chlor-alkali operations.

Remedial actions performed to date have focused on the 133-acre uplands portion of the LCP site where the industrial activities took place, and the 670-acres of tidal marshlands with varying levels of contaminated sediments. These actions include removal of wastes and contaminated soil, and design of a dredging and thin-layer cover placement remedy for on-site creeks and marshlands.

In 2006, remedial efforts began to focus on the CBA, including the former mercury cell chlor-alkali process operations and associated releases of process liquids, sodium hydroxide (caustic), and brine solutions which formed the caustic brine pool (CBP) of contaminated ground water. Carbon dioxide (CO2) was injected into the CBP from 2013 to 2019 to reduce the pH of the CBP, from as high as 14 (the most-basic level of the pH scale), and to reduce the specific gravity of the CBP (promoting precipitation of dissolved metals). A temporary soil cover was placed over the cell buildings slabs to prevent direct exposure to mercury and its vaporization into the ambient air.

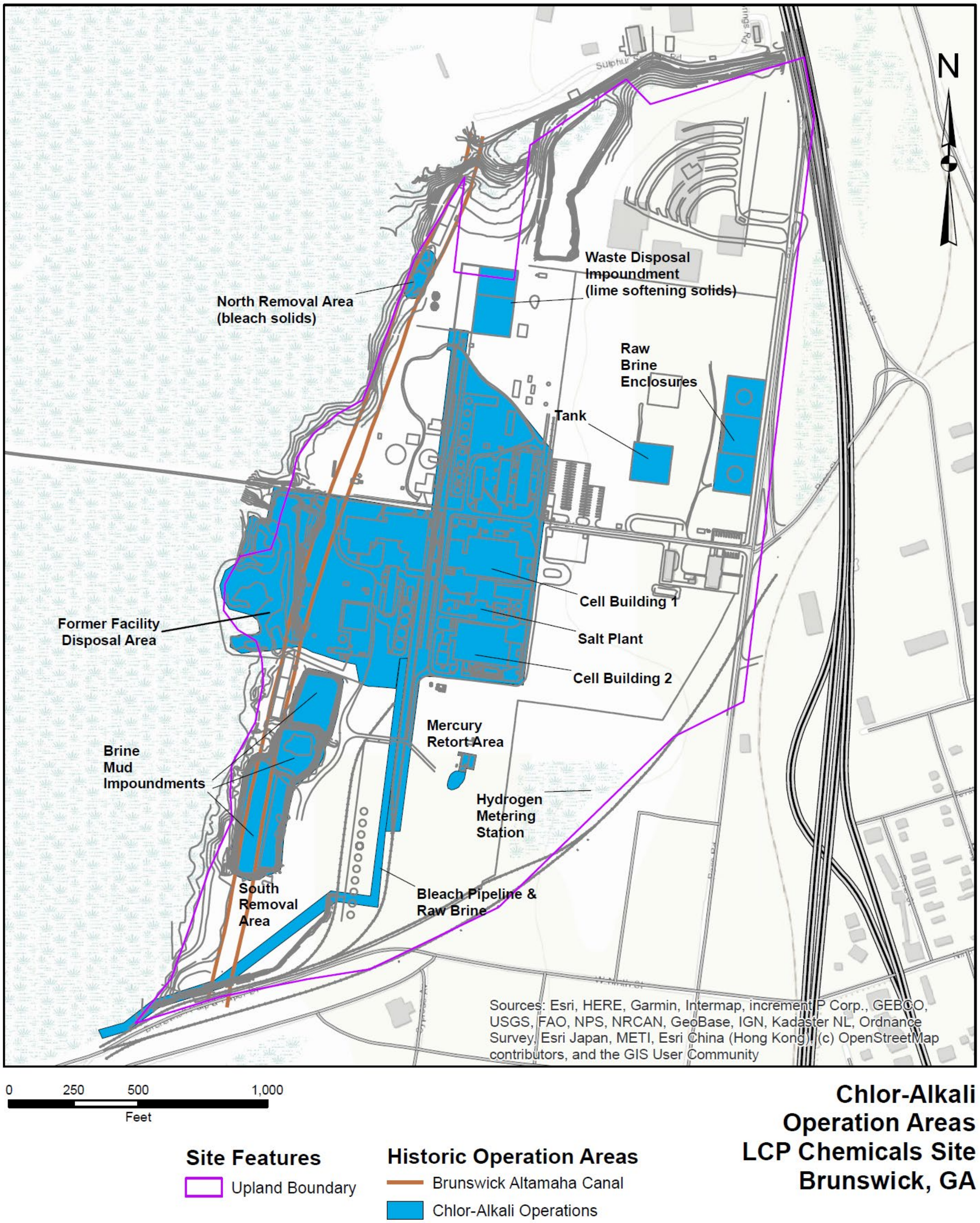
Historical Releases and Resulting Contamination

<u>Cell Building Area</u>

The history of operations at the CBA began with Allied Chemical and Dye Corporation operating the chlor-alkali facility in 1955, producing caustic solution, chlorine gas, and hydrogen gas. The mercury cell process was used, which involves concentrated brine solution and a flowing elemental mercury (Hg0) liquid layer cathode to produce chlorine gas, sodium hydroxide (caustic), and hydrogen gas. Sodium hypochlorite (bleach) was also produced in a secondary reaction. Linden Chemicals and Plastics purchased the property in 1979 and continued to operate the chlor-alkali facility until 1994 when Georgia revoked the facility's permit.

The chlor-alkali operation took place south of B-Street in two buildings (No. 1, the north building) and No 2, the south buildings, each containing an independent mercury cell process. The process involved a salt purification plant and holding tanks for process liquids. Historical release of mercury is attributed to leaks and spills of Hg0 during operations, and dissolved mercury in caustic releases. Leaks and spills also occurred for liquid caustic, sodium chloride brine, and bleach.

Leaked process liquids were denser than ground water, so the process liquids flowed downward as a dense non-aqueous phase liquid through the shallow sands until it came to a 10-foot thick



layer of cemented sandstone with lower permeability that lies about 50 feet below ground surface (bgs). The caustic brine pool spread out laterally as it settled on top of the sandstone. The sandstone is the top of the Ebenezer Formation, a water-bearing sand layer about 40 feet thick lying beneath it. Contamination migrated through the sandstone into the water-bearing sand, known as the Upper Ebenezer Formation. In some locations, contaminants including dissolved mercury are present.

The chlor-alkali operations included several impoundments for dewatering waste process slurries (lime softening muds, bleach muds, brine muds, and raw-brine solids). These impoundments were not lined to prevent leakage, and included some of the Brunswick-Altamaha Canal that historically traversed the western half of the Site. The former impoundments extended up to 10 feet or more below ground surface, and therefore liquid wastes deposited in them was in direct contact with ground water.

Mercury and mercury-contaminated alkaline sludges were present in CBA, Mercury Retort Area, Caustic Tanks Area, bleach mud at the North Removal Area, lime softening mud at the Waste Disposal Impoundment, the Brine Mud Impoundments, Former Facility Disposal Area, and adjacent portions of the marsh, including tidal channels. The above-grade wastes were removed, and Hg0 was collected from the process equipment. The Cell Buildings were demolished, and a temporary soil cover was placed over the CBA to prevent direct exposure to the cell building slabs and to mitigate potential mercury vapor emission. At the Mercury Retort Area, the above-ground concrete structures, as well as the soil and retort waste were removed. Above ground tanks and soils that were contaminated with mercury and caustic were removed from the Caustic Area. The mercury-containing alkaline sludges were also removed.

The wastes released in the CBA and related operations areas contaminated the ground water. The area of contaminated ground water (the caustic brine pool, or CBP) extended beyond the footprint of the Cell Building Area as well as beneath the buildings. Eventually, CO2 was injected through 257 wells to reduce ground water pH to below 10.5 and reduce certain dissolved-phase metals, including mercury. This resulted in precipitation of the metals, including elemental mercury, in the sands of the shallow aquifer.

Petroleum Refining/Power Generating/Paint and Varnish Operations Areas

Atlantic Richfield operated a petroleum refinery across the uplands part of the site from 1919 to the early 1930s, with more than 100 process and storage tanks. The refinery was first fueled by coal (until 1922) and then primarily by oil until it ceased operations in 1935. Georgia Power purchased portions of the Site in 1937, 1942, and 1950 and generated more than 4 megawatts of electricity at the site using Bunker C oil as fuel. Dixie Paint and Varnish Company operated a paint and varnish manufacturing facility from 1941 to 1955 on part of the site south of the Georgia Power property.

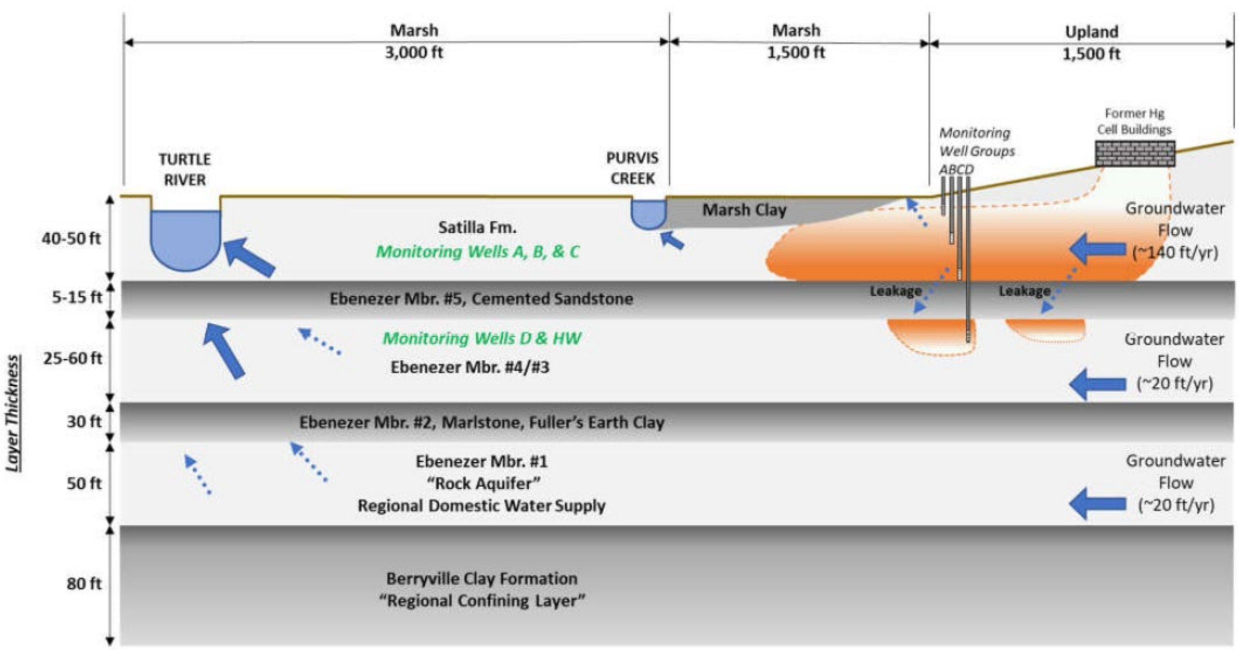
Petroleum refining and related operations, fuel tanks, and wastewater processing in the North and South Removal Areas, North and South Separators, and Bunker C Oil Tank Area released petroleum tar-sludge wastes and liquid petroleum products which saturated the soils. Also, petroleum process sludges were buried in portions of the former Brunswick-Altamaha Canal. A petroleum-hydrocarbon smear zone is present across much of the upland portion of the site, at the depth range of the historic water table. This weathered petroleum product has contributed several contaminants to site-wide ground water. Waste management procedures are not known for the paint and varnish plant, however it is considered likely that releases from it had ground water impacts.

Site Hydrogeology

The site has a generally flat surface that grades gently from the east with elevation of about 15 ft. above sea level (msl) to the west with elevation of about 4 ft. msl near the edge of the marsh. Drainage channels constructed after waste removal activities promotes runoff to the marshlands along the western border of the site. The water table is generally about three to four feet bgs.

About 50 feet of sands of the Satilla Formation underlie the site. This unit represents the shallow water-table aquifer with relatively high hydraulic conductivity. Under the Satilla is the Ebenezer Formation, the top of which marked by a layer of cemented sandstone of lower conductivity which serves as a semi-confining layer between the shallow Satilla aquifer and deeper ground water in Ebenezer sands, sandstone and marlstone. Ground water flow in the Satilla Formation and Ebenezer Formation is generally to the west. The Turtle River is the downgradient hydrologic site boundary; it is a regional discharge boundary for groundwater flowing within the surficial aquifers. The Berryville clay underlies the Ebenezer at about 175 feet bgs. The generalized hydrogeology beneath the site appears in the figure below.

Generalized Hydrogeologic Setting Surficial Aquifer System



The Upper Satilla sands range from fine- to coarse-grained and reach a thickness of about 30 to 40 feet, but it is thinner near the marsh edge. Discontinuous thin layers of silty clay are present in some places. Lower Satilla strata range from clay and silty clayey sands to clean coarse sand with shells, with combined thickness of 12 to 14 feet in the northeastern part of the site to about two to four feet in the southeastern part of the Site. In some areas, and across the southwest portion of the site, there is no clay present.

The top of the Ebenezer Formation is a cemented sandstone at a depth of approximately 50 feet bgs. The sandstone is strongly to weakly cemented and contains a matrix of silica, dolomite, and phosphate cements. The variably cemented sandstone was present in every drilled to that depth boring across the entire site. Its thickness ranges from about five to 15 feet. The sandstone is considered a semi-confining unit based upon petrographic testing, pumping test response, and chemical concentration profiles between wells screened above and below the unit. Water bearing sands and silty strata beneath the sandstone reach a total thickness of about to 30 to 60 feet.

The majority of the site ground water flux discharges from the Upper Satilla into Purvis Creek, with lesser discharge to the marsh at seepage areas near the marsh-upland border. Groundwater seeps were first noted during early studies in 1995, occurring west of the brine mud impoundments on the southwest part of the Site. Potential preferential groundwater pathways that could result in releases to surface water were investigated, and 14 areas of groundwater discharge or seeps were identified at the marsh surface, near the marsh shoreline, and along the channel edges. Seeps north of the causeway appeared significant. The remaining seeps identified had low groundwater discharge and did not appear to impact the water in the marsh surface channel.

Eight of the 14 seeps were instrumented with pore water samplers (referred to as peepers) placed at two depths within the marsh clay layer that overlies the Satilla water-bearing zone.
The RI report states that the peeper results "suggest that transport of mercury, lead, total PAHs, and Aroclor-1268 via focused groundwater pathways in the marsh result in nominal concentrations at the point of discharge" and that "the marsh clay layer is effective in attenuating the chemical transport as groundwater upwells to discharge."

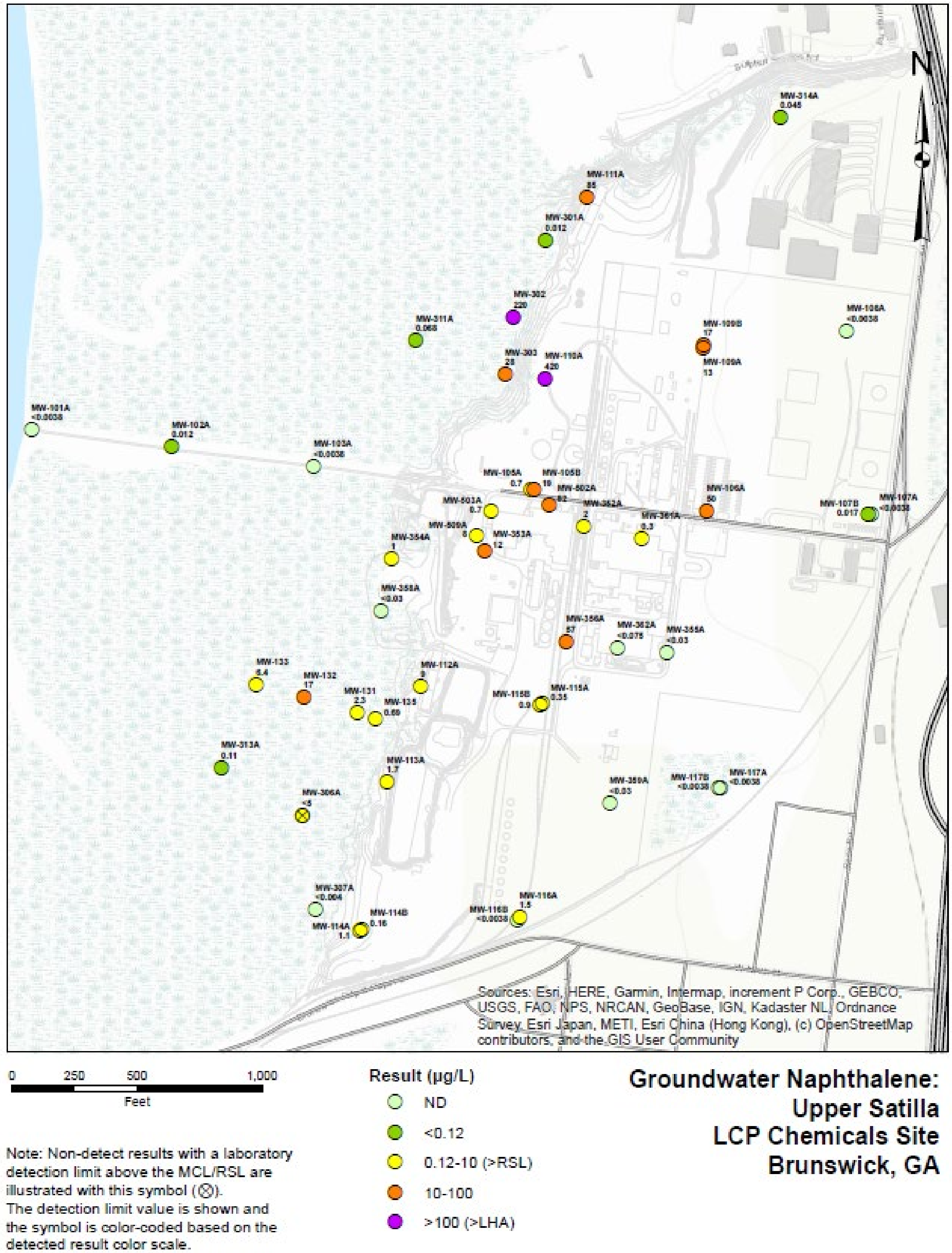
RI Findings and Conclusions

<u>Ground Water</u>

Ground water investigations have been conducted since 1995. Section 4 of the RI report recounts the many phases of sampling. In addition to many direct-push discrete ground water sampling borings, more than 100 monitor wells were installed and sampled from 1995 to 1997. Between 199 and 2000, additional wells were installed and sampled, including two sets of horizontal wells drilled beneath the cemented Ebenezer sandstone strata. Each of the two horizontal well sets consist of six separate screened zones for sampling set along the approximate 1300 feet length of each horizontal well bore. Ground water sampling continued through 2020 to close data gaps and ensure a current and complete understanding of ground water contamination at OU2.

Based on the definitive data set for OU2, the RI report presents the following findings on ground water contamination (see RI Figures 5.5A through 5.17E for the nature and extent for each COC):

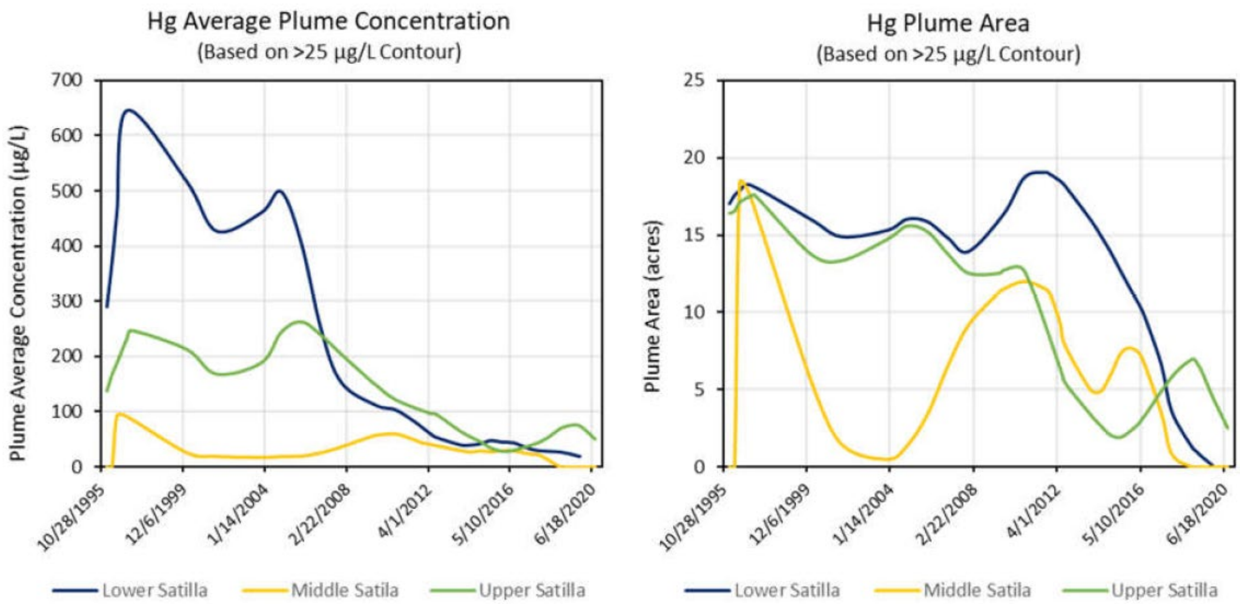
- No light non-aqueous phase liquid (LNAPL) petroleum product remains on the ground water surface (from previous petroleum refining, storage, and waste management operations). Elevated levels of several petroleum hydrocarbon compounds, such as benzene and naphthalene, remain however, due to the weathered residual petroleum adsorbed on the sandy soil at the water table. The following figure (RI Fig. 5.9A) presents the distribution of naphthalene in upper Satilla ground water across the site.



- Contaminants including metals, VOCs, and PAHs are present in shallow ground water of the Satilla formation at elevated levels in some locations due to historical releases during past industrial operations and on-site waste disposal. The most recent and complete data set shows that the levels of some of these contaminants exceed MCLs at the farthest downgradient (westerly) sampling locations.

- VOCs and SVOCs detected in some monitoring wells screened within the deeper Ebenezer Formation indicate some transport of contaminants has occurred across the variably cemented sandstone layer.

- Metals were elevated at and near the CBA and associated CBP as a result of the extremely high pH caused by caustic releases from the chlor-alkali plant operations and related waste disposal. Levels are now reduced following the CO2 injections which neutralized ground water pH. The RI evaluates the presence and concentrations over time of the metal COCs mercury, arsenic, beryllium, chromium, lead, selenium, and vanadium. Various dissolved metals are present at levels that exceed drinking-water maximum contaminant levels (MCLs) at various depths and locations. The following graphs from the RI report illustrate this situation for Hg0 (elemental mercury).

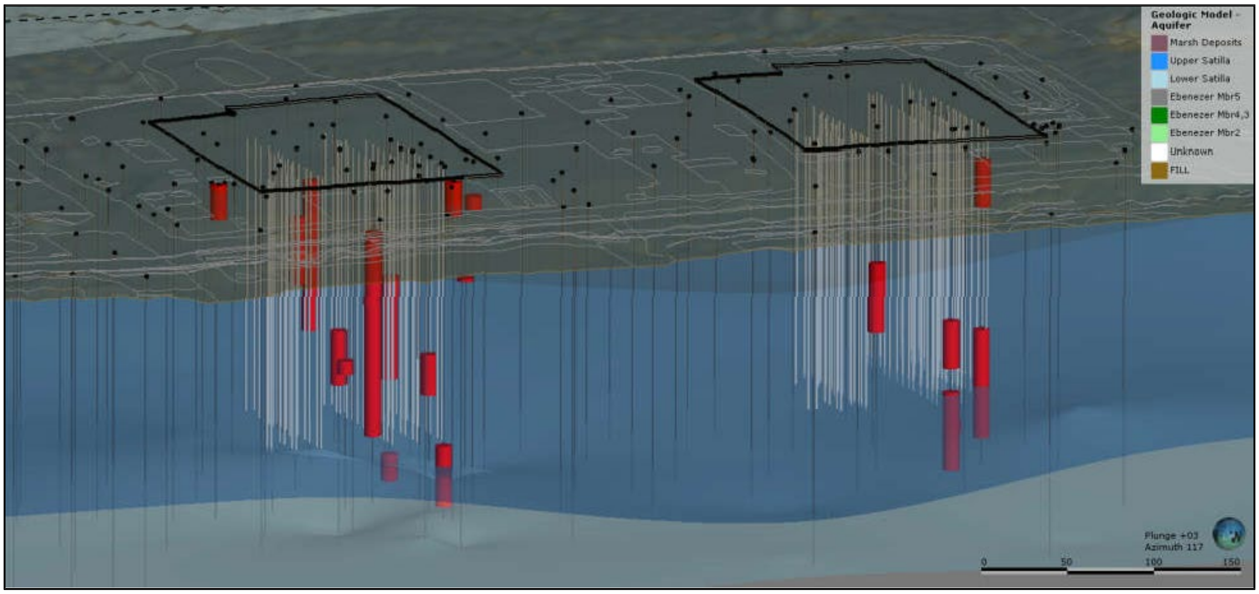


- While the impacts of releases from the past industrial operations are greatest in the shallow Satilla aquifer, elevated levels of pH, sodium, chloride, mercury, and some petroleum hydrocarbon compounds are present beneath the cemented sandstone layer in the deeper water of the Ebenezer aquifer.

<u>Cell Building Area Soil</u>

The two cell buildings and the salt purification plant make up the CBA. Significant subsidence (sinking) occurred during operations due to caustic releases weakening the Satilla sands (partial dissolution of quartz grains within the sandy matrix). This promoted migration of Hg0 downward within the Satilla sands. The distribution of Hg0 was delineated from the hand-augered soil borings, digging test pits, and deep soil boring coring. These investigations are summarized in Section 6 of the RI report, and the major findings are summarized below.

The assessment of Hg0 was performed primarily through visual observance of beads of Hg0. Laboratory testing for mercury in soil samples was also employed. The soil core borings revealed Hg0 to be present as small discrete droplets observed in the vicinity of the subsidence area beneath Cell Building 1 and at shallow depths along the southern side of Cell Building 2. In the subsidence area, discrete droplets of Hg0 were observed to a depth of 50 ft-bgs. Hg0 was not observed at depth in the former caustic loading area or at the former retort pad. The following figure from the RI report illustrates the vertical migration of mercury down through the Satilla sands, and into the top of the underlying cemented sandstone layer of the Ebenezer formation.



Observational soil borings marked with a black dot at the ground surface interface and vertical trace. Soil boring intervals with Hg^0 marked with a red cylinder. Pilings are illustrated with narrow silver cylinders and the former cell buildings are outlined in black.

Specific findings for CBA soil reported in the RI were as follows:

- Other than mercury, contaminants detected at elevated levels in CBA soil include the PAHs naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene and PCBs;
- Hg0 was present in void space under and between the concrete slabs of Cell Building 1;
- Hg0 was observed at depth mainly to the south and east of the Cell Building 1 subsidence;
- Small discrete droplets or beads of Hg0 were observed in the soil cores in aquifer sands (not in clay strata), and ranged from 20 micrometer (µm) to 2 mm in size; and
- Hg0 bead stringers are typically less than 1 inch thick but range up to 3 inches thick.

Fate and Transport Analyses

The fate and transport of COCs were evaluated and modeled to forecast metals behavior under the range of groundwater conditions including effects of the CBP and CO2 sparging. The CBP's very high pH, and very low ORP (reducing condition) were major factors promoting mobilization of metals. The CBP conditions increased metal solubility, formed solubilized organic matter, and broke down of the aquifer silica matrix. Away from the CBP, levels of metals such as mercury and arsenic were reduced due to adsorption and precipitation.

Modeling of metals migration from the former CBP show that after CO2 injections reduced the pH, increased adsorption and/or precipitation of metal COCs occurred. Arsenic and mercury precipitate as insoluble sulfides, and chromium occurs as the insoluble and benign Cr3+ oxidation state under all future site groundwater conditions. Dissolved phase organic matter should also reduce dissolved concentrations of beryllium and vanadium.

These evaluations predict a trend toward lower levels of dissolved metals in ground water as the system returns to neutral ground water pH conditions in and down gradient from the former CBP area.

Risk Assessment Findings and Conclusions

The RA is contained in Section 7 of the RI report. It considers potential exposures to Hypothetical Future Resident (child and adult), Future Site Worker, Excavation Worker, and Trespasser. These receptors' potential exposures are depicted in RI report Figures 7.2 and 7.4 (conceptual exposure models for ground water and CBA soil) which are reproduced below.

Figure 7.2
Human Health Conceptual Site Model - OU2 Groundwater

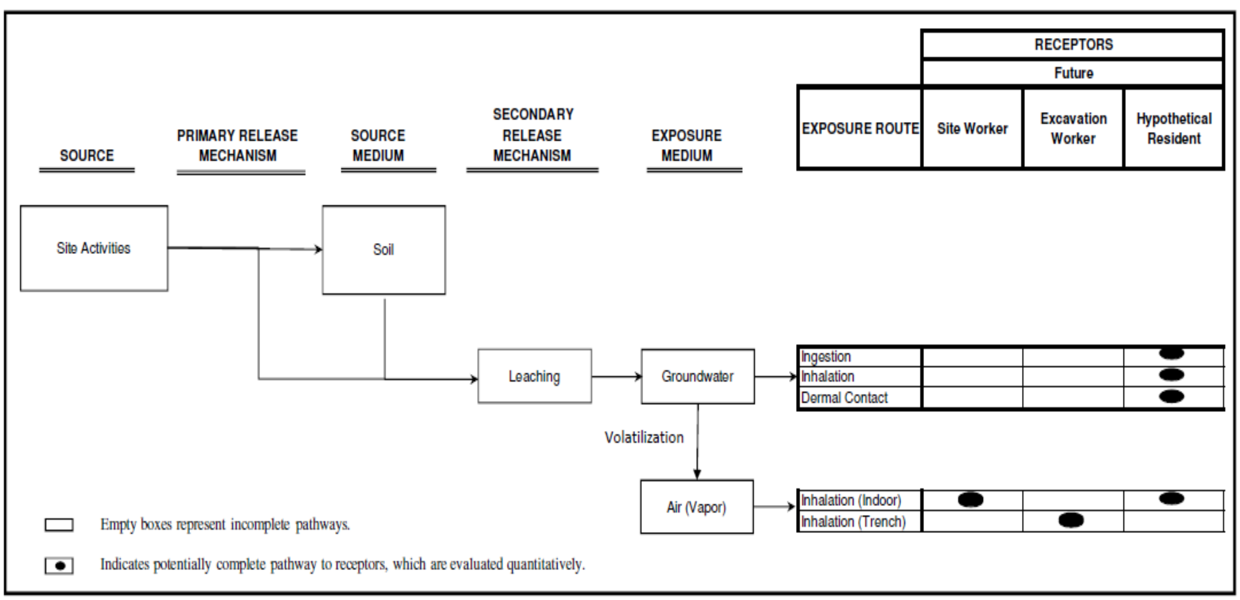
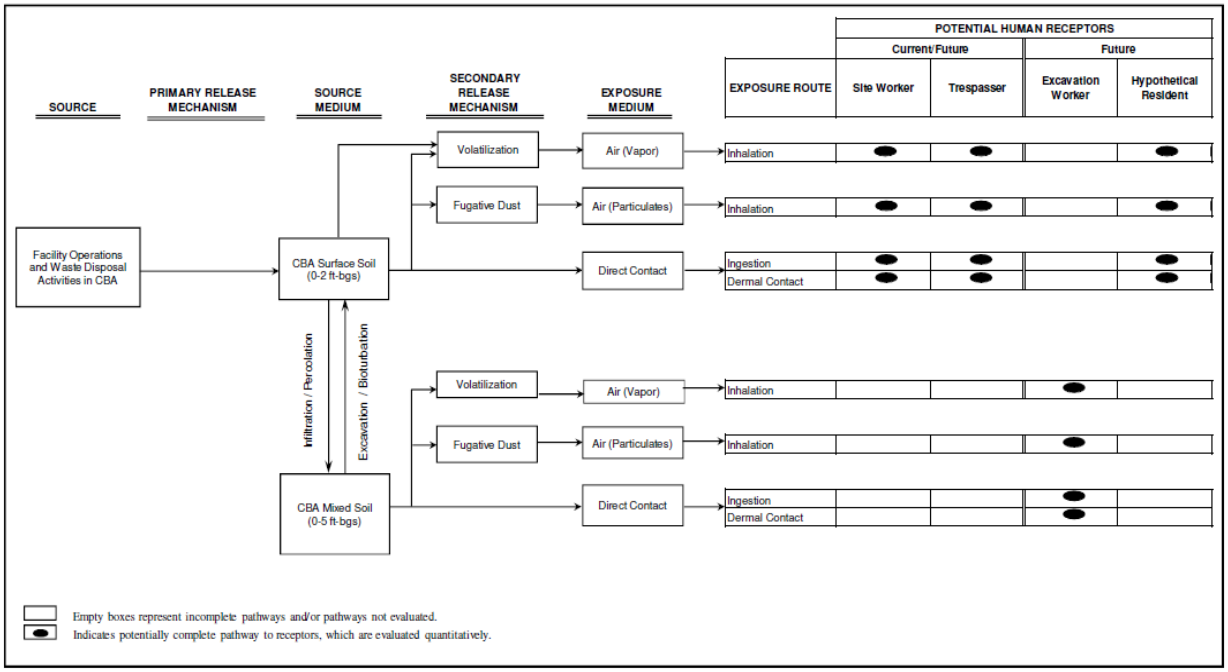


Figure 7.4
Human Health Conceptual Site Model - CBA Soil



The estimated health risks shown in Tables 7.15 (ground water) and 7.31 (soil) can be summarized as:

- Health risks from contaminants in ground water for a future resident and an excavation worker would exceed acceptable levels; and

- Health risks from contaminants in CBA soil for a future resident, future industrial worker, and an excavation worker would exceed acceptable levels. [The calculation of industrial worker risk was found to be inaccurate after EPA review; corrected risk is acceptable.]

As the site is zoned for Industrial use, and EPA has mandated institutional controls on the site to prevent any future residential use, the estimated excess risks to hypothetical future residents is moot.

Next Steps

I will continue to be in contact with EPA on the resolution of their and GA EPD's outstanding issues as Honeywell works to address them. I will monitor progress on the overall OU2 RI/FS project and keep GEC informed of all developments.

I trust this memorandum provides GEC and the community with a good understanding of the status of the OU2 RI/FS project. Feel free to contact me if you have any questions or desire any additional information.