Technical Support for Acid Brook Delta Upland Soil Area
Corrective Action Implementation
Pompton Lakes, New Jersey

Overview

This document was prepared as a supplement to the Remedial Action Selection Report/Corrective Measures Study (RASR/CMS; DuPont CRG, September 2009) to develop Remedial Action Objectives (RAOs) for the Acid Brook Delta (ABD) Upland Area Soils. RAOs are long-term, media-specific goals developed to protect human health and the environment. The methodology and supporting calculations for the derivation of ecological soil criteria based on bioaccumulation and wildlife ingestion pathways are provided in Appendix C of the ABD Uplands Remedial Investigation Work Plan (RIWP; DuPont CRG, January 2009). As discussed in the Baseline Ecological Evaluation (DuPont CRG, January 2009), the limited size, fragmented habitat, and frequent disturbance of the ABD Upland Soil Area limits its value as an ecological habitat.

For ABD Upland Area Soils outside the wetland/wetland transition zone (Removal Areas A1, E1, E2, E3, E7, and upper portions of E4, E5, and E6 – Figure U-1), both human health and ecological criteria have been selected as the RAOs (DuPont CRG, January 2009). In surface soils (0 to 0.5 foot), the RAOs are based on the lower value of the New Jersey Department of Environmental Protection (NJDEP) November 2009 Residential Direct Contact Soil Remediation Standards (NJRDCSRS) and ecological soil delineation criteria as listed in the table below. Using the lower value of the NJRDCSRS and ecological soil delineation criteria and backfilling with soil meeting NJDEP clean backfill requirements will allow protection for uplands use by humans, while also providing adequate protection for ecological receptors.

Analyte	Surface Soil Criteria (mg/kg)	Subsurface Soil Criteria (mg/kg)
Copper (Cu)	1,100*	3100
Mercury (Hg)	20.5*	23
Lead (Pb)	400	400
Selenium (Se)	5.05*	390
Zinc (Zn)	1,507*	23,000

*ecological criteria

The RAO for ABD Upland Area Soils within the wetland and wetland transition zones (Removal Areas A, B, B1, C, D1, D2, lower portions of E4, E5, E6, and F – Figure U-1) will be:

- To eliminate or minimize the potential exposure to ecological receptors within the wetland and wetland transition zone to surface and subsurface soils in these areas by limiting the potential for mercury methylation, bioaccumulation, and translocation.

To accomplish this RAO, areas landward of the ABD Pompton Lake Corrective Action Implementation boundary (ABD removal area) within the ABD Upland Soil Area wetland and wetland transition zone will be excavated to a depth of three feet below the final restoration elevation or one foot below the assumed water table elevation of 200.5 (i.e., 1 foot below full pool lake level), whichever is encountered first. The resulting excavation will be backfilled with soil meeting NJDEP requirements for such material. The inclusion of excavation in the wetland transition zone (Area F) adds an additional conservative measure in support of the ecological protectiveness of the above approach as related to restoration planting rooting depths and the potential for translocation of mercury remaining in at depth soils following removal activities. Studies have demonstrated that rooting depth is generally limited to the top two feet of soil, by water table depth, and other physiological factors such as nutrient availability. By providing a clean layer for restoration planting to grow it will eliminate or minimize the potential for ecological receptor exposure by limiting the potential for mercury methylation, bioaccumulation, and translocation.

Continued technical discussions with EPA identified additional considerations (AC) which were evaluated as part of the ABD Upland Soil Area remedy to address the potential ecological exposure pathways to mercury in soil in the wetlands and wetland transition zones which include:

- AC-1. The root depth of the various plant species proposed for use in the restoration (roots should not reach into the contaminated zone);
- AC-2. The rate of mercury uptake by the various plant species proposed for use in the restoration (to demonstrate that the selected species will not act as a vegetative pump);
- AC-3. The rate of mercury deposition in leaf litter and of mercury bioaccumulation;
- AC-4. The need to develop a site-specific criteria for delineating limits for any soil excavation in the Plan; and
- AC-5. The ability of any engineering controls to eliminate or minimize ecological exposure.

The following narrative presents the rationale to address potential ecological exposure pathways to wetland and wetland transition area soils, as well as each of the aforementioned five considerations raised by EPA during technical discussions. These are preceded by a discussion defining the project specific wetlands and wetland transition zone.

Wetland

As used herein, the term wetland refers to those areas that meet the definition of "freshwater wetland" as defined by N.J.A.C. 7:7A-1.4 and occur landward of the ABD Pompton Lake Corrective Action Implementation boundary (Figure U-1). The upland/wetland boundary of this area was last delineated in 2009 in accordance with NJDEP rules and methodology (N.J.A.C. 7:7A-2.3). The site is stable and the presented upland/wetland delineation boundary is considered accurate to current conditions.

Wetland Transition Area/ Zone

Given that the intent of the required action is to address potential ecological exposure pathways that may occur within the interface between wetland and upland areas, a site-specific transition zone will be defined herein based on hydrological and ecological principles that control ecological exposure to mercury in wetland and wetland transition soils. The first step in addressing the consideration is to provide a working definition of the wetland transition area or zone for the ABD Upland Soil Area.

The NJDEP definition of a "Transition Area" as stated in the NJDEP 7:7a Freshwater Wetlands Protection Act Rules is "an area of upland adjacent to a freshwater wetland which minimizes adverse impacts on the wetland or serves as an integral component of the wetlands ecosystem" (N.J.A.C. 7:7A-1.4). Services of this area identified by the rule include:

1. “An ecological transition zone from uplands to freshwater wetlands which is an integral portion of the freshwater wetlands ecosystem, providing temporary refuge for freshwater wetlands fauna during high water episodes, critical habitat for animals dependent upon but not resident in freshwater wetlands, and slight variations of freshwater wetland boundaries over time due to hydrologic or climatologic effects; and
2. A sediment and storm water control zone to reduce the impacts of development upon freshwater wetlands and freshwater wetlands species.”

The transition zone for the ABD Upland Soil Area will be defined as an area extending from the wetland delineation boundary to an elevation of two feet above that line, consistent with the understanding of the site-specific conditions as they relate to an ecologically-based wetland transition area. The general findings of studies evaluating ecologically-based wetland transition areas suggest that defining characteristics and leading indicators of transition areas include vegetation species richness and distribution, soil water content, and topographic position (Anderson et al. 1978; Lewis et al. 1995; Veneman and Tiner 1990).

Vegetation surveys conducted at the ABD site as part of wetland delineation and restoration planning document herbaceous and shrub/tree species and their locations within the study area. These site-specific studies indicate an increase in presence of tree species, such as *Robinia pseudoacacia*, *Prunus serotina*, and *Juglans nigra*, at elevations approximately two-feet above the delineated wetland boundary (approximately 203 to 204.5 NAVD 88). These tree species are more commonly associated with upland environments [(facultative upland (FACU) indicator status)] and may serve as indicators of the division between the transition area and wholly upland systems. At the elevations greater than those where these tree species are present, ground surface is minimally two feet above indicators of wetland hydrology and soil moisture would be solely reflective of upland conditions. Moreover, based on historical USGS gage information, these elevations are approximately 1 to 1.5 feet above the highest elevation flood events within Pompton Lake (USGS 2014). A steep topographic divide separates lower elevation wetlands and uplands; therefore, the horizontal distance associated with two-feet of elevation change is generally less than 15 feet in width (Area F, Figure U-1).

Given the understanding of the site-specific conditions as they relate to an ecologically-based wetland transition area, the remedy for the ABD Upland Soil Area will include a transition zone to an area extending from the wetland delineation boundary to an elevation of two feet above that line. This functional definition of the wetland transition zone is defined based on hydrological and ecological principles and is consistent with the general intent of the NJDEP definition provided above. This area, which encompasses portions of Acid Brook (NJDEP state open water), will be incorporated into soil removal actions as described in the following text.

AC-1 – Restoration Planting Rooting Depth and Soil Removal:

The Remedial Investigation Report, Pompton Lake Uplands (Uplands RIR; Parsons, June 2010) presents analytical data used to delineate the limits of soil removal in the uplands based on criteria protective of human health and ecological receptors presented in the 2009 RASR. Those efforts determined that horizontal extents (based on the lower value of the NJRDCSRS and ecological soil delineation criteria) to be addressed in the upland area are primarily associated with the low elevation wetland areas in proximity to Acid Brook (Areas A to D). Isolated areas for removal have also been identified within the uplands and wetland transition zone (Areas E1 to E7)(Figure U-1).

Preliminary vertical limits of remedial excavation of subsurface soils (deeper than 0.5 feet) outside the ABD Upland Soil Area wetland and wetland transition zone are based on NJRDCSRS and have been estimated for each of the designated removal areas based on the removal of soil to the next deepest 0.5 feet study interval below which criteria exceeding levels were observed. Moreover, an investigation has been conducted in Acid Brook immediately downstream of Lakeside Avenue and in vicinity of two sanitary sewer line crossings to more precisely identify soil removal limits that both protects the sewer infrastructure and addresses ecological/human health concerns. Also, in the majority of removal areas, site restoration will result in the backfill of the removal areas with clean fill and planting medium (i.e., topsoil) to establish either pre-activity elevations, or those designed for habitat restoration. Beyond these measures and in keeping with the above RAO, to eliminate or minimize exposure of the majority of restoration plant root systems in wetland and wetland transition zone to mercury concentrations in post remediation subsurface soils, a minimum of three feet of soil will be removed below the final restoration elevation or soils will be removed to one foot below the water table (whichever is encountered first) and then backfilled with soil planting medium meeting NJDEP requirements.

In support of the protectiveness of the above approach as related to restoration plantings and the potential for contact with remaining soils following removal activities, studies have demonstrated that rooting depth is generally limited to the top two feet of soil by water table depth and other physiological factors such as nutrient availability. Rooting depth of woody shrub and tree species similar to those proposed within the restoration plans has been shown to be significantly correlated with and or restricted by water table depth (Stone and Kalisz 1990; Canadell et al 1996; Ray and Nicoll 1998; Crow 2005). Stone and Kalisz (1990) summarized multiple studies that evaluated rooting of 211 species including many wetland related species and of which only approximately 15% showed rooting below the limits of the water table. Other studies suggest that 90 to 99% of tree root length occurs within the first 3.28 feet (1 meter) of soil depth (Crow 2005). Wetland hydrology within the ABD Upland Soil Area is largely driven by surface water elevation within Pompton Lake, which has an average level of 201.4 and will result in saturated soils and/or a shallow water table that will limit restoration planting rooting depths to near surface soils.

Rooting depth of herbaceous emergent wetland plants is also limited by such factors as nutrient availability (Manning et al 1989; Moore and Rhoades 1966). Studies of ecophysiology of wetland plant roots conducted by Sorrell et al (2000) demonstrated rooting depth to approximately two feet for a *Typha* species, a common wetland plant. Moore and Rhoades (1966) found 66% of roots within the top two inches of soil profile for other wetland plant species. Similarly, Bernard and Fiala (1986) found 64% to 92% of living roots of three *Carex* species occurred within the top six inches of soil, equating to over 90% of the root mass. Manning et al (1989) also demonstrated that root mass within two distinct wetland meadow-types was predominately associated with the upper 15 inches of the soil profile. These plants are related to or similar in type to those proposed within the project restoration plan.

The ABD Upland Soil Area remedy will include the removal of soil to meet the RAO criteria. Given site conditions (existing and proposed) that pose limitations to tree and shrub species rooting depths (soil saturation/water table elevation) and the above findings that highlight the relatively shallow primary rooting depths for emergent vegetation within wetlands, the proposed remedy will eliminate or minimize the potential for ecological exposure to underlying soils and the contact with restoration plants with remaining soils.

AC-2 – Mercury Uptake by Plant Species:

As previously described, soil removal conducted within wetland areas and wetland transition zones will eliminate or minimize the potential exposure of the majority of root systems to mercury concentrations in subsurface soils. Potential contact of minor portions of root systems to subsurface soils poses minimal chance for elevated mercury concentrations into above ground plant biomass due to the limited uptake (i.e., translocation) potential of mercury from soil.

The uptake of mercury from soils to plant material and tree leaves is a relatively minor process, with mercury concentrations in above-ground biomass (i.e., leaves) representing a low percentage of soil mercury. For example, *Impatiens wallerina* plants grown in soil at the Oak Ridge Reservation in Oak Ridge, TN with high mercury concentrations translocated only 0.11% of the mercury mass in soil (Pant et al. 2011). Yarrow (*Achillea millefolium*) plants growing in in highly mercury impacted soils in Slovakia with concentrations of approximately 50 mg/kg translocated only 2.8% of meadow soil mercury; similar results were found in larger trees, such as the Norway spruce (*Picea abies*), white oak (*Quercus polycarpa*) and brittle willow (*Salix fragilis*), which translocated less than 1% of forest soils (Dombaiova 2005). Finally, the translocation of mercury from plant roots to shoots is low and restricted by the retention of mercury within cell walls within the roots (Stamenkovic 2008).

With the above understanding and the plan to expand the overall lateral and vertical extents of soil removal and clean backfill in wetlands and wetland transition zones, the potential for mercury uptake and translocation is eliminated or minimized.

AC-3 – Mercury Deposition in Leaf Litter and Mercury Bioaccumulation:

Mercury concentrations in above-ground plant biomass are generally associated with atmospheric sources. In an evaluation of mercury pathways in northern forest ecosystems, Bushey et al (2008) found that mercury occurrence within leaf tissue is primarily derived from atmospheric sources and, as such, represent new versus recycled mercury contributions to leaf litter. Stamenkovic (2008) noted similar findings and also reported that accumulation within leaves as a result of atmospheric gas exchange is gradual, but does increase with time. Given these findings, it is understood that mercury deposition in leaf litter from restoration plantings and bioaccumulation of mercury that may be related to remaining soils will not be an important transport processes following soil removal and restoration in wetland and wetland transition areas.

AC-4 – Need for Site-Specific Criteria for Soil Excavation Limits:

The planned remedial activities for soils in the wetland and wetland transition zones address the associated RAOs. The remedy in the associated wetland and wetland transition zones (Area F, Figure U-1) to depths of three feet below final restoration grade elevations or one foot below the water table coupled with backfilling with material that meets NJDEP requirements for such material will minimize/eliminate the potential for any remaining soils that contain concentrations of mercury, if any, to impact restored plantings via mercury methylation, bioaccumulation and/or translocation. Use of this approach is considered to either eliminate or minimize the potential for ecological exposure following removal and restoration actions and as such site-specific criteria are not applicable.

AC-5 – Ability of Engineering Controls to Eliminate or Minimize Ecological Exposure:

The planned engineering control actions (i.e., implemented remedy for ABD Upland Soil Area) will result in the expanded removal of all soils from the Upland Soil Area within wetlands and wetland transition zones to address the RAO criteria presented above. These actions are protective and will result in primary ecological exposure within depths that will be backfilled with clean fill. Thus, the backfill of the removal areas with clean fill and additional planting medium in concert with restoration efforts will eliminate or further minimize any potential for unacceptable ecological exposure. Vegetative growth characteristics and physiological capabilities add further technical support that interactions with the restored habitats will also not result in unacceptable ecological exposures under realistic scenarios. Finally, related to ecological concerns, the proposed planned engineering controls also address the protection of infrastructure associated with the sanitary sewer crossings and thereby eliminate or minimize the potential for system failure.

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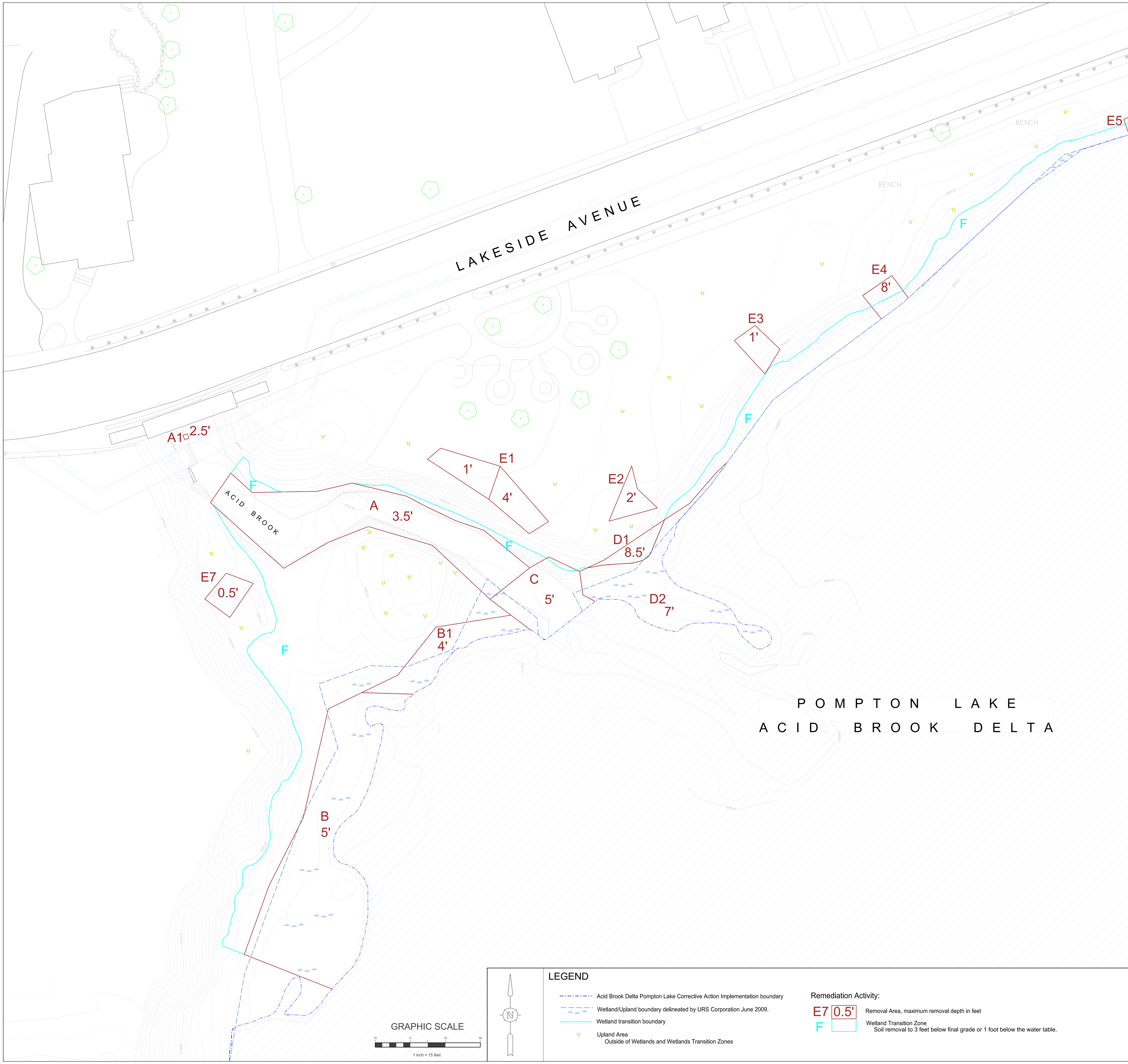

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Upland Corrective Action Implementation Area

Acid Brook Delta
DuPont Pompton Lakes Works
Figure U-1