STATEMENT OF BASIS

FUEL STORAGE AREA NO. 1
SOLID WASTE MANAGEMENT UNIT NO. 57
45TH SPACE WING
CAPE CANAVERAL AIR FORCE STATION
BREVARD COUNTY, FLORIDA

PURPOSE OF STATEMENT OF BASIS

This Statement of Basis (SB) has been developed to inform the public and solicit comments on the proposed remedy for clean up of contamination at Fuel Storage Area No. 1 (FSA No. 1), Cape Canaveral Air Force Station (CCAFS). The 45th Space Wing (45th SW) installation restoration program (IRP) team, consisting of the National Aeronautics and Space Administration (NASA), the United States Air Force (USAF), United States Environmental Protection Agency (USEPA), and the State of Florida Department of Environmental Protection (FDEP), has determined that the proposed remedy is cost effective and protective of human health and the environment. Prior to implementation of the proposed remedy, the 45th SW IRP team is offering the public an opportunity to comment on the proposed remedy and the alternatives that were evaluated. At any time during the public comment period, comments may be submitted as described in the "How Do You Participate" section of this SB.

Brief Site Description

FSA No. 1 is located on the Samuel C. Phillips Parkway, between Lighthouse Road and Mission Control Road. FSA No. 1 is on United States Air Force property and is currently operated by the National Aeronautics and Space Administration.

The fenced portion of FSA No. 1 has been used for liquid fuel storage since the early 1950s. Present operations include the receiving, storing and dispensing of fuels and oxidizers, including anhydrous hydrazine, monomethyl hydrazine, unsymmetrical dimethyl hydrazine, Aerozine 50, nitrogen tetroxide, jet fuel, rocket propellant and hydrogen peroxide. Historically, additional site operations included management of inhibited red fuming nitric acid and Otto fuel.

The area immediately surrounding FSA No. 1 is uninhabited and naturally vegetated land, including some wetlands near the Banana River Lagoon.

Upon closure of the comment period, all comments and issues raised will be addressed and it will be determined whether there is a need to modify the proposed remedy prior to implementation.

WHY IS CLEANUP NEEDED?

The results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), along with subsequent investigations, indicated that volatile organic compounds (VOCs) are present in the groundwater at concentrations that could be potentially harmful to human health. Benzo(a)pyrene is present in the surface soil at concentrations that could be harmful to human health under residential land use scenarios.

The RFI also identified a number of contaminants present in soil or sediment at concentrations that posed a potential risk to ecological receptors and/or exceeded FDEP Industrial Soil Contaminant Cleanup Target Levels (CCTLs). Interim

The Clean-up Remedy

Soil and sediment interim measures (IM) to eliminate potential human health risks to industrial workers have already been completed. The proposed clean-up remedy for groundwater and soil at FSA No. 1 includes the following components:

- Monitored Natural Attenuation (MNA) of groundwater will be conducted to monitor the continued degradation of volatile organic compound (VOC) contaminants through natural processes.
- Land use controls will be implemented to prevent exposure to site contaminants. These controls include:
  - Prohibiting of residential development
  - Prohibiting on consumption of groundwater
  - Maintaining fencing
  - Periodic monitoring of groundwater to document water quality, plume stability, and contaminant levels.
  - Posting warning signs on-site

A complete list of land use controls and other protective measures are found in the proposed FSA No. 1 Land Use Control Implementation Plan (LUCIP).

In accordance with RCRA Section 7004(b), this Statement of Basis summarizes the proposed remedy for CCAFS FSA No. 1. For detailed information, consult the FSA No. 1 RFI or CMS Reports, which are available for review at the 45th SW Environmental Management Office (See "How Do You Participate") or on-line at http://www.mission-suppport.org/45SW_IRP_EA.

Measure (IM) soil removals were conducted following the RFI to remediate soils throughout the site to the industrial Soil CCTLs to ensure the safety of the aerospace workforce. These IM activities also remediated soil and sediment outside the fenceline to levels deemed safe for wildlife. Land within the fenceline was identified as poor quality ecological habitat due to a variety of factors, including human presence, traffic, and periodic mowing.

DEFINITIONS

For purposes of this SB, terms used herein shall have the same meaning as those in RCRA and 40 Code of Federal Regulations (CFR) Parts 124, 260, 261, 264, 268, and 270, unless this SB specifically provides otherwise. Where terms are not defined in the regulations, the CCAFS Hazardous and Solid Waste Amendments (HSWA) Permit, or USEPA guidelines or publications, the meaning associated with such terms shall be defined by a standard dictionary reference or the generally accepted scientific or industrial meaning of the term.

HOW DO YOU PARTICIPATE?

NASA, the USAF, USEPA, and FDEP solicit public review and comment on this SB prior to implementation of the proposed remedy as a final remedy. This SB is intended to highlight key information from the various site investigations and summarize the process used to select the final remedy, however the SB is not a substitute for those documents. For additional information on the investigation and remedy selection process at FSA No. 1, site documents can be consulted, as described in this section. The final remedy for FSA No. 1 will eventually be incorporated into the Hazardous and Solid Waste Amendments (HSWA) Permit for Cape Canaveral Air Force Station (CCAFS Permit No. 0070725-001-HO, 2005), issued by FDEP.

The public comment period for this SB and the proposed remedy will begin on the date that a notice of the SB's availability is published in a major local newspaper of general circulation. The comment period will end 45 days thereafter. All public comments will be addressed and, if warranted, the final remedy modified. If requested during the comment period, a public meeting to respond to any oral comments or questions regarding the proposed remedy will be held. To request a hearing or provide comments, contact the following person in writing within the 45-day comment period:

Mr. John R. Armstrong
FDEP-Bureau of Waste Cleanup
2600 Blair Stone Road, MS-4535
Tallahassee, FL 32399-2400
E-mail: john.armstrong@dep.state.fl.us
Telephone: (850) 245-8981

The HSWA Permit, the SB, and the associated administrative file including the RFI and subsequent reports will be available to the public for viewing and copying at:

Environmental Management, CEV
Facility 1638, Samuel Phillips Parkway
Cape Canaveral Air Force Station, FL
For public access call (321) 853-0965

This information can be found on-line at http://www.mission-support.org/45SW_IRP_EA.

The HSWA Permit, the SB, and FSA No. 1 RFI and CMS Report summaries will be available for viewing and copying at:

Central Brevard Library
308 Forrest Avenue
Cocoa, FL 32922

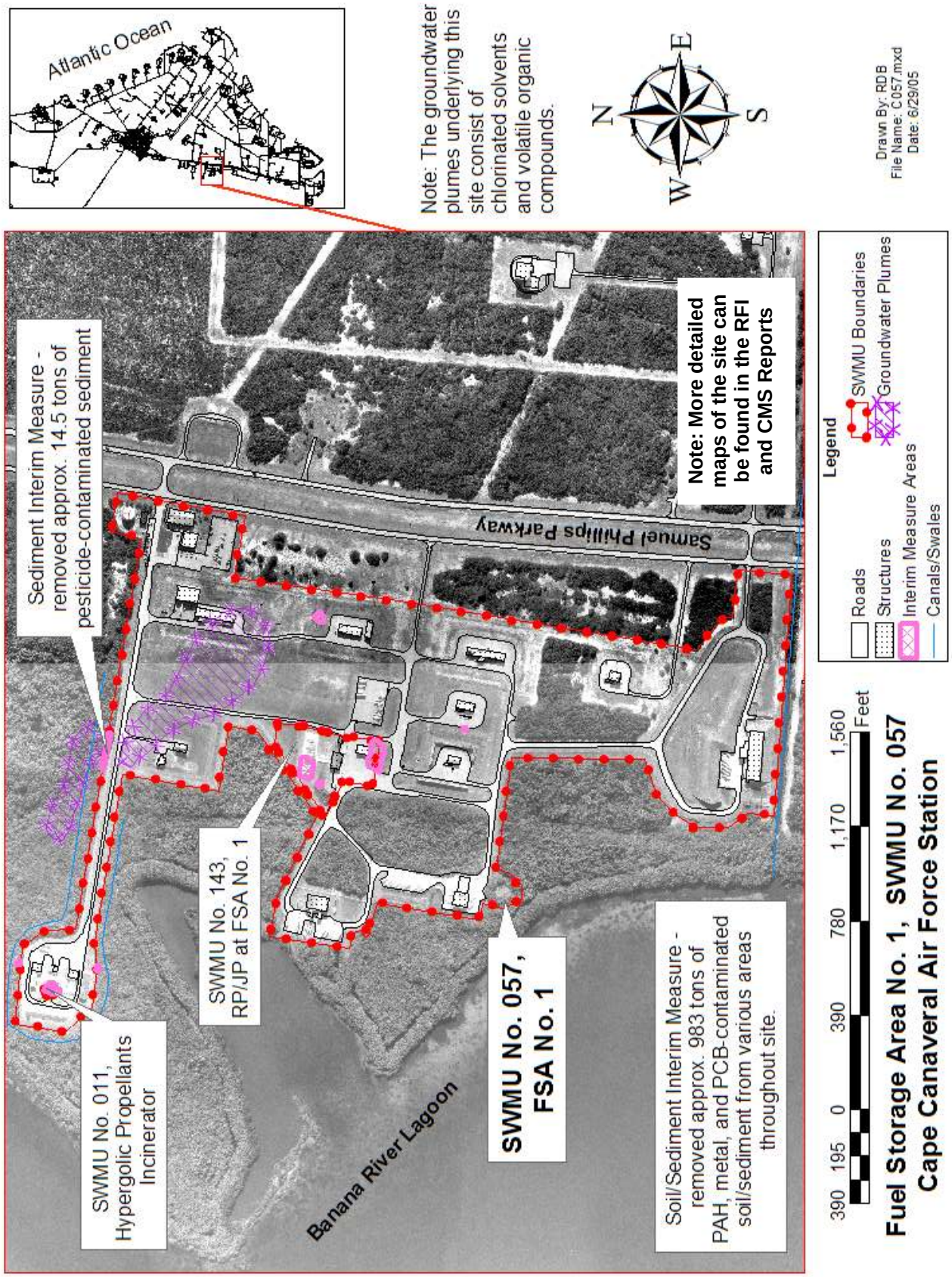
To request further information, you may contact one of the following people:

Mr. Patrick Giniewski
Environmental Restoration Element Chief
45 CES/CEVR
1224 Jupiter Street
Patrick Air Force Base, FL 32925-3343
E-Mail: patrick.giniewski@patrick.af.mil
Telephone: (321) 853-0965

Mr. John R. Armstrong
See previous contact information

Mr. Stephen Ball
EPA Federal Facilities Branch
Waste Management Division

FIGURE 1—FUEL STORAGE AREA NUMBER 1 (SWMU 057) SITE MAP



In accordance with RCRA Section 7004(b), this Statement of Basis summarizes the proposed remedy for CCAFS FSA No. 1. For detailed information, consult the FSA No. 1 RFI or CMS Reports, which are available for review at the 45th SW Environmental Management Office (See "How Do You Participate") or on-line at http://www.mission-suppport.org/45SW_IRP_EA.

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FACILITY DESCRIPTION

The USAF established the 45th SW as the primary launch site for the Department of Defense aerospace programs. Historically, NASA also performed space launch related operations on the 45th SW property. NASA continues to maintain and oversee certain operational areas on CCAFS, including FSA No. 1. These operations have involved the use of toxic and hazardous materials. Under the Resource Conservation and Recovery Act (RCRA) and the HSWA Permit (CCAFS Permit No. 0070725-001-HO) issued by the FDEP (2005), the 45th SW was required to perform an investigation to determine the nature and extent of contamination from Solid Waste Management Unit (SWMU) No. 57, FSA No. 1. Under a Memorandum of Agreement with the Air Force, NASA agreed to conduct environmental investigations at certain NASA-accountable sites located on CCAFS property that were suspected of having environmental contamination.

SITE DESCRIPTION AND HISTORY

SWMU No. 057, FSA No. 1, is located on USAF property and is currently operated by NASA. The facility is located on Samuel Phillips Parkway, between Lighthouse Road and Mission Control Road (See Figure 1). The site is presently used for industrial activities and continued industrial land use is anticipated in the future.

The FSA No. 1 facility encompasses an area of approximately 27 acres and has been utilized for liquid fuel storage since the early 1950's. Present-day operations at FSA No. 1 primarily focus on the receiving, storing, and dispensing of fuels and oxidizers, including anhydrous hydrazine, monomethyl hydrazine, unsymmetrical dimethyl hydrazine (UDMH), Aerozine 50, nitrogen tetroxide, jet fuel, rocket propellant, and hydrogen peroxide. Historically, other operations on the site included management of inhibited red fuming nitric acid (IRFNA) and Otto fuel.

The FSA No. 1 facility is currently operated as a secure, fenced facility under 24-hour per day guard. Access is restricted to trained or escorted personnel. The facility has a 50-year operational history and currently there are no plans to discontinue fuel-storage and hazardous operations in this area.

Two smaller SWMUs (SWMU Nos. 011 and 143) are located within the boundaries of FSA No. 1. Both have been separately assessed and are already approved for No Further Action.

SITE INVESTIGATION HISTORY

The following environmental assessment investigations have been conducted at FSA No. 1:

- 1993: Based on the use and storage of hazardous materials and potential for a release to the environment, the site was originally identified as an area of concern in 1993 through a Preliminary Assessment (PA). During the initial PA, eighteen potential release locations (PRLs) were identified within FSA No. 1. Fifteen of the PRLs were recommended for subsequent sampling to determine the presence or absence of contaminants in various environmental media.
- 1998: Confirmation Sampling included soil sampling, monitoring well installation and sampling, surface water sampling, and sediment sampling. Analysis indicated that constituents exceeded screening levels in groundwater, soil, and sediment. On this basis, an RFI was recommended to assess the nature and extent of contamination.
- 2000: An RFI was performed, detailing the sampling and analysis of site soil, groundwater, surface water, and sediment. These results were used to assess human health and ecological risks. A comparison to risk-based residential and industrial CCTLs indicated that potential human health risk existed from exposure to soil, sediment, and groundwater. The human health risk

assessment indicated that following an IM, remaining soil and sediment constituents would be safe under all but residential use scenarios. The ecological risk assessment indicated that potential unacceptable ecological risk existed from exposure to site soil and sediment contamination outside the fenceline. Based on the risk assessments, an IM was recommended to mitigate soil and sediment contamination and a Corrective Measures Study (CMS) was recommended to assess possible groundwater remedies.

- 2001: A Soil Removal IM Report documented the removal of soil impacted with polychlorinated biphenyls (PCBs) and metals and the sediments impacted by PCBs, semivolatile organic compounds (SVOCs) and metals. A total of 446.22 tons of industrial waste soil (<50 mg/kg PCBs) and 537.84 tons of Toxic Substance Control Act (TSCA) waste soil (>50 mg/kg PCBs) was removed.
- 2004: A Sediment Removal IM Report documented the removal of sediment impacted with pesticides in a canal located north of the north perimeter fence line. A total of 14.48 tons of pesticide-impacted sediment was removed. Following completion of this removal, sediment was approved for No Further Action.
- 2000–2005: A CMS was completed to determine the most appropriate remedy for mitigating the groundwater contamination. Groundwater contamination at the site consists of VOCs related to the use of chlorinated solvents. During the CMS, additional groundwater sampling was conducted and it was determined that there are actually two separate, groundwater plumes at the site. The CMS documented that natural attenuation processes are already working to control and reduce groundwater contamination. Monitored Natural Attenuation (MNA) was recommended as the most appropriate remedy to treat both plumes.

SITE ENVIRONMENTAL CONDITIONS

Soil, groundwater, surface water, and sediment are all present in the vicinity of the FSA No. 1 and have been sampled and characterized during the on-going investigation process.

Site Soil Conditions

The specific source of soil contamination at FSA No. 1 is unknown. Historically, paint used on metal structures at CCAFS was often formulated with PCBs to make it more weather and corrosion-resistant. Lead and other heavy metals were also common pigment additives during the same period. Routine sandblasting activities to maintain and refurbish painted structures often dispersed the PCB- and metal-laden paint particles throughout surface soils. Given the number of tanks and other metal structures at FSA No. 1, this is a likely source of PCB and metal contamination in soil.

Other soil contaminants at FSA No. 1 (metals and polynuclear aromatic hydrocarbons) are frequently found in industrial settings in Florida and may be associated with common man-made sources such as storm water run-off from paved areas, vehicle emissions, or pesticide application for mosquito control.

Site Groundwater

The RFI for FSA No. 1 identified a plume of chlorinated VOCs in groundwater beneath the site. The CMS subsequently determined that there are actually two plumes at the site. The South Plume is located within the fenced perimeter of the FSA No. 1 facility and extends in the direction of the second plume, the North Plume, which is located outside the FSA No. 1 facility fenceline. The South Plume covers approximately two acres, while the North Plume is approximately one acre in areal extent. Monitoring data indicates that both plumes appears to be stable and are not impacting the Banana River Lagoon.

The specific source of groundwater contamination has not been identified; however, it is probable that the groundwater contamination

resulted from solvent spills and/or runoff from equipment rinsing. In the past, chlorinated solvents were commonly used for cleaning and degreasing.

Analytical results suggest that reductive dechlorination may be responsible for the degradation and breakdown of trichloroethene (TCE) at FSA No. 1, resulting in the presence of daughter products such as dichloroethene (DCE) isomers and vinyl chloride (VC) in the plume at the site.

The present classification for groundwater at the site is listed in the Chapter 62-520 Florida Administrative Code (F.A.C.) Groundwater Classes, Standards, and Exemptions. This classification system establishes water quality standards and determines the present and future most beneficial uses of all groundwater of the state. Although there is no current use of groundwater at the site, it is classified as G-II and is considered a potable water source. Waters classified as G-II groundwater must meet the primary and secondary drinking water quality standards for public water systems established pursuant to Florida Safe Drinking Water Act, which are listed in Rules 62-550.310 and 62-550.320, F.A.C. These standards, which incorporate F.A.C. 62-777 by reference, are the regulatory driver for cleanup of groundwater at the site.

Site Surface Water and Sediment

A drainage canal that flows into a wetland system is present in the vicinity of the North Plume. The wetland system discharges into the Banana River Lagoon, an estuary system that is a Federally-designated "Manatee Sanctuary" and a State-designated "Outstanding Florida Water."

The most downgradient edge of the North Plume is located approximately 1,000 feet from the Banana River Lagoon. Unacceptable levels of contamination have not been detected in either surface water or sediment in the vicinity of this plume. So although the plume extends beneath a wetland area, it does not appear to have a significant impact on surface features; however, surface water will continue to be a consideration throughout the cleanup process to ensure that groundwater contaminants do not create adverse impacts on the surrounding environment.

As with soils, the specific source of sediment contamination at FSA No. 1 is not known. The nature and extent of sediment contamination indicates that the majority of contamination likely resulted from the dispersion of contaminated soil into site drainage features via runoff and rainfall.

Based on the findings of the ecological screenings conducted during the RFI and CMS, two IMs were conducted to remove sediments that exceeded ecological screening criteria and were located outside the perimeter security fence. Contaminants that were removed by these actions included polynuclear aromatic hydrocarbons (PAHs), pesticides, metals, and SVOCs.

SUMMARY OF SITE RISK

As part of the RFI activities, a baseline Human Health Risk Assessment (HHRA) and a screening level Ecological Risk Assessment (ERA) were conducted to estimate the health and environmental risks associated with the site-specific contamination. The risk assessments were performed in accordance with risk management decision processes established by NASA, the USEPA, FDEP, and the USAF at the time the RFI was initiated.

Human Health Risk Assessment

The HHRA assessed risk under both residential (potential future residents) and industrial (industrial worker, construction worker, trespasser) exposure scenarios to determine if a cleanup action was warranted under any land use scenario. The initial risk assessment was conducted under the RFI and included an assessment of the groundwater plume located inside the facility fenceline. During the CMS, an additional chlorinated solvent plume was identified outside the fenceline. A human health Preliminary Risk Evaluation (HHPRE) was performed to assess the supplemental data

collected under the CMS. Chemicals of Concern (COCs) for human health were identified during the RFI and CMS risk assessment process. During this process, IMs were completed to mitigate potential soil concerns. Following completion of IMs, remaining COCs that require further remediation or control are:

- Soil – benzo(a)pyrene,
- Groundwater – TCE, cis-DCE, methylene chloride, trichloromethane, and VC

Sediment at FSA No. 1 was not addressed in the RFI HHRA or the CMS HHPRE based on incomplete exposure pathways for all potential receptors. Surface water was not addressed in the original RFI HHRA based on incomplete exposure pathways for all potential receptors. Surface water was assessed during the CMS HHPRE. Mercury was initially identified as a COC based on concentrations detected in surface water; however, studies completed in Florida have indicated that the atmospheric deposition of mercury is a widespread anthropogenic concern. There is no apparent source of mercury at FSA No. 1, mercury has not been identified as a COC in any other environmental medium at the site, surface waters at the site are not readily accessible or routinely contacted by humans, and concentrations are consistent with atmospheric deposition throughout Florida. Based on these mitigating factors, mercury was not carried forward as a COC that required remedial action.

During preliminary RFI screening, PCBs in soil exceeded the FDEP industrial Soil CCTL and several metals exceeded other risk-based screening criteria. The HHRA completed during the RFI indicated that following removal of impacted soils, human health risk would be in the acceptable range (less than both the one in one million cancer threshold for human health risk and the noncarcinogenic hazard index target of 1.0) for all exposure scenarios.

Additional soil data was collected during the CMS and evaluated under the HHPRE included in the CMS Report. No noncarcinogenic compounds were identified in excess of PRE screening levels during CMS soil sampling. Arsenic was the only soil constituent that exceeded the one in one million (1/1,000,000) cancer threshold for human health risk during the CMS HHPRE; however, since the maximum concentration was only slightly above CCAFS background levels and the risk was within the one in one million (1/1,000,000) to one in ten thousand (1/10,000) range established by EPA, arsenic was not carried forward as a COC that required remedial action.

Following completion of the soil IM, benzo(a) pyrene remains in soil at concentrations that exceed the residential Soil CCTL, but are less than the industrial Soil CCTL. Since the Soil CCTLs are risk-based standards established by FDEP in order to protect human health under residential and industrial use scenarios, this contaminant was retained in this SB as a COC that requires a land use control to prevent residential development.

Under the RFI HHRA, groundwater posed a potentially unacceptable risk under several potential receptor scenarios, including: future industrial workers, future construction workers, and hypothetical future adult and child residents. A potentially unacceptable noncarcinogenic hazard was identified only under hypothetical future resident scenarios. The CMS HHPRE also identified potentially unacceptable carcinogenic risk and noncarcinogenic hazard from groundwater exposure.

The major contributors to carcinogenic risk were VC, TCE, and arsenic, while the major contributors to noncarcinogenic hazard were arsenic and cis-DCE. Arsenic was eliminated from further consideration as a COC because the maximum concentrations detected in groundwater at FSA No. 1 were well below the FDEP Groundwater CCTL which is a risk-based concentration that is deemed protective of drinking water resources.

Ecological Risk Assessment

A screening-level ERA was conducted to evaluate the potential risk posed by site contamination to common receptors including various freshwater and marine fish, birds, mammals, and reptiles. Initial RFI screening indicated that various contaminants including

metals, PAHs, SVOCs, and pesticides exceeded ecological screening criteria. On this basis, an IM was conducted to remove impacted soil and sediment. The CMS identified additional pesticide contamination in sediments outside the north fenceline and a second IM was conducted to eliminate the associated ecological risk.

WHAT ARE THE CLEANUP OBJECTIVES?

The ultimate goal is to be protective of human health and the environment. As such, the specific remedial action objectives are to:

1) Prevent unacceptable human contact with remaining site soils.
2) Ensure that residual, dissolved contamination in the groundwater continues to attenuate in an acceptable timeframe.
3) Protect humans from exposure to residual groundwater from the shallow aquifer [until COCs fall below health-based standards for unrestricted (residential) use].

WHAT ARE THE CLEANUP ACTION LEVELS?

The following definition is from the CCAFS HSWA Permit:

Action Levels are the Department's conservative health-based concentrations of hazardous constituents determined to be indicators for the protection of human health or the environment. Action Levels shall be set for all hazardous constituents, a subset of hazardous wastes, identified in the RFI Report(s) or for those hazardous constituents that the Department has reason to believe may have been released from a SWMU or Area of Concern (AOC) at the facility. Should the concentration of a hazardous constituent(s) in an aquifer, surface water, soils, or air exceed its Screening Level for any environmental medium, the Department may require that the Permittee conduct a Corrective Measure Study (CMS) to meet the requirements of HSWA Part V, Appendix C, and 40 CFR 264.101. If the Department determines that a constituent(s) released from a SWMU or AOC in quantities below its respective Screening Level(s) may pose a threat to human health or the environment, given site-specific exposure conditions, cumulative effects, ecological concerns, etc., then the Department has the authority to require a CMS to meet the requirements of HSWA Part V, Appendix C, and 40 CFR 264.101.

Action Levels shall be concentration levels, which satisfy the following criteria:

A.1. Is derived in a manner consistent with Department guidelines for assessing human and environmental health risks from hazardous constituents; and

2. Is based on scientifically valid studies conducted in accordance with the Toxic Substances Control Act (TSCA) Good Laboratory Practice Standards, or equivalent; and

3. For human health Action Levels to address carcinogens, represents a concentration associated with an excess upper bound lifetime cancer risk of $1x10^{-6}$ for carcinogens due to continuous constant lifetime exposure; and

4. For human health Action Levels to address systemic toxicants, represents a concentration to which the human population (including sensitive subgroups) could be exposed on a daily basis that is likely to be without appreciable risk of deleterious effects during a lifetime in accordance with Department procedures.

B. For constituent(s) detected in groundwater, air, surface water, or soils, for which a concentration level that meets the criteria specified in section I.A.1 through I.A.4 of this appendix is not available or possible, the Screening Level for the constituent(s) shall be the background concentration of the constituent(s).

The ground water at this site is classified as Class G-II and is considered a potable water source. Waters classified as Class G-II ground water shall meet the primary and secondary drinking water quality standards for public water systems established pursuant to the Florida Safe Drinking Water Act, which are listed in Rules 62-550.310 and 62-550.320, F.A.C.

These standards incorporate F.A.C. 62-777, the FDEP CCTLs, by reference. F.A.C. 62-777 also contains cleanup levels for soil, sediment, and surface water. Therefore, the clean up levels for the site generally are based upon FDEP CCTLs, F.A.C. 62-777, and are listed in Table 1.

Table 1 lists the COCs currently present at FSA No. 1 addressed as part of the CMS. The first column lists the chemical name, the second column lists the maximum concentration present in each environmental media at FSA No. 1 during past investigations, and the last column presents the site-specific clean-up levels to be achieved.

The soil cleanup levels reference only the residential cleanup standards. IMs have already successfully remediated all soil contamination to industrial Soil CCTLs. Currently, human exposure to site soils is, therefore, safe under industrial use scenarios. The residential Soil CCTL is the level that must be achieved for unrestricted re-use. The long term remedy for remaining soil contamination will focus on the implementation of land use controls. These controls will ensure that the site remains industrial in nature or that an additional cleanup action is conducted to achieve the residential Soil CCTL prior to residential land use.

Based on the risk assessment, it has been determined that these cleanup levels will be protective of human health and the environment. A Land Use Control Implementation Plan (LUCIP) will be prepared outlining the processes in place to protect human health and the environment from residual soil concerns while the land use of FSA No. 1 remains industrial and from groundwater.

Table 1— Cleanup Goals

Site-Related Chemicals of Concern (COCs)	Maximum Detected Concentration	Site-Specific Clean-up Level[1]
GROUNDWATER (in µg/L)		
cis-1,2-DCE	8,180	70
methylene chloride	197	5
TCE	2,380	3
trichloromethane	299	5.7
vinyl chloride	58,000	1
SOIL (in mg/kg)		
benzo(a)pyrene	0.2	0.1[2]

[1] Clean-up levels are based upon FDEP Contaminant Cleanup Target Levels (CCTLs), Florida Administrative Code 62-777.

[2] Residential Soil CCTL that must be met in order to receive approval for unrestricted land use. IMs have already removed any soil contamination that exceeded the Industrial Soil CCTL.

REMEDY SELECTION PROCESS

In accordance with the CCAFS HSWA permit and EPA guidance on developing a CMS and selecting a remedy (USEPA OSWER Directive 9902.3-2A), the IRP Team screened the corrective measure technologies to eliminate those that may prove infeasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably, or that do not achieve the corrective measure objective within a reasonable time period. This screening process focused on eliminating those technologies that had severe limitations for a given set of waste and site-specific conditions. The screening step may also eliminate technologies based on inherent technology limitations.

Each cleanup alternative was evaluated to determine how each potential remedy would comply with the four threshold criteria for corrective measures. The threshold criteria are used to determine if a remedial alternative meets the minimum requirements for consideration. If the proposed alternative fails to satisfy any of the threshold criteria, it is eliminated from consideration. The four threshold criteria for corrective measures are:

- Overall Protection of Human Health and the Environment;
- Attainment of Media Cleanup Standards;
- Source Control; and
- Compliance with Waste Management Standards.

There are five decision balancing criteria that are considered as appropriate by the IRP Team in selecting/approving a remedy once the remedy is determined to meet the threshold criteria listed above. These five decision balancing criteria are used when selecting a remedy during the corrective measures study and are listed in the CCAFS HSWA permit and EPA guidance (OSWER Directive 9902.3-2A). They include:

- Long-term reliability and effectiveness;
- Reduction in the toxicity, mobility or volume of wastes;
- Short-term effectiveness;
- Implementability; and,
- Cost

The decision balancing criteria are also summarized in an EPA Fact Sheet (Directive 9355-3-01 FS3) titled *The Feasibility Study-Development and Screening of Remedial Action Alternatives).* The decision balancing criteria are used to focus the selection of a remedial alternative on a final remedy that considers practical, technical and economic factors.

SOIL CLEANUP ALTERNATIVES

A soil and sediment IM was completed in response to the RFI to mitigate potential unacceptable human health and ecological risk. Subsequently, an additional sediment IM removed pesticide-impacted sediment [4,4-dichlorodiphenyldichloroethane (DDD)] that was identified as a potential ecological risk during the CMS. No unacceptable ecological risk remains at the site, and since the soil IM was completed to FDEP Industrial Soil CCTLs, remaining soil contamination would only pose an unacceptable risk under residential land use scenarios. It is anticipated that land use at the site will remain industrial for the foreseeable future. Based on this data, Land Use Controls were identified as the default soil remedy in the CMS.

A LUCIP will be prepared outlining the processes in place to protect human health and the environment while the land use of FSA No. 1 remains industrial.

GROUNDWATER CLEANUP ALTERNATIVES

Clean-up alternatives are different combinations of plans to restrict access, contain, remove, and treat contamination in order to protect public health and the environment. Since two plumes with different site cleanup considerations have been identified at FSA No. 1, each plume was evaluated independently with regard to the potential corrective measure alternatives. Since contamination in groundwater exceeds cleanup goals, Land Use Controls must be implemented as part of any selected groundwater cleanup action to ensure continued protection of human health and the environment. These controls will restrict groundwater use and minimize groundwater contact. The specific constraints and control mechanisms will be documented in the LUCIP.

The cleanup alternatives considered for groundwater at FSA No. 1 are summarized below.

South Plume

***No Action*:** The No Action alternative is included as a benchmark for the evaluation of other alternatives. Due to the presence of contaminated media above acceptable regulatory levels, the No Action alternative does not meet the threshold criteria discussed earlier or the corrective measure objectives. Consequently, additional consideration is not given to this alternative. There is no cost associated with this alternative.

Air sparging: Air sparging is a technique used for the remediation of VOCs dissolved in the groundwater, sorbed to the saturated zone soils, and trapped in the soil pores of the saturated zone. A typical air sparging system has one or more subsurface points through which air (or another gas) is injected below the water table in order to volatilize the contaminants. As the gas

passes through the subsurface, volatile contaminants may partition into the gas phase. Vacuum extraction systems are often employed to extract the air (or other gas) and the associated contaminants from the subsurface.

The effectiveness of air sparging is limited by the heterogeneity of subsurface conditions and depth of contamination. An air sparge pilot test was completed for Facility 1381, Cape Canaveral Air Force Station (CCAFS) in 1998. The conclusions drawn from the pilot test indicated that air sparging might be applicable for chlorinated solvent groundwater contamination even at depths up to 50 feet.

It is unlikely that air sparging alone, would be capable of meeting the desired cleanup levels. A period of MNA also would be required to meet cleanup goals. The estimated cost for the implementation of this alternative is $999,836 over a 10-year period.

Monitored Natural Attenuation: MNA relies upon subsurface processes such as advection, dispersion, diffusion, volatilization, biodegradation, adsorption and chemical reactions with subsurface materials to reduce contaminant concentrations to acceptable levels. Typically, evaluation of this alternative is supported by modeling contaminant degradation rates and pathways. The objective of site modeling is to evaluate and demonstrate natural processes of contaminant degradation and their ability to reduce contaminant concentrations below regulatory standards before potential exposure pathways are completed. In addition, sampling and data analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with cleanup projections.

At FSA No. 1, the fate and transport model indicates that the plume is stable. No exposure pathways currently exist for current human or ecological receptors. Moreover, any potential transport of contaminants due to advection is toward a more concentrated plume outside the fenced perimeter (North Plume). The duration of MNA is dependent upon the site-specific contaminant degradation rates and half-lives. Modeling indicates that employing MNA as a stand-alone remedy will achieve Groundwater CCTLs in approximately 40 years within the South Plume at FSA No. 1. The estimated cost for the implementation of this alternative is $414,903.

Enhanced Biological Remedies: Nutrient addition is the process of using nutrients, oxygen or other amendments to enhance bioremediation and contaminant desorption from subsurface soils. Because of the persistent cis-1,2-DCE plume, oxygen is the most appropriate nutrient additive to create an aerobic environment that will possibly stimulate native bacteria to enhance the degradation of cis-1,2-DCE. The addition of other nutrients or microbes may be necessary if aerobic conditions alone are not sufficient to degrade cis-1,2-DCE. Various technologies can be used to deliver oxygen to the groundwater including iSOC^{TM}, ozone, hydrogen peroxide, or biosparge.

Due to the costs of ozone and hydrogen peroxide applications, the utilization of the site as an active fuel storage area, and the special handling requirements for oxidant type technologies, these two technologies were not retained for further consideration.

Biosparging represents a lower cost method of introducing oxygen into the subsurface. Biosparging is similar to air sparging except that the focus is to promote biological degradation without physical removal (i.e. volatilization). In biosparging, air (or oxygen) and nutrients (if needed) are injected into the saturated zone to increase the biological activity of the indigenous microorganisms. The estimated cost for the implementation of this alternative is $624,106 over a 10-year period.

The iSOC^{TM} technology delivers oxygen and an alkane gas to the groundwater treatment area. This aerobic treatment stimulates native soil bacteria by adding oxygen and a growth substrate, triggering the production of enzymes that can oxidize the target pollutant. The estimated cost for the implementation of this alternative is $1,212,025 over a 10-year period.

North Plume

***No Action*:** The No Action alternative is included as a benchmark for the evaluation of other alternatives. Due to the presence of contaminated media above acceptable regulatory levels, the No Action alternative does not meet the threshold criteria discussed earlier or the corrective measure objectives. Consequently, additional consideration is not given to this alternative. There is no cost associated with this alternative.

***Physical Remedies*:** Physical remedy alternatives, such as air sparging and pump and treat would be intrusive and disruptive and would likely impact the wetland's ecosystem by the noise, habitat destruction, aeration of hydric soils, and increased sedimentation in the surface water. Based on these considerations, physical remedies were not retained for further consideration.

***Chemical Remedies*:** Chemical remedy alternatives, such as chemical oxidation have the potential for process-induced detrimental effects to the wetland system. In addition, remediation without disruption of the wetland system poses a logistical problem related to implementation and adequate delivery of the oxidant. Therefore, chemical remedy alternatives were not retained for further consideration.

***Biological Remedies*:** Biological remedy alternatives include wetland treatment/MNA, nutrient addition, cometabolism, and bioaugmentation. Nutrient addition, cometabolism, and bioaugmentation are also classified as enhanced bioremediation technologies. Most enhanced bioremediation technologies were not retained for further consideration because any enhancement would likely interfere with the balance of the wetland's natural ecosystem and established biological processes. Biosparging was retained for further evaluation as the enhanced bioremediation technology least likely to negatively impact the wetland environment; however any additive could upset the delicate balance of biological processes that are already at work in the North Plume.

Recent research suggests that natural attenuation may be an effective remediation option for chlorinated solvents in wetland systems. Although chlorinated solvents can be resistant to degradation within some aquifer systems, rapid and complete transformations can occur within the organic-rich reducing environments typical of wetland sediments (USGS 2002). At FSA No. 1, degradation is occurring within the wetland system as demonstrated by the presence of several orders of TCE degradation products.

In addition to the organic-rich reducing environment found in the wetland sediments, phytoremediation can also be an effective part of the remediation process in wetlands. Studies conducted at Kennedy Space Center and CCAFS have shown that native plants, such as willows, Brazilian pepper and saw palmetto contribute to phytoremediation and natural attenuation. The plants contribute to the mineralization of the parent VOCs by supplying plant exudates and oxygen. The plant exudates (i.e. phenols, benzoic acid, acetate) attract and sustain the growth of anaerobic bacteria that are known to enhance natural attenuation. In addition, the native plants uptake and phytodegrade or volatilize the VOCs, as evident from plant tissue studies.

The duration of MNA is dependent upon the site-specific contaminant degradation rates and half-lives. Modeling indicates that employing wetland treatment/MNA as a stand-alone remedy will achieve Groundwater CCTLs in approximately 50 years within the North Plume at FSA No. 1. The estimated cost for the implementation of natural wetland treatment/MNA is $441,924. The estimated cost for the implementation of Biosparging is $624,106 over a 10-year period.

EVALUATION OF REMEDY ALTERNATIVES

Several of the alternatives, including the No Action option, physical remedies and chemical remedies were eliminated due to their failure to meet the threshold criteria. Each of the remaining cleanup alternatives were evaluated

Table 2—Ranking of Performance of Alternatives for South Plume (Scale of 1 to 4)

	Alt 1	Alt 2	Alt 3	Alt 4
Balancing Criteria	Air Sparging	Monitored Natural Attenuation	Biosparging	iSOC™
Long term reliability and effectiveness	2.5	2.5	2.5	2.5
Reduction in the toxicity, mobility, or volume of wastes	2.5	2.5	2.5	2.5
Short term effectiveness	4	1	2	3
Implementability	2	4	3	1
Cost	2	4	3	1
Total Score	**13**	**14**	**13**	**10**

Note: Scoring was conducted on a sliding scale where 1 was assigned to the technology believed to be the least effective and a 4 assigned to the technology believed to be the most effective.

against the five corrective action balancing criteria to determine the preferred final remedy.

NASA, the USAF, USEPA, and FDEP developed a scoring system to objectively evaluate each alternative that met the threshold criteria against the balancing criteria. Each of these balancing criteria were weighted evenly and were numerically scored. The scores for all five criteria were then totaled for each cleanup alternative. The highest score thus indicates the most preferable cleanup alternative. Tables 2 and 3 illustrate the evaluation of the various alternatives against the decision balancing criteria for the South Plume and North Plume, respectively.

South Plume

Contaminants in the South Plume, DCE and TCE, were detected at concentrations approximately an order of magnitude greater than FDEP Groundwater CCTLs. Geochemical data was tabulated and scored in accordance with the methodologies presented in the USEPA document titled, *"Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater."* Monitoring well data presented either limited or adequate evidence for anaerobic biodegradation. In addition, during the latest round of groundwater sampling, cis-1,2-DCE and TCE groundwater concentrations were within the FDEP's Natural Attenuation Default Criteria. The current groundwater fate and transport model indicates that Groundwater CCTLs will be achieved in 20 years for TCE and 40 years for cis-1,2-DCE through the natural attenuation processes that presently exist at the site.

Table 3—Ranking of Performance of Alternatives for North Plume (Scale of 1 to 2)

	Alt 1	Alt 2
Balancing Criteria	Monitored Natural Attenuation	Biosparging
Long term reliability and effectiveness	1.5	1.5
Reduction in the toxicity, mobility, or volume of wastes	1.5	1.5
Short term effectiveness	1	2
Implementability	2	1
Cost	2	1
Total Score	**8**	**7**

Note: Scoring was conducted on a sliding scale where 1 was assigned to the technology believed to be the least effective and a 2 assigned to the technology believed to be the most effective.

FSA No. 1 is a secure, active fuel storage area and access to the site is restricted and controlled by a fenced and monitored perimeter. The facility has a 50-year operational history and there are no plans to discontinue fuel storage or hazardous operations in the foreseeable future. Additionally, the site groundwater is not used. Therefore, based on current site conditions, the plume poses a minimal risk to human health or ecological receptors.

Logistics and safety considerations heavily favor implementing a passive remedial solution at this hazardous, secure facility. Other remedies, such as air sparging or iSOC™, might have a greater short term effectiveness than MNA, but have significant implementability issues in the form of logistics and safety, as discussed above. The other alternatives were also considerably more expensive than MNA. Therefore, MNA was selected as the most appropriate, cost efficient, reliable and easiest to implement technology.

North Plume

TCE and degradation products were detected in the wetland system north of the FSA No. 1 perimeter fence. Data collected at the site indicates the plume is stable and currently shrinking in areal extent. The site characterization data shows the plume is fully delineated, vertically and horizontally. Natural attenuation enhanced by organic-rich sediment and phytoremediation processes is naturally occurring within the wetland system. The current model indicates that Groundwater CCTLs will be achieved in 35 years for TCE, 16 years for cis-1,2-DCE, and 50 years for vinyl chloride through the natural processes that presently exist.

Based on current site conditions, the plume poses minimal risk to human health or ecological receptors. As evidenced from the investigation of the wetland system, access for vehicles and machinery necessary to implement enhanced bioremediation would be difficult and it is probable that adequate delivery of the enhancement could not be achieved without some wetland destruction. MNA would be less intrusive and disruptive and less likely to impact the wetland's ecosystem by noise, habitat destruction, hydric soil aeration, or increased sedimentation in the surface water. Therefore, MNA was selected as the most appropriate, cost effective, reliable, and easiest to implement technology.

LAND USE CONTROLS

In accordance with the CCAFS HSWA permit, a land use control is defined as any restriction or control, arising from the need to protect human health and the environment that limits use of or exposure to any portion of that property, including water resources. The term land use control (LUC) encompasses and is used interchangeably with the term "institutional controls." LUCs can include engineering controls, such as fences, or non-engineered controls. Non-engineered controls include estate interests, governmental permitting, zoning, public advisories, and deed notices. Considered altogether, the "LUCs" for a site, in conjunction with the Base Master Plan, will provide a blueprint for how its property shall be used in order to enforce the level of protectiveness which one or more remedial/corrective actions were designed to achieve.

The HSWA permit states that where Land Use Controls comprise part of the final remedy, the USAF shall prepare and submit a LUCIP as part of, appended to, or in lieu of a Corrective Measures Implementation (CMI) Work Plan. The permit provisions that apply to the CMI Work Plan apply to any such LUCIP. The LUCIP would provide detail and specific measures required for the Land Use Controls selected, including establishing, implementing, monitoring, maintaining, reporting, and enforcing requirements for the unit. This CMI Work Plan must be approved by FDEP prior to implementation.

In order to effectively manage the site following corrective measure implementation, the Base would implement land use controls and develop a site-specific LUCIP as outlined above. A LUC would be implemented for soils and limit the use of groundwater while contamination exceeds CCTLs. In general, the USAF conducts the following activities to ensure the LUC remedy is protective of human health and the environment:

- Note the LUCIP and LUC requirements in the Base General Plan (BGP). (The BGP is similar to a city's master plan and includes future zoning and building areas. The BGP is reviewed prior to siting of new buildings and building additions).
- Add LUC and LUCIP requirements to installation real property records. This is

conducted to place a restriction on a property's use. While deed restrictions and restrictive property covenants are used for private properties, they are not used on active Air Force installations.

- Install physical structures and signs, where required, to limit access to the site. Conduct periodic inspection of LUC sites to ensure any physical requirements are maintained.
- Brief the Facilities Use Board, the Environmental Protection Committee, and Installation Commander on the LUC requirements.
- Review all projects requiring intrusive work (e.g. construction) via an AF Form 103 (dig permit), AF Form 332 (Base Civil Engineer Work Approval), and AF Form 813 (Environmental Assessment) for impacts to LUCs on sites.
- Develop a LUC Management Plan that outlines LUC processes, roles, and responsibilities of key installation personnel.

Specific details of how the LUC will be implemented will be documented in the FSA No. 1 Land Use Control Implementation Plan. The 45th Space Wing, Civil Engineering Squadron, Environmental Flight is responsible for implementing, monitoring, maintaining, and reporting on the Land Use Controls in accordance with the LUCIP.

WHAT IMPACTS WOULD THE CLEANUP HAVE ON THE LOCAL COMMUNITY?

There would be no impacts to the surrounding communities during the cleanup phase because groundwater underlying the site currently is not used for potable water and the site is located in an industrial setting at CCAFS. Because of the potential for future potable use of groundwater or future residential land use, all soil or ground water that exceeds cleanup goals following implementation of this action will have land use controls to ensure continued protection of human health and the environment. Any change in future site use that would utilize, impact, or create a potential exposure pathway to contaminated soil or groundwater would be evaluated by NASA, the USAF, USEPA, and FDEP to determine if any further cleanup action would be required.

WHY DOES THE 45th SW INSTALLATION RESTORATION PARTNERING TEAM RECOMMEND THIS REMEDY?

The IRP Team (NASA, USAF, USEPA, and FDEP) recommends this remedy (Monitored Natural Attenuation with LUCs) because it meets the threshold and decision balancing criteria and has been identified as being the most cost effective, safely implemented, and reliable technology available for remediation of the dissolved groundwater contamination.

An efficient process is needed to reduce high concentration dissolved phase VOCs in groundwater at FSA No. 1. Based on data collected throughout the RFI and CMS, natural attenuation appears to be working to control the groundwater plume and reduce contaminant concentrations. LTM for MNA will be used to assess and document long term reduction in contaminant concentrations to the cleanup goals, while land use controls will prevent unacceptable exposure to contaminants prior to the cleanup levels being achieved.

Soil contamination at the site has already been remediated to levels safe for an industrial setting. Outside the fenceline, soil and sediment contamination were further remediated to ecologically safe concentrations. Land use controls should be effective in preventing land use scenarios that might result in unacceptable future human exposure or allow the development of significant ecological habitat within the fenceline.

The proposed combination of soil and groundwater remedies meets the four threshold criteria for corrective measures and best balances the practical, technical, and economic factors that must be considered.

NEXT STEPS

NASA, the USAF, USEPA, and FDEP will review all comments on this SB to determine if the proposed remedy needs modification prior to implementation and prior to incorporating the proposed remedy into the CCAFS HSWA permit. If the proposed remedy is determined to be appropriate for implementation, then the final remedy will be implemented as follows:

1) Long Term Monitoring for Natural Attenuation will be conducted until groundwater contaminant levels are less than the Groundwater CCTLs for two consecutive sampling rounds. MNA of groundwater for VOCs will be periodically evaluated against projected/estimated reduction milestones.

2) Land Use Controls will be implemented concurrent with MNA to prevent residential land use scenarios at the site and to restrict groundwater contact and consumption. A Land Use Control Implementation Plan will be developed.

3) The site conditions will be evaluated periodically, to provide a comparison for the predictive model and ensure that groundwater contaminant levels are satisfactorily declining.

4) Additional remedial measures may be considered during annual or five-year reviews, if the proposed groundwater remedy has not effectively reduced dissolved groundwater contaminant concentrations.