FINAL

DUPONT CHAMBERS WORKS FUSRAP SITE PROPOSED PLAN

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U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM

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LIST OF ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
AOC(s)	Area(s) of Concern
AOI(s)	Area(s) of Interest
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
BNI	Bechtel National, Inc.
BRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethylbenzene, xylene
CABRERA	Cabrera Services Inc.
CDD	Central Drainage Ditch
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC(s)	Constituent(s) of Concern
COPC(s)	Constituent(s) of Potential Concern
COPEC(s)	Constituent(s) of Potential Ecological Concern
CSM	Conceptual Site Model
DOE	U.S. Department of Energy
DuPont	E.I. DuPont de Nemours & Company
EU(s)	exposure unit(s)
FS	Feasibility Study
ft	feet/foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GAC	Granular Activated Carbon
HHRA	Human Health Risk Assessment
HI	Hazard Index
ILCR(s)	Incremental Lifetime Cancer Risk(s)
ISV	investigative screening value
LNAPL	light non-aqueous phase liquid
LUC(s)	land use control(s)
MCL	maximum contaminant level
MNA	monitored natural attenuation
mrem/yr	millirem per year
µg/L	micrograms per liter
MED	Manhattan Engineer District
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NAVD 88	North American Vertical Datum of 1988
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
O&M	operation and maintenance
OU(s)	Operable Unit(s)
ORNL	Oak Ridge National Laboratory
pCi/g	picocuries per gram
Ra-226	radium-226
RAGS	Risk Assessment Guidance for Superfund
RAO(s)	remedial action objective(s)
RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactivity
RG	remediation goal

RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SGS	Segmented Gate System
SLERA	Screening-Level Ecological Risk Assessment
SWMU	solid waste management unit
Th-230	thorium-230
U-234	uranium-234
U-235	uranium-235
U-238	uranium-238
U(4+)	tetravalent uranium ion
U(6+)	hexavalent uranium ion
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
yd^3	cubic yard

GLOSSARY OF TERMS

Technical or unfamiliar terms (italicized in text) are defined below for reference purposes.

Adsorption: A process in which a substance (e.g., contaminant) accumulates on the surface of a solid material, forming a thin film, often only one molecule thick. Adsorption is the process that transfers contaminants from air or water onto the surfaces of activated carbon particles.

Aquifer: An underground, porous layer of sand or rock or group of layers that contains water and can be used as a source of groundwater to supply wells and springs.

Aquitard: A water-saturated soil or rock layer whose permeability is so low it is not capable of transmitting any useful amount of water.

Burrito Bag: A specialized waste transport bag with a four-flap enclosure method utilized for top loading; most commonly used when bulk-loading soil or debris into a container for transport.

Granular Activated Carbon Canister: A component of a treatment system, acting as a filter, used to remove organics and other contaminants from air or water. The carbon has been processed (or 'activated') to make it extremely porous and capable of attracting the contaminants (by adsorption) as the air or water passes through the canister.

Isopleth: On a map, a line connecting points that have the same numerical value, such as a topographic contour line.

Light Non-Aqueous Phase Liquid (LNAPL) Organic liquids that are relatively insoluble (do not mix easily) in water and are less dense than water. As a result, LNAPLs, such as oil and petroleum chemicals float on the surface of the water table, forming a distinct layer on top of the water.

Limited Restricted Use Remedial Action: Under the New Jersey Administrative Code; "any remedial action that requires the continued use of institutional controls but does not require the use of an engineering control." (NJAC 7:28-12.3 Definitions).

Monitored Natural Attenuation A cleanup approach that relies on natural attenuation processes to reduce (or lessen) the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater over time. The *in situ* (in place) processes include absorption, adsorption, degradation, dilution, and/or transformation.

North American Vertical Datum of 1988 (NAVD 88) A vertical control datum used for measuring the elevation of points on the Earth's surface. NAVD 88 is the official vertical datum in the United States and Canada.

GLOSSARY OF TERMS (continued)

Oxidizing Environment:	Environmental conditions characterized by an abundance of oxygen or the loss of electrons from an ion. Oxidizers (e.g., oxygen, chlorine, and fluorine ions) combine with reducing agents in a redox reaction. Rusting is an example of an oxidizing reaction.
Radionuclide:	A radioactive particle with a distinct atomic weight number. Radionuclides undergo spontaneous change by emission of charged particles and/or gamma rays, a change known as radioactive decay.
Reasonable Maximum Exposure (RME):	In a risk assessment, the RME is the highest level of human exposure to contaminants that could reasonably be expected to occur.
Redox	Chemical reactions in which atoms have their oxidation states changed. Generally, redox reactions refer to reactions that involve the transfer of electrons between ions.
Reducing Environment:	Environmental conditions characterized by little or no free oxygen or the abundance of hydrogen or electrons. The gain of electrons by an ion or molecule. The metals potassium, calcium, barium, sodium and magnesium are common reducing ions.
Residual Contamination:	The contamination remaining in the environment after a completed cleanup (response) action.
Resin:	Solid or semi-solid viscous organic substances, like shellac or lacquer of plant origin.
Response Action:	A response action is a short-term removal action or a long-term remedial action, authorized under CERCLA that is taken at a site to address releases of hazardous substances.
Restricted Use Remedial Action:	Under the New Jersey Administrative Code; "any remedial action that requires the continued use of engineering and institutional controls in order to meet the established health risk or environmental standards." (NJAC 7:28-12.3 Definitions).
Segmented Gate System:	A cleanup technology that physically separates soils based on their level of radioactivity. The term is used generically in this document. There are a number of vendors for similar systems with similar names, such as 'radiological soil sorting system' or 'soil sorting survey system'.
Unrestricted Use Remedial Action:	Under the New Jersey Administrative Code; "any remedial action that does not require the continued use of engineering or institutional controls in order to meet the established standards." (NJAC 7:28-12.3 Definitions).

Volatile Organic Compounds: Organic liquids with a high vapor pressure that evaporate readily at normal temperatures and pressures.

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) - Philadelphia District is conducting the environmental restoration of the DuPont Formerly Utilized Sites Remedial Action Program (FUSRAP) Chambers Works Site (Chambers Works). As a part of the restoration efforts, USACE is addressing radiological contamination at the Chambers Works, resulting from past uranium refinement processes performed for the Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) in the early years of the nation's atomic energy program. USACE is issuing this Proposed Plan as part of its public participation responsibilities under the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), 42 United States Code (U.S.C.) § 9617(a), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) § 300.430(f)(2).

Chambers Works, located in Deepwater, NJ, is an active chemical manufacturing facility owned and operated by E.I. DuPont de Nemours & Company (DuPont). From 1942 to 1947, the MED and AEC (succeeded by the U.S. Department of Energy, [DOE]) contracted with DuPont to process uranium compounds and uranium scrap to produce uranium tetrafluoride, uranium hexafluoride and a small quantity of uranium metal. For simplicity, throughout this plan MED will be used to describe the work related to the nation's early atomic energy program whether or not the activities were performed under contract to MED or AEC. These activities resulted in residual radiological contamination at the site. USACE is utilizing the administrative, procedural, and regulatory provisions of the CERCLA and the NCP to guide the FUSRAP investigation and ***response action*** (including remedial action) at three operable units (OUs) within Chambers Works.

1.1 Purpose of Proposed Plan

This Proposed Plan describes the remedial alternatives considered for addressing soil and groundwater contamination in OU 1 and Area of Concern (AOC) 6 (which is part of OU 3), and identifies the USACE's preferred remedial alterative(s) and supporting rationale. The other FUSRAP areas investigated during the Sitewide Remedial Investigation (RI) do not require a response action under CERCLA. The maximum risk and dose for OU 2 (consisting of AOC 3 and AOC 5) and AOC 4 (a part of OU 3) are within acceptable risk and dose criteria (Section 5.1). As a result, USACE is planning no further action at these FUSRAP areas.

Only FUSRAP-eligible contamination will drive USACE's response action in OU 1 (consisting of AOCs 1 and 2) and AOC 6. The constituents determined to be eligible for a response action under FUSRAP include the radioactive constituents associated with the MED uranium processing activities performed at Chambers Works. These constituents are primarily uranium, thorium, radium and the short-lived decay products of these elements (Cabrera Services, Inc. [CABRERA] 2011a). The scope of this plan does not include addressing non-FUSRAP-related contamination that may be associated with past DuPont chemical manufacturing operations unless it happens to be commingled with materials related to the FUSRAP remediation. Non-FUSRAP contaminants will be removed along with the eligible FUSRAP contaminants to the extent necessary to successfully complete the FUSRAP response action.

The site characteristics, nature and extent of contamination, associated human health and ecological risks, and possible remedial action alternatives are summarized herein with more detailed information found in the following documents:

- *Sitewide RI Report for All Operable Units, DuPont Chambers Works FUSRAP Site* (CABRERA 2011b),
- *Baseline Risk Assessment (BRA) DuPont Chambers Works FUSRAP Site* (CABRERA 2011c), and
- *Feasibility Study (FS), DuPont Chambers Works FUSRAP Site* (CABRERA 2012).

The RI, BRA, FS, and other project-related documents are available in the administrative record file located at the USACE Philadelphia District Office and at the Salem Community College Library. USACE encourages the public to review available material about the DuPont Chambers Works FUSRAP Site and to comment on the preferred remedial action alternative presented in this Proposed Plan. At the conclusion of the public comment period, the USACE will fully consider and respond to all significant comments received. USACE will then select the remedial action for the DuPont Chambers Works FUSRAP site in the Record of Decision (ROD).

1.2 Preferred Remedial Alternative

This Proposed Plan summarizes the findings of the RI, BRA, and FS in order to present USACE's preliminary recommendation, the preferred remedial alternative for addressing MED-related contamination, and to solicit public and regulatory agency comments pertaining to the remedial alternative evaluation and selection process. The USACE has carefully studied the MED-related areas and believes the best way to protect human health and the environment is to implement the preferred remedial alternative. The preferred remedial alternative includes the following components:

1) Excavate contaminated soils above the remediation goal (RG)(or 'cleanup goal');
2) Transport and dispose contaminated soils at a permitted off-site disposal facility;
3) Employ ***monitored natural attenuation***, or ***MNA,*** to address the residual uranium groundwater concentrations through a defined monitoring program after completion of the soil response action; and
4) Use land use controls (LUCs) to limit potential onsite exposure to contaminants during remedial action activities.

Excavation and disposal of contaminated soil will eliminate the source of groundwater contamination and significantly reduce contaminant concentrations in groundwater. This reduction in groundwater concentrations is expected because contaminated groundwater will also be removed during any soil excavation (CABRERA 2012). The defined monitoring program associated with MNA will document residual groundwater contamination after completion of the soil remedial action (excavation) and the effectiveness of natural attenuation processes over time. USACE expects that residual levels of contamination will remain in groundwater after excavation of soil but at levels well suited for the selection of excavation combined with MNA as a preferred alternative.

USACE proposes a demonstration period of two to five years to evaluate the effectiveness of MNA. The demonstration timeframe will depend on results of both analytical sampling results and statistical trend analysis. During this time, USACE will collect both field measurements and analytical data to demonstrate that naturally occurring *in situ* processes are working to reduce contaminant concentrations. Assuming that MNA is confirmed to be effective during the demonstration period, monitoring will continue until compliance with remedial action objectives (RAOs) has been achieved for all monitoring wells included in the program.

LUCs will be implemented as part of the preferred alternative to restrict access and protect workers during remedial action activities and rely on existing DuPont site access restrictions and controls. The LUCs for this site include physical, legal, and administrative controls and are designed to protect public health and the environment by limiting land use and onsite activities to prevent exposure to contaminants. LUCs implemented during the remedial action to protect site workers will include but are not limited to fencing, site access restrictions, and current DuPont procedures and safeguards that control the disturbance of soils (excavation permits) and restrict the use of groundwater as a potable source.

The preferred remedial alternative is anticipated to result in a permanent and irreversible reduction of soil and groundwater contamination since the source of radioactive contamination will be removed. Based on the current and most reasonably anticipated future land use for Chambers Works, the USACE developed an RG and evaluated potential remedial alternatives suitable for the continued industrial use of the property. This means that upon completion of the remedial action to the industrial use cleanup goal, limited contamination could remain onsite but at levels which are safe for industrial use. After excavation, USACE will assess the contamination and perform a dose assessment in order to evaluate the effectiveness of the remedial action. ***Residual contamination*** is expected to be very low and could possibly allow for a future unrestricted use of the areas with regard to FUSRAP contaminants.

1.3 Public Participation

USACE is requesting public review and comment on the preferred alternative as well as other alternatives presented in this plan. At the conclusion of the public comment period USACE will review comments, including both those from the public and from the New Jersey Department of Environmental Protection (NJDEP). After careful consideration of comments, USACE will select a remedial action for the soil and groundwater in the FUSRAP areas at Chambers Works. As the lead agency for the DuPont Chambers Works FUSRAP site, USACE may ultimately select the preferred alternative for remediation of the soil and groundwater, modify aspects of the preferred alternative, or select any of the other alternatives presented in this plan based on public comments received. Consequently, USACE encourages the public to review available documents and provide comments. In order to receive consideration, commenters must submit their comments to USACE by the dates specified in Section 10 of this plan.

2.0 SITE BACKGROUND

The Chambers Works is located in Pennsville and Carneys Point Townships, along the southeastern shore of the Delaware River, north of the I-295 Delaware Memorial Bridge, and adjacent to the residential community of Deepwater, NJ. The location of the DuPont property is shown in Figure 2-1. The Chambers Works extends 2.7 miles between Helms Cove to the north and the Salem Canal to the south. Henby Creek separates the active Chambers Works manufacturing area from the former Carneys Point Dye Works. The Pennsylvania and Reading Seashore Line railroad track bounds the property to the east.

2.1 Site History

MED operations involving uranium began at Chambers Works in 1942, when MED contracted with DuPont to perform several uranium-processing activities. In 1946, all MED activities were transferred to the AEC, and DuPont continued research for AEC until late 1947. The DuPont contracts with MED and/or AEC involved uranium refinement operations. In addition to the uranium refinement, Chambers Works also converted quantities of green salt (uranium tetrafluoride) to uranium hexafluoride in a process known as the hexafluoride process. Uranium refinement using the brown oxide, green salt, and recovery processes were also conducted. No uranium enrichment or depletion processes were conducted at Chambers Works.

Based on the nature and location of past MED activities, USACE identified six AOCs at Chambers Works for investigation. To facilitate further investigation and remedial decisions, the USACE organized the AOCs into the following three OUs for a phased investigation under FUSRAP:

- <u>OU 1 consists of AOC 1, Former Building 845 and AOC 2, the F Corral.</u> Production areas where uranium recovery and processing took place between 1943 and 1947. Residual processing wastes were discharged into a wooden trough. The wooden trough is still in existence, collects storm water, and discharges to the Central Drainage Ditch (CDD) located in AOC 1. Production of uranium metal occurred in AOC 2 in former Building 708.
- <u>OU 2 consists of AOC 3, CDD and AOC 5, Building J-26 Area.</u> These AOCs include the location of a former laboratory building (J-16) and the drainage ditches leading away from uranium production areas through which processing wastes were discharged.
- <u>OU 3: AOC 4, the Historical Lagoon and AOC 6, the East Area.</u> These AOCs were primarily disposal areas for building rubble, discarded equipment, and process wastes. After MED activities began, the East Area was also used by DuPont for the production of

fluorinated solvents and fluorinated lubricants. MED uranium processing did not take place in the East Area.

Figure 2-2 shows the location of each FUSRAP OU/AOC with respect to DuPont's active manufacturing areas.

2.2 Previous Investigations

After MED operations ceased, a number of cleanup activities occurred at the Site consistent with regulatory standards and guidelines in effect at the time. Later, additional radiation surveys and investigations were conducted and resulted in Chambers Works being designated for investigation and potential cleanup under FUSRAP. These investigations are briefly summarized below with more detailed information found in the Sitewide RI Report (CABRERA 2011b):

- 1948/1949: AEC conducted radiological surveys and decontamination of building surfaces, based on the existing radiological criteria of the time, and then released the buildings back to DuPont. DuPont demolished Building J-16 in AOC 5, excavated several feet of soil from beneath the building, and constructed Building J-26 over the former Building J-16 footprint (DOE 1996).
- 1977: Oak Ridge National Laboratory (ORNL) conducted a radiation survey of the Chambers Works to determine if contamination existed at the site at levels above the current guidelines. Results showed that exposure rates in the F Parking Corral (AOC 2) were consistent with background radiation levels, while the external gamma radiation levels along the CDD (AOC 3) and the East Area (AOC 6) exceeded background levels. Based on these results, DOE designated Chambers Works as a FUSRAP site (ORNL 1978).
- 1983: Bechtel National, Inc. (BNI) performed a radiation survey of the Chambers Works to define the areas and boundaries of contamination identified in 1977. In the F Parking Corral (AOC 2), near-surface gamma radiation readings were below the average background level, with the exception of one. Based upon 19 boreholes, contamination was indicated in layers to a depth greater than nine feet (ft). Results from the analysis of two soil samples indicated that uranium-238 (U-238) was the major contaminant with concentrations ranging from 0.9 to 4,347 picocuries per gram (pCi/g). Eleven groundwater samples were also collected from the boreholes, with total uranium results ranging from background value of 1.8 to a maximum of 105,105 picocuries per liter (BNI 1985).
- 1988 - Present: Unrelated to the FUSRAP work, DuPont has been conducting Resource Conservation and Recovery Act (RCRA) corrective actions at Chambers Works since 1988 to address contamination from its chemical manufacturing activities. In accordance with the facility's RCRA permit, DuPont has been operating an extensive sitewide groundwater pump and treat system to control off-site groundwater migration of chemical contaminants (unrelated to FUSRAP). The system has been effective in hydraulically

containing contaminants in groundwater within the property boundaries. As part of its RCRA investigation, DuPont has designated the areas of former MED activity as Solid Waste Management Unit (SWMU) 33 but has not performed remediation work in these areas.

3.0 SITE CHARACTERISTICS

3.1 Environmental Setting

Topography: The Chambers Works complex is located within the Lowland Subprovince of the Atlantic Coastal Plain physiographic province. The surrounding topography is gently rolling, with elevations from zero to 85 ft (top of landfill elevation) ***North American Vertical Datum of 1988 (NAVD 88)***. Elevations at the complex are typically approximately 10 ft above NAVD 88.

Drainage: A major drainage feature at the Chambers Works is the CDD. The water flow direction of the CDD is eastward with water depths averaging one to two ft. The CDD exhibits perennial water flow. Historically, the CDD connected MED operational areas with the Historical Lagoon A. Lagoon A was composed of three settling basins – referred to as the A, B, and C Basins. Basins A and C are no longer in use and have been closed in accordance with regulatory requirements by DuPont. The former Basin B area is designated as RCRA SWMU 15. The lower half of Basin B is currently being used for site storm-water collection whereas the remaining portion of Basin B has undergone remediation and received clean closure approval.

Surface Water Features: The Delaware River is tidal and brackish at Deepwater, NJ and is not a potable water source in the area of Chambers Works; however, the river is a major supplier of potable water to communities upstream or north of Chambers Works. At the Reedy Point Delaware tide gage (station ID 8551910) located across the Delaware from Chambers Works, the yearly mean tide range is 5.34 ft and the mean tide level is -0.12 ft NAVD 88. Mean high tide is 2.87 ft NAVD 88 while mean low tide is -2.97 ft NAVD 88.

Land Uses: The Chambers Works is currently zoned for industrial use and expected to remain industrial into the future. The land use directly adjacent to Chambers Works is a mix of recreational (forested/wetlands areas) and light industrial; although 43% of Salem County is used for agricultural purposes.

Regional and Local Geology: Native site soils are of alluvial and palustrine (marsh) origin, but have been substantially modified by landfilling and construction activities. The land along the shoreline has most likely been accreted as point-bar deposits from the Delaware River, or possibly, from over-bank deposition during periodic flooding, which has resulted in the formation of a natural levee. Behind these shoreline deposits, which consist of sands and silty sands, there once existed a tidal marsh consisting of silty clays, with an elevation near sea level. DuPont has gradually expanded Chambers Works by filling in the marsh and low lying areas. Generally, up to a distance of 200 yards from the river's edge, the soils at sea-level are the naturally occurring marsh deposits, while the soils above sea level are fill material (DERS 1995).

Regional and Local Hydrogeology: The sedimentary deposits beneath Chambers Works can be divided into five major sequences consisting of ***aquifers*** and ***aquitards*** (nomenclature used by DuPont, and for clarity, adopted for use in the RI):

(1) The A and B aquifers and A-B and B-C aquitards: The A aquifer is the uppermost water-bearing zone at the Chambers Works. The B aquifer consists of sands that are interpreted to be Delaware River alluvium. The B aquifer is not widely developed as a groundwater source in Salem County, although yields of up to 1,500 gallons per minute have been reported. The A-B aquitard is discontinuous and thins to zero to the east, as well as in areas where stream channels were once present.
(2) The C aquifer: composed mainly of Pleistocene-age coarse-grained sands and gravels;
(3) The C-D aquitard: composed of clays and silts of estuarine origin.
(4) The D aquifer: consisting of coarse-grained sands and gravels. Unit is valley-fill sediment that is incised in the underlying Potomac Group
(5) The D-E aquitard and the E and F aquifers: Cretaceous-Age sediments of the Potomac Group, representing the lowest sedimentary sequence.

Although the surficial aquifers beneath Chambers Works are not used for drinking water, they are designated by the NJDEP as Class II groundwater. The State of New Jersey divides groundwater into classes based on groundwater use and sets corresponding water quality standards based on its designated use. Class II groundwater is designated as having a potential use as a drinking water source in the future. When groundwater quality in an area does not meet the standard, but is being monitored or treated, the State can issue an exception to the classification. An exception provides notice that there is groundwater contamination in a localized area, and suspends all designated groundwater use in the area for the specified duration of the exception.

The shallow, near surface aquifers are not used for drinking water purposes. In this area, the deeper Potomac Group (F Aquifer) is widely used as drinking water source in southern New Jersey and Delaware.

3.2 Nature and Extent of Contamination

The RI and BRA identified site features, assessed the nature and extent of constituents of potential concern (COPCs), and evaluated risks to human health and the environment from constituents associated with uranium processing activities conducted at Chambers Works. USACE evaluated radioactive and chemical compounds associated with the MED activities and determined that five ***radionuclides*** were eligible for FUSRAP investigation and remediation. They are uranium-234 (U-234), uranium-235 (U-235), U-238, thorium-230 (Th-230), and radium-226 (Ra-226). No chemical compounds were identified as FUSRAP-eligible contaminants. Further detail on the identification of eligible contaminants is included in the *Memorandum: USACE Determination of Eligible Contaminants for FUSRAP Investigation* (CABRERA 2011a). Investigation results for the FUSRAP OUs and AOCs are detailed in the *Final Sitewide RI report* (CABRERA 2011b). As previously mentioned the Sitewide RI and BRA concluded that onsite soils and groundwater have been impacted by FUSRAP-eligible contaminants and required further evaluation in the FS for possible remedial actions at two areas, OU 1 and AOC 6. The nature and extent of the MED-related contamination in soils and groundwater in these areas are summarized in the following subsections.

3.2.1 Soils

The soil sampling results for OU 1, OU 2, and OU 3 were compared against an investigative screening value (ISV) of 14 pCi/g for total uranium in order to define the nature and extent of MED-related soil contamination. Cross section views of OU 1 and AOC 6 are shown in Figures 3-1 through 3-3.

Within OU 1, uranium contamination was detected at depths up to 5.5 ft below ground surface (bgs) in AOC 1 and to a depth of 11 ft bgs in AOC 2. Maximum uranium concentrations in AOC 1 and AOC 2 were reported as 677 pCi/g and 16,584 pCi/g, respectively. The soil contamination above the ISV has been estimated to encompass approximately one acre within AOC 1 and 1.7 acres within AOC 2. Figures 3-1 and 3-2 show the vertical cross section view of MED uranium contamination across AOC 1 and AOC 2, respectively. The reader is also referred back to the Sitewide RI report, Section 4 for more detailed sampling results in OU 1 (AOC 1 and AOC 2).

Within OU 1, elevated Ra-226 and Th-230 concentrations were identified at locations within or in close proximity to uranium source areas. At AOC 1, Ra-226 and Th-230 results in soil range from 0.4 to 2.3 pCi/g, and 0.4 pCi/g to 64 pCi/g, respectively. At AOC 2, Ra-226 and Th-230 results in soil range from 0.37 to 2.87 pCi/g, and 0.19 pCi/g to 15 pCi/g, respectively.

Soils in AOC 6 were contaminated above the ISV at depths less than four ft bgs. The highest concentration of total uranium was 3,910 pCi/g at one ft bgs. The total area of soils impacted above the ISV is approximately 4,800 square ft (0.1 acres). Figure 3-3 shows a vertical cross section view of MED uranium contamination across AOC 6. The reader is also referred to the Sitewide RI report, Section 6 for more detailed sampling results in OU 3 (AOC 4 and AOC 6).

3.2.2 Groundwater

The extent of groundwater contamination was determined by comparison of total uranium concentrations to the U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) of 30 micrograms per liter (µg/L). The reader is referred to the Sitewide RI report for more detailed groundwater sampling results. Uranium was detected above the MCL in both the A and B Aquifers within OU 1. For the A Aquifer, the maximum concentrations for total uranium in AOC 1 and AOC 2 are 26,317 µg/L and 14,027 µg/L, respectively. The horizontal extent of uranium impact to groundwater in the OU 1 A Aquifer is approximately 0.5 acres as presented in Figure 3-4. Groundwater flow in the A Aquifer is controlled and captured by the drainage ditches. The area of impacted groundwater is located within the area of uranium-impacted soils.

In the B Aquifer in OU 1, uranium concentrations above the 30 µg/L MCL were found in two wells, and concentrations averaged 29,560 (2-MW-03B) and 167 µg/L (2-MW-05B). There is no evidence that uranium has been mobilized and transported any significant lateral distance within the B Aquifer. Vertical control is provided by the C aquifer well in this area, which has consistently shown uranium levels below the MCL. Within the B Aquifer uranium-impacted groundwater is limited to approximately 0.2 acres as presented in Figure 3-5 and is located beneath the footprint of the former Building 708.

Investigations of OU 1 groundwater have identified the presence of benzene, toluene, ethylbenzene, and xylene (BTEX) constituents in excess of their representative MCLs, as well as the presence of a ***light non-aqueous phase liquid (LNAPL)***. These organic compounds are typically associated with petroleum products, coal tar, and other chemical derivatives. The LNAPL appears to be coal tar or coal tar distillate with a mixture of other compounds. Sampling for radioactivity in the LNAPL has shown uranium concentrations are at background levels. Neither the coal tar components nor BTEX are FUSRAP eligible contaminants. These chemical constituents were not used in MED processes but are instead associated with the facility's non-FUSRAP chemical manufacturing operations (CABRERA 2011a).

The A Aquifer is not present in AOC 6, so the B Aquifer is nearest to ground surface. One B aquifer well in this area (located down gradient of contaminated soils) exhibited total uranium concentrations exceeding the 30 µg/L MCL, with an average uranium concentration of 267 µg/L (6-MW-01B). Sampling methods have determined that the uranium is in the aqueous phase and has not sorbed or attached to mobile particles. The extent of contaminated groundwater in AOC 6 is shown in Figure 3-6. The ***isopleth***, a line through all points having the same numerical value, is not centered on the impacted well but is implied to include the area of uranium contamination in soil located under East Road.

Uranium concentrations exceeded the MCL in one well in AOC 4, Area of Interest (AOI) 1 (Historical Lagoon Area), with an average of 145 µg/L total uranium (well number I17-M01A) over four quarters of monitoring. This well is located within DuPont's closed waste cell, SWMU 5 and is approximately 280 ft from the Delaware River. In this area, the groundwater flow direction in the A Aquifer is toward the river. However, the RI monitoring results have consistently shown that the uranium is not migrating toward the river. A slurry wall installed by DuPont is located between this well and the downgradient wells near the river. Although no soil remedial action is warranted in AOC 4, it is recommended that Well I17-M01A and associated downgradient wells be included in a future monitoring program in order to confirm these conclusions and to monitor uranium concentrations in groundwater in both the A and B Aquifers in AOC 4. Figure 3-7 shows the location of this well in AOC 4, the slurry wall, and the other monitoring wells in this area. No other monitoring wells in AOC 4 exhibited groundwater contamination above 30 µg/L total uranium.

3.3 Contaminant Fate and Transport

This section provides a qualitative discussion of the chemical and physical properties of uranium and the fate and transport mechanisms affecting its movement in the environment. Mobility is an important consideration because non-mobile compounds tend to stay in the same location instead of spreading and, by virtue of staying in the same location, are easier to clean up. The solubility of a compound is an important transport parameter in groundwater because it determines the concentration of the dissolved phase. The oxidation reduction ***(redox)*** potential of the groundwater is the primary controlling factor in determining uranium solubility and mobility. Soluble uranium compounds are less likely to attach to soil or sediment particles, and therefore, will be more mobile in groundwater.

Uranium occurs in six oxidation states ranging from U(1+) to hexavalent uranium (U(6+)), with tetravalent uranium [U(4+)] and U(6+) being the most common oxidation states of uranium in nature. The U(4+) species typically dominates in ***reducing environments*** while the U(6+) form is prevalent in ***oxidizing environments*** (USEPA, 1999). The hexavalent form, U(6+), generally is more soluble than the tetravalent form U(4+) and therefore, more mobile in groundwater. Chemicals that are not readily soluble in water tend to attach to soil particles and not move in the environment. Therefore, low-solubility U(4+) compounds, like uraninite are less mobile in the environment.

Groundwater in the OU 1 and AOC 6 source zones is oxidizing due to the presence of the U(6+) mineral metastudtite (uranium peroxide dihydrate), which creates hydrogen peroxide (and hydrogen) by alpha irradiation of water molecules. U(6+) compounds are quite soluble in oxidizing environments. Hydrogen peroxide is not persistent in natural environments. The available dissolved oxygen is consumed a short distance from the metastudtite source. Therefore, due to the presence of less available dissolved oxygen, hexavalent U(6+) ions are reduced to the low-solubility tetravalent U(4+) ions. This transformation has been inferred to take place within a short distance from the source zones because dissolved uranium concentrations decrease by three orders of magnitude within a distance of 100 ft. The predominant uranium compound occurring in the reducing area of the plume is thought to be a U(4+) species such as uraninite with lower solubility.

Due to the presence of organic contamination in the shallow Chambers Works aquifers, the groundwater is characterized by little or no dissolved oxygen. Microbial activity and organic contaminants in the environment can lead to reducing conditions by using up the available dissolved oxygen. Reducing groundwater conditions at Chambers Works help to limit the movement of aqueous uranium. Based upon extensive RI groundwater sampling data in both the A and B aquifers, it has been established that due to reducing conditions in groundwater, the existing dissolved MED uranium is not mobile, either vertically or horizontally. The OU 1 groundwater plume has migrated only a very short distance (less than 100 ft) since the MED activities in the 1940s. During the RI groundwater monitoring program (2002 to 2007), the leading edge of the plume did not migrate. However, there is a potential for radiological contaminants in soil to leach into the groundwater and continue to impact the A and B Aquifers.

4.0 SCOPE AND ROLE OF THE REMEDIAL ACTION

The primary objectives of this proposed remedial action are: (1) to address the OU 1 and AOC 6 soils containing FUSRAP-related constituents in concentrations above site-specific cleanup criteria, and (2) to minimize further impacts to groundwater in the FUSRAP AOCs in order to ensure protection of groundwater for some future use.

Under FUSRAP, the USACE is authorized to investigate and conduct a response action (including remedial action) only for those constituents of concern (COCs) resulting from past MED activities. The COCs are uranium including U-234, U-235, and U-238 as well as Th-230, and Ra-226. Constituents not associated with the uranium refinement processes at Chambers Works may be remediated only if commingled with the above MED-related COCs. If commingled, USACE will remove the non-MED constituents along with FUSRAP eligible contaminants to the extent necessary to accomplish the FUSRAP response action. Therefore, the scope of this proposed response action is limited to the constituents found to be associated with MED activities: U-234, U-235, and U-238 as well as Th-230, and Ra-226. Criteria established in the ROD will be implemented using final status surveys compatible with the Multi-Agency Radiation Site Survey and Investigation Manual and applicable or relevant and appropriate requirements (ARARs) at all areas addressed by this response action.

Current land use at Chambers Works is industrial and expected to remain industrial well into the reasonably foreseeable future. Chambers Works has an extensive and rich manufacturing history and it is expected that the chemical manufacturing operations, although reduced in scale over recent years, will continue at the Deepwater, NJ, location under DuPont ownership. For the purposes of the FUSRAP investigation and remedial action, the USACE considers the most reasonably anticipated future land use for Chambers Works to be industrial. This is based on DuPont's intentions for land use, the non-FUSRAP environmental contamination that is present, surrounding land use, and the community's expectations for the property's continued industrial use. Therefore, based on risk assessment results (Section 5) and determination of site specific RAOs (Section 6), the USACE is planning to clean up the FUSRAP areas to an industrial use cleanup standard.

5.0 SUMMARY OF SITE RISKS

As part of the BRA, both a Human Health Risk Assessment (HHRA) and a Screening Level Ecological Risk Assessment (SLERA) were performed for each exposure unit (EU) to determine the current and future effects, or risks, on human health and the environment from both radiological and non-radiological chemicals if no remedial actions were taken. For evaluation in the BRA, the six FUSRAP AOCs were grouped into five separate EUs based on physical location and receptor exposure patterns within the Chambers Works. The EUs are shown in Figure 5-1:

- EU 1 includes AOC 1 and AOC 2 (OU 1)
- EU 2A is AOC 3 (OU 2)
- EU 2B is AOC 5 (OU 2)
- EU 3A is AOC 4 (OU 3)
- EU 3B is AOC 6 (OU 3)

5.1 Human Health Risk Assessment

Four current and potential future land users were evaluated for potential exposure to radioactive and chemical contaminants. They include the industrial worker, construction worker, maintenance worker, and utility worker. Potential exposure was based on the concentration of contaminants as well as frequency and duration of the workers' (receptors) exposure. A ***reasonable maximum exposure (RME)*** was determined for each land use scenario; the RME is the highest level of human exposure that could reasonably be expected to occur (USEPA 1989). The industrial worker scenario was considered as the current and likely future land use scenario for Chambers Works. Even though industrial land use is the expected and most reasonable current and future land use scenario for the site, the USACE performed a risk assessment for a residential receptor. This evaluation was only used for comparative purposes.

A Conceptual Site Model (CSM) was utilized to determine complete exposure pathways for each receptor scenario, based upon sources of contamination, contaminated media and the pathways of migration as shown in Figure 5-2. Based upon the CSM, only the soil medium was evaluated as a source of contamination. The groundwater ingestion pathway was eliminated from evaluation as no receptors are currently utilizing the groundwater beneath the Site as a potable water source; FUSRAP contamination is not likely in the future to move enough to endanger off-site users; and it is not likely that groundwater will be utilized by future receptors. However, as part of the chemical risk assessment, inhalation of ***volatile organic compounds*** from groundwater was considered as a complete exposure pathway under the worker scenario specifically for the utility and construction workers. Since none of the FUSRAP-related radionuclides are volatile, the groundwater exposure pathway was considered an incomplete pathway for FUSRAP-related contamination. Even though receptors are not using the groundwater as a potable water source, the groundwater ingestion and homegrown garden vegetable ingestion pathways were evaluated for the future residential receptor, using groundwater data collected from the B aquifer.

The State of New Jersey classifies the aquifers beneath Chambers Works as Class IIA groundwater. This classification indicates either a designated use, or potential use, as a potable water source using conventional treatment (New Jersey Administrative Code [NJAC] 7:9C). However, NJDEP has designated Chambers Works as a Classification Exception Area (CEA) where the designated uses (i.e., potable water source) are suspended for the duration of the CEA. This classification is tied to the duration of DuPont's New Jersey Pollution Discharge Elimination System discharge to groundwater permit and is re-evaluated every five years at the time of permit renewal. While the A Aquifer is a water bearing zone, it is composed of fill and building rubble/materials and does not support sustained pumping rates of more than two to three gallons per minute in any of the AOCs. Therefore, USACE does not consider the A Aquifer as a viable water producing zone.

Four types of screening were performed to identify COPCs, including: data reduction, weight of evidence screen, background screen, and risk-based screening. Human health screening values from USEPA Region VI guidance document were used to screen chemicals for inclusion in the HHRA. There were no screening levels available for radionuclides in soil; therefore, no radionuclides were screened out of the HHRA as a result of risk-based screening criteria.

USACE used the residual radioactivity computer code (RESRAD) Version 6.3 to perform the human health dose and risk assessment for COPCs. USEPA's standard Risk Assessment Guidance for Superfund (RAGS) equations were utilized by USACE to perform radiological dose and risk assessment for exposure pathways involving existing groundwater, surface water or sediment (USEPA 1989). USACE combined the results of intake calculations with chemical toxicity information for each COPC in order to characterize the carcinogenic and noncarcinogenic risks for each land use scenario. With the exception of uranium, the toxicity criteria for radionuclides were limited to carcinogenic risk; uranium is evaluated as both a carcinogen and noncarcinogen.

Dose and risks were calculated over a period of 1000 years for each receptor at each EU. Based on New Jersey's *Soil Remediation Standards for Radioactive Materials* (NJAC 7:28-12), a dose limit criterion of 15 millirem per year (mrem/yr) was identified by USACE as the acceptable dose criterion for the Site. The results of the highest radiological dose assessments over a period of 1000 years were compared based on the 15 mrem/yr dose criterion. Any resulting highest dose less than 15 mrem/yr was considered acceptable by USACE, while any highest dose greater than 15 mrem/yr was considered unacceptable. The results of the highest radiological risk assessment over a period of 1,000 years were compared to the risk range specified in the NCP of 10^{-6} to 10^{-4} (one in one million to one in ten thousand) (USEPA 1990). Radiological risks are considered acceptable if less than 10^{-6}, while the risks greater than 10^{-4} are considered unacceptable risks. Risks that fall between 10^{-6} and 10^{-4} are generally referred to as within the "acceptable risk range."

For chemical carcinogens, the incremental lifetime cancer risks (ILCRs) were calculated. Total site risk refers to the risks associated with all radiological and non-radiological COPCs; however, risks from these two classes of COPCs were not summed. The resulting ILCRs indicate a probability of developing cancer and are compared to the risk range specified in the NCP of 10^{-6} to 10^{-4} (USEPA 1990). ILCRs are considered acceptable if less than 10^{-6}, while ILCRs greater than 10^{-4} are considered unacceptable risks. Risks that fall between 10^{-6} and 10^{-4} are generally referred to as within the "acceptable risk range."

For non-carcinogen chemicals, a hazard index (HI) was calculated for each receptor in each EU. If an HI exceeds one (1), there is some possibility, although not a certainty, that noncancer adverse health effects could occur. Where the total HI is less than or equal to unity (i.e., 1.0 or 1.0E+00), it is believed that there is no appreciable risk that noncancer adverse health effects will occur (USEPA 1989). An HI less than one is considered acceptable.

Table 5-1 presents the results of the highest radiological dose and risk assessments over a period of 1000 years for each receptor scenario at each EU. Highlighted values indicate that the results of the highest dose and risk assessments exceed the acceptable dose and risk criteria.

Table 5-1: Results of Radiological Dose and Risk Assessment

Receptor Scenarios	Category	EU 1 (OU 1)	EU 2A (OU 2-AOC 3)	EU 2B (OU 2-AOC 5)	EU 3A (OU 3-AOC 4)	EU 3B (OU 3-AOC 6)
Industrial Worker	Dose (mrem/yr)	6.2	1	0.7	0.02	**18.5**[a]
	Risk	1E-04	3E-05	3E-06	3E-06	**4E-04**
Construction Worker	Dose (mrem/yr)	**69.3**	1.8	1.7	7.6	**27.1**
	Risk	4E-05	5E-06	3E-06	8E-06	1E-05
Utility Worker	Dose (mrem/yr)	**25**	0.6	0.6	3	10
	Risk	1E-05	2E-06	9E-07	3E-06	5E-06
Maintenance Worker	Dose (mrem/yr)	2.5	0.1	0.1	0.15	1.1
	Risk	4E-05	7E-06	6E-07	1E-05	2E-05
Residential Receptor [b]	Dose (mrem/yr)	**1547**	2.6	2.4	**16.2**	**75.7**
	Risk	**1E-02**	**2E-04**	2E-05	**5E-04**	**1E-03**

a Bolded values exceed the acceptable dose and risk criteria for soil in each EU or AOC.
b The residential receptor was evaluated only for comparison purposes using groundwater as a drinking water source; however, this scenario is highly unlikely because of projected future land use and groundwater conditions in the area of Chambers Works.

The results of the radiological risk assessments for both current and future land use scenarios showed that the highest risk to industrial workers at EU 3B exceeded the CERCLA acceptable target risk range (>1E-4), and for EU 1, the highest risk was at the upper end of the acceptable risk range (1E-4). Results of the radiological dose assessments showed that the highest doses for construction workers and utility workers at EU 1, and the highest doses for industrial workers and construction workers at EU 3B exceeded the dose limit of 15 mrem/yr. Therefore, in concert with the elevated risks (>1E-4) and doses (>15 mrem/yr) for the industrial, construction and the utility workers, continuation of the CERCLA response process is warranted for EUs 1 (OU 1) and 3B (AOC 6). The results of radiological risk and dose assessments also showed that the five radionuclides contribute to the majority of the risks and doses to various receptors present (CABRERA 2011c). The radionuclides U-234, U-235, U-238, Th-230, and Ra-226 have been identified as the COCs.

The highest doses and risks did not exceed their corresponding acceptable criteria for EU 2A, EU 2B and EU 3A, therefore, no further action will be required for those EUs. While risks were exceeded for the residential receptors for all EUs except EU 2B, this receptor scenario was evaluated only for comparative purposes.

Table 5-2 presents the results of chemical risk assessments for each receptor scenario at each EU. The results of risk assessments were highlighted when they exceeded their corresponding risk criteria.

Table 5-2: Results of Chemical Risk Assessment

Receptor Scenarios	Risk Type	EU 1	EU 2A	EU 3A	EU 3B
Industrial Worker	ILCR	2E-05	2E-05	2E-05	**3E-04** [a]
	HI	0.5	0.1	0.03	0.1
Construction Worker	ILCR	2E-05	3E-06	1E-05	**1E-03**
	HI	**4.9**	0.7	**3.1**	**5.7**
Utility Worker	ILCR	7E-06	1E-06	5E-06	**1E-03**
	HI	**1.8**	0.3	**1.1**	**2**
Maintenance Worker	ILCR	1E-05	2E-06	1E-05	2E-05
	HI	0.1	0.02	0.1	0.2
Residential Receptor [b]	ILCR	**5E-03**	**1E-02**	**2E-02**	**4E-02**
	HI	**175**	**166**	**1096**	**90**

a Bolded values exceed the acceptable dose and risk criteria for soil in each EU or AOC. Five chemicals were identified as major risk contributors; these chemical compounds are not associated with the MED operations and therefore, are not within the scope of the FUSRAP response action.

b The residential receptor was evaluated only for comparison purposes using groundwater as a drinking water source; however, this scenario is highly unlikely because of projected future land use and groundwater conditions in the area of Chambers Works.

The risk assessment results for chemicals showed that except for EU 3B, the carcinogenic risks are comparable with respect to radiological contaminants. For EU 3B, the carcinogenic risks are either equal to or higher than the associated risk from radiological contaminants. For non-cancer hazards, the HI exceeded one for both the construction worker and utility worker at EU 1, EU 3A, and 3B. The chemical risk assessment identified five chemicals as major risk contributors for the site: two metals (antimony and nickel), three semi-volatile organic compounds (benzo(a)pyrene, benzo(a)anthracene, and azobenzene) and one polychlorinated biphenyl congener (Aroclor 1254). These constituents are not related to and a result of MED activities and therefore, are not within the scope of the FUSRAP remediation. However, where commingled with FUSRAP radioactive soil contamination that needs to be removed, the chemical constituents will be addressed and cleaned up to the extent appropriate as part of the FUSRAP remedial action.

5.2 Ecological Risk

A SLERA was conducted by USACE to determine the potential for adverse ecological impacts resulting from exposure to radionuclides and chemicals released into the environment through past site operations related to the DuPont Site. Prior to performing SLERA, a preliminary qualitative risk evaluation was performed for each EU using an Ecological Exclusion Worksheet and Ecological Assessment Checklist, developed by USEPA's Region VI to determine whether or not further ecological evaluation is necessary for an affected property. The assessment results showed that due to the absence of ecological habitat, a SLERA was not required for EU 1, EU 2B, and EU 3B. Therefore, the scope of the SLERA included only EU 2A and EU 3A.

Risk characterization for radionuclides was performed for both terrestrial and aquatic ecological receptors. The results showed that the absorbed doses to both terrestrial and aquatic ecological receptors at both EUs are less than their corresponding dose limits. Therefore, radionuclide constituents of potential ecological concern (COPECs) are not a concern for the DuPont Chamber Works FUSRAP site.

For non-radiological contaminants, the results of risk characterization showed that few media-specific COPECs resulted in low ecological risk to terrestrial and aquatic receptors. However, the Site currently has and is expected in the future to continue to have physical features that would severely reduce potential exposure to soil. As a result, no ecological habitats and associated receptors are known to be associated with the current and future land use for the site. Since the soil exposure pathway, and ecological habitats and associated receptors are not present, no additional ecological evaluation is necessary for the site.

6.0 REMEDIAL ACTION OBJECTIVES

RAOs specify the requirements that the remedial alternatives must fulfill in order to protect human health and the environment and comply with ARARs. Essentially, they provide the basis for identifying and evaluating remedial alternatives. The RAOs for the Chambers Works FUSRAP Site are established, in general, to eliminate or minimize the potential human exposure to soils and groundwater contaminated with FUSRAP-related COCs at levels that exceed the standards established in ARARs and the site-specific RGs. A completed remedial action will result in post remediation site conditions that allow for the long-term protection of human health and the environment. The RAOs and COCs for the Chambers Works FUSRAP Site are presented in Sections 6.1 and 6.2. The selection of site-specific ARARs and RGs are discussed in Sections 6.3 and 6.4, respectively. In Section 6.5, the extent of contaminated soil above the RG is presented.

6.1 Media-Specific RAOs

USACE selected media-specific RAOs based on the nature and extent of contaminants, the potential for human and environmental exposure, and the most reasonably anticipated future land use assumptions. RAOs provide goals for protecting human health and the environment from media-specific constituents. The RAO for soil contamination in OU 1 and AOC 6 is to:

- Eliminate or minimize potential human exposure to soils contaminated with FUSRAP-related COCs at levels that exceed the standards established in ARARs or the site-specific RGs (whichever is more stringent).

Even though groundwater was identified as an incomplete exposure pathway in the BRA for radiological COPCs, radiological constituents have been detected in the groundwater through RI sampling at concentrations exceeding the New Jersey ambient groundwater quality standards in OU 1 and AOC 6. Due to leaching, the radiological constituents in soil have impacted the groundwater within the areas of the MED soil contamination. However, based on groundwater monitoring results, the uranium in groundwater has not migrated from the source areas due to the unique geochemical conditions at Chambers Works. Reducing groundwater conditions in the FUSRAP areas have limited the movement of radioactive constituents in the groundwater. If future groundwater conditions change from reducing to oxidizing, there could be the possibility that aqueous uranium may become mobile, leading to potential aqueous uranium migration beyond the boundaries of these areas. Therefore, USACE developed the following RAOs for the groundwater in the FUSRAP areas despite the fact that there is no exposure and no risk to the RME receptors:

- Eliminate or minimize any further impact to groundwater (by minimizing the source of groundwater contamination) and
- Eliminate or minimize potential human exposure to groundwater contaminated with FUSRAP-related COCs at levels that exceed the standards needed to be attained to meet ARARs or the site-specific RGs.

USACE did not develop RAOs for ecological receptors since the SLERA results indicated a low ecological risk to terrestrial and aquatic receptors from exposure to media-specific COPECs.

6.2 Constituents of Concern

As mentioned, the USACE identified the final list of COCs in the FS based on risk assessment results. The following COCs were found to be associated with MED operations at the site and exceeded the dose-based criteria (ARAR-based standards): U-234, U-235, U-238, Ra-226, and Th-230. The COCs will be the focus of any remedial action evaluated for the FUSRAP areas.

6.3 Applicable or Relevant and Appropriate Requirements

Response actions developed under CERCLA must comply with ARARs. Federal law (the NCP) defines “applicable requirements” and “relevant and appropriate requirements” as follows: Applicable requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. USEPA's guidance, *CERCLA Compliance with Other Laws Manual* (USEPA 1988) classified ARARs into three categories: chemical-specific requirements, location-specific requirements, and action-specific requirements.

The chemical-specific ARARs found in the New Jersey Remediation Standards for Radioactive Materials (NJAC 7:28-12) were identified for the DuPont Chambers Works FUSRAP Site. The State of New Jersey promulgated NJAC 7:28-12, *Remediation Standards for Radioactive Materials* in August 2000. This regulation establishes minimum standards for the remediation of real property (including soil, groundwater, surface water and sediment) contaminated by radioactive materials at sites located within the State of New Jersey. For the Chambers Works soil remediation, the requirements found in NJAC 7:28-12.8(a)(1) and NJAC 7:28-12.11(e) have been identified as ARARs for OU 1 (EU 1) and AOC 6 (EU3B). NJAC 7:28-12.8(a)(1) requires that a maximum dose of 15 mrem/yr above background be met for an ***unrestricted use remedial action***, a ***limited restricted use remedial action***, or a ***restricted use remedial action*** (see glossary for definitions). Additionally, NJAC 7:28-12.11(e) is an ARAR when an alternate remediation standard is developed and requires the use of institutional or engineered controls. This requirement states that a resulting dose must not exceed 100 mrem/yr should all institutional or engineered controls fail at some time in future. We refer to this as the "All Controls Fail" provision (ACF).

6.4 Development of Remediation Goals (RGs)

By meeting the State of New Jersey's 15 mrem/yr dose criterion, protectiveness would be achieved for the Site. The 15 mrem/yr dose criterion was used to derive site-specific risk-based RGs for COCs. The COCs include U-234, U-235, U-238, Th-230, and Ra-226. Various receptor scenarios were evaluated in the BRA based on the current and most reasonable future land use assumptions for the property (industrial use). The RG for total uranium was calculated to be 65 pCi/g based on the most conservative (i.e., most protective) land use scenario, the construction worker (CABRERA 2012 *Appendix A*). The 65 pCi/g RG for total uranium includes contributions and considerations of the other two COCs (Th-230 and Ra-226). Therefore, there is no need for separate RGs for Ra-226 and Th-230. Meeting the total uranium RG will reduce risk and exposure and meet the dose limit for all COCs. This means that the soils in OU 1 and

AOC 6 that exceed a concentration of 65 pCi/g total uranium will be addressed during the remedial action. This RG will comply with all ARARs and will achieve RAOs identified for the soil at the site. The RG of 65 pCi/g total uranium was used to develop soil volume estimates and will form the basis for confirmatory sampling during the final status survey.

Additionally, USACE performed dose assessments to demonstrate compliance with NJAC 7:28-12.11(e), the ACF provision. The ACF requirement states: "Regardless of the factors used by the petitioner or licensee, the department shall not approve alternative standard petitions that include institutional and engineering controls where failure of those controls, not including the failure of a radon remediation system, would result in more than 100 mrem total annual effective dose equivalent."

The USACE performed the dose assessments to evaluate the hypothetical residential receptor using the RG (65 pCi/g), an estimated post remediation vertical extent of contamination of four feet, and the residential exposure pathways (including the drinking water and crop ingestion pathways). The results show that the resulting peak total dose to the hypothetical residential receptor occurred within the 1000-year calculation period and was estimated to be significantly less than 100 mrem/yr (13 mrem/yr). The results demonstrate that the site-specific RG of 65 pCi/g for total uranium complies with the 100 mrem/yr dose criterion. Therefore, it is expected that the final status survey will demonstrate compliance with the “all controls fail scenario” by targeting the RG of 65 pCi/g total uranium during remediation.

Groundwater is an incomplete exposure pathway for the four receptor scenarios evaluated in the BRA; therefore, the USACE did not identify any risk-based RGs for groundwater. The RAOs for groundwater were developed to protect the groundwater for some future use and are based on the ACF requirement found in NJAC 7:28-12.11(e). RAOs are to 1) eliminate any further impact to groundwater and 2) eliminate potential human exposure to groundwater containing FUSRAP-related COCs at levels that exceed the standards needed to be attained to meet ARARs or the site-specific RGs.

6.5 Area and Volume of Contaminated Media

Figures 6-1, 6-2, and 6-3 show the area of contaminated soil above the RG (65 pCi/g total uranium) at AOC 1, AOC 2, and AOC 6, respectively. The area of contaminated soil in the figures represents *in situ* soil volumes. The total *in-situ* soil volume for the three FUSRAP areas is estimated at approximately 11,600 cubic yards (yd^3).

7.0 SUMMARY OF REMEDIAL ALTERNATIVES

Table 7-1 presents the remedial alternatives evaluated in the FS and summarized in this Proposed Plan for addressing soil and groundwater contamination at the DuPont Chambers Works FUSRAP Site. Detailed evaluations are presented in Section 5.0 of the FS (CABRERA 2012). The alternatives as originally presented in the FS were designated with an AOC extension (e.g., Alternative S1-1 or S1-6) to describe the specific remedial action components for each area, OU 1 or AOC 6. In this Proposed Plan, for simplicity, the remedial action alternatives are designated without an AOC extension (e.g., S1, S2, and S3). Therefore, descriptions of each soil and groundwater alternative will include the same components for the two areas (OU 1 and AOC 6). Based upon the evaluation in this Proposed Plan, the USACE will recommend the Preferred Remedial Action Alternative, consisting of the most effective combination of a soil and groundwater remedial alternative.

Table 7-1: Summary of Remedial Action Alternatives

Medium	Alternative Designation	Description
Soil	S1	No Action
	S2	Excavation Followed by Off-Site Disposal
	S3	Excavation, Treatment, and Off-Site Disposal
Groundwater	GW1	No Action
	GW2	*Ex Situ* Groundwater Treatment
	GW3	Monitored Natural Attenuation (MNA)

7.1 Alternatives S1 and GW1: No Action

The “No Action” alternative is developed to provide a baseline for comparison with other alternatives, as required under CERCLA. A “No Action” alternative is presented for both soil and groundwater although it provides no additional protection of human health and the environment. This alternative would not achieve the RAOs for soil or groundwater.

7.2 Soil Alternatives

In addition to the “No Action” alternative, two alternatives are presented to address soil contamination. The alternatives use removal (excavation) technologies and rely on off-site disposal of contaminated soil. One alternative, S3, combines a soil treatment or waste minimization step with the excavation of soil prior to off-site disposal. Both soil alternatives include the following common technologies and processes for implementation:

- *Excavation*: Alternatives S2 and S3 involve excavation of soil and debris. The excavations will be performed to achieve the soil RGs. To verify removal of radiological contaminants, confirmatory sampling will be conducted following excavation as part of the final status survey. Figures 7-1 and 7-2 show the areas requiring excavation based on the soil RG in OU 1 and AOC 6, respectively. Figure 7-3 shows the location of the soil excavation and processing area for both alternatives. The flow diagram in the figure depicts the soil treatment process, a component of Alternative S3, intended to reduce the amount of soil requiring off-site disposal.
- *Land Use Controls*: LUCs will be implemented to restrict access and protect workers during the remedial action activities. LUCs will:
  - Utilize DuPont’s existing site access restrictions and controls; and
  - Remain in place for the duration they are needed.
- *Transportation and Waste Management*: Local transportation of contaminated materials [e.g., from excavation sites to onsite rail spurs] would use sealed or covered trucks. Movement within areas of excavation would be performed using open trucks and conventional construction equipment. Long distance shipment would be primarily by rail from the rail spurs to off-site permitted disposal facilities. Rubble and similar materials would be crushed as appropriate for disposal. It is assumed that excavated soil could be used as backfill if it meets the soil RG.
- *Monitoring*: Short-term monitoring would be continued during the remedial actions to ensure that contamination from the soils does not significantly impact air, groundwater, surface water and sediment. The results of the short-term monitoring of surface water, sediment and groundwater would be used to assess any potential impacts to the CDD resulting from the remedial actions, and would assist in evaluating the effectiveness of the remedial actions.
- *Remedial Action Control Measures*: Water encountered during remedial actions will be characterized, treated in an onsite treatment system (if necessary), and discharged to the DuPont sewer system, as permitted. Collection and treatment of storm water will be coordinated with the management of groundwater in excavations for those actions that involve excavation below the water table. Mitigation actions may include re-vegetation, dust mitigation, covers, sedimentation basins, and dewatering. After excavation, backfill would be added, and the site would be graded to ensure appropriate surface water drainage. Erosion and sediment controls would be used and described in a Sedimentation Control Plan.

7.2.1 Alternative S2: Excavation Followed by Off-Site Disposal

Alternative S2 consists of excavation of soils containing radionuclides above the RG and subsequent off-site disposal at a permitted facility. The removal of impacted soils would substantially reduce potential risks to human health and the environment. In addition, this alternative would remove the source of groundwater contamination (see Section 7.4, Uranium Mass Balance).

Under Alternative S2, impacted soils would be excavated and immediately loaded into dump trucks and transferred to the loading and staging area present at the Site. Soil piles within the loading and staging area will be weighed and transferred into gondola rail cars lined with "***burrito bags***" for containment during shipping. The railcars would transport the contaminated materials to the disposal facility or permitted transload facility where they would be offloaded and materials placed in the appropriate waste cell.

The total disposal volume (i.e., bulk soil volume with a 15% contingency applied) is estimated to be 17,700 yd^3 (combined) from OU 1 (AOC 1 and 2), and 6,200 yd^3 from AOC 6. The bulk soil volume includes FUSRAP-related waste soil plus the cut-back soil removed during excavation. Additionally, USACE estimates that approximately 900 yd^3 of soil from OU 1 will contain organic constituents (coal tar) that is located at the base of the excavation. This non-FUSRAP chemical waste material would require appropriate handling and health and safety measures during excavation. Standard construction equipment such as excavators, bulldozers, front-end loaders, and scrapers would be used to remove and manage any contaminated material.

Soils that have been excavated from below the water table will require a dewatering step using a well point dewatering system. The groundwater and accumulated rainwater from the excavation area would be collected in aboveground storage tanks. Both groundwater and surface water would be treated onsite and sampled prior to discharge to DuPont's permitted wastewater treatment facility.

Areas of the site where soil has been excavated will be backfilled with clean soil (off-site borrow source) and returned to present condition (paved or gravel-covered). The clean fill material would be tested prior to placement to ensure it meets criteria as established in the design.

7.2.2 Alternative S3: Excavation, Treatment and Off-Site Disposal

Alternative S3 consists of excavation of impacted soils above RGs followed by a soil treatment process which sorts the soil into two piles depending on soil concentration levels (above or below the cleanup goal or RG). Soils not meeting the cleanup goals would be shipped off-site to a permitted disposal facility. The purpose of the treatment process is to reduce the volume of excavated soils that require off-site disposal. Soil excavation, handling and transport control measures would be similar to those presented under Alternative S2. Following excavation, the impacted soil would be transported to a soil processing/treatment area. The soils would be kept moist or covered with tarps to minimize dust generation.

The treatment technology identified for Alternative S3 is a ***segmented gate system (SGS)***, which would be utilized for soil sorting. Although there are other waste minimization technologies available, the SGS was considered as a representative soil sorting system for evaluation and cost estimating purposes. Figure 7-4 presents the schematic of the soil sorting equipment and process. The purpose of the soil sorting process is to concentrate the radiological contaminants in a smaller volume of the excavated soil. In the first treatment step, excavated soils are put through a coarse separation-sizing screen to remove any debris or large objects. During processing, the soils are placed as a thin layer on a conveyor belt and moved through the SGS equipment. Radiation sensors above the belt identify soils with activity levels above the RG, and then activate “gates” to divert the contaminated soils. Soils that pass under the sensors without indicating contamination proceed to a “reuse” stockpile.

Soils that have been excavated from below the water table will require a dewatering step using well point dewatering system, because the SGS equipment requires loose and “clump-free” soil so that the soil passing under the radiation sensors is in a relatively thin layer. The groundwater and accumulated rainwater from the excavation area would be collected in aboveground storage tanks. Both groundwater and surface water would be treated onsite and sampled prior to discharge to DuPont’s wastewater treatment facility. Implementation of Alternative S3 would be performed sequentially, beginning in OU 1 and concluding in AOC 6, utilizing the same SGS equipment. It is assumed that 30% of the excavated soil would meet the soil RGs and would be available to backfill the excavation or for another beneficial use.

The effectiveness of soil treatment with SGS relies on some assumptions that require verification. In order to determine the effectiveness of the soil treatment process, a treatability study would be performed prior to full scale operation. During the treatability study several assumptions and technical considerations would be confirmed.

After processing, the treatment residuals (soil with radionuclide concentrations above RGs) will be loaded into dump trucks and moved to the soil loading area in OU 1. Soil piles within the loading and staging area will be weighed and transferred into gondola rail cars lined with "burrito bags" for containment during shipping. The railcars would transport the contaminated materials to the disposal facility or permitted transload facility where they would be offloaded and materials placed in the appropriate waste cell. As discussed under Alternative S2, there is the possibility that some excavated soils from OU 1 may contain non-FUSRAP hazardous constituents. Under Alternative S3, the management, treatment and disposal issues related to such material are the same as presented for Alternative S2.

Areas of the site where soil has been excavated will be backfilled with the treated soil that is below the cleanup goal (RG) combined with clean soil (off-site borrow source), then compacted, and re-vegetated. Fill material would be tested prior to placement to ensure it meets criteria as established in the remedial design.

7.3 Groundwater Alternatives

In addition to the "No Action" Alternative, two alternatives are presented to address groundwater contamination. Both groundwater alternatives rely on the assumption that they would be implemented only when combined with one of the soil remedial actions (excavation). Contaminated soil in the FUSRAP areas is the source of the groundwater contamination. It is expected that groundwater concentrations will be significantly reduced as a result of soil removal. The groundwater alternatives include the implementation of an active groundwater treatment (*ex situ*) process or a specific sampling and analysis program to monitor natural attenuation rates after completion of the soil remedial action. Both groundwater alternatives include the following common technologies and processes for implementation:

- *Land Use Controls*: For both groundwater remedial alternatives, DuPont's existing LUCs are expected to protect workers from exposure to groundwater and restrict groundwater use during the implementation of the remedial action. A long-term stewardship plan would be developed which would address requirements for future monitoring and maintenance activities. The plan would also include the process by which DuPont or any future property owner(s) can contact the DOE Office of Legacy Management, who will be responsible for periodic reviews, maintenance, and monitoring. LUCs would be used to restrict access and protect workers during the remedial action activities at areas in which the residual groundwater contamination exceeds the concentrations as specified in groundwater RAOs. The LUCs will:

1) Utilize DuPont's existing site access restrictions, controls, and groundwater use restrictions; and

2) Remain in place for the duration of need.

- *Backfill Augmentation:* During backfilling of the excavation areas, the addition of mulch (or other slow release electron donor material) to the backfill material could be considered in pre-design activities. The incorporation of mulch in the unsaturated zone (above the water table) would help to ensure that reducing conditions are maintained in the groundwater over several years, particularly for the duration of both groundwater alternatives.
- *Short and Long Term Monitoring of Groundwater*: the groundwater alternatives (GW2 and GW3) will include short and long term groundwater monitoring as a component of the remedial action.
- *AOC 4 (AOI 1) Additional Monitoring of Groundwater:* the periodic groundwater sampling of existing FUSRAP monitoring wells in AOC 4 will be a common feature of each groundwater alternative. This monitoring will be performed in conjunction with the short and long-term groundwater sampling in OU 1 and AOC 6. A limited sampling regime is proposed for the specific purpose of monitoring geochemical conditions, groundwater hydraulics, and total uranium concentrations in the area. The purpose of the sampling would be to evaluate the observed trends as documented in the Sitewide RI which showed limited movement of FUSRAP COCs towards the Delaware River. Existing FUSRAP wells in AOC 4 will be used to monitor these conditions.

As previously mentioned, the completion of one of the soil remedial actions, either S2 or S3, is expected to remove the source of groundwater contamination as well as significant portions of the groundwater plume in OU 1 and AOC 6. In AOC 1 (OU 1), the entire groundwater plume is included within the assumed excavation cutlines as shown in Figure 7-5. In AOC 1, 97% of the aqueous uranium in the A Aquifer would be removed by excavation alone. Figures 7-6 and 7-7 show the areas of impacted groundwater in relation to the assumed cutlines for AOC 2 and AOC 6, respectively. In AOC 2 (OU 1) the percent of uranium removal is estimated to be 90% in the A Aquifer and 100% in the B Aquifer. In AOC 6 only the B Aquifer is present and both excavation alternatives (S2 and S3) will result in 81% reduction of the aqueous uranium in groundwater. Since residual groundwater concentrations in AOC 2 and AOC 6 will be significantly reduced, the two groundwater alternatives presented in this Proposed Plan would meet RAOs and reduce contaminant concentrations in groundwater.

7.3.1 Alternative GW2: Ex Situ Groundwater Treatment

Alternative GW2 consists of a groundwater pump and treat system and would be implemented in conjunction with Alternatives S2 or S3 (i.e., soil [source] removal). Alternative GW2 relies on the installation of wells to extract impacted groundwater. After excavation, the extraction wells installed in OU 1 would be screened from approximately 10 to 20 ft, in the backfilled area. During backfilling operations, it is not expected that the aquitard will be reconstructed in OU 1 as it currently exists. However, it is assumed that a uniform, low permeability backfill material would be used. The design team could consider the addition of mulch or similar material to the unsaturated zone to promote reducing groundwater conditions over time. In AOC 6, the well would be screened at approximately the same interval. Once extracted, the contaminated groundwater would be piped to an onsite treatment area, where contaminants would be removed by ***adsorption*** via solid media (ion exchange for dissolved uranium). Because of high concentrations of organics from non-FUSRAP sources in the groundwater, pretreatment of the groundwater may be required to remove these contaminants in order to protect components (the ***resin)*** of the ion exchange treatment process. This pretreatment step would rely on the use of ***granular activated carbon (GAC) canisters***. When exhausted, these GAC canisters will have to be tested for radiological content and shipped off-site for proper disposal or regeneration.

Figure 7-8 presents a schematic of the groundwater treatment system setup and associated flow diagram for the ion exchange process to be used in OU 1. The approximate location of the pumping wells and the treatment system within OU 1 is also shown in the figure. The treated water would be discharged to the DuPont stormwater drainage system for subsequent treatment in the DuPont wastewater treatment plant.

The waste streams generated from the ionic exchange process would be transported to a waste processor for proper disposal since limited quantities are expected to be generated. Disposal for this material is expected to meet the waste acceptance criteria for the Energy Solutions facility in Clive, Utah. The waste brine will be solidified and sent to the same permitted disposal facility as the soil waste stream. If large quantities are generated, the brine will be put through a flocculation/precipitation process to concentrate the uranium for disposal, and the brine would be disposed of appropriately.

Figure 7-9 presents the groundwater treatment system setup, associated flow diagram and approximate location of the pumping well for AOC 6. Although the treatment process shown in Figure 7-9 does not include a pre-treatment step before the ion exchange process, it is possible that a GAC step may be necessary. AOC 6 groundwater differs from OU 1 in that LNAPL is not expected to be present. However, other groundwater conditions, like high levels of dissolved organic carbon, may require that the extracted groundwater be pre-treated via GAC, or other processes, before it reaches the ion exchange vessels. The extent of impacted groundwater is much less in AOC 6 than in OU 1. Excavation of impacted soil in AOC 6 is likely to address impacted groundwater. However, if further groundwater treatment using ion exchange is necessary after source removal then it is anticipated that one pumping well would be located at the present location of 6-MW-01B.

7.3.2 Alternative GW3: Monitored Natural Attenuation (MNA)

Alternative GW3 relies on MNA to address impacted groundwater once impacted soils are removed. Therefore, Alternative GW3 would be implemented in conjunction with either Alternative S2 or Alternative S3. During backfilling of the excavation areas, the design team may consider the addition of mulch or similar organic material to the unsaturated zone to promote and maintain reducing groundwater conditions.

As mentioned earlier, USACE estimates that the excavation of soil will result in a substantial reduction of aqueous uranium in groundwater. As an example, USACE estimates that completion of Alternative S2 will result in 97% removal of the aqueous uranium from both aquifers within AOC 1. For AOC 2 (OU 1), the percentage of uranium removal in the A and B aquifers is estimated to be 90% and 100%, respectively. In AOC 6, the excavation alternatives will result in 81% reduction of the aqueous uranium in Aquifer B. After the removal of uranium source zone, the dissolved uranium concentration is expected to decrease naturally over time. Natural processes work in the environment to attenuate or lessen the contamination in groundwater. At Chambers Works, it is expected that adsorption, dilution, and radioactive decay will be the primary mechanisms to reduce contaminant levels in groundwater over time. Therefore, groundwater monitoring would be conducted under MNA to demonstrate that geochemical conditions within OU1 and AOC 6 are not changing, that the uranium in groundwater is being effectively attenuated, and that the remedy is ensuring protection of human health and the environment.

Under the MNA alternative, monitoring wells would be installed to monitor concentrations of uranium and geochemical conditions in groundwater. Monitoring wells are expected to be located in areas based on observed constituent trends and groundwater flow directions. The exact location for well placement will be determined during pre-design efforts based on available monitoring data. Installation of replacement wells will be required, and where possible, existing wells will be used for sampling and groundwater flow direction. New well construction will be necessary to ensure viability during the potentially long duration associated with MNA as well as the possibility of damage to or removal of wells during the soil remedial action. Currently existing monitoring wells which may be removed during soil remediation include the following OU 1 wells: 1-MW-08A, 1-MW-09B, 2-MW-02A, 2-MW-03B and 2-MW-25 C. In AOC 6 the following wells will be removed during any soil remediation: 6-MW-01B and 6-MW-07B. For cost estimating purposes, a total of 7 newly-installed monitoring wells are estimated; the monitoring well locations will be determined in remedial design plans.

A long-term monitoring program would be developed to include a routine monitoring schedule, a comprehensive list of constituents to be analyzed, reporting requirements, and statistical criteria for data evaluation to determine when RAOs have been achieved. The comprehensive list of constituents will be used to verify a decreasing trend in COC concentrations and the oxidation/reduction status of the groundwater.

A minimum of 10 groundwater sampling rounds will be required to perform a trend analysis and to determine the attenuation rate. If monitoring results demonstrate changes to environmental conditions or the attenuation process is not proceeding effectively, then decisions regarding what actions are necessary will be made based on the data and information gathered during the monitoring program. Confirmatory sampling would be conducted as part of the five-year review process after MNA demonstrates a decreasing trend in contaminant concentrations in groundwater.

7.4 Other Common Elements

The following common elements would be implemented for the soil and groundwater alternatives considered (S2, S3, GW2, and GW3):

- Close coordination of remediation and monitoring activities with DuPont or future land owner(s) and/or tenants to minimize the health and safety risks to onsite personnel and to minimize disruption to their activities consistent with a safe and effective remediation.
- Five year reviews would be conducted in accordance with CERCLA and the NCP. The five year reviews would provide the opportunity for USACE or DOE to evaluate the effectiveness of the remedial action and to confirm that land use assumptions have not changed including site ownership and groundwater use.
- Long-term operation and maintenance (O&M) activities would be conducted for the two groundwater alternatives, GW2 and GW3. The estimated O&M period for GW2 and GW3 is 10 and 30 years, respectively, after source removal has been completed. Time frames for groundwater cleanup via *ex situ* groundwater treatment (GW2) could be extended if significant LNAPL contamination is encountered in OU 1.
- USACE is responsible for surveillance and O&M for a two year period after Site closeout, consistent with the *Memorandum of Understanding Between the U.S. Department of Energy and the U.S. Army Corps of Engineers Regarding Program Administration and Execution of the Formerly Utilized Sites Remedial Action Program, effective March 1999.* USACE would conduct a two year review to document compliance with RAOs prior to transfer to DOE. Following review and pursuant to agreement between USACE and DOE, the Site would be released to DOE to fulfill the long-term surveillance, O&M responsibilities of the Federal Government that are necessary for the selected remedial action(s).

8.0 EVALUATION OF REMEDIAL ALTERNATIVES

The nine criteria established by the USEPA to evaluate remedial alternatives are described in Figure 8-1. The discussion below provides a general comparison of the five alternatives relative to the nine evaluation criteria. The first category is termed the Threshold Criteria. Each alternative must meet these criteria to receive further consideration. The two Threshold Criteria are: (1) Overall Protection of Human Health and the Environment, and (2) Compliance with ARARs.

The next five criteria are the Primary Balancing Criteria, those on which the alternatives analysis is based. The individual Primary Balancing Criteria are: (3) Long-term Effectiveness and Permanence, (4) Reduction of Toxicity, Mobility, and Volume through Treatment, (5) Short-term Effectiveness, (6) Implementability, and (7) Cost.

The final criteria are the Modifying Criteria. These include: (8) State Acceptance and (9) Community Acceptance. Both will be evaluated after the public comment period.

Results of the Threshold and Primary Balancing Criteria evaluation are summarized in Table 8-1 and Table 8-2, for soil and groundwater respectively, and are discussed further in the *Detailed Analysis of Alternatives* presented in the FS (CABRERA 2012).

Table 8-1: Comparative Analysis of Alternatives – Soil

Evaluation Criteria	**Alternative S1 No Action**	**Alternative S2 Excavation and Disposal**	**Alternative S3 Excavation, Treatment and Disposal**
Overall protection of human health and the environment	Alternative does not meet threshold criteria	Yes	Yes
Compliance with ARARs		Yes	Yes
Long-term effectiveness and permanence		High	High
Reduction of toxicity, mobility and volume through treatment		Low	Medium
Short-term effectiveness		High	Medium
Implementability -Administrative - Technical		High High	High Medium
Cost	High	Low	Low

High represents a favorable rating for the specific criteria; whereas Low represents the least favorable rating.

Table 8-2: Comparative Analysis of Alternatives – Groundwater

Evaluation Criteria	**Alternative GW1 No Action**	**Alternative GW2 *Ex Situ* Treatment**	**Alternative GW3 Monitored Natural Attenuation**
Overall protection of human health and the environment	Alternative does not meet threshold criteria	Yes	Yes
Compliance with ARARs		Yes	Yes
Long-term effectiveness and permanence		High	High
Reduction of toxicity, mobility and volume through treatment		High	Medium
Short-term effectiveness		High	Medium
Implementability		High	High
Cost	High	Low	Medium

High represents a favorable rating for the specific criteria; whereas Low represents the least favorable rating.

8.1 Threshold Criteria

The two threshold criteria discussed below must be met for an alternative to be considered viable.

<u>(1) Overall Protection of Human Health and the Environment:</u> *Addresses whether an alternative provides adequate protection and describes how exposure risks are eliminated, reduced, or controlled through treatment or LUCs.*

The "No Action" alternatives (S1, GW1) would not be protective of human health and the environment, as the RAOs would not be achieved. Human exposure to COCs at unacceptable levels could occur in the future if no remedial action is taken.

The soil excavation and off-site disposal alternatives (Alternatives S2 and S3) rank high in overall protection of human health and the environment because materials above the media-specific RG would be excavated and shipped off-site for disposal. Alternative S3 would result in less soil being sent offsite for disposal. Both alternatives will permanently remove the source of contamination to groundwater (the contaminated soil) but will also result in the removal of significant portions of the contaminated groundwater areas.

Alternatives GW2 and GW3, when implemented in conjunction with a soil alternative, are protective of human health and the environment. GW2 is more protective since it involves active remediation and will take less time to achieve RAOs. GW3 will be protective of human health and the environment but a longer time is required for the attenuation processes to reduce COC concentrations. Until the RAO for groundwater is achieved, LUCs and land use restrictions prohibiting groundwater use will be maintained.

<u>(2) Compliance with ARARs:</u> *Addresses whether a remedy will meet all of the ARARs related to hazardous substances released to the environment.*

The "No Action" alternatives do not achieve media-specific cleanup goals established by the ARARs. Alternatives S2 and S3 satisfy ARARs for soils. Alternatives GW2 and GW3 satisfy the RAOs for groundwater when implemented in conjunction with one of the soil remedial alternatives. However, the time frame to meet the groundwater RAO may be as long as 30 years for Alternative GW3.

8.2 Primary Balancing Criteria

The five primary balancing criteria discussed below are used to identify major trade-offs among the alternatives.

(3) Long-Term Effectiveness and Permanence: *Refers to the ability of the alternative to protect human health and the environment over time, once cleanup levels have been met.*

The "No Action" alternatives would not be effective in the long term as there are no long-term management measures to prevent exposures to or the spread of contamination.

Alternatives S2 and S3, when coupled with one of the groundwater alternatives, provide the greatest long-term effectiveness as both alternatives permanently remove all soils above ARAR-based, industrial-use cleanup goals. Groundwater Alternatives GW2 and GW3 provide long-term effectiveness when coupled with one of the soil remedial alternatives. Alternative GW3 is protective over time as long as geochemical conditions remain stable. Precipitated uranium could become remobilized in groundwater if geochemical conditions markedly changed.

(4) Reduction in Toxicity, Mobility, or Volume through Treatment: *Refers to anticipated ability of the remedy to reduce the toxicity, mobility, or volume of the hazardous components present at the site through treatment.*

Alternative S3 is the only alternative that incorporates treatment of soils, and would effect a reduction in contaminant volume requiring offsite disposal. This reduction is estimated to be 30% of the throughput (CABRERA 2012, *Appendix B*). Alternative GW2 reduces the volume of the contaminated groundwater through an active pump and treatment system. The uranium would be trapped in a solid matrix and disposed appropriately, thereby reducing its mobility.

(5) Short-Term Effectiveness: *Addresses the impacts to the community and site workers during the time it takes to complete the remedial action and meet RAOs.*

For both soil excavation alternatives (S2 and S3), short-term risks due to accidents involving remediation workers and DuPont employees are increased because of the activities related to construction, excavation, and rail transportation. Short-term effectiveness of Alternative S3 is similar to Alternative S2 with one possible exception. During implementation of Alternative S3, there would be additional short term risks to site workers from increased soil handling and the potential exposure to contaminated soil that would be associated with soil sorting operations. Remediation workers would follow a site-specific health and safety plan and wear appropriate protective clothing and equipment which would minimize potential exposures. During soil treatment operations there is the added potential for airborne releases of contaminants due to increased handling and moving of soil. Therefore, the short term risks to the surrounding community may be slightly greater with Alternative S3.

Increased short term risks associated with Alternatives GW2 and GW3 are due to potential accidents or exposures from well drilling operations, installation of the treatment system piping, including power systems, and handling of ion exchange media and contaminated filter materials from the pretreatment steps. However, time to complete the remedial action may be higher for GW3 (five to 30 years) as compared to that for GW2 (10 years). Therefore, short term effectiveness was ranked "Medium" for GW3.

(6) Implementability: *Addresses the technical and administrative feasibility of an alternative, including the availability of material and services required for cleanup.*

Materials and services for removal of contamination and environmental monitoring activities for the various alternatives are readily available. The degree of difficulty to technically accomplish the remedy increases with the amount and type of impacted soils being excavated (i.e., potential presence of non-FUSRAP chemical contamination), the level of the design/transportation required to dispose of soils in accordance with regulations, and the time/coordination involved in completing the alternative.

All remedial action alternatives are considered implementable on a technical and an availability-of-services basis. Alternatives S2, S3, GW2 and GW3 use readily available technologies and equipment. Alternative S3 involves greater uncertainties with respect to treatment performance. The proposed soil treatment process (sorting) is available from commercial sources, and has been effectively demonstrated at other FUSRAP sites to reduce the amount of soil requiring off-site disposal. However, the following site specific considerations at Chambers Works may require additional soil handling and therefore require additional time to complete the remedial action. Therefore, the following site specific factors may affect the implementability of S3 at Chambers Works:

(1) Soil Texture: Fine-grained soils are not effectively sorted with the SGS or other sorting technologies. The predominant soil texture at Chambers Works is fine-grained silty sand in the A aquifer, silt in the A/B Aquitard in OU 1, and fine sand grading to sand in the B Aquifer.
(2) Saturated Soil: A major percentage of the excavated soil will be from below the water table where the soil is water-saturated. Dewatering followed by treatment is feasible for sands but is not efficient for silts and silty clays. The A/B Aquitard which is a saturated silt unit accounts for 20% of the excavation. This soil type is not effectively treated with SGS or similar sorting systems.
(3) Rubble and Fill Material: Source zones in AOC 1 and AOC 2 are the former building foundations (Buildings 845 and 708, respectively). A persistent rubble layer was encountered in the A Aquifer. Typically, feed material with diameters less than 0.5 inch is desirable for soil sorting and screening. Material greater than approximately 1.5 inches (3.8 cm) in diameter cannot be processed without crushing. The FS assumes that rubble will be crushed but the process is not very efficient and debris such as rebar cannot be crushed. Therefore, rubble and debris may not be easily sorted during the treatment operation.

All the remedial action alternatives rely, to some extent, on LUCs. The implementability of these controls during the soil excavation activities (S2 and S3) is feasible and easily achieved due to DuPont's existing site access and land use restrictions. The existing LUCs will be implemented during remedial action. Alternative S2 would be easily implemented on an administrative and technical basis, since many of the existing DuPont site access restrictions, worker protections, and excavation safeguards would be utilized.

Remedial actions in AOC 6 will be conducted in close proximity to an active roadway used during DuPont's routine industrial operations. The implementability of all alternatives will disrupt DuPont plant operations to some extent. Alternatives S3 and GW3 with the longer durations would have a greater impact on DuPont's plant operations.

Alternatives GW2 and GW3 may be difficult to implement administratively due to the potentially longer time frames involved for groundwater remediation (10 and 30 years, respectively).

(7) Cost: *Evaluates the estimated capital, and O&M costs.*

The total cost for each alternative (present net worth (with an accuracy of +50% to -30%) is estimated as follows:

Alternative S2: $33.1 million
Alternative S3: $30.7 million
Alternative GW2: $8.7 million
Alternative GW3: $6.5 million.

Alternatives S1 and GW1 rank the highest with respect to the cost criterion (i.e., no cost). However, neither of these No Action alternatives would meet CERCLA's threshold criteria (i.e., overall protection of human health and the environment and compliance with ARARs), nor would they be permanent solutions.

Alternatives S2 and S3 are both ranked low with respect to cost; however, both alternatives provide the highest level of protectiveness for human health and the environment. They also represent permanent solutions to the contaminated soil present at the site. By excavating the contaminated soil, both alternatives also support the groundwater RAOs by removing the source of groundwater contamination. The costs for Alternative S3 do not reflect the uncertainty with the proposed beneficial re-use of soils below RGs. If soils cannot be reused, the cost benefit of volume reduction for disposal would be eliminated.

Alternatives GW2 and GW3 rank low and medium, respectively, however, if coupled with soil source removal, they both would provide a high level of protectiveness and are considered permanent solutions.

8.3 Modifying Criteria

The modifying criteria of State and Community Acceptance (Criteria Nos. 8 and 9) are dependent on the comments received. They are not addressed in this plan, but will be formally evaluated after the public comment period concludes.

9.0 PREFERRED ALTERNATIVE

USACE recommends a combination of soil Alternative S2 (Excavation and Disposal) and groundwater Alternative GW3 (MNA) as the preferred alternative for the DuPont Chambers Works FUSRAP site. Alternative S2 is the excavation and off-site disposal of contaminated soils. After the soil remedial action is completed Alternative GW3, MNA, would be implemented. This combination is preferred over other alternatives because (1) it is expected to remove elevated concentrations of the FUSRAP COCs from both contaminated soil and groundwater; (2) it eliminates further release of contaminants to the groundwater through source removal; (3) it eliminates potential exposure to both contaminated media; and therefore; (4) it will achieve substantial risk reduction. Following completion of the soil alternative, MNA would be initiated with the installation of monitoring wells. Natural attenuation processes in the groundwater system will prevent migration of existing contaminated groundwater from beneath OU 1 and AOC 6, and eventually reduce groundwater contaminant concentrations to meet RAOs. Results of the fate and transport discussion presented in Section 3.3 support the conclusion that MNA would be a viable means of treating the groundwater at the Site, based upon the observed oxidation states of uranium, the documented geochemical conditions within each AOC, and an evaluation of transport and attenuation processes.

Under preferred Soil Alternative S2, soils where total uranium concentrations exceed 65 pCi/g would be excavated using conventional techniques. The excavated soils would be transported via dump truck to the rail spur located adjacent to OU 1. Soil piles would be staged at a loading area where soils will be weighed and transferred into gondola railcars for containment prior to shipment. The railcars would transport the contaminated materials to the off-site permitted disposal facility where they would be offloaded and placed in a waste cell.

Due to the presence of LNAPL at the top of the B Aquifer in parts of OU 1, some excavated soils from OU 1 may contain both radionuclide COCs and non-FUSRAP hazardous constituents (volatile and semi-volatile organics). Management of these soils would likely involve treatment at the disposal site to remove hazardous organics, followed by land disposal of the treated soils still containing radionuclides. Although expected to be a small volume of soil, the associated treatment and disposal costs of such wastes can be very expensive. Since the RI did not identify any LNAPL in AOC 6, no additional treatment costs for non-FUSRAP hazardous constituents in soils are estimated for this AOC.

Treatment of recovered water from the excavations and any decontamination water will be required. The water would be treated onsite and sampled prior to discharge to DuPont's permitted wastewater treatment facility.

LUCs would be utilized to assure protectiveness during the remedial action activities. LUCs would include continuing DuPont's existing site access restrictions, excavation permit requirements, and groundwater use restrictions. During remediation it may be necessary to install additional site access restrictions, maintain appropriate fencing and signs, and periodically inspect the site to ensure these land use restrictions are being enforced. The controls would include measures such as governmental controls, proprietary controls and informational devices. It should be noted once again, that USACE does not anticipate the need for any LUCs beyond the ones currently imposed by DuPont or any future property owner once the soil remedial action is completed to the industrial-use RG.

During the implementation of MNA, DuPont's existing groundwater use restrictions would be utilized to assure protectiveness. A long-term stewardship plan would be developed to address requirements for future monitoring and maintenance of LUCs. The plan would also include provisions addressing the process by which DuPont or any future property owner can contact the designated federal government agency (USACE and/or DOE) responsible for long-term maintenance of FUSRAP-impacted areas, including periodic reviews and monitoring (as necessary). LUCs for the groundwater alternative will ensure protectiveness at areas in which the residual groundwater contamination exceeds the concentrations as specified in the RAOs.

As required by CERCLA and the NCP, a site review would be conducted every five years. The five year review process would provide the opportunity for USACE or DOE to evaluate the effectiveness of the remedial action and to confirm that land use assumptions have not changed including site ownership and groundwater use.

Implementation of the preferred alternative for soil and groundwater will allow the FUSRAP areas to be available for activities consistent with the property's industrial land use within a reasonable timeframe. The proposed remedial action for soil would require 1.5 years to complete; after which the USACE would perform a final status survey and dose assessment to confirm the results of the remedial action and document the residual radiological levels in soil in coordination with NJDEP and DuPont. Upon completion of the soil remedial action and in order to satisfy the RAO for groundwater, monitoring wells would be installed so that MNA sampling and evaluation could be initiated. While there would be an estimated 30-year O&M period associated with MNA, it is anticipated that the FUSRAP areas would be available for use consistent with the property's industrial use upon completion of well installation. After USACE demonstrates the effectiveness of MNA in reducing groundwater concentrations, the overall site management would be transferred to DOE for long-term stewardship in accordance with the memorandum of understanding between the DOE and USACE.

Based on information currently available, USACE believes that this Preferred Alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing criteria. USACE expects the preferred alternative to satisfy the following statutory requirements of CERCLA §121(b):

- Be protective of human health and the environment;
- Complies with ARARs;
- Is cost-effective; and
- Utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

USACE will review, respond to and, as necessary, reconsider the Preferred Alternative in response to public comments received during the public comment period or the availability of new information.

10.0 COMMUNITY PARTICIPATION

USACE encourages the public's input regarding the preferred remedial alternative. While this Proposed Plan presents a recommendation for addressing soil and groundwater contamination, USACE will not select the response action until all significant comments have been received and reviewed by USACE in coordination with NJDEP and USEPA. Documents may be reviewed at the Pennsville Public Library or downloaded from the USACE Philadelphia District's website (www.nap.usace.army.mil/missions/fusrap). Written comments on the Proposed Plan and USACE's preferred alternative will be accepted for 30 days after the Public Meeting, scheduled to be held on January 17, 2013. USACE will place a Public Notice in the *South Jersey Times* on December 16, 2012, December 30, 2012, and January 6, 2013 to announce the availability of the Proposed Plan and the public meeting date and location. The public comment period will extend from January 17, 2013 through February 16, 2013.

The USACE will hold the public meeting at the Hampton Inn in Pennsville, NJ, on Thursday, January 17, 2013 at 7:00 p.m. to present the results of the RI/FS, USACE's reasons for recommending the preferred alternative, and to receive comments from the public. Written comments will be accepted at any time during the comment period, but must be postmarked by February 16, 2013 for consideration. USACE will accept comments at the public meeting on January 17th or written comments may be mailed to: Mr. Edward Voigt, Public Affairs Office, U.S. Army Corps of Engineers, Philadelphia District, 100 Penn Square East, Wanamaker Building, Philadelphia, PA 19107.

USACE will evaluate all significant comments submitted during the comment period, with responses to public comments formally documented in a Responsiveness Summary. After considering all significant comments, USACE, in coordination with NJDEP and USEPA Region II, will make a decision regarding the most appropriate soil and groundwater remedial action. USACE's decision will be detailed in the Site ROD, which will include the Responsiveness Summary. All significant comments received by USACE during the public comment period will be addressed in the Responsiveness Summary. All documents supporting the ROD will be included in the Administrative Record for the Site, which is available for review at the Pennsville Public Library, located at 190 South Broadway, Pennsville, NJ 08070.

11.0 REFERENCES

Bechtel National, Inc. (BNI). 1985. Radiological Survey of the E. I. DuPont De Nemours and Company, Chambers Works Plant, Deepwater, New Jersey. DOE/QR/20722-22. 143 pgs. Dames & Moore Record No. 1007.

CABRERA 2011a. Memorandum: USACE Determination of Eligible Contaminants for FUSRAP, Investigation, DuPont Chambers Works FUSRAP Site, Deepwater, NJ. June 2011.

CABRERA 2011b. Sitewide Remedial Investigation Report for All Operable Units, Final, DuPont Chambers Works FUSRAP Site, Deepwater, NJ. June 2011.

CABRERA 2011c. Baseline Risk Assessment, Final, DuPont Chambers Works FUSRAP Site, Deepwater, NJ. June 2011.

CABRERA 2012. Feasibility Study, Final, DuPont Chambers Works FUSRAP Site, Deepwater, NJ. October 2012.

DuPont Environmental Remediation Services (DERS). 1995. RCRA Facility Investigation Report, DuPont Chambers Works Site, Deepwater, New Jersey.

New Jersey Administrative Code (NJAC) 7:9C. Ground Water Quality Standards.

New Jersey Administrative Code (NJAC) 7:28-12. Remediation Standards for Radioactive Materials.

Oak Ridge National Laboratory (ORNL). 1978. U.S. Department of Energy, Formerly Utilized MED/AEC Sites Remedial Action Program, Radiological Survey of the E.I. DuPont de Nemours Company, Deepwater, New Jersey. DOE.EV-0005/8. December.

U.S. Department of Energy (DOE). 1996. DuPont Site – NHPA (Section 106) Determination, 15 pgs., Dames and Moore Record No. 1083.

U.S. Environmental Protection Agency (USEPA). 1988. CERCLA Compliance with Other Laws.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002. December.

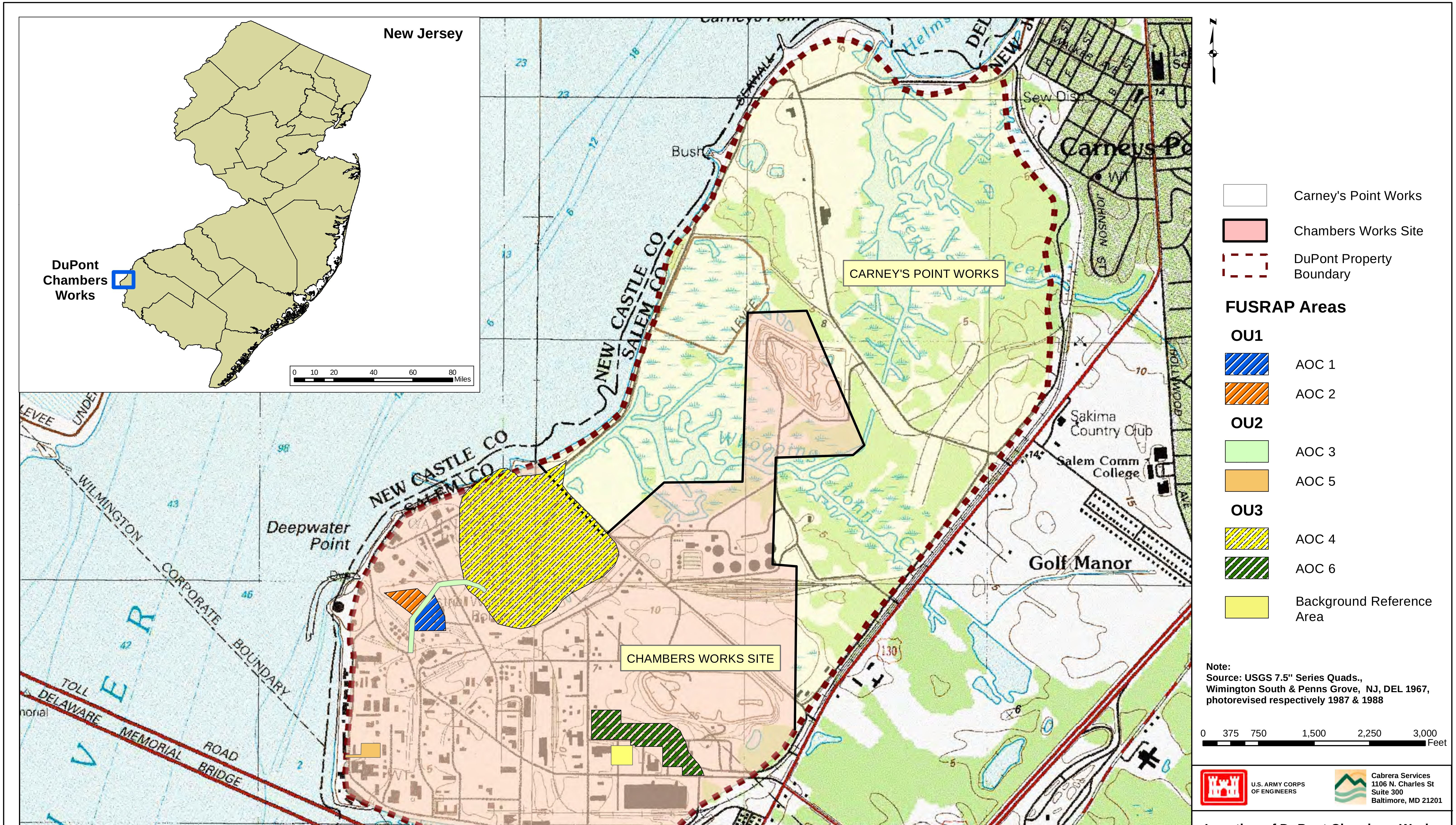
USEPA. 1990. "National Oil and Hazardous Substances Pollution Contingency Plan," Final Rule, FR Vol. 55, No. 46, March 8, 1990, available from U.S. Government Printing Office, Washington, D.C.

USEPA. 1997. Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination. OSWER Directive No. 9200.4-18. August.

USEPA. 1999. Understanding Variation in Partition Coefficient, K_d, Values, Volume II, Review of Geochemistry and Available K_d Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^3H), and Uranium. EPA 402-R-99-004B. August.

USEPA. 2010. Monitored Natural Attenuation of Inorganic Contaminants in Groundwater, Volume 3, Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium. EPA/600/R-10/093. September.

FIGURES

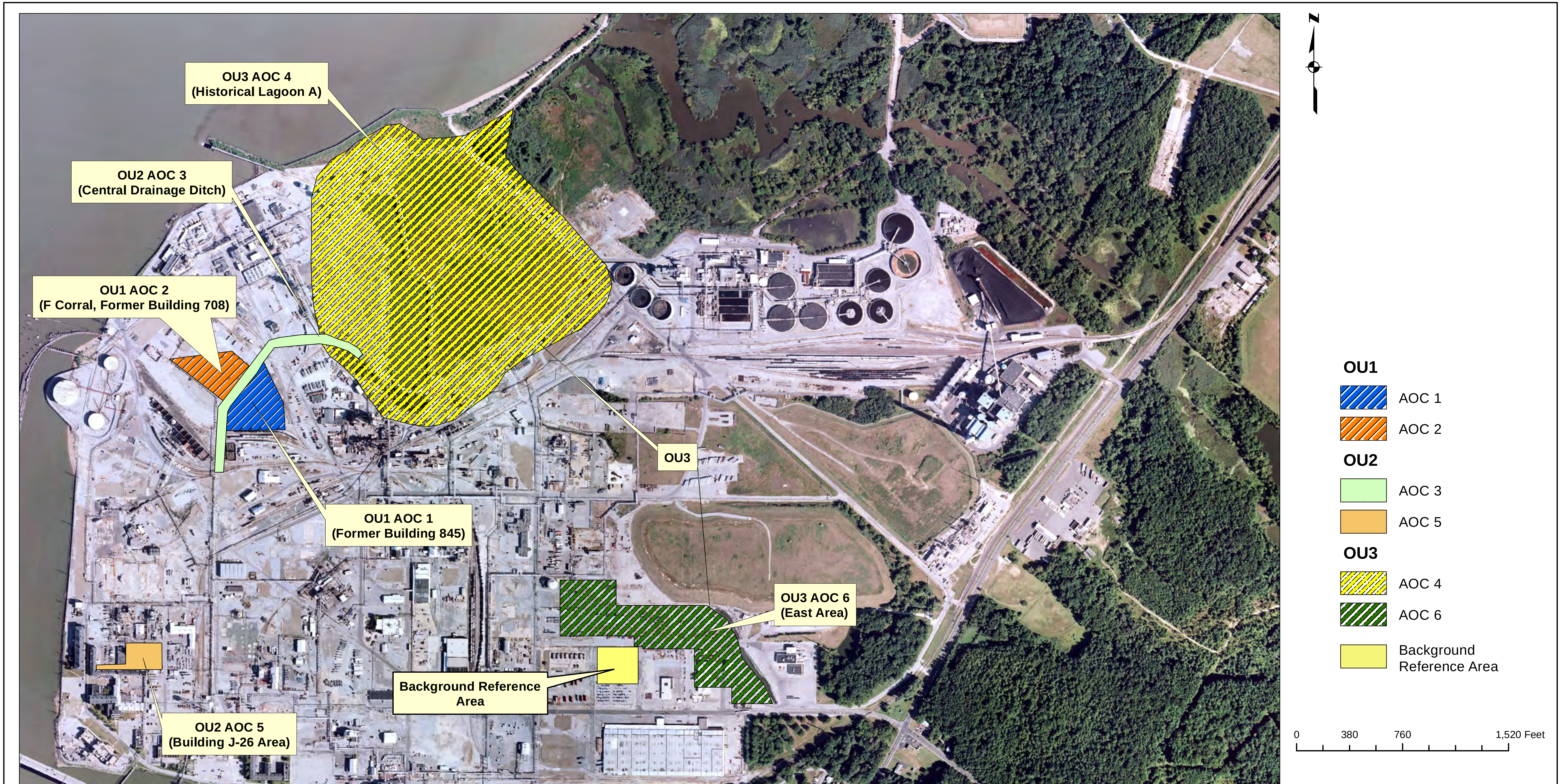


Location of DuPont Chambers Works

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012

Figure 2 - 1



Note: Aerial Photo taken in September 2005

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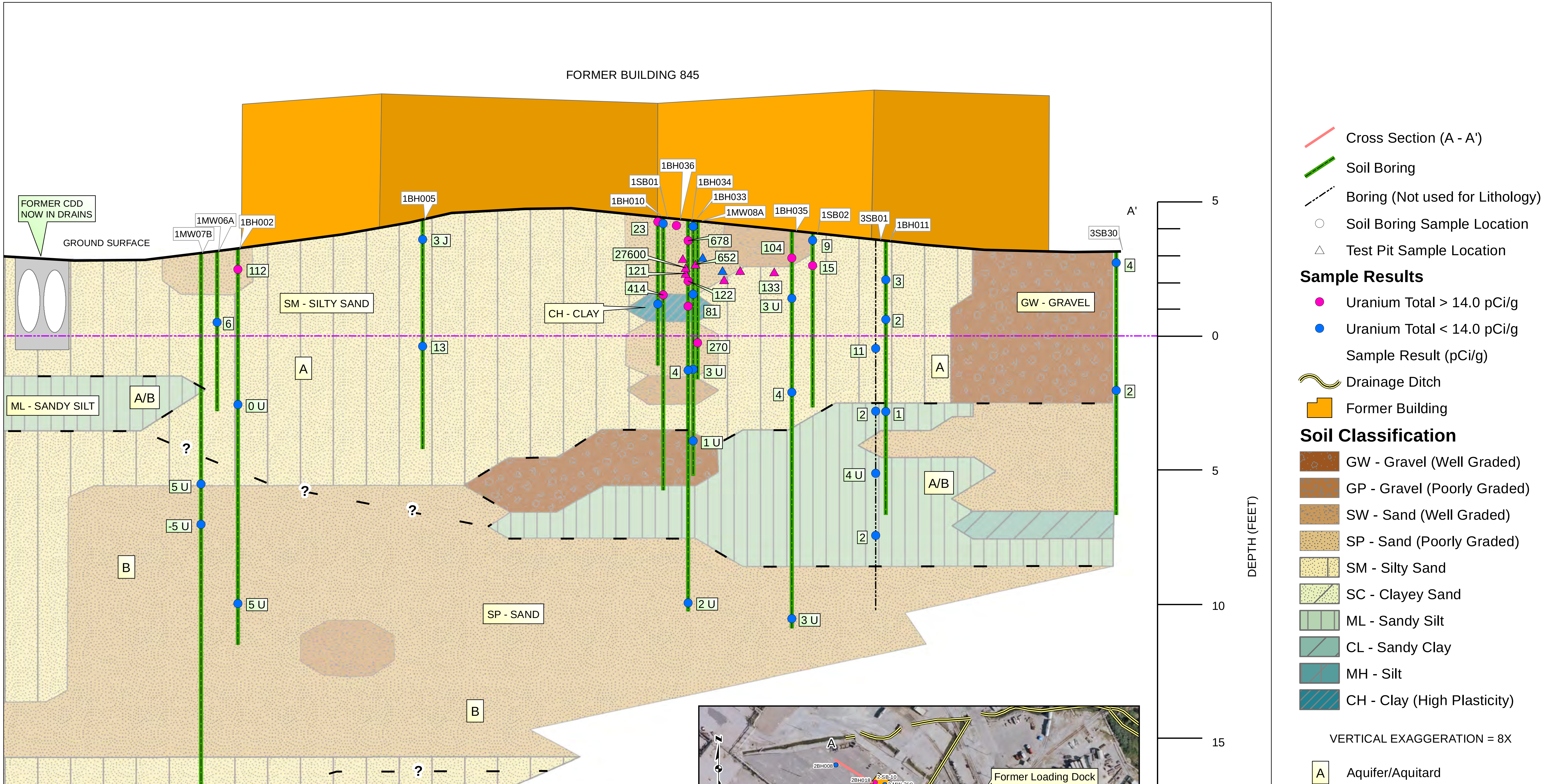
Designations of Operable Units (OUs) and Areas of Concern (AOCs)

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012

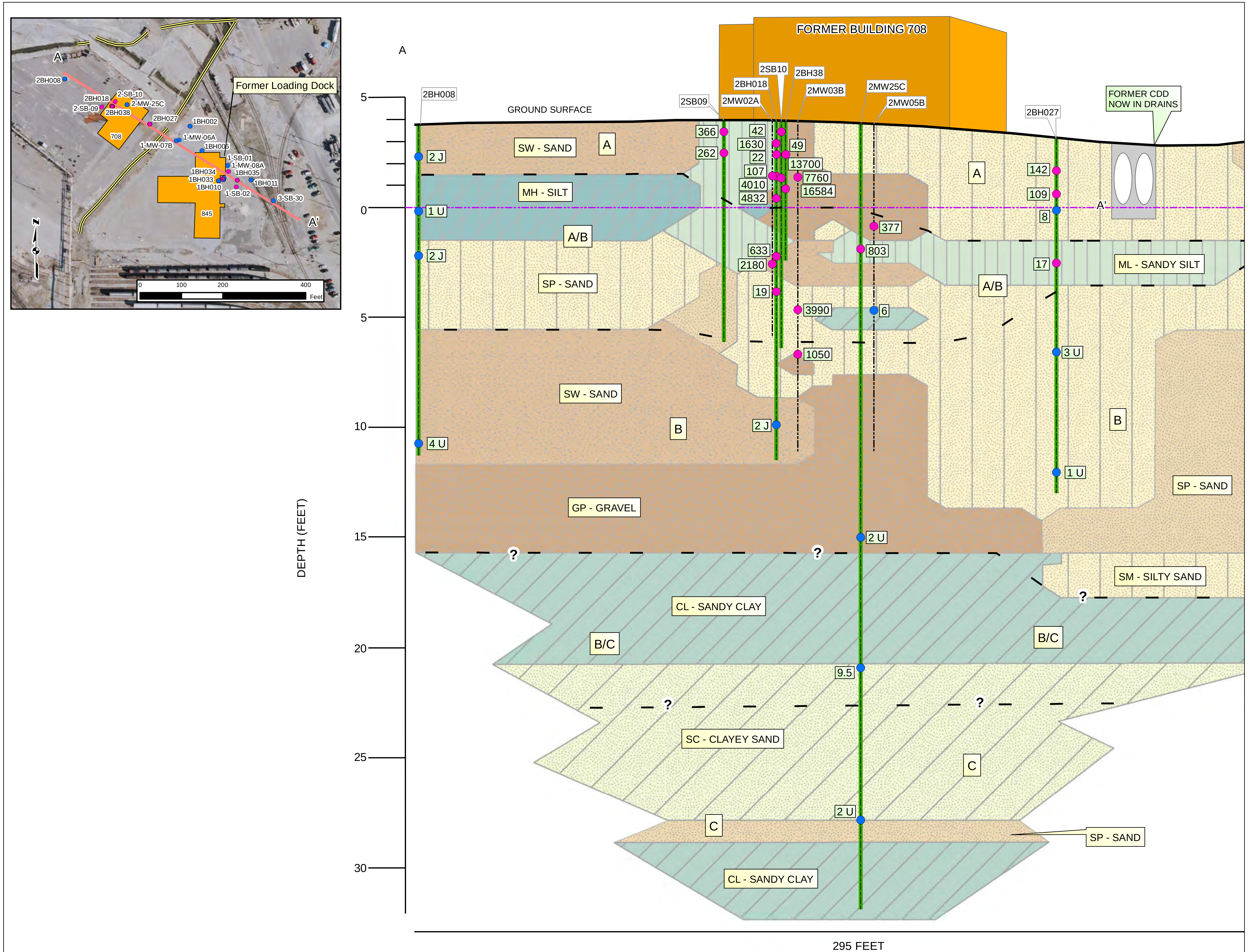
Figure 2- 2



Total Uranium Concentrations in AOC 1, Cross Section View (A - A')

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012	Figure 3 - 1



Cross Section (A - A')

Soil Boring

Boring (Not used for Lithology)

Soil Boring Sample Location

Test Pit Sample Location

Sample Results

Uranium Total > 14.0 pCi/g

Uranium Total < 14.0 pCi/g

Sample Result (pCi/g)

Drainage Ditch

Former Building

Soil Classification

GW - Gravel (Well Graded)

GP - Gravel (Poorly Graded)

SW - Sand (Well Graded)

SP - Sand (Poorly Graded)

SM - Silty Sand

SC - Clayey Sand

ML - Sandy Silt

CL - Sandy Clay

MH - Silt

CH - Clay (High Plasticity)

VERTICAL EXAGGERATION = 8X

A Aquifer/Aquitard

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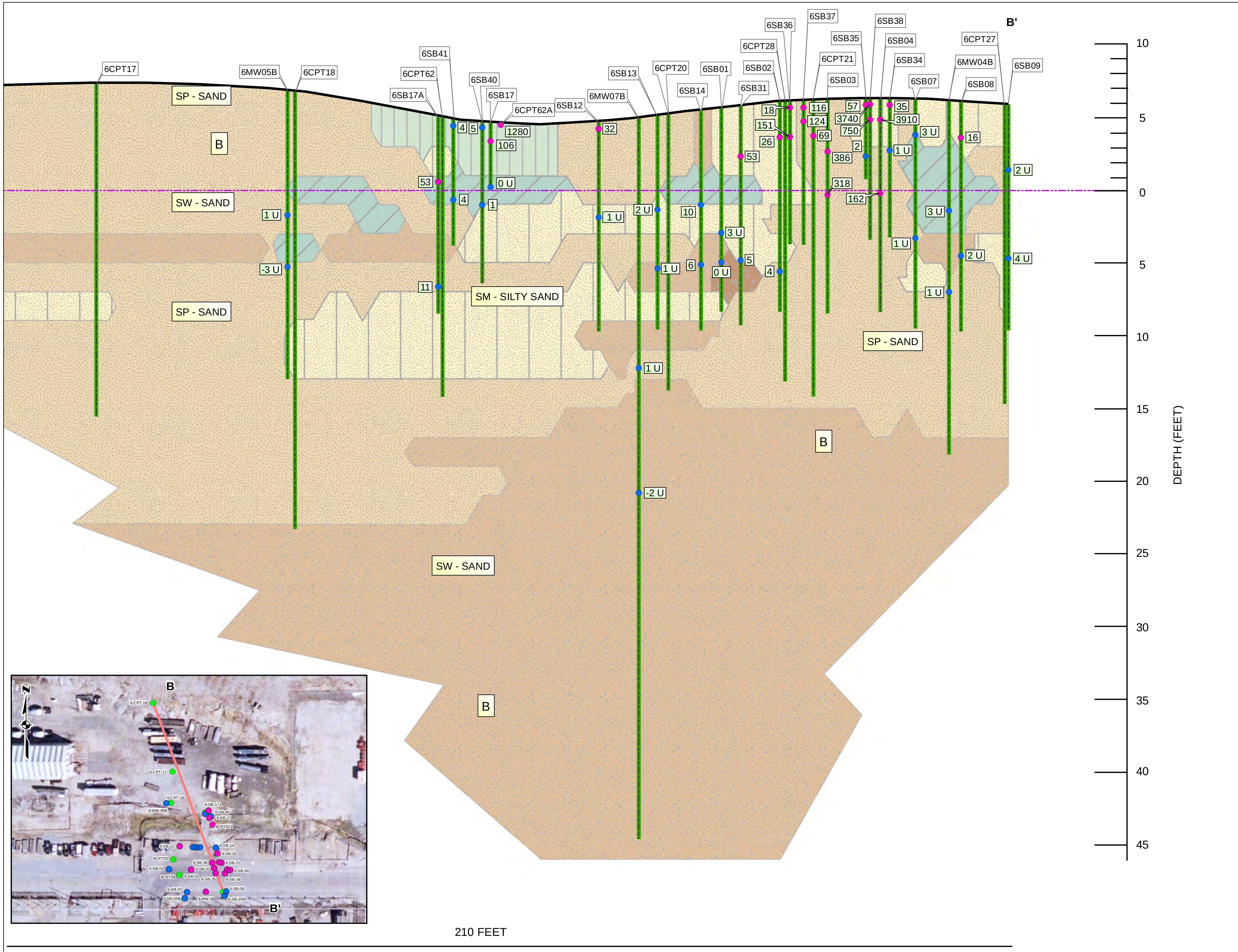
Total Uranium Concentrations in AOC 2, Cross Section View (A - A')

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012	Figure 3 - 2



Cross Section (B - B')

Soil Boring

Sample Results

- Uranium Total > 14 pCi/g
- Uranium Total < 14 pCi/g
- 4 Sample Result (pCi/g)
- CPT Location (No Sample)

Soil Classification

- GW - Gravel (Well Graded)
- GP - Gravel (Poorly Graded)
- SW - Sand (Well Graded)
- SP - Sand (Poorly Graded)
- SM - Silty Sand
- SC - Clayey Sand
- ML - Sandy Silt
- CL - Sandy Clay
- MH - Silt
- CH - Clay (High Plasticity)

VERTICAL EXAGGERATION = 3X

B Aquifer/Aquitard

Note: The A Aquifer is not present in AOC 6

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Total Uranium Concentrations in AOC 6 (OU 3), Cross Section View (B - B') under East Road

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012	Figure 3 - 3

N

Temporary Well Locations, July 2007

Monitoring Well Location

Uranium Total results that exceeds 30 micrograms per Liter (ug/L)

Former Drainage Ditch Location

Former Buildings 845 and 708

Current Drainage Ditch Location

Average Groundwater Flow Direction

0 37.5 75 150 Feet

Notes:

1. Uranium Total results are reported in micrograms per liter (ug/L)

2. Aerial Photo taken in September 2005

3. Additional borings and temporary wells used to delineate groundwater contamination.

4. Drainage ditches control and capture groundwater flow in A Aquifer.

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Total Uranium Concentrations in OU 1 Groundwater, A Aquifer (AOCs 1 and 2)

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USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	**Figure 3 - 4**

Monitoring Well Location

Uranium Total results that exceeds 30 micograms per liter (ug/L)

Former Drainage Ditch Location

Former Buildings 845 and 708

Current Drainage Ditch Location

Average Groundwater Flow Direction

0 35 70 140 Feet

Notes:

1. Uranium Total results are reported in micrograms per liter (ug/L)
2. Well 2MW-25C is completed in the C Aquifer to evaluate vertical migration
3. Aerial Photo taken in September 2005

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Total Uranium Concentrations in OU 1 Groundwater, B Aquifer (AOCs 1 and 2)

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012 | **Figure 3 - 5**

N

Monitoring Well Location

Uranium Total results that exceeds 30 micrograms per liter (ug/L)

Average Groundwater Flow Direction

0 12.5 25 50 Feet

Notes:
1. Uranium Total results are reported in micrograms per liter (ug/L)
2. Aerial Photo taken in September 2005
3. 6MW07B is completed at the base of the B Aquifer for vertical delineation

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Total Uranium Concentrations in AOC 6 Groundwater, B Aquifer

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DuPont Chambers Works
Deepwater, New Jersey

	June 2012	**Figure 3 - 6**

Note: Aerial Photo taken in September 2005

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Area of Interest (AOI 1)
Well Locations (AOC 4)

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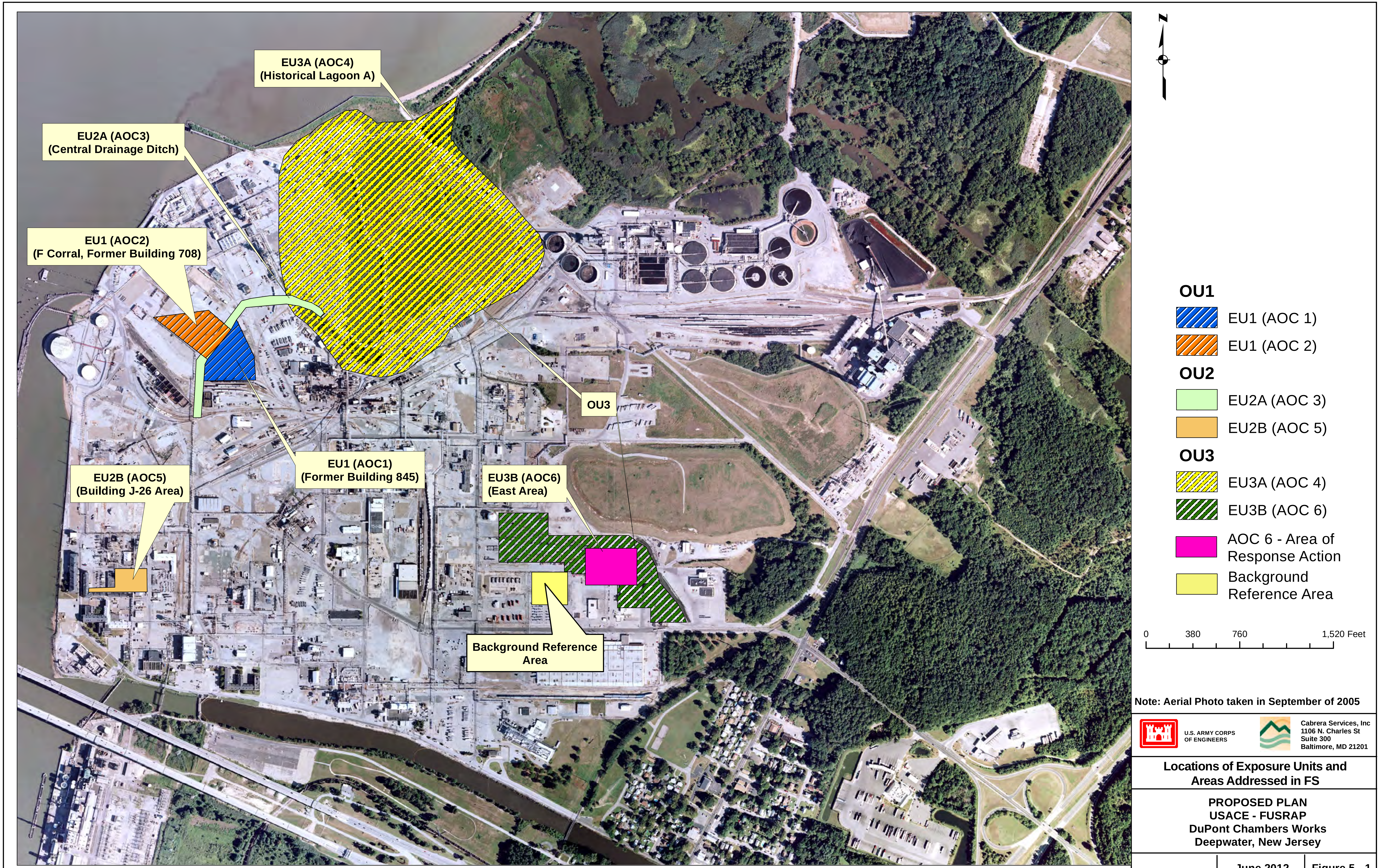
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

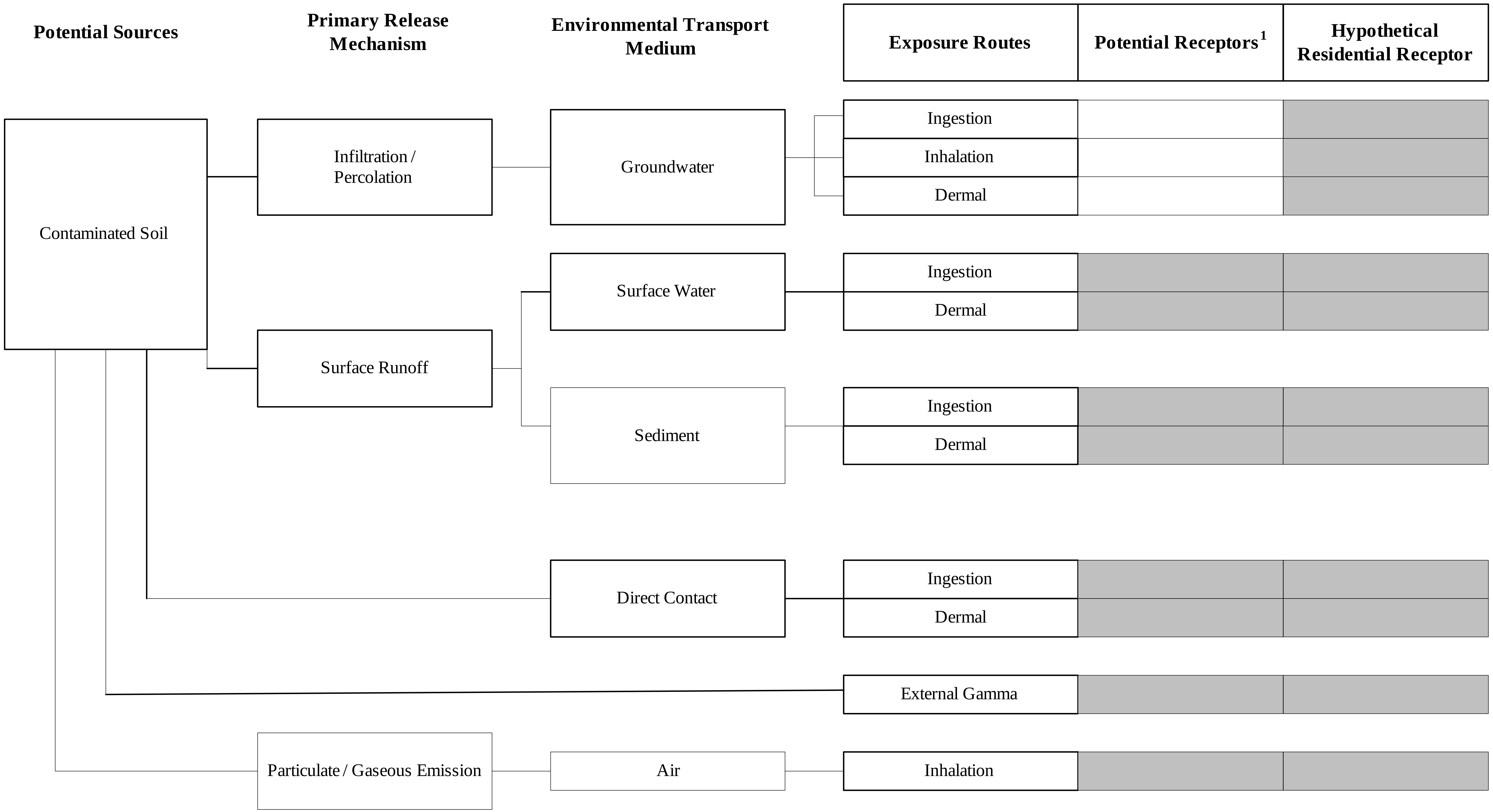
	June 2012	Figure 3 - 7



Locations of Exposure Units and
Areas Addressed in FS

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012 | Figure 5 - 1



Complete Exposure Pathway

Incomplete Exposure Pathway

[1] Potential receptors include industrial, construction, utility and maintenance workers

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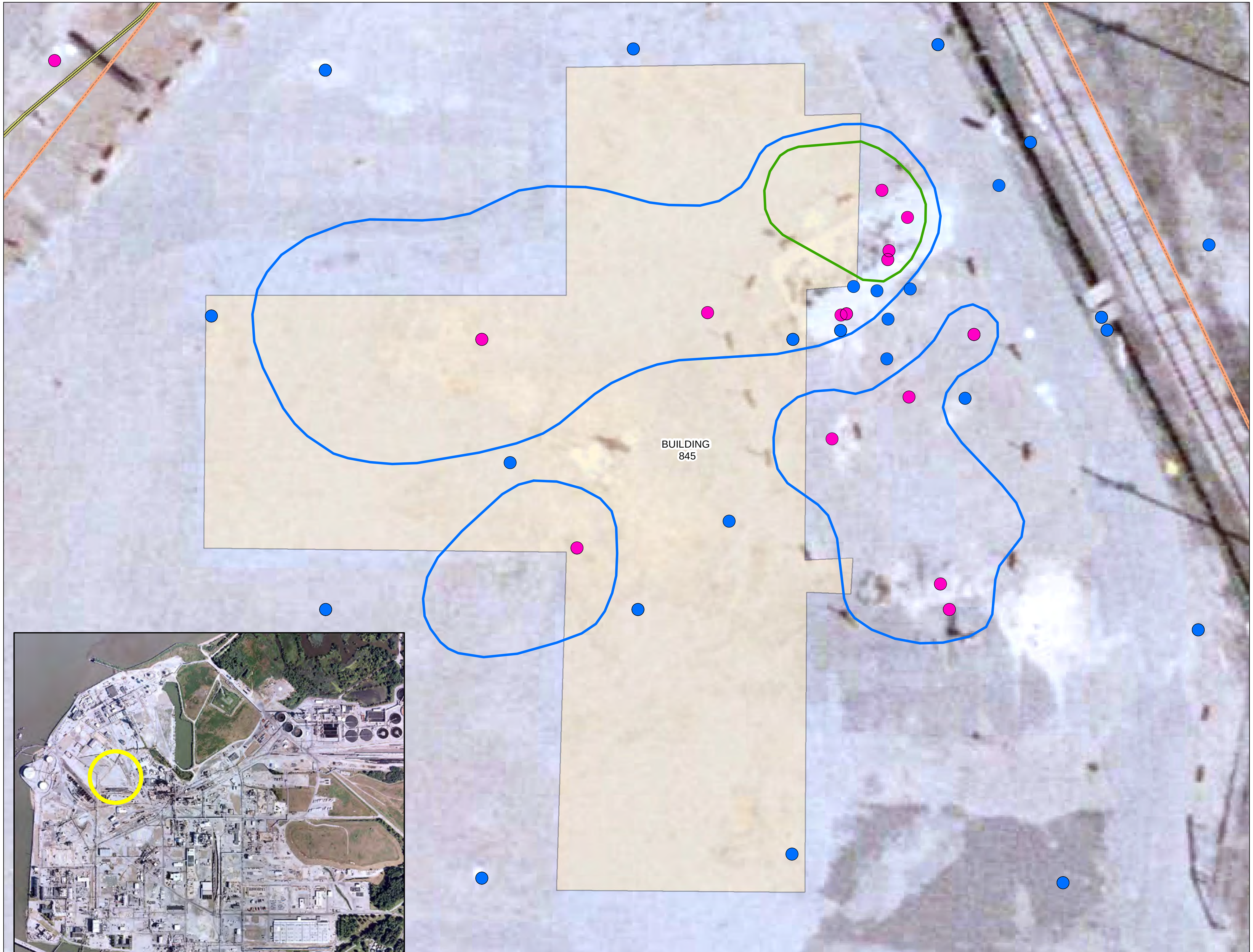
General Conceptual Site Model

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 5 - 2



N

Legend

Sample Station Location

- U-Total < 65 pCi/g
- U-Total > 65 pCi/g

Isoconcentration (Uranium Total)

- U-Total > 65 pCi/g (0-4 ft. bgs)
- U-Total > 65 pCi/g (4-8 ft. bgs)

0 10 20 40 Feet

Note:
1. Aerial Photo taken in September 2005

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Total Uranium Isoconcentrations in Soil for AOC 1 (Above Remediation Goal)

PROPOSED PLAN
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012	Figure 6 - 1

Legend

Sample Station Location

- U-Total < 65 pCi/g
- U-Total > 65 pCi/g

Isoconcentration (Uranium Total)

- U-Total > 65 pCi/g (0-4 ft. bgs)
- U-Total > 65 pCi/g (4-8 ft. bgs)
- U-Total > 65 pCi/g (8-12 ft. bgs)

0 12.5 25 50 Feet

Note:
1. Aerial Photo taken in September 2005

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Total Uranium Isoconcentrations in Soil for AOC 2 (Above Remediation Goal)

PROPOSED PLAN
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012 | **Figure 6 - 2**

Legend

Sample Station Location

- U-Total < 65 pCi/g
- U-Total > 65 pCi/g

Isoconcentration (Uranium Total)

- U-Total > 65 pCi/g (0-4 ft. bgs)
- U-Total > 65 pCi/g (4-8 ft. bgs)
- CPT Sounding Locations at Background
- Drainage Ditch
- Former Building
- AOC 6

0 30 60 120 Feet

Note:
1. Aerial Photo taken in September 2005

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Uranium Total Isoconcentrations in Soil for AOC 6

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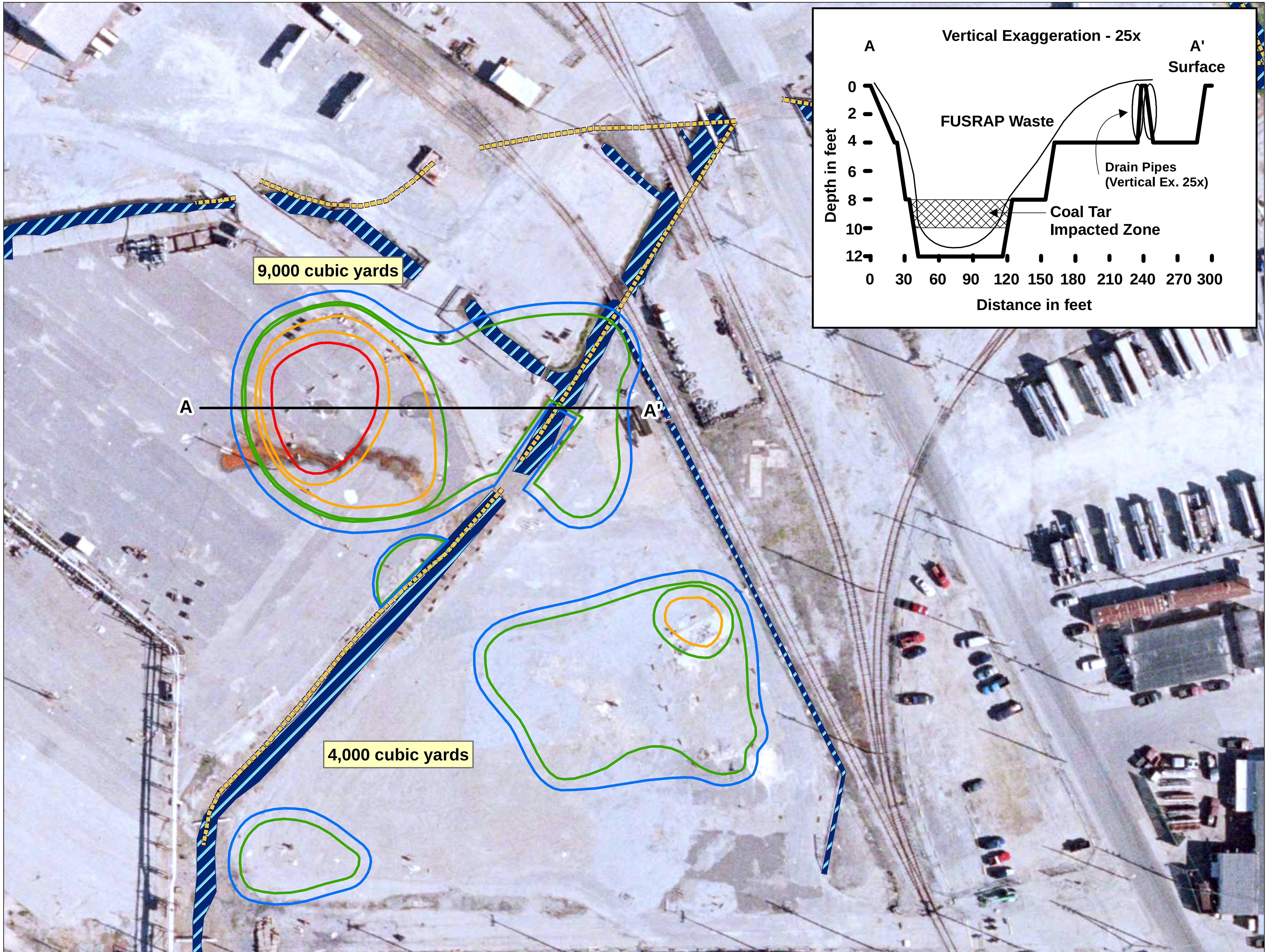
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 6-3



N

Excavation Extent Contours

Uranium Total > 65 pCi/g

- Extent of Excavation
- 4 ft. bgs
- 8 ft. bgs
- 12 ft. bgs
- Former Drainage Ditch Location
- Current Drainage Ditch Location

0 35 70 140 Feet

Notes:
1. Aerial Photo taken in September 2005

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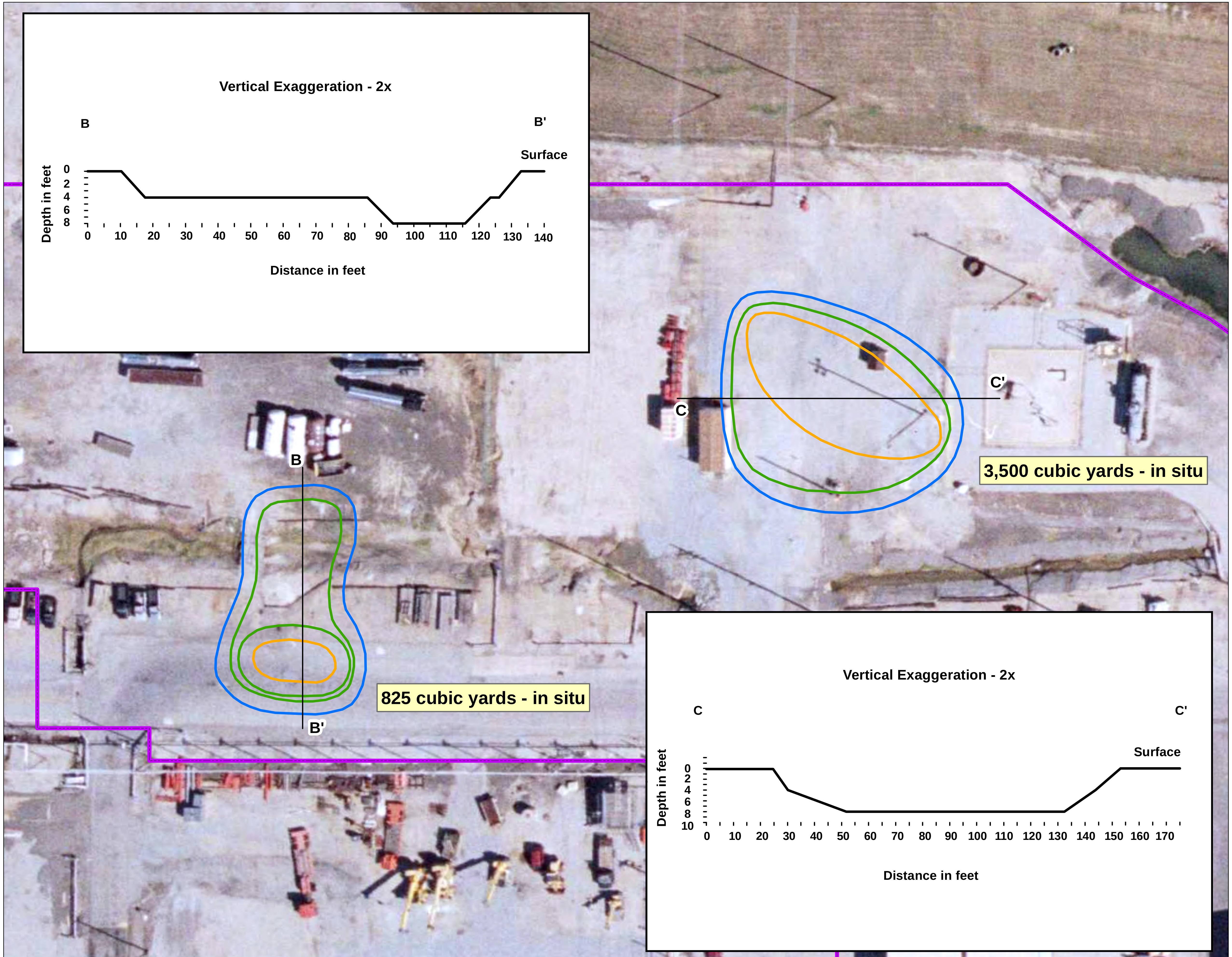
Assumed Excavation Cutlines for OU 1

PROPOSED PLAN
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 7-1



Excavation Extent Contours

Uranium Total > 65 pCi/g

- Extent of Excavation
- 4 ft. bgs
- 8 ft. bgs
- AOC 6

0 30 60 120 Feet

Notes:
1. Aerial Photo taken in September 2005

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Assumed Excavation Cutlines AOC 6

PROPOSED PLAN
USACE- FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 7-2

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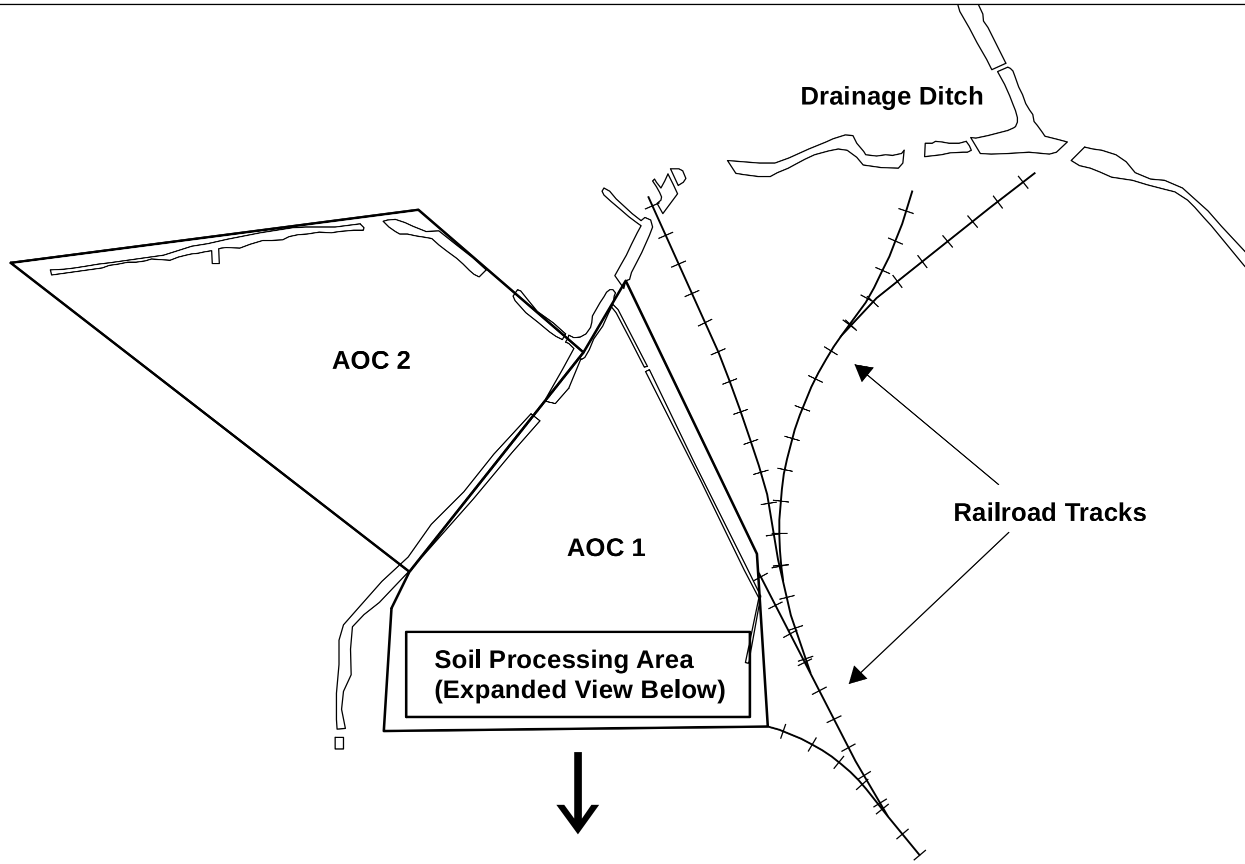
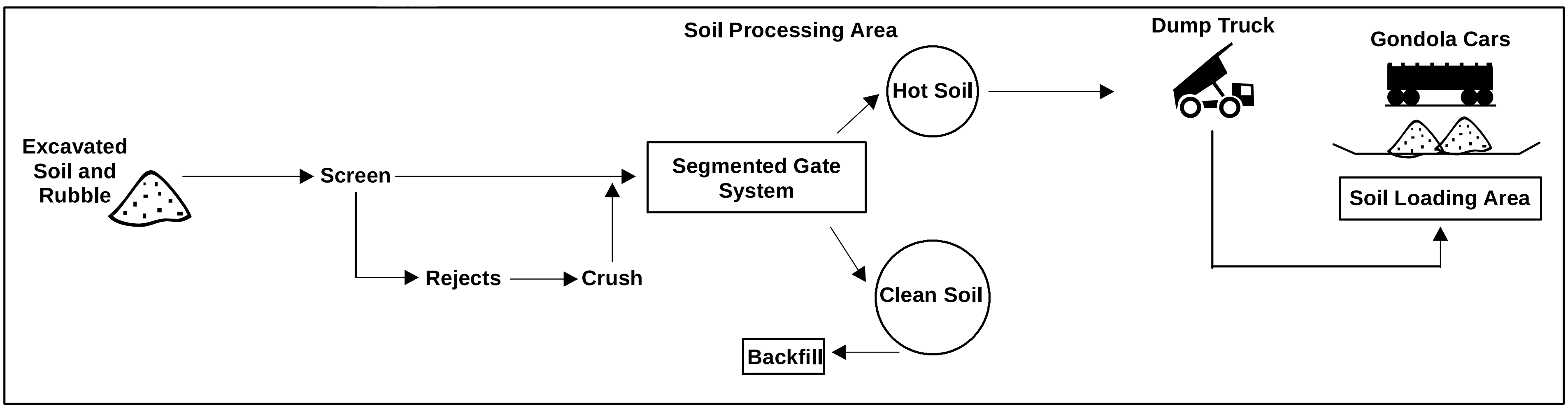
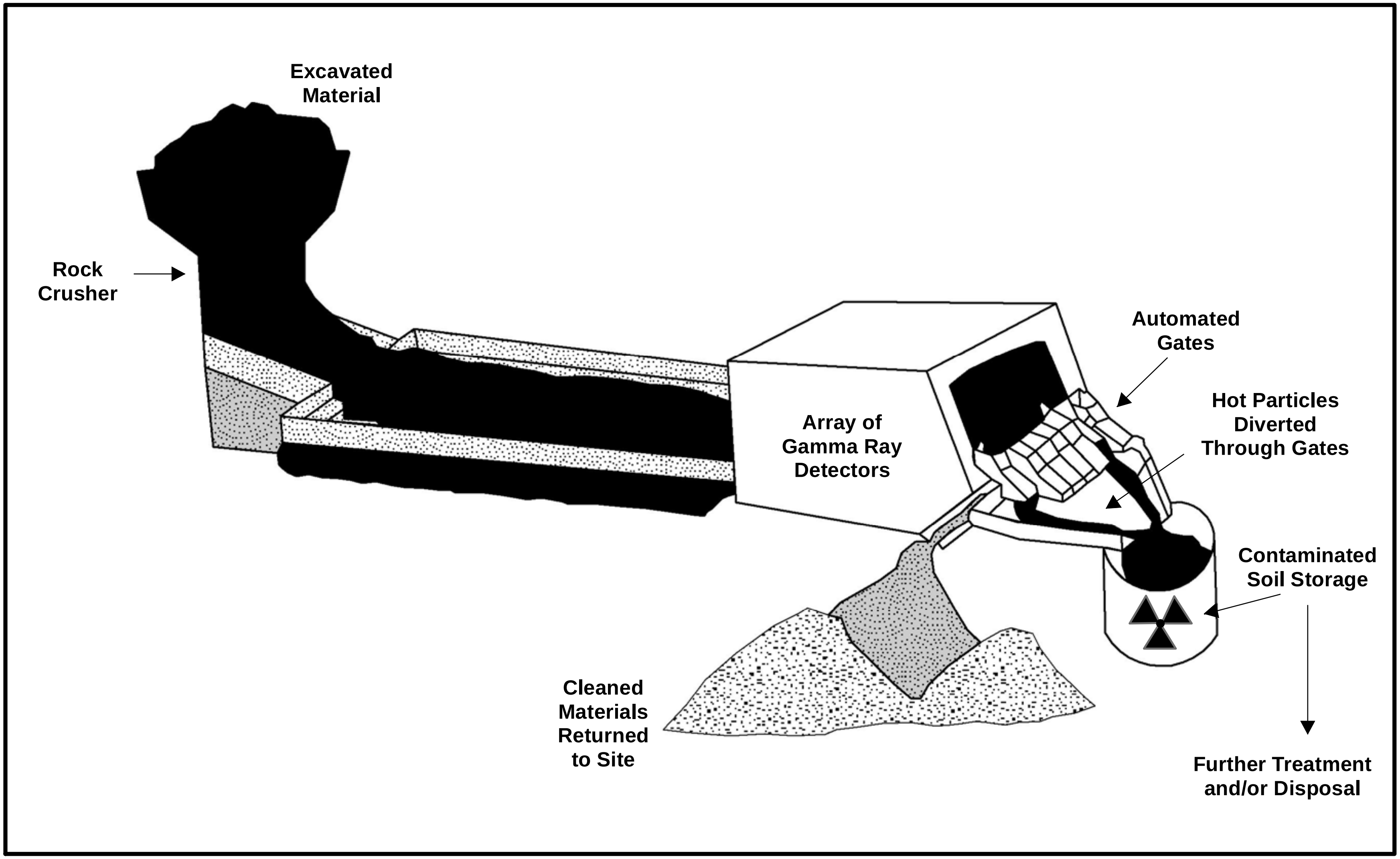
Soil Excavation Location and Treatment Diagram

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012 | Figure 7 - 3







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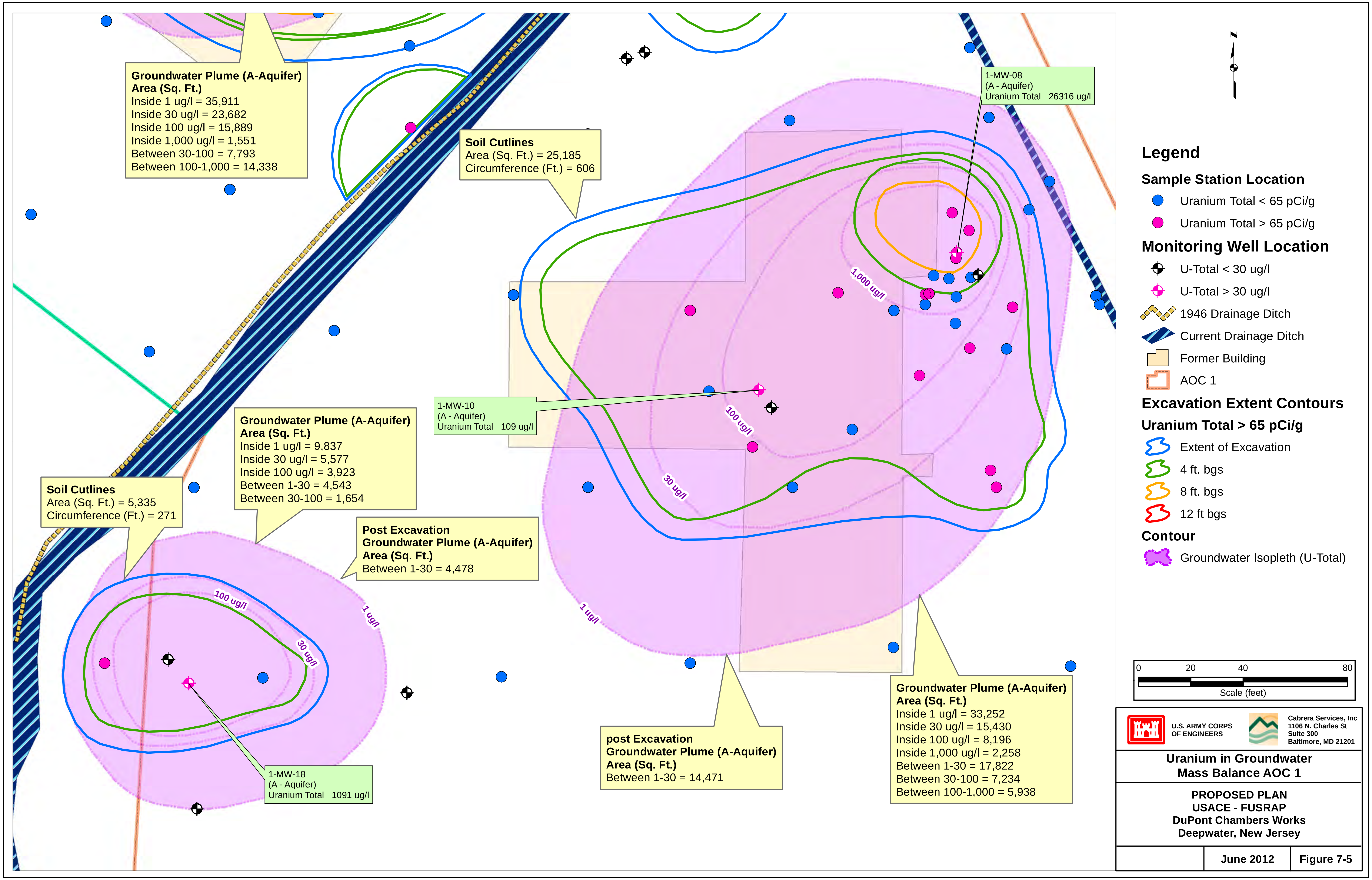
Schematic of Soil Sorting
with Segmented Gate System

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

June 2012 | Figure 7 - 4



Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Inside 1 ug/l = 35,911
Inside 30 ug/l = 23,682
Inside 100 ug/l = 15,889
Inside 1,000 ug/l = 1,551
Between 30-100 = 7,793
Between 100-1,000 = 14,338
Soil Cutlines
Area (Sq. Ft.) = 25,185
Circumference (Ft.) = 606
1-MW-08
(A - Aquifer)
Uranium Total 26316 ug/l
1,000 ug/l
100 ug/l
30 ug/l
1 ug/l
1-MW-10
(A - Aquifer)
Uranium Total 109 ug/l
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Inside 1 ug/l = 9,837
Inside 30 ug/l = 5,577
Inside 100 ug/l = 3,923
Between 1-30 = 4,543
Between 30-100 = 1,654
Soil Cutlines
Area (Sq. Ft.) = 5,335
Circumference (Ft.) = 271
Post Excavation
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Between 1-30 = 4,478
100 ug/l
30 ug/l
1 ug/l
1-MW-18
(A - Aquifer)
Uranium Total 1091 ug/l
post Excavation
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Between 1-30 = 14,471
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Inside 1 ug/l = 33,252
Inside 30 ug/l = 15,430
Inside 100 ug/l = 8,196
Inside 1,000 ug/l = 2,258
Between 1-30 = 17,822
Between 30-100 = 7,234
Between 100-1,000 = 5,938
N
Legend
Sample Station Location
Uranium Total < 65 pCi/g
Uranium Total > 65 pCi/g
Monitoring Well Location
U-Total < 30 ug/l
U-Total > 30 ug/l
1946 Drainage Ditch
Current Drainage Ditch
Former Building
AOC 1
Excavation Extent Contours
Uranium Total > 65 pCi/g
Extent of Excavation
4 ft. bgs
8 ft. bgs
12 ft bgs
Contour
Groundwater Isopleth (U-Total)
0 20 40 80
Scale (feet)
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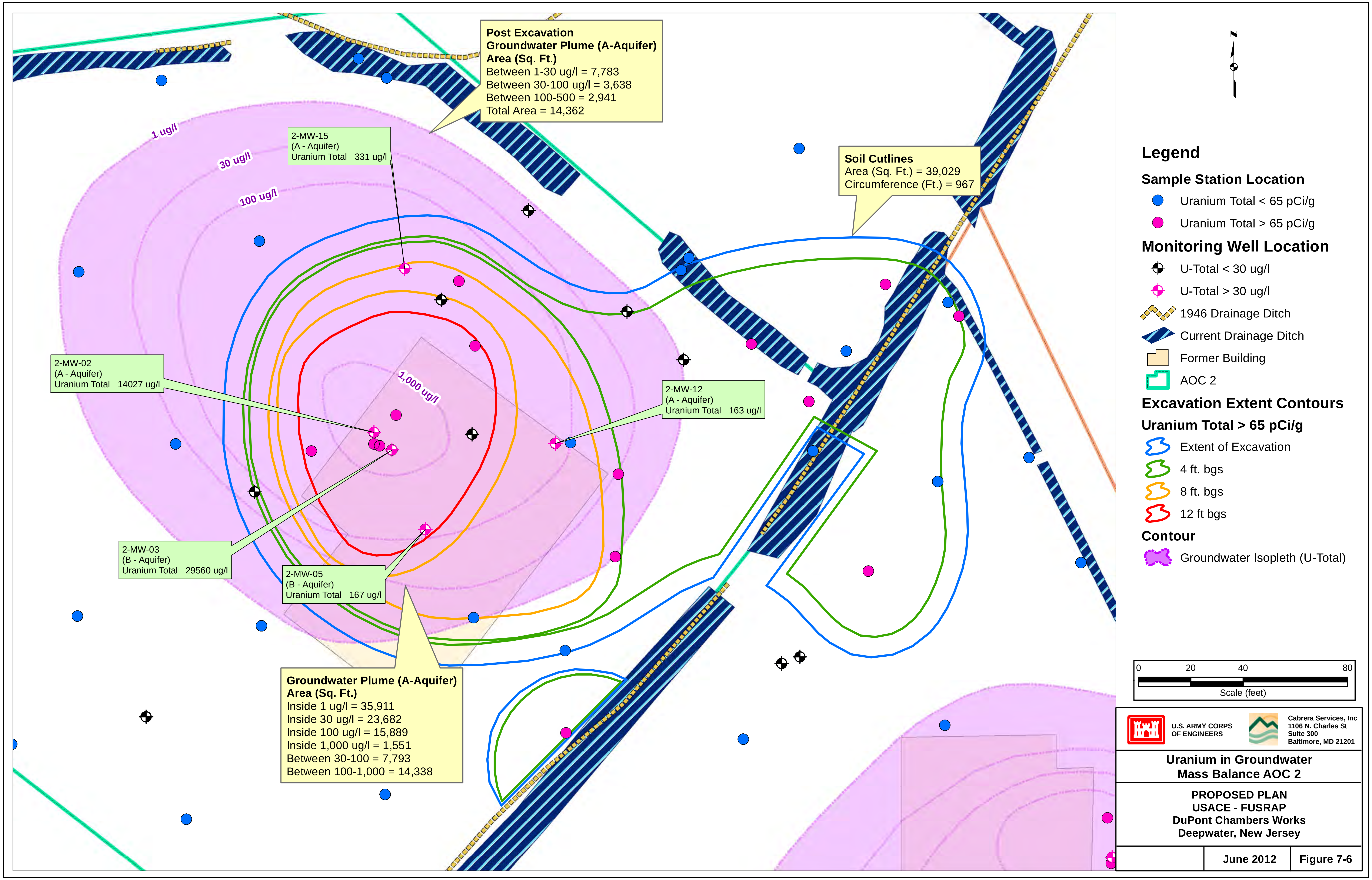
Uranium in Groundwater
Mass Balance AOC 1
PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey
June 2012
Figure 7-5



Post Excavation
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Between 1-30 ug/l = 7,783
Between 30-100 ug/l = 3,638
Between 100-500 = 2,941
Total Area = 14,362
1 ug/l
30 ug/l
100 ug/l
1,000 ug/l
2-MW-15
(A - Aquifer)
Uranium Total 331 ug/l
Soil Cutlines
Area (Sq. Ft.) = 39,029
Circumference (Ft.) = 967
2-MW-02
(A - Aquifer)
Uranium Total 14027 ug/l
2-MW-12
(A - Aquifer)
Uranium Total 163 ug/l
2-MW-03
(B - Aquifer)
Uranium Total 29560 ug/l
2-MW-05
(B - Aquifer)
Uranium Total 167 ug/l
Groundwater Plume (A-Aquifer)
Area (Sq. Ft.)
Inside 1 ug/l = 35,911
Inside 30 ug/l = 23,682
Inside 100 ug/l = 15,889
Inside 1,000 ug/l = 1,551
Between 30-100 = 7,793
Between 100-1,000 = 14,338
N
Legend
Sample Station Location
Uranium Total < 65 pCi/g
Uranium Total > 65 pCi/g
Monitoring Well Location
U-Total < 30 ug/l
U-Total > 30 ug/l
1946 Drainage Ditch
Current Drainage Ditch
Former Building
AOC 2
Excavation Extent Contours
Uranium Total > 65 pCi/g
Extent of Excavation
4 ft. bgs
8 ft. bgs
12 ft bgs
Contour
Groundwater Isopleth (U-Total)
0 20 40 80
Scale (feet)
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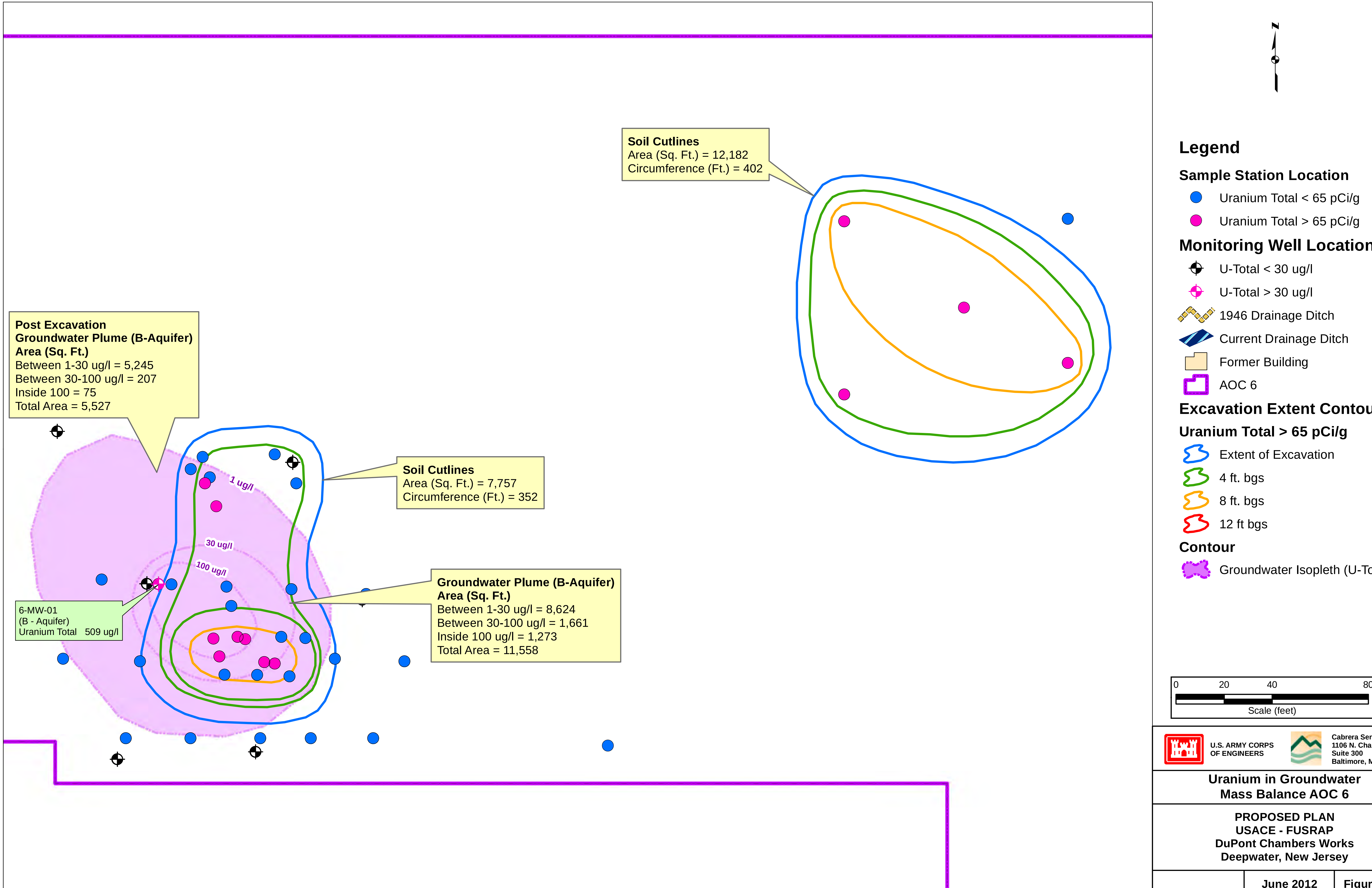
Uranium in Groundwater
Mass Balance AOC 2
PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey
June 2012
Figure 7-6



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Uranium in Groundwater Mass Balance AOC 6

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 7-7

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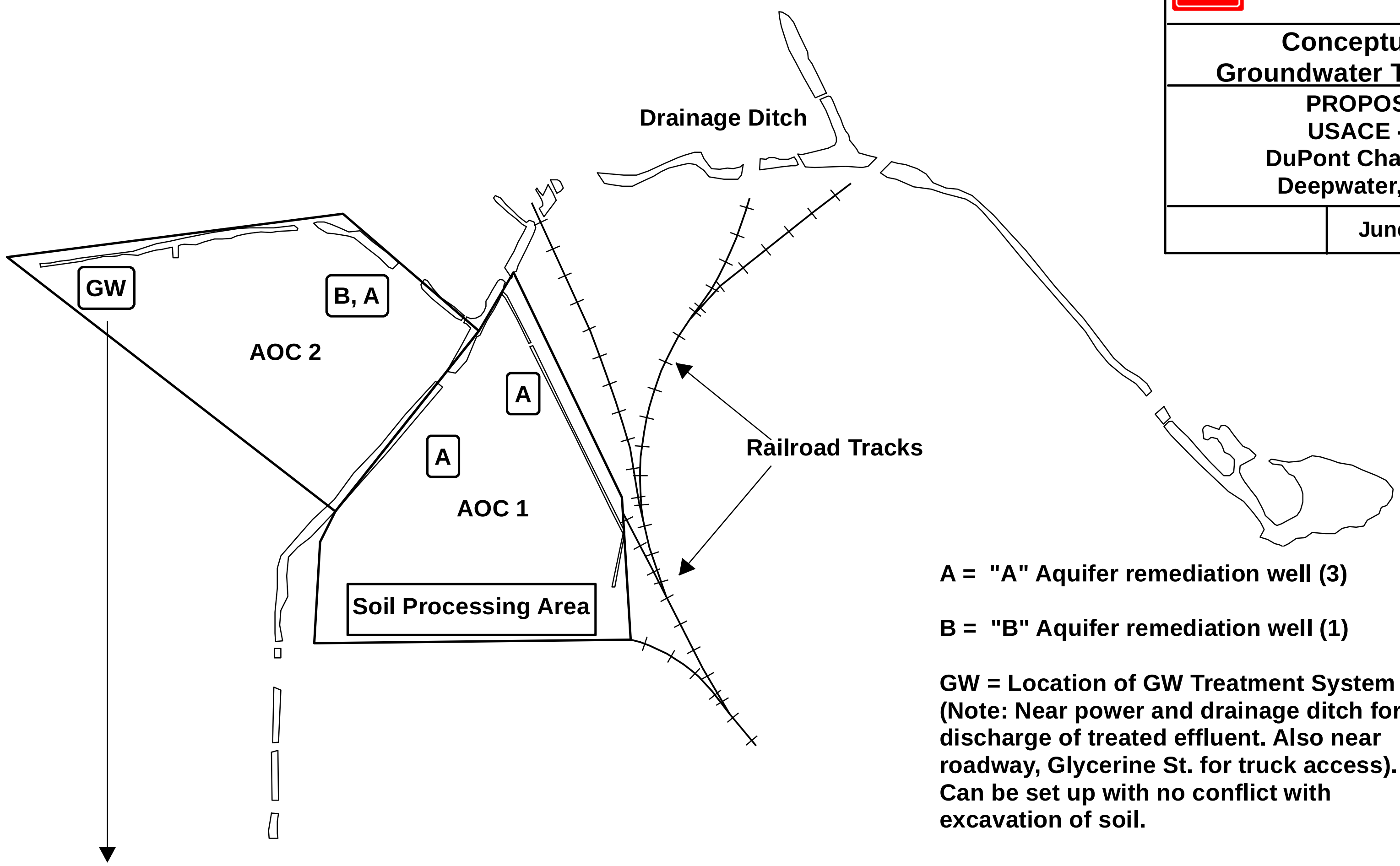
Conceptual Layout
Groundwater Treatment OU 1

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

	June 2012	Figure 7-8

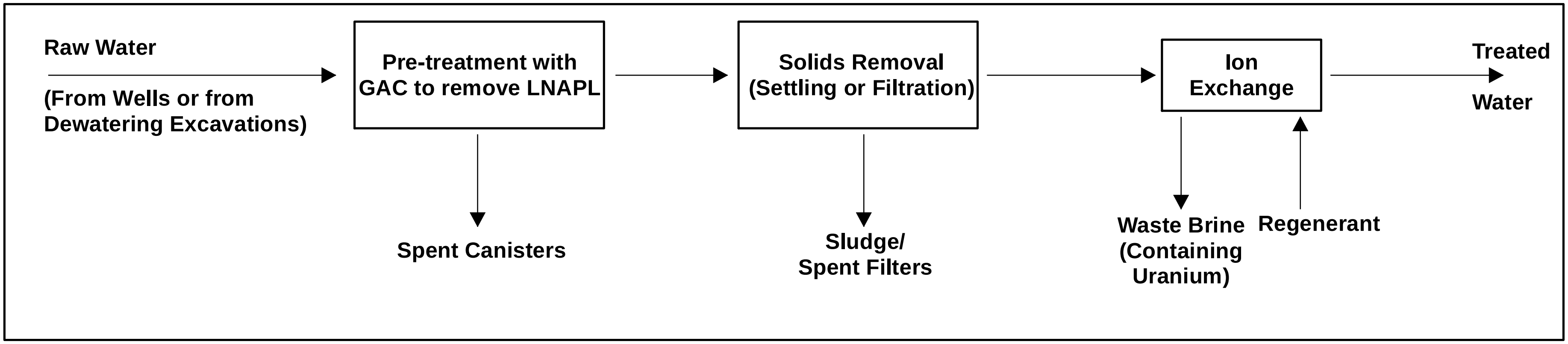


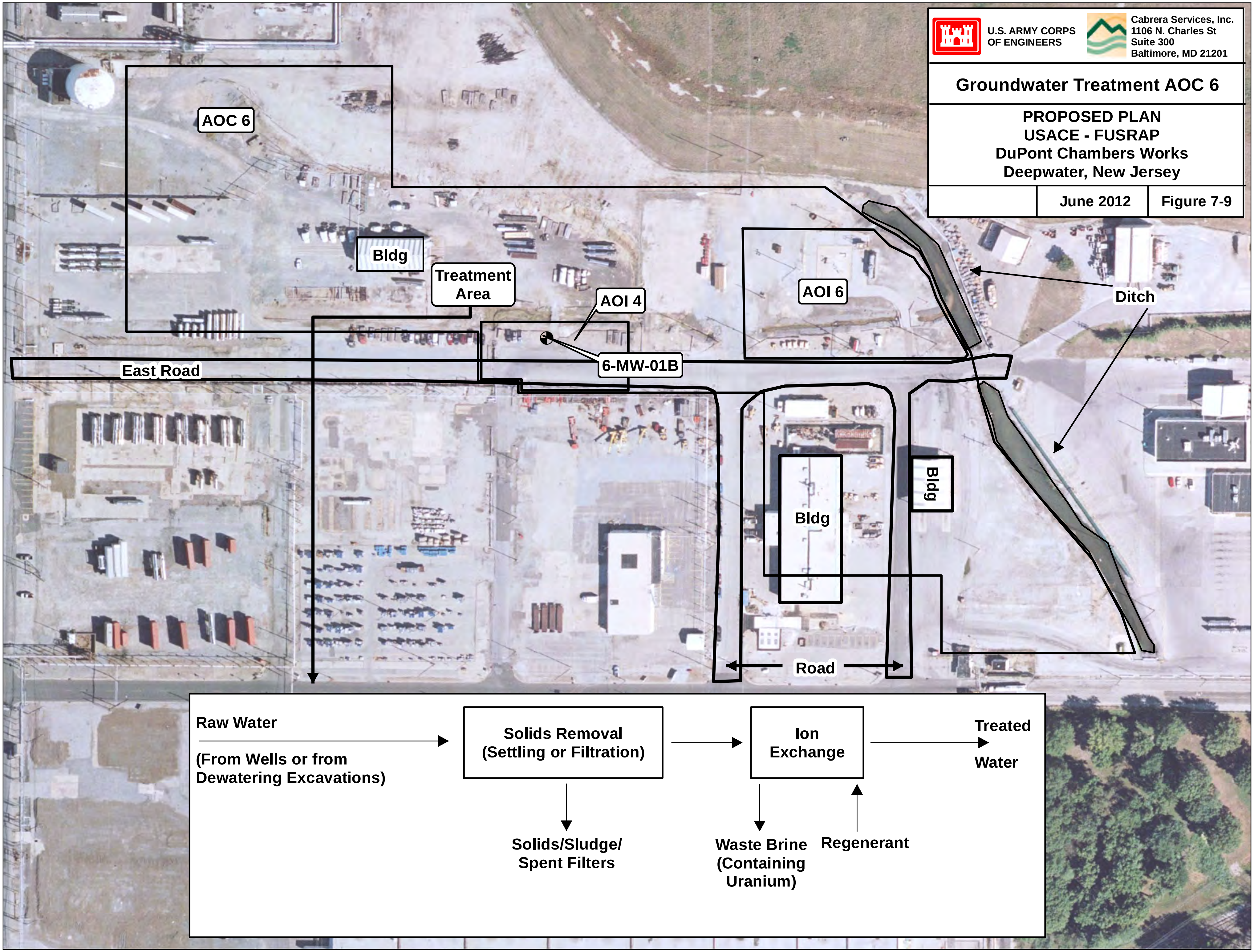
A = "A" Aquifer remediation well (3)

B = "B" Aquifer remediation well (1)

GW = Location of GW Treatment System (Note: Near power and drainage ditch for discharge of treated effluent. Also near roadway, Glycerine St. for truck access). Can be set up with no conflict with excavation of soil.

Ion Exchange





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Groundwater Treatment AOC 6
PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey
June 2012
Figure 7-9
AOC 6
Bldg
Treatment Area
AOI 4
AOI 6
Ditch
6-MW-01B
East Road
Bldg
Bldg
Road
Raw Water
(From Wells or from Dewatering Excavations)
Solids Removal (Settling or Filtration)
Ion Exchange
Treated Water
Solids/Sludge/ Spent Filters
Waste Brine (Containing Uranium)
Regenerant

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternative Provides Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance with Chemical-Specific ARARs
- Compliance with Action-Specific ARARs
- Compliance with Location-Specific ARARs
- Compliance with Other Criteria, Advisories, and Guidances

LONG TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment is Irreversible
- Type and Quanity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Actions
- Protection of Workers During Remedial Actions
- Environmental Impacts
- Time Until Remedial Action Objectives are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Actions, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals from Other Agencies
- Coordination with Other Agencies
- Availabilty of Offsite Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment and Specialist
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE* ACCEPTANCE

COMMUNITY* ACCEPTANCE

*Assessed following comment on RI/FS and PP.

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Detailed Anaysis Criteria for the Evaluation of Remedial Alternatives

PROPOSED PLAN
USACE - FUSRAP
DuPont Chambers Works
Deepwater, New Jersey

Figure 8 - 1