SITEWIDE
INVESTIGATION REPORT

ALCOA EASTALCO
Frederick, MD

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1.0 INTRODUCTION

This document was prepared by MFG, Inc. (MFG) for Alcoa, Inc. (Alcoa) to summarize the field activities and findings from the site-wide investigation performed to evaluate potential sources of contamination and their impacts to environmental media at the Alcoa Eastalco facility (Site), an aluminum smelter located in Frederick, Maryland (Figure 1-1).

The facility manufactures aluminum using the electrolysis process. Waste materials that contain fluoride and cyanide are generated in the aluminum manufacturing process and are the reason behind fluoride and cyanide contamination of the underlying groundwater. In addition to fluoride and cyanide, chlorinated solvent (primarily tetrachloroethene [PCE]) releases have also impacted groundwater.

This contamination of groundwater eventually resulted in a plume that reached the southern property line. Consequently, in 1992, the plant entered into an Administrative Consent Order (ACO) with the Maryland Department of the Environment (MDE), which was later amended in 1997. The elements of the ACO included requirements to investigate and potentially remediate off-site migration of contaminants at concentrations exceeding the United States Environmental Protection Agency (EPA) drinking water maximum contaminant levels (MCLs). In addition, the ACO required Eastalco to implement a groundwater and surface water monitoring program, and to pump and treat groundwater at source areas for fluoride plume control.

A multi-phase investigation that addressed the potential sources was performed from 2000 to 2005. The PCE source was known to be the Plant's electrical substation (Figure 1-2) where this chlorinated solvent had been used historically to clean electrical components. An MDE-mandated vacuum extraction system (VES) was operated in 1996-1997 to remove contaminants from the subsurface. At MDE's request, Alcoa conducted a three-phase investigation of the substation area in 2002 and 2003, to further evaluate post-remediation conditions. A report documenting the results of the investigation (MFG, 2003) was provided to MDE in May 2003.

As described below in the ACO, several remedial actions have been taken to address potential sources of fluoride and cyanide releases to groundwater at the plant. MDE stated in the April 23, 2001 letter to Alcoa Eastalco that they were not requiring additional remedial action for fluoride contamination at that time. However, MDE stated that the plant must continue to pump and treat groundwater from three wells near what were then considered the primary sources of fluoride contamination (i.e., the Former Spent Pot

Liner [SPL] Pad and Closed Industrial Landfill). With MDE's approval, Alcoa has updated and enhanced the pumping program to better contain groundwater near the center of the fluoride plume.

Although MDE did not require further action for fluoride or cyanide, Alcoa decided to further investigate potential sources of fluoride and cyanide and evaluate the potential for groundwater contaminated above the ACO limits to migrate off-site. The investigated sources included the Former SPL Pad, historical waste disposal sites (WDS-1 through 9), the Closed Industrial Landfill, Rain Water Ponds 102 and 103, the Primary and Secondary Lagoons and Surge Pond, and the North and South Ponds (see Figure 1-2). The investigation, performed in phases from 2003 to 2005, focused first on characterizing the sources. This was followed by the strategic placement of monitoring wells and a site-wide round of sampling to characterize the groundwater plume.

Several work plans and associated field sampling plans (FSPs) were developed for the intrusive portion of the investigation (MFG, 2004a and b, 2005a) which was started in 2004 during a due-diligence assessment of a parcel of land that Alcoa was considering for sale. Because the investigation was a voluntary effort performed by Alcoa, and not required by the ACO, the work plan was not submitted to MDE for review. However, because the ACO states that the MDE must approve the location and design of monitoring wells, a brief letter-style work plan was submitted to MDE in a letter dated October 27, 2004 that outlined proposed well locations and design specifications prior to the well installation phase of the investigation. MDE approved the well installation plan in a letter dated November 8, 2004.

1.1. REPORT ORGANIZATION

Section 2 provides background information about the site, and Section 3 describes the general methodologies used in conducting the investigation. Section 4 summarizes the investigative activities and results. Section 5 describes the site conceptual model based on the results and Section 6 presents a summary and the conclusions. Section 7 lists the cited references.

2.0 SITE BACKGROUND

2.1. FACILITY BACKGROUND

The facility started operations in 1969 and occupies approximately 400 acres of a 2,200-acre parcel. Alcoa purchased the Eastalco facility in 1998. In addition to the operating facility, Alcoa owns approximately 1,879 acres of surrounding property that consists of eight former privately-owned farms. However, to the east of the plant, is a church, St. Joseph's Carrolton Manor, which occupies approximately 6.2 acres and is not owned by Alcoa. Figure 2-1 shows the relative locations of the plant, the farm properties and the church.

The extended property consists of approximately 1,390 acres of open farm fields, 489 acres of wooded area, and contains several ponds. Alcoa leases the farm fields to private farmers for crop production. Several farm support structures and an historic landmark, the Manor House, are present on the former Pascal Renn Farm property. The farm support structures include four buildings used for equipment storage and offices for the farm operations. A Phase I and limited Phase II environmental site assessment were performed on the extended property as described by MFG (2002) which provides more information regarding the history and setting of the properties.

2.2. ENVIRONMENTAL SETTING

2.2.1. Topography and Surface Water

The Eastalco plant site is located in the Frederick Valley, a synclinal structure characterized by gently rolling topography. Natural elevations at the site range from approximately 300 feet above sea level in the low areas to about 400 feet in the higher areas (Figure 1-1). The site is drained by Tuscarora Creek, a tributary of the Potomac River. A few other unnamed tributaries and man-made drainage paths (ditches) flow into Tuscarora Creek north of Adamstown. Surface water flow from the actual plant is both east into Tuscarora and west into an unnamed tributary, which flows south to join Tuscarora Creek (Figure 1-2). Tuscarora Creek flows south into the Potomac River (Geraghty and Miller, 1984).

2.2.2. Regional Geology and Hydrogeology

The site is located in the western portion of the Lowland Section of the Piedmont Plateau Province in central Maryland, and lies approximately 3 miles east of the boundary between the Blue Ridge and Piedmont Provinces. The Piedmont Province is composed of hard, crystalline igneous and metamorphic rocks. In the central portion of Frederick County, the relatively flat Frederick Valley overlies Cambrian and Ordovician limestone and dolomite. Triassic-aged red shale, siltstone and sandstone are also present in some areas.

Information on the regional hydrogeology was obtained from the Groundwater Atlas of the United States published by the US Geological Survey. In the Frederick Valley area, significant sources of groundwater exist in the carbonate rock aquifers. The Frederick Limestone, which underlies most of the site, has a typical well yield of 120-170 gallons per minute (gpm) and can yield up to 275 gpm in some areas. The carbonate rocks of the Piedmont have virtually no primary porosity, and water in these rocks moves through secondary openings such as fractures, bedding planes, joints and faults. Water moving through the secondary openings dissolves the carbonate rock and forms dissolution channels to form an interconnected network of openings greatly increasing the porosity of the rock. Most of the water obtained from bedrock in this area is found in fractures and dissolution channels.

2.2.3. Site Geology

Based on lithologic logs generated during installation of soil borings and monitoring wells at the facility, unconsolidated materials above bedrock (overburden) are comprised of clay and silt with varying amounts of sand, gravel, and angular rock fragments. Near surface materials are composed of reddish orange to reddish brown, dense, compact silty clay, with occasional sandstone and shale fragments, gravel, and cobbles. Poorly graded limestone gravel is present at the surface at some locations.

Site boring logs indicate that deeper unconsolidated materials (weathered bedrock) are composed of reddish brown to yellowish orange silt, clay, and occasional zones of clayey gravel. The logs note relict bedding (inclined 20 to 30 degrees from horizontal), micaceous inclusions, and quartzite fragments. Several past reports identify this unconsolidated residual material as saprolite; however, saprolite is derived from the in-situ weathering of igneous or metamorphic material retaining many of the visual characteristics of the parent rock. The deeper unconsolidated materials at the site retain some of the characteristics of the parent rock; but they are derived from in-situ weathering of limestone. The thickness of this highly weathered limestone, which grades into the overlying silty clay unit, varies but averages about 5 feet.

The Alcoa Eastalco property is located within the northeast-trending Frederick syncline. According to geologic maps prepared by the Maryland Geological Survey (MGS), two bedrock formations are present beneath the site: the New Oxford and Frederick Limestone Formations (MGS, 1968). The New Oxford Formation is composed of interbedded red and gray arkosic sandstone, red shale and siltstone, with a basal conglomerate containing a red and gray calcareous matrix (MGS, 1981). The New Oxford Formation overlies the Frederick Formation. To the northwest of the Substation Area, the New Oxford Formation is reportedly about 90 feet thick (beneath the new industrial landfill) and thicknesses of the New Oxford increase to the west (Atlantic, 1996). The Upper Cambrian bedrock beneath the eastern portion of the Site is the Frederick Limestone Formation, which consists of highly jointed and fractured, thinly bedded, argillaceous limestone with minor shale (MGS, 1981).

Figure 2-2 shows the bedrock topography from the western portion of the plant to the southern property boundary based on survey data and logs of existing wells and former construction borings. The undulating bedrock surface slopes from north to south with a bedrock trough that starts north of the Closed Industrial Landfill and appears to extend southward to the property boundary.

2.2.4. Site Hydrogeology

The groundwater system beneath the site consists of two water-bearing units: the overburden and bedrock zones. Based on lithologic descriptions of the overburden materials, most groundwater flow likely occurs in the highly fractured zone (weathered limestone material) located directly above the competent bedrock (Atlantic, 1996). The lower saturated unit occurs within fractured limestone bedrock. Groundwater movement in bedrock beneath the site occurs through fractures in the limestone bedrock because the primary porosity of the limestone is low. As discussed in Section 4, the general direction of horizontal groundwater flow in both the overburden and bedrock is toward the southeast.

The undulating bedrock surface, including the closed depressions and the trough, as well as the discontinuous presence of relatively impermeable materials may locally control the horizontal flow direction and the vertical migration of groundwater.

2.2.4.1. Groundwater Containment

As mentioned in Section 1, a requirement of the 1997 amendment to the ACO was for the plant to pump groundwater from three monitoring wells near what were then considered the primary source areas (i.e., the Former SPL Pad and Closed Industrial Landfill). Consequently, the plant initiated a pumping program whereby groundwater was extracted via pneumatic pumps from monitoring wells MW-56 and MW-57 (overburden wells near the former SPL Pad) and MW-68 (shallow bedrock well near the Closed Industrial Landfill). The pumped groundwater was run through the plant's wet scrubber system and was eventually treated before being discharged to an outfall under a state National Pollutant Discharge Elimination System (NPDES) permit.

In 2003, Alcoa converted a bedrock monitoring well (MW-29), located downgradient of the SPL Pad, into a groundwater recovery well (RW-29) and performed a 3-month pumping test to determine if RW-29 could augment or replace MW-56, MW-57, and MW-68 for groundwater recovery. The reason behind the test was the historically low flow rates (1to 2 gpm) that were reportedly achievable for the three wells. The test results (MFG, 2004c) indicated that RW-29 would likely be capable of containing groundwater in both the overburden and bedrock zones downgradient of the former SPL Pad. As such, Alcoa recommended to MDE that RW-29 be pumped in lieu of MW-56 and MW-57. RW-29 was not found to be capable of containing groundwater in the vicinity of the Closed Industrial Landfill; therefore, Alcoa recommended that MW-68 continue to be pumped. Although MDE approved the modified pumping program, MW-56 is still being pumped because it was learned after the RW-29 test that this monitoring well was capable of sustaining a flow rate of approximately 6 gpm with a submersible pump. Even with a submersible pump, MW-57 produced only 1 gpm or less and was thus removed from the program. The submersible pump from MW-57 was moved to MW-68 as a replacement for the original pneumatic pump.

As a result of the enhancements to the pumping program, the pumping rates for the three wells are as follows: RW-29 approximately 5.5 gpm); MW-56 (approximately 6 gpm); and MW-68 (approximately 2 gpm). Each well is equipped with a submersible pump connected to PVC riser pipe. At each wellhead, the PVC is connected to a rubber discharge hose which runs along the ground surface from the wellhead to the Cryolite Plant from which the water is transferred to the wet scrubber system. Heat tape and insulation have been applied along the full lengths of each discharge hose to protect against freezing.

The well screen, pump and discharge line at RW-29 require periodic maintenance to remove lime scale that accumulates over time. Consequently, an operation and maintenance (O&M) plan (MFG, 2004d) was submitted to MDE. Under the O&M plan, the pump and discharge line are removed and inspected for scale buildup that could restrict flow. If needed, these components are cleaned or replaced if cleaning is not possible. In addition, the well is treated with Muriatic acid to remove scale buildup from the well screen and filter media in order to maintain production.

2.2.4.2. Groundwater Flow Velocity

To estimate aquifer transmissivity and flow velocity, three single well pumping tests were conducted in December 1995. Results of the pumping tests indicate that the hydraulic connection between the overburden and bedrock varies across the site. A hydraulic connection between the overburden and bedrock exists at MW-90 and MW-91 where the pumping of the bedrock well had a greater effect on the water level in the overburden well than the pumping of the overburden well had on the bedrock well. At the creek confluence area, the pumping tests did not indicate the presence of a hydraulic connection between the overburden and bedrock at MW-52 and MW-60.

The transmissivity in the lower portion of the overburden zone (weathered bedrock) was calculated as 3.51 x 10^{-2} ft^2/min based on data collected from MW-91. The hydraulic conductivity assuming a saturated thickness of 13 feet is 2.7 x 10^{-3} ft/min. Using an effective porosity of 0.29 and gradient of 0.006, the flow velocity in the weathered bedrock zone was estimated at approximately 30 feet/year (Atlantic, 1996).

Transmissivities in the deep bedrock wells were estimated as 1.78 x 10^{-1} ft^2/min in the vicinity of MW-90 and 1.1 x 10^{-3} ft^2/min in the vicinity of MW-60. The hydraulic conductivity in bedrock, which was calculated by Atlantic assuming an estimated saturated thickness of 150 feet, ranges from 7.6 x 10^{-6} ft/min at MW-60 to 1.2 x 10^{-3} ft/min at MW-90. Based on a gradient of 0.006 and effective porosity of 0.17, the groundwater flow velocity estimates for bedrock range from 0.14 ft/year to 22 ft/year (Atlantic, 1996).

The calculated groundwater flow velocities conflict with the distance fluoride has migrated from the primary source area. For example, the earliest possible releases of fluoride would have been in the early 1970's when the plant became operational. If the fluoride migrated at the velocity of the groundwater in the overburden deposits, it would take approximately 140 years to migrate the distance between MW-56 near the South Pond to MW-72 near the southern property boundary. If fluoride migrated at the velocities calculated for bedrock, it would take between 190 years to more than 30,000 years to migrate the distance between MW-46 near the South Pond and MW-73 near the southern property boundary. As a result, it was assumed that groundwater flow velocity is faster than the calculated values.

In a report by Menzie-Cura & Associates (1996), groundwater seepage velocities and travel times were estimated based on time intervals between contaminant releases at various sources and detections at downgradient wells, and the distance between the source area and downgradient wells. The report estimated that seepage velocities of 200 to 400 feet per year may represent contaminant migration at the site. This suggests that groundwater will take 10 to 20 years to flow from the source areas at the main plant operations area to the southern property boundary. It should be noted however, that these estimates were based on detections in a property boundary well that occurred immediately after installation in 1985. Therefore, the plume reached the property boundary before the well was installed, but is not known precisely when that occurred.

It is possible that the effective saturated thickness was overestimated due to the secondary porosity of the aquifer and that hydraulic conductivities are an order of magnitude higher than what was reported. Groundwater flow may be preferentially occurring within thin, high permeability zones (e.g., conduit flow may occur within relatively thin fractures or solution channels in weathered bedrock or the underlying competent bedrock). The results of the 3-month hydraulic containment test at RW-29 support these explanations, particularly conduit flow. As described in the report of that test (MFG, 2004c), water levels in certain monitoring wells responded quickly to variations in pumping at RW-29 (i.e., the start of the test, interruptions, etc.). Wells that responded quickly include overburden well MW-4 located about 600 feet to the northwest and bedrock well MW-41 located about 800 feet to the southwest. Given the relatively low flow rate at RW-29, the size of its area of influence suggests that the saturated zones have relatively high hydraulic conductivity and low storage capacity.

3.0 FIELD PROCEDURES

The following sections summarize the procedures utilized during the test pit, soil boring, well installation, and field sampling activities. For more information, including standard operating procedures (SOPs), refer to MFG (2004a and b, and 2005a). A compact disc of the reports documenting the methods used for conducting geophysical surveys is provided in Appendix A.

3.1. TEST PIT EXCAVATIONS

Prior to mobilizing to excavate any test pit, plant personnel cleared the area for underground utilities and issued a dig permit. The positions of any underground utilities were clearly marked and made known to the excavating subcontractor.

As applicable, a Global Positioning System (GPS) unit capable of locating points in Universal Transverse Mercator (UTM) coordinates was used to locate proposed test pits and trenches in the field. These positions were based on the geophysical survey findings, and were marked and labeled prior to the mobilization of the excavating subcontractor. Test pit and trench excavations were performed according to SOP-1 contained in MFG (2004a and b).

To avoid contaminating the ground surface with excavated waste, the first 1 to 2 feet of soil was first excavated from the pit and from an area immediately adjacent to the pit, where the excavated material was placed on top of plastic sheeting (i.e., the spoils pile). The size of the adjacent area was determined in the field and was large enough to contain all of the excavated material. The clean topsoil was placed on the other side of the pit to prevent mixing with the spoils pile. Test pits were generally excavated in 2-foot intervals. At each of these intervals, ambient air measurements were made with a photoionization detector (PID), and decisions were made on whether to continue excavating based on observations of excavated material. After samples were collected and the test pit had reached its final depth, the excavator pushed the spoils pile back into the pit. The clean topsoil was then placed on top of the excavation.

The type of waste that was expected to be encountered during test pit excavations was unknown. Therefore, the sampling strategy was not fixed so as to avoid the unnecessary collection of samples. For example, if the only wastes observed in an area were construction debris (e.g., concrete, metal, wood, etc.) the sampling requirements were minimal. On the other hand, if areas of potential contamination were observed in a disposal area, a greater quantity of samples was collected to characterize the area. Also, when the same types of waste were present in multiple pits within a given investigated area, a limited number of samples were collected to represent the whole area as opposed to collecting samples from each pit. Samples were collected according to SOP-2 contained in MFG (2004a and b).

Three soil samples were collected at test pit locations; however, soil samples were not collected from every test pit. Test pits were sampled at the surface, at the base of the pit, and from the full depth (composite). A fourth additional sample was collected between the surface and base only when there were visual indications of contamination in a zone not already sampled.

3.2. SOIL BORINGS

Continuous soil samples were collected from soil borings using a Geoprobe (direct push). Geoprobe borings utilized macro core samplers with acetate liners. The soil borings were drilled to the water table surface and lithologic information was recorded. After sampling, the boreholes were filled with a cement/bentonite grout.

When needed, Shelby tube samples were collected from the saturated portion of the overburden zone for geotechnical analyses (i.e., grain size/hydrometer, permeability, and density). The 5-inch diameter Shelby tubes were hydraulically advanced with a hollow-stem auger rig approximately 2 feet to collect the sample. The Shelby tubes were recovered and sealed at both ends with a melted wax plug. The tube was properly labeled and the top and bottom depths of the sample interval were marked on the tube. Plastic end caps were duct-taped over the ends. The Shelby tubes were carefully packed so that the sample remained undisturbed during shipment to the laboratory.

3.3. WELL INSTALLATION

Prior to installing monitoring wells, the driller (B.L. Myers of Frederick, MD) obtained the required permits from the Frederick County Health Department. During well drilling, the field geologist observed and created a log of the borehole cuttings, and created a well construction diagram showing materials, depths, etc.

3.3.1. <u>Overburden Wells</u>

Overburden wells were installed using hollow-stem augers and were advanced to the point of refusal. Each well was constructed of 2-inch diameter PVC with 10-foot screens (0.010-inch slot) according to SOP-6 (MFG, 2004b). Shorter screen lengths were appropriate in some cases based on the thickness of the saturated zone. A sand pack was installed around the well screen to approximately 2 feet above the top of the screen. A bentonite seal was installed above the sand pack, and the remaining annular space was grouted to the ground surface using bentonite-amended cement. A protective casing was installed at the ground surface to protect the PVC casing from damage, and a lock was installed. A concrete pad with a sloping surface was installed around the protective casing to drain precipitation away from the ground surface adjacent to the well. Protective bollards (bumper posts) were installed to protect wells installed in areas containing vehicular traffic.

3.3.2. Bedrock Wells

Bedrock monitoring wells were installed as 4-inch open rock wells with 6-inch surface casing set approximately 10 feet into bedrock to prevent migration of contaminants from the upper portion of the boring to the bedrock zone. Bedrock wells were installed using air rotary drilling. Final well depths were based on depths of water-producing fracture zones.

3.3.3. Well Development

Development of the unconsolidated zone monitoring wells was accomplished according to SOP-7 in Appendix B of the Work Plan (MFG 2004b) using a surge block and pump to remove fines from the sand pack and well screen. Development of the bedrock monitoring wells was accomplished using either an airlift method when material accumulating at the bottom of the wells was rock rubble, or a pump when fine-grained silt and clay particles were encountered. Specific conductance, pH, and temperature were recorded throughout development because stabilization of these parameters is an indication that development is complete.

3.4. SURFACE WATER AND SEDIMENT SAMPLING

Sediment and surface water samples were collected according to SOP-9 and SOP-12, respectively, contained in MFG (2004b). Sediment samples were collected using a steel trowel and homogenized in a steel bowl prior to filling sample jars. Surface water samples were collected by dipping the sample jar into the surface water. Where sediment and surface water samples were collocated, surface water samples were collected first to avoid disturbing the sediment and increasing the level of suspended solids in the water sample. Surface water samples were field-screened with a turbidity meter to ensure that samples with turbidity above 20 Nephelometric Turbidity Units (NTUs) were not collected for laboratory analysis.

3.5. GROUNDWATER SAMPLING

Groundwater samples were collected using a variable speed (24 volt, four stage) submersible pump equipped with a low flow sampling controller. Based on the general procedure outlined in SOP-12 contained in MFG (2004b), three well volumes of groundwater were purged prior to sampling. During sampling, field parameters including pH, specific conductance, turbidity, dissolved oxygen, redox potential, and temperature were recorded. Samples were not collected for PCB or PAH analysis when turbidity exceeded 20 NTUs.

3.6. DERIVED WASTE MANAGEMENT

Soils removed from the Geoprobe borings were containerized in 55-gallon drums for disposal by the plant. Waste generated during the installation, development, and sampling of wells was performed according to the strategy detailed in the FSP (MFG, 2005a). Used personal protective equipment and other solid waste were placed in plastic bags and disposed on-site in a plant dumpster.

3.7. SAMPLE SHIPPING

Samples were preserved as directed by the analytical laboratory, and placed in coolers with ice bags immediately after being collected. Coolers containing samples for analysis at an off-site laboratory were shipped either by direct drop-off or by an overnight delivery service.

3.8. QUALITY ASSURANCE/QUALITY CONTROL

Quality-control procedures used during field sampling included the collection and analysis of field duplicate samples and equipment blanks (when non-dedicated equipment was used to collect samples). The frequency of collection was typically 5 percent of investigative samples for field duplicates and equipment blanks. Trip blanks were submitted with shipments of samples for Volatile Organic Compound (VOC) analysis.

4.0 INVESTIGATIVE ACTIVITES AND RESULTS

As mentioned in Section 1, the site-wide investigation of potential sources of fluoride and cyanide contamination included various ponds and lagoons that handle storm water and/or process water, as well as various waste storage and disposal sites. Following the characterization of fluoride and cyanide sources, a follow-up investigation of groundwater was performed to assess impacts from the investigated sources.

A description of the investigative activities performed at the various potential sources and the associated results are provided in the subsection below. While analytical data summary tables are provided in this section, a compact disc containing the analytical laboratory reports is provided in Appendix B. The locations of monitoring wells referred to in this section are shown on Figure 4-1.

4.1. PONDS AND LAGOONS

There are seven constructed ponds and lagoons at the plant that were investigated as potential sources of contamination to groundwater.

4.1.1. North and South Ponds

The North Pond was originally lined with asphalt during its construction in the 1970's. The asphalt lining has not been rehabilitated since its original construction. The pond had historically been used to capture runoff from what was referred to as "Snake Mountain," which was a waste pile containing approximately 10,000 tons of fluoridated alumina and some SPL. Until mid 2005, the pond was used for purging the clarifier or the thickener tank. Although it is no longer in routine service, the North Pond remains an emergency overflow discharge point for the treatment plant thickener tank.

The South Pond formerly received leachate containing elevated fluoride concentrations directly from the Closed Industrial Landfill and via direct runoff from the Former SPL Pad. It was also sometimes used as a process tank for handling wet scrubber water. Cracks in the lining were reportedly repaired by filling them with tar, and the pad was last relined with asphalt in 1996. In 1988, the SPL stored on the pad was removed and disposed off-site, so runoff from the pad no longer contacted first-cut spent potliner materials. In 1991, the plant stopped discharging leachate from the Closed Industrial Landfill to the South Pond. Solids (alumina) from the wet scrubbers were removed from the South Pond and placed in the New Industrial Landfill. Currently, the South Pond is used for collecting runoff from the brick pad (Former SPL Pad) and for purging the clarifier or the thickener tank.

Process water and sludge were removed from the North Pond in the fall of 2004. At that time, the asphalt lining of this pond appeared highly weathered with large fissures and cracks. On the day the sludge removal was completed, the base of the pond did not contain any standing water. Overnight, plant workers noticed 1 to 2 inches of groundwater had collected in the base of the pond. In addition, a plant worker noticed that the bottom 1 foot of the eastern pond wall was damp, indicating that groundwater was seeping into the pond through the asphalt. Beginning in April 2005, the South Pond was temporarily taken out of service and partially cleaned. Because not all water and sludge were removed, the asphalt liner near the bottom of the South Pond could not be inspected for cracks; however, visible portions of the lining indicate it is in much better condition than the lining of the North Pond.

The North Pond was placed back in service to handle the process water until the South Pond was reactivated in June 2005. The water and sludge that accumulated in the North Pond while the South Pond was cleaned were removed in August 2005.

Surface water samples were collected in October 2003 from the North and South Ponds and analyzed for fluoride and free cyanide to assess whether the ponds were potential sources of contamination to groundwater. The North Pond sample contained 85 mg/L fluoride and 0.12 mg/L free cyanide. Plant records showed that the process water placed in the North Pond during its active use could contain fluoride in excess of 1,300 mg/L. The South Pond sample contained 362 mg/L fluoride and 0.18 mg/L free cyanide.

Given the extensive well coverage in the vicinity of the ponds, no new wells were installed during this investigation. The existing wells were sampled for fluoride and free cyanide as part of the site-wide plume assessment. Refer to Section 4.7 for a discussion of the results.

4.1.2. Rain Water Pond 102

Storm water runoff from the Cryolite Plant and the western side of the pot lines area may become impacted with fluoride as it drains to Rain Water Pond 102. There is an overflow drain in the pond, which when the surface water reaches a certain level, directs the excess water to the pump house. From the pump house, the water discharges under a NPDES permit to the Potomac River. Balter (1974a) indicates the pond had a bituminous lining, but it does not specify the type of material used. However, recent interviews with plant personnel suggest the pond was not lined at all but was simply excavated through the overburden down to bedrock. When the pond was last drained and sediments were removed (sometime around 1995), bedrock was observed. As such, the water in the pond likely consists not only of rainwater, but groundwater also.

Surface water samples collected monthly from Rain Water Pond 102 in 2001 show fluoride concentrations ranging from 21.3 to 150 mg/L, which is well above the ACO limit of 4 mg/L. Although the pond is apparently in direct communication with groundwater, the concentrations of fluoride in groundwater around the pond are relatively low compared to concentrations near the SPL Pad and the North and South Ponds. Bedrock monitoring well MW-44 is located at the northeast corner of the pond. Samples were collected from the well in 1983, 1985 through 1988, 1996, and 2002. Only the 1983 and 2002 samples contained fluoride at concentrations (5.8 and 5.63 mg/L, respectively) above the ACO limit. The samples collected during the other monitoring rounds contained less than 2 mg/L fluoride.

Overburden monitoring well MW-4 appears downgradient of Rain Water Pond 102 (upgradient of the Closed Industrial Landfill) and sample results since 1983 show fluoride concentrations are less than 2 mg/L. MW-4 is located near the top edge of a north-to-south bedrock trough located just west of Rain Water Pond 102 (Figure 2-2). The trough likely influences local overburden groundwater flow, and as a result, the location of MW-4 may not be appropriate for monitoring potential releases from Rain Water Pond 102. However, a study conducted by Balter (1974a) included the installation and sampling of two overburden piezometers (P-3 and P-4 [see Figure 1-2]) downgradient of Rain Water Pond 102. Although P-3 was apparently abandoned, it was located within the bedrock trough, and was therefore a suitable downgradient monitoring point. P-4 likely corresponds to the present day MW-4. The fluoride concentrations ranged from 1 to 2.4 mg/L in P-3 and were steady at 0.2 mg/L in P-4. Cyanide was not detected in either piezometer. The Balter report does not specify the analytical methodology used and does not state whether the samples were analyzed for free or total cyanide. Based on the piezometer data, Balter (1974a) concluded the rainwater pond is not leaching fluoride and that the bituminous lining is intact and functioning. However, as stated above, plant personnel are not aware of any such lining.

Overburden monitoring wells MW-6 and MW-33 are both located closer to the middle of the trough. MW-6 has been sampled numerous times since 1983 and the fluoride concentrations were generally between 3 to 4 mg/L with occasional concentrations above the ACO limit. MW-33 was only sampled in 2002 and the fluoride level was only 1.28 mg/L. Both of these wells are located several hundred feet away from Rain Water Pond 102 and may be monitoring potential releases from other potential sources such as the historical waste disposal sites near the western fence line.

The concentrations observed in the pond surface water are much greater than observed in downgradient overburden groundwater even though the pond is apparently unlined and thus in direct communication with the overburden zone. Because the pond was excavated to bedrock, the contaminated water in the pond may be discharging directly to the bedrock aquifer through fractures. Consequently, a new downgradient bedrock well (MW-103) was installed during this investigation near overburden well MW-4 to monitor the potential impacts in the bedrock aquifer. MW-4 and MW-103 were both sampled for fluoride and cyanide and the results are provided on Table 4-1. The fluoride concentration in bedrock well MW-103 (3.46 mg/L) was higher than the concentration detected in overburden well MW-4 (1.92 mg/L). Free cyanide was detected at 0.0009 mg/L in MW-103, but was not detected in MW-4.

4.1.3. Rainwater Pond 103

Currently, Rain Water Pond 103 receives storm water runoff from the eastern portion of the pot lines and cast house areas. Surface water samples collected monthly from Rain Water Pond 103 in 2001 contained fluoride at concentrations ranging from 7.5 to 51 mg/L. There is an overflow drain acting as a weir in the side of the pond from which overflow water is directed to the pump house. The water is pumped from the pump house through piping to the permitted NPDES Outfall, which ultimately discharges to the Potomac River. According to plant personnel, Rainwater Pond 103 is similar to Rainwater Pond 102 in that it is not lined and is simply an excavated pit that extends to bedrock.

Because there were no wells downgradient of the pond to determine whether groundwater has been impacted, a well pair consisting of overburden well MW-104 and bedrock well MW-105 were installed and sampled for fluoride and free cyanide. The results are provided on Table 4-1. The fluoride concentration in overburden well MW-104 (8.09 mg/L) was an order of magnitude higher than the concentration detected in bedrock well MW-105 (0.77 mg/L). Free cyanide was detected at 0.0002 mg/L in MW-104, but was not detected in MW-105.

4.1.4. Primary and Secondary Lagoon Area

The primary and secondary lagoons, as well as the Surge Pond, are unlined surface impoundments constructed by excavating into the overburden materials at the north ends and using the excavated material for berms along the southern ends. The lagoons are approximately 5 to 6 feet deep. The depth of the Surge Pond is uncertain, but plant personnel have indicated that, like the rainwater ponds, the Surge Pond extends to the bedrock surface.

The primary and secondary lagoons were originally constructed and used for sanitary sewage treatment until a package treatment plant was installed in the late 1970's. Currently, the lagoons receive storm water runoff from the Bake Oven area and effluent from the sanitary sewage treatment plant. Groundwater from the Bake Oven dewatering wells is also discharged to the primary lagoon. The primary lagoon discharges to the secondary lagoon. The secondary lagoon discharges to the pump house pit where the water is pumped through piping to NPDES Outfall 001, which discharges to the Potomac River. Based on discussions with plant staff, 150 tons of spent pot liner was removed in 1998 from the northwest corner of the primary lagoon and disposed off-site. In December 2001, a sinkhole formed in the primary lagoon, the lagoon drained, and it was revealed that not all of the SPL had been removed in 1998. As such, the remaining SPL was removed from the bottom of the lagoon.

Stormwater may also enter the Surge Pond located directly north of the secondary lagoon, and all plant process water passes through the Surge Pond. Similar to the rainwater ponds, the Surge Pond is also an unlined excavated pit which discharges to the pump house and then to NPDES Outfall 001.

Surface water samples were collected from the primary and secondary lagoons and the surge pond in November 2002, and analyzed for fluoride and cyanide. The results show that fluoride concentrations were approximately 7 mg/L in the primary and secondary lagoons and 14 mg/L in the surge pond. Free cyanide concentrations were approximately 0.006 mg/L in the primary and secondary lagoons and 0.004 mg/L in the surge pond. Because there were no monitoring wells located directly downgradient of the lagoons and pond to evaluate potential impacts, overburden well MW-106 was installed downgradient and sampled for fluoride and free cyanide. The results are provided on Table 4-1. The fluoride concentration was 4.42 and the free cyanide concentration was 0.013 mg/L.

4.2. STORAGE AREAS

There are several areas around the plant where waste or equipment is currently or was previously stored which were considered potential sources of contamination. The locations of the investigated sources are shown on Figure 4-1. These areas were sampled during this investigation as described in the following subsections. Summaries of the sample data are presented in Tables 4-2 to 4-4.

4.2.1. Former Spent Potliner Pad

From 1972 to 1974, spent potliner was placed on the ground surface in an area that was later paved and called the Spent Potliner (SPL) Pad. In 1974, the first in a series of 12-inch thick concrete pads was constructed for storage of spent potliner materials. The pad area was divided into two regions separated by a wall. Spent potliner carbon was placed on the west side and potliner brick on the east side. As the materials continued to accumulate, more pads were added. Storage of spent potliner continued on these pads except for several months in 1983, when trucks could not gain access to the pads. During this period, potliner was again stored on bare ground at a location adjacent to the east side of the pads.

After 1983, the bricks were moved to the Industrial Landfill and the entire pad area was used for spent potliner carbon. Meta Systems (1989) reported that no cracks were observed during a visual inspection of the integrity of the concrete pad. However, reports indicated that the pads are joined by keyed expansion joints lined with a synthetic gasket and that there is some potential for leachate to have migrated to the subsurface through the joints. In 1988, the spent potliner was removed from the pads and disposed at an out-of-state landfill. Subsequent to discontinuing use of the pads for SPL storage, an enclosed building was constructed for temporary storage of spent potliner and elimination of run-off. In 1993, the facility began using covered roll-off boxes to store spent potliner.

Past spent potliner and brick storage practices may have resulted in fluoride contamination of soils beneath and surrounding the concrete pad area. The degree of spent potliner clean-up performed prior to construction of the concrete pads in 1974 is not known. The degree of soil contamination beneath and next to the pad from the storage of spent potliner and from the leachate run-off from the pad was also not known. Therefore, in September 2004, soil samples were collected using direct push technology (Geoprobe®) from beneath and around the storage pad to assess whether remaining soils are acting as a secondary source of fluoride and/or cyanide contamination to groundwater. Boring logs for the Geoprobe soil borings are located in Appendix C.

Three Geoprobe borings, SPL-GP1 through SPL-GP3, were installed through the concrete pad, while four Geoprobe borings, SPL-GP4 through SPL-GP7, were drilled around the perimeter of the pad. The borings were advanced to the top of the water table with depths ranging from 12 to 30 feet below ground surface (bgs). The depths to water in the borings ranged from 9 to 19.5 ft-bgs, but water was not encountered in boring SPL-GP3 which was drilled to 30 ft-bgs. Soil samples were collected continuously from the surface to total depth of the boring using a macro-core sampler. Soils consisted of clay with occasional limestone rock fragments near the bottom of some borings. At each boring location, one soil sample was collected at the surface (0 to 2 feet bgs) and one from the 2-foot interval immediately above the water table, except at SPL-GP3. At relatively deep borings, a third sample was collected at the approximate mid-point depth between the ground surface and water table. A fourth sample was collected at SPL-GP3 because of the greater depth of the boring. The samples were analyzed for total fluoride and cyanide.

Table 4-2 presents the analytical results which are also shown on Figure 4-2. Total cyanide was detected in soil samples collected from all borings. Surface soils had concentrations ranging from an estimated 0.50 mg/kg to 12.2 mg/kg, with the highest concentration in the sample from SPL-GP7, located on the western side of the pad. Total cyanide concentrations generally increased with depth, with the highest concentration, 61.5 mg/kg, found in SPL-GP7 at 13 ft-bgs; however, the deepest sample at 28 ft-bgs from SPL-GP3 (where no water was encountered during drilling) had a concentration of 34.2 mg/kg.

Fluoride was detected in all soil samples. Surface soils had concentrations ranging from 118 to 1,210 mg/kg, with the highest concentration in the sample from SPL-GP7. Fluoride detections in the subsurface ranged from non-detect to 1230 mg/kg, with the highest concentration in the sample from SPL-GP1 at 15 ft-bgs. Concentrations of fluoride generally increased with depth in soils collected from beneath the storage pad, whereas concentrations generally decreased with depth in the soils collected from around the pad.

In May 2005, two hollow-stem auger soil borings were installed to collect soil samples for sequential batch leach tests to evaluate the ability of the fluoride contaminated soils to leach fluoride to groundwater. Boring logs for these two soil borings are located in Appendix C. The hollow-stem auger borings, SPL-SB1 and SPL-SB2, were drilled in the vicinity of Geoprobe boring SPL-GP1 and SPL-GP7 which were found during the Geoprobe investigation to have the highest fluoride concentrations under and adjacent to the pad. Split-spoon samples were collected from the same depth intervals as the Geoprobe samples collected earlier at SPL-GP1 and SPL-GP7. The tests were run according to a modified version of method SW846-1320 (Multiple Extraction Procedure [MEP]). The method was modified to allow all extractions to be based on SW846-1312 (Synthetic Precipitation Leaching Procedure). As described in the method, the MEP is designed to simulate the leaching that a waste will undergo from repetitive precipitation of acid rain on an improperly designed sanitary landfill. The repetitive extractions reveal the highest concentration of each constituent that is likely to leach in a natural environment.

As shown on Table 4-5, the samples collected from SPL-SB2 had the higher soluble fluoride concentrations with initial extract concentrations in the range of 25 to 32.9 mg/L. Fluoride concentrations in the initial extracts from SPL-SB1 had soluble fluoride concentrations in the range of 22 to 51 mg/L. The fluoride concentrations decreased in successive extracts. As shown on Table 4-5, the results of the sequential batch leach tests show that the majority of the fluoride leached out during the first two extractions with all but one of the samples leaching at least 95% of its available soluble fluoride by the third extraction.

In addition to the split-spoon samples, an undisturbed Shelby tube sample was collected from the 2-foot zone above the bedrock surface at SPL-SB1 for analysis of geotechnical parameters (grain size/hydrometer, permeability, and density) to obtain data describing the physical and hydraulic characteristics of the shallow aquifer materials (i.e., weathered bedrock). The results are provided in Appendix D.

Given the extensive well coverage in the vicinity of the Former SPL Pad, no new wells were installed during this investigation. The existing wells were sampled for fluoride and free cyanide as part of the site-wide plume assessment. Refer to Section 4.7 for a discussion of the results.

4.2.2. Waste Alumina Storage Pad

The Waste Alumina Storage Pad was used to store miscellaneous fluoridated waste and alumina from the wet scrubber system. In 1974, calcium fluoride sludge that had accumulated in the North and South Ponds was removed and placed in this area. The area was then paved with asphalt to create the current pad.

The degree of soil contamination beneath the pad was not known. Therefore, soil samples were collected from beneath the storage pad to assess whether remaining soils are acting as a secondary source of fluoride and/or cyanide contamination to groundwater. Three Geoprobe borings, WA-GP1 through WA-GP3, were advanced to approximately 16 to 20 ft-bgs. Soils underneath the pad consisted of clay with occasional limestone rock fragments near the bottom of some borings. Water was encountered at approximately 12 to 18 ft-bgs.

Soil samples were collected continuously from the surface (below the asphalt) to the total depth of the boring using a macro-core sampler. At each boring location, one soil sample was collected from the 2-foot interval immediately below the asphalt and one from the 2-foot interval immediately above the water table. The third sample was collected at each boring from the approximate mid-point depth between the ground surface and water table. The samples were analyzed for fluoride and total cyanide. Additionally, one sample from WA-GP1 was analyzed for VOCs because of elevated PID readings.

Table 4-3 presents the soil sample analytical results. Total cyanide was not detected in any sample. Fluoride was detected in all samples immediately below the asphalt. Concentrations ranged from 52.7 to 110 mg/kg, with the highest detection from boring WA-GP2. Fluoride was not detected in subsurface soils from boring WA-GP1; however, it was detected in WA-GP2 at a concentration of 69.5 mg/kg at 11 ft-bgs and in WA-GP3 at 21.4 mg/kg at 16 ft-bgs. Fluoride detections decreased with depth.

Additionally, VOCs were not detected in the sample collected from WA-GP1. This suggests that the elevated PID readings in this sample, as well as others collected at the Waste Alumina Storage Pad (and Former SPL Pad), are likely attributable to ammonia generated from soils that were impacted from historical waste storage.

An overburden well (MW-97) was installed downgradient of the Waste Aluminum Storage Pad and sampled for fluoride and free cyanide to describe contaminant concentrations downgradient of the Waste Aluminum Storage Pad and east of the SPL Pad and North and South Ponds. As shown on Table 4-1, fluoride was detected at 3.13 mg/L and free cyanide was detected at 0.03 mg/L.

4.2.3. Bone Yard

The Bone Yard is an unpaved storage area located south of and across the railroad tracks from the Former SPL Pad. It has been used for storage of equipment such as aluminum fluoride hoppers, conveying equipment, and hydraulic units. It is uncertain whether equipment containing PCBs was ever stored at this location, but plant personnel interviewed did not recall the area ever being used for electrical equipment such as transformers. Currently, the Bone Yard is used for the storage of vehicles, general debris, unused bricks, and machine parts. No stained soil was observed in Bone Yard during the site walk.

Based on past or current storage practices, the soils at the Bone Yard were investigated as a potential source of contamination (e.g., fluoride, SVOCs, PCBs) to groundwater. Surface soil samples were collected within this area and analyzed for fluoride, PCBs, SVOCs, and metals. Two surface soil samples, BY-SS2 and BY-SS4, were collected within the area of the stored materials. A composite surface soil sample, BY-SS1-COMP, was collected from the northern part of the pad from three locations.

Table 4-4 summarizes the soil sample analytical results. As expected, metals were detected in all soil samples; however, the metal concentrations were not elevated. Fluoride was detected in all soil samples ranging from 26.6 to 56.7 mg/kg. The higher fluoride concentrations were detected in the discrete grab samples. Low levels of Aroclor 1248 were also detected in the discrete samples: 0.049 mg/kg in BY-SS2 and an estimated 0.026 mg/kg in BY-SS4. SVOCs, in particular PAHs, were detected in all samples with concentrations below 3 mg/kg. The higher PAH concentrations were detected in BY-SS2.

4.2.4. Former Cryolite Bunker Pond

The cryolite bunkers were used to dispose of high-carbon waste cryolite (sodium aluminum fluoride) in the mid 1970’s at the location shown on Figure 4-1. The bunkers are also identified on 1975, 1977, 1979, 1981 and 1983-86 aerial photographs in Appendix E. The cryolite was excavated from the bunkers in 1986 and the bunker area was brought to grade. Records indicate that the bunkers accumulated surface water and that there was once a bermed runoff collection pond associated with the bunkers. The pond, which is no longer present, appears in the May 1979 aerial photograph in Appendix E. The records suggest that during storm events the bunkers and pond may have overflowed to the nearby stream. Available records describe a plan to drain the pond by pumping the water to the cryolite plant and then removing the berm after the bunkers were excavated and graded.

Because the cryolite was removed from the bunkers, this area is not suspected to be a significant source of the fluoride contamination to groundwater. Therefore, no further investigation of the bunkers was performed. However, because the sediments in the former pond may still be contaminated, a surface soil sample, BP-SS1 was collected at the location shown on Figure 4-3 and analyzed for fluoride. Fluoride was detected at a concentration of 43.5 mg/kg.

4.3. SOUTHERN DISPOSAL SITES

Alcoa investigated an approximately 53-acre grassy field located south of the main plant operations area to better understand potential environmental conditions. Because the plant had planned to construct a third potline (C-Line) in a portion of this field in the early 1970's, the grassy field is sometimes referred to as the former C-Line area, even though the potline was never constructed.

The phased investigation led to the identification and characterization of impacts from several historical waste disposal sites located south of the main plant operations. The preliminary investigation included interviews with plant workers, a review of records at the plant and at MDE, and the interpretation of aerial photographs. This was followed by a geophysical survey and then test pit excavation and soil sampling. After the waste disposal sites were identified during the preliminary investigation, additional sampling was performed to address data gaps and to determine if the waste disposal sites had impacted soils, sediments, and/or surface water in surrounding areas and streams. The following subsections present the results of the preliminary investigation, the geophysical survey and test pit sampling, a description of the identified historical waste disposal sites, and the results of the additional sampling.

4.3.1. Preliminary Investigation

The investigation began by conducting interviews with plant workers to discuss historical waste disposal operations including the types of wastes that were disposed, disposal methods, and locations of disposal sites. The workers interviewed recalled that a trench-style landfill was in operation in the early 1970's somewhere within the grassy field, but specific details such as the exact locations of waste disposal and the types of waste disposed were uncertain. However, they suspected that the types of waste included construction debris, general plant refuse, bricks, and possible carbon sources, such as cathode or anode materials and petroleum-based solvents. During a site walk of the area, bag house filters were observed protruding from the ground surface, and debris such as spent pot bricks were observed in a sinkhole and in groundhog burrows.

After interviewing the plant workers, a records review was performed at the plant and at MDE's offices in Baltimore, Maryland. Several documents were found in the plant's files that discussed waste disposal operations. Most of these were memoranda from the early 1970's which made references to landfills, trash trenches, disposed wastes, etc. The exhibits in Appendix F are scanned images of certain records that aided in the investigation of the disposal sites across the plant. These exhibits (e.g., Exhibit F-1, F-2, etc.) are referenced as applicable throughout this section

In addition to the records review, historical aerial photographs were obtained and reviewed to aid in the identification of disposal sites. The sources that were contacted to obtain aerial photographs as well as scanned images of the aerial photographs are provided in Appendix E.

The records contained information on a disposal site referred to as Waste Disposal Site 4 (WDS-4) which is located south of the Bake Ovens (Figure 4-1). Plant workers indicated that this was a landfill used for the disposal of various kinds of fluoridated waste, excluding SPL, before the now closed Industrial Waste Landfill (located west of the SPL Pad, Figure 4-1) was constructed. However, there is no specific information provided in the records regarding the wastes that were disposed of in WDS-4. This landfill was not constructed under a state permit, and has no liner or leachate collection system. WDS-4 was operated from the late 1970's to the early/mid 1980's. In 1986, the site was covered with 2 feet of compacted soil and vegetation. The plant's records (Exhibits F-1 to F-7) contained various documents, including correspondence between MDE and Eastalco, that show that MDE was aware of this closure (and also the closure of WDS-1, 2, and 3 described in Section 4.4); however, there are no available formal post-closure documents.

For unknown reasons, the aerial extent of WDS-4 shown on Figure 4-1 is smaller and shaped differently than that shown on plant maps such as the one reproduced as Exhibit F-8. The boundary of WDS-4 shown on Figure 4-1 was based on visual observations, aerial photographs, geophysical data, and a sketch in the soil compaction test report (Exhibit F-6), prepared after the soil cover was installed. Based on

Figure 4-1, WDS-4 covers approximately 4.5 acres; however, the soil cover may extend beyond the disposed waste. In addition, the thickness of the waste layer is unknown.

Two documents (Balter, 1974a and Geraghty & Miller [G&M], 1983) were reviewed and found to contain plant diagrams depicting disposal sites elsewhere in the grassy field in addition to WDS-4. Both Balter and G&M contained a map showing the approximate location of a “trash disposal site” located south of WDS-4. These are reproduced as Exhibits F-9 and F-10. G&M showed a second “trash disposal site” located west of the first one.

The aerial photographs (Appendix E) showed different areas of ground disturbance at various times. There is some correlation between disturbed areas shown on the aerial photographs from the early to mid-1970’s, and the “trash disposal sites” depicted on maps in Exhibits F-9 and F-10. In addition to aiding the preliminary investigation, the aerial photographs were also useful in assessing when disposal took place at the historical waste disposal sites that were identified though the geophysical and test pit investigations described below.

4.3.2. Geophysical and Test Pit Investigations

The C-Line area investigative field work began with an electromagnetic (EM) geophysical survey by Mundell & Associates, Inc. An electronic copy of the EM report is provided in Appendix A. Mundell performed the survey with an EM-31 instrument and delineated 18 areas with anomalously high EM terrain conductivity or anomalously low EM in-phase values. The anomalies (A, A’, B, C, D1, D2, E, F, G, H, I, I’, J, K, L, M, N, O) are identified on Figures 4-4 and 4-5, which are the conductivity and in-phase maps generated from the EM survey. In addition to the anomalies identified by Mundell, two other areas (OA1, OA2) were selected for investigation and are identified on Figures 4-4 and 4-5. These anomalies were subjected to an intrusive (test pit) investigation, the results of which are presented in the subsections below.

The test pit and trench locations are presented on Figures 4-4 and 4-5. Areas identified as background by the EM survey were also included in the test pit investigation to evaluate the accuracy of the geophysical data and to ensure that buried waste was not present.

Prior to mobilizing to the field, plant personnel cleared the 53-acre parcel for underground utilities. Test pits and trenches were excavated to characterize the potential disposal sites in accordance with the C-Line Area Work Plan and Field Sampling Plan (MFG, 2004a). Test pits were excavated within the geophysical anomalies to characterize the contents and to facilitate the collection of subsurface soil samples. When an area of buried waste was identified within a geophysical anomaly, test trenches were excavated around the perimeter of the anomaly to verify the boundary delineated by the EM survey. The number of test trenches varied depending on the accuracy of the geophysical data.

A GPS unit was used in the field to locate the position, in UTM coordinates, of the test pits and trenches in order to delineate the boundary of each buried waste area.

The general test pit sampling strategy was as follows:

- Samples collected at the surface and at the base of the test pits were analyzed for fluoride, and also total cyanide if carbon materials were observed.
- Samples from the base of test pits were additionally analyzed for VOCs.
- Composite samples were analyzed for metals, PCBs and SVOCs.

Appendix G presents the descriptions and photographs of the test pits and trenches. Figure 4-6 presents the determined waste disposal boundaries, sample locations, and analytical results for fluoride, cyanide, PCBs and PAHs. Table 4-6 contains a summary of the analytical data.

In planning this investigation, the primary chemicals of concern were fluoride and cyanide, which are prevalent in various types of plant process wastes that have been disposed of on-site. Metals, VOCs, SVOCs and PCBs were added to the analytical suite for full characterization of the area. As expected, metals were detected in all soil samples; however, with the possible exception of arsenic, the metal concentrations were not elevated and are therefore not discussed in detail in this report. PCBs and SVOCs (mainly PAHs) were detected frequently. As such, the results summaries provided below focus mainly on fluoride, cyanide, PCBs and PAHs.

4.3.2.1. Anomaly A

This area corresponds to Waste Disposal Site 4 (WDS-4), which as described above, was used for the disposal of fluoride waste materials. The EM survey maps show that the entire Anomaly A area on Figure 4-4 has elevated conductivity, and a linear metallic anomaly (identified as Anomaly I on Figure 4-5) is shown running through its center in a north to south direction. The overall elevated conductivity may be related to the soil cover if it was constructed with clay. Also, a high-intensity conductivity anomaly (purple) is located near the northwest portion of the Anomaly A area. The EM report indicates this could possibly be SPL or metal; however, plant workers did not recall this area being used for SPL disposal.

A file review was performed at MDE after the C-Line investigation activities, but no information was found pertaining to this historical disposal site. Although no formal closure documents were found, the site was considered closed since records indicated MDE was aware of the 2-foot soil cover. As such, no intrusive activities were performed during the investigation.

4.3.2.2. Anomaly B

Based on the EM survey, Anomaly B was identified as a large high-conductivity area located in the southwest portion of the parcel. The basis for this anomaly was uncertain, meaning it could have been related to a carbon material or clay fill.

Two test pits, B-TP2 & B-TP3, were excavated in the high-conductivity area (red portion), and one test pit, B-TP1, in the highest-conductivity area (purple portion), with depths ranging from 13 to 15 ft-bgs. Test trenches, B-TT1 to B-TT10, were also excavated to depths ranging from 4 to 15 ft-bgs to determine the horizontal and vertical extent of possible buried waste in Anomaly B. Surface soils typically consisted of reddish brown silt with some clay at the excavation locations. A carbon layer that included anode, pitch material, and some SPL was irregularly encountered throughout Anomaly B. However, the waste deposit appeared to be thickest from the center (4 to 12.5 ft-bgs) extending down to the southern end (6 to 15 ft-bgs) at B-TP3. Other buried materials including bath, oven bricks, and construction waste were also encountered. The soils at the base of the pits and trenches primarily consisted of light brown silty clay with occasional gravel. The buried waste area was delineated on the north and east based on test trenches, and on the west and south based on the topography. This area is approximately 150 feet east to west and 700 feet north to south.

A surface, a composite, and a base sample were collected from B-TP1, and one composite and base sample from B-TP3. The surface soil sample from B-TP1, analyzed for fluoride and total cyanide, had a detection of fluoride (6.9 mg/kg). The samples taken from the base of B-TP1 and B-TP3 were analyzed for fluoride, total cyanide, and VOCs. Both samples had detections of fluoride (38 and 0.71 mg/kg) and only B-TP1-BASE had estimated concentrations of total cyanide (0.27 mg/kg) and a VOC (acetone at 0.0097 mg/kg). The composite samples from both test pits were analyzed for PCBs, SVOCs, and metals. Both composite samples had detections of metals at low concentrations, and also detections of Aroclor 1242. Samples B-TP1-COMP and B-TP3-COMP had concentrations of Aroclor 1242 at 54 mg/kg, and 2.1 mg/kg, respectively. SVOCs, particularly PAHs, were also detected in both composite soil samples. For example, benzo(a)pyrene was detected at 41 mg/kg in B-TP1 and at 21 mg/kg in B-TP3. Other SVOCs were detected at concentrations ranging from 1.6 (estimated) to 98 mg/kg. Based on the detected concentrations of Aroclor 1242 and some PAHs in the composite sample from B-TP1, the archived surface soil sample was then analyzed for PCBs and SVOCs. Aroclor 1242 was not detected in this surface sample; however, Aroclor 1248 was detected at a concentration of 5 mg/kg. The PAH concentrations in the surface sample were generally an order of magnitude lower than the levels detected in the composite sample.

4.3.2.3. Anomaly C

Anomaly C is a large area near the northwest portion of the parcel, just south of the former Cryolite Bunkers. The conductivity map showed this area had greater conductivity than background soils. The EM report stated that this anomaly might be related to wastes buried in a hole, which may have corresponded to a former pond that reportedly received runoff from the Cryolite Bunkers. The former pond was mentioned in historical records, but the location was unknown. Anomaly C also contained three small areas (dark blue) where the combination of conductivity and in-phase measurement suggested the potential presence of a highly conductive material, such as a carbon source or metal.

One test pit, C-TP1, was excavated to a depth of 11 ft-bgs in the red conductivity area. Three additional test pits, C-TP2, CTP-3, and C-TP4, were excavated to depths of 5 to 10 ft-bgs in each of the dark blue areas (metallic anomalies). Two test trenches (C-TT2 and C-TT3) were excavated to 10 ft-bgs around the anomaly area to define the boundary of potential buried waste. The surface soils generally consisted of reddish brown silt with some clay. Subsurface soils typically consisted of light brown silty clay with occasional gravel. No waste materials were observed in the test pits and trenches of Anomaly C.

Samples, which included one surface, one composite, and one from the base of the pit, were only collected from test pit C-TP1 since waste was not observed in the test pits from this area. The surface sample was only analyzed for fluoride, which was not detected. The composite sample, collected from 0-11 ft-bgs, was analyzed for metals, PCBs, and SVOCs. Several metals were detected at low concentrations; however, PCBs and SVOCs were not detected. The soil sample from the base of the pit was analyzed for fluoride and VOCs. No constituents were detected in this sample.

4.3.2.4. Anomaly D

Anomaly D was identified as a large, irregularly shaped area in the south central/southwest portion of the parcel. The conductivity map showed it as two sub-anomalies (D1 and D2) with multiple isolated areas of varying conductivity, some of which are greater than background soils.

Anomaly D1 borders the southern boundary of the grassy field. As shown on Figure 4-4, it contained an area of high conductivity near its center (red), as well as a small area where buried metal was suspected (dark blue). One test pit, D-TP1, was excavated in this red conductivity area, and another, D-TP2, in the dark blue area of D1. One test trench, D-TT1, was also excavated north of the test pits for delineation. Excavations extended to approximately 15 ft-bgs. Surface and subsurface soils primarily consisted of reddish brown silty clay. Debris materials were found at both test pits: dust filters, cable, plastic and wood at D-TP1; and pipes and rebar at D-TP2. Test trench D-TT1 appeared clean and did not have any disposal materials. Although there was some scattered debris, there was no evidence of landfilling in this area. Soil samples were only collected from D-TP1, as defined in the FSP. Samples were not collected from D-TP2 since waste materials were not observed.

Anomaly D2 had three identified high conductivity areas (in red), which were located in the same general area as the western "trash disposal site" previously identified by Geraghty & Miller (G&M, 1983). This same area also aligned with a mound in the western portion of the parcel shown in old topographic maps. This site is thought to be associated with a disposal site referred to in historical records as "Waste Disposed on the Hill", which may have contained waste that was originally stored at the old Biser Farm located west of the plant.

Test pits, D-TP3 to D-TP5, were excavated in the three red areas in D2. Soil samples were collected from D-TP3, located in the largest conductivity area. Two test trenches, D-TT2 and D-TT3, were excavated to define the extent of D2. Excavations extended to approximately 15 ft-bgs, in which soils typically consisted of reddish brown silty clay with some limestone gravel. Test pit D-TP4 did not encounter debris or waste materials; however, occasional debris including anode, filter cloth, and bricks were revealed in the shallow soils at D-TP3 and D-TP5. Test Pit D-TP5 also had an occurrence of pitch at approximately 13 ft-bgs. The test trenches, excavated to the north and south of the test pits, did not have waste materials.

Soil samples were collected from D-TP1 in Anomaly D1 and D-TP3 in Anomaly D2 from the surface, at the base of the pits and from the full composite depth. The surface soil samples were analyzed for fluoride, and the sample from D-TP1 was also analyzed for total cyanide. Fluoride was the only constituent detected in surface soils at both test pits with concentrations of 4.1 and 8.9 mg/kg. Total cyanide was detected at D-TP1 at an estimated concentration of 0.25 mg/kg. The samples collected from the base of the test pits were analyzed for fluoride and VOCs. D-TP1-BASE was also analyzed for total cyanide. No constituents were detected in either base sample. The two composite samples were analyzed for metals, PCBs, and SVOCs. Several metals were detected at low concentrations. Concentrations of PAHs were less than 0.5 mg/kg. Aroclor 1242 was detected in both composite samples, 1.1 mg/kg at D-

TP1 and 0.32 mg/kg at D-TP3. The archived surface sample from D-TP1 was later analyzed for PCBs and SVOCs. Aroclor 1242 was not detected in the surface sample, but Aroclor 1248 was found at an estimated concentration of 0.2 mg/kg. Fewer SVOCs were detected in the surface sample and at even lower concentrations (i.e., <0.08 mg/kg).

4.3.2.5. Anomaly E

Anomaly E consisted of an elongated area and was suspected to be a trench landfill. Personnel interviewed at the plant recalled that a trench landfill operation occurred somewhere in the grassy field, but they were not sure where it was located.

Two test pits, E-TP1 and E-TP2, were excavated in the linear red conductivity area and four test trenches, E-TT1 to E-TT4, were excavated to determine the boundary of this area. Depths of excavations ranged from approximately 5 ft-bgs to 12 ft-bgs on the southern edge. The soil primarily consisted of reddish brown silty clay. Waste material, which consisted of a cryolite/alumina powder, was found at: E-TP1, the center of the area; E-TT1, the eastern boundary; and E-TT4, the western boundary. Test pit E-TP1 had the thickest amount of waste at a depth of 3 to 5 ft-bgs. The delineated elliptical area is approximately 110 ft from west to east and 40 ft from north to south.

Soil samples were collected from E-TP1 at the surface, from the base of the pit, and from the full depth. The surface sample was analyzed for fluoride, which was detected at a low concentration of 4.5 mg/kg. The sample from the base of the pit at 5.5 ft-bgs was analyzed for fluoride and VOCs. VOCs were not detected; however, fluoride was detected at a concentration of 1.1 mg/kg. The composite soil sample was analyzed for metals, PCBs, and SVOCs. Several metals were detected at low concentrations. PAH concentrations were less than 0.9 mg/kg. Aroclor 1242 was detected at a concentration of 0.049 mg/kg.

4.3.2.6. Anomalies F, G, H & O

Based on the EM survey, Anomalies F, G and H (Figure 4-4) consisted of multiple elongated or semi-circular areas of potential disposal intermingled with natural or clean fill. Anomaly O (Figure 4-5) was identified as several small isolated areas of metallic anomalies at various locations across the parcel. The combined area of Anomalies F, G, H, and O roughly correspond to the eastern “trash disposal site” identified by Balter (1974a) and G&M (1983), and to a large disturbed area shown on historical aerial photos from the early 1970’s. In addition, the combination of conductivity and in-phase measurements suggested one of the areas in Anomaly O may contain a highly conductive material, such as a carbon source.

Anomaly F

Two test pits, F-TP1 and F-TP2, and nine test trenches, F-TT1 to F-TT9, were excavated to depths ranging from 6 ft-bgs to 18 ft-bgs. Soils in this area commonly consisted of reddish brown to brown clayey silt. Debris materials found in the test pits and trenches were buried at relatively shallow depths (0 to 8 feet bgs) and included oven bricks, wood, plastic, and scrap metal. Additionally, waste materials, consisting primarily of pitch and occasionally anode, were observed in trenches F-TT1 from the surface to 4 ft-bgs, F-TT5 at 12 ft-bgs, and F-TT8 from 4 to 8 ft-bgs. A small former waste disposal trench, oriented east to west, was delineated around F-TT1 and F-TT4, which was approximately 90 feet long and 25 feet wide. Test trenches, F-TT6 to F-TT8 were used to delineate the western end of Anomaly O because of the close proximity, which is discussed later in this section.

Soil samples were collected from both test pits, F-TP1 and F-TP2, due to the presence of waste materials in the second test pit. Additionally, soil samples were collected from F-TT1 based on the field observations where pitch and anode were found from the surface to 4 ft-bgs. A surface soil sample was collected from F-TP1 and analyzed for fluoride. Both composite and base samples were collected from each location. Composite samples were analyzed for metals, PCBs, and SVOCs, and base samples were analyzed for fluoride (and total cyanide at F-TP2 and F-TT1). At F-TP1, fluoride was detected a concentration of 0.69 mg/kg in the surface sample and at 5.8 mg/kg in the base sample. VOCs were not detected in the sample from the base of the pit. Metals were detected at low concentrations in the composite sample. PAH concentrations in F-TP1 at the surface ranged from an estimated 0.041 to 0.31 mg/kg [benzo(a)pyrene was detected at an estimated 0.19 mg/kg]. PAH concentrations from the full depth in F-TP1 ranged from 0.063 (estimated) to 0.18 mg/kg (estimated) [benzo(a)pyrene was detected at 0.11 mg/kg]. PCBs were not detected in the F-TP1 composite sample. In F-TP2, neither fluoride nor VOCs were detected in the base of the pit. Metals were detected in the composite sample at low concentrations. The PAH concentrations were generally an order of magnitude higher than those found in F-TP1. For example, benzo(a)pyrene was detected at 25 mg/kg. Also, Aroclor 1248 was detected at 21 mg/kg. At F-TT1, the sample collected from the base of the trench had detections of fluoride and total cyanide (0.67 and an estimated 0.25 mg/kg, respectively). Only one VOC, toluene, was detected at the base of the trench at an estimated value of 0.0012 mg/kg. The composite sample from the trench had low concentrations of metals. PAH concentrations were slightly higher than those in F-TP2. Aroclor 1242 was detected at a concentration of 25 mg/kg.

Due to the detection of PCBs in the composite samples, an archived surface sample collected in this anomaly was analyzed for PCBs and SVOCs. The only surface sample collected within this area was from F-TP1. Aroclor 1248 was detected at an estimated concentration of 0.61 mg/kg in surface sample F-TP1-SURF.

Anomaly G

Five test pits, G-TP2 to G-TP6, were excavated within and around the red conductivity areas in Anomaly G. Several test trenches were excavated within and around this area to define the extent both horizontally and vertically. Soils typically consisted of reddish brown to brown silty clay/clayey silt. Four former waste disposal trenches were found that were generally oriented from north to south. They were approximately 150 feet long by 20 feet wide, and were apparently filled with general construction debris (plastic, wood, scrap metal) and waste materials (pitch, anode, bath, alumina/cryolite powder, oven brick). The depth of buried waste ranged from the surface to approximately 6 ft-bgs.

Soil samples were collected from two test pits, G-TP2 and G-TP4, which were excavated within the 150 foot-long disposal trenches in the anomaly. Samples were collected from the base of the test pits and from the full depths. Soils collected from the base of the pits were analyzed for fluoride and VOCs, and the base sample at G-TP4 was also analyzed for total cyanide. Fluoride was the only constituent detected in a base sample. At G-TP4, fluoride was detected in the base sample at a concentration of 1.0 mg/kg. The composite samples from both test pits were analyzed for metals, PCBs, and SVOCs. Metals were detected at low concentrations. PCBs and SVOCs, particularly PAHs, were also detected. Aroclor 1242 was detected in both samples: 190 mg/kg at G-TP2 and 260 mg/kg at G-TP4. PAH concentrations ranged from an estimated 23 to 300 mg/kg in G-TP2 [benzo(a)pyrene at 140 mg/kg], and from an estimated 25 to 520 mg/kg in G-TP4 [benzo(a)pyrene at 380 mg/kg].

Anomaly H

The EM survey had indicated three small red areas of high conductivity as Anomaly H. Initially, three test pits were planned for excavation in the red areas. However, based on the field observations, additional test pits and trenches were excavated to determine the boundary of the observed waste materials. General construction materials (scrap metal, pipe, wood) were found in this area. Waste materials, including pitch, oven brick, anode and possible SPL, extended from approximately 8 ft-bgs to at least 18 ft-bgs. The vertical extent could not be delineated because of the limited span of the backhoe.

Soil samples were collected from three test pits including H-TP1, H-TP3, and H-TP3N, which is the northern extent of H-TP3. At all three locations, soils were collected from the surface and from the full depth (composite). Base samples were collected from H-TP1 and H-TP3N, but not from H-TP3 because the depth of the waste in that pit exceeded the reach of the excavator. In the surface soils, which were analyzed for fluoride and total cyanide, fluoride was detected at all three locations, with the highest concentration of 29.9 mg/kg occurring at H-TP1, which is located on the western end of Anomaly H. Total cyanide was detected in the surface soils at H-TP3 and H-TP3N at just over an estimated concentration of 0.5 mg/kg. Soils from the base of the pit were collected from H-TP1 and H-TP3N and analyzed for fluoride, total cyanide, and VOCs. Fluoride was detected in both base samples, but was comparatively lower (i.e., < 0.7 mg/kg) than the detections in the surface soils. Total cyanide was detected at the base of H-TP3N at 0.85 mg/kg. VOCs were not detected in either base sample. Composite samples were collected from the three test pits and were analyzed for metals, PCBs, and SVOCs. Metals were detected at relatively low concentrations. Aroclor 1242 was found in H-TP1 (0 to 5 ft-bgs) at 20 mg/kg and in H-TP3 (0 to 18 ft-bgs) at 1,300 mg/kg. Aroclor 1248 was found in H-TP3N (0 to 14 ft-bgs) at 17 mg/kg. SVOCs were also detected in each of the three composite Anomaly H samples. Individual PAH concentrations ranged from an estimated 4.6 to78 mg/kg [benzo(a)pyrene at 57 mg/kg] in H-TP1, from an estimated 14to 190 mg/kg (benzo(a)pyrene at 68 mg/kg) in H-TP3, and from an estimated 2.5 to 57 mg/kg [benzo(a)pyrene at 25 mg/kg] in H-TP3N.

The archived samples collected from the surface from H-TP1 and H-TP3 were then analyzed for PCBs and SVOCs, based on the detections in the composite samples. H-TP1-SURF did not have a detection of Aroclor 1242; however, it did have a detection of Aroclor 1248 at an estimated concentration of 56 mg/kg. The surface sample from H-TP3 had a detection of Aroclor 1242 at an estimated concentration of 6 mg/kg. PAH concentrations ranged from an estimated 7 to 210 (estimated) mg/kg in H-TP1 [benzo(a)pyrene at an estimated 150 mg/kg] and from an estimated 0.18 to an estimated 3.9 mg/kg in H-TP3 [benzo(a)pyrene at an estimated 3.6 mg/kg].

Anomaly O

This anomaly was in the same vicinity of Anomaly F. Originally, four test pits were planned for excavation based on the separate areas identified on the in-phase EM survey map. One of the planned test pits was replaced by locations in Anomaly F. Therefore, three test pits, O-TP1, O-TP2, and O-TP3, and five test trenches, O-TT1 to O-TT5, were excavated to define and delineate Anomaly O. Test trenches excavated during Anomaly F activities were also used as part of the delineation in Anomaly O because of the close proximity and similarity of deposited materials. The excavations, which ranged in depth from approximately 6 ft-bgs to 10 ft-bgs, determined that a fifth former waste disposal trench, with an east to west orientation, was present 170 feet north of the four waste disposal trenches identified during the investigation of Anomaly G. Debris consisting of plastic, wire, and scrap metals, as well as waste consisting of pitch and anode, were observed in several of the pits and trenches down to a maximum depth of 8 ft-bgs. The depth and thickness of the waste materials area decreased on the eastern boundary. Based on observations of the test pits and test trenches, the area of the waste disposal trench is approximately 350 feet long from east to west and 45 feet wide.

Samples were collected in Anomaly O from O-TP3 and O-TT2 from the base of the pit and trench and from the full depths based on field observations. The samples from the bases of the excavated pit and trench were analyzed for fluoride, total cyanide, and VOCs. No constituents were detected in the sample from O-TP3; however, fluoride was detected in the O-TT2 base sample at a concentration of 9.2 mg/kg and toluene was detected at an estimated value of 0.002 mg/kg. The composite samples from both locations were analyzed for metals, PCBs, and SVOCs. Both samples had low detections of metals. O-TP3 had detectable concentrations of SVOCs, particularly PAHs, which ranged from an estimated 0.56 to 9.6 mg/kg (benzo(a)pyrene at 6.9 mg/kg) in O-TT2, and from 39 to 730 mg/kg (benzo(a)pyrene at 450 mg/kg) in O-TP3. Aroclor 1242 was detected at 2 mg/kg in O-TT2 and at 17 mg/kg in O-TP3.

4.3.2.7. Anomaly I

The EM survey defined Anomaly I (Figure 4-5) as a long narrow metallic anomaly in a north to south direction through the center of Anomaly A to the southern fence line. The anomaly area widened at the southern end. This anomaly was peculiar because it was defined as potential metal on the in-phase map, but as background soil on the conductivity map.

One test pit, I-TP1, and two test trenches (I-TT1 and I-TT2) were excavated to depths ranging from 13 to 18 ft-bgs within the red area and along the north and south boundary of the anomaly. Soils typically consisted of reddish brown silt with some clay at the surface to light brown silty clay in the subsurface with occasional limestone gravel. Debris or waste materials were not observed in any of the excavations in this anomaly. Since waste materials were not observed and the excavation areas were relatively clean, no samples were collected from this anomaly.

4.3.2.8. Anomaly J

Anomaly J (Figure 4-5) was shown as a narrow, L-shaped area located near the center of the parcel between Anomalies D and E. The combination of conductivity and in-phase measurements suggested this area could contain a highly conductive material, such as a carbon material and/or metal. Two test pits, J-TP1 and J-TP2, were excavated to approximately 12 ft-bgs. Waste materials were observed in both test pits. From the surface to approximately 2 feet-bgs, large black virgin cathode pot liners, identified by plant personnel, were encountered in J-TP1. Additional excavations showed a circular disposal area approximately 20 feet in diameter containing 10 virgin cathode blocks, each approximately 5 feet long by 1.5 feet wide. The southern test pit, J-TP2, contained anode debris from 1 to 3 ft-bgs and alumina/cryolite mixed with soil from 3 to 4 ft-bgs. No additional excavation was performed as part of Anomaly J; however, this area was delineated by excavation of other anomalies (E, K, and OA).

Soil samples were collected from J-TP1 from the surface, at the base of the pit, and from the full depth. The surface soil sample was analyzed for fluoride and total cyanide. Only fluoride was detected at 15.4 mg/kg. The sample from the base of the pit was analyzed for fluoride, total cyanide, and VOCs, none of which were detected. The composite sample was analyzed for metals, PCBs, and SVOCs. Metals were detected at low concentrations, while Aroclor 1242 was detected at 0.37 mg/kg. SVOCs were also detected with PAH concentrations ranging from 0.076 (estimated) to 0.21 mg/kg (estimated).

4.3.2.9. Anomaly K

A single test pit, K-TP1, located approximately 50 feet south of Anomaly J, was excavated to approximately 11 ft-bgs, uncovering only one large piece of debris material. A portion of an oven brick wall, approximately 9 feet by 5 feet, was unearthed at 2 ft-bgs. Soils excavated from the test pit primarily consisted of reddish brown silt with some clay at the surface to light brown silty clay towards the base of the pit.

Samples were collected from the base of the pit and from the full depth. The base sample was analyzed for fluoride, total cyanide, and VOCs. Total cyanide was not detected, however, fluoride was detected at a concentration of 3.7 mg/kg, and toluene was detected at an estimated value of 0.0014 mg/kg. As with other samples, the composite sample was analyzed for metals, PCBs, and SVOCs. Metals were detected at low concentrations. Aroclor 1242 was detected at an estimated 0.33 mg/kg while the PAH concentrations ranged from 0.1 (estimated) to 0.6 mg/kg.

4.3.2.10. Anomalies L through N

Anomalies L, M, and N were identified as several small isolated areas of metallic anomalies at various locations across the parcel. The EM report indicated there was a potential for these anomalies to contain buried drums. However, Anomalies M and N were also in the same vicinity as Anomaly A where WDS-4 was formerly located. Excavation work was not performed in Anomaly A as described in Section 4.3.2.1; therefore, excavation work was also not performed in Anomalies M and N.

One test pit, L-TP1, was excavated in the vicinity of Anomaly L. This anomaly was located close to Anomaly D and test pit D-TP2. Disposed materials were not encountered in L-TP1. This anomaly, identified on the in-phase map, was located within the Anomaly D1 area and could have been associated with the blue metallic area, identified on the conductivity map. Soil samples were not collected in this anomaly because waste materials were not observed.

4.3.2.11. Other Anomalies

In addition to the anomalies identified by Mundell, the in-phase map showed two areas of weaker negative in-phase responses that warranted further investigation. The first, OA-1, was the 150-foot wide light pink zone that had the same general orientation and length as Anomaly I and was located about 200 feet west of Anomaly I. The conductivity map showed this area to be background soil or clean fill, but the relatively uniform appearance of this area on the in-phase map suggested this might have been indicative of some unnatural subsurface feature.

The other area, OA-2, was a 300 by 50 foot linear feature that had the same general orientation as Anomaly E and was located between the northern edge of the 53-acre parcel and the north edge of Anomaly E. This feature appeared light pink on the in-phase map and light blue on the conductivity map. The fact that its boundary showed up on both maps and had a linear shape also suggested a possible unnatural subsurface feature.

As planned in the FSP, test pits OA-TP1 and OA-TP2 were excavated in these additional anomalies. A third additional anomaly, OA-3, consisting of stressed vegetation was identified in the field and was subsequently investigated with test pit OA-TP3. These three test pits were excavated to approximately 10 to 12 ft-bgs. Soils were reddish brown silt with some clay to light brown silty clay. No debris or waste materials were found in these excavations; therefore, no sampling was conducted.

4.3.2.12. Background Areas

To test the validity of the geophysical data, three test pits, BK-TP1 to BK-TP3, were excavated in areas not identified as anomalous on either the in-phase or conductivity maps, that is, areas that were identified as background soil or clean fill. These test pits were excavated to approximately 8 to 13 ft-bgs and soils typically consisted of reddish brown to light brown silty clay.

Samples were only collected from BK-TP1 at the surface, from the base of the pit, and from the full depth. The surface sample was analyzed for fluoride, the base sample for fluoride and VOCs, and the composite sample for metals, PCBs, and SVOCs. Only metals were detected. The archived surface sample was later analyzed with the other anomaly surface soil samples for PCBs and SVOCs. PCBs and SVOCs were not detected in background surface sample.

4.3.3. New Waste Disposal Site Identification

The outcome of the investigation was the identification of several areas of former disposal activities within the 53-acre grassy field located south of the main plant operations and between two streams (Figure 4-7) which was proposed by the plant for use as a dump site in 1973. The topography of the grassy field originally had a knob or topographic high near its center with an overall gentle slope towards the farmlands to the south. The field now contains a large amount of fill material that was deposited in the 1970's. This resulted in the present grade, which now gently slopes from the south back towards the plant and has steep slopes along the southern and western boundaries.

The newly identified historical disposal sites were named in a manner to be consistent with the nomenclature used to identify other former on-site disposal areas (e.g., WDS-4). Estimates of the area and waste volume are provided below for informational purposes; however, more precise data would be needed if remedial designs were pursued. Figure 4-7 presents the locations of the waste disposal areas. All other areas within the 53-acre parcel were found not to have had disposal activities, including geophysical Anomaly C, portions of Anomaly D, and the large area between Anomalies A and C.

- WDS-5 – This disposal area is located in the southeast corner of the field adjacent to the edge/slope of the grassy field and east of the bend in the gravel perimeter road. Approximately 7,740 cubic yards of waste consisting mainly of carbon materials (mostly anodes and pitch with some SPL), as well as construction debris are present in this former disposal area, which covers approximately 0.6 acres. WDS-5 is within the eastern "trash disposal site" area identified by Balter (1974a) and G&M (1983) as well as an area of disturbed ground shown on aerial photographs form the early 1970's. The buried waste occurs at depths from about 6 to at least 18 feet-bgs. The bottom depths in some portions of WDS-5 exceeded 18 feet and could not be determined with the excavator. The waste appears to be surrounded with silty clay; however, the type of soils underlying the deepest portions is not known. Relative to other disposal areas within the grassy field, WDS-5 is the most contaminated in terms of PCBs in surface and subsurface soils (6 to 1,300 mg/kg), and has low to moderate PAH contamination in surface and subsurface soils (<1 to 190 mg/kg).

- WDS-6 –This disposal area is located in the south-central portion of the field adjacent to and west of the bend in the gravel perimeter road. WDS-6 consists of six waste disposal trenches (four oriented north to south and two oriented east to west), and a semi-circular disposal area located near the bend in the perimeter road. WDS-6 is also within the eastern "trash disposal site" area identified by Balter (1974a) and G&M (1983), as well as an area of disturbed ground shown on aerial photographs from the early 1970's. The four north-to-south trenches are approximately 6 feet deep, 20 feet wide, and 150 feet long. The northern east-to-west trench is approximately 6 feet deep, 45 feet wide, and 350 feet long. The southern east-to-west trench is 4 feet deep, 25 feet wide, and 90 feet long. The semi-circular disposal area is approximately 3 feet deep and has a diameter of about 35 feet. Combined, the disposal areas within WDS-6 contain approximately 6,200 cubic yards of waste consisting mainly of carbon materials (mostly anodes and pitch), as well as construction debris, and have an effective area of 1.9 acres. The buried waste is covered with just a few inches of soil and extends to depths of about 5 to 6 feet-bgs. The waste is underlain and surrounded laterally by silty clay. Relative to other disposal areas within the grassy field, WDS-6 is the most contaminated in terms of PAH contamination in subsurface soils (<1 to 730 mg/kg) and has moderate PCB contamination in subsurface soils (<1 to 260 mg/kg). Lower levels of PAHs and PCBs were present in the surface soil sample collected from within the combined area; however, because the waste is present near the surface, PAH and PCB contamination of surface soils could be elevated in some portions of the disposal area that were not sampled.

- WDS-7 –This disposal area is located just west of WDS-6 and approximately 200 feet north of the gravel perimeter road. WDS-7 is a relatively small disposal area (3,476 sq.ft.) that contains approximately 258 cubic yards of cryolite and alumina that is present in a layer located about 3-5 feet-bgs. The waste is surrounded in all directions by silty clay. Relative to other disposal areas within the grassy field, WDS-7 is the least contaminated in terms of PAH (<0.9 mg/kg) and PCB (0.05 mg/kg) contamination in subsurface soils. Although PAH and PCB concentrations in surface soil are not known, elevated surface soil contamination would not be expected given the type of buried waste materials.

- WDS-8 – This disposal area roughly coincides with the geophysical Anomaly B in the southwest corner of the field. Approximately 21,150 cubic yards of waste consisting mainly of carbon materials (mostly anodes and pitch with some SPL), as well as bricks, metal, and plastic debris are present in this former disposal area, which covers approximately 2.6 acres. The most significant deposit of carbon is from the center of the area to the southern edge. Across WDS-8, the buried waste occurs at depths ranging from 3 to 15 feet bgs and is generally well surrounded by silty clay; however, some portions are underlain by more permeable silty sands. The west and southern boundaries of WDS-8 are defined by the steep-sloped edges of the grassy field. Relative to other disposal areas within the grassy field, WDS-8 has low to moderate PAH (3.4 to 98 mg/kg) and PCB (2.1 to 54 mg/kg) contamination in subsurface soils, and also has low PAH (<10 mg/kg) and PCB (5 mg/kg) contamination in surface soil.

The test pit excavations provided useful information regarding the location and depths of buried waste as well as the lithology of the soils surrounding the waste. However, the full lithologic profile down to the bedrock surface could not be determined due to the limitations of the excavators. Soil borings were installed during a subsequent phase of the investigation (see Section 4.3.5 below) near these buried waste areas to determine the thickness and type of soils that exist between the waste and bedrock.

In addition to WDS-5 through WDS-8, scattered buried debris was encountered in several test pits in other portions of the grassy field, which included Anomalies D, J, and K. This area is outlined on Figure 4-7; however, the debris is not continuously located within the area. For example, geophysical Anomaly J contained several virgin cathode blocks, and Anomaly K contained a section of a pot brick wall. Elsewhere, such as geophysical Anomaly D, the presence of this scattered debris mixed with the fill soil is most likely the result of historical grading operations associated with the construction of the C-Line, which was started in the late 1970’s but was canceled soon after. Anomaly D is located in approximately the same area as the western “trash disposal site” identified by G&M (1983). However, the test pits indicated that there is no disposal site at that location.

4.3.4. Waste Disposal Chronology

Because PCBs were detected in soil samples from WDS-5 though 8, the time in which the disposal occurred is important with regards to the Toxic Substances Control Act (TSCA). According to 40 CFR 761.50(b)(3), the United States Environmental Protection Agency (EPA) presumes that PCB sites that meet the following criteria do not represent an unreasonable risk of injury to health or the environment and are not required to be cleaned up in accordance with 40 CFR 761.61:

- Wastes containing as-found concentrations of PCBs ≥ 50 mg/kg (regardless of the concentration of the original spill or release) that were disposed of prior to April 18, 1978; or

- Wastes containing as-found concentrations of PCBs ≥ 50 mg/kg that were disposed of after April 18, 1978 and before July 2, 1979, where the concentration of the original spill or release was <500 mg/kg.

To gain an understanding as to when wastes were deposited in the southern disposal sites (SDS), records from the plant and MDE were reviewed, aerial photographs were evaluated, and a site reconnaissance was performed. The following summarizes the information obtained and the related conclusions regarding disposal timeframes. Aerial photographs and scanned images of Eastalco and MDE records referred to in the following subsections are provided in Appendices E and F, respectively.

4.3.4.1. WDS-4

An EPA Site Investigation Report (EPA, 1983) states that the plant constructed a new landfill (now referred to as WDS-4) in a depression south of the Bake Ovens in 1975 and that the landfill was reaching its capacity.

4.3.4.2. WDS-5, 6, and 7

An internal Eastalco memo dated 1/23/73 from Nagel to Paul & Schroer (Exhibit F-11) discussed a proposed dump site that was to be located south of the potline area and between the streams on a topographic knob. The memo referenced an attached map, but the map was not included in the plant's files. However, a map showing the proposed dump site was found in MDE's files, a portion of which is presented as Exhibit F-12. The border of the proposed site is very similar to the current SDS fill area (Figure 4-8). The memo called for a minimum of four seepage pits to be installed between the proposed dump site and the creeks (note that four seepage pits were identified during a 2005 site reconnaissance – see Figure 4-8). The memo also called for two separate disposal areas within the proposed dump site: the area farthest from the creeks was to receive the high fluoride materials; and the one closer to the creek was to receive bricks and trash.

Balter (1974a) contained a map (Exhibit F-9) showing a "Trash Disposal Site" located in the eastern portion of the dump site proposed in the 1/23/73 memo. Balter discusses piezometers installed downgradient of "Trash Disposal Site" in which fluoride was detected in groundwater at 3.2 ppm. Balter concluded that the "Trash Disposal Site" had been used for disposal of fluoride wastes.

An internal Eastalco memo dated 11/18/74 from Walk to Meyer (Exhibit F-13) discusses digging up and moving 25,000 cubic yards of waste from 11 trash trenches to a new landfill. A 12/26/74 internal memo from MacCormack to Meyer regarding waste volumes (Exhibit F-14) stated that "Buried Material" had a trench volume of 20,000 cubic yards. Later, an internal Eastalco memo dated 4/14/75 from Janson to Giraudy (Exhibit F-15) states that "Buried Material" will be investigated for possible treatment (with calcium). It is presumed that the “Trash Trenches” and “Buried Material” refer to the "Trash Disposal Site" identified by Balter (1974a). It is also presumed that this disposal area is the one that was proposed to be located closer to the creeks as discussed in the 1973 memo regarding the proposed dump site.

During the site investigation, it was learned that the "Trash Disposal Site" contained buried waste materials, which were mostly disposed of in trenches. These disposal sites have been identified as WDS-5, 6, and 7 as shown on Figure 4-8. Based on the records as well as an analysis of aerial photographs, these wastes were deposited between 1973 and 1974 and as such are not required to be cleaned up in accordance with TSCA regulations.

During a follow-up site reconnaissance, two ponds (bermed areas with overflow pipes) were found adjacent to and downgradient of WDS-4 through 7 as shown on Figure 4-8. These are likely the “seepage pits” discussed in the 1/23/73 memo. The western pond (south of WDS-5 and 6) is dry and heavily wooded. The eastern pond (south of WDS-4) is now a wetland marsh.

4.3.4.3. WDS-8

The 4/14/75 memo from Janson to Giraudy also indicated that "Material Disposed on the Hill" is being piled up and will be covered with layers of clay and plastic until a future solution is developed. The memo indicates that bake oven pond material (pitch), Rod Shop sweepings, and material from the Biser Farm (cryolite dust) were stored on the "hill". Balter (1974b) designed a trench landfill for SPL disposal that was approved by the State, but was ultimately not constructed due to high construction costs and the anticipated re-use of the SPL carbon. A map in Balter’s landfill design (Exhibit F-16) identifies an area of existing waste situated on top of a hill south of the plant. Based on it name, "Material Disposed on the Hill" is presumed to be the existing waste described by Balter (1974b). It is also presumed that this disposal area site is the one that was proposed to be located further from the creeks as discussed in the 1973 memo regarding the proposed dump site.

An internal Eastalco memo dated 2/25/74 from Meyer to MacCormack described "Material Disposed on the Hill" as waste spread out on the field. According to the memo, the proposed solution for "Material Disposed on the Hill" was to pile the waste and cover it with plastic. An internal memo dated 6/3/75 from Janson to Giraudy (Exhibit F-17) states that "Material Disposed on the Hill" has been piled up and will be covered as soon as possible. Later, an internal memo from Janson to Giraudy dated 7/14/75 (Exhibit F-

18) states that some covering has been placed on the "Material Disposed on the Hill", and that material from the Biser Farm has to be placed on the pile. According to the 4/14/75 internal memo from Janson to Giraudy, the Biser Farm contained cryolite dust.

Concerning the disposal timeline for "Material Disposed on the Hill", the aerial photographs show disturbance beginning in 1974. Although a March 1977 aerial photograph still shows some disturbance in this area, it is presumed based on these records that after transfer of wastes from the Biser Farm described in the 7/14/75 memo, no other wastes were placed at the "Material Disposed on the Hill". The presumption is considered reasonable given that beginning in 1975, the plant likely began depositing of their waste in the new fluoride landfill (i.e., WDS-4). The 7/14/75 memo was the latest reviewed record that mentioned the "Material Disposed on the Hill."

During the site investigation, no waste materials, other than miscellaneous scattered debris were found in the area where the "Material Disposed on the Hill" was originally spread out on the ground surface. Therefore, this waste was moved. As stated earlier, the 4/14/75 memo from Janson to Giraudy, stated that the "Material Disposed on the Hill" was to be piled up and covered with layers of clay and plastic until future solution was developed. Apparently, the ultimate solution was to move the waste pile from the hill to the southwest edge of the dump site proposed in the 1/23/73 memo. A seepage pit located between WDS-8 and the creek was used to control runoff. The pit, now dry and heavily wooded, was identified during a January 2005 site reconnaissance of the area.

Aerial photos show that the present location of WDS-8 was undisturbed as late as March 1977. The next available aerial photograph (May 1979) shows disturbance throughout the entire dump site proposed in the 1973 memo, which is now the grassy field. Apparently, between March 1977 and May 1979, the entire dump site proposed in the 1/23/73 memo was re-graded. The May 1979 aerial photograph shows that most if not all of the fill material had been placed, as the surface of the field appears similar to its current state. The re-grading resulted in the movement of waste from the "Material Disposed on the Hill" location to the southwest edge of the proposed dump site (i.e., the area now identified as WDS-8). During the investigation of WDS-8, PCB concentrations were detected as high as 54 mg/kg.

Based on the 1977 and May 1979 aerial photographs, it is reasonable to conclude that the movement occurred prior to April 18, 1978. Given the large volume of soil that was placed across the entire area that is now the grassy field, it is unlikely that all of the soil and wastes were placed in this area between April 1978 and May 1979. It is reasonable to conclude that the placement of the soil and waste was started between March 1977 and April 1978, and was completed before May 1979. Given that the waste materials in WDS-8 are buried beneath soil with depths ranging from 3 to 15 feet bgs, the movement of the wastes from the "Material Disposed on the Hill" would have occurred early in the process and likely before April 18, 1978. In addition, because the movement of the waste occurred before July 2, 1979, and samples collected during the investigation suggest the PCB concentrations of the original source (i.e., "Material Disposed on the Hill") were less than 500 mg/kg, this site is not required to be cleaned up in accordance with TSCA regulations.

The re-grading also resulted in a slope reversal in some areas. While there is no current detailed topographic map of the grassy field, ground surface elevations of local monitoring wells and field observations suggest that the re-grading and filling operations resulted in lower surface elevations at the "Material Disposed on the Hill" location (326 feet in 1974 based on Balter [1974b] compared to approximately 316 to 322 feet today based on well survey data), and higher elevations elsewhere, particularly in the vicinity of WDS-8). In 1974, the ground surface in the vicinity of where WDS-8 is now located was sloped with elevations of approximately 304 to 312 feet. Today, the area is relatively flat with an elevation of approximately 328 ft.

The present topography appears to have been designed to channel drainage away from the disposal sites. As illustrated on Figure 4-8, runoff flows either towards a swale located near the northern portion of the field (which drains to a former seepage pit that is now dry and grass-covered), or to the seepage pits located at the base of the steep slopes located to the west of WDS-8 and south of WDS-5, 6, and 7.

4.3.5. Additional Sampling

Samples from the C-Line area were archived at the laboratory pending a review of the fluoride results. As stated in the C-Line Area Work Plan (MFG, 2004a), one sample from each pit was to be selected for soil pH analysis and for conducting deionized (DI) water leach tests (fluoride, pH, alkalinity, TDS, ORP, and major cations/anions) to evaluate fluoride contaminant fate and transport if elevated fluoride levels were present in the soils. However, based on the sampling results, no additional analyses for pH and DI leach tests were necessary. Additional analyses of PCBs and SVOCs on surface soil samples were conducted based on the analytical results of the composite samples.

As part of the second phase of the soil investigation, additional soil sampling was conducted utilizing a Geoprobe to define the extent of the waste disposal sites that could not be determined by the test pit excavation. Soil borings were drilled in the vicinity of these buried waste areas to determine the thickness, type and permeability of the soils that exist between the waste and bedrock. It was also not known if these waste deposits impacted surface water or sediments in the nearby streams, surface soils in the former seepage pits, or surface soils in the adjacent farm fields that Alcoa leases. Therefore, surface water, sediment, and surface soil samples were collected from the locations shown on Figure 4-9, which also presents the Geoprobe locations.

4.3.5.1. Soil Borings

Geoprobe soil borings were drilled in several locations (Figure 4-9) to better understand the lithology in the vicinity of the waste disposal sites identified during the test pit investigation. Boring logs for the Geoprobe soil borings are located in Appendix C.

Soil boring WDS5-SB1, located along the northern boundary of WDS-5, was advanced to the top of bedrock at 36 ft-bgs. The fill material consisted of clay and gravel to approximately 8 ft-bgs, and then stiff clay to the top of bedrock. The clay appeared to be wet at approximately 24 ft-bgs. A second boring was planned for the southern boundary of WDS-5, but was not drilled due to the steep slope of the fill material. Therefore, it was assumed that the southern boundary of WDS-5 extended to the edge of the fill material.

Soil boring WDS6-SB1, located north of WDS-6, was advanced to top of limestone bedrock that was observed at 20 ft-bgs. Fill material consisting of clay and some gravel was present to 4 ft-bgs and was underlain by a layer of clay that extended to the top of bedrock. Water was encountered at 19 ft-bgs.

Boring WDS7-SB1 was drilled until bedrock refusal at 34 ft-bgs. Fill material consisting of clay and gravel was present to approximately 8 ft-bgs and was underlain by a layer of clay that extended to the top of the claystone bedrock. Water was present at approximately 32 ft-bgs.

Two borings were advanced along the perimeter of WDS-8: WDS8-SB1 to the north and WDS8-SB2 to the east. At WDS8-SB1, fill material consisted of clay with limestone rock fragments from the surface to 8 ft-bgs; clay from 8 ft-bgs to the top of the limestone bedrock, which was encountered at 33 ft-bgs. Water was observed at approximately 25 ft-bgs. At WDS8-SB2, similar fill material was observed to 9 ft-bgs with clay continuing to top of bedrock at 27.5 ft-bgs. Water was not observed in this boring.

4.3.5.2. Surface Soil, Sediment, and Surface Water Sampling

Tables 4-7 and 4-8 summarize the sediment/soil and surface water sample analytical results, respectively. Sediment and surface water samples were collected at three locations as shown on Figure 4-9. Samples TT-SD1/SW1 were collected in the unnamed tributary, and TC-SD1/SW1 and TC-SD2/SW2 were collected in the Tuscarora Creek. PCBs were not detected in any of the sediment and surface water samples. Only one PAH, naphthalene, was detected in the surface water samples and its maximum concentration was an estimated 0.0004 mg/L. In sediment, low levels of multiple PAHs were detected with a maximum concentration 0.73 mg/kg.

Four surface soil samples, SP-SS1 through SP-SS4, were collected from the former seepage pits located near the perimeter of grassy field in which the southern disposal sites are located (Figure 4-9) to determine if the soils in the ponds have residual contamination resulting from operation of the former disposal sites. The samples were collected at depths of approximately 0.5 to 1 foot below grade were and analyzed for PCBs and PAHs. PCBs were detected in three of the four pits, and PAHs were detected in all four pits. The highest PCB concentrations were in sample SP-SS1, collected from the pit that is downslope of WDS-5 and 6, which as discussed earlier, contained the highest concentrations during the test pit investigation. SP-SS1 had Aroclor 1248 and 1254 at 10 and 2.5 mg/kg, respectively. PCBs were at concentrations less than 0.1 mg/kg in two of the other pits. Although not included in the analytical suite, validation of the raw laboratory data suggested that Aroclor 1262 may also be present in samples at low concentrations. Multiple PAHs were detected in each sample, with SP-SS1 again having the highest concentrations. For example, benzo(a)pyrene was detected at 3.5 mg/kg in SP-SS1, while samples from the other pits contained benzo(a)pyrene at concentrations less than 1 mg/kg.

Two surface soil samples, FF-SS1 and FF-SS2, were collected in the field south of the southern disposal sites to determine the impact to soils, if any, in the agricultural fields. The samples were collected and analyzed for PCBs and PAHs. The locations of these samples are shown on Figure 4-9. No PCBs were detected in FF-SS2; however, Aroclor 1242 was detected in FF-SS1 at a concentration of 0.19 mg/kg. Low levels of multiple PAHs were detected in both samples. The maximum PAH concentration was 0.62 mg/kg.

4.3.5.3. Groundwater Sampling

Because of PCB and PAH concentrations detected in the soil samples from WDS-5 and WDS-6, a new well pair consisting of an overburden well (MW-100) and a bedrock well (MW-101) were installed in the area between WDS-5 and WDS-6 and Tuscarora Creek to evaluate impacts from these sites to groundwater. An additional new well pair consisting of an overburden well (MW-109) and a bedrock well (MW-110), installed east of Tuscarora Creek, were also included as part of the evaluation. Existing bedrock well MW-62 and overburden wells MW-51 and MW-53 were in suitable locations for monitoring potential releases from WDS-8; therefore, no new wells were installed. With the exception of

MW-100, samples were collected from these new and existing wells. MW-100 could not be sampled as the well could not produce enough water for purging and sampling.

The samples were analyzed for total fluoride, free cyanide, PCBs, and PAHs and the results are provided on Table 4-1. While low levels of PAHs (<0.022 ug/L) were detected in some wells, PCBs were not detected in groundwater samples from any of the monitoring wells. The fluoride concentration downgradient of WDS-5 and WDS-6 in MW-101 was 1.55 mg/L and free cyanide was not detected. Samples from wells MW-51, MW-53, and MW-62 respectively contained fluoride at 1.3, 1.43, and 4.38 mg/L. Free cyanide was detected at respective concentrations of 0.003 and 0.007 mg/L in MW-51 and MW-62, but was not detected in MW-53. The fluoride and free cyanide results are included in the site-wide plume assessment discussed in Section 4.7

4.4. WESTERN DISPOSAL SITES

Alcoa investigated approximately 14 acres of land located west of the main plant operations area on both sides of the fence line to better understand potential environmental conditions. The identification of historical waste disposal sites located west of the main plant operations resulted from interviews with plant workers, a review of records at the plant and at MDE, interpretation of aerial photographs, geophysical surveys, and test pit excavation and soil sampling. The following subsections present the results and key findings of the investigation.

4.4.1. Preliminary Investigation

As was the case for the southern disposal sites, this investigation began by conducting interviews with plant workers to discuss historical waste disposal operations in this area, reviewing records at the plant and MDE, and interpreting aerial photographs. Plant maps, such as the one reproduced on Exhibit F-8, show three waste disposal sites (WDS-1, 2, and 3) located near the western fence line, which have a combined area of approximately 2 acres. Records indicated that these sites were used for the one-time disposal of SPL and tarry scrubber solids in 1973. In 1986, the sites were covered with 2 feet of compacted soil and vegetation. The plant's records (Exhibits F-1 to F-7) contained correspondence between MDE and Eastalco that show that MDE was aware of the closure, but there are no available formal closure documents.

There were no as-built or other formal engineering drawings or maps associated with the three waste disposal sites found during the records review. Furthermore, information obtained during the records search (Exhibits F-8 and F-19) showed conflicting locations and boundaries of WDS-1, 2 and 3. As such, the locations and boundaries of WDS-1, 2 and 3, as well as the depth of the disposed wastes, are uncertain. For example, as shown on Figure 4-10, the locations and shapes of these sites as depicted on the plant map (Exhibit F-8) differ from the locations and shapes depicted on a site sketch from the soil compaction test report (Exhibit F-19) which, at the time referred to these sites as landfill areas 2, 3, and 4. Disposal sites depicted in maps from G&M 1983 (Exhibit F-10) show still other variations on the locations and shapes.

In addition to SPL disposal at WDS-1, 2 and 3, plant personnel interviewed during a site walk of the area indicated that a larger area, totaling approximately 14 acres, may have historically been used for waste disposal. These 14 acres include WDS-1, 2, and 3 as well as other areas near the western fence line. The workers could not recall the exact types of wastes that were disposed, but indicated the wastes may have included construction debris, spent carbon materials, and waste containing Therminol (PCBs).

In addition, EPA Site Investigation Report (EPA, 1983) obtained during a review of MDE's records, described a 5-acre landfill that was in this area and was used from 1970 to 1975 for the disposal of plant waste including SPL. The location and boundary of this landfill is uncertain as the memorandum contained only a crude location sketch of the landfill (Exhibit F-20).

A review of aerial photographs (Appendix E) showed areas with disturbed ground in several locations near the western fence line. It is uncertain whether the disturbances were related to waste disposal or other activities.

4.4.2. Geophysical and Test Pit Investigations

Due to the uncertainty regarding the locations and boundaries of WDS-1, 2, and 3, and the potential for disposal to have occurred elsewhere near the western fence line, the investigation continued with a geophysical survey, followed by the excavation and sampling of test pits.

In March 2004, an EM geophysical survey was conducted by Mundell & Associates, Inc. on potential areas of disposal identified through the worker interviews, record searches and aerial photograph review. An electronic copy of the complete geophysical report is provided in Appendix A.

An EM-31 terrain conductivity meter was used to map site-wide apparent conductivity of subsurface materials to depths of 10 to 15 feet-bgs. EM-31 data (conductivity and in-phase) were collected along parallel lines spaced approximately 15 feet apart, oriented north to south over the investigated areas. In low noise environments, the EM-31 can distinguish very subtle variations in soil conductivity, and is sensitive to metallic objects in the in-phase mode. The EM-31 instrument is also susceptible to electromagnetic noise near power lines. Power lines were present within the surveyed area; therefore, an EM-38 electromagnetic conductivity meter was also used in areas where power lines would potentially affect the data quality. The EM-38 is not as susceptible to noise from power lines; however, the effective depth is limited to 5 feet bgs. The positions of the EM-31 and EM-38 were tracked using a GPS.

Maps showing color-filled contours of the conductivity and in-phase responses are provided on Figures 4-11 to 4-13. The conductivity maps were used to assess the nature of the fill materials, whereas the in-phase map was used to assess the nature and extent of mainly metal objects. Thirteen areas were delineated with anomalously high EM terrain conductivity or anomalously low electromagnetic in-phase values.

Five anomalies (A through E) were identified on the conductivity maps. High conductivity readings, shown as dark red to purple, in Anomalies A, B, and C, indicate potential areas of large carbon accumulation. Anomalies D and E, shown as dark blue, were identified as potential metallic or other highly conductive objects that were outside the normal range. Eight anomalies (F through M) were outlined on the in-phase map indicating potential areas of metallic accumulation, represented by red for responses over metal objects and blue for responses at the ends of the metal objects.

Based on the EM survey results, as well as information obtained from records and aerial photographs, test pit/trench excavations and soil sampling were conducted to further investigate these anomalies and complete the characterization of the area.

Figure 4-14 shows the geophysical anomalies and the outlines of the potential locations of WDS-1, 2, and 3 (based on Exhibits F-8, F-10, and F-19) overlaid on a 2003 aerial photograph. As discussed in Section 4.4.1, there was considerable uncertainty regarding the locations of these historical waste disposal sites. Although no formal closure documents were found, these sites were considered closed since records indicated MDE was aware of the 2-foot soil covers that were placed over the sites. As such, the objective of the intrusive investigation of these sites was to define the perimeters of the sites while avoiding any disturbance of the soil covers. Since it would be difficult to differentiate between the native clay soils and the clay covers, a “no dig” area was outlined around all potential locations of these sites to ensure that no excavation would occur through the soil covers.

The general test pit sampling strategy was as follows:

- Samples collected at the surface and at the base of the test pits were analyzed for fluoride, and also total cyanide if carbon materials were observed;
- Samples from the base of test pits were also analyzed for VOCs; and
- Composite samples were analyzed for metals.

The test pit locations are shown on Figure 4-15. Lithologic descriptions of all test pits and photographs are provided in Appendix H. Table 4-9 presents a summary the soil sample analytical data.

In planning this investigation, as with the C-Line Investigation, the primary chemicals of concern were fluoride and cyanide, which are prevalent in various types of plant process wastes that have been disposed of on-site. Metals, VOCs, SVOCs and PCBs were added to the analytical suite for a more thorough characterization of the area. As expected, metals were detected in all soil samples; however, with the possible exception of arsenic, the metal concentrations were not elevated, and are therefore not discussed in detail in this report. PCBs and SVOCs (mainly PAHs) were detected frequently, although at much lower concentrations relative to the Southern Disposal Sites. The results summaries provided below focus mainly on fluoride, cyanide, PCBs and PAHs.

4.4.2.1. Anomalies A, C, F, G, and M

Anomalies A, C, F, G, and M, identified by Mundell, overlay the locations of WDS-1, 2, and 3 as outlined by the plant, though the shapes and sizes of the waste disposal sites depicted on plant maps are different in some cases than that of the anomalies. Anomaly A was the largest anomaly identified in the WDS-1, 2, and 3 area, covering a widespread area that was observed in both the EM-31 and EM-38 surveys. As shown on Figure 4-14, Anomaly A overlies the plant outline of WDS-1. High conductivity values are represented by the red and purple colors on Figures 4-11 and 4-12. The combination of EM-31 and EM-38 data suggested the possibility of buried materials within the upper 5 feet of the subsurface near the northwest central portion of Anomaly A. Anomalies F and G on the in-phase map overlay Anomaly A and indicate metallic objects in this area. The possible locations of WDS-1 as indicated on the plant map (Exhibit F-8), and the sketch in the soil compaction test report (Exhibit F-19) fall within the boundary of Anomaly A and have relatively similar orientations. However, the size of the Anomaly A is larger than the site boundaries shown on Exhibits F-8 and F-19. This may be explained by the high-conductivity compacted soil cover which would likely have extended beyond the edges of the disposal site.

Anomalies C and M are large areas near the approximate location of WDS-2. The location of WDS-2 indicated in the compaction test report (Exhibit F-19) appears to overlay the two anomalies as shown on Figure 4-14. However, the sizes, shapes, and orientations of Anomalies C and M and the outline depicted on the sketch in the soil compaction test report (Exhibit F-19), differ from that depicted on the plant map (Exhibit F-8). For example, the compaction test sketch indicates the area has a rectangular shape and an east-west orientation, compared to the plant map that indicates WDS-2 has triangular shape and north-south orientation. The outline depicted on the compaction test sketch more closely resembles Anomalies C and M, and therefore is considered the most likely location of WDS-2.

The general location of WDS-3 provided by the plant did not appear to line up with any of the anomaly outlines identified by Mundell. However, as indicated on Figure 4-14, the approximate location of WDS-3 from the sketch in the compaction test report (Exhibit F-19) is within a relatively high conductivity area (orange to red) shown on the EM-31 conductivity map (Figure 4-11), west of an underground utility line. This area was not identified by Mundell as an anomaly, yet it has relatively high conductivity readings on both the conductivity and in-phase maps (Figures 4-11 and 4-13), indicating a potential for buried materials. This other area, identified on Figure 4-14 as OA1, is considered the most likely location of WDS-3.

The “no dig” area around the potential locations of WDS-1, 2 and 3 encompassed the geophysical anomalies, the plant map and compaction test outlines, and extended out 25 feet. It was assumed, based on the geophysical survey, plant maps, aerial photographs, etc., that WDS-1, 2, and 3 were located within this 6.5-acre area. Test pits were excavated outside the comprehensive perimeter to confirm that wastes were not present.

Nineteen test trenches, WDS-123-TT1 to -TT3 and WDS-123-TT5 to -TT20, were excavated to depths ranging from 8 to 11 ft-bgs along the outside edge of the “no dig” area. These locations are presented on Figure 4-15. Surface and subsurface soils consisted of silty clay, with weathered sandstone and limestone fragments observed throughout the subsurface. While general construction debris (i.e., brick fragments, asphalt, and plastic sheeting) was occasionally found in a few test pits, areas of buried waste were not found.

One test trench, WDS-G-TT1, was excavated in the eastern portion of Anomaly G (metallic anomalies). Soils at this location consisted of clayey silt and fine-grained sand. No waste material was observed; therefore, no samples were collected.

Soil samples were collected from three test pits (WDS-123-TT6, -TT13, and -TT16) around the outside of the "no dig" area. Surface soil samples were analyzed for total cyanide, fluoride, PCBs, and SVOCs. PCBs were not detected. Total cyanide was only detected in WDS-123-TT6 with an estimated concentration of 0.27 mg/kg. Fluoride was detected in all three at concentrations below 34 mg/kg. PAHs were detected in all three samples at estimated concentrations at or below 0.12 mg/kg. Additionally, a low concentration of 2-methylnapthalene was detected in WDS-123-TT13 only, which is where asphalt was observed in the surface of the test pit.

The soil samples collected from the base of the test pits had minimal detections, if any. No constituents were detected in the base samples from WDS-123-TT6 and WDS-123-TT16, with the exception of a trace amount of toluene estimated at an estimated 0.00087 mg/kg from WDS-123-TT6 which may be attributed to laboratory contamination. Subsurface soils from WDS-123-TT13 had several detections: fluoride at 45 mg/kg; 2-methylnapthalene at an estimated concentration of 0.021 mg/kg; and PAHs below concentrations of 0.10 mg/kg.

4.4.2.2. Anomalies B, H, and I

Anomaly B is a high-conductivity (red to purple) area located in the southeast portion of the investigation area. This area, south of the old Biser Farm, was included in the EM survey based on plant personnel interviews and field observations during the site walk. In-phase mapping identified Anomalies H and I (red areas within Anomaly B) as having the potential for containing metal objects. It was also apparent from the EM-38 survey that most of the potential buried material extended to within the upper 5 feet of the subsurface.

To characterize the anomalies, one test pit, WDS-B-TP1, was excavated in the center of Anomaly B (purple), and two test pits, WDS-BH-TP1 and WDS-BI-TP1, were excavated in Anomalies H and I (red). Four test trenches, WDS-B-TT1 to WDS-B-TT4, were also excavated around Anomaly B, one along each side. Total depth of the test pits and trenches excavations ranged from 3 to 11 ft-bgs. Surface and subsurface soils consisted of red silty clay. Excavation initially began at WDS-B-TP1. Anode rubble and high-carbon cryolite were observed from 1 to 5 ft-bgs. WDS-B-TP1 was excavated to the north until the extent of the buried waste was found. During the trenching, concrete trench silos were found, which were used by the farm when it was in operation. A layer of general construction debris was observed in WDS-BI-TP1 from 0.5 to 2 ft-bgs. A mixture of buried waste, consisting of anode rubble, high-carbon cryolite, and general construction debris was found down to 7 ft-bgs in WDS-BH-TP1. A thin layer of anodes and high-carbon cryolite was also observed from 0.5 to 2 ft-bgs at WDS-B-TT1 along the northern edge, and at WDS-B-TT4 along the western edge. This buried waste area was subsequently named WDS-9.

Soil samples were only collected from WDS-B-TP1 since the buried waste observed in the test pits was similar. PCBs were not detected in the surface; however, fluoride was detected at a concentration of 548 mg/kg. PAHs were also detected at or below estimated concentrations below 0.030 mg/kg. Soil from the base of the pit contained fluoride at a concentration of 8.6 mg/kg and Aroclor 1248 at an estimated concentration of 0.026 mg/kg. VOCs and SVOCs were not detected in the subsurface soil sample.

4.4.2.3. Anomalies D and E

Anomalies D and E were identified as areas of negative conductivity (dark blue) during the EM-38 survey, and therefore had the potential to contain metallic or other highly conductive objects or materials. Anomalies D and E were not observed in the EM-31 conductivity and in-phase mapping because of the interference from the power lines.

Anomaly D is within the boundaries of Anomaly A, and was therefore investigated with the test trench locations discussed for Anomalies A, C, F, G, and M (Section 4.4.2.1). Anomaly E is in the northwest corner of the EM survey boundary. Test pit WDS-E-TP1 was excavated in the center of Anomaly E to a depth of 10 ft-bgs. Buried waste was not observed at this test pit; therefore, samples were not collected.

4.4.2.4. Anomalies J, K, and L

Anomalies J, K, and L were identified as areas of negative conductivity (red) during the EM-31 in-phase mapping, and therefore had the potential to contain metallic objects.

Test pits were excavated in each anomaly: two (WDS-J-TP1 and WDS-J-TP2) in Anomaly J; two (WDS-K-TP1 and WDS-K-TP2) in Anomaly K; and one (WDS-L-TP1) in Anomaly L. Anomalies K and L were close to the “no dig” area, so the test pits excavated in these anomalies also served as perimeter test trenches for WDS-1, 2, and 3.

The test pits were excavated to depths of 9 to 11 ft-bgs, with the exception of WDS-J-TP2 (3 ft-bgs). Surface and subsurface soils consisted primarily of silty clay. Weathered silty sandstone was observed in the base of test pit WDS-K-TP1 at 9 ft-bgs. A 3-ft. thick, 6-ft. diameter slab of an aluminum/bath aggregate was found in WDS-K-TP2, at approximately 3-ft-bgs. No buried waste was found in any of the other test pits. However, samples were proposed to be collected at these locations in the work plan (MFG, 2004a).

Soil samples were collected from test pits WDS-J-TP1, WDS-K-TP2, and WDS-L-TP1. No constituents, with the exception of metals, were detected in WDS-J-TP1. At WDS-K-TP2, total cyanide was not detected in the surface soil; however, fluoride was detected at a concentration of 62.1 mg/kg and Aroclor 1242 at a concentration of 0.14 mg/kg. PAHs were also detected at concentrations below 2.0 mg/kg. The base sample had no detections of total cyanide, fluoride, PCBs, or SVOCs. The only VOC detected was toluene at an estimated concentration of 0.00081 mg/kg, which may be attributed to laboratory contamination. Total cyanide was not detected in surface soils from WDS-L-TP1; however, fluoride was detected at 26.1 mg/kg, Aroclor 1248 at 0.096 mg/kg, and PAHs below 0.30 mg/kg. The base sample only had a detection of total cyanide with an estimated concentration of 0.23 mg/kg. PCBs, VOCs, and SVOCs were not detected.

4.4.2.5. Other Anomalies

Four other areas included in the test pit investigation had been identified in addition to the anomalies, presented by Mundell, based on plant interviews and historical aerial photographs. The first additional area, OA1, covered the likely location of WDS-3 and was included in the “no dig” area as described in Section 4.4.2.1. The second additional area for investigation was OA2. This area encompassed the approximate location of the 5-acre landfill identified by EPA (EPA, 1983), and the parcel included in the EM survey based on interviews with plant personnel who recalled historical disposal activities in the northern portion of this area located southwest of monitoring well MW-64. Although, the EM survey did not indicate the potential for buried materials, one test pit (WDS-OA2-TP1) was excavated to 2 ft-bgs within this area. A concrete pad was initially encountered at 2 ft-bgs, so the test pit was re-located several times. Within this area, the excavations extended from 4 to 10 ft-bgs, but no disposal site was encountered. A second test pit, WDS-OA2-TP2, was excavated to 8 ft-bgs south of WDS-OA2-TP1, and north of the “no dig” area to determine whether buried waste was present in a portion of the area identified by EPA as a 5-acre landfill that was not included in the EM survey. Subsurface soils consisted of silty sand and silty sandstone at the base of the pit. No general debris or buried waste was encountered; therefore, no samples were collected.

The third additional area, OA3, was based on reviews of historical aerial photographs. The EM survey did not map areas further west; however, an aerial photograph from March 1971 (Appendix E) showed disturbance in this western area. Three test pits, WDS-OA3-TP1 to WDS-OA3-TP3, were excavated with depths ranging from 6.5 to 10 ft-bgs. Soils consisted of clayey silt with limestone fragments. No buried waste was observed; therefore, no samples were collected.

The fourth additional area, OA4, was also based on reviews of historical aerial photographs. A rectangular depression, approximately 80 by 230 feet (0.4 acres) was visible on the aerial photograph from 1979. WDS-OA4-TP1 was excavated to 8 ft-bgs. Soils consisted of silty clay with occasional limestone rock fragments. No buried waste was observed; therefore, no samples were collected.

4.4.2.6. Non-Anomalous Geophysical Areas

To test the validity of the geophysical data, two test pits, WDS-BK-TP1 and WDS-BK-TP2, were excavated in areas not identified as anomalous on either the in-phase or the conductivity maps (i.e., areas that are identified as containing just background soil or clean fill). WDS-BK-TP1 was located within OA2, the area identified by EPA as a 5-acre landfill. WDS-BK-TP1 was excavated to 10 ft-bgs and WDS-BK-TP2 to 11 ft-bgs. Soils consisted of silty clay with limestone rock fragments. No buried wastes were observed; however, samples were still collected at both locations.

Total cyanide was not detected in surface soil at WDS-BK-TP1; however, fluoride was detected at 24.7 mg/kg and Aroclor 1248 was detected at 0.55 mg/kg. PAHs were also detected at estimated concentrations below 0.040 mg/kg. No constituents were detected in the base of the pit. At WDS-BK – TP2, fluoride was detected at 11.9 mg/kg and Aroclor 1248 at 0.047 mg/kg in the surface soil sample. PAHs were detected at concentrations below 0.15 mg/kg. Soils collected from the base of the pit had no constituents detected with the exception of two VOCs, 2-butanone at 0.012 mg/kg and acetone at 0.049 mg/kg. The detections of these two VOCs are likely due to laboratory contamination.

4.4.3. Groundwater Sampling

Because of fluoride concentrations detected in the soil sample from WDS-9, a new overburden monitoring well (MW-98) was installed downgradient to assess impacts to groundwater from the disposed wastes. A groundwater sample was collected and analyzed for fluoride and free cyanide and the results are provided on Table 4-1. The fluoride concentration was 1.22 mg/L and the free cyanide concentration was 0.012 mg/L. These data are included in the site-wide plume assessment discussed in Section 4.7

4.5. CLOSED INDUSTRIAL LANDFILL

The Closed Industrial Waste Landfill was originally constructed in 1983, and was used for disposal of plant wastes including potliner brick. The landfill was lined with 18 inches of clay, a 30-mil polyvinyl chloride (PVC) liner, and an additional 18-inches of clay. The final volume of disposed waste at the 3.6-acre landfill was approximately 62,500 cubic yards.

The landfill was closed and capped with a PVC liner, clay cover, and vegetation at the end of 1994. As part of the closure, a leachate collection system was constructed to direct leachate to the South Pond. The pipeline that carried the Industrial Landfill leachate to South Pond tested tight in 1988 and as a result no line leaks are suspected.

A leak was detected in the landfill liner in 1990; therefore, actions were taken to address the suspected leakage of leachate at the southeast corner of the Industrial Landfill in 1991. The liner in this area was replaced with a double liner, the leachate removal system was modified to enhance the efficiency of operation, and a leachate collection tank was installed. Leachate entering the holding tank flowed to a wet scrubber system bypassing the South Pond. The piping to the leachate collection tank is double walled with inspection ports, and most of the lines are located above ground. In mid 2002, a leak was found in the containment tank lining. The tank was taken out of service and the piping was rerouted to the SO_2 process water supply tank. From there the leachate is directed to the SO_2 scrubber system.

As part of the site-wide investigation, available engineering drawings of the landfill including the liner, cover, and leachate collection and transport system were reviewed and a site inspection was performed to identify potential sources of leakage. Additionally, a flow totalizer was installed on the leachate discharge line so that leachate volume trends can be reviewed for evidence of cap deterioration. Previous reports suggest the landfill produces approximately 100 gallons of leachate per day which translates to about 0.07 gpm. Based on the initial totalizer readings, the landfill produces leachate at rates up to approximately 0.2 gpm. As a follow-up to this report, additional totalizer readings will be collected to more accurately gauge the leachate generation rate which will be compared to precipitation data to assess the condition of the cap.

The plant is not required to sample the leachate under the regulatory program; however, leachate samples were collected in August and September 2005 to support the evaluation of the landfill to potentially impact groundwater. Fluoride concentrations in the leachate ranged from approximately 2,800 to 3,100 mg/L, while free cyanide concentrations ranged from approximately 0.004 to 0.027 mg/L.

Given the extensive well coverage in the vicinity of the landfill, no new wells were installed during this investigation. The existing wells were sampled for fluoride and free cyanide as part of the site-wide plume assessment. Refer to Section 4.7 for a discussion of the results.

4.6. OLD ANODE OVEN PITCH POND

The Old Anode Bake Oven Pitch Pond is located north of the Bake Oven dry scrubber and several hundred feet east of the Spent Potliner Storage Area. The Pitch Pond was phased out with conversion from Bake Oven wet scrubbers to an alumina-injected dry scrubber. The pond is lined with asphalt and coated with coal tar pitch and petroleum coke. In 1980, with state approval, Eastalco disposed of 500 tons of spent pot insulating brick in the pond. After placement of the brick in the pond, the surface was paved with a blacktop surface, totally encasing the brick.

An attempt was made to install an overburden monitoring well immediately downgradient of the pond to assess its potential to contribute fluoride to groundwater. However, the overburden zone was found to be unsaturated in this area. The well, which was to be identified as MW-102, was abandoned by removing the PVC riser and grouting the borehole. Although the overburden was unsaturated, it was determined that a new bedrock well was not needed at this location because the existing well network was sufficient for monitoring any impacts to the bedrock aquifer in this area. A nearby downgradient bedrock extraction well, MW-94, was found to contain fluoride at 3.27 mg/L and free cyanide at 0.002 mg/L.

4.7. GROUNDWATER INVESTIGATION

Following the investigation of the individual source areas, a groundwater investigation was performed to determine what impacts, if any, these sources had on groundwater, and to better understand groundwater flow. To accomplish the investigation, geophysical surveys were performed, monitoring wells and staff gauges were installed and surveyed, site-wide water level measurements and groundwater samples were taken, and a residential well survey was performed.

4.7.1. Geophysical Surveys

A geophysical survey, consisting of one electromagnetic conductivity (EM34) line and eight two-dimensional (2D) resistivity lines was conducted prior to the well installation phase of this investigation. A compact disc containing the complete geophysical report (methodology and results) is provided in Appendix A.

The EM-34 survey was performed in an attempt to approximate the horizontal limits of a dissolved phase fluoride groundwater plume. The original scope of work called for the survey to be run across multiple lines. However, after the geophysical contractor reviewed the data from the first line, it was determined that subsurface conditions were not suitable for using this technology, thus the survey was terminated.

The 2D resistivity survey was performed to guide the placement of additional groundwater monitoring wells, particularly to the east of Tuscarora creek where the plume limits were previously not well defined. Figures 4-16 and 4-17 were copied from the Mundell Geophysical Report in Appendix A. Figure 4-16 shows the locations of the 2D lines in plan view and Figure 4-17 is an example cross section of the results from Lines 5 and 6. In general, the blue color across the top 20 feet of most sections represents the overburden zone. The yellow to red colors on the cross-sections are indicative of competent bedrock. The green to blue colors below the top 20 feet (approximately) represent fractured/weathered bedrock. In some cases, large blue zones were identified at considerable depths which could be attributable to solution-enhanced fracture porosity as well as a greater amount of clay. In other cases, large red zones appear surrounded by green zones. These red zones ("floaters") apparently represent large rocks that have a resistivity similar to the competent bedrock but are essentially floating in the otherwise weathered bedrock zone.

The geophysical contractor identified potential fracture zones as well as possible depressions or channels in the competent bedrock surface as areas that represent the most suitable locations for installing wells. Based on the apparent flow direction, locations of disposal sites, and the data gaps in the fluoride plume, the geophysical data assisted in locating the proposed wells. For example, the results for Lines 5 and 6 (Figure 4-17) were used to guide the placement of new monitoring wells MW-109 and MW-110 which were located based on the potential fracture zone indicated by the asterisk symbol (*) located about 825 feet east of the starting point for these lines. Lines 7 and 8 were also used to help locate new monitoring wells MW-100 and MW-101; however, due to interferences from the Tuscarora Creek and the property boundary fence, the lines could not be located directly downgradient of WDS-5 and WDS-6.

4.7.2. Well and Staff Gauge Installation

Although there were over 50 monitoring wells located across the site, there were still some potential source areas that lacked well coverage. Therefore, 13 new monitoring wells (eight overburden and five bedrock) were installed, and repairs were made to existing well MW-28. Table 4-10 lists these new wells, identifies the zone they monitor, and provides the purpose for their installation. Construction information for the new and existing wells is provided on Table 4-11. The new wells were constructed in a manner similar to the existing wells. The locations of the new and existing wells are shown on Figure 4-1. Most of the new wells were installed to monitor groundwater in the vicinity of potential contamination sources; however, MW-109 and MW-110 were installed east of Tuscarora Creek to better understand groundwater flow direction and plume configuration. The locations and construction methods for the new wells were approved by MDE in a letter to MFG dated November 8, 2004.

Six staff gauges were installed during the investigation to evaluate interaction between groundwater and surface water. Four of these were placed in Tuscarora Creek and two were placed in its unnamed tributary (Figure 4-1).

Each new monitoring well and staff gauge was surveyed by an Alcoa-approved registered surveyor for horizontal and vertical control. The measuring point elevation (top of casing for wells, 1-foot mark on staff gauges) was surveyed to mean sea level at an accuracy of +/- 0.01 feet and correlated to a United States Geological Survey (USGS) benchmark on or near the site. Each monitoring well and staff gauge was also surveyed to establish horizontal coordinates to an accuracy of +/- 0.1 feet latitude and longitude values. In addition, the ground surface elevation at monitoring wells was surveyed to an accuracy of +/- 0.1 feet. Survey information for the new wells and staff gauges is provided on Table 4-11.

4.7.3. Water Level Measurements

After the new wells were installed and before groundwater sampling or purging was performed, static water-level measurements were collected from the new and existing monitoring wells and from the staff gauges to provide elevation data for use in constructing groundwater flow maps. With the exception of MW-71, all water level measurements were collected on June 15, 2005. MW-71 could not be located until the following day. The water level measurements are provided on Table 4-12 and were used to construct the site-wide flow maps for the overburden and bedrock zones shown on Figures 4-18 and 4-19.

Figures 4-18 and 4-19 show that beneath the main plant operations area, groundwater in both zones generally flows to the southeast to Tuscarora Creek. As groundwater approaches the confluence of Tuscarora Creek and its unnamed tributary, the flow direction is more towards the south. Beyond the main plant operations area, the influence of Tuscarora Creek becomes apparent, especially in the overburden zone. As shown on Figure 4-18, Tuscarora Creek acts as a gaining stream southeast of the plant. The creek is a discharge point for overburden groundwater beneath most of the plant as well as the farm fields located east of the creek.

The unnamed tributary shows less influence on groundwater flow. West of the main plant operations area and south of the WDS-1, 2, and 3, the tributary acts as a gaining stream with overburden groundwater discharging from both sides. Further downstream, the water level data collected during this investigation show that overburden groundwater flows from the northwest, intercepts the tributary and continues to the southwest towards Tuscarora Creek.

The flow regime and water level elevations for the bedrock aquifer as shown on Figure 4-19 appear very similar to that presented on Figure 4-18 for the overburden zone. This suggests an overall high degree of hydraulic connectivity between the two zones, although as discussed in Section 2.2.4.2, the connectivity varies across the site. The closed depression in the bedrock potentiometric surface shown on Figure 4-19 is related to operation of bedrock pumping wells RW-29 and MW-68. Although MW-56 has the highest pumping rate of the three pumping wells, the pumping does not create a noticeable area of influence on the water table (Figure 4-18). This may be explained by increased recharge from the North Pond and possibly the South Pond.

4.7.4. Site-Wide Groundwater Sampling

In addition to collecting groundwater samples from the newly installed wells, the existing wells were also sampled for fluoride and free cyanide during this investigation to evaluate the extent of the contaminant plumes. The fluoride and free cyanide analyses were performed by the Eastalco laboratory. Samples from certain wells across the site were also analyzed by an off-site laboratory for water quality parameters (i.e., alkalinity, total suspended solids (TSS), total dissolved solids (TDS), and major cations/anions). The laboratory results are provided on Table 4-1. Field water quality parameters including pH, conductivity, turbidity, dissolved oxygen, and oxidation reduction potential (ORP) were monitored with field instruments as described in the Work Plan (MFG, 2004b). The field measurements are summarized on Table 4-13.

Free cyanide was detected in 50 of the 65 wells sampled with a concentration range of 0.0002 to 0.06 mg/L. The two highest concentrations occurred in the pumping wells RW-29 and MW-68; however across the site, all detections of free cyanide were below the ACO limit of 0.2 mg/L.

Fluoride was detected in all 65 wells sampled with a concentration range of 0.07 to 87 mg/L. The results are plotted on Figure 4-20 for the overburden wells and Figure 4-21 for the bedrock wells. These maps show that the fluoride plume has a linear shape and extends from the main plant operations area to the southern property boundary. The origin of the plume is in the vicinity of the North and South Ponds where the highest fluoride concentrations (40-87 mg/L range) occur. From there, the concentrations decrease (17-54 mg/L range) as the plume migrates in a south/southwest direction toward the southern end of the Closed Industrial Landfill. The plume tends to become more narrow south of the landfill as the concentrations decrease substantially (5-10 mg/L range) and the orientation becomes more to the south. The narrow linear shape extends to the southern property boundary, with relatively consistent concentrations along the center of its long axis.

4.7.5. Residential Well Survey

A residential well survey was completed to determine if there are water wells in use within the area immediately downgradient of the plant. The survey started by contacting the three government agencies to determine the presence or absence of potable water wells downgradient of the site. These included the Maryland Department of the Environment Groundwater Permits Program, the Frederick County Public Works Division Utilities Solid Waste Management, and the Frederick County Health Department Environmental Health Services. The information provided by these agencies was supplemented with information from the Frederick County Water Authority billing records which helped to identify properties that were not connected to the public water supply.

Figure 4-22 is a copy of local tax map showing the various properties that were included in the survey. Some of the properties included in the survey were located as far as 1 mile away from the plant's southern property boundary. As shown on Figure 4-22, most of the properties located west of Tuscarora Creek are not connected to the public water supply and use water wells for potable water. Based on on-site groundwater flow data, overall groundwater flow is assumed to be to the south/southeast and not to areas located west of Tuscarora Creek. Most of the properties east of Tuscarora Creek (south/southeast of the plant) are connected to the public water supply. Six of these properties also have water wells, and one commercial property (Trans Tech) has an industrial well. It is not known if these wells are being used for non-potable purposes because interviews with property owners were not conducted as part of the survey.

5.0 SITE CONCEPTUAL MODEL

A site conceptual model based on the investigation of PCE contamination at the Substation source area was presented in MFG (2003). The following subsections describe the site conceptual model based on the investigation of other contaminants, primarily fluoride, at potential sources across the plant.

5.1. CONTAMINANT SOURCES

5.1.1. Ponds and Lagoons

A total of seven constructed ponds and lagoons were investigated as potential sources of fluoride groundwater contamination. These include the North and South Ponds, Rain Water Ponds 102 and 103, the Primary and Secondary Lagoons, and the Surge Pond. Each of the ponds and lagoons receive process water or storm water containing fluoride; however, the North Pond was identified as the primary source of a fluoride plume in groundwater that reaches the southern property boundary at concentrations exceeding the ACO limit. The North Pond was used to receive process water containing elevated concentrations of fluoride and the deteriorated condition of the pond’s asphalt lining led to the subsequent leakage of the process water to the underlying aquifer. The North Pond was taken out of service in August 2005, and assuming it is no longer used, it will not contribute further fluoride contamination to groundwater.

The process water formerly discharged to the North Pond is now discharged to the South Pond, which historically received leachate from the SPL Pad and the Closed Industrial Landfill. The asphalt lining of the South Pond appears to be in much better condition, so less leakage from the pond would be expected. However, quantifiable estimates of leakage rates are not available, so impacts to groundwater from the South Pond cannot be estimated with certainty.

5.1.2. Storage Areas

Current and former waste storage areas were investigated as potential sources of fluoride groundwater contamination. These include the included the former SPL Storage Pad, the Waste Alumina Storage Pad, the Bone Yard, and a pond associated with the former Cryolite Bunkers. None of these storage areas were found to be contributing significant amounts of fluoride to groundwater. Of all the storage areas evaluated, only the soils at the former SPL Storage Pad have elevated concentrations of fluoride which is present throughout the vadose zone both under and adjacent to the pad. However, modeling of the data determined that concentrations of fluoride in soils under and around the pad would not be expected to cause the elevated fluoride concentrations detected in local groundwater. This is supported by the MEP fluoride analyses which indicate that the soils are not capable of releasing enough fluoride to sustain the fluoride plume.

5.1.3. Disposed Waste Sites

A total of 11 sites containing disposed wastes were investigated as potential sources of groundwater contamination. These include the Southern Disposal Sites (WDS-4 through WDS-8), the Western Disposal Sites (WDS-1, 2, 3, and 9), the Closed Industrial Landfill, and the Old Anode Oven Pitch Pond. The Southern and Western Disposal Sites have soil covers of varying thickness, and are underlain and surrounded by clayey soils. The Closed Industrial Landfill has a synthetic cap and liner, as well as a leachate collection system. The Old Anode Oven Pitch Pond has a coal tar lining and an asphalt cap.

While all of these sites contain various types of fluoridated wastes, none were found to be significantly contributing fluoride to groundwater. An analysis of soil sample data and/or downgradient groundwater data suggests that the disposed wastes do not contain significant amounts of soluble fluoride, with the exception of the wastes at the Closed Industrial Landfill. In the case of the Closed Industrial Landfill, although the leachate contains fluoride at concentrations as high as approximately 3,100 mg/L, the elevated concentrations of fluoride in monitoring wells located downgradient of the landfill are believed to be related to the releases from the North Pond and possibly the South Pond. An analysis of fluoride concentrations in bedrock pumping wells RW-29 and MW-68 (Figure 5-1) shows that the temporal trends for fluoride concentrations in both wells are very similar even though RW-29 is upgradient of MW-68. This suggests, and is supported by the groundwater flow maps, that the elevated concentrations in MW-68 and other nearby landfill monitoring wells are not related to releases from the Closed Industrial Landfill, but are instead related to the same upgradient source that is responsible for the elevated concentrations in RW-29 (i.e., the North Pond and possibly the South Pond).

Although wastes within the Southern Disposal Sites also contain PCBs and PAHs, the seepage pits, farm fields, and streams adjacent to the southern disposal sites were not significantly impacted as a result of the waste disposal. In addition, the sites were not found to be contributing PCBs and PAHs to groundwater.

5.2. GROUNDWATER CONTAMINATION

Based on MCLs, the ACO sets property boundary action levels for fluoride and free cyanide at 4 mg/L and 0.2 mg/L, respectively. Although free cyanide has been detected above the MCL at the plant in the past, present site-wide concentrations of this contaminant are below the MCL. Fluoride concentrations, however, are above the MCL from the main plant area to the southern property boundary.

5.2.1. Fluoride Plume

As depicted on Figures 4-20 and 4-21, the fluoride plume is elongated with a north to south orientation and its origin is under the main plant operations. The elongated shape of the plume is related to the direction of groundwater flow which is influenced by the streams as well as the bedrock trough discussed in Section 2 that extends from the main plant operations area south towards the property boundary.

The site-wide investigation of fluoride contamination in groundwater showed that only the SPL Pad soils and the North and South Ponds were potential sources located near the center of the fluoride plume. An in-depth assessment of these sources determined that the North Pond, and possibly the South Pond, are the primary sources. Fluoride concentrations in wells near the other investigated sources suggest they are not significant contributors to the fluoride plume. This is supported by groundwater flow maps (see Figure 4-18 and 4-19) which show that the other sources are located either hydraulically downgradient or cross-gradient of the plume origin.

Near the plume's origin, fluoride concentrations are in the range of 40-90 mg/L. From the origin, the plume moves in a southwesterly direction towards the southeast corner of the Closed Industrial Landfill where concentrations are still elevated. From there, the concentrations rapidly decrease by an order of magnitude and then remain fairly consistent in the range of 5 to 8 mg/L along the narrow long axis of the plume as it migrates south between the two streams to the southern property boundary.

The rapidly reduced concentrations that occur within a few hundred feet of the source area are likely related to factors such as dilution, adsorption, and chemical precipitation. As the plume migrates from the source area, it mixes with cleaner water which lowers the fluoride concentrations through dilution.

With regards to adsorption, Schnoor, et al. (1995) describes model simulations performed by Dzombak, et al. (1993) which indicated that fluoride ions in SPL leachate can adsorb onto oxide/hydroxide minerals at moderate to high pH values. Given the relatively high pH (9 to 9.5) near the source area, it is possible that the high concentrations of fluoride in groundwater are adsorbing onto oxides in the clayey soils that comprise most of the overburden zone. The pH is closer to neutral from just beyond the source area to the southern property boundary, which may explain why the fluoride concentrations in that stretch of the plume remain fairly consistent in the 5 to 8 mg/L range.

The fluoride may also be precipitating out of solution near the source area which would also lower concentrations. As described by Geraghty and Miller, Inc. (G&M, 1984), the fluoride ion has a tendency at relatively high concentrations to combine with calcium to form fluorite (CaF_2), and as such, calcium concentrations would be expected to be lower in areas where fluorite is forming. Given the limestone geology at the site, there is likely an abundant source of dissolved calcium. A comparison of analytical data from recovery well RW-29 and distant monitoring wells suggests that fluoride is precipitating near the source area. While the fluoride concentration in RW-29 (59 mg/L) is two to three orders of magnitude higher than the fluoride concentrations in wells located away from the plume's center, the calcium concentration in RW-29 (7 mg/L) is one to two orders of magnitude lower. G&M (1984) provides several calculated equilibrium concentrations for calcium and fluoride ions. As an example, if the calcium ion concentration is 10 mg/L, the calculated maximum equilibrium concentration for the fluoride ion would be 7 mg/L. Based on the fluoride and calcium concentrations in RW-29, a supersaturated condition exists near the source. As the plume migrates away from the source area, fluoride likely continues to precipitate out of solution as the system approaches equilibrium.

5.2.2. Concentration Trends

5.2.2.1. Fluoride

In terms of temporal trends, Figure 5-2 shows the average annual fluoride concentrations in wells near the primary source area (i.e., North and South Ponds) where elevated fluoride concentrations (<1000 mg/L) were observed in the 1980's. This was thought to be due principally to the storage of SPL on the Former SPL Pad which drained leachate to the South Pond. Beginning in 1988 when SPL was no longer being stored on the pad, fluoride concentrations in groundwater near the pad began to decrease sharply from nearly 1000 mg/L in 1988 to less than 200 mg/L in 1996. Since 1996, fluoride concentrations have continued to decrease, albeit at a slower rate. The concentrations currently fluctuate within a range of 40 to 90 mg/L.

MW-57, which is located adjacent to the southwest corner of the SPL Pad and was installed in 1988, has generally had higher fluoride concentrations relative to the other wells near the source area. Based on the boring log for this well, the increased contaminant concentrations may be due to a deposit of waste materials, which includes cryolite and bricks, encountered at 9 to 11 feet bgs during the installation of this well. It should be noted that soil borings installed near MW-57 during this investigation did not encounter any waste material in the subsurface. As such, the waste deposit identified on the boring log for MW-57 appears isolated and limited in extent, and capable of causing only limited impacts to local groundwater.

Figure 5-1 depicts monthly fluoride concentrations for source area pumping wells from June 2004 to September 2005 and identifies key events regarding the sources and the wells. As shown on Figure 5-1, when pumping at MW-57 was started in July 2004 (after an inoperable pump was replaced), the fluoride concentrations began to decline from over 100 mg/L to about 42 mg/L in December 2004, at which point the pumping of MW-57 was terminated as part of the modified pumping program (see Section 2.2.4.1). The concentrations started to increase beginning in January 2005, and exceeded 80 mg/L in May 2005. This suggests that the waste materials leach fluoride into the screened interval of this monitoring well and that when it is being pumped, the concentrations decrease due to cleaner water being drawn into the well and diluting the leachate.

At MW-56, located adjacent to the northwest corner of the Former SPL Pad, the fluoride concentrations are typically lower than those in MW-57. Since the beginning of 2005, the average concentration in MW-56 has been approximately 46 mg/L. The concentrations of fluoride in MW-29 (now RW-29) decreased from the early 1990's until 2003, at which time they began to rise, likely as a result of the well being deepened and tested as a recovery well (pumping the recovery well pulled in groundwater with higher concentrations of fluoride). The fluoride concentrations have also declined in MW-68 where the average in 1990 was over 500 mg/L. Since the beginning of 2005, the average concentration in MW-68 has been about 41 mg/L.

Concentrations have also been declining in downgradient groundwater including near the southern property boundary (see Figures 5-3 and 5-4). As shown on Figure 5-4, fluoride concentrations in several wells (MW-52, MW-60, MW-72 and MW-73) near the property boundary increased from just below the MCL in the 1980's to a peak of about 7 to 10 mg/L in the mid 1990's. A downward trend has been observed since the mid 1990's with recent data for these wells showing a concentration range of about 5 to 8 mg/L, which still exceeds the ACO limit. Other wells near the property boundary (MW-58 and MW-61) and the offsite well MW-13 show relatively stable concentrations far below the ACO limit.

5.2.2.2. Cyanide

Cyanide contamination of groundwater has also resulted from past waste disposal and storage practices, but to a lesser extent. In terms of temporal trends, Figure 5-5 shows the average annual free cyanide concentrations in wells near the primary source area. The concentrations peaked in the late 1980's and early 1990's with maximum concentrations in MW-29 (now RW-29), MW-56, MW-57, and MW-68 ranging from approximately 1.5 to 3 mg/L, which were above the ACO limit of 0.2 mg/L. After peaking, the concentrations dropped to below 0.1 mg/L during the mid-1990's. From 1998 to 2002, the concentrations rose again in MW-29, MW-57, and MW-68 to levels at or above the ACO limit with concentrations in MW-57 rising to as high as 0.45 mg/L. In 2003 the concentrations in MW-57 and MW-68 returned to the lower levels observed during the mid-1990's. The cause of the rise in free cyanide concentrations in MW-29, MW-57, and MW-68 from 1998 to 2002 is uncertain but may be due to variations in process water concentrations discharged to the North and South Ponds. The concentrations in RW-29 increased again in 2003 and 2004 likely as a result of the well reconstruction and 3-month pumping test described in Section 2.2.4.1. The current free cyanide concentrations in these wells range from 0.006 to 0.03 mg/L, which is well below the ACO limit.

Downgradient of the primary source areas, including the property boundary, the concentrations have never exceeded the ACO limit as shown on Figures 5-6 and 5-7, and since the late 1980's and early 1990's, the concentrations show an overall declining trend. However, some wells such as MW-88 and MW-89 have too few data to evaluate trends.

5.2.3. Projections

The North Pond was recently taken out of service. Process water containing elevated amounts of fluoride is still discharged to the South Pond; however, the impact to groundwater from this pond is uncertain. The asphalt liner in the South Pond appears to be in better condition than the North Pond, so if it is leaking, its leakage rate would likely be lower.

Figures 5-8 and 5-9 show projected concentrations trends for select wells near the source area and near the southern property boundary. These projections are based on temporal trends in average annual fluoride concentrations observed since 2001. It should be noted that based on the fluctuations in concentrations at any one well, and given that the operational status (loading potential) of the North and South Ponds has recently been modified, the projections have an associated degree of uncertainty. Figure 5-8 predicts fluoride levels in the most highly contaminated wells near the source area will drop below the ACO limit between 2007 and 2010. Near the property boundary, the Figure 5-9 predicts fluoride concentrations will fall below the ACO limit between 2009 and 2013. These figures suggest that it will likely take longer for the concentrations at the property boundary to fall below ACO limit than the concentrations at the source area. This is due to groundwater transport times from the source area to the property boundary.

As discussed in Section 2.2.4.2, Menzie-Cura & Associates (1996) estimated groundwater seepage velocities and travel times based on time intervals between contaminant releases at various sources and detections at downgradient wells, and the distance between the source area and downgradient wells. The report estimated groundwater will take 10 to 20 years to flow from the source areas at the main plant operations area to the southern property boundary. It should be noted however, that these estimates were based on detections in a property boundary well that occurred immediately after installation in 1985. Therefore, the transport times are likely faster than indicated by the observations.

Figure 5-2 shows that fluoride concentrations in source area wells peaked around 1988, after which the concentrations started to decline as a result of SPL no longer being stored on the pad and draining to the South Pond. Figure 5-4 shows that fluoride concentrations in property boundary wells were increasing from the mid 1980's to the mid 1990's, and peaked around 1997, after which the concentrations started to decline. Assuming the concentration peaks and declines in both the source area and property boundary wells are related to termination of SPL storage on the pad, the travel time between the source area and the southern property boundary would be 9 years, which converts to a seepage velocity of about 500 feet per year. Additionally, Figure 5-3 shows that the peak in fluoride concentrations at MW-62, which is located approximately half way between the source area and the southern property boundary, occurred in 1991. This suggests a seepage velocity of about 700 feet per year, which translates into a travel time of about 6 years from source area to property boundary.

Given the karst hydrogeology of the site, particularly the potential for preferential flow, it is probable that plume migration occurs at different rates in different areas. This may explain the variability in estimates of contaminant transport times as well as estimates of when fluoride concentrations will fall below ACO limits in different portions of the plume.

6.0 SUMMARY AND CONCLUSIONS

6.1. SUBSTATION PCE INVESTIGATION

Because the results of the PCE investigation were previously reported (MFG, 2003), only a brief summary is provided here. PCE was used from 1970 to 1987 to clean electrical components at the plant's electrical substation. The chlorinated solvent was released to soils and migrated to groundwater. Over time, the parent solvent began to degrade forming degradation products trichloroethene (TCE), 1,2-dichloroethene and vinyl chloride. The ACO identifies the MCL of 5 ug/L for PCE as the property boundary action level. An MDE-mandated vacuum extraction system was operated in 1996-1997 to remove contaminants from the subsurface. At MDE's request, Alcoa conducted a three-phase investigation of the substation area in 2002 and 2003, to further evaluate post-remediation conditions. The report concluded that the past remediation was successful and that there was only a very limited residual source of PCE remaining in the subsurface. As such, no further action was recommended for soils provided the PCE concentrations in groundwater remain at the same level or less. The report also concluded that contaminant concentrations in groundwater, which are near or below MCLs at the southern property boundary and are generally non-detect offsite, are declining across the site via natural attenuation. Therefore, continued monitoring of the decreasing PCE concentrations in groundwater was recommended for a period of 2 years beginning in August 2003. Alcoa agreed to consult with MDE after 2 years to determine the appropriate course of action. MDE approved the report and the recommendations.

6.2. SITE-WIDE SOURCE INVESTIGATION

Following the PCE investigation, a site-wide investigation was performed in phases from October 2003 to September 2004 to identify and evaluate potential sources of contamination across the plant. The primary contaminants at the site are: fluoride and cyanide, resulting from the historical storage or disposal of SPL carbon ("first-cut") and bricks ("second-cut"), cryolite, and other fluoridated wastes; PCBs, resulting from the historical disposal of Therminol (heat transfer medium); and PAHs, resulting from the historical disposal of carbon waste materials such as pitch and anodes.

Potential contaminant sources investigated included ponds and lagoons that handle process and/or storm water, historical and current waste storage areas, and areas where wastes were historically buried. The investigation started with a site visit, interviews with plant personnel, record searches at the plant and at MDE, and an analysis of aerial photographs. This was followed by geophysical surveys, test pit excavations, and sampling of soil, sediment, and surface water to evaluate impacts from potential sources. The last phase included the strategic placement of monitoring wells and a site-wide round of sampling to characterize the groundwater plume, and a residential well survey to determine if downgradient groundwater was being used as a potable water supply.

6.2.1. Ponds and Lagoons

The North and South Ponds are asphalt-lined pits that have been used to handle various types of fluoridated process wastes, as well as SPL leachate from the Former SPL Pad and leachate from the Closed Industrial Landfill. Until mid 2005, the North Pond received process wastes from the treatment plant clarifier and thickener tank, which now goes to the South Pond along with runoff from the brick pad (Former SPL Pad). In 2004, the North Pond was observed to be in communication with the subsurface and based on fluoride concentrations in the process waste, it was determined to be a significant source of groundwater contamination. Contaminant flux calculations demonstrated that the contaminant loading from the North Pond, as a result of active process operations, was capable of sustaining the fluoride concentrations measured in local groundwater (40 to 90 mg/L). Because the asphalt lining in the South Pond was replaced in 1996, it appears to be in better condition relative to the North Pond, thus its leakage rate would likely be lower.

Rain Water Ponds 102 and 103 are unlined pits that receive fluoride-impacted storm water runoff and drain via Outfall 001 to the Potomac River under a NPDES permit. While the ponds' water contained elevated concentrations of fluoride (7.5 to 150 mg/L), impacts to groundwater are relatively minor based on low concentrations of fluoride (0.77 to 8.09 mg/L) in downgradient monitoring wells.

The Primary and Secondary Lagoons, as well as the Surge Pond, are unlined surface impoundments that receive fluoride-impacted process water and/or storm water runoff, and drain via Outfall 001 to the Potomac River. Over 150 tons of first cut SPL was found and removed from the Primary Lagoon in 1998 and 2001. The water in these impoundments contained low concentrations of fluoride (7 and 14 mg/L) and impacts to groundwater are relatively minor based on a low concentration of fluoride (4.4 mg/L) in a downgradient monitoring well.

6.2.2. Storage Areas

Storage areas investigated included the former SPL Storage Pad, the Waste Alumina Storage Pad, the Bone Yard, and the former Cryolite Bunker Pond. Fluoride is the primary constituent of concern.

The soils under and around the Former SPL Pad were considered a potential source because SPL was stored there first on bare ground from 1972 to 1974, and then on concrete pads until 1988. While the vadose zone soils under and around the SPL Pad contained elevated concentrations of fluoride (400 mg/kg average), they are not considered to be a significant source of groundwater contamination. Contaminant flux calculations demonstrated that the contaminant loading from the soils would result in a groundwater concentration of less than 1 mg/L, which considerably less than the 40 to 90 mg/L concentrations observed in local groundwater.

The Waste Alumina Storage Pad, used to store miscellaneous fluoridated waste and alumina, is paved with asphalt. The soils under the pavement contained fluoride at concentrations ranging from 52.7 to 110 mg/kg. Impacts to groundwater are minor based on a relatively low concentration of fluoride (3.13 mg/L) in a downgradient monitoring well.

The Bone Yard is an unpaved storage area used for storage of miscellaneous plant equipment, vehicles, general debris, unused bricks, etc. Surface soils contained fluoride at concentrations ranging from 26.6 to 56.7 mg/kg. The contaminant levels detected in the soils suggest the Bone Yard is not a major contributor to fluoride groundwater contamination. Although fluoride was detected at 12 mg/L in a monitoring well just downgradient of the Bone Yard, this is believed to be associated with the plume originating at the North and South Ponds.

The cryolite bunkers were used to dispose of high-carbon waste cryolite in the mid 1970's. Because the cryolite was removed from the bunkers in 1986, this area is not suspected to be a significant source of the fluoride contamination to groundwater. A sediment sample from a former runoff collection pond associated with the bunkers, contained fluoride a concentration of 43.5 mg/kg. Based on fluoride groundwater concentrations in that area (approximately 1 mg/L), the former pond is not considered a significant contaminant source to groundwater.

6.2.3. <u>Disposal Sites</u>

A total of nine historical waste disposal sites have been identified across the plant. Five are located south of the main plant operations area, and four are located near the western fence line. Of the nine sites, the presence of WDS-1, 2, and 3 in the western disposal area and WDS-4 in the southern disposal area was known prior to the investigation. Information obtained during the investigation indicated that WDS-1, 2, and 3 were used in the early 1970's for the one-time disposal of first cut SPL (cathodes), whereas WDS-4 served as the plant's fluoride landfill where miscellaneous fluoride waste, but no first cut SPL, were disposed of from 1975 until 1983. The four sites were each covered with 2 feet of compacted soil and are vegetated with grass and small shrubs. While MDE was apparently aware of these site closures, there were no formal closure documents found in either Eastalco's or MDE's files. To avoid jeopardizing the closures, intrusive activities were not performed within the known or suspected boundaries of WDS-1 to 4. Based on historical records, the combined area of WDS-1, 2, and 3 is approximately 2 acres; however, due to the uncertainty regarding the locations of WDS-1, 2, and 3, a "no dig" area that covers approximately 6.5 acres was established around the potential locations of WDS-1, 2, and 3 to prevent intrusive activities. The boundary of WDS-4, which was re-defined based on historical records and visual observations, covers approximately 4.5 acres. The depth of the disposed waste at WDS-1 to 4 is uncertain.

As summarized in the following subsections, five new disposal sites were identified as a result of the geophysical survey and test pit excavations. WDS-5 through WDS-8 were identified in the southern disposal area and WDS-9 was identified in the western disposal area. Surface soil, subsurface soil, and composite soil samples were collected during the investigation; however, the sampling strategy varied according to specific site conditions. Although fluoride and cyanide were the primary chemicals of interest at the onset of the sampling investigation, soil samples collected from the disposal sites were also analyzed for metals, VOCs, SVOCs, and PCBs. Concentrations of metals detected in soil samples likely represent natural background concentrations. VOCs were seldom detected and were at very low concentrations. Therefore, solvent disposal is not an issue for the disposal sites.

6.2.3.1. Southern Disposal Sites

The 53-acre grassy field located south of the main plant operations and between two streams contains a large amount of fill material that was deposited in the 1970's. While most of this is clean fill, five distinct areas of buried waste (WDS-4 through WDS-8) are present. WDS-5 through WDS-8 were identified during this investigation and were found to contain waste consisting mainly of carbon materials (mostly anodes and pitch with some isolated pieces of first cut SPL), as well as cryolite and construction debris. Combined, WDS-5 through WDS-8 contain about 35,000 cubic yards of waste, and occupy approximately 5 acres of the 53-acre field (WDS-4 occupies another 4.5 acres). In addition to WDS-5 through WDS-8, scattered buried debris (e.g., virgin cathode blocks and a furnace brick wall section) was encountered in other portions of the grassy field.

In general, the disposed wastes are covered by significant layers of clayey soils and are not readily accessible for exposure. However, one of the sites (WDS-6) has waste materials near the surface that could be accessible for exposure, especially if activities are performed in the area that disturb the ground surface. Clayey soils are also present below the waste disposal sites to the top of the bedrock which is approximately 20 to 36 ft-bgs. The low permeability clayey soils provide a barrier between the waste and the underlying groundwater.

Impacts to groundwater from these waste sites are minor based on contaminant concentrations in nearby downgradient monitoring wells. Fluoride concentrations ranged from approximately 1 to 4 mg/L. Although PCBs and PAHs were detected at elevated concentration in soils (maximum concentrations were 1,300 mg/kg for PCBs, and 730 mg/kg for PAHs), PCBs and PAHs were not detected in downgradient groundwater. In addition, surface soil, sediment, and the surface water in the seepage pits, farm fields, and surface water bodies adjacent to the southern disposal sites were not significantly impacted as a result of the waste disposal.

Because PCBs were detected in soil samples from WDS-5 though 8, the time in which the disposal occurred is important with regards to the TSCA regulations. Based on a review of historical records and an analysis of aerial photographs, the wastes at WDS-5 through WDS-8 were apparently deposited between 1973 and 1974. Because these wastes were disposed of prior to April 18, 1978 and the wastes are not believed to present an unreasonable risk of injury to health or the environment, these sites are not required to be cleaned up in accordance with TSCA regulations.

6.2.3.2. Western Disposal Sites

An area covering approximately 14 acres near the western fence line was investigated to determine if historical waste disposal sites, other than WDS-1, 2, and 3, were present. WDS-9 was found to contain a significant amount of buried waste (mostly high-carbon cryolite with some anode chunks). The site covers approximately 0.7 acres with buried wastes from near the surface to 5 feet bgs. WDS-9 has waste materials near the surface that could be accessible for exposure, especially if activities are performed in the area that disturb the ground surface. While soil at WDS-9 contained fluoride concentration of 548 mg/kg, impacts to groundwater are minor based on the fluoride concentration in a downgradient monitoring well of about 1 mg/L.

Clayey soils were observed beneath and around WDS-9, and based on observations of clayey soils in test pits outside the “no dig “area, it is likely that WDS-1, 2, and 3 are also surrounded and underlain by the same clayey soils which would provide a barrier between the waste and the underlying groundwater.

Sample data from other investigated areas outside the “no dig” zone, suggest that fluoride and cyanide contamination of soils is not a significant issue. PAHs and PCBs were also detected in soil samples;

however, the concentrations were much lower than what was measured at the southern disposal sites and are not considered a significant source of contamination to groundwater. Impacts to groundwater from these waste sites in terms of fluoride are minor based on fluoride concentrations in nearby downgradient monitoring wells which ranged from approximately 0.2 to 3.5 mg/L.

6.2.3.3. Closed Industrial Landfill

The Closed Industrial Waste Landfill was operated from 1983 to 1994 for the disposal of plant wastes including potliner brick. The 3.6-acre landfill that contains 62,500 cubic yards of waste is both lined and capped with clay and PVC, and has a leachate collection system that directs leachate for treatment through the plant's wet scrubber system. While the leachate generation rate is currently being assessed, earlier reports suggest the landfill produces about 100 gallons per day (gpd) of leachate. Recent data show fluoride concentrations in the range of 2,800 to 3,100 mg/L, and free cyanide concentrations in the range of 0.004 to 0.027 mg/L.

A liner leak detected in 1990 was repaired, but may have impacted groundwater. Consequently, the ACO required groundwater to be pumped from one of the landfill's monitoring wells (MW-68). Fluoride concentrations are declining in MW-68 but are still elevated above the ACO limit. At the start of this investigation, it was believed that the elevated concentrations in MW-68 (54 mg/L during this investigation) were related to either residual effects from the 1990 liner leak or possibly from other leaks. However, an analysis of fluoride concentrations in bedrock pumping wells RW-29 and MW-68 show that the temporal trends for fluoride concentrations in both wells are very similar even though RW-29 is upgradient of MW-68. This suggests, and is supported by the groundwater flow maps, that the elevated concentrations in MW-68 and other nearby monitoring wells are not related to the Closed Industrial Landfill, but are instead related to the same upgradient source that is responsible for the elevated concentrations in RW-29 (i.e., the North Pond and possibly the South Pond).

6.2.3.4. Old Anode Oven Pitch Pond

The Old Anode Bake Oven Pitch Pond was formerly used to handle wet scrubber water from the Bake Ovens. It is now lined with asphalt, and coated with coal tar pitch and petroleum coke. With state approval, Eastalco disposed of 500 tons of spent pot insulating brick in the pond in 1980 and covered it with blacktop. The overburden zone was found to be unsaturated in this area, but a nearby downgradient bedrock well, MW-94, showed only minimal concentrations of fluoride and free cyanide (3.27 and 0.002 mg/L, respectively). Based on the groundwater data and the method of closure, this site is not considered a significant source of groundwater contamination.

6.2.4. Site-Wide Groundwater

6.2.4.1. Groundwater Flow

Water level data suggests an overall high degree of hydraulic connectivity between the overburden and bedrock zones. Beneath the plant, the flow in both zones is generally to the southeast. Groundwater flow is influenced by a trough in the bedrock surface and the local streams. Beyond the main plant operations area, Tuscarora Creek to the east shows more influence along its length than the unnamed tributary to the west. During the investigation, Tuscarora Creek was a discharge point for overburden groundwater flowing from most of the plant as well as the farm fields located to east. Beyond the confluence of the streams, the flow direction is less certain and may be more towards the south.

The operation of bedrock pumping wells RW-29 and MW-68 create a closed depression in the bedrock potentiometric surface. While a depression is not apparent in the water table based on available elevation data, a 3-month test at RW-29 (MFG, 2004c) suggested groundwater within both zones is contained within a similar area as a result of the RW-29 pumping. Although MW-56 has the highest pumping rate of the three pumping wells, the pumping does not create a noticeable area of influence on the water table, which may be explained by increased recharge from the North Pond and possibly the South Pond.

6.2.4.2. Groundwater Contamination

Based on MCLs, the ACO sets property boundary action levels for fluoride and free cyanide at 4 mg/L and 0.2 mg/L, respectively. Although free cyanide has been detected above the MCL at the plant in the past, present concentrations of this contaminant are below the MCL across the plant. Fluoride concentrations, however, are above the MCL from the main plant area to the southern property boundary. The fluoride plume is elongated with a north to south orientation. Fluoride concentrations along the plume range from 40-90 mg/L near the source area to 5-8 mg/L near the southern property boundary. Plume migration is controlled by groundwater flow which is influenced by the streams as well as the bedrock topography.

The North Pond, and possibly the South Pond, were identified as the primary sources. Other investigated sources were not found to be significant contributors to the fluoride plume. Concentrations decrease rapidly (within a few hundred feet of the source area), likely as a result of factors such as dilution, adsorption, and chemical precipitation.

Average annual fluoride concentrations in wells near the primary source area were elevated (less than 1000 mg/L) in the 1980's, which was thought to be due principally to the storage of SPL on the Former

SPL Pad and the subsequent drainage of SPL leachate to the South Pond. Beginning in 1988 when SPL was no longer being stored on the pad, fluoride concentrations in groundwater began to decrease sharply; however, since 1996, fluoride concentrations have continued to decrease, albeit at a slower rate. The concentrations currently fluctuate within a range of 40 to 90 mg/L. Concentrations also declined in groundwater near the southern property boundary where the current concentrations range from about 5-8 mg/L in certain wells, which still exceeds the ACO limit. An offsite well shows relatively stable concentrations far below the ACO limit.

Cyanide contamination of groundwater has also resulted from past waste disposal and storage practices, but to a lesser extent. The current free cyanide concentrations in wells across the site are below the ACO limit.

The North Pond was recently taken out of service. Process water containing elevated amounts of fluoride is still discharged to the South Pond; however, the impact to groundwater from this pond is uncertain. The asphalt liner in the South Pond appears to be in better condition than the North Pond, so if it is leaking, its leakage rate would likely be lower.

Projected temporal trends suggest it could take 2 to 5 years before groundwater in the vicinity of the North and South Ponds has fluoride concentrations below the ACO limit assuming there is no additional contaminant loading. Due to groundwater transport times from the source area, the property boundary concentrations could take longer to attenuate. Projected temporal trends suggest it could take 4 to 8 years for groundwater at the property boundary to reach the ACO limit. It should be noted that the projections have an associated degree of uncertainty based on temporal concentration fluctuations, the modified operational status (loading potential) of the North and South Ponds, and variability of contaminant transport times associated with the karst hydrogeology at the site.

6.2.4.3. Potable Water Use

South of the property boundary, most properties located west of Tuscarora Creek are not connected to the public water supply and use water wells for potable water; however, based on groundwater flow data at the site, these properties are not downgradient of the site. Most of the properties east of Tuscarora Creek (south/southeast of the plant) are connected to the public water supply. Six of the properties that are connected to the public water supply also have water wells, and one commercial property (Trans Tech) has an industrial well. It is not known if these wells are being used for non-potable purposes because interviews with property owners were not conducted as part of the survey.

7.0 REFERENCES

Atlantic Environmental Services, Inc., 1996, Eastalco Aluminum Company, Aquifer Characteristics Investigation, May 29, 1996.

Balter Soil and Foundation Consultants, Inc. 1974a. Groundwater Study No. 2, Eastalco Aluminum Company, November 1974.

Balter Soil and Foundation Consultants, Inc. 1974b. Eastalco Landfill Study, May 1974.

Dzombak, D.A, A. Ali, C. Dobbs. 1993. Evaluation of Subsurface Fate/Transport of Chemical Species in Spent Potlining Leachate, 1993.

Geraghty & Miller, Inc. 1983. Second Phase Study Proposal, Eastalco Aluminum Company, August 1983.

Geraghty & Miller, Inc., 1984. Hydrogeologic Investigation at the Eastalco Plant Site. August 1984.

Maryland Geological Survey (MGS), 1968. Geologic Maps of Maryland, Frederick County, Detail 12.

Maryland Geological Survey (MGS), 1981. A Brief Description of the Geology of Maryland.

Menzie-Cura & Associates, Inc., 1996. Report on Groundwater Velocities and Travel Times Eastalco Aluminum Company Property. August 1996.

Meta Systems, Inc., 1989. Groundwater Investigation at the Eastalco Facility. April 1989.

MFG, Inc. 2002. Phase I and Limited Phase II Environmental Site Assessment and Buffer Zone Evaluation of Non-Manufacturing Areas, November 2002.

MFG, Inc. 2003. PCE Investigation Results and Site Conceptual Model, Alcoa Eastalco Works. May 2003.

MFG, Inc. 2004a. C-Line Area Work Plan and Field Sampling Plan, Alcoa Eastalco, March 2004.

MFG, Inc. 2004b. Site-Wide Investigation Work Plan, Alcoa Eastalco, August 2004.

MFG, Inc. 2004c. Groundwater Recovery Well 29 Hydraulic Containment Test Report, Alcoa Eastalco, July 2004.

MFG, Inc. 2004d. Fluoride Plume Recovery System Operation and Maintenance Plan, Alcoa Eastalco, December 2004.

MFG, Inc. 2005a. Site-Wide Investigation Work Plan Addendum, Phase II Field Sampling Plan, Alcoa Eastalco, May 2005.

MFG, Inc. 2005b. Fluoride Plume Source Assessment. Alcoa Eastalco, August 2005.

Schnoor, G.G., D. Dzombak. 1995. Evaluation of Subsurface Fate/Transport of Cyanide and Fluoride at Spent Potlining Leachate Field Sites, June 2005.

USEPA, 1983. Site Investigation Report, Eastalco Aluminum Company, United States Environmental Protection Agency Region III, October 7, 1983.

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(Compact Discs)

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Laboratory Reports

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Appendix F

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Appendix G

Southern Disposal Sites

Test Pit Soil Sample Descriptions and Photographs

Appendix H

Western Disposal Sites

Test Pit and Soil Sample Descriptions and Photographs

Appendix I

Fluoride Source Assessment