FINAL

# FEASIBILITY STUDY FOR THE
# SHALLOW LAND DISPOSAL AREA SITE
# PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA


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**PREPARED FOR:**

**DEPARTMENT OF THE ARMY**

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## ACRONYMS, FORMULAS, AND SYMBOLS

| | |
|---|---|
| AEC | United States Atomic Energy Commission |
| ALARA | As Low As Reasonably Achievable |
| Am | Americium |
| ANL | Argonne National Laboratory |
| ARAR | Applicable or Relevant and Appropriate Requirements |
| ARCO | Atlantic Richfield Company |
| BCG | Biota Concentration Guideline |
| bgs | Below Ground Surface |
| BNL | Brookhaven National Laboratory |
| BRA | Baseline Risk Assessment |
| B&W | Babcock and Wilcox |
| BWXT | BWX Technologies |
| CDM | Camp, Dresser, & McKee, Inc. |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| cm/s | Centimeter per Second |
| Cs | Cesium |
| $m^3$ | Cubic Meters |
| $yd^3$ | Cubic Yards |
| DOD | United States Department of Defense |
| DOE | United States Department of Energy |
| EIS | Environmental Impact Statement |
| EPA | United States Environmental Protection Agency |
| E&SCP | Erosion and Sedimentation Control Plan |
| EU | Exposure Unit |
| FS | Feasibility Study |
| ft/day | Foot per Day |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| GRA | General Response Action |
| HEPA | High-Efficiency Particulate Air |
| HI | Hazard Index |

## ACRONYMS, FORMULAS, AND SYMBOLS – cont'd

| | |
|---|---|
| IAEA | International Atomic Energy Agency |
| LLW | Low-Level Radioactive Waste |
| MARSSIM | Multi-Agency Radiation Survey and Site Investigation Manual |
| MED | Manhattan Engineer District |
| MOU | Memorandum of Understanding |
| mrem/yr | Millirem per Year |
| 8-OH | 8-Hydroxyquinoline |
| MSL | Mean Sea Level |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NCRP | National Council on Radiation Protection and Measurements |
| NMDR | Nuclear Material Discard Report |
| NMSS | Nuclear Material Safety and Safeguards |
| NRC | United States Nuclear Regulatory Commission |
| NUMEC | Nuclear Materials and Equipment Corporation |
| O&M | Operation and Maintenance |
| ORAU | Oak Ridge Associated Universities |
| ORNL | Oak Ridge National Laboratory |
| PADEP | Pennsylvania Department of Environmental Protection |
| pCi/g | picoCuries per gram |
| pCi/L | picoCuries per liter |
| Pu | Plutonium |
| PP | Proposed Plan |
| PPE | Personal Protective Equipment |
| PRG | Preliminary Remediation Goal |
| PVC | Polyvinyl Chloride |
| Ra | Radium |
| R&D | Research and Development |
| rad/d | Radiation Absorbed Dose Per Day |
| RAO | Remedial Action Objective |
| RCRA | Resource Conservation and Recovery Act |
| redox | Oxidation/Reduction |

## ACRONYMS, FORMULAS, AND SYMBOLS – cont'd

| | |
|---|---|
| RESRAD | Residual Radioactivity |
| RI | Remedial Investigation |
| ROC | Radionuclide of Concern |
| ROD | Record of Decision |
| ROPC | Radionuclide of Potential Concern |
| SARA | Superfund Amendments and Reauthorization Act |
| SLDA | Shallow Land Disposal Area |
| SLERA | Screening Level Ecological Risk Assessment |
| SNM | Special Nuclear Material |
| SOR | Sum of Ratios |
| S/S | Solidification/Stabilization |
| SVOC | Semivolatile Organic Compound |
| TBC | To Be Considered |
| TBP | Tributyl Phosphate |
| TCE | Trichloroethene |
| TEDE | Total Effective Dose Equivalent |
| Th | Thorium |
| TPP | Technical Project Planning |
| TSDF | Treatment, Storage, and Disposal Facility |
| TWSP | Temporary Waste Sampling Point |
| U | Uranium |
| URS | URS Corporation |
| USACE | United States Army Corps of Engineers |
| USDOT | United States Department of Transportation |
| VOC | Volatile Organic Compound |
| WAC | Waste Acceptance Criteria |

# FINAL

# FEASIBILITY STUDY FOR THE SHALLOW LAND DISPOSAL AREA SITE PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA

## EXECUTIVE SUMMARY

### Introduction

The Shallow Land Disposal Area (SLDA) is a 44-acre site in Parks Township, Armstrong County, Pennsylvania, about 23 miles east-northeast of Pittsburgh, Pennsylvania. The site contains nine trenches and a backfilled settling pit (referred to as trench 3) that were used for the disposal of radioactive waste generated by Nuclear Materials and Equipment Company (NUMEC) between 1961 and 1970. NUMEC operated the nearby Apollo nuclear fuel fabrication facility beginning in the late 1950s to convert enriched uranium to naval reactor fuel. Waste from this facility was disposed of in the trenches at the SLDA in accordance with the United States Atomic Energy Commission (AEC) regulation in effect at the time, 10 CFR 20.304 (this regulation was rescinded in 1981).

In 1967, the Atlantic Richfield Company (ARCO) purchased the stock of NUMEC. In 1970, NUMEC discontinued use of the SLDA for radioactive waste disposal. In 1971, the Babcock & Wilcox Company (B&W) acquired NUMEC. In 1997, BWX Technologies, Inc. (BWXT) assumed ownership of the SLDA as well as the Apollo and Parks properties. Until 1995, the SLDA site was included under a license issued by the United States Nuclear Regulatory Commission (NRC) for the adjacent Parks nuclear fuel fabrication facility (Spent Nuclear Material [SNM]-414). In 1995, to facilitate the decommissioning of the Parks facility, the SLDA site was issued a separate license (SNM-2001). BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of NRC License SNM-2001.

### Authority

In Public Law 107-117, Section 8143(a)(2) (Jan. 10, 2002), Congress authorized The United States Army Corps. Of Engineers (USACE) to “cleanup radioactive waste” at the SLDA, consistent with the Memorandum of Understanding (MOU) between USACE and the NRC dated

July 5, 2001, and subject to Public Law 106-60, Section 611, subsections (b) through (e). This legislation, in Section 8143(b), also directed USACE to seek to recover response costs incurred for the cleanup of SLDA from responsible parties in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 USC 9601 et seq., and authorized the use of Formerly Utilized Sites Remedial Action Program (FUSRAP) appropriations for these purposes in Section 8143(c). Section 611 of P.L. 106-60 provides programmatic authority to USACE to select and conduct response actions at designated FUSRAP sites, subject to and in accordance with CERCLA and the National Contingency Plan, 40 CFR Part 300 (NCP). CERCLA and the NCP provide a process for characterizing the nature and extent of releases of hazardous substances, such as radionuclides, evaluating alternatives for remedial actions, proposing and considering state and public comments on a remedial action, and deciding upon and carrying out the remedial action. The MOU was entered into by USACE and the NRC to provide a process for interagency coordination on FUSRAP sites where the NRC has an existing regulatory responsibility in the form of an Atomic Energy Act license. The MOU is intended to address issues of coordination and public health and safety oversight during the course of FUSRAP remedial action work after the issuance of a FUSRAP Record of Decision (ROD) selecting a remedy. The MOU provides an established procedure for interagency consultation if the decommissioning criteria at 10 CFR Section 20.1402 are determined to be an Applicable or Relevant and Appropriate Requirement (ARAR) for the site. If 10 CFR Section 20.1402 is not selected as an ARAR a site specific consultation process will be developed. Once the ROD is issued for the SLDA Site establishing the Applicable or Relevant and Appropriate Requirements (ARARs) and the cleanup goals for the remedial action, then USACE will consult with the NRC to ensure that the interagency consultation procedures provided in the MOU or a site-specific consultation process is followed.

**Site Characterization**

The USACE conducted a thorough investigation of the radiological contamination at the SLDA site consistent with guidance issued by the United States Environmental Protection Agency (EPA). The results of these investigations are presented in the Remedial Investigation (RI) report, which was issued in October 2005. To support preparation of the RI report, USACE conducted a number of field investigations from August 2003 through January 2004 to determine the nature and extent of radioactive contamination at the site. These field investigations were conducted in accordance with field sampling plans that were provided to the Pennsylvania Department of Environmental Protection (PADEP) and NRC, and were discussed with local regulatory agencies prior to implementation. All input received from these oversight agencies was reflected in the characterization process.

Prior to this fieldwork, in-depth historical record searches and analyses were conducted, and detailed interviews performed with individuals familiar with disposal operations at the SLDA. In conducting the RI, USACE sampled surface and subsurface soils, trench waste, the five water-bearing geologic units, sediment, surface water, and groundwater seeps. In addition, the air in the work zone and at the site perimeter was monitored while on-site activities were being conducted. Follow-up field efforts were performed in May and June 2004 to collect additional groundwater, surface-water, sediment, and seep data. The execution and results of these activities are presented in the comprehensive RI report.

This sampling program indicated that surface water and sediment in Carnahan Run were uncontaminated, while low levels of radioactive contamination is present at on-site locations in Dry Run and groundwater seeps in the upper trench area. This indicates that the radioactive wastes in the trenches may be impacting on-site surface water and sediment in Dry Run. Such impacts were not noted at off-site locations. Groundwater at the site, outside of perched areas within the trenches, does not appear to be contaminated, other than some localized areas in the upper trench area in the upper shallow bedrock water-bearing zone downgradient of disposal trenches 1 and 2. Some low levels of contamination were identified at this location, which may be associated with the radioactive wastes in these two trenches. In summary, the contaminated media identified at the site are the trench wastes, surface and subsurface soils, and sediment in Dry Run.

**Risk Assessment**

A human health baseline risk assessment (BRA) was performed as part of the RI process consistent with EPA risk assessment guidance to support the determination of appropriate actions for the site. The assessment was limited to the radioactive constituents at the SLDA, consistent with the authorizing legislation for the site which directs USACE to 'clean up radioactive waste' at SLDA. The chemical toxic effects of the radioactive constituents were considered in this BRA, specifically for uranium, which is chemically toxic to the kidney.

The results of the human health BRA indicate that the previously disposed of wastes within the trenches contain significant concentrations of radioactive constituents, and these materials could pose a potential risk to human health in the future. The estimated annual dose to a hypothetical subsistence farmer from exposures to these materials exceeds decommissioning criteria established in 10 CFR 20.1402, Radiological Criteria for Unrestricted Use. Hence it was deemed necessary to evaluate remedial action alternatives to address the contaminated materials present at the SLDA site. These alternatives are developed and evaluated in this Feasibility Study (FS) report.

Under current conditions the SLDA site presents very little risk to human health. The site is currently vacant and surrounded by a fence that is actively maintained. There is very little radioactive contamination outside the footprints of the ten trenches, and the contamination that is present at those isolated areas pose very little current and future risk. However, reasonable assurance cannot be provided that these conditions would remain, and the radionuclides in the trenches could be gradually released into the environment over time. In addition, mine subsidence could result from the collapse of the abandoned mine workings beneath the site.

A screening-level ecological risk assessment was also performed for the SLDA using the maximum detected concentrations of radionuclides in soil, sediment, and surface water. The results of this conservative assessment indicated that the radionuclides at the SLDA did not pose a potential risk to terrestrial and aquatic receptors.

**Development of Remedial Action Alternatives**

Preliminary remedial action alternatives were developed considering the impacted site media (trench wastes, surface and subsurface soils, and sediment), the distribution and concentrations of radioactive constituents in these media, the estimated volume of contaminated materials, the human health and ecological risk assessment results, and a consideration of ARARs. No remedial actions are warranted for surface water and groundwater.

For the purposes of this FS, the volume of contaminated material requiring remediation within and around the disposal trenches and in surface soils was estimated to be 23,500 cubic yards (18,000 cubic meters) and 800 cubic yards (600 cubic meters), respectively, for a total volume of 24,300 cubic yards (18,600 cubic meters). These volumes were determined on the basis of all available information including historical estimates (that were based on various cleanup criteria), information compiled by the site owners, interviews conducted with local citizens, and the field investigations performed for the RI.

Remedial action objectives (RAOs) were developed as part of the FS process for the SLDA in accordance with EPA guidance. The RAOs were determined to be:

- Prevent the external exposure to, and the ingestion and inhalation of radionuclides (U-234, U-235, U-238, Th-232, Ra-228, Pu-239, Pu-241, and Am-241) present in trench wastes, surface and subsurface soil, and sediments at the SLDA site so that the total effective dose equivalent (TEDE) to an average member of the critical group, when combined with the potential dose due to the ingestion of radionuclides in groundwater, and does not exceed 25 millirem per year (mrem/yr) and does not result in an unacceptable non-cancer risk (i.e., a hazard index of greater than 1) for uranium.

- For those potential remedies that incorporate engineering and land use controls as part of a restricted release, prevent the external exposure to, and the ingestion and inhalation of radionuclides (U-234, U-235, U-238, Th-232, Ra-228, Pu-239, Pu-241, and Am-241) remaining at the SLDA site so that the TEDE to an average member of the critical group, when combined with the potential dose due to the ingestion of radionuclides in groundwater, and would not exceed 100 mrem/yr and would not result in an unacceptable non-cancer risk (i.e., a hazard index of greater than 1) for uranium, if the institutional controls were no longer in effect.

The potential ARARs identified for the site are 10 CFR 20.1402 (Radiological Criteria for Unrestricted Use) and 10 CFR 20.1403 (Criteria for License Termination Under Restricted Conditions). Provisions of both 10 CFR 20.1402 and 10 CFR 20.1403 require that the annual dose to an average member of the critical group (determined to be a future subsistence farmer) not exceed 25 mrem/yr and that the residual radioactivity be reduced to levels that are as low as reasonably achievable (ALARA). However, unlike 10 CFR 20.1402, 10 CFR 20.1403 allows this dose limit to be achieved through the use of engineering and land use controls, with the added requirement that the annual dose does not exceed 100 mrem/yr should those institutional controls fail or if they are no longer in effect. The level of site cleanup under 10 CFR 20.1403 would be expected to be less than under 10 CFR 20.1402, as institutional controls would be used to limit the radiation dose to potential receptors. Although both regulations are considered relevant and appropriate under the circumstances of the release of the hazardous substances at the site, only one ARAR would be relevant to the selected remedy depending on the condition of release (i.e. for restricted or unrestricted future uses).

Six general response actions (GRAs) were identified for the site: No Action, Limited Action, Containment, Removal, Treatment, and Disposal. These GRAs are broad categories of responses that may include several technologies or process options, some of which might be extensive enough to satisfy the RAOs and approved cleanup criteria alone, while others must be combined with different technologies or process options to achieve the RAOs for the site. The overriding objective is to satisfy CERCLA in a cost-effective and environmentally sound manner.

Technology types and process options were identified for each GRA based on the research and experience of the United States Department of Energy (DOE), USACE, and EPA on remediation of radioactive wastes and previous FUSRAP remediation projects. The process options examined included conventional, emerging, and innovative technologies. The remedial technologies and process options were initially screened based on their ability to satisfy the RAOs considering use of these approaches at the site. Those that failed the screening process were dropped from further consideration. The remedial technologies and process options that passed the technical implementability screening were subjected to a more detailed evaluation based on their relative effectiveness, implementability, and cost.

Five preliminary remedial action alternatives were identified on the basis of these evaluations of potentially applicable remedial technologies and process options. These five preliminary alternatives are:

- Alternative 1: No Action
- Alternative 2: Limited Action
- Alternative 3: Containment

- Alternative 4: Excavation, Treatment, and On-Site Disposal

- Alternative 5: Excavation, Treatment, and Off-Site Disposal

These alternatives cover the full range of remedial actions including No Action (as required by the NCP to provide a baseline for comparison), in situ management alternatives (Limited Action and Containment), excavation and development of an improved on-site disposal facility (Alternative 4), and excavation and disposal at existing off-site licensed disposal facilities (Alternative 5).

For the purposes of this FS, and to adhere to the intent of CERCLA guidance, the evaluation of the No Action alternative is based on the assumption that, in the future, the site would be neither controlled nor maintained. Under this assumption, all current land-use controls would no longer be maintained and therefore would be rendered ineffective. However, at SLDA that scenario is not likely since SLDA is a currently licensed site. If no action were taken under the FUSRAP, the SLDA site would continue to be regulated under the current NRC license (SNM-2001). In the future, pursuant to law, one of the following would happen:

- The site would continue to be maintained by the licensee, under the requirements of the license, or;

- The licensee would successfully meet agreed-to license termination criteria, the license would be terminated, and the site would be lawfully released for a specified use.

It is not possible, within the scope of this FS, to reliably determine the consequences of pursuing a No Action alternative, therefore, as stated above, the No Action analysis presented here applies only to the site in a hypothetical state of abandonment.

**Screening of Preliminary Alternatives**

The five preliminary remedial action alternatives were screened on the basis of their relative effectiveness, implementability, and cost to meet the RAOs identified for the site. The performance period used to demonstrate compliance with the site ARARs is 1,000 years and is consistent with the time frame identified in 10 CFR 20.1401(d). This time period was also used in developing the exposure scenarios for future uses of the site in the human health BRA.

On the basis of this screening evaluation, Alternatives 2 and 3 were eliminated from further consideration because (1) Alternative 2 would not provide any remedial or engineering controls should a release to the environment occur, and (2) although Alternative 3 would provide release controls, these controls could not be relied upon for long term protection due to the presence of the mine workings beneath the engineering barriers. In addition, Alternative 4 was considered the most protective, cost-effective, on-site restricted use alternative. That is, Alternative 4 would provide a more reasonable assurance that the criteria set forth in 10 CFR 20.1403 would be met. Alternative 4 would also provide this increased protectiveness while maintaining a similar level of implementability and cost compared to the other on-site alternatives. Alternative 5 was retained for further analysis since it would meet the criteria set forth in 10 CFR 20.1402. The No Action alternative (Alternative 1) was retained for detailed evaluation consistent with EPA guidance and the NCP. Hence, three alternatives were subjected to the detailed evaluation process in the FS.

**Detailed Evaluation of Final Alternatives**

The three alternatives that passed the screening process were evaluated in accordance with the nine evaluation criteria identified in the NCP. The nine criteria are grouped into three categories based on their level of relative importance: Threshold, Balancing, and Modifying Criteria. The two Threshold criteria are (1) Overall Protection of Human Health and the Environment, and (2) Compliance with ARARs. These two criteria must be satisfied for a remedial action alternative to be considered a viable remedy. The No Action alternative is not a viable remedy, as this alternative does not comply with the ARARs identified for the site. Alternative 4 would satisfy the decommissioning criteria of 10 CFR 20.1403 (restricted use), while Alternative 5 would satisfy 10 CFR 20.1402 (unrestricted use). However, the level of site cleanup under 10 CFR 20.1403 would be expected to be less than under 10 CFR 20.1402, as institutional controls would be used to limit the radiation dose to potential receptors.

The five Balancing criteria are Long-term Effectiveness and Permanence; Short-term Effectiveness; Reduction of Toxicity, Mobility, and Volume through Treatment; Implementability; and Cost. These are the five criteria that form the basis for comparing the two remaining action alternatives, both of which involve excavation of contaminated materials. The difference between these two alternatives is that Alternative 4 consists of placement of contaminated soils and debris in an on-site disposal cell, while Alternative 5 consist of transportation of contaminated materials and disposal off-site at facilities permitted to receive such wastes. Both alternatives involve treatment activities to sort, profile, and characterize excavated materials. Alternative 4 treatment activities would be less intensive, but would include a stabilization process (as necessary) for selected wastes based on chemical and physical composition. Alternative 5 treatment processes would be more labor intensive to satisfy the requirements of the disposal facility's waste acceptance criteria. Due to the less intensive treatment activities, Alternative 4 is expected have a greater throughput rate, decreasing the amount of time that workers would be exposed to these materials. Both alternatives are expected to result in minimal radiation exposures to remediation workers, members of the general public in the vicinity of the SLDA site, along transportation corridors, and at the disposal sites.

The radiation dose to an individual worker for Alternative 4 is estimated to be 110 mrem and the dose to a worker implementing Alternative 5 is estimated to be 150 mrem. These dose estimates include the contributions from direct external gamma radiation, inhalation of contaminated dust, and incidental ingestion of soil. These estimates assume that the same workers would be at the site for the duration of the action and that engineering controls and respiratory protection would be used whenever there is visible dust. The total occupational dose for Alternative 4 is estimated to be 0.33 person-rem and the total occupational dose for Alternative 5 is estimated to be 0.91 person-rem. These dose estimates include the doses to both workers at the SLDA site and transportation personnel. The estimate for Alternative 4 assumes three remediation workers for potential exposure assessment, while the estimate for Alternative 5 assumes six workers. With respect to Alternative 5, the increased cost due to more intensive treatment activities would need to be weighed against the decreased volume of wastes requiring off-site disposal to determine an optimal approach for site remediation. The estimated costs for Alternatives 4 and 5 are $20.2 million and $35.5 million, respectively.

The two Modifying criteria are (1) State Acceptance and (2) Community Acceptance. Both State and Community Acceptance of the preferred remedial alternative will be addressed in the Responsiveness Summary of the ROD.

**Next Steps**

Based on the information contained in this FS report, USACE is initiating development of the PP, which will summarize results included in the FS and present the preferred remedy for site remediation. Public input to this process is important, and individuals are encouraged to provide formal comments on the PP, or to provide any additional information on the site that will aid in identification of an environmentally sound remedy for the radioactive contamination at the site. Responses to public comments will be included in the ROD, which documents the selected remedial alternative.

**FINAL**

**FEASIBILITY STUDY FOR THE
SHALLOW LAND DISPOSAL AREA SITE
PARKS TOWNSHIP, ARMSTRONG COUNTY, PENNSYLVANIA**

# 1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE) has completed a Remedial Investigation (RI) at the Shallow Land Disposal Area (SLDA) site located on Mary Street in Vandergrift, Pennsylvania (see Figure 1-1). The RI was completed in October 2005 to further characterize the SLDA site, identify the nature and extent of radiological contamination, determine fate and transport of contaminants, and complete a baseline risk assessment. This Feasibility Study (FS) was completed to provide sufficient engineering analysis to present feasible and cost-effective remedial alternatives that protect public health and the environment from the potential risks posed by the on-site radiological contamination.

The 44-acre (17.8-hectare) SLDA site is largely undeveloped and was used for disposal of radioactive wastes between 1961 and 1970. Based on results of geophysical surveys performed at the site, the disposal areas appear as a linear series of excavated pits, referred to as “trenches 1 through 10” on site drawings. An estimated 23,500 to 36,000 cubic yards (18,000 to 27,500 cubic meters) of potentially contaminated waste and soil cover material (ARCO, 1995b and 2000) was placed into nine trenches and a backfilled settling pit (referred to as trench 3). The total estimated disposal surface area is approximately 1.2 acres (0.5 hectare). Figure 1-2 presents the Site Plan illustrating site characteristics and disposal areas.

In 1957, the Nuclear Materials and Equipment Company (NUMEC) initiated small-scale production of high- and low-enriched uranium and thorium fuel in Apollo, Pennsylvania. The Apollo facility was located approximately 2.5 miles (4 kilometers) south of the SLDA site. NUMEC operated the Apollo facility under United States Atomic Energy Commission (AEC) license No. Spent Nuclear Material (SNM)-145. By 1963, a majority of the Apollo facility was dedicated to continuous production of uranium fuel. Throughout its operation, the facility converted low-enriched uranium hexafluoride to uranium dioxide, which was used as fuel in commercial nuclear power plants. In 1963, a second product line was added to produce high-enriched uranium fuel for United States Navy propulsion reactors. Other operations included analytical laboratories, scrap recovery, uranium storage, and research and development (DOE, 1997).

The SLDA site and the Apollo nuclear fabrication facility were originally owned by NUMEC. Between 1961 and 1970, NUMEC buried process and other wastes from the Apollo facility in a series of pits (trenches) at the SLDA site in accordance with 10 CFR 20.304, "Disposal by Burial in Soil" (which was subsequently rescinded in 1981). In 1967, the Atlantic Richfield Company (ARCO) purchased the stock of NUMEC. The SLDA site was not used for radioactive waste disposal after 1970. In 1971, the Babcock & Wilcox Company (B&W) acquired NUMEC. In 1997, BWX Technologies, Inc. (BWXT) assumed ownership of the SLDA as well as the Apollo property. BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of the United States Nuclear Regulatory Commission (NRC) License SNM-2001.

NUMEC also owned and operated the Parks Nuclear Fabrication facility located between State Route 66 and the SLDA site. The Parks facility has been decommissioned, the NRC license was terminated, and the property has been released for unrestricted use (NRC, 2004). The Parks site is currently vacant land owned by BWXT. Wastes from the Parks facility were not permitted for burial at the SLDA site.

The AEC, a predecessor to the United States Department of Energy (DOE), established the Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1974 to identify, remediate, or otherwise control sites contaminated with residual radioactivity resulting from activities of the USACE Manhattan Engineer District (MED) and early AEC sites. These FUSRAP sites were involved in research, development, processing, and production of uranium and thorium ores. In 1997, Congress transferred the responsibility for the administration and execution of cleanup at eligible FUSRAP sites to USACE. As part of the Energy and Water Development Appropriations Act of 2000, Congress indicated that any response action taken under the

FUSRAP program shall be subject to the process outlined in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

In March of 1999, USACE and DOE signed a Memorandum of Understanding (MOU) between the agencies for the purpose of delineating the administration and execution of the respective responsibilities of each party under the FUSRAP. Pursuant to that MOU, when a new site is considered for inclusion in the FUSRAP, DOE is responsible for performing historical research to determine if the site was used for activities that supported the Nation's early atomic energy program. If DOE concludes that the site was used for that purpose, the department will provide USACE with that determination.

On May 25, 2000, after performing historical research regarding the SLDA site, the DOE provided USACE with a determination that the site was eligible for inclusion in FUSRAP. In November 2000, as a result of DOE’s determination, USACE referred the site to the Great Lakes and Ohio Rivers Division for a Preliminary Assessment (PA) to determine if the site was contaminated with hazardous substances at a level sufficient to warrant a CERCLA response action.

In accordance with the CERCLA process, a PA was completed by USACE in March 2002 (USACE, 2002). The PA recommended no further action at the site under FUSRAP, due to the absence of an unpermitted release, as defined by CERCLA. However, this recommendation was superceded by the United States Department of Defense (DOD) Appropriations Act of 2002, Section 8143 of Public Law 107-117, which directs the Secretary of the Army, acting through the Chief of Engineers, to clean up ‘radioactive waste’ at the SLDA site consistent with a 2001 MOU between the USACE and NRC. In accordance with Public Law 107-117 this FS is focused on evaluation of remedial actions to address ‘radioactive wastes’ and does not address any chemical contamination unless it is commingled with the ‘radioactive wastes’.

Based on the 2002 legislation cited above and in accordance with the CERCLA process, an RI was completed at the SLDA site to further characterize the nature and extent of radiological on-site contamination. The RI field investigations were conducted between August 2003 and

June 2004. An RI report was subsequently prepared, which presents the findings of the RI environmental sampling, including discussions of the nature and extent of contamination, fate and transport of contaminants, and a baseline risk assessment (USACE, 2005). Subsequent to the RI, an FS was completed to assess various remedial alternatives. This report documents the findings of the FS, describes and evaluates several remedial alternatives, presents a detailed analysis of the most viable technologies, and presents conclusions.

## 1.1 Purpose and Organization of the Feasibility Study Report

The purpose of this FS report is to document the rationale and procedures used to identify, develop, screen, and evaluate a range of remedial alternatives to address radiological contamination present at the SLDA site. The primary objective of the FS is to provide sufficient engineering analysis to identify a feasible and cost-effective remedial alternative that protects public health and the environment from the potential risks posed by the radiological contamination on-site. The remedial alternative evaluations are based on the nature and extent of radiological contamination and site-specific conditions as documented in the RI report (USACE, 2005).

This FS report is organized in a format similar to the outline suggested by the United States Environmental Protection Agency (EPA) in the document entitled, Guidance for Conducting Remedial Investigations and Feasibility Studies (EPA, 1989). Applicable or Relevant and Appropriate Requirements (ARARs) were identified for the SLDA site and considered during the evaluation of remedial alternatives. Remedial Action Objectives (RAOs) and General Response Actions (GRAs) were also developed during the FS process and were used to assess the remedial alternatives. Volume estimates of impacted media were prepared based on site characterization data and compared to estimates previously prepared (both the site characterization data and the volume estimates prepared by others based on various cleanup criteria and are presented in Appendix A). Cost estimates were then developed for the most applicable remedial technologies, and additional data needs were identified, where necessary.

This FS report is comprised of the following sections with associated figures and tables:

- Section 1.0 – Introduction. The introduction section consists of the site regulatory framework, organization of the report, and background information. The background information section includes a description of the site and site history as well as a summary of nature and extent of contamination, contaminant fate and transport, and the baseline risk assessment.

- Section 2.0 – Identification and Screening of Remedial Technologies. In this section, RAOs are developed for the media of interest: sediment, soil, and debris, and ARARs are identified. GRAs are also developed based on the physical characteristics of the SLDA site and contaminated media. Technology types and process options are identified for each GRA and include conventional, emerging, and innovative technologies. Remedial technologies and process options considered technically implementable are screened based on their relative effectiveness, implementability, and cost.

- Section 3.0 – Development and Screening of Remedial Alternatives. In this section, preliminary remedial action alternatives are developed from the technologies and process options that were retained from Section 2.0. Each remedial alternative is analyzed based on its effectiveness, implementability, and cost.

- Section 4.0 – Detailed Analysis of Remedial Alternatives. This section presents a more detailed analysis of the remedial alternatives retained from Section 3.0. This analysis consists primarily of a comparison against the nine CERCLA FS criteria, and includes preparation of cost estimates and a comparison between alternatives.

- Section 5.0 – Results of Partnering and Public Involvement Activities. An important aspect of the CERCLA process is public involvement, which has been successfully incorporated into the SLDA RI/FS process. This section discusses how partnering was encouraged through citizen interviews, public information sessions, and Technical Project Planning (TPP) meetings.

- Section 6.0 – Conclusions. This section summarizes the FS process completed for the SLDA site. The remedial alternatives found to best satisfy the remedial action objectives are identified as potential preferred remedies. In addition, a discussion is presented of how the preferred remedy will be included in the Proposed Plan (PP) and how regulatory agency and public input will be considered during preparation of the Record of Decision (ROD).

- Section 7.0 – References. This section contains a list of the documents referenced throughout the report.

Data presented in this report will be in English units with the metric equivalent in parentheses.

## 1.2 Background Information

This section presents an overview of the physical characteristics of the SLDA site, site history, nature and extent of contamination, contaminant fate and transport, and the baseline risk assessment performed during the RI (USACE, 2005). Historical disposal information and previous environmental sampling data were gleaned from documents and statements provided by current and former site owners, regulatory agencies, and concerned citizens. Environmental and physical site information was confirmed and updated with information obtained during the RI.

### 1.2.1 Site Description

The SLDA site is predominately an open field with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners. As shown on the Site Plan (see Figure 1-2), site topography in the vicinity of the upper trench area generally slopes from the southeast to the northwest toward the Kiskiminetas River. The elevation decreases from about 950 feet (290 meters) above mean sea level (MSL) in the southeastern end of the site to about 830 feet (253 meters) above MSL in the northwestern end of the site. This is an elevation change of approximately 120 feet (37 meters) over a distance of approximately 2,500 feet (760 meters). A significant portion of this elevation drop occurs at the “High Wall” area in the northwestern end of the site where a bedrock outcrop is present.

Surface water drainage from the site is primarily into Dry Run, an intermittent stream located along the north boundary of the site. During peak rain events, surface water in Dry Run flows off site across the adjacent former Parks facility property, and ultimately to the Kiskiminetas River (located approximately 800 feet [244 meters] northwest of SLDA). During dry or low flow conditions, the flow in Dry Run infiltrates into the mine spoils near the High Wall and no surface water discharges to the Kiskiminetas River. The surface water consists of precipitation runoff and, to a much more limited degree, water from seeps along the banks of Dry Run.

The SLDA site occupies approximately 44 acres (17.8 hectares) and is bounded by Kiskimere Road to the southwest and vacant undeveloped land to the southeast and northeast. The former Parks Nuclear Fabrication facility site is located adjacent to and northwest of the SLDA site. The three buildings that comprised the Parks facility were decommissioned in 2000; the license was terminated and the property released for unrestricted use in 2004. Currently, the Parks site is vacant land owned by BWXT. Land use within the vicinity of the SLDA site is mixed, consisting of small residential communities, individual rural residences, small farms with croplands and pastures, idle farmland, forested areas, and light industrial properties. Figure 1-3 presents a digital orthophotograph illustrating the SLDA site, the former Parks facility, and vicinity properties.

The limited site improvements consist of a small storage building, access roads, electric service, three underground natural gas pipelines, and a chain link fence surrounding the site. Approximately seventy percent of the site is vegetated with grasses and annuals. Wooded areas are also present along the northeastern, southeastern, and southern portions of the site. The fenced area is posted and maintained by BWXT.

The community of Kiskimere is adjacent to and southwest of the site. Drinking water for the community of Kiskimere is obtained from the Beaver Run Reservoir and is supplied by the Parks Township Municipal Authority. According to the Authority, there are approximately 12 residences within 2,000 feet (610 meters) of SLDA that currently use private well water (USACE, 2003a&b). Carnahan Run, a stream feeding into the Kiskiminetas River, is located approximately 2,000 feet (610 meters) southeast of the SLDA site.

The geology and hydrogeology at the SLDA site is complex due to the presence of extensive coal mines and several hydrogeologic zones. Surface soils southeast of the High Wall are described as Rainsboro silt-loam, which is classified as a deep and moderately well-drained silt loam with moderately low permeability. Infiltration rates in the upper trench area are between 2.8x10-3 and 2.8x10-4 feet per day, (ft/day)(10-6 and 10-7 centimeters per second [cm/s])(USACE, 2002). The Rainsboro soils range in slope from less than 3 to 8 percent. When these soils are disturbed, they present a moderate erosion hazard.

The age of the near-surface geologic units in the SLDA site is typical of this region of Pennsylvania, and the units consist of sequences of sandstone, siltstone, claystone, shale, and coal. Several coal seams underlie the site, the uppermost of which, known as the Upper Freeport Coal, was strip mined and deep mined before 1950 within the boundaries of the SLDA.

The mine workings that underlie the upper trench area (approximately 80 feet [24.4 meters] below ground surface) consist of a combination of room-and-pillar constructions and open mine haulage-ways. Potential collapse of mine structures predominantly overlain by shale, has been well documented and these site conditions at the SLDA site may lead to eventual development of trough-type subsidence (ARCO/B&W, 1995a).

The area northwest of the High Wall was strip-mined and backfilled with mine spoil, which has a high erosion hazard potential. Hydraulic conductivity values in the mine spoils range from 269 to 5.7 ft/day (9.5x10-2 to 2.0x10-3 cm/s)(USACE, 2002).

The hydrogeologic system of the upper trench area is fundamentally different from that of the lower trench area. Trenches 1 through 9 were excavated into approximately 11 to 16 feet (3.4 to 4.9 meters) of Pleistocene terrace deposits that overlie 54 to 80 feet (16.5 to 24.4 meters) of shale and sandstone, which in turn overlie the Upper Freeport Coal seam. The bottom of trenches 1 through 9 rest on weathered shale bedrock. In general, retardation of uranium migration is relatively high due to the presence of the cohesive soils and carbonaceous shale beneath and adjacent to the upper trenches. The soils and weathered shale contain up to 3 percent organic matter, which adsorbs uranium and reduces migration.

Trench 10, located at the base of the High Wall in the lower elevations of the site, was excavated into coal mine spoils, where the Upper Freeport Coal seam was strip mined. The base of trench 10 rests on a clay and shale layer that lies beneath the Upper Freeport Coal seam.

In the upper trench area, the distribution of hydraulic head is strongly influenced by the open-channel flow that occurs in the abandoned mine workings within the Upper Freeport Coal seam. This influence creates a dominant vertical gradient in the surficial deposits. The hydraulic gradient in the shallow bedrock is in the direction of Dry Run. Several groundwater seeps were identified along the banks of Dry Run where groundwater from the upper trench area drains. Groundwater flow and storage in the shallow bedrock layer is primarily in secondary features such as fractures and joints.

Groundwater flow within the mine spoils near trench 10 is along the underclay present between the coal and the Deep Bedrock zone. A significant component of groundwater flow within the mine spoils follows the dip of the underclay and ultimately enters the mine workings. Groundwater flow within the open mine is to the south. Because of the hydraulic properties of the mined coal seam (open channel flow), it is unlikely that constituents from the trenches would migrate below the coal mine. Beneath the Upper Freeport coal seam is a layer of sandstone identified as the Deep Bedrock hydrogeologic unit.

Although the adjacent community of Kiskimere is supplied with municipal water, groundwater is obtained from approximately 12 private wells located within 1.25 miles (2 kilometers) of the SLDA area (ARCO/B&W, 1995b). Based on the depths of these wells, it appears that groundwater is pumped from both the Glenshaw and the Deep Bedrock formations, situated directly above and below the Freeport coal seam, respectively.

### 1.2.2 Site History

A review of site history indicates that, in the early 1900s, the Upper Freeport Coal seam was deep-mined beneath the majority of the site (southeast of the High Wall). Subsurface mine voids and residual coal underlie the upper trenches at a depth of about 60 to 100 feet (18 to 31 meters) below ground surface (bgs). Later, coal was strip-mined where it outcropped at the northwestern end of the site (USACE, 2002b). Figure 1-4 illustrates the extent of the deep mine workings beneath the site.

In 1957, the Apollo Nuclear Fabrication Facility (Apollo Facility) began operations in Apollo, Pennsylvania, under AEC license No. SNM-145. From 1957 to 1962, the Apollo Facility was used for small-scale production of high- and low-enriched uranium and thorium fuel. By 1963, most of the Apollo Facility was dedicated to continuous production of uranium fuel and, throughout its operation, the facility converted low-enriched uranium hexafluoride to uranium dioxide, which was used as fuel for commercial nuclear power plants. In 1963, a second product line was added to produce high-enriched uranium fuel for United States Navy propulsion reactors; other operations included analytical laboratories, scrap recovery, uranium storage, and research and development (DOE, 1997).

Between 1961 and 1970, NUMEC, who owned both the Apollo Facility and the SLDA, buried process and other wastes from the Apollo Facility at the SLDA site. These wastes were buried in accordance with 10 CFR 20.304, "Disposal by Burial in Soil," which was subsequently rescinded in 1981. In 1967, NUMEC stock was bought by ARCO and the use of the SLDA for radioactive waste disposal was discontinued after 1970. In 1971, ARCO sold the stock of NUMEC to the Babcock & Wilcox Company. BWX Technologies, Inc. (BWXT) became the owner of the site in 1997.

The uranium-contaminated materials disposed of at the SLDA are present at various levels of enrichment, ranging from depleted to enriched. Activity percentages indicate levels of enrichment from less than 0.2 percent uranium-235 (U-235) by weight, to greater than 45 percent. Due to its economic value, NUMEC and ARCO likely made significant efforts to limit the amount of enriched uranium wastes they disposed of at SLDA (USACE, 2002).

Based on reports prepared by ARCO/B&W, and discussions with individuals familiar with disposal operations at SLDA, the waste materials were placed into a series of pits that were constructed adjacent to one another. From geophysical surveys performed at the site, these pits appear as linear trenches and are depicted on site drawings as trenches. These geophysical anomalies were labeled as "trenches 1 through 10"; this numbering scheme was based partially on the trenches respective assumed dates of construction, with 1 being the oldest trench and 9 being the most recently constructed trench in the upper trench area. Trench 3 was actually a backfilled settling pond used during the exhumation of trenches 2, 4, and 5 in 1965. Trench 10 was excavated in coal strip mine spoils on the northwest side of the High Wall and was used for disposal purposes throughout the 1960s and during 1970. As previously stated, disposal activities at the SLDA site were reportedly terminated during 1970.

The disposal trenches were reportedly excavated to the top of bedrock, which averaged approximately 14 feet (4.3 meters) bgs in the upper trench area (trenches 1 through 9) and 21 feet (6.4 meters) bgs at trench 10 (ARCO/B&W, 1995b). Four feet (1.2 meters) of clean soil was required (per AEC requirements) as a cover over the waste material. Therefore, waste deposition (as reported) ranged from 4 to 14 feet (1.2 to 4.3 meters) in the upper trench area and from 4 to 21 feet (1.2 to 6.4 meters) in trench 10. A perched water table is present in the upper trenches due to the low permeability of the subsurface soils and bedrock. Consequently, a significant portion of the waste material in the upper trenches is saturated. The perched water condition is not as evident in Trench 10 due to the presence of the mine fill and the adjacent deep mine opening.

Various wastes placed in the disposal trenches are described in Table 1-1 and generally consisted of:

- Process wastes (slag, crucibles, spent solvent, unrecoverable sludge, organic liquids, debris, etc.)
- Laboratory wastes (sample vials, reagent vials, etc.)
- Outdated or broken equipment
- Building materials
- Protective clothing
- General maintenance materials (paint, oil, pipe, used lubricants, etc.)

- Solvents (trichloroethene, methylene chloride, etc.)

- Trash (shipping containers, paper, wipes, etc.)

Some of the radiological wastes were placed in fiber and metal drums, some were bagged, and some, particularly pieces of equipment and building materials, were placed in the trenches with no special packaging or containers (USACE, 2002).

The wastes placed in the disposal trenches were generated from activities conducted under NUMEC's Apollo Facility license. The Apollo Facility was located approximately 2.5 miles (4 kilometers) south of the SLDA site. Processed uranium and, to a much lesser extent, thorium was generated at the Apollo Facility. Processing operations included conversion of uranium hexafluoride (UF6) to uranium dioxide (UO2) by the ammonium diuranate process, and subsequent metallurgical and ceramic processes to produce uranium compounds and nuclear fuel compounds. The entire UF6 conversion process resulted in U-235-enriched uranium-bearing nuclear fuel compounds such as U metal, UO2, UC, and UC2. A corollary process for thorium produced ThO2, ThO2-UO2, and UC-ThC as sintered pellets, powder, and other particulate forms. Process wastes, including off-specification products and incinerated high-efficiency particulate air (HEPA) filters and rags, were recycled at the Apollo Facility in a nitric acid solvent extraction scrap recovery process to recover usable uranium. The Apollo Facility processed uranium at a capacity of 385 to 440 tons/year (350 to 400 metric tons/year) (ARCO/B&W, 1995b).

Documentation of the waste placed in the disposal trenches was not detailed and drawings of disposal areas if prepared, could not be located. The Nuclear Material Discard Reports (NMDRs) that comprise the bulk of the waste disposal documentation list only the materials of interest (U-235, total uranium, and thorium). Any other information, such as the presence of specific metals, chemical compounds, or the waste origin process, was qualitative. Raffinate (aqueous phase waste from the solvent extraction step) was treated prior to discharge into a local stream outfall at the Apollo Facility, although NUMEC records indicate that some raffinate may have been disposed of at SLDA. Recoverable used solvent was recycled (ARCO/B&W, 1995b).

Fuel fabrication and other metalworking operations used lubricants, solvents (e.g., trichloroethene [TCE], methylene chloride, etc.), and acids that may have been disposed of at SLDA. Disposal of spent equipment, which may have contained lubricants and hydraulic fluids, also occurred. The process control and research and development (R&D) laboratories were additional sources of SLDA wastes. Spent solvent, unrecoverable sludge and filtration media, and other process wastes were disposed of at SLDA, but are not quantified in disposal records (ARCO/B&W, 1995b).

In general, records show that solvents disposed of at SLDA consisted of tributyl phosphate (TBP), TCE and other chlorinated solvents, and kerosene. Review of the historical database and compounds detected at SLDA indicates that volatile organic compounds (VOCs) of concern include TCE, trans-l,2-dichloroethene, vinyl chloride, 1,1,1-trichloroethane, 1,1-dichloroethane, chloromethane, benzene, toluene, ethylbenzene, and xylene (ARCO/B&W, 1995b).

The historical records do not indicate the burial of metallic compounds other than those associated directly with Apollo Facility operations. Metals processed at the Apollo Facility include beryllium, zirconium, and zirconium compounds or alloys. In addition, the scrap recovery process utilized nitric acid, which forms soluble nitrate salts with most metals. This may have resulted in the inadvertent disposal of small amounts of other metallic compounds. If acids were disposed of in the trenches, they may have leached and mobilized various naturally occurring metals in the site soils. The Apollo Facility also used basic compounds such as ammonium hydroxide and lime to neutralize hydrofluoric acid waste prior to disposal (ARCO/B&W, 1995b).

Two semivolatile organic compounds (SVOCs) are known to be associated with operations at Apollo: TBP and 8-hydroxyquinoline (8-OH). The compounds are considered site-specific markers of trench-related constituents. Other potential SVOCs present at the site include phthalates (from the disposal of gloves and other plastic materials) and kerosene constituents (ARCO, B&W, 1995b).

In 1965, NUMEC exhumed the contents of trenches 2, 4, and 5 to investigate discrepancies in the quantities and activities of uranium-containing wastes at SLDA (ARCO/B&W, 1995b). The materials removed from the trenches were placed on the ground south of the upper trenches and sorted. Some of the exhumed materials were placed back in the trenches in 1966, and the remainder was shipped off site for disposal at a low-level radioactive waste (LLW) disposal facility.

In 1986 and 1989, B&W completed soil remediation projects at the SLDA site to remove surface soils found to contain uranium isotopes at activity levels above the NRC guideline of 30 picoCuries per gram (pCi/g). There were no reports identified that describe the actual remediation work (e.g., excavation depths, volumes removed, etc.); however, confirmation sampling reports corresponding to each remediation project were found and reviewed. Figure 1-5 illustrates the approximate limits of surface soil remediation completed by B&W (ORAU, 1987, 1990).

Nuclear material production conducted at the Parks facility (adjacent to the SLDA site) included manufacturing plutonium-beryllium (Pu-239-Be) neutron sources and americium (Am) devices (ARCO/B&W, 1995b). The raw materials used and wastes generated were not authorized for SLDA burials. It is possible that some of the waste materials associated with the Parks facility operations are present at SLDA based on the fact that some radionuclides (i.e., Pu-239 and Am-241), which are indicative of Parks materials, were detected in SLDA soils. Section 1.2.3 further discusses the nature and extent of these soils, including processes suspected of causing the contamination.

ARCO/B&W indicated that one potential explanation for the americium and plutonium detected in surface and subsurface soils in the vicinity of trench 10 was the practice of storing Parks facility equipment in that area (ARCO/B&W, 1995b). Therefore, based on the presence of americium and plutonium in SLDA soil, these constituents (specifically Am-241, Pu-239, and Pu-241) were included in the list of radionuclides of potential concern (ROPCs) for the RI.

Prior to the RI, numerous environmental investigations were completed at the SLDA over the past two decades. The vast majority of the work was conducted by ARCO/B&W during the

1990s. These investigations focused on radiological and chemical contamination from past site operations potentially impacting the environment with special emphasis on the ten disposal trenches. The data generated during the site investigations and post-excavation confirmation sampling were evaluated; most of the data were considered useful for determination of nature and extent of contamination. The details of these previous investigations and associated analytical results were presented in the RI report (USACE, 2005).

Prior to 1995, B&W held NRC license SNM-414 for the Parks Facility, which included the area now defined as the SLDA. In 1995, the SLDA site was given a separate license (SNM-2001) in order to expedite decommissioning activities at the Parks facilities. Following findings of SLDA-related contamination on Parks facilities property during a confirmatory survey, BWXT was granted an amendment to SNM-2001 in March 2002. This amendment added an approximately 12-acre (4.9-hectare) area, which was formerly part of the SNM-414 license, to the southeastern edge of the SLDA (SNM-2001). The 12-acre (4.9-hectare) parcel is that portion of the site southeast of the interior chain link fence shown in Figure 1-2.

Under license SNM-2001, BWXT is required to properly maintain the site in order to ensure protection of workers and the public, and to eventually decommission the site in compliance with NRC regulations as part of its license termination activities (ORNL, 1997).

### 1.2.3 Nature and Extent of Contamination

This summary of the nature and extent of contamination is based on a review of historical environmental investigations, available records, and data collected during the RI as well as discussions with individuals familiar with disposal operations at the SLDA (USACE, 2005).

Preliminary ROPCs were developed for the SLDA site during RI work plan development based on historical uses (specifically the radiological characteristics of the wastes generated at the Apollo Facility) and previous characterization activities. These preliminary ROPCs were divided into primary ROPCs and secondary ROPCs, and this designation was used to focus site characterization activities and develop the RI work plans.

The primary ROPCs were those radionuclides expected to be present at the site at activity levels posing a potential risk concern. Uranium isotopes and Th-232 were present in wastes generated at the Apollo Facility, disposed of at the SLDA, and detected in historical soil samples collected from SLDA. Am-241, Pu-239, and Pu-241 were present in materials processed at the adjacent Parks nuclear fuel fabrication facility and were also reported in soil samples previously collected from SLDA. Ra-228 is present due to radionuclide in growth (from Th-232) and was also detected in previous SLDA soil samples. Therefore, the primary ROPCs for the SLDA site were: thorium-232 (Th-232), U-234, U-235, U-238, Am-241, Pu-239, Pu-241, and radium-228 (Ra-228). It should be noted that radium is a decay product of thorium and uranium and is commonly present in the natural background for this area.

The secondary ROPC list also includes those radionuclides considered likely to be present based on historical information, previous SLDA sampling, and activities conducted at the adjacent Parks facility. However, these radionuclides were not expected to be present at activities posing a potential risk concern, but were addressed for completeness. These secondary ROPCs were determined to be: cobalt-60 (Co-60), cesium-137 (Cs-137), Pu-238, Pu-240, Pu-242, Ra-226, and Th-230.

Background surface and subsurface soil sampling was conducted as part of the RI at Gilpin/Leechburg Community Park located approximately 3-miles northwest of the SLDA site. Background soil sampling results are presented in Table 1-2.

Results of sampling completed at the SLDA site indicated that the uranium-contaminated materials placed in the trenches are present in a wide range of enrichments, from less than 0.2 percent by weight U-235 to greater than 45 percent. The uranium isotopes of concern at the site are those associated with natural uranium, i.e., U-234, U-235, and U-238.

Localized areas of surface soils near trench 10 contain elevated activities of plutonium (Pu-239 and Pu-241) and Am-241; these transuranic radionuclides were not found at depths greater than 6 inches (15 centimeters) during the recent characterization program. The presence of the americium and plutonium contamination in this area was attributed to storage of contaminated equipment used at the former Parks facility.

While the RI found little radioactivity in soils outside the general area of the trenches, some localized areas of contaminated soils were present outside these areas, specifically in the southwestern end of trench 10 and northwest of trench 4. The activities of radionuclides in most soil samples were generally comparable to background (see Table 1-2). The maximum surface soil activities measured at the SLDA site were for Am-241 (320 pCi/g), Pu-239 (325 pCi/g), and Pu-241 (628 pCi/g) near trench 10; the maximum subsurface soil activity was for U-234 (508 pCi/g) in the upper trench area. The maximum sediment activity in Dry Run was 29 pCi/g for U-234. The average activities of these radionuclides, however, were much lower. Other than isolated areas near trench 10, which showed elevated activities of americium and plutonium in surface soil, U-234 was generally the radionuclide that had the highest activity in soil, which is indicative of enriched uranium contamination.

Surface water in Dry Run (on site) and Carnahan Run (off site) contained at or near background levels of radionuclides. Groundwater at the site, outside of perched areas within the trenches, also contained below or near background levels of radionuclides. Trench-related radionuclides were detected in surface and subsurface soils, including Dry Run sediments.

Waste materials were detected in trench borings at depths ranging from 4 to 14 feet (1.2 to 4.3 meters) bgs. Analyses of these wastes showed the presence of U-234, U-235, and U-238 at activities exceeding the background levels presented in Table 1-2 and preliminary remediation goals (PRGs) presented in Table 1-3 and discussed in Section 1.2.5. Based on waste disposal records, elevated activities of Th-232 and Ra-228 may also be present in the trench wastes, but they were not encountered during the trench boring program.

Elevated activities of the secondary radionuclides were detected infrequently during site characterization activities, and the detections that did exceed background were not significantly elevated (all of the values were less than twice background). The secondary radionuclides were eliminated from quantitative assessment in the baseline risk assessment (BRA) based on the low frequency of detection and the reported low activities. Therefore, the quantitative evaluation of risks in the BRA was limited to the eight primary ROPCs.

Based on the results of the RI, as well as results of previous environmental investigations, the primary ROPCs will be considered radionuclides of concern (ROCs) throughout the remainder of the FS.

### 1.2.4 Contaminant Fate and Transport

The mechanisms and pathways by which the contaminants at the SLDA could be released from their current locations (generally within the ten trenches), move through environmental media, and potentially impact human and ecological receptors were evaluated in the RI (USACE, 2005). Potential release mechanisms include wind erosion; surface water runoff, erosion, and deposition; and infiltration of water into the trenches (whether intact or damaged due to mine collapse) with leaching of radionuclides from the waste materials. These release mechanisms could act on the source media, increasing radionuclide mobility and enabling migration from their current locations to adjacent media (e.g., from the buried wastes to subsurface soil and bedrock). The transport mechanisms affecting the migration of radionuclides within and away from the SLDA include wind transport, surface water runoff, and groundwater flow.

Wind erosion is not considered to be a significant mechanism for radionuclide releases from the site. The radioactive wastes are located about 4 feet (1.2 meters) below the ground surface and are covered with clean soil. Most areas of the site having surface soil contamination were previously remediated, and surface vegetation limits the likelihood for airborne emissions of any remaining contaminated surface soil. The results of the recent site investigations indicate that surface soils that have activities above approved cleanup criteria are only present in isolated areas and these areas are covered by vegetation (grasses). The site's low average wind speeds and high moisture content of the soil in this area further limit the amount of fugitive dust generation. Air sampling was conducted at the site perimeter between August 2003 and August 2004. Radionuclide activity in the air samples was below action levels, confirming that wind erosion is not a significant release and transport mechanism at this time (USACE, 2005).

Surface water runoff following a rain or snowmelt event is also not considered a significant pathway for radionuclide transport from the SLDA. Most of the radioactivity on site is below ground and the site is covered with vegetation that limits the amount of soil erosion from surface water runoff. Small areas of radioactive surface soils are present at the site, but these are generally in areas where the terrain is flat (such as near Trench 10).

Surface water and sediment in Dry Run were sampled during the RI. The surface water was determined to be uncontaminated (activities were at or near background), and only localized areas of sediment had low levels (maximum of 29 pCi/g U-234) of uranium activity, supporting the conclusion that migration of surface water and sediment are not major transport mechanisms at the site. Moreover, surface water flow from Dry Run infiltrates into the mine spoils northwest and east of trench 10, which minimizes offsite migration, unless a peak rain event occurs (USACE, 2005).

Precipitation at the SLDA site could run off the site, return to the atmosphere through evaporation or through plant uptake and transpiration, or infiltrate into surface soils. Water that infiltrates into surface soils could remain fixed in the unsaturated vadose zone soils or percolate to groundwater. Water percolating through contaminated soil or the disposal trenches could result in the dissolution of water-soluble compounds, which could be transported to groundwater. However, the solubilities of the ROCs are low, given the pH ranges measured at the SLDA site may constrain leaching (USACE, 2005).

Transport through groundwater is the most likely mechanism by which radionuclides could move from the site and impact human and ecological receptors in the long term, since the wastes are located below ground and the groundwater table is high. The upper trenches are intermittently saturated, especially during periods of heavy precipitation such as during spring when groundwater levels are elevated. However, the soil in this portion of the site contains a significant amount of clay particles (which are effective at adsorbing positively charged ions such as those in the primary ROCs), and there has been little contaminant migration from these trenches. Although groundwater flow through the mine spoils in the proximity of trench 10 is more rapid, the wastes disposed of in this trench likely have much lower radioactivity than those in the upper trenches based on disposal information provided by ARCO, leachate sample results (ARCO/B&W, 1995b), and trench sampling conducted during the RI (USACE, 2005).

The data collected during the RI program and previous investigations indicate that the radioactive constituents in wastes placed in the disposal trenches are generally confined to the immediate vicinity of the trenches. While isolated pockets of surface and subsurface radionuclides are present at the site, sampling of air, surface water, sediment, and groundwater show no elevated levels of radionuclides migrating from the site (the contaminated sediment in Dry Run is within the site boundaries). However, these conditions could deteriorate over time, and it is possible that the radionuclides in the trenches could leach to percolating water and reach groundwater (USACE, 2005). The upper shallow bedrock water-bearing zone in the upper trench area is the groundwater system of most concern, and potential contamination of this zone was a major consideration in development of the PRGs. Additionally, the potential subsidence of the coal mine under the trenches may cause alternate pathways for radionuclide migration. It should be noted, there was no specific testing conducted during the RI to evaluate the leachability of radionuclides from trench waste or impacted soils to groundwater.

### 1.2.5 Baseline Risk Assessment

The BRA process for the SLDA site consisted of two separate evaluations based on site-specific considerations, i.e., a human health BRA and a screening-level ecological risk assessment. The human health BRA was performed in accordance with EPA CERCLA risk assessment guidance to support the determination of appropriate actions for the site, and is included as Section 6.0 of the RI report; the ecological risk assessment is presented in Section 7.0 of the RI report (USACE, 2005). A summary of the human health BRA is provided here.

The results of the human health BRA were developed according to the standard four basic risk assessment steps: identification of the contaminants of concern, development of exposure scenarios and input parameters, identification of the major toxic effects for the contaminants of concern, and presentation of the health risk characterization results. The assessment was limited to the radioactive constituents at the SLDA (specifically the eight ROCs identified in Section 1.2.3), consistent with the authorizing legislation for the site. The chemical toxic effects of these radioactive constituents were considered in this assessment, specifically for uranium, which is chemically toxic to the kidney.

The SLDA was divided into three exposure units (EUs) to support the BRA process. These EUs were developed based on environmental conditions, historical uses of specific areas, reasonableness of size in terms of representing receptor behavior, geographical similarity, and contamination potential. A consideration in developing these EUs was the need to identify final status survey units for future site closeout activities as identified in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (DOD et al., 2000). These three EUs, shown in Figure 1-6, address the upper trench area (EU 1), the lower trench area (EU 2), and an area near the fence southeast of the upper trench area (EU 3). The EUs include both contaminated surface and subsurface media and represent areas over which receptors are assumed to spend their time while at the site; therefore, the exposures are averaged over these areas. The assessments of the three EUs did not include an evaluation of the wastes in the trenches themselves. These materials were addressed separately, largely by comparison to the site-specific PRGs (shown in Table 1-3), which were developed using the probabilistic version of the Residual Radioactive Materials computer code (RESRAD) as described in Appendix A of the RI work plan (USACE, 2003a). In addition to evaluating exposures in the three EUs, a site-wide assessment was performed in which the receptors were assumed to access all areas of the site.

Four hypothetical scenarios were developed to reflect reasonably likely patterns of human activity that might result in exposures to the radioactive constituents at the SLDA. The two current-use scenarios (Maintenance Worker and Adolescent Trespasser) reflect possible exposures in the near term given the land use controls at the site, and two future-use scenarios (Construction Worker and Subsistence Farmer) consider greater exposures that could occur in the future should these land use controls be lost. These scenarios address a range of potential exposures and intakes, and provide useful information for guiding future remedial action decisions at this site. Patterns of activity were identified for these hypothetical individuals to determine the frequency and duration of potential exposures, the concentrations of radioactive constituents to which these receptors could be exposed, and appropriate intake parameters. The Subsistence Farmer was evaluated as the conceivable and worst case (bounding) scenario for the SLDA site. This scenario is the same as that previously used to develop the PRGs.

The results of the human health risk assessment were given in terms of the increased possibility that the hypothetical receptor would develop cancer over their lifetime as a result of exposures to the ROCs at the site. The EPA has noted that cancer is generally the only toxic effect that needs to be evaluated for radionuclides, and standard risk coefficients have been developed by EPA to represent this toxicity. The cancer risk estimates in the BRA were developed using these coefficients. The human health BRA also included estimates of the radiation doses associated with potential exposures at the SLDA because cleanup criteria for the site need to be evaluated on this basis, i.e., to allow for unrestricted future use, the dose to an average member of the critical group must be limited to 25 millirem per year (mrem/yr) as given in 10 CFR 20.1402. The radiation doses represent the 50-year total effective dose equivalent (TEDE), and were calculated using standard dose conversion factors developed by EPA. Finally, since uranium also represents a noncarcinogenic hazard to the kidney, this was addressed in the BRA by calculation of the hazard index (HI) consistent with EPA guidance. An HI of less than one indicates that there is little or no potential risk of noncarcinogenic health effects due to exposures to the ROCs.

Current information indicates that there is little radioactive soil contamination outside the footprint of the ten trenches, and the radioactive contamination that is present poses very little current and/or future risk. However, the previously disposed-of wastes contain significant concentrations of radioactive constituents (in excess of the PRGs developed for soil), and these materials could pose a potential risk to human health in the future. The carcinogenic risk to the Subsistence Farmer was calculated to be $3x10^{-3}$ using the results of the samples obtained from the trenches in the recent characterization program. This risk increases to $1x10^{-2}$ if the results are limited to the 13 samples that have field-screening evidence of waste. The HI exceeds one for both situations, and the annual doses are approximately 300 and 900 mrem/yr, respectively, which is well in excess of the annual dose limit of 25 mrem/yr necessary for unrestricted use of this site. These results confirm that the concentrations of radionuclides in the buried wastes are high enough to present a potential future risk to human health, and development and evaluation of remedial action alternatives for these materials is necessary.

The estimated radiological risks, radiation doses, and HIs associated with exposures for the four hypothetical receptors are given in Table 1-4. The data set used to develop Table 1-4 does not include samples collected from the disposal trenches. The radiological cancer risks for the two current-use scenarios were calculated to be at or below the lower end of the EPA target risk range of $1x10^{-6}$ to $1x10^{-4}$, reflecting the generally low levels of radioactive contamination at accessible areas and the relatively small amount of time that individuals would reasonably be expected to visit contaminated areas at the site. The estimated risks for the two future-use scenarios are also within or below the EPA target risk range. The maximum risk was calculated to be 1x10-5 for the Subsistence Farmer in the vicinity of Trench 10 (the major contributor to this risk is consumption of produce grown in contaminated soil). The annual radiation dose to this Subsistence Farmer was calculated to be about 5 mrem/yr (the exposure duration for this scenario was taken to be 30 years), or 20% of the annual dose limit of 25 mrem/yr identified in 10 CFR 20.1402 (Radiological Criteria for Unrestricted Use). The estimated HIs ranged from less than 0.001 to 0.010, indicating little potential for noncarcinogenic health effects.

The results of the human health BRA indicate that the SLDA site presents very little risk to human health under current conditions. The site is currently vacant and surrounded by a security fence that is actively maintained. The SLDA is routinely monitored and its open field is mowed twice a year. Air at the site perimeter is being monitored, and there are a number of groundwater monitoring wells in the vicinity to monitor groundwater movement and quality. However, reasonable assurance could not be provided that these conditions would remain in perpetuity and, over time, the radionuclides in the trenches would be expected to gradually leach to groundwater. Subsidence is also a concern at the SLDA site due to the numerous mine workings beneath the site. It is thought that if there were to be a mine workings collapse, subsidence could occur, creating potential new migration pathways for radionuclides.

In addition to the human health BRA, a screening-level ecological risk assessment (SLERA) was performed in order to determine the potential for adverse ecological effects to occur from exposures to radionuclides at the SLDA in the absence of remedial actions. The SLERA was performed using DOE’s graded approach for ecological risk assessments, as described in Section 7.0 of the RI report (USACE, 2005).

The SLERA was performed utilizing established biota dose limits of 1 radiation absorbed dose per day (rad/d) for aquatic animals, 1 rad/d for terrestrial plants, and 0.1 rad/d for terrestrial animals. The National Council on Radiation Protection and Measurements (NCRP) and the International Atomic Energy Agency (IAEA) developed these biota dose limits. If the doses to hypothetically exposed ecological receptors do not exceed these limits, it can be concluded that populations of plants and animals are adequately protected from the potential effects of ionizing radiation.

The SLDA is covered with various species of grasses, shrubs, and trees, and the entire site was addressed as a single terrestrial EU. Since plants and animals could be exposed to soils down to a depth of about 4 feet (1.2 meters), characterization data extending to this depth were used in this assessment. Most burrowing animals and plant roots do not extend beyond this depth, so deeper soil and waste samples were not considered. Dry Run sediments were also included in this terrestrial EU because Dry Run is an ephemeral stream. Two aquatic EUs were identified to address exposures (such as to riparian receptors) at Dry Run and Carnahan Run.

Radiation doses to hypothetical terrestrial, riparian, and aquatic organisms were modeled to develop biota concentration guidelines (BCGs) for the various radionuclides at the SLDA. The BCG is the limiting concentration of a radionuclide in soil, sediment, or water that would keep the protective dose limits (given above) from being exceeded. The BCGs were developed using conservative assumptions and are analogous to the PRGs developed for protection of human health. A sum of ratios (SOR) was calculated in cases where there were multiple radionuclides present in environmental media, in a manner identical to that used for the human health evaluations.

The maximum detected concentrations of radionuclides in soil, sediment, and surface water were used to calculate the SORs for the three ecological EUs. The SORs ranged from 0.3 to 0.5 for the three EUs, meaning that the biota dose limits were not exceeded. It was also determined that there is little potential for unacceptable risk to ecological receptors due to the chemical toxic effects of uranium at the site. Since the results of this conservative assessment indicate that the radionuclides at the SLDA do not pose a potential risk to ecological receptors, the SLERA was completed at the first screening stage, and no further evaluation of the potential risks to ecological receptors was warranted. Potential environmental impacts from implementing various remedial action alternatives, however, are addressed in this FS.

## 2.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

### 2.1 General

The identification and screening of remedial technologies consist of establishing remedial action objectives, identifying general response actions to satisfy these objectives, and identifying and screening specific remedial technologies associated with each general response action. Remedial technologies must address the ROCs and meet applicable ARARs. Technologies identified for the site fulfilling these criteria are then screened with respect to their relative effectiveness, implementability, and cost. Following the screening process, the most feasible technologies are further developed into alternatives in Section 3.0, Development and Screening of Remedial Alternatives.

### 2.2 Remedial Action Objectives

Remedial action objectives are established to protect human health and the environment and provide the basis for selecting appropriate technologies and developing remedial alternatives for the site. The development of RAOs is based on ARARs, the human health BRA, the SLERA, and analytical results of environmental samples from the site including those from: solid waste (trench contents), surface soil, subsurface soil, groundwater, surface water and seeps, sediment, leachate, biota, and air. The requirements discussed in Section 2.2.2 include 10 CFR 20.1402 (Radiological criteria for unrestricted use) and 10 CFR 20.1403 (Criteria for license termination under restricted conditions).

The RAOs were determined to be:

- Prevent the external exposure to, and the ingestion and inhalation of radionuclides (U-234, U-235, U-238, Th-232, Ra-228, Pu-239, Pu-241, and Am-241) present in trench wastes, surface and subsurface soil, and sediments at the SLDA site so that the TEDE to an average member of the critical group, when combined with the potential dose due to the ingestion of radionuclides in groundwater, and does not exceed 25 mrem/yr and does not result in an unacceptable non-cancer risk (i.e., a hazard index of greater than 1) for uranium.

- For those potential remedies that incorporate engineering and land use controls as part of a restricted release, prevent the external exposure to, and the ingestion and inhalation of radionuclides (U-234, U-235, U-238, Th-232, Ra-228, Pu-239, Pu-241, and Am-241) remaining at the SLDA site so that the TEDE to an average member of the critical group, when combined with the potential dose due to the ingestion of radionuclides in groundwater, and would not exceed 100 mrem/yr and would not result in an unacceptable non-cancer risk (i.e., a hazard index of greater than 1) for uranium, if the institutional controls were no longer in effect.

### 2.2.1 Radionuclides of Concern

Radionuclides of concern were developed as part of the BRA discussed in Section 1.2.5. The ROCs for the SLDA site are: Th-232, U-234, U-235, U-238, Am-241, Pu-239, Pu-241, and Ra-228.

### 2.2.2 Applicable or Relevant and Appropriate Requirements

Applicable requirements are defined by EPA as those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations published by the federal government, or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (EPA, 1989).

Regulatory standards defined by EPA are promulgated for specific types of activities at particular kinds of facilities; thus, these standards are limited in jurisdictional scope (EPA, 1989). However, if a regulatory standard would be legally enforceable against the facility under the circumstances of the release even without the CERCLA action, then the regulatory standard would also be applicable to the CERCLA action.

Relevant and appropriate requirements are defined by EPA as those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations published by the federal government, 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, nonetheless address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is suited to the particular site (EPA, 1989).

ARARs are divided into three categories, which may overlap: contaminant-specific (i.e., govern the extent of remediation); location-specific (i.e., protect existing natural and cultural features that may be affected by the site); and action-specific (i.e., govern implementation of the remedial alternative). There are no location-specific ARARs identified for the SLDA site at this time since no known features such as wetlands, floodplains, endangered or threatened species of fish and/or wildlife, or historically significant areas are present as the site is currently understood. Action-specific ARARs generally set performance or design standards, controls, or restrictions on particular types of activities.

Section 8143(a)(2) of Public Law 107-117 directs the USACE to clean up "radioactive waste" at the SLDA site, subject to Public Law 106-60 Section 611 consistent with the MOU between NRC and USACE. Accordingly, cleanup actions should be selected and conducted pursuant to CERCLA and the NCP.

The Potential ARARs for the site are 10 CFR Sections 20.1402 and 1403. Criteria in 10 CFR 20.1402 provide for unrestricted use for an average member of the critical group (i.e., dose ≤ 25 mrem/year), and ensuring that the residual radioactivity has been reduced to levels that are ALARA. Criteria in 10 CFR 20.1403 provide for restricted use for an average member of the critical group (i.e., dose ≤ 100 mrem/year if controls on the site are no longer effective). It would be expected that the level of site cleanup under 10 CFR 20.1403 would be less than that under 10 CFR 20.1402, as institutional controls would be used to limit the radiation dose to potential receptors.

Both potential ARARs are properly promulgated Federal requirements that provide cleanup standards or standards of control that specifically address the hazardous substances at the site. However, since USACE is neither the site owner nor a NRC licensee, the requirements are not legally applicable for a remediation conducted by USACE at the site. Instead, both are considered relevant and appropriate requirements under the circumstances of the release of the hazardous substances at the site. Specifically, the medium and substances, the actions or activities and the type of place regulated by the requirements are sufficiently similar to the circumstances at the site and the requirements are well-suited to the site.

A human health BRA was performed consistent with EPA risk assessment guidance to support the determination of appropriate actions for the site. The assessment was limited to the radioactive constituents at the site since, as stated previously, Section 8143 of Public Law 107-117 directs the Secretary of the Army to clean up radioactive waste at the SLDA site. The public law clearly identifies the requirement to address radioactive waste and does not discuss chemical waste. Therefore, there were no ARARs identified associated with the potential presence of chemical waste.

### 2.2.3 Development of Remediation Goals

As previously presented in Section 1.2.5, PRGs were developed for the ROCs based on an annual dose of 25 mrem/yr above background to a Subsistence Farmer residing at the site using the RESRAD computer code (ANL, 2001b). The PRGs were calculated using a probabilistic version of RESRAD consistent with NRC decommissioning guidance (NRC, 1999, 2000a, 2002), and were developed with the concurrence of the PADEP. No RI results indicated the need to modify the PRGs and, therefore, these values continue to be used as remediation goals. The PRGs are listed in Table 1-3. It is important to note that these values are above the background levels listed in Table 1-2 and are applied through the sum of ratios approach.

## 2.3 Estimated Volume of Material Requiring Remediation

While the exact volume of waste disposed of at SLDA is not known, several estimates of waste and associated contaminated soil have been developed over the past three decades. These estimates are summarized in Table 2-1 and range from 4,000 to 37,000 cubic yards (3,000 to 28,000 cubic meters). The inconsistency within the range of estimates is due to the different media volumes that are included in the various estimates. The lowest estimates represent the volumes of waste buried in the trenches. The highest estimates represent the total volume of waste and soil within the footprints of the trenches. The uncertainty associated with the actual volume of contaminated materials should be taken into consideration prior to developing any remedial design for the site.

For the purposes of this FS, the volume of contaminated soil and waste is taken to be 23,500 cubic yards (18,000 cubic meters) within and around the disposal trenches, and approximately 800 cubic yards (600 cubic meters) at various surface locations. These volumes are felt to best represent the actual volume of materials that will need to be remediated at the SLDA based on all available information, including the historical estimates given in Table 2-1, information compiled by the site owners, interviews conducted with local citizens, and the recent field investigations performed as part of the RI for the site. These volumes are intermediate between the two extremes given above, and were used to evaluate the various alternatives in the FS, including development of cost estimates for implementing the alternatives.

Five volume estimates have been prepared to determine the volume of material requiring remediation. These five estimates are presented in Appendix A in chronological order. It should be noted that only the fifth estimate attempts to calculate contaminated soil/waste volumes outside of the disposal trenches (i.e. surface soils). The first estimate was prepared by BWXT in 1971 shortly after the practice of waste disposal at the SLDA site was terminated (see Appendix A-1). The volume estimate of 31,000 cubic yards (23,500 cubic meters) was based on the BWXT's knowledge of the disposal trench dimensions, as well as assumed over-excavation due to construction practices.

The second estimate was developed by ARCO as part of a comprehensive site characterization completed between 1990 and 1994 (see Appendix A-2). This volume estimate of 23,500 cubic yards (18,000 cubic meters) consisted of the estimated volume of the geophysical anomalies thought to be the lateral limits of the disposal trenches, and a limited amount of contaminated soil encountered adjacent to these geophysical anomalies. The cleanup criterion used for this assessment was 30 pCi/g uranium. Although comprehensive, this estimate did not include an analysis of surface contamination and was limited to soil and waste in and around the disposal trenches.

The third volume estimate was submitted by ARCO to the United States Department of Justice in March 2000 and consisted of a brief summary of the materials placed in the trenches, the approximate time periods of disposal, and the estimated volume of contaminated soil and waste (see Appendix A-3). The estimated volume of 37,000 cubic yards (28,000 cubic meters) was based on operational records of the Apollo Facility and a cleanup criterion of 30 pCi/g uranium.

The fourth volume estimate was prepared by the USACE in 2004 and was based on a review of disposal records provided by ACRO (see Appendix A-4). The quantity of waste disposed of at the SLDA was estimated to be 4,000 cubic yards (3,000 cubic meters).

The fifth volume estimate was prepared by the USACE as part of this FS and utilized the empirical sampling data generated during the RI and previous characterization efforts (see Appendix A-5). This estimate of waste, soils, and debris assumed for purposes of this FS evaluation to require remediation was prepared using the following approach:

1. Isotopic data from collected surface soil, subsurface soil, and trench contents (waste) samples were compared to PRGs to determine whether remediation is required. If more than one isotope was analyzed for, the data were evaluated using the SOR approach to determine if remediation is required. If SOR values were 1.0 or greater, they indicated a dose greater than 25 mrem/yr.

2. ARCO collected a limited set of isotopic uranium data during the site characterization work completed in 1993. Evaluation of this data using the sum-of-ratios approach indicated that a total uranium activity of approximately 100 pCi/g or higher resulted in an SOR value of 1.0 or higher. Therefore, a total uranium criterion of 100 pCi/g was also used to identify areas potentially requiring remediation. Although the total uranium data are not isotopic data suitable for a direct SOR calculation, they do provide a strong indication that the PRGs are exceeded.

3. Volume estimates of surface soils and subsurface waste, soil, and debris requiring remediation were prepared based on the criteria discussed above and using standard contouring practices and interpolation between data points.

The results of the fifth volume estimate indicated that the total volume of radioactive waste, soils, and debris requiring remediation using the empirical data described above was estimated to range from 5,800 to 12,500 cubic yards (4,400 to 9,500 cubic meters). Overburden soils requiring excavation to permit access to these radiologically impacted subsurface soils and trench contents were not included in these volume calculations.

Considering all this information, a volume estimate of 23,500 cubic yards (18,000 cubic meters) of subsurface soil and waste and 800 cubic yards (600 cubic meters) of surface contamination were determined to be reasonable but somewhat conservative estimates of the volume of waste and contaminated soil requiring remediation. This total volume of 24,300 cubic yards (18,600 cubic meters) is greater than the most recent estimate developed for the site (the fifth estimate given above), but is felt appropriate for use in the FS given the uncertainties associated with the limited number of samples collected from the waste trenches. In addition, this estimate better considers the larger volume estimates previously developed by BWXT and ARCO. The only way to accurately determine the waste and contaminated soil volume at the SLDA would be to excavate these materials as part of site characterization, which was determined to be inappropriate.

## 2.4 General Response Actions

General response actions are broad response categories capable of satisfying the RAOs for the site. Each GRA may include several technologies or process options, some of which might be extensive enough to satisfy the RAOs and approved cleanup criteria alone, while others must be combined with different technologies or process options to achieve the RAOs for the site.

The SLDA GRAs were established based on site-specific concerns including the contaminants and impacted media (i.e., soil, sediments, and trench waste). The GRAs were identified as actions that could satisfy the RAOs and approved cleanup criteria so that the potential hazards to human health and the environment could be minimized. The SLDA site GRAs include No Action, Limited Action, Containment, Removal, Treatment, and Disposal.

The selection of the technologies and process options within each GRA was based on USACE experience in remediating other FUSRAP sites, EPA guidance, technology resource documents, and the potential ARARs identified for the site. The remedial technologies and process options associated with each GRA are shown in Table 2-2; a brief description of each GRA follows.

### 2.4.1 No Action

In this response, no action would be taken, and the hazard to potential human or ecological receptors would continue. The NCP and CERCLA require development of this response action as a baseline for comparison of the other alternatives.

For the purposes of this FS and to adhere to the intent of CERCLA guidance, the evaluation of the No Action alternative is based on the assumption that, in the future, the site would be neither controlled nor maintained. Under this assumption, all current land-use controls would no longer be maintained and therefore would be rendered ineffective. However, at SLDA that scenario is not likely since SLDA is a currently licensed site. In the future, one of the following would happen:

- The site would continue to be maintained by the licensee, under the requirements of the license, or;
- The licensee would successfully meet agreed-to license termination criteria, the license would be terminated, and the site would be lawfully released for a specified use.

It is not possible, within the scope of this FS, to reliably determine the consequences of pursuing a No Action alternative, therefore, as stated above, the No Action analysis presented here applies only to the site in a hypothetical state of abandonment.

### 2.4.2 Limited Action

Although this GRA assumes that no active remedial measures would be conducted, it could still be an effective action against exposure or access to contaminated media. The activities or technologies included within this response, which would provide some protection to public health and the environment, consist of site access restrictions, site inspection, site maintenance, environmental monitoring, and future land use controls. Some common land use controls and access restrictions include posting signs, resource restrictions, deed restrictions or notices, well-drilling prohibitions, and groundwater use advisories. Site maintenance activities identified during site inspections may include repair of fencing or signage, or repair of site topography adversely affected from erosion to guard against exposure of materials within the trenches or migration of radionuclides.

Environmental monitoring would allow assessment of radionuclide migration, which is an important component of preventing exposures above the allowable risk range. The environmental monitoring at the SLDA site would include air, groundwater, surface water, sediments, and external gamma radiation exposure monitoring.

### 2.4.3 Containment

Although containment actions would involve little or no treatment, they could protect human health and the environment by eliminating or reducing exposure to, and mobility of, the ROCs. Containment actions would be effective in minimizing exposure pathways by isolating the contaminated media from receptors. The containment technologies evaluated for SLDA included capping of the disposal trenches, installation of a slurry wall and grout curtain arrangement, and stabilization of the deep mine through grout injection. Capping involves covering a contaminated area with a low-permeability single or multi-layer cap to shield receptors from radioactivity and reduce the migration of contaminants to the atmosphere, adjacent soils, or groundwater. Slurry walls and grout curtain technology are designed to minimize lateral migration of groundwater into and impacted groundwater out of the remediation area. Injection of grout into the deep mine would minimize the potential for mine subsidence. Each of these containment actions would also include site access restrictions, site inspections, site maintenance, environmental monitoring, and land use controls.

### 2.4.4 Removal

Removal activities would reduce the contaminant levels in the remaining soils and waste debris to acceptable levels, eliminate contaminant migration, and mitigate the long-term potential of human exposure to radioactivity above the threshold levels. Technologies under this action would be effective in reducing contaminant mobility since the contaminated media would be physically removed and isolated. However, they would not reduce the volume or contaminant levels of the removed material. As a result, this activity is often used in combination with other response actions, such as treatment or disposal.

### 2.4.5 Treatment

This response action is the preferred action under the Superfund Amendments and Reauthorization Act (SARA), and utilizes in situ and ex situ technologies. Treatment actions are preferred because they generally reduce toxicity, mobility, or the volume of the contaminated media and, thus, provide a greater degree of protection to human health and the environment. Ex situ treatment could be performed on or off site; however, in situ treatment occurs in the ground on site. The treatment technologies considered for SLDA include physical, chemical, and solidification/stabilization processes. Biological and thermal processes are not addressed in this FS because of their inability to effectively degrade or destroy radionuclides. Brief descriptions of each option are presented in Table 2-2 and described in more detail in Section 2.5.

### 2.4.6 Disposal

Contaminated soil and waste disposal activities may be implemented on or off site. Disposal actions would not reduce the volume or contamination level of the affected media, but they would reduce the mobility of contaminants through the permanent and final placement of the waste materials in a manner that protects human health and the environment. The on-site disposal option for contaminated waste, soil, and debris would consist of placement of waste materials into a waste disposal cell constructed at a suitable location on-site. The off-site disposal options considered for waste, soil, and debris would be the appropriate solid waste and LLW disposal facilities. Contaminated liquid wastes collected during remedial activities would also be disposed of off site at a licensed treatment facility. Disposal of collected liquid wastes that meets surface water discharge criteria could occur at a licensed or permitted treatment facility. Residual materials encountered during remediation and found to be uncontaminated could be disposed of on site.

## 2.5 Identification and Screening of Technology Types and Process Options

This section identifies and screens the technologies and process options that may be used to meet the RAOs for the remedial efforts at the SLDA site. As mentioned in the previous sections, the remedial technologies and process options have been selected for evaluation based on (1) research performed by the DOE, USACE, and EPA on remediation of radiological wastes, (2) the potential ARARs identified for the site, and (3) experience with previous CERCLA and FUSRAP cleanups (see Section 7.0, References). The selected process options include conventional, emerging, and innovative technologies that are initially screened based on the technical implementability of the option to accomplish the RAOs. As defined by EPA, the following questions are considered during this screening process:

- Would the technology be effective at removing, containing, or treating the radionuclides of concern at SLDA or, by contrast, would it facilitate their migration?
- Would interference from other elements found in the waste, soil, and debris prevent the technology from effectively removing, containing, or treating the radionuclides?
- Are site conditions optimal for proper operation of the technology?
- Has the effectiveness of the technology been demonstrated in the field?
- Does the basis for the technology focus on remediating the soil and waste debris or does it relate to other media, such as groundwater or air?
- Would the technology be effective in a reasonable amount of time?

During the initial screening, those technologies and options that are not applicable to this remedial project based on one or more of the above factors are removed from further consideration as a remedial option. Those technologies or process options highlighted in bold in Table 2-2 passed the screening process and are retained for further evaluation. The process and results are discussed in more detail in the following sections.

### 2.5.1 No Action

No remedial technologies or process options would be employed for this response action. For purposes of this FS it is assumed that all activities, including basic site maintenance and environmental monitoring currently completed by BWXT in conformance with their license with NRC, would be discontinued under this response action (refer to Section 2.4.1). This option is considered because it is required by the NCP and CERCLA as a baseline for comparison to the other alternatives. As a result, the No Action remedial response is retained for further evaluation.

### 2.5.2 Limited Action

No active remedial measures would be conducted under the Limited Action GRA. Access restrictions to the site (e.g., fencing and barriers) and security allowing only authorized access, would be implemented under this process. In addition, deed restrictions and modified zoning would be implemented to prevent future owners from performing certain activities. Groundwater and surface water sampling and analysis would be instituted as part of a long-term environmental monitoring program to be completed over the performance period of 1,000 years. Radiation exposure monitoring and soil sampling may also be conducted where necessary. Site maintenance activities identified during site inspections would be required over the performance period, such as repair of fencing or signage and repair of site topography adversely affected from erosion or mine subsidence.

The Limited Action GRA and associated process options would be controlled through NRC license and are applicable to the SLDA site, especially when combined with other technologies. As a result, the Limited Action GRA, including all of the technologies and process options, is retained for further consideration.

### 2.5.3 Containment

The purpose of containment would be to minimize contact with the contaminated soil and waste debris, reduce exposure to radiation, control the release of airborne contamination, and reduce the likelihood of contaminated materials coming in contact with precipitation or groundwater. The containment technologies screened for this remedial project include capping, slurry walls/grout curtains, and mine stabilization.

The capping technology could be applied to contaminated media to reduce radiation exposure, prevent direct human contact, and isolate the contaminated media from surface water and precipitation. Capping could also reduce infiltration of rainwater through the contaminated media, thus mitigating contaminant transport to groundwater. Capping would not, however, prevent horizontal migration of contaminants in groundwater. Although capping would provide dust control, it would not reduce the hazards associated with migration of the waste material, as the concentrations or volume of the ROCs would not change.

The two basic capping designs were considered consisting of either a single- or multiple-layer cap. Each of the cap configurations could be constructed over the top of the contaminated media to inhibit infiltration and exposure to surface soils. Synthetic liners and multiple layer caps (composite caps) are the most common capping designs and are not as susceptible to cracking as other types of caps. Other capping examples include asphalt, concrete, native soil, and clay caps. If capping is the selected technology, various surface controls may also be required to control erosion from surface water runoff, uneven settling over time, or unwanted vegetation on the cap surface.

Slurry wall and grout curtain technologies are commonly used to limit lateral migration of groundwater into or out of the contaminated area. Both slurry walls and grout curtains involve the placement or injection of a low permeable material that isolates the impacted media from unimpacted media. Slurry walls typically extend from groundwater surface to the top of a lower confining layer (i.e. bedrock, native till, clay) while grout curtains are installed into bedrock. Injection of grout into the deep mine void would involve installation of numerous grout injection points and pumping grout into the mine until the area beneath the cap is stabilized. Since the effectiveness of capping, slurry walls, grout curtains, and mine grouting has been field demonstrated and the characteristics of the media of concern do not interfere with the performance of these containment components, Containment is retained for further consideration.

### 2.5.4 Removal

Removal technologies would involve the active excavation, handling, and management of contaminated media prior to some type of treatment or disposal action in order to control further migration of the contaminants. Conventional soil excavation techniques include the use of a variety of construction equipment to remove waste, soil, and debris from the contaminated source areas.

Activities that are often performed during excavation include dust suppression, the use of particulate capture equipment, and the collection, treatment, or disposal of accumulated residual water. These activities are common and have been successfully used in response actions at many CERCLA sites and may be required to adequately protect worker safety and minimize contaminant migration at the SLDA. Excavation would be effective at removing the radioactive constituents on-site, as it is a proven technology. Although the waste media at the SLDA site would not preclude the use of conventional construction equipment, certain ground and surface water control measures may be necessary in order to effectively excavate the buried wastes. This technology is retained for further consideration.

### 2.5.5 Treatment

The technologies and process options screened for treatment of wastes, debris, and soils at the SLDA site include a variety of in situ and ex situ processes. The basic technology groups are physical, chemical, and solidification/stabilization processes. Biological and thermal treatment options are not considered because of their ineffectiveness in remediating radionuclides.

#### 2.5.5.1 Ex situ Treatment

Ex situ treatment technologies include a number of process options that are evaluated based on their ability to reduce contaminant toxicity, mobility, and volume. The process options screened include the following:

- Physical Processes
    - Separation/size reduction
    - Radiological sorting
    - Soil washing
- Chemical Processes
    - Oxidation/reduction
    - Solvent extraction
- Solidification/Stabilization Processes
    - Grouting
    - Polyethylene encapsulation
    - Vitrification

##### 2.5.5.1.1 Physical Processes

The physical processes screened for this project are separation/size reduction, radiological sorting, and soil washing. All of these techniques involve some type of physical handling method that separates radiological contamination from wastes, debris, and soils, thus concentrating the waste into smaller volumes.

**Separation/size reduction:** The separation technique that would be most implementable at the SLDA site would be sieving/physical separation. This is a screening process that is sometimes a precursor technology implemented prior to treatment or disposal. The separation of oversize material (e.g., boulders, cobbles, trash items, etc.) from the finer material that typically binds the contaminants (e.g., clays and silts) can reduce the amount of waste that would have to be treated further or disposed of. Radiological screening (release characterization) would take place after the physical segregation.  Size reduction techniques using crushers and shredders are complementary processes to separation techniques and could be necessary for the oversized contaminated material that is  with the soils at the SLDA.  Although some separation techniques can be only marginally effective on soils consisting of silty loams, the wide range of media sizes at the SLDA could make the sieving/physical separation processes useful.  For this reason, this process option is retained for additional consideration.

**Radiological sorting:** Sorting is a type of volume reduction process that separates variably contaminated mixtures or batches of contaminated media into different output streams based upon radioactivity levels (i.e., above and below clean up levels).  The end result of the sorting process is a reduction in the volume of contaminated media that needs to be disposed of.  This technology has proven to be effective in addressing various levels of radioactivity.  Radiological sorting can be accomplished outside the excavation area utilizing an automated process with specialized equipment, or within the excavation area using radiation technicians, scintillation scanners, and common excavation equipment.

Radiological sorting is more effective at sites where there is a wide range of radioactivity typical of heterogeneous wastes.  The effectiveness of radiological sorting would be reduced when used in conjunction with separation/size reduction since in most cases the debris containing the highest radioactivity would be removed during the separation/size reduction phase of the work.  The resulting material subject to radiological sorting would be typically comprised of mostly soil containing more uniform radioactivity levels, which are more difficult to sort.

Radiological sorting is more effective for unsaturated, granular wastes and soils.  The overburden soils at the SLDA site consist of mine spoils near trench 10 and clayey silts with fine sand near the upper trenches.  The mine spoils should be suitable for radiological sorting techniques especially since the soils were excavated during mining operations in the mid 1950s, are unsaturated, and are more granular.  The clayey silt soils present in the upper trench area, although not ideal, may be receptive to this process option especially in conjunction with pre-treatment processes such as sieving, screening, pulverizing, and drying.  Implementation of these pre-treatment processes would likely produce a more suitable physical soil composition necessary to overcome limitations associated with cohesive soils. Based on the potential implementation of radiological sorting at the SLDA site, it has been retained for additional consideration.

**Soil washing:** In soil washing, excavated contaminated soils are "scrubbed" to separate clean soil from contaminated soil, thereby reducing the volume of waste requiring further treatment or disposal. Soil washing generally uses a water solution of surfactants and chelating agents to remove contaminants from the soil or waste media. This process can be enhanced through mixing and agitation, which promote suspension of the contaminants in the solution and separate smaller, fine-grained particles from coarser particles. Soil washing would not reduce the toxicity of a contaminant, and the process could be complicated if the waste media consist of a large percentage of silts and clays that may be difficult to remove. Although this process could be effective in removing the radiological contamination and has been demonstrated on other sites, implementability would be difficult due to the homogeneous nature of the silty and sandy clays at the SLDA site. As a result, this process option is removed from additional evaluation.

#### 2.5.5.1.2 Chemical Processes

Chemical process options evaluated in this FS involve the extraction or conversion of radionuclides from the wastes, soils, and debris by means of dissolution or suspension in solvents or other chemicals. The liquid waste stream that is created is then treated to remove the contaminants. The process options initially screened in this FS include oxidation/reduction (redox) and solvent extraction.

**Oxidation/reduction:** Redox reactions involve the addition of oxidizing agents to chemically convert hazardous contaminants in wastes and soils to non-hazardous or less toxic compounds. This process is often used as a form of supplemental treatment to physical processes for removing inorganic contaminants from wastes or soils. Although this process option is effective in removing inorganic contaminants and has been demonstrated in the field, its main focus is on heavy metals in liquid waste streams. In addition, chemical reduction usually supplements a "wet separation" technique, such as soil washing, which has already been removed from further consideration. Therefore, this process option is also removed from further evaluation.

**Solvent extraction:** Solvent extraction is a process that is similar to other chemical mixing and separation processes, and it is often used in conjunction with other technologies such as soil washing or solidification/stabilization. In this process, an organic chemical is used as a washing agent to remove contaminants from wastes or soils. Although various forms of this process can be suitable for the removal of some inorganic constituents, it has been demonstrated to be most effective for removing organics. In addition, the high percentage of silts and clays in SLDA soils can make this process inefficient. Due to the focus of radionuclide cleanup at SLDA, this process option is removed from further evaluation.

#### 2.5.5.1.3 Solidification/Stabilization Processes

Solidification/stabilization (S/S) technologies are specific types of immobilization processes that physically or chemically reduce the movement of contaminants in wastes, soils, and debris by the use of a stabilizing agent. The process options selected for screening in this FS include grouting, polyethylene encapsulation, and vitrification.

**Grouting:** This process involves the mixing of the media of concern with binding material (i.e., grout or other equivalent matrix) and water to produce a volume of waste that is resistant to leaching and potentially possesses increased structural strength/stability. Unlike stabilization, which is a process that converts the contaminated media into a chemically stable form, the process of grouting is a solidification process that mechanically binds the contaminant and additive together. Although the presence of organics in the media of concern may interfere with the effectiveness of this process option, grouting has been demonstrated in the field under similar circumstances, and site conditions are compatible with the use of this technology. Therefore, this process option is retained for further consideration.

**Polyethylene encapsulation:** Encapsulation is a process similar to grouting in that it seals the contaminated media into a monolithic, solidified form. Polyethylene encapsulation mixes polyethylene with the contaminated media to produce a homogeneous mixture of waste and polyethylene binder. This technology is retained for further evaluation because it has been shown to be effective in containing the ROCs (BNL, CDM, 1999). Additionally, no interferences from other substances in the soils or debris are expected, site conditions would not preclude the use of this technology, and the process has been demonstrated in the field.

**Vitrification**: This process is also considered a stabilization method; however, it employs heat energy (up to 2,200 degrees Fahrenheit [1,204 degrees Celsius]) in order to convert the waste soils and crystalline material into a solid matrix. The radionuclides are actually incorporated into the glass-like structure, which is a strong, durable product that is resistant to leaching. For these reasons, and because vitrification has been shown to reduce the gamma dose rate from certain radioactivity, this process is retained for further evaluation.

#### 2.5.5.2 In situ Treatment

In situ treatment technologies include a number of process options that are evaluated based on their ability to reduce contaminant toxicity, mobility, and volume. The process options that were screened include the following:

- Chemical Processes
  - Soil Flushing
  - Acid Leaching
- Solidification/Stabilization Processes
  - Solidification/Stabilization
  - Encapsulation

##### 2.5.5.2.1 Chemical Processes

The chemical processes initially screened for this FS are soil flushing and acid leaching.

**Soil Flushing:** In situ soil flushing is very similar to the ex situ process of soil washing. Flushing uses a solution to saturate the contaminated media in order to remove the contaminants. Soil flushing is done in situ and, therefore, an extraction system is necessary in order to retrieve the wash water. This technology may have limited effectiveness because the majority of contaminants within the clayey silt soils matrix present in the upper trench area would not come in contact with the injected solution. In addition, this process would occur just above or below the groundwater table and the use of washing solutions at these depths may further impact the groundwater quality. Therefore, the use of soil flushing may be difficult to implement due to potential regulatory obstacles. Therefore, this process is removed from further consideration.

**Acid Leaching:** In situ acid leaching is also similar to soil washing. This process removes metals (including uranium) from soils by converting them into a more soluble form through the use of an acid leaching solution. The effectiveness of this technology has not been proven in the field due to regulatory issues involving the introduction of hazardous chemicals into the ground and the associated potential impact on groundwater. Therefore, it is removed from further consideration.

#### 2.5.5.2.2 Solidification and Stabilization Processes

The in situ solidification and stabilization processes that are initially screened for this FS are solidification/stabilization and encapsulation.

**Solidification/Stabilization:** This process is almost identical to the ex situ version of grouting. The process produces a non-leachable matrix that possesses the same qualities as the ex situ matrix, and the in situ process can be almost as effective. However, there have been problems demonstrating this technology in the field due to the difficulty of producing a homogeneous matrix. In some cases, the lack of homogeneity has been found to allow continued leaching. Therefore, this technology is removed from further consideration.

**Encapsulation:** In situ encapsulation is performed by injecting a grout made of calcium carbonate precipitating solutions into the contaminated area. The resultant formation is an in-ground monolith that is strongly resistant to water infiltration. Similar to in situ solidification/stabilization, this process has not been found to consistently produce a homogeneous matrix. Therefore, this technology is also removed from further consideration.

#### 2.5.6 Disposal

Disposal technologies that are applicable to SLDA remediation include on- and off-site disposal of contaminated soil, sediments, debris, and other solid wastes generated by containment, removal, or treatment options. On- and off-site disposal of residual waters that are byproducts of removal, treatment, or solidification technologies would also be considered for alternative development. Therefore, on- and off-site disposal are retained for further evaluation.

##### 2.5.6.1 Off-site Disposal of Soil and Debris

The process option for off-site disposal initially screened during this FS consists of disposal at an appropriate off-site disposal facility permitted to receive LLW. Selection of the disposal facility would be done in compliance with applicable federal and state regulations. Chemical wastes will be addressed only to the extent that they are commingled with the radioactive wastes at the site.

##### 2.5.6.2 On-site Disposal of Soil and Debris

On-site disposal would consist of an aboveground encapsulation facility or engineered cell with a cover system to inhibit water infiltration, contaminant migration, and direct radiation exposure. A new encapsulation facility or engineered cell would require significant construction. The SLDA site is located in an area with agricultural, residential, and light commercial land use surrounding the property and the proximity of an encapsulation facility may not be well accepted by the public.

### 2.6 Evaluation of Technologies and Selection of Representative Technologies

This section presents an evaluation of the technologies and process options presented in Section 2.5 and retained for further evaluation. The screening methodology in this section uses the factors of effectiveness, implementability, and cost to evaluate the remedial options in relation to site-specific conditions.

**Effectiveness:** This evaluation criterion focuses on whether or not the process options protect human health and the environment during and after implementation, comply with the RAOs given the nature and estimated volume of the media of concern, and are proven and reliable with respect to the contaminants. Accordingly, evaluating this criterion requires addressing the ability of technology or process option to reduce radioactivity or exposure levels, recover contaminated media for subsequent treatment (where applicable), and perform its intended function in a reasonable length of time. Lastly, evaluating the effectiveness involves assessing the reliability of each process option, including reviewing its operation and maintenance (O&M) requirements.

**Implementability:** Implementability encompasses both the technical and administrative feasibility of the process option or technology. Technical feasibility relates to the availability of the technology, the relative ease or difficulty of operating and maintaining the technology, and the time in which the technology can be constructed and implemented. Administrative feasibility addresses the availability of treatment, storage, and disposal facilities (TSDFs), the availability of workers/contractors to implement the technology, and the ability to obtain approval to implement the technology from the appropriate government agency. Governing agency approval is based upon their stance on the technology, which could be influenced by the need for additional steps that may be required to implement a technology, such as pretreatment or management of residual wastes. The additional process steps may be viewed as complications that could increase the potential of an environmental release, and thereby adversely impact human health and the environment.

**Cost:** This criterion plays a limited role in the evaluation process prior to the development of alternatives. At this time, relative capital costs and O&M costs are considered rather than detailed estimates. The cost analysis is based on engineering judgment, and each process is evaluated to determine whether the costs are higher, about the same, or lower relative to other process options. The performance period for which costs are evaluated is 1,000 years.

Based on EPA guidance, this evaluation focuses on the effectiveness criterion and places less emphasis on implementability and relative cost. Those technologies and process options that pass this second level of screening are either required by law or expected to achieve the RAOs for the site, either alone or in combination with other technologies or process options. The results of this screening process are summarized in Table 2-3 and described below. Since descriptions of the technologies were presented in the previous section, only the conclusions of the evaluation are presented here.

### 2.6.1 No Action

#### 2.6.1.1 Effectiveness

The No Action remedial response would not reduce the toxicity, mobility, or volume of the contamination present at the SLDA site. As a result, No Action is not considered effective in achieving the RAOs presented in Section 2.2. No remedial activities would be implemented to reduce the potential for exposure and it is assumed that current engineering controls and monitoring conducted by BWXT would not be maintained (refer to Section 2.4.1). However, in accordance with CERCLA, this remedial response action is retained for development of a baseline for comparison to other alternatives.

#### 2.6.1.2 Implementability

The No Action remedial response is readily implementable since no remedial actions would be undertaken.

#### 2.6.1.3 Cost

Since there are no remedial actions, the No Action remedial response has the lowest anticipated cost of the technologies and process options considered for the SLDA site.

### 2.6.2 Limited Action

#### 2.6.2.1 Effectiveness

The Limited Action remedial response would not reduce the toxicity, mobility, or volume of the contamination present at the SLDA site. The process options under Limited Action controls (i.e., deed restrictions, monitoring, and barriers) are considered effective in limiting exposure and would provide more protection to public health and the environment than the No Action alternative. Nevertheless, Limited Action would have a relatively low level of effectiveness in achieving the remedial action objectives presented in Section 2.2 since there would be no active remedial activities preventing a release to occur over time. Such a release could impact nearby areas causing exposures that may not be immediately detected.

#### 2.6.2.2 Implementability

Limited Action is technically implementable since the only activities involved consist of environmental monitoring, site inspection, and site maintenance; and these activities would be subject to NRC control through the existing license. However, administration of Limited Action tasks could be considered difficult since this response would require coordination with governmental agencies to implement deed restrictions and groundwater use restrictions, as well as tasks necessary to coordinate and document the findings of the environmental monitoring program throughout the 1,000-year performance period.

#### 2.6.2.3 Cost

Implementing Limited Action process options would require low capital and high O&M costs projected over the 1,000 year performance period. These costs would be considered low compared to the other technologies and process options considered for the SLDA site. It is assumed that funding for this action would be established at the beginning of the performance period.

### 2.6.3 Containment

#### 2.6.3.1 Effectiveness

The Containment technologies retained for further consideration consist of surface controls, caps, slurry walls, grout curtains, and deep mine grouting. Surface controls, such as construction of drainage swales, would be effective in controlling stormwater flow by reducing precipitation infiltration into the impacted areas and minimizing erosion.

Capping is effective in reducing direct radiation, inhalation, and dermal exposures to acceptable levels for human receptors at the surface. It can also inhibit the migration of contaminants by controlling direct contact between infiltrating surface water and contaminated wastes and soils. The cap installed at the SLDA site would be designed as a single or multiple layer cap to reduce radiation exposure and limit infiltration.

Slurry walls and grout curtains constructed at the SLDA site would effectively reduce the mobility of ROCs by diverting groundwater flow around impacted areas and/or containing impacted groundwater within the impacted areas.

Injection of grout into the deep mine would fill the mine void beneath the capped area and reduce the potential for mine subsidence.

Containment technologies such as capping, slurry walls, grout curtains, and mine grouting however, would not remove the source of contamination, which could limit future use of the property. Also, these structures would have to be maintained as long as contamination exists at the site and would require institutional controls to limit site access. The long-term effectiveness of slurry walls, grout curtains and grout injected into the mine voids would be difficult to evaluate over the performance period since inspection of these types of installations would not be cost effective. The long-term monitoring associated with containment would be effective in evaluating potential migration of ROCs both within the confines of the site and off site.

#### 2.6.3.2 <u>Implementability</u>

The Containment remedial response action is technically implementable since construction of the various containment components could be accomplished using conventional construction equipment and techniques. The construction period to implement containment would be on the order of two years, which is equal to or less than the time expected to be required for the removal and disposal technologies. Another important consideration is the implementability of the long-term monitoring that would be required to evaluate the potential migration of ROCs. In addition, site inspections would need to be conducted at least annually and maintenance would have to be conducted as warranted. Like the limited action activities, these containment action activities would also be subject to NRC control through the existing license.

Administrative activities would be required to support the long-term environmental monitoring, inspection, and maintenance program required throughout the 1,000-year performance period. It is assumed that governmental agency oversight of the containment action would be present along with durable institutional controls to ensure protectiveness over time.

#### 2.6.3.3 Cost

Implementing Containment process options would require moderately high capital costs and moderate O&M costs. It is assumed that funding for this remedial response action would be established at the beginning of the performance period. Construction costs associated with the various containment components (surface controls, caps, slurry walls, grout curtains, mine grouting) could be estimated with a relatively high degree of accuracy, assuming the impacted areas of the site are accurately identified. The overall cost for containment is higher than the Limited or No Action scenarios, but it is expected to be lower than costs for the Removal and Disposal technologies.

### 2.6.4 Removal

#### 2.6.4.1 Effectiveness

Excavation could be used to remove the radionuclide-contaminated wastes, soils, and debris to the extent necessary to achieve the approved cleanup criteria. It is expected that, during excavation activities, protection of the workers, public, and environment from contamination would be achieved though the use of dust suppression and surface and groundwater control techniques, such as dewatering, treatment, and disposal. Removing wastes and soils to the established excavation limit would be effective in reducing contaminant exposure levels to the public and environment within a reasonable length of time and with few O&M requirements.

The Removal remedial response action is considered effective in achieving the remedial action objectives presented in Section 2.2, assuming the impacted materials would be transported off site for disposal or managed on site to reduce the exposure risk to acceptable levels.

#### 2.6.4.2 Implementability

Removal is considered readily implementable since excavation-related activities would be accomplished using conventional construction equipment and practices. The availability of equipment and labor is not expected to be problematic. If removal and off-site disposal are implemented, a long-term environmental monitoring program would not be required since the impacted material would be removed from the site.

Administrative tasks associated with the coordination of a removal technology would be moderately difficult. The level of effort required to obtain approval of this technology from the governing agency and the general public would be relatively low since removal is a preferred remedial response and it is generally recognized to satisfy all RAOs. Administrative activities required to coordinate the removal work itself, however, would be significant, especially in conjunction with permitting and approvals for off-site disposal.

#### 2.6.4.3 Cost

Implementing Removal process options would require high capital costs and low O&M costs. It is assumed that funding for this remedial response action would be established in the beginning of the performance period. Construction costs associated with the Removal remedial response action have some degree of uncertainty since the extent of ROCs in the subsurface wastes and soils are often not well defined. The overall costs associated with removal process options are generally higher than the No Action, Limited Action, and Containment remedial response actions.

### 2.6.5 Ex situ Treatment

The ex situ treatment technologies retained after the pre-screening process included physical and solidification/stabilization processes. Ex situ treatment process options would likely be implemented in combination with removal and on-site or off-site disposal.

#### 2.6.5.1 Physical Processes

##### 2.6.5.1.1 Effectiveness

The two ex situ physical processes retained for further consideration are separation/size reduction and radiological sorting. Separation/size reduction is a full-scale, well-established technology for effectively concentrating like-sized particles and debris. Based on the contaminated particle sizes, this process can be effective in concentrating radiologically contaminated media into smaller volumes. This process option utilizes screens and sieves to segregate wastes, soils, and debris based on size and composition. Although separation/size reduction would not protect human health and environment as a standalone technology, it could result in a significant reduction in the volume of radiologically contaminated materials requiring disposal with relatively small equipment in a reasonable length of time.

Radiological sorting is an innovative technology designed to reduce the volume of contaminated wastes and soils based on measured radioactivity levels. Similar to separation/size reduction, radiological sorting would not protect human health and environment as a standalone technology; however, it could significantly reduce the volume of radiologically contaminated materials. The effectiveness of radiological sorting can be dependent on both the conditions of input materials (i.e., debris versus soils, cohesive soils versus granular soils, moisture content, etc.) and activity screening level (usually the remediation goal). The effectiveness of radiological sorting equipment is increased if there is a heterogeneous distribution of radioactivity within the media being processed.

The effectiveness of radiological sorting would be reduced when used in conjunction with separation/size reduction since in most cases the debris containing the highest radioactivity would be removed during the separation/size reduction phase of the work. Since the separation/size reduction process usually results in several well-mixed, homogeneous waste piles of like-sized particles, the resulting material would typically be comprised of mostly soil containing more uniform radioactivity levels which are more difficult to separate by radiological sorting.

#### 2.6.5.1.2 Implementability

Separation/size reduction is technically implementable as it is based on the fact that a significant percentage of the radioactive material is associated with debris buried on site during historical disposal operations. The debris could be readily separated from the clayey silt-type soils prevalent in the upper trench area or from the mine spoils present in the lower trench area. In addition, weathered bedrock could be separated from the process stream using separation/size reduction.

Radiological sorting is technically implementable since the soils at the SLDA site, although not ideal, should be suitable to this technology. Gradation curves of the mine spoils present near trench 10 indicate the mine spoils are comprised of approximately 43 percent sand, 30 percent silt and 27 percent clay. Observations made during RI field investigations indicate that some gravel is also present, as would be expected from historical strip mining activities. The clayey silt soils present in the upper trench area, although not ideal, may be receptive to this process option especially in conjunction with pre-treatment processes such as sieving, screening, pulverizing, and drying. Implementation of these pre-treatment processes would likely produce a more suitable physical soil composition necessary to overcome limitations associated with cohesive soils.

The implementability of radiological sorting at the SLDA site may be reduced, however, when performed subsequent to separation/size reduction since the resulting media would likely consist of mostly soil with more uniform radioactivity levels. A pilot test should be considered to better evaluate the implementability of radiological sorting when used with separation/size reduction.

#### 2.6.5.1.3 Cost

The capital and O&M costs associated with separation/size reduction process options are considered relatively low. Radiological sorting equipment is considered a relatively complicated, innovative technology, which is typically leased from a specialty vendor at a moderately high cost. Similarly, the labor and O&M costs are moderately high; however, these costs may be offset by a significant savings in the transportation and disposal costs associated with off-site disposal of LLW. A cost benefit analysis should precede selection of this technology.

### 2.6.5.2 Solidification/Stabilization

#### 2.6.5.2.1 Effectiveness

All of the solidification/stabilization treatment technologies were retained after the initial screening process. These processes are quite similar in the sense that they remediate waste, soil, and debris by physically reducing the mobility of the radionuclides in the impacted materials. These treatment technologies are often combined with on-site disposal since in many cases the radiological dose is reduced to acceptable levels. While grouting can be used on most waste/soil media, its effectiveness is most evident on radionuclides and inorganic constituents than on organic constituents. The composition of the SLDA soils (mine spoils at Trench 10 and clayey silts in the upper trench area) would likely facilitate adequate mixing of the binders or chemicals with the contaminated soils. Polyethylene encapsulation has also been shown to be effective in solidifying soils contaminated with radionuclides and metals. In addition, O&M requirements for this process are similar to other immobilization process options. Vitrification could effectively convert the waste soils into a solid matrix that is strong, durable, and resistant to leaching.

#### 2.6.5.2.2 Implementability

Ex situ solidification/stabilization processes are technically implementable since the process would utilize conventional construction equipment and techniques. Labor requirements are not specialized and local resources could be utilized. However, this group of ex situ treatment process options would need to be completed in conjunction with another remedial response action such as disposal.

Ex situ solidification/stabilization processes, used in conjunction with on-site disposal, would be difficult to implement administratively since this remedial response action would likely face significant governmental agency and public approval problems.

Contaminated wastes, soils, and debris treated through solidification/stabilization processes would often require additional acceptance testing beyond that normally performed for off-site waste disposal. Administrative feasibility may be an issue because all of these process options could be viewed as unnecessary steps prior to disposal, if disposal is selected as the ultimate remedial response action. Each of these issues would invoke seemingly unnecessary additional costs. In addition, the process of excavating and disposing of the waste material would be less complex and less expensive than excavating, solidifying, and then disposing of the waste. Also, based on past experience with similar waste streams, the characteristics of the contaminated wastes, soils, and debris would not call for stabilization to meet disposal facility waste acceptance criteria. Lastly, the addition of solidifying/stabilizing agents used in this process could significantly increase the volume of the contaminated waste, soil, and debris, thereby significantly raising disposal costs.

**2.6.5.2.3 Cost**

The capital and O&M costs to complete ex situ solidification/stabilization processes on site are considered low to moderate. Vitrification costs may be significantly higher, depending on the results of pilot tests to determine the effectiveness and power requirements. In all likelihood, the impacted materials would be transferred to a temporary on-site structure where the treatment process would be completed. The overall remedial response action cost would be high due to the cost of excavation, ex situ treatment, and ultimate disposal on site or off site. As discussed in Section 2.6.5.2.2 (Implementability), ex situ solidification or stabilization may not provide any benefit for off-site disposal and it would increase the overall cost since the process typically increases the mass to be disposed of. Compared to the other remedial response actions evaluated in this section, ex situ treatment using solidification/stabilization processes in combination with disposal would result in the highest cost.

### 2.6.6 Disposal

#### 2.6.6.1 Effectiveness

The waste disposal options considered in this evaluation that were retained after the initial screening include on-site disposal of soil and waste debris, off-site disposal of soil and waste debris, off-site disposal of residual water, and on-site disposal of residual water.

Options for off-site disposal of excavated wastes include solid waste and LLW facilities. On-site and off-site disposal would be effective in preventing the contaminants of concern from migrating into the surrounding environment. These process options would also provide a high level of protection to human health and reduce waste mobility, but they would not reduce the toxicity or volume of waste. However, it can be assumed that the long-term effectiveness of off-site disposal would be higher than on-site disposal, especially given the performance period of 1,000 years.

Potentially impacted water would be generated during remedial construction activities. The water would be characterized and discharged on site if its radionuclide levels meet state and federal regulations. Contaminated water would be treated prior to disposal off site or discharge on site.

#### 2.6.6.2 Implementability

The implementability of off-site disposal would largely depend on the availability of a LLW facility. For this level of technology screening, it is assumed that a LLW facility would be available that would accept radioactive waste materials at the time of the SLDA remediation. This is further evaluated in Section 4.0, where the detailed analysis of alternatives is presented.

Implementation of off-site disposal would involve characterizing the waste materials designated for off-site disposal and confirming that the materials are in conformance with the waste acceptance criteria specified by the designated disposal facility. Off-site disposal is the most common remedial response action currently implemented to remediate radionuclides in soils and waste debris.

Off-site disposal would be completed with conventional equipment and techniques. Labor requirements are not considered problematic. The most difficult aspect of off-site disposal implementation would likely involve the arrangement of transportation of the waste material from the SLDA site. Technical aspects of transportation off-site would likely consist of infrastructure modifications to the site (and possibly Parks Township roads) to accommodate truck traffic, as well as coordination for transportation to the disposal facility by rail.

Administrative tasks associated with off-site disposal would be difficult during remediation but non-existent after remediation assuming successful cleanup is achieved. It is assumed that governmental approval would be readily obtained since the impacted material would ultimately be removed from the site. However, transportation of low-level radioactive materials through communities on route to the closest railroad would likely be a concern to the public. In addition, effort would be required to coordinate and document off-site waste disposal. If removal and off-site disposal is implemented, a long-term environmental monitoring program would not be required since the impacted material would be removed from the site.

Implementation of on-site disposal would involve construction of an engineered waste disposal cell on-site, disposal of impacted materials in the cell, and long-term monitoring. On-site disposal would be completed using conventional equipment and techniques. Labor requirements, although higher than those for off-site disposal, could be addressed locally.

Administrative tasks associated with on-site disposal would be difficult during remediation and moderate throughout the performance period. Approval of on-site disposal by governmental agencies and the public would be difficult since it would not be consistent with surrounding land use and the site has not been evaluated for suitability as a permanent waste disposal site. The long-term post remediation monitoring program would require a variety of administrative tasks related to environmental monitoring, site inspection, waste disposal cell maintenance, and financial tracking. Similar to other on-site remedial actions, disposal would be subject to NRC control through the existing license.

Implementation of on-site disposal of water would involve construction and operation of a water treatment plant to remove radionuclides as well as other contaminants to levels acceptable for direct discharge to surface waters. On-site disposal of water is readily implementable and has been completed on similar remediation projects to aid in the management of water during construction activities. Similarly, off-site treatment/disposal of water would also be readily implementable. Both on-site or off-site disposal of water would be completed using conventional equipment and techniques. Labor requirements are expected to be minimal low and could be satisfied locally.

Administrative tasks associated with on-site or off-site water disposal would be relatively straightforward and would consist largely of documentation related to water quality, transportation, and quantities.

#### 2.6.6.3 Cost

Costs associated with off-site disposal of contaminated soil and waste debris are variable, and depend on the volume to be disposed of, the levels of contamination that exist, the proximity of the disposal site, and the waste handling and packaging that may be required. Compared to the other remedial response actions evaluated in this section, off-site disposal will be the most costly, and the cost would vary depending on the level of on-site treatment.

Costs associated with on-site disposal of contaminated soil and waste debris would be related to construction of the disposal cell, placement of the impacted materials into the cell, and the long-term monitoring program. These costs are expected to be high but not as high as those of off-site disposal.

Costs associated with on-site or off-site disposal of water are expected to be low to moderate and are viewed as costs associated with the removal of impacted materials.

### 2.6.7 Representative Technologies

The remedial technology types and corresponding process options remaining after the screening and evaluation processes are considered to represent the viable response actions for the remedial efforts at the SLDA. These options are shown in Table 2-4 and discussed in Section 3.0, Development and Screening of Remedial Alternatives.

The No Action remedial response is retained as required by the NCP to develop a baseline level of effort and cost for comparison of other alternatives. The Limited Action remedial response is also retained for analysis in Section 3.0 since it would provide some level of protection to human health at a relatively low cost.

The Containment technology and process options are retained for further evaluation since they would be effective in minimizing exposure pathways to both human and ecological receptors. The Removal technology and process options were retained since they are commonly used on similar sites and would be effective in reducing the mobility and possibly (in combination with other remedial response actions) the toxicity and volume of impacted material.

Ex situ treatment process options retained consist of separation/size reduction, radiological sorting, and grouting. Polyethylene encapsulation and vitrification are not retained due to the uncertainty of the effectiveness of their full-scale application.

On-site disposal is also retained for further evaluation since it would meet the remedial action objectives. Off-site disposal, although the most costly of the various technologies evaluated, is retained for further evaluation since it would also meet of the remedial action objectives would meet all of the remedial action objectives for unrestricted use.

# 3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

## 3.1 General

In this section, the remedial action technologies and process options that were retained after the initial screening and evaluation in Section 2.0 are developed into alternatives that represent a range of remedial options. This section also documents the results of the screening process conducted to eliminate from further consideration those alternatives with only limited opportunity for success at the SLDA site. Alternatives passing this screening step are then analyzed further in Section 4.0 by evaluating them against the nine CERCLA criteria.

The general response actions that are either required by CERCLA or considered applicable for the SLDA site include: No Action, Limited Action, Containment, Removal, Treatment, and Disposal. The technologies and process options derived from each of these general response actions are listed in Table 2-4 and the corresponding alternatives are developed in Section 3.2. The performance period for which these technologies are evaluated is 1,000 years, consistent with the evaluations presented in the baseline risk assessment completed as part of the RI (USACE, 2005).

## 3.2 Development of Remedial Alternatives

The USACE is evaluating alternatives for the SLDA site consistent with Section 8143 of Public Law 107-117, which directed the Secretary of the Army, acting through the Chief of Engineers, to clean up radioactive waste at the SLDA site consistent with the 2001 MOU between the USACE and NRC (NRC, 2001b). Accordingly, a range of remedial action alternatives were developed for the SLDA site based on the technologies and process options that were retained following the screening process conducted in Section 2.0. These alternatives were then assessed in accordance with EPA CERCLA guidance to screen out those that cannot ensure effectiveness in addressing the contaminants at the site, cannot be implemented with certainty, or are more expensive than other alternatives without offering significantly better reduction in the risks to human health and the environment. The results of this screening process are given in Section 3.3.

It is important to note that groundwater is not considered in this FS or as an operable unit requiring a separate remedial action. The groundwater is not currently contaminated, but because organic contaminants are migrating from the trenches showing that release pathways exist, it will continue to be monitored under all alternatives except the no action and off-site disposal alternatives. For purposes of analysis in this FS, it is assumed that groundwater monitoring would be conducted for the entire performance period of 1,000 years under alternatives involving on-site management of the radioactive waste and contaminated soil and sediment.

Requirements specified by the EPA in the NCP for developing alternatives include the following:

- A No Action alternative should be developed. Cases where some removal or remedial action has already occurred at the site may be described as No Action or No Further Action.

- One or more alternatives should be considered that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants through engineering controls.

- A range of alternatives should be developed in which a principal element is treatment resulting in a reduced toxicity, mobility, or volume of contaminants. Accordingly, an alternative could be included that removes or destroys the contaminants, thus eliminating the need for long-term management of the waste.

Considering these requirements and the site-specific ROCs and environmental conditions, the remedial action alternatives developed for the SLDA site consist of:

- Alternative 1: No Action

- Alternative 2: Limited Action

- Alternative 3: Containment

- Alternative 4: Excavation, Treatment, and On-site Disposal

- Alternative 5: Excavation, Treatment, and Off-site Disposal

There are a number of factors that have a major bearing on the development and screening of alternatives for the site. The public law authorizing cleanup of the site limits USACE responsibility to radioactive waste; chemical contaminants will be addressed only to the extent that they are collocated with the ROCs. There are no effective treatment options for reducing the toxicity of radionuclides (such as by thermal treatment). Radionuclides lose their toxicity over time by radioactive decay.

As discussed in Section 1.2.1, the abandoned room-and-pillar mine workings that underlie the upper trench area could possibly result in the eventual development of trough-type subsidence (ARCO/B&W, 1995b, Appendix K). Such subsidence could seriously compromise the integrity and longevity of an on-site waste containment system if it is located in that portion of the site that is underlain by these mine workings. Current organic contaminant migration is an indicator of future plume conditions if subsidence should occur and less sorptive pathways are created. While various approaches for addressing this issue have been proposed (including filling the underground voids with grout), the implementability and long-term effectiveness of such engineering approaches is highly uncertain.

Subsidence is not the only concern associated with the abandoned mine workings at the site. For example, it is possible for methane gas to build up in the abandoned coal mine over time, and a spark (such as from a lightning strike or man-made causes) could result in an explosion in the mine. The results of such an event at the SLDA site are unknown, but they could include compromising the integrity of the onsite disposal trenches which could facilitate migration of radionuclides over time. The risks and radiation doses to individuals following such an event would be expected to be comparable to those estimated for mine subsidence given above.

In addition, most of the characterization activities at the site focused on the areas surrounding the disposal trenches, with the goal of defining the aerial extent of on-site contamination. This approach avoided breaching the competent and continuous soil barrier that exists and governs the containment of the contaminants in the trenches. As a result, there are limited characterization data on the actual trench contents. These limited trench data make it difficult to estimate with any degree of accuracy the actual risks posed by these materials to human health and the environment. High concentrations of uranium have been measured in trench leachate (i.e., up to 29,500 picoCuries per liter [pCi/L]), and average leachate concentrations indicate that there could be an unacceptable risk to an individual consuming water at the site in the future should the trench contents come in contact with groundwater.

Finally, the available historical records for previous waste disposal activities do not contain detailed information on the wastes disposed of at the SLDA site, as the records only focused on the contaminants being regulated at the time the disposals took place (i.e., uranium and thorium). In addition, although chemical contaminants are not the responsibility of the USACE, information on them is sparse and it is not clear how they could affect the long-term leaching of the radionuclides out of the trenches (ANL, 2001a). It should be noted, there was no specific testing conducted during the RI to evaluate the leachability of radionuclides from trench waste or impacted soils to groundwater.

Given the inability to reduce the toxicity of radioactive constituents in the wastes by treatment, the presence of abandoned room-and-pillar mine workings beneath the upper portion of the SLDA, the limited characterization data on the buried waste within the trenches, and the lack of detailed waste disposal records, it would be difficult to ensure that any type of in situ remedial alternative would adequately protect human health and environment in the long term. These considerations, along with a discussion of how each alternative was screened for effectiveness, implementability, and cost, are addressed in the following subsections.

### 3.2.1 Alternative 1: No Action

The NCP requires that a No Action alternative be evaluated as part of the FS process. This alternative is included as a baseline for comparison with other alternatives. Surface soil remediation was performed at the SLDA in the 1980s; however, currently there are no remediation activities being conducted on site. Under the current license with the NRC (SNM-2001), BWXT maintains engineering controls to limit site access and conducts environmental monitoring to assess contaminant levels on-site (see Section 2.4.2). In the No Action alternative, BWXT (and any other party) would hypothetically terminate all activities at the site. Existing engineering controls such as fencing and signage would not be maintained and there would be no authorized personnel at the site.

### 3.2.2 Alternative 2: Limited Action

Alternative 2 would consist of continuing the land use controls and environmental monitoring currently conducted by BWXT. Under this alternative, the existing NRC license (SNM-2001) would remain in place for the entire performance period of 1,000 years, effectively restricting site use. The existing land use controls, including the perimeter fence and warning signs, would be maintained to restrict public access to the property. The property would be periodically inspected to identify maintenance needs for the engineering controls and the required maintenance would be completed to restrict site use.

The ongoing environmental monitoring program currently being conducted by BWXT would continue into the future. The monitoring program would consist of routine sampling and analysis of groundwater, surface water, and sediments as well as external gamma radiation monitoring, and would be conducted by an organization having the responsibility to ensure the safety of the site. In addition to environmental monitoring, five-year reviews would be conducted in accordance with CERCLA to assess the effectiveness of the remedy with regards to protecting human health and the environment.

### 3.2.3 Alternative 3: Containment

Under Alternative 3, the existing NRC license (SNM-2001) would remain in place for the entire performance period of 1,000 years, effectively restricting site use. To effectively contain the radioactive waste, several modifications to the SLDA site would be implemented to reduce the potential for migration of radionuclides from the trench contents to nearby soil, surface water, sediment, and groundwater. Specific components of Alternative 3 would include the following:

- Constructing drainage swales upgradient (south) of trenches 1 through 9 to divert stormwater away from the disposal trenches.

- Re-routing the existing underground natural gas line from the upper trench area to a location several hundred feet southeast of trench 8. The existing gas line would be abandoned in-place.

- Re-routing Dry Run away from trenches 1 through 9 to enhance geomorphic stability, and lining the new streambed with erosion resistant stone and biotechnical vegetation.

- Installing a multi-layered engineered cover over all ten trenches at the site. The cover would include very low permeability soils, sand and gravel for lateral drainage, a biointrusion riprap barrier, and a geomembrane infiltration barrier.

- Constructing a slurry wall around the disposal trenches to prevent lateral migration of groundwater into or out of the trench areas. The slurry wall would be of conventional construction, consisting of a trench extending from the ground surface to the bottom of the weathered bedrock, which would then be filled with a low permeability slurry. The geomembrane cap would connect into the slurry wall to minimize infiltration vertically downward into the disposal trenches.

- Constructing a perimeter grout curtain directly below the slurry wall in the upper trench area. The grout curtain would extend through the First Shallow Bedrock unit to an average depth of 30 to 40 feet (9.2 to 12.2 meters) below ground surface. Either a chemical or cement grout would be used. The grout curtain would control lateral seepage into or out of the upper trench area within the First Shallow Bedrock unit.

- Stabilizing the mine workings beneath the upper trenches and immediately adjacent to trench 10 with the use of grout. The grout would consist of cement, aggregate, and water and be placed by gravity injection using a combination of vertical and angled borings. It would extend a sufficient distance beyond the upper trench area to prevent the propagation of settlement into the trench area.

A containment system maintenance program would be included to periodically inspect the various components of the containment system to the extent possible, identify maintenance needs, and implement the required maintenance to improve the long-term effectiveness of the system. In addition to the containment system maintenance program, the land use controls and monitoring described in Alternative 2 would also be included in this alternative.

### 3.2.4 Alternative 4: Excavation, Treatment, and On-site Disposal

Alternative 4 would consist of the excavation, characterization, treatment, and on-site management of the radioactive waste in an engineered disposal cell. The existing NRC license (SNM-2001) would remain in place for the entire performance period of 1,000 years, effectively restricting site use. The excavation would be completed using conventional earthwork equipment. Treatment processes could include physical separation, size reduction, radiological sorting, and, if necessary, stabilization of excavated material prior to placement into the disposal cell.

Verification soil sampling and a MARSSIM final status survey would be conducted following removal of the contaminated waste, soil and debris. Residual contamination identified during the verification sampling that exceeds the remedial action goals would be excavated, treated (if necessary), and disposed of in the on-site disposal cell. The site would be restored as close to its original grade as possible using backfill and topsoil, and would be hydro-seeded and fertilized.

The proposed location of the on-site disposal cell is in the northern corner of the site adjacent to trench 10 and north of the deep mine workings. This location would be free of any potential effects of long-term mine subsidence. The dimensions of this conceptual disposal cell would be approximately 275 by 320 feet (83.8 by 97.6 meters), with an approximate average waste depth of 15 feet (4.7 meters). This cell could accommodate a waste volume of nearly 49,000 cubic yards (37,500 cubic meters), which is over twice the estimated waste volume at the

SLDA site (24,300 cubic yards [18,600 cubic meters]). However, the actual dimensions of this conceptual disposal cell would be determined during the detailed engineering design phase of the project.

The conceptual disposal cell would be designed to address the stabilized contaminated wastes and soil at the site, as well as any soils impacted by the remedial actions at the site. It would be constructed in a manner to be protective of human health and the environment and incorporate features used in other disposal cell designs for similar radioactive wastes. Design details of the disposal cell would presented in the remedial design documents, but in general, it would include the following components:

- A double liner base system consisting of very low permeability soils (such as silts and clays), sand and gravel for lateral drainage, and two geomembrane liners.

- A multi-layered engineered cover consisting of vegetation, very low permeability soils (such as silts and clays), sand and gravel for lateral drainage, riprap for biobarrier intrusion, and a geomembrane infiltration barrier.

- A leachate collection and detection system to collect and manage leachate generated from water infiltration.

- Monitoring wells screened in both the Freeport Coal Seam and Deep Bedrock hydrogeologic units to monitor the long-term performance of the disposal cell.

The areas preliminarily identified for remedial excavation would be further delineated during the detailed engineering design phase of the project. Prior to excavation, the underground natural gas lines located within the remediation areas would be taken out of service. In the area of the proposed disposal cell, the underground gas line would be relocated along the property line and the existing line removed during construction of the new disposal cell. The gas line located near disposal trenches 2 through 9 would be re-located several hundred feet southeast of trench 8 and the existing gas line abandoned in-place. Associated real estate costs for the relocation of the natural gas pipelines will be specified in the Real Estate Plan included with the Proposed Plan.

Clearing and grubbing activities would also be performed in the wooded areas of the site prior to remedial excavation.

A limited area of the site would require remediation of impacted surface soils. All excavated surface soils that exceed approved cleanup criteria would be loaded onto trucks and transported to the disposal cell where they would be emplaced without treatment. In general, surface soils are not expected to be impacted beyond a depth of one foot; as such, no shoring or groundwater management is anticipated for this activity. Excavations would be backfilled with either uncontaminated on-site soils or imported clean fill.

The majority of the remedial activities would be associated with impacted subsurface materials. The trench cover soils would be removed and stockpiled on site with the intent of reusing them as backfill following sampling, analysis, and classification. If steel sheeting is used, it would be perforated to allow sidewall verification sampling.

During deep excavation, dewatering would be performed using a combination of sump and well extraction points. These dewatering points could be installed prior to excavation or as needed during excavation. A portable water treatment system would be designed, fabricated, and operated on site to remove contaminants from the extracted groundwater. Treated water would be sampled and either discharged on site in Dry Run (if it meets surface water discharge criteria) or transported off site for further treatment and/or disposal.

Excavation of subsurface waste, soil, and debris would be completed primarily using an excavator. However, large objects such as drums and equipment may require the use of other equipment such as a crane. This alternative assumes that all debris, equipment, or any other non-soil-like material would be placed into the disposal cell after it is size reduced.

Excavated materials would be segregated at the excavation (source separation) using physical separation, size reduction, and radiological sorting techniques. The focus of treatment activities would be to reduce the volume of material to be placed in the disposal cell, and reduce the size of large contaminated items to allow for easier handling and management during disposal operations. Radiological sorting would be based on data collected during manual surveys conducted at the excavation, and physical separation would be performed through the use of mechanical equipment and visual inspection.

Although it is not anticipated based on current waste characterization data and the conservative design of the conceptual disposal cell, stabilization of certain wastes using grout may be conducted to ensure their long-term stability and minimize the likelihood for future leaching of contaminants from these wastes. These wastes would be identified based on the specific physical or chemical characteristics. The grouting process would include mixing the impacted material with a cement-like grout to physically stabilize the waste.

At the conclusion of contaminated soil/debris removal, treatment, and placement into the disposal cell, a final assessment of the effectiveness of the remedial action would be conducted in accordance with the guidance provided in MARSSIM. Excavations would then be backfilled with on-site soils and/or imported clean fill. Monitoring and land use controls discussed in Alternative 2 would also be included in this alternative; however, since the radioactive materials would have been removed from the majority of the site, these activities would focus on maintaining the integrity of the disposal cell and managing any collected leachate. Leachate generated in the disposal cell would be periodically transported off site for treatment and disposal.

For purposes of this FS, it was assumed for Alternative 4 that contaminated wastes, soils, sediments, and debris would be managed such that only the engineered disposal cell, and an appropriately sized buffer zone immediately surrounding it, would require land use controls. Any residual concentrations of the ROCs remaining outside this area would meet the 25 mrem/yr dose limit. Therefore, the assumed volume of wastes, soils, sediments, and debris to be excavated is the same for both Alternatives 4 and 5.

### 3.2.5 Alternative 5: Excavation, Treatment, and Off-site Disposal

Alternative 5 would consist of excavation of radionuclide-contaminated soil/waste; on-site treatment through physical separation, size reduction, and radiological sorting; and off-site disposal of contaminated materials at appropriate commercial facilities. The existing NRC license (SNM-2001) would be terminated after implementation of this alternative and the durable institutional controls would be removed.

Excavation of contaminated material would be completed using conventional earthwork equipment, and verification soil sampling and a MARSSIM final status survey process would be implemented following removal of contaminated soil and waste debris. All residual contamination identified during verification sampling that is above the approved cleanup criteria would be excavated and transported off site for disposal. The site would be restored as close to original grade as possible using backfill and topsoil, and the entire site would be hydro-seeded and fertilized.

Excavation, site work, and on-site physical treatment activities would be similar to those described in Alternative 4 except that separation of the different waste streams would be performed more thoroughly for off-site disposal (to minimize the volume of material requiring transportation off-site), and none of the wastes would be stabilized more than would be necessary for transport. In addition, the re-location of the natural gas line in the northwestern end of the site would not be necessary.

Alternative 5 would include sampling and analysis to establish and document that the characteristics of the waste meet the acceptance criteria of the off-site commercial disposal facility to which it would be shipped. In addition, work may be required to coordinate and potentially modify the site infrastructure to facilitate transportation of materials off site.

Segregated LLW would be packaged and transported by truck from the SLDA site to a nearby rail-line for transfer onto railcars, and then shipped by rail to an appropriate disposal facility permitted to receive and dispose of such waste. For this FS, it is assumed that all transported radioactive waste would be classified as Class A radioactive waste as defined in 10 CFR 61.55. This waste class assumption is based on the current characterization data given in the RI Report (USACE, 2005). Mixed wastes (i.e., waste that contains both source, special nuclear, or by-product material subject to the AEA of 1954, as amended, and a hazardous component subject to RCRA) would be transported by truck to an approved facility for treatment and disposal. Since the public law authorizing cleanup of this site is limited to radioactive waste at the site, chemical contaminants will be addressed only if they are collocated with the radioactive wastes.

## 3.3 Screening of Remedial Action Alternatives

This section presents the results of the screening process for the preliminary alternatives based on the criteria of effectiveness, implementability, and cost; those alternatives that remain following this screening process are evaluated in more detail in Section 4.0. The criteria that are used to screen the alternatives are more fully described below in Section 3.3.1, and the results of this screening process are presented in Sections 3.3.2 through 3.3.6. The preliminary screening of the remedial action alternatives is summarized in Table 3-1.

### 3.3.1 Effectiveness, Implementability, and Cost Criteria

Effectiveness addresses the extent to which an alternative satisfies the RAOs and contributes substantially to the protection of human health and the environment. The ability of an alternative to reduce contaminant toxicity, mobility, or volume is considered a measure of its effectiveness.

The implementability of an alternative is defined by its technical feasibility, availability, and administrative feasibility. Technical feasibility involves the construction, operation, maintenance, replacement, and monitoring of an alternative's technical components, as appropriate. Availability addresses the resources required to implement specific components of an alternative and the ability to obtain them. Administrative feasibility is dependent upon the acceptability of an alternative to applicable agencies and other interested parties, and it can be affected by the permanence of the solution.

The overall cost to implement the remedy includes capital, operation and maintenance (if required), and monitoring costs. Due to the limited number of alternatives being considered, and the fact that the cost estimates are more fully developed in Section 4.0, this preliminary evaluation only uses general cost ratings, such as low cost (below $100,000), moderate cost (up to $1,000,000), high cost (up to $10 million), and very high costs (over $10 million). At the alternative screening stage, the cost of an alternative is merely considered to compare alternatives to each other.

### 3.3.2 Alternative 1: No Action

#### 3.3.2.1 Effectiveness

For purposes of analysis in this FS, all activities would cease at the site under the No Action alternative. That is, no remedial action would be performed to actively reduce the mobility, toxicity, or volume of the ROCs in site waste, soils, sediment, and debris, and the previously disposed of wastes would remain in the trenches in their current configuration. All site control activities would be terminated and the site would not be maintained or inspected. Note that this alternative is inconsistent with the requirements identified in the current NRC license for the site.

The No Action alternative would rely on natural degradation and leaching processes to reduce radionuclide concentrations in site media. Degradation consists of those processes in which contaminant concentrations are reduced through physical, chemical, and biological mechanisms that occur naturally in the environment. Radioactive decay is one such process, but this is not expected to significantly reduce the concentrations of the ROCs over the 1,000-year performance period due to their long half-lives.

This alternative would not be effective in meeting the approved cleanup criteria established for this site or in protecting human health and the environment in the long term. An estimate of the future on-site risks and doses to a Subsistence Farmer and Construction Worker associated with exposures to contaminated soils at the site (excluding the trench contents) was included in the human health BRA (USACE, 2005). The maximum radiological lifetime carcinogenic risk to a Subsistence Farmer was calculated to be $1 \times 10^{-5}$ and the maximum annual dose to such a hypothetical receptor was calculated to be 5 mrem/yr. The risk level is within the EPA target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$, and the annual radiation dose to this receptor would meet the limits identified in 10 CFR 20.1402 (for unrestricted release) and 10 CFR 20.1403 (for restricted release). However, these results do not consider potential exposures to the disposal trench contents.

An estimate of the radiological carcinogenic risks and radiation doses to a future Subsistence Farmer from exposures to the trench contents was also included in the BRA. The results of this assessment indicated that the excess lifetime cancer risk to a Subsistence Farmer from exposures to the radiological constituents in the trench contents would be $3 \times 10^{-3}$ using the results of the samples obtained from the trenches in the recent characterization program. This risk increases to $1 \times 10^{-2}$ if the results are limited to the 13 samples that had field-screening evidence of waste. Both of these values exceed the upper end of the EPA target cancer risk range. The annual dose would be approximately 900 mrem/yr (above background) when considering only the results of the 13 samples that had field-screening evidence of waste. In addition, uranium contains chemical toxicological properties. Exposure to concentrations of uranium in the trenches would result in non-cancer risks above EPA's acceptable threshold of a hazard index of 1.

This radiological risk/dose calculation given in the BRA for the trench contents implicitly assumes that the cover soil over the trenches is not present, which is a conservative approach. To evaluate the significance of the 4 feet (1.2 meters) of clean soil over the waste trenches for the No Action alternative, additional evaluations were performed using the RESRAD computer code. The site-specific RESRAD input parameters that were used in the development of cleanup criteria were also used for these evaluations and only the values relating to soil cover were changed. However, these evaluations showed that the maximum dose to the Subsistence Farmer over a 1,000-year time period is reduced by less than 20% with the presence of the soil cover. The major radiological exposure pathway for the Subsistence Farmer scenario is ingestion of produce grown at the site, and the model used a distribution of root depths ranging up to 4 feet (1.2 meters), which is consistent with NRC guidance for dose assessments to support license terminations.

Between the effects of soil erosion over 1,000 years and the assumed distribution of root depths, there is only a small difference between the calculated results for the Subsistence Farmer scenario with the soil cover and that with no cover. This indicates that the results given for the Subsistence Farmer scenario in the BRA are applicable to this alternative, provided that the results of the samples collected for the trench contents are representative of the previously disposed of wastes (the 95% upper confidence limit of the arithmetic average was used in these calculations). As noted previously, there is uncertainty associated with the concentrations used for the trench contents in these calculations because of the limited number of samples. However, based on these results, it can be concluded that this alternative would not be effective in protecting human health and the environment over a 1,000-year time horizon and would not meet the RAOs identified in Section 2.2.

The assessment for the Subsistence Farmer scenario in the BRA was prepared in accordance with EPA risk assessment guidance and is very conservative. This individual was assumed to reside on the site for 30 years and be exposed to the trench contents for this entire time period. In addition, this individual was assumed to obtain most of their food and drinking water using onsite sources, consistent with NRC guidance for dose assessments at sites undergoing decommissioning under 10 CFR 20. Use of a less conservative future residential exposure scenario would likely result in doses more consistent with those identified in the RAOs presented in Section 2.2, i.e., 25 to 100 mrem/year.

However, there are many uncertainties associated with the site, including its long-term geologic stability as well as the physical, chemical, and radiological characteristics of the previously disposed of wastes. It is also not known where the more highly contaminated wastes may be within the individual trenches. Exposures to the more highly contaminated wastes could result in radiation doses and carcinogenic risks significantly greater than those associated with the average contaminant concentrations within all of the wastes. It was therefore determined appropriate to use this conservative scenario as a bounding situation for future conditions at the site. This scenario was also the basis of the PRGs developed for the SLDA site.

#### 3.3.2.2 Implementability

The No Action remedial action alternative would be readily implementable as well as technically feasible. In terms of administrative feasibility, it would be difficult to obtain concurrence for No Action from governmental agencies since the RAOs would not be attained and no activities would be preformed to protect human health and the environment from a contaminant release in the future.

#### 3.3.2.3 Cost

Since there would be no remedial actions or monitoring activities associated with the No Action alternative, there would be no associated cost.

#### 3.3.2.4 Summary

The No Action alternative would be technically feasible and implementable, and there would be no costs associated with this alternative. However, contaminant characterization data suggest that the No Action alternative would exceed the RAOs, and this alternative is not likely to be accepted by regulatory agencies. Despite these inadequacies, it is retained for further consideration since the NCP requires that this alternative be developed throughout the FS.

### 3.3.3 Alternative 2: Limited Action

#### 3.3.3.1 Effectiveness

Similar to Alternative 1, the Limited Action alternative would not reduce the mobility, toxicity, or volume of the ROCs in site wastes, soils, sediment, and debris. This alternative would rely on the same natural degradation and leaching processes identified for the No Action alternative to reduce radionuclide concentrations in site media. However, the current land use controls and existing NRC license (SNM-2001) would help to reduce the future risk to human health and the environment by restricting access to the site and limiting the number of exposure pathways to media containing ROCs. Maintenance of these land use controls would be required throughout the 1,000-year performance period to effectively limit the risk to human health and environment to acceptable levels.

Monitoring the environment in the nearby vicinity would also help to minimize the risk to human health and the environment by tracking the migration of the ROCs both on and off site, as well as documenting the reduction of ROCs due to natural attenuation processes. It is anticipated that the environmental monitoring currently being implemented at the site by BWXT to conform to the requirements of their license with NRC would continue throughout the 1,000-year performance period. The sample analysis would be modified to include site ROCs.

The effectiveness of the Limited Action alternative is considered suspect due to the uncertain stability of the abandoned mine workings beneath the disposal trenches. Accordingly, if mine subsidence were to occur under this alternative, the trench contents could be exposed to the groundwater, and an individual drinking this water could be subject to unacceptable exposures. Conservative estimates of the concentrations of uranium that could be present in site groundwater if mine subsidence occurs in the future indicate that the HI would exceed two and the annual radiation dose could be in excess of 200 mrem/yr to an individual using this water as a source of drinking water. These estimates are based on the average concentrations of uranium detected in leachate collected from the trenches, which is assumed to be indicative of the maximum concentrations that would be present in groundwater should the integrity of the trenches fail in the future.

Clearly, loss of land use controls, mine subsidence leading to groundwater contamination, and an individual drinking this contaminated water, would not be a likely set of events. In addition, there would be significant dilution in the contaminant concentrations in the leachate when it reached an on-site or nearby off-site potable source of water. Accounting for this dilution, ingestion of such contaminated water could result in annual doses on the order 25 mrem/year or lower, consistent with the dose limits identified in the RAOs. However, as noted previously, there is considerable uncertainty associated with the geologic stability of the site and the characteristics of the wastes. The long-term protection of groundwater resources in this area cannot be guaranteed with the wastes left in place. While institutional controls will serve to protect human health, such controls may not be effective in protecting impacted environmental receptors.

While this alternative represents an improvement over Alternative 1 in terms of protectiveness, it may not provide sufficient protectiveness of human health and the environment over the long term.

#### 3.3.3.2 Implementability

Established procedures and mechanisms already exist to implement Limited Action over the long term. The engineering controls currently in place at SLDA would continue to be maintained by BWXT throughout the performance period of 1,000 years. In the event the property owner failed to maintain these controls, it is expected that this responsibility would then be accepted by the governmental agency providing regulatory oversight. Land use controls such as the existing NRC license, deed notices, restrictive covenants, access restrictions, well permitting, and zoning controls related to site use are and would continue to be administratively feasible.

The groundwater monitoring wells installed at the site during the RI and previous investigations would provide sufficient coverage to implement a long-term monitoring program. Standard procedures and protocols for monitoring site groundwater, surface water and sediment for migration of radionuclides from the waste trenches are readily available. Administrative activities would be required to support the long-term environmental monitoring, inspection, and maintenance program required throughout the 1,000-year performance period. It is also assumed that governmental agency oversight and durable institutional controls under this alternative would be present over time.

In terms of administrative feasibility, it would be difficult to obtain concurrence for Limited Action from governmental agencies since there would remain significant uncertainty as to its protectiveness of human health and the environment in the long term, especially if the integrity of the underlying abandoned mine workings were compromised in the future.

#### 3.3.3.3 Cost

The capital costs for implementing the Limited Action alternative at the SLDA site would be in the high cost range, given the criteria presented in Section 3.3.1. This assumes that the existing fence would remain in place and a staffed security post would not be necessary to maintain site control. Annual costs would include operation and maintenance costs for groundwater, surface water, and sediment sampling and analysis; radiation exposure monitoring; site inspection; mowing the grass; general site maintenance; and management.

#### 3.3.3.4 Summary

While the Limited Action alternative would represent an improvement over the No Action alternative in terms of protecting human health and the environment, uncertainty still exists in terms of whether or not the RAOs for the site would be met. This alternative would not reduce the mobility, toxicity, or volume of ROCs. The Limited Action alternative could result in unacceptable exposures to an individual should the integrity of the underlying abandoned mine workings be compromised.

A monitoring program directed at tracking the migration of radionuclides in surface water, sediment, and groundwater on- and off-site is currently implemented by BWXT in accordance with the existing NRC license, and this program would be effective to identify releases at the site. This type of monitoring program would also be effective in documenting the reduction of ROCs from natural attenuation.

The Limited Action alternative has been removed from further evaluation due to the uncertainty of whether or not the RAOs for the site would be met and because other on-site remedial alternatives have a greater potential to be effective.

### 3.3.4 Alternative 3: Containment

#### 3.3.4.1 Effectiveness

Alternative 3 would reduce the mobility of ROCs present in site wastes, soils, and debris, but would not reduce their toxicity or volume. Containment could be effective in reducing future risk to human health and the environment by limiting the number of exposure pathways to media containing ROCs, provided that the various components of the containment system performed as designed over the 1,000-year performance period. Monitoring could be performed to confirm the effectiveness of the containment system to ensure continued protection of human health and the environment in the future. The current land use controls and existing NRC license (SNM-2001) would help to reduce the future risk to human health and the environment by restricting access to the site and limiting the number of exposure pathways to media containing ROCs. Maintenance of these land use controls would be required throughout the 1,000-year performance period to effectively limit the risk to human health and environment to acceptable levels.

It is very difficult to implement a containment system that will be effective over the 1,000-year performance period given the uncertainties in the characteristics of the wastes, and concerns associated with how the wastes could impact the properties of the system over time. Even though this alternative includes measures to stabilize the underlying room-and-pillar mines using grout and these techniques have been used successfully in Western Pennsylvania, the effectiveness of such measures through the 1000-year performance period is still uncertain. Failure to properly stabilize the mine workings to the required extent could allow for future subsidence within the trench area, which could significantly damage the containment system and reduce its long-term effectiveness.

This alternative includes the installation of a multi-layered engineered cover as described in Section 3.2.3. The cover should be effective in minimizing the amount of water infiltrating into the wastes, which would reduce the likelihood of future groundwater contamination. The cover should also limit the likelihood that produce would be grown on top of the trenches (and, by extension, into the underlying contaminated material) by limiting root penetration. Intake of this produce was a major exposure pathway to the Subsistence Farmer in the human health BRA. However, due to the uncertain stability of the mine workings that would lie beneath the multi-layer cover, the potential would still exist for an unacceptable exposure to an individual. Conservative estimates indicate that there could be unacceptable exposures to an individual using groundwater at the site as a source of drinking water should the integrity of the underlying abandoned mine workings be compromised and the trench contents be exposed to groundwater (see Section 3.3.3.1). It is also important to note that, if the slurry wall and bedrock grouting maintain integrity over time while the exposed containment cap does not, then infiltration that exceeds the horizontal and vertical outflow from the containment system could cause the trenches to fill with water, which could fully compromise the performance of the entire containment system. This scenario has happened at a number of other waste disposal sites.

While this alternative represents an improvement over both over Alternatives 1 and 2, uncertainty as to its effectiveness remains due to the unknown chemical characteristics of the wastes and the potential for future groundwater contamination, which could cause unacceptable exposures in the future.

#### 3.3.4.2 Implementability

Various containment systems such as caps, slurry walls, and grout curtains are routinely included as part of remediation programs. Each of these containment features could be constructed using conventional equipment. Although grouting of the deep mine beneath trenches 1 through 9 and re-location of the natural gas lines is not considered a typical remedial action, it could also be implemented using conventional drilling equipment. Injection of grout into the deep mine adjacent to trench 10 may not be as easily implementable, however, since it may require angle drilling and a better understanding of the mine void elevation than is currently available. The equipment, materials, and labor necessary to implement containment would be readily available.

The ability to evaluate the long-term performance of the various containment design components would vary depending on whether they could be effectively inspected and monitored. It is expected that the direct or indirect effects of weather would adversely impact the containment system components. Inspection of the re-routed section of Dry Run and various drainage swales constructed to control storm water run-off could be easily accomplished, and corrective measures implemented when necessary. Inspection of the containment cap would provide some understanding of the cap performance and help identify corrective measures to reduce cap deterioration from erosion. However, evaluation of the integrity of the grout stabilization of the mine voids would be much more difficult since this component could not be adequately inspected or accurately monitored. These containment features would in all likelihood perform at a reduced level in the later stages of the performance period, potentially resulting in increased infiltration rates. The long-term monitoring program would help to identify migration of ROCs if the performance of the containment components becomes adversely impacted.

The groundwater monitoring wells installed at the site during the RI and previous investigations would provide sufficient coverage to implement a long-term monitoring program. Standard procedures and protocols for monitoring site groundwater for migration of radionuclides are readily available. Administrative activities would be required to support the long-term environmental monitoring, inspection, and maintenance program required throughout the 1,000-year performance period. It is also assumed that governmental agency oversight and durable institutional controls under this alternative would be present over time.

In terms of administrative feasibility, it would be difficult to obtain concurrence for this alternative from governmental agencies since unacceptable exposures could result due to potential compromise of the integrity of the underlying coal mine workings and subsequent groundwater contamination from trench contents.

#### 3.3.4.3 Cost

The capital costs for the Containment alternative at the SLDA site are expected to be in the very high cost range. These costs would include those associated with construction of the containment caps, slurry walls, grout curtains, mine grouting, and drainage swales, as well as the re-routing of the underground natural gas lines and Dry Run. In addition, the costs to carry out the long-term inspection, monitoring, and containment system maintenance program over the performance period of 1,000 years are considered high.

#### 3.3.4.4 Summary

While this alternative would represent an improvement in terms of protecting human health and the environment over the No Action and Limited Action alternatives, uncertainty would still exist with respect to elevated hazards and doses that could occur due to the geologic instability of the underlying mine workings. This alternative would be effective in reducing the potential human health risks by reducing the mobility of contaminants; however, it would not reduce their toxicity or volume. In addition, there are data gaps associated with the chemical characteristics of the trench contents. These data gaps make it difficult to predict the long-term risks to human health and the environment with any certainty. Conservative estimates indicate that unacceptable impacts could result, should trench contents come in contact with groundwater due to failure of the underlying geologic media at the site.

Construction of the various containment components would be readily implementable, but evaluation of the stability and long-term performance of the grouted mine workings could be problematic over the 1,000-year performance period. The monitoring program designed to track the migration of radionuclides in site media would be effective in identifying potential incremental future risks resulting from the reduced effectiveness of the containment system over the performance period. However, this alternative could be difficult to implement based on anticipated problems associated with obtaining approval from governmental agencies. The overall cost to implement this alternative over the performance period is expected to be very high.

Alternative 3 is not evaluated further in Section 4.0 since it would not reduce the toxicity or volume of ROCs and it's uncertainty with respect to the mine stabilization, the collapse of which could contaminate the groundwater and cause unacceptable impacts to individuals should they ingest the water over a relatively long period of time. In addition, Alternative 4 is a comparable, on-site remedial action alternative that would afford more protectiveness of human health and the environment.

### 3.3.5 Alternative 4: Excavation, Treatment, and On-site Disposal

#### 3.3.5.1 Effectiveness

Alternative 4 would be more effective than Alternative 3 in that the wastes would be excavated from the trenches and relocated to the northern portion of the site, where they would be free of any potential effects associated with potential mine subsidence. In addition, the effectiveness of Alternative 4 is enhanced due to the fact the wastes would be subjected to treatment (physical separation, size reduction, radiological sorting, ex situ grouting), prior to placement in a lined disposal cell. Since the contaminated materials would be excavated from the trenches, radiologically scanned, and sampled as appropriate, there would also be a more complete understanding of the physical and chemical characteristics of these materials. The disposal cell would be constructed in accordance with design criteria intended to contain the materials for the performance period of 1,000 years. Land use controls, site maintenance, and an NRC license would be in place to reduce future risk to human health and the environment by restricting access to the disposal cell area throughout the 1,000-year performance period.

Alternative 4 would reduce the mobility of the ROCs present in site wastes, soils, and debris due to placement in the disposal cell. The volume of material designated for disposal into the on-site disposal cell could be reduced due to treatment processes such as radiological sorting. It is not anticipated that the toxicity of the ROCs would be reduced. Excavation and on-site disposal would be effective in reducing future risk to human health and the environment by limiting the number of exposure pathways to media containing ROCs provided that the various components of the disposal system performed as designed over a period of 1,000 years. Monitoring could be performed to confirm the disposal cell's effectiveness, and corrective measures could be implemented as necessary to ensure its long-term integrity.

The tentative location of the on-site disposal cell would be adjacent to trench 10. This is the only portion of the site that is not underlain by abandoned room-and-pillar mine workings. However, this portion of the site currently consists of coal mine spoils that may need to be removed before cell construction in order to reach the 4-foot (1.2-meter) thick clay layer that underlies these spoils. As currently seen with the gullying of Dry Run, the susceptibility of the mine spoils to erosional forces could be higher than local soils since it has been recently disturbed, and thus less competent. If these spoils were not removed, then specific design consideration to address this issue would be required. To construct the engineered base, sidewalls, and multi-layer cover of the disposal cell, construction materials (e.g., low permeability soil, sand and gravel) would be brought to the site and placed as described in Section 3.2.4. Construction and long-term management of the disposal cell could face unique geophysical challenges such as the overburden coal mine spoils, proximity of the deep mine, Kiskiminetas River flood water elevations, and space constraints.

Treatment processes related to this alternative would consist of physical separation, size reduction, radiological sorting, and stabilization through ex situ grouting (if necessary). Excavated materials would be segregated at the excavation (source separation) using physical separation and radiological sorting techniques. The focus of physical separation and radiological sorting is to reduce the volume of material placed in the disposal cell by removing uncontaminated soils from the waste stream and using these on-site soils as backfill.

Physical separation would entail separation of uncontaminated soils from waste debris and contaminated soils as determined through visual inspection. The effectiveness of physical separation is expected to be high since the waste was originally disposed of into a series of pits separated by 6 feet (1.8 meters) of clean soil. Excavation of trenches could result in a significant volume of uncontaminated soils being removed.

Radiological sorting, which is also considered to be effective, would involve separation of uncontaminated soils from the waste stream based on data collected from manual radiological surveys conducted primarily at the excavation. Size reduction activities would only be performed on large debris items that are better suited for disposal in smaller volumes. This would provide more assurance that the integrity of the cover and liner systems would not be compromised during operations.

Based on sampling efforts completed during the RI, it is not expected that a significant quantity of hazardous, mixed, or sludge-type wastes would be encountered during remedial excavation. However, in the event that they are discovered and removed from the trenches, a determination as to whether these wastes should be stabilized would be made. If stabilization prior to placement into the disposal cell is necessary, the wastes will be treated using ex situ grouting. The grouting process would involve mixing the impacted material with a cement-like grout. The effectiveness of this treatment process is expected to be high due to the fact that most of the impacted material subjected to treatment would be soil and small debris, and it is not expected that the chemical contamination present would adversely affect the grouting process.

The overall effectiveness of this alternative in meeting the RAOs for the site would be similar to that given for Alternative 3. These controls would be necessary to limit the potential radiation dose to future receptors to acceptable levels. As mentioned above, this alternative represents an improvement over the first three alternatives in terms of protectiveness because the disposal cell would be located, constructed, and managed within an area of the site where mine subsidence would not occur.

#### 3.3.5.2 <u>Implementability</u>

Excavation, Treatment, and On-site Disposal is a common component in CERCLA remediation programs. Excavation of radioactive materials, construction of a disposal cell, and associated site preparation activities could be completed using conventional equipment. Standard excavation and dewatering techniques would be implemented during soil and waste debris removal. The proposed treatment processes of physical separation, size reduction, radiological sorting, and stabilization would be readily implementable at the SLDA site.

Although preliminary estimates of the land required for construction of a disposal cell north of trench 10 indicate there could be sufficient space available, the feasibility of this location would require further evaluation. Factors requiring consideration in this evaluation would include typical landfill siting criteria as well as site-specific limitations, such as geotechnical and erosive properties of the mine spoils and Kiskiminetas River flood elevations. The close proximity of trench 10 to the proposed disposal cell location may require excavation of the radioactive materials from trench 10 and staging on site while the disposal cell is constructed. The equipment, materials, and labor necessary to implement excavation and on-site disposal would be readily available.

Administrative activities would be required to properly license the disposal cell and to support the long-term environmental monitoring, inspection, and maintenance program required throughout the 1,000-year performance period. It is assumed that governmental agency oversight of the containment action would be present along with durable institutional controls to ensure protectiveness over time. However, the global administrative feasibility of constructing a disposal cell at the SLDA site may be difficult due to anticipated regulatory obstacles. The construction of a facility would likely meet resistance from the regulatory agencies. As a result of these uncertainties, the administrative feasibility of Alternative 4 is low.

The ability to evaluate the long-term performance of the disposal cell would be uncertain. It is expected that the direct or indirect effects of weather would adversely impact the disposal cell components over several years. Inspection of the containment cap would provide some understanding of the cap performance and information that would help identify corrective measures to reduce cap deterioration from erosion, settlement, and other natural processes. In addition, monitoring of leachate volumes over time would provide an indication of how well the cap and geomembrane liner systems are performing. Evaluation of the performance of the subsurface components of the disposal cell could also be accomplished through the use of leachate detection and monitoring systems. The various disposal cell containment features would probably perform at a reduced level in the later stages of the performance period, which could result in some contaminant migration; however, the long-term monitoring program would most likely identify any potential releases into site media if disposal cell components become severely compromised.

Sufficient well coverage exists to implement a long-term monitoring program. A few select new wells may be constructed once the final location of the disposal cell is selected to improve the well network since some wells would be removed during construction. Standard procedures and protocols for monitoring site groundwater for migration of radionuclides are readily available. It is anticipated that the property owner would implement the long-term monitoring program. In the event the property owner could not fulfill this obligation it is expected that the monitoring would continue due to governmental regulatory oversight.

#### 3.3.5.3 <u>Cost</u>

The capital costs for Alternative 4 are expected to be in the very high cost range. These costs include those associated with re-location of the existing natural gas lines, construction of the disposal cell, excavation and treatment of wastes, soils, and debris, placement of radionuclide-contaminated materials into the disposal cell, disposal cell capping, final status survey, backfilling excavated areas with acceptable materials, grading the site to promote drainage, and long-term monitoring and maintenance.

The long-term monitoring and maintenance program associated with this alternative would focus on the immediate vicinity of the disposal cell since the radionuclide-contaminated soil and waste debris would be removed from the disposal trenches and placed into the disposal cell. Therefore, the long-term monitoring for Excavation, Treatment, and On-site Disposal would be less expensive than the monitoring programs for Alternatives 2 and 3. Nevertheless, the costs to carry out tasks associated with the long-term monitoring and maintenance program over the performance period of 1,000 years are still considered high. Specific activities contributing to the high cost of the long-term monitoring and maintenance program include off-site leachate transportation and disposal, groundwater sampling and analysis, radiation exposure monitoring, cell component maintenance and repair, general site maintenance, and reporting requirements.

#### 3.3.5.4 Summary

Excavation, Treatment, and On-site Disposal would represent an improvement in terms of protecting human health and the environment over the first three alternatives. A higher probability of maintaining compliance with the site RAOs would exist because there would be more certainty regarding the chemical and physical characteristics of the wastes in the containment cell. Stabilization of wastes would also reduce the likelihood of significant contaminant leaching in the long term. In addition, the use of a new disposal cell in the northern area of the site would mitigate the concern of mine subsidence, and it would also be more effective in reducing the mobility of contaminants. However, this alternative would have an increased short-term risk to remediation workers and the nearby public during excavation, treatment, and disposal activities.

A long-term monitoring program directed at tracking the migration of radionuclides in groundwater both on and off site would be implemented that would be effective in the near term in identifying potential problems with the containment cell. In addition, excavation, treatment, and on-site disposal could be difficult to implement due to anticipated problems in obtaining the required approval from regulatory agencies. The overall cost for this alternative over the performance period is expected to be very high.

This alternative is evaluated further in Section 4.0 (Detailed Analysis of Remedial Alternatives) since it would reduce the mobility of ROCs, could meet the RAOs for the site, and represents the most protective on-site remedial action alternative for long-term effectiveness.

### 3.3.6 Alternative 5: Excavation, Treatment, and Off-site Disposal

#### 3.3.6.1 Effectiveness

Excavation, Treatment, and Off-site Disposal would result in the permanent removal of the ROCs in the contaminated wastes, soils, and debris from the site. This alternative would eliminate the on-site risks associated with the ROCs present in site soil and waste debris, and would minimize the volume of material requiring disposal by separating contaminated materials from those that are uncontaminated. Similar to Alternative 4, the toxicity of contaminants would not be reduced, but proper disposal would isolate them from receptors and the environment.

The removal and treatment of impacted waste, soil, and debris would increase the potential risks associated with short-term exposures to remediation workers and the public near the site. However, health and safety procedures and techniques are available that could be implemented to minimize the likelihood of short-term impacts. Excavation, treatment, and off-site disposal of impacted wastes, soils, and debris would be effective in reducing the long-term risk to human health and the environment at the site and would satisfy the RAOs identified in Section 2.2.

Similar to Alternative 4, the wastes would be characterized following excavation under this alternative. This would eliminate uncertainties as to the physical and chemical composition of these materials. A more complete understanding of the chemical characteristics of these wastes would aid in identifying the appropriate long-term disposal facility for these materials. Treatment processes related to this alternative consist of physical separation, size reduction, and radiological sorting. A structure would be constructed on site to facilitate treatment operations, capture and treat air emissions, minimize potential hazards to the nearby community and workers, and minimize the effect of adverse weather on the treatment processes.

Excavated materials would be initially segregated at the excavation (source separation) using physical separation and radiological sorting techniques. Once the excavation is completed, the wastes, soils, and debris would be transported to the on-site treatment building where additional physical separation and radiological sorting would be implemented; debris size reduction would be conducted as necessary. The focus of physical separation, size reduction, and radiological sorting is to reduce the volume of radioactive waste requiring disposal at a commercial LLW facility.

Physical separation would entail separation of uncontaminated materials and debris from the excavated materials using screening techniques and visual inspection. Size reduction of large debris items could be necessary for proper disposal and adherence to any applicable waste acceptance criteria. These treatment activities should be effective since it is expected that the majority of the radioactive material requiring disposal is comprised of debris and impacted soils. See Section 3.3.5.1 for additional discussion on the effectiveness of radiological sorting or volume reduction techniques.

The off-site disposal facility receiving the waste would be required to comply with federal, state, and local regulations regarding waste acceptance and disposal. Although this helps to ensure the effectiveness of this alternative, the total effectiveness of this alternative in the short-term would be compromised due to risks (both radiological and accident-related) associated with the transportation of wastes to an off-site disposal facility. These risks are reduced through the use of health and safety procedures, which would be implemented to minimize the likelihood of short-term impacts.

The long-term effectiveness of this alternative would also be high, as off-site disposal would eliminate the need for any on-site management strategies over a 1,000-year performance period, such as a long-term monitoring program. Post-excavation sampling and analysis and a final status survey conducted in accordance with MARSSIM would verify the effectiveness of the cleanup effort.

#### 3.3.6.2 Implementability

Excavation, treatment, and off-site disposal is routinely included as part of remediation programs. Excavation and off-site transportation of radioactive materials as well as the necessary site preparation activities could be completed using conventional equipment. Standard excavation and dewatering techniques would be implemented during removal of impacted wastes, soils, and debris. Equipment, materials, and labor would be readily available.

Physical treatment processes have been a successful component of similar remediation programs. Physical separation and size reduction could be readily implemented since they use traditional engineering concepts and the necessary equipment is readily available. Radiological sorting by means of radiation surveys is also a common and readily implemented treatment technique. Radiological sorting using mechanized systems would not be as easily implementable, and would likely be further evaluated during remedial design through pilot testing.

Disposal of excavated wastes, soils, and debris at an off-site facility would involve loading and transporting the impacted materials off site for disposal. As part of these activities, decontamination and manifesting would be required to address both intra- and inter-state transport. Off-site disposal would be technically feasible; however, it may involve detailed and lengthy permitting and administrative processes. In addition, given the relatively large volumes of wastes requiring disposal, local truck traffic would be significant during implementation.

**3.3.6.3 Cost**

The capital cost for implementing Excavation, Treatment, and Off-site Disposal would be considered very high. This cost assumes that the majority of the impacted materials would be disposed of at a LLW or solid waste facility. Costs for this alternative include those for re-location of the existing natural gas line; excavation, treatment, transportation, and disposal of contaminated material; the final status survey; backfilling the excavated areas with either on-site soils or imported clean fill; and grading the site to original grade to promote surface water drainage. Similarly to Alternative 4, however, real estate costs associated with the relocation of the natural gas pipeline will be specified in the Real Estate Plan included with the Proposed Plan.

The estimated costs of this alternative are expected to be higher than that of Alternative 4. Many of the removal and treatment activities are the same for each alternatives. However, it is anticipated that the cost for off-site disposal would be significantly higher than the cost to design, construct, operate, close, and monitor an on-site disposal facility.

#### 3.3.6.4 <u>Summary</u>

Excavation, Treatment, and Off-site Disposal would meet the RAOs presented in Section 2.2. This alternative would be feasible and implementable, but it would have a very high cost. It is also important to note that this alternative would have an increased short-term risk to remediation workers and the public during excavation, treatment, and transportation activities. The Excavation, Treatment, and Off-site Disposal alternative is further evaluated in Section 4.0 (Detailed Analysis of Remedial Alternatives) since it would meet all of the RAOs and be effective over the long-term given the volume of impacted materials present.

### 3.3.7 <u>Summary of Remedial Action Alternative Screening</u>

Based on the screening of preliminary remedial action alternatives in Section 3.3, the following three alternatives were retained for more detailed evaluations in Section 4.0:

- Alternative 1: No Action
- Alternative 4: Excavation, Treatment, and On-site Disposal
- Alternative 5: Excavation, Treatment, and Off-site Disposal

The No Action alternative (Alternative 1) was retained to provide a basis for comparison with the action alternatives consistent with the requirements identified in the NCP. Of the three alternatives involving on-site management of radionuclide-contaminated waste, soil, and debris (Alternatives 2, 3, and 4), Alternative 4 was determined to be superior compared to the other two and was retained for detailed evaluation. In this alternative, the trench contents would be excavated, characterized, and treated prior to disposal in a new, engineered disposal cell constructed in a geologically stable area of the site. The other two on-site alternatives are in situ management alternatives, and would be far less likely to provide long-term protection of human health and the environment. Finally, Alternative 5 involves the removal of all radioanuclide-contaminated materials from the site with transport to licensed commercial facilities for disposal.

These three alternatives cover the range of possible approaches for addressing the radionuclide-contaminated materials at the SLDA, from taking no additional action at the site to performing complete removal and off-site disposal of all contaminated materials.  This is consistent with EPA guidance for conducting evaluations under CERCLA, and conducting a detailed analysis of them should provide the necessary information for determining the most appropriate remedy for the site.

# 4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed analysis of the remedial alternatives remaining after the screening and evaluation performed in Section 3.0. The criteria used to evaluate each alternative are presented in Section 4.1. The remedial alternatives retained for detailed analysis are further defined in Section 4.2 and evaluated with respect to the nine CERCLA evaluation criteria in Section 4.3. A comparative analysis of the remedial alternatives that identifies the advantages and disadvantages of each is presented in Section 4.4.

## 4.1 Evaluation Criteria

The statutory requirements in the NCP that guide the evaluation of alternatives in an FS (40 CFR 300.430) should result in a remedial action that would:

- Protect human health and the environment.
- Attain ARARs or define criteria for invoking a waiver.
- Be cost effective.
- Use permanent solutions and alternative treatment technologies to the maximum extent practical.
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element (or explain why this is not obtainable).

The EPA established nine criteria against which each remedial alternative must be evaluated as part of the FS process (40 CFR 300.430). The acceptability and performance of each alternative with regard to these criteria are evaluated individually so that relative strengths and weaknesses can be identified. The performance period used to evaluate each alternative is 1,000 years, which is the same duration that was used for the BRA (USACE, 2005).

The nine criteria are grouped into three categories (Threshold, Balancing, and Modifying) based on their level of relative importance. Threshold criteria (Overall Protection of Human Health and the Environment and Compliance with ARARs) must be satisfied for a remedial alternative to be considered a viable remedy. The five Balancing criteria (Long-term Effectiveness and Permanence; Short-term Effectiveness; Reduction of Toxicity, Mobility, or Volume Through Treatment; Implementability; and Cost) represent the primary criteria upon which the detailed analysis is based. These balancing criteria are used to analyze major tradeoffs among alternatives. Modifying criteria (State Acceptance and Community Acceptance) are typically evaluated following comment on the RI/FS and Proposed Plan and will be addressed during the preparation of the ROD.

### 4.1.1 Overall Protection of Human Health and the Environment

The analysis of each alternative with respect to overall protection of human health and the environment presents/illustrates how the alternative reduces or eliminates short- and long-term unacceptable risk by controlling exposures to levels at or below the approved cleanup criteria developed in Section 2.0. The assessment of this criterion is correlated to the evaluation of other criteria such as compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness.

### 4.1.2 Compliance with ARARs

Each alternative is evaluated with respect with compliance with the potential ARARs established for the SLDA site. The potential ARARs identified are:

- 10 CFR 20.1402 - Radiological criteria for unrestricted use, and
- 10 CFR 20.1403 - Criteria for license termination under restricted conditions.

Provisions of 10 CFR 20.1402 require that the annual dose to an average member of the critical group (determined to be a future subsistence farmer) not exceed 25 mrem/yr and that the residual radioactivity be reduced to levels that are as low as reasonably achievable (ALARA).

Provisions of 10 CFR 20.1403 require that the annual dose to an average member of the critical group not exceed 100 mrem/yr if institutional controls are no longer present.

### 4.1.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence are evaluated with regard to the magnitude of residual risk and dose remaining at the site after remedial efforts and the adequacy and reliability of controls to manage the risk and dose over the performance period. The magnitude of residual risk and dose is based upon the remaining waste's persistence, toxicity, mobility, and propensity to bioaccumulate at the conclusion of remedial activities.

### 4.1.4 Short-Term Effectiveness

The short-term effectiveness criterion addresses the effects to human health and the environment associated with the alternative during implementation. The factors that are typically assessed include protection of the community during the remedial action, associated environmental impacts, time required until RAOs are achieved, protection of the public and the environment during transportation of wastes, and protection of workers during the remedial action.

### 4.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

The regulatory preference is a remedial action that employs treatment or recycling to reduce the toxicity, mobility, or volume of the contaminants of concern. This evaluation assesses the performance of the alternative in achieving this preference. Relevant factors in this criterion include the quantity of contaminated materials to be treated, destroyed, or recycled; the degree of expected reduction in toxicity, mobility, or volume; the irreversibility of the treatment process; the type and quantity of residuals remaining after the treatment process; and the degree to which treatment is used as the principle element of the alternative.

### 4.1.6 Implementability

The analysis of implementability addresses the technical and administrative feasibility of implementing the alternative, as well as the availability of necessary goods and services. This evaluation includes the feasibility of construction and operation; the reliability of the proposed technology; the ease of undertaking additional remedial action (if necessary); monitoring considerations; activities needed to coordinate with regulatory agencies; availability of adequate equipment, services, and materials; and availability of off-site treatment, storage, and disposal services (if necessary).

### 4.1.7 Cost

Cost estimates for each alternative include direct and indirect capital costs and O&M costs. Costs are based on information obtained from a variety of sources, including quotes from suppliers, published cost information for previous similar projects, generic unit costs, vendor information, conventional cost-estimating guides (i.e., RSMeans®, 2005), and prior experience at similar sites. The actual cost of the project will depend on true labor and material charges, actual site conditions, competitive market conditions, final project scope, engineering design, the implementation schedule, and other variables. However, the estimates presented in this FS are expected to provide an accuracy of plus 50 percent to minus 30 percent of the actual cost. Capital costs include items such as excavation, transportation, and disposal of contaminated waste, soil, and debris as well as backfilling of excavations. O&M costs include environmental monitoring of site media, site maintenance, and program support.

### 4.1.8 State, Support Agency, and Community Acceptance

State, support agency, and community acceptance of the remedial action alternatives will be formally addressed in the ROD following comments on the RI/FS and the Proposed Plan. These assessments will evaluate any technical and administrative issues and concerns that the governing agencies and the public may have regarding each of the alternatives.

## 4.2 Detailed Descriptions of Remedial Action Alternatives

In Section 3.0, five remedial action alternatives were developed based on the initial screening and evaluation of remedial action technologies completed in Section 2.0. A preliminary screening was completed to eliminate those alternatives with limited opportunity for success at SLDA. This section further describes the following three remedial alternatives that were retained from Section 3.0 for detailed analysis:

- Alternative 1: No Action
- Alternative 4: Excavation, Treatment, and On-site Disposal
- Alternative 5: Excavation, Treatment, and Off-site Disposal

### 4.2.1 Alternative 1: No Action

The No Action alternative is considered in the detailed analysis in accordance with NCP requirements found in 40 CFR 300.430(e)(6). Under this alternative, no remedial actions would be undertaken to address radiological waste present at the SLDA site. For purposes of this FS, it is assumed that all activities, including basic site maintenance and environmental monitoring currently performed by BWXT in conformance with their license with NRC, would be discontinued under this response action (refer to Section 2.4.1). Engineering and land use controls would not be implemented and those currently in place at the site (e.g., access restriction) would not be maintained. The absence of land use controls would eliminate the applicability of 10 CFR 20.1403. Therefore, the No Action alternative was compared to 10 CFR 20.1402.

### 4.2.2 Alternative 4: Excavation, Treatment, and On-site Disposal

Alternative 4 consists of the excavation, treatment, and on-site disposal of contaminated waste, soil and debris. Under this alternative, the contaminated materials would be removed from the disposal trenches and placed into an on-site, engineered, disposal cell. Access to the completed disposal cell would be restricted through the use of engineering controls, land use controls and a long-term monitoring and maintenance program would be implemented to demonstrate this alternative's effectiveness.

The new disposal cell would be constructed in the northern corner of the site, north of the deep mine workings. This location was proposed because it is anticipated that it would be free of any potential effects of long-term mine subsidence. Excavated soils and debris found to be impacted would be treated on site as necessary and disposed of in the disposal cell. Under this alternative, no off-site disposal would be necessary.

For purposes of this FS, it was assumed for Alternative 4 that contaminated wastes, soils, sediments, and debris would be managed such that only the engineered disposal cell, and an appropriately sized buffer zone immediately surrounding it, would require land use controls. Any residual concentrations of the ROCs remaining outside this area would meet the 25 mrem/yr dose limit. Therefore, the assumed volume of waste, soils, sediments, and debris to be excavated is the same for both Alternatives 4 and 5. Since the site would have land use controls, Alternative 4 was compared to 10 CFR 20.1403 (restricted use) and requirements of 10 CFR 20.1402 (unrestricted use) are not applicable.

#### 4.2.2.1 Disposal Cell Construction

Site preparation and construction of support facilities would be required prior to construction of the disposal cell or remedial excavation. These activities would include, but not be limited to, mobilization of construction trailers for offices and an on-site laboratory; construction of a temporary building for treatment and waste handling activities; identification and location of existing utilities; re-location of the existing underground natural gas lines; establishment of utility connections to support the work; construction of a haul road; clearing of obstacles that would interfere with the implementation of this alternative; and installation of erosion and sediment controls to mitigate the off-site migration of potentially contaminated soil. In addition, dust suppression measures would be implemented as needed to protect the workers and minimize airborne migration of radionuclides. Site access restrictions and environmental monitoring (air, surface water, and sediments) would be maintained throughout the remedial program.

The new disposal cell would be constructed in a manner to be protective of human health and the environment, and be similar to previously constructed disposal cells at comparable sites (i.e., Monticello, Weldon Spring, Fernald, etc.). The proposed disposal cell dimensions would be 250 by 350 feet (83.8 by 97.6 meters) with an average depth of 15 feet (4.7 meters), which is sufficient to receive a waste volume of approximately 49,000 cubic yards (37,500 cubic meters).

The base of the disposal cell would be constructed of a double geomembrane liner system that would be placed over three feet of impervious clay. The cell would be capped with a multi-layer cover system constructed of a biointrusion layer, bedding layer, filter sand, drain gravel, and a geomembrane liner system (see details in Appendix B). The cap would be several feet thick and designed to withstand erosion and other adverse impacts anticipated over the 1,000-year performance period. A leachate collection system would be included in the disposal cell design to provide a mechanism for the removal of any free liquids. The ground surface in the vicinity of the disposal cell would also be graded in such a manner that infiltration and erosion would be minimized.

#### 4.2.2.2 Excavation and Treatment of Soils and Debris

The limits of soils and debris to be remediated would be better delineated during the remedial design and potentially contaminated material would be excavated with conventional earth moving equipment, such as backhoes, cranes, and excavators. Prior to remedial excavation the existing natural gas lines located in the northwest and southeast parts of the site will be re-located so as to not interfere with remedial activities. It is anticipated that excavators would be used for the majority of the work, but backhoes with smaller buckets or smaller earth removal equipment may be used to remove soil/debris from difficult-to-reach locations. Excavation of wastes, soils, and debris targeted for remediation would continue until approved cleanup criteria are satisfied. Standard dewatering techniques would be implemented during excavation. Calculations estimating the quantity of water generated during dewatering activities are presented at the end of Appendix B.

Alternative 4 involves the excavation of all material that exceeds the approved cleanup criteria, which does not include an assumed two-foot-thick layer of uncontaminated cover soils that would also be removed prior to excavation of the impacted materials. Table 4-1 summarizes the volume of cover soils, volume of soil/debris generated from excavation cutbacks, and volume of subsurface soils/debris designated for remediation. Assumptions made to estimate these volumes are presented in Appendix B. Table 4-2 presents several key aspects of Alternatives 4 and 5 such as assumed production rates, relative risk to remediation workers, duration of remedial activities, and cost.

Figures 4-1 through 4-4 illustrate the estimated aerial extent of surface and subsurface soil/debris requiring remediation. As illustrated in Figures 4-1 and 4-2, approximately 800 bank cubic yards (610 bank cubic meters) of surface soils would be excavated, field screened, profiled and, if found to be contaminated, placed into the on-site disposal cell. Applying a 20 percent factor to account for the uncertainty in delineation of actual excavation limits, as well as the limitations of excavation equipment, results in a surface soil volume of 960 bank cubic yards (730 bank cubic meters). A bulking factor of 30 percent was also applied to the estimated volume to calculate the ex situ soil volume generated. Therefore, the estimated surface soil volume would be approximately 1,200 bulk cubic yards (920 bulk cubic meters).

It was assumed for the FS cost evaluation and quantity calculations that the top two feet of soil within the disposal trench area would consist of uncontaminated cover soils. This assumption is somewhat conservative as the trench waste was originally buried with four feet (1.2 meters) of cover soils. Therefore, the volume of each disposal trench was calculated using the average depth to bedrock less the two feet (0.6 meters) of cover soils, multiplied over the trench surface area. Using this approach, the volume of the trench contents was calculated to be approximately 25,000 bank cubic yards (19,000 bank cubic meters).

As shown on Figures 4-3 and 4-4 as well as in Appendix A-5, additional areas requiring subsurface remediation exist adjacent to the disposal trenches. Using the same cover soil assumption and depth to bedrock factor, the estimated volume of these additional remediation areas was calculated to be approximately 10,000 bank cubic yards (7,600 bank cubic meters). Therefore, the total volume of subsurface soils and trench waste was estimated to be 35,000 bank cubic yards (27,000 bank cubic meters), and the volume of cover soils over the subsurface soils requiring remediation was estimated to be 5,600 bank cubic yards (4,300 bank cubic meters; see Table 4-1).

The assumed method of excavation would be to employ sloped excavation sidewalls. The volume of the excavation cutbacks for the upper trenches was estimated to be 13,000 bank cubic yards (9,900 bank cubic meters) based on a 1:1.5 slope for cohesive soils. The estimated cutback soil volume for the trench 10 area was estimated to be 10,000 bank cubic yards (7,700 cubic meters) based on a 1:2 slope for mine spoils. The total cutback soil volume was therefore estimated to be 23,000 bank cubic yards (17,600 bank cubic meters). These surface and subsurface soil volumes were used as the basis for estimating the costs of Alternatives 4 and 5.

Based on the volume discussion presented in Section 2.3, it was assumed that the volume of subsurface soils and debris requiring remediation is approximately 23,500 bank cubic yards (18,000 bank cubic meters). Assuming that 35,000 bank yards (27,000 bank cubic meters) of subsurface soils/debris would be excavated, approximately 11,500 bank cubic yards (8,800 bank cubic meters) of incidental material would be excavated that would not need to be disposed of in the onsite cell.

Based on past project experience and conventional engineering estimates, an over-excavation factor of 20 percent was also applied to the subsurface soils/debris, cover, and cutback volumes, which is similar to the approach used for surface soils, to account for uncertainty regarding the delineation of the actual excavation limits and limitations of the excavation equipment. This factor was also used to account for contaminated leachate adsorbing to the surrounding trench soils from years of water level fluctuations and outflow. Accordingly, the resulting volume of cover soils, cutback soils, and subsurface soils/debris requiring remediation was estimated to be 6,700, 28,000, and 42,000 bank cubic yards, respectively (5,100, 21,000, and 32,000 bank cubic meters, respectively; see Table 4-1). After applying the assumed bulking factor of 30 percent, the resulting ex situ volume of cover soils, cutback soils and subsurface soils/debris requiring remediation was calculated to be 8,700, 36,000, and 55,000 bulk cubic yards, respectively (6,700, 28,000, and 42,000 bulk cubic meters, respectively; see Table 4-1).

Figure 4-5 illustrates the conceptual layout for implementing Alternative 4 including the location of new facilities and infrastructure such as the new disposal cell, leachate collection building, construction trailers, on-site laboratory, power service, water service, natural gas line, haul road, and treatment building.

Figures 4-6 and 4-7 illustrate the location of cross sections through the remediation areas and Figure 4-8 presents the cross sections. As shown on the cross sections, water levels measured in temporary waste sampling points (four-inch-diameter [10-centimeter-diameter] slotted polyvinyl chloride [PVC] pipes driven to the top of bedrock) are typically near ground surface in the upper trench area. This may be attributed to the perched water condition within the previously excavated disposal areas.

To protect workers and the public during excavation, precautions would be incorporated into the remedial design and the project Health and Safety Plan, as appropriate. Prior to excavation of potentially contaminated material, a two-foot-thick (0.6-meter-thick) layer of cover soils would be removed, stockpiled, and characterized. Stockpiled soils would be profiled through soil sampling and analysis and the clean soils would be used as backfill.

All excavated material found to be impacted by radionuclides above the established cleanup goals would be placed into the disposal cell. Chemical contamination that is commingled with the radioactive wastes would also be placed into the on-site disposal cell. It is anticipated that the average production rate for excavation, treatment, and on-site disposal would be approximately 20 cubic yards (15 cubic meters) per hour. This rate was based on excavation rates presented in standard engineering estimating documents and actual rates achieved at similar sites (refer to Appendix B for rationale).

Provisions for groundwater, leachate, and surface water control during removal work would be established as part of this alternative and detailed in an erosion and sedimentation control plan (E&SCP) that would be included in the final design.

Excavated materials would be segregated at the excavation (source separation) using physical separation, size reduction, and radiological sorting techniques. Since the contaminated materials would be disposed of on site, sampling and analysis associated with waste profiling would be minimal. Therefore, it is anticipated that the level of effort and delays associated with treatment (i.e., separation, size reduction, and sorting) and characterization would be less than that required for off-site disposal.

The focus of physical separation, size reduction, and radiological sorting would be to reduce the volume of material placed in the disposal cell by removing uncontaminated soils from excavated materials. Separation or delineation of uncontaminated soils would be conducted through visual inspection, the use of hand-held radiation detection equipment, and sampling and analysis. Debris that may be detrimental to the disposal cell liner system or difficult to handle would be cut into manageable pieces at the excavation or within a treatment building using standard size reduction equipment.

Radiological sorting would be conducted primarily at the excavation by radiation technicians using hand-held scanning devices (e.g., sodium iodide scintillation detectors); however, if the waste is saturated or heterogeneous, then it would be staged for dewatering or size separated before it is scanned, sampled, and analyzed. These activities would likely be conducted within the treatment building by laborers and radiation technicians to estimate radioactivity levels.

Ex-situ grouting of wastes, soils, and debris characterized as mixed wastes would be conducted, if deemed necessary, to stabilize the material based on physical or chemical considerations. The grouting process would include mixing the impacted material with a cement-like grout to stabilize the waste and reduce its hazardous or radiological leaching capabilities. The grouting treatment process would take place within or adjacent to the treatment building and would likely result in "blocks" of stabilized waste.

Following excavation, confirmatory sampling would be conducted to ensure the remedy is protective. For estimating purposes, it is assumed that one soil sample would be collected representing every 400 square feet of excavation walls and floor. Each sample would be analyzed for the eight ROCs at the on-site laboratory. Based on the results of the confirmatory sampling, additional contaminated material may be excavated, and excavation would continue until the approved cleanup criteria are satisfied.

Post-excavation soil sampling would be conducted to confirm that the cleanup criteria have been met. To properly evaluate the success of the removal action, MARSSIM procedures and protocols would be implemented during and after excavation activities (see MARSSIM

Sections 2.4.5, Remedial Action Support Survey, and 2.4.6, Final Status Survey). Backfilling and compaction activities would be conducted once acceptable final status survey results are obtained to reduce the time the excavation remains open. The site would be restored as close to its original grade as possible using backfill and topsoil, and the disturbed areas within the site would be hydro-seeded and fertilized.

#### 4.2.2.3 On-Site Disposal, Cap Construction, and Long-Term Operation and Maintenance

Subsequent to treatment, contaminated wastes, soils, and debris would be placed into the disposal cell. A limited number of samples would be collected from the wastes prior to placement in the disposal cell to document contaminant levels. Soils and small debris suitable for direct placement onto the liner system would be disposed of first to minimize the potential for damage to both the disposal cell base and final cover. Materials placed in the disposal cell would be compacted as appropriate; the disposal cell cap would be constructed once sufficient subgrades have been attained.

A small building would be located adjacent to the disposal cell to house a leachate collection tank and any associated equipment. All buildings, trailers, decontamination pads, etc. related to the remediation work would be removed from the site once the disposal cell construction is complete and the site is restored. Site restoration would consist of backfilling excavations with imported clean fill or site soils, grading the site to promote drainage, placing four inches of topsoil, and hydro-seeding the disturbed areas. The disposal cell and supporting facilities would be surrounded by a locked 6-foot high chain link fence with signage restricting access to the area by unauthorized people.

A long-term operation and maintenance program would be implemented once the remediation work is completed. Tasks included in operations would consist of cutting the grass, transportation and off-site disposal of leachate, site inspection, groundwater sampling and analysis, and reporting. Maintenance tasks would include maintenance to the fence, road, disposal cell equipment, and monitoring wells as well as repairs of damages to the cap from erosion.

The annual environmental monitoring program would consist of collection and analysis of groundwater samples from the vicinity of the disposal cell. It is expected that the existing network of monitoring wells could be supplemented by four to six additional wells screened in the Upper Freeport and Deep Bedrock water bearing zones.

### 4.2.3 Alternative 5: Excavation, Treatment, and Off-site Disposal

Alternative 5 consists of the excavation, treatment, and off-site disposal of contaminated soils and waste debris. Under this alternative, the contaminated wastes, soils, and debris would be removed from the disposal trenches, subjected to treatment, and transported off site for disposal in a facility permitted to receive such materials. After a determination has been made that the approved cleanup criteria have been attained (based largely upon post-excavation sampling and analysis), there would be no need for environmental monitoring, engineered controls to limit site access, or an O&M program. Essentially, the site would meet the requirements of unrestricted use as defined in 10 CFR 20.1402. Therefore, this alternative was compared to 10 CFR 20.1402 since requirements of 10 CFR 20.1403 are not applicable.

#### 4.2.3.1 Excavation and Treatment of Soils and Debris

Site preparation and construction of support facilities would be required prior to excavation. These activities would be similar to those described in Alternative 4 and would include mobilization of construction trailers for offices and an on-site laboratory; construction of a temporary building for treatment activities; identification and location of existing utilities; re-location of the existing underground natural gas line in the southeastern end of the site; establishment of utility connections to support the work (power, water service, etc.); construction of a haul road; clearing of obstacles that would interfere with the implementation of this alternative; and installation of erosion and sediment controls as necessary to mitigate off-site migration of potentially contaminated soil during remedial activities. In addition, dust suppression measures would be implemented as needed to protect the workers and minimize airborne migration of radionuclides. Site access restrictions and environmental monitoring (air, surface water, and sediments) would be maintained throughout the remedial program. To protect workers and the public during excavation, precautions would be incorporated into the remedial design and the project Health and Safety Plan, as appropriate. Figure 4-9 illustrates the conceptual layout for implementing Alternative 5 including the location of new facilities and infrastructure described above. Provisions for groundwater, leachate, and surface water control during removal work would be established as part of this alternative and detailed in an E&SCP that would be included in the final design.

The limits of soils and debris to be remediated would be better delineated during the remedial design and potentially contaminated material would be excavated with conventional earth moving equipment, such as backhoes, cranes, and excavators. It is anticipated that excavators would be used for the majority of the work, but backhoes with smaller buckets or smaller earth removal equipment may be used to remove soil/debris from difficult-to-reach locations. Excavation of wastes, soils, and debris targeted for remediation would continue until approved cleanup criteria are satisfied. Standard dewatering techniques would be implemented during excavation.

The bank and bulk volumes of surface and subsurface soils/debris designated for remediation under Alternative 5 are the same as those described for Alternative 4 (see Section 4.2.2.2). The estimated volume of surface soil designated for remediation is 960 bank cubic yards (1,200 bulk cubic yards [920 bulk cubic meters]). The estimated volume of subsurface soil and waste designated for remediation is 35,000 bank cubic yards (55,000 bulk cubic yards [42,000 bulk cubic meters]) as summarized in Table 4-1. Figures 4-1 through 4-4 illustrate the estimated aerial extent of surface and subsurface soil/debris requiring remediation. Assumptions made to estimate these volumes are presented in Appendix B. Table 4-2 presents several key aspects of Alternatives 4 and 5 such as assumed production rates, relative risk to remediation workers, duration of remedial activities, and cost.

Prior to excavation of potentially contaminated material, a two-foot-thick (0.6-meter-thick) layer of cover soils would be removed, stockpiled, and characterized. Stockpiled soils would be profiled through soil sampling and analysis, and all excavated material found to be impacted from radionuclides above the established site cleanup goals would be transported off site for disposal. It is anticipated that the average production rate for excavation, treatment, and off-site disposal would be approximately 12 cubic yards (9 cubic meters) per hour. This rate was based on excavation rates presented in standard engineering estimating documents and actual rates achieved at similar sites (see Appendix B for rationale).

The excavated materials would be subjected to on-site physical treatment to reduce the volume of impacted material requiring transport to an approved LLW disposal facility. Treatment process options would consist of physical separation, size reduction, and radiological sorting techniques. These treatment processes would be used to preliminarily characterize the material as either low-level radioactive waste, radiologically impacted solid waste, or potentially uncontaminated material. They could also reduce the volume of contaminated material requiring disposal and limit the size of large debris items, which would both help to reduce the overall disposal cost.

Physical treatment of excavated materials would be completed both at the excavation (source separation) and within the treatment building. The treatment building structure would be enclosed to contain emissions, minimize potential hazards to the public and remedial action workers, and minimize the effect of adverse weather on sorting processes. Since the contaminated materials would need to be profiled in accordance with the disposal facility's waste acceptance criteria (WAC), it is anticipated that the associated sampling and analysis for this alternative would be more time consuming than that required for disposal in an on-site disposal cell (Alternative 4).

Physical separation and size reduction would entail separation of debris from soils, and contaminated soils from uncontaminated soils, based on visual inspection. This would likely consist of the removal of larger items (such as equipment, steel or plastic drums) and other containerized waste from excavated soils. Size reduction techniques would be performed as necessary to reduce large items down to appropriate sizes for waste handling and disposal. Radiological sorting would also be conducted at the excavation through manual screening of excavated soils and debris by radiation technicians using hand-held instruments to estimate radioactivity levels. It is anticipated that these treatment processes at the excavation would be general in scope and that additional, more detailed treatment of the impacted materials would follow within the treatment building.

Once the excavated soils and debris have been processed through source separation at the excavation, potentially contaminated material would be transported to the treatment building for additional treatment and profiling. Obvious waste materials would be separated from apparently uncontaminated soils. Potentially impacted soil and smaller debris items would then be separated utilizing a mechanical screening technique. Wastes generated from this process may include filter paper, personal protective equipment (PPE), glassware, smaller containers, etc., which would be subject to radiological sorting to determine the appropriate facility for their disposal. Radiological sorting would also be conducted within the treatment building by radiation technicians, who would perform a thorough screening of soils and debris using hand-held instruments to estimate radioactivity levels.

Once the treatment activities within the treatment building have been completed, the various waste streams planned for off-site disposal would be profiled to conform to the respective disposal facility's waste acceptance criteria based on each waste steam's physical composition and contaminant levels. Soil sampling and analysis would also be conducted to finalize the preliminary waste profiling, as necessary.

Following excavation, confirmatory sampling would be conducted to ensure the remedy is protective. For estimating purposes, it is assumed that one soil sample would be collected representing every 400 square feet of excavation walls and floor. Each sample would be analyzed for the eight ROCs at the on-site laboratory. Excavation would continue until the approved cleanup criteria satisfied. To reduce the time the excavation remains open, backfilling and compaction activities would be conducted once acceptable final status survey results are obtained. The site would be restored as close to its original grade as possible using backfill and topsoil, and the disturbed areas within the site would be hydro-seeded and fertilized.

#### 4.2.3.2 Transportation and Disposal

The USACE has been directed to remediate radioactive waste at SLDA. Therefore, this FS is focused on evaluation of remedial actions to address radioactive wastes and does not address any chemical contamination unless it is commingled with radioactive wastes. Based on sampling conducted during the RI and previous investigations, it is not expected that a significant quantity of hazardous wastes would be present. The off-site disposal options would include facilities for radioactive, mixed, and solid waste. For the purposes of this FS evaluation, it was assumed that radiologically impacted waste that could be accepted at a solid waste facility would be shipped and disposed of at a facility located approximately 30 miles (48 kilometers) from the SLDA site. It was also assumed that LLW exceeding solid waste facility acceptance criteria would be shipped and disposed of at a facility located in the western United States approximately 2,000-miles (3,219 kilometers) from the SLDA site.

The USACE will consider any approved facility during implementation that, based upon various criteria or considerations (including cost), it determines to be appropriate. There are no significant delays expected with the use of the proposed disposal facilities because there are similar licensed or permitted facilities currently receiving the types and concentrations of contaminated materials present at the SLDA. However, if remediation work were delayed for several years, the availability of a LLW facility to receive radioactive material would have to be re-evaluated.

Any waste designated for off-site disposal would be transported off site by truck. For those disposal sites that have rail access and facilities for offloading rail cars or containers, it was assumed that waste would be transported by truck approximately 60 miles west of the SLDA site to Wampum, Pennsylvania where it would be transferred into rail cars and then transported to the disposal facility. It was assumed for this FS that trucks would be used to transport all low-activity LLW to the appropriate disposal facility and trucks and railcars would be used for transport of the remaining LLW.

Waste shipments would be manifested and transported according to applicable State and Federal regulations and in a manner to be protective of human health and the environment. Designated routes would be traveled and an emergency-response program would be developed to address potential accidents. Vehicles used to transport excavated materials would be inspected before use and surveyed for radioactive contamination before and following loading, transport, and off-loading. Decontamination would be performed, as appropriate.

## 4.3 Detailed Analysis of Individual Alternatives

In this section, the three alternatives described in the previous section are evaluated using the process outlined in the NCP. The nine CERCLA evaluation criteria are the basis of the detailed analysis of alternatives. Three alternatives were developed; one includes no action and two are action alternatives. The performance period used for evaluation was 1,000 years, which is the same as the time frame used for the BRA. The evaluation of alternatives is summarized in Table 4-3.

### 4.3.1 Alternative 1: No Action

The detailed description of the No Action alternative is presented in Section 4.2.1. The NCP requires that the No Action alternative be evaluated to establish a baseline for comparison of other alternatives, especially in terms of cost and protection of human health and the environment. The No Action alternative involves no remedial actions to prevent exposure to contaminated soils and waste. Essentially, the site would be abandoned and have no land use controls, which would eliminate the applicability of 10 CFR 20.1403. Therefore, the No Action alternative was compared to 10 CFR 20.1402. Under this alternative, current and future risk to human health and the environment would neither be eliminated nor reduced. The detailed assessment of this alternative with respect to the nine CERCLA evaluation criteria is presented in the following sections.

#### 4.3.1.1 Overall Protection of Human Health and the Environment

The No Action alternative is not considered protective of human health or the environment in the long term because it would do nothing to reduce exposures to the radioactive constituents at the site. Potential exposure pathways of direct contact, ingestion, and inhalation of contaminated material would likely increase over time as current control measures deteriorate (such as public awareness, access restrictions, and fencing).

Estimates show that the future on-site risks to a Subsistence Farmer from exposure to trench contents would exceed the acceptable CERCLA range of $10^{-6}$ to $10^{-4}$ excess cancer risk (refer to Section 3.3.2.1). In addition, the hazard index would exceed the acceptable limit of one, and the corresponding annual dose would exceed the limits identified in 10 CFR 20.1402.

#### 4.3.1.2 Compliance with ARARs

Since no remedial actions would be conducted and no engineering controls would be enforced, this alternative must be evaluated against the standards for unrestricted use. The requirements of 10 CFR 20.1402 would not be met due to the deterioration of existing controls over time.

#### 4.3.1.3 Long-Term Effectiveness and Permanence

This alternative would provide no controls to prevent exposure to contaminants and no long-term engineering or control measures. Therefore, this alternative would provide no long-term effectiveness or permanence, and current and potential future risks and doses would remain. Therefore, the estimated annual dose to a future subsistence farmer at the site would exceed the dose standards specified in 10 CFR 20.1402. Also, the time until response objectives and protection would be achieved could be thousands of years. Accordingly, concerns about human health and negative impacts on property values would remain and could increase under this alternative.

#### 4.3.1.4 Short-Term Effectiveness

Under the No Action alternative, no additional short-term exposure risks to remediation workers or the community would result since no remedial action would take place. There would also be no short-term impacts to soil, geology, air quality, water resources, biotic resources, or ambient noise levels if this alternative were implemented. Furthermore, knowledge of on-site contamination and existing fencing would effectively limit future use of the SLDA site in the short term, and impact future use of surrounding properties where the potential for off-site migration exists.

#### 4.3.1.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

No treatment or recycling processes are proposed under this alternative. In addition, all of the contamination would remain on site, and there would be no reduction in the toxicity, mobility, or volume of contaminated soil and waste. Although dispersion and radioactive decay processes would slowly reduce the concentration and toxicity of contaminated soils and waste, this could take thousands of years to occur.

#### 4.3.1.6 Implementability

The No Action alternative is readily implementable since no actions would be undertaken.

#### 4.3.1.7 Cost

There would be no capital or O&M costs associated with the No Action alternative (see Table 4-4).

### 4.3.2 Alternative 4: Excavation, Treatment, and On-site Disposal

The detailed description of Alternative 4 is presented in Section 4.2.2. Alternative 4 would consist of excavation, treatment, and on-site disposal of contaminated waste, soil, and debris. Under this alternative, the contaminated materials would be removed from the disposal trenches, subjected to treatment, and placed into an on-site, engineered, disposal cell. Access to the completed disposal cell would be restricted through the use of engineering controls, and a long-term operation and maintenance program would be implemented to demonstrate this alternative's effectiveness. Since the site would have land use controls, Alternative 4 was compared to 10 CFR 20.1403 (restricted use) and requirements of 10 CFR 20.1402 (unrestricted use) are not applicable.

The total project duration for Alternative 4 is estimated to be 29 months. Mobilization, site preparation, and construction of the disposal cell are expected to require six months. The duration of remedial excavation work was calculated to be 17 months based on a production rate of 20 cubic yards per hour. An additional six-month period is anticipated for construction of the final cap and site restoration.

The detailed assessment of this alternative with respect to the nine CERCLA evaluation criteria is presented in the following sections.

#### 4.3.2.1 Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment in the short and long term. Implementation of Alternative 4 would reduce the radiological dose to below the decommissioning criteria for restricted use (10 CFR 20.1403). In addition, a portion of the site would be encumbered by the presence of the waste disposal cell and associated monitoring wells and security fence. By eliminating the potential for radiological exposure, both human health and the environment would be adequately protected from unacceptable risk. Engineering controls, associated signage, and land use controls would be necessary to limit access to the disposal cell area. In addition, a long-term operation and maintenance program (including environmental monitoring) would be implemented over the 1,000-year performance period to facilitate operation and maintenance activities and evaluate performance of the disposal cell.

For purposes of this FS, it was assumed for Alternative 4 that contaminated wastes, soils, sediments, and debris would be managed such that only the engineered disposal cell, and an appropriately sized buffer zone immediately surrounding it, would require land use controls. Any residual concentrations of the ROCs remaining outside this area would meet the 25 mrem/yr dose limit. Therefore, the assumed volume of wastes, soils, sediments, and debris to be excavated is the same for both Alternatives 4 and 5.

Post-excavation, confirmatory sampling and analysis would ensure protectiveness (i.e., confirm that the residual risk outside the disposal cell is at an acceptable level). In addition, actions under this alternative would eliminate the potential for future off-site migration of contaminants by placing the waste into the secure disposal cell. Under this alternative, there would exist the potential for short-term impacts to human health and the environment associated with excavation, waste handling, and on-site disposal of contaminated materials. However, these exposures would be mitigated through appropriate safety, dust, and residual water control measures.

#### 4.3.2.2 Compliance with ARARs

The excavation, capping, and soil sampling activities associated with this alternative would ensure that contaminated soil and waste exceeding remediation clean-up goals are removed and properly contained in an engineered disposal cell. Accordingly, these actions for ROCs would satisfy the decommissioning criteria for 10 CFR 20.1403.

#### 4.3.2.3 Long-Term Effectiveness and Permanence

The removal of contaminated soil/debris and subsequent disposal in an approved on-site disposal cell would provide long-term effectiveness and permanence by lowering risk to levels considered to be protective of human health and the environment. The disposal cell would be constructed in accordance with applicable requirements and designed to withstand the effects of erosion (with periodic maintenance), potential contaminant migration through groundwater, etc. The disposal cell would be designed based on a 1,000-year performance period to meet the dose criteria identified in 10 CFR 20.1403. However, a significant portion of the site would be encumbered by the presence of the disposal cell, security fence, land use controls, and related facilities.

At the completion of contaminated soil and debris removal, the effectiveness of the remediation activities would be verified by a post-excavation, confirmatory sampling and analysis program. A long-term operation and maintenance program would be implemented to establish procedures to maximize the effectiveness of the disposal cell over the performance period. As part of the O&M program, environmental monitoring would provide data to aid in the evaluation of the disposal cell's effectiveness. In addition, CERCLA five-year reviews would be required since the contaminated material would remain on site.

#### 4.3.2.4 Short-Term Effectiveness

Any potential risk and dose to the public that may occur during implementation of the Excavation, Treatment, and On-site Disposal alternative would likely be from inhalation and ingestion of airborne contaminants. These risks would be low due to engineering controls that would be implemented to control off-site migration of contamination during remedial activities. These measures, which would include proper dust-suppression techniques, would also minimize impacts to uncontaminated surface soils, surface water, and sediments.

Short-term risks could be present for remediation workers responsible for the excavation of impacted materials, and the construction, filling, and capping of the on-site disposal cell. A remediation worker engaged in the implementation of this alternative could potentially be exposed to radiation and chemical contamination. As calculated in Appendix C, the remediation dose to an individual worker over the project duration was estimated to be approximately 110 mrem. The total project dose for Alternative 4 was estimated to be 0.33 person-rem (or 0.25 person-rem/year) based on potential exposure to three remediation workers. This risk would be mitigated through the proper use of safety protocols and personal protective clothing and equipment, environmental monitoring, and access restrictions to contaminated areas. There would also exist risks associated with waste handling and construction activities involved with construction, filling, and closure of the disposal cell that would only be applicable to Alternative 4, the fatalities were calculated to be slightly less at approximately $8 \times 10^{-4}$ (calculation based on information from NUREG 1496, Volume 2).

This alternative could also adversely affect soil and groundwater in the area because the large-scale excavation, waste transportation, and backfilling may potentially result in soil disturbance, leachate releases, breaching of weathered bedrock, and erosion. Therefore, precautions would be included in this alternative to prevent any migration of contamination and preserve soil and water quality. These precautions would include identification of the overburden and weathered bedrock interface, use of dewatering techniques during excavation activities and implementation of erosion, sediment, and dust controls established and approved by the appropriate regulatory agencies.

Biotic resources could be affected temporarily by the disturbance of existing habitats during excavation activities at the site. However, the total on-site area of disturbance would only be approximately six acres, and the populations of these areas would likely return to the site following remediation, which should be completed in less than three years. In addition, since there are no known threatened or endangered species in habitat at the site, this alternative would have no impact on these types of species. The site is not located within a 100-year floodplain, and no wetlands are present on site. Construction activities would be minimized near Dry Run to protect that ecosystem.

Noise impacts expected under this alternative could result in annoyances to the public, but they should not affect hearing or pose occupational health hazards. Noise levels associated with this alternative would be temporary and would occur during normal work hours. The noise levels would be reduced, when feasible, by constructing a haul road for waste transportation within the site; by maintaining and operating equipment properly; by scheduling the noisiest operations at times when ambient levels are highest and when the public may not be nearby; by increasing the distance between the noise source and receptor; and by providing enclosures and other sound barriers.

Some community concern would be expected due to short-term impacts during construction of the disposal cell, excavation of the contaminated material, on-site treatment activities, transportation to contaminated materials to the disposal cell, and capping of the disposal cell. However, these concerns would be effectively addressed by implementing the controls previously described and through public information sessions.

The estimated time to complete Alternative 4 site work and achieve protection would be approximately 29 months.

#### 4.3.2.5 <u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u>

Under Alternative 4, treatment of excavated wastes, soils, and debris would be performed to reduce the volume of contaminated media. In addition, select wastes could be stabilized prior to placement into the disposal cell resulting in a reduced mobility. As a result, this alternative would satisfy the statutory preference for treatment as a principle element of the remedial alternative. The toxicity would not be reduced in Alternative 4 as a result of treatment.

Treatment processes such as physical separation are effective in minimizing the overall volume of material designated and handled as contaminated by removing uncontaminated soils. In addition, ex situ grouting may be implemented to stabilize selected mixed wastes encountered (if any) that exhibit physical or contaminant characteristics deemed unsuitable for direct land disposal.

#### 4.3.2.6 Implementability

Alternative 4 would be technically feasible to implement. Construction of a disposal cell, waste excavation, treatment, and on-site disposal have been used in similar FUSRAP remedial projects, are reliable and easy to employ, and can be monitored for effectiveness. All of the facilities necessary to perform the specific remedial activities, such as borrow sites for backfill, have not yet been identified, but it is assumed that they would be available at the time of remedial action implementation. Construction of a treatment structure and haul road to support contaminated material treatment and transportation to the on-site disposal cell are standard components of many remediation programs; therefore, no special construction or excavation techniques would be required for this alternative.

All remedial activities at the SLDA would be coordinated with Federal, State and local governmental authorities. Active communications would be maintained with the public; local media; and Federal, State, and local officials throughout the remedial action. Durable controls would be instituted to ensure protectiveness over time, and long-term environmental monitoring, inspection, and maintenance program would be performed under NRC license throughout the 1,000-year performance period. However, the administrative feasibility of Alternative 4 could face a significant challenge from regulatory agencies since the contaminated waste, soil, and debris would remain on site in a disposal cell that would be situated adjacent to the community of Kiskimere. It is not anticipated that the site would be considered ideal for long-term waste disposal based on typical siting criteria. Therefore, the overall implementability of Alternative 4 is low due to the over-riding issues related to administrative feasibility.

#### 4.3.2.7 Cost

As shown in Table 4-4, the total present worth cost to implement the Excavation, Treatment, and On-site Disposal alternative is estimated to be approximately $20.2 million. Details of this cost estimate are presented in Appendix B. Included in this cost are infrastructure improvements; construction of the on-site disposal cell; excavation, treatment, and disposal of waste materials; post-excavation confirmation sampling; site restoration activities; long-term O&M program; and all labor and equipment required to conduct the work.

### 4.3.3 Alternative 5: Excavation, Treatment, and Off-site Disposal

The detailed description of Alternative 5 is presented in Section 4.2.3. Alternative 5 would consist of the excavation, treatment, and off-site disposal of contaminated soil and debris. Under this alternative, the contaminated soil and debris would be removed from the disposal trenches, subjected to treatment, and transported off site for disposal in a facility permitted to receive such materials. After a determination has been made that the approved cleanup criteria have been attained (based largely upon post-excavation sampling and analysis), there would be no requirement for environmental monitoring, engineered controls to limit site access, land use controls, or an O&M program. Essentially, the site would satisfy the decommissioning requirements of 10 CFR 20.1402 (unrestricted use). Therefore, this alternative was compared to 10 CFR 20.1402 since requirements of 10 CFR 20.1403 are not applicable.

The total project duration for Alternative 5 is estimated to be 32 months. Mobilization and site preparation are expected to require six months. The duration of remedial excavation work was calculated to be 26 months based on a production rate of 12 cubic yards per hour.

The detailed assessment of this alternative with respect to the nine CERCLA evaluation criteria is presented in the following sections.

#### 4.3.3.1 Overall Protection of Human Health and the Environment

Similar to Alternative 4, this alternative would be protective of human health and the environment in the short and long term. Reduction of the radiological dose would also be the same. Other aspects similar to those in Alternative 4 include controls for ensuring protectiveness and the elimination of off-site migration of contaminants, and the potential short-term impacts to human health and the environment during excavation and waste handling activities. As in Alternative 4, short-term impacts to remediation workers would be mitigated through appropriate safety, dust, and residual water control measures. Since the wastes and contaminated soils would be transported off site for disposal, Alternative 5 is considered the most protective of human health and the environment of the alternative considered.

#### 4.3.3.2 Compliance with ARARs

Similar to Alternative 4, the excavation, disposal, and sampling activities associated with this alternative would ensure that contaminated soil and waste exceeding remediation approved cleanup criteria are removed and properly disposed of at a permitted off-site disposal facility. Accordingly, these actions for ROCs would satisfy the decommissioning criteria for 10 CFR 20.1402.

In addition to the identified contaminated material, volume estimation includes an assumption of approximately 20 percent over-excavation to address concerns regarding the feasibility of the proposed construction practices. An ALARA evaluation will be completed during remedial design to determine if any further remediation and consequent reduction in the site dose is justified (ALARA is a requirement of 10 CFR 20.1402).

#### 4.3.3.3 Long-Term Effectiveness and Permanence

This alternative would also provide long-term effectiveness by limiting risks to levels protective of human health and the environment. The removal and off-site disposal of contaminated soils and debris would reduce the annual dose to below the ARAR levels identified in 10 CFR 20.1402. At the completion of the work, the effectiveness of the remediation approach would be verified by a post-excavation confirmation sampling and analysis program. Long-term monitoring and CERCLA five-year reviews would not be included in this alternative because the concentrations of residual material left at the site would be below levels associated with health-based standards under unrestricted use conditions.

The off-site disposal of excavated soil and waste at an approved facility would place the responsibility for long-term management, monitoring, and O&M on the receiving facility rather than the government or property owner. Because of permit/license approval requirements, the disposal facility would be expected to have adequate and reliable controls. For this reason, and because the SLDA site would be released without restrictions under this alternative, the adequacy and reliability of controls criteria associated with residual waste are not applicable.

#### 4.3.3.4 Short-Term Effectiveness

As with Alternative 4, the potential risk and dose to the public from inhalation and ingestion of airborne contaminants during remedial activities would be low. Appropriate measures and safety protocols to control the migration of contamination during remedial activities and exposure risks during transportation and handling of wastes would be employed in a manner similar to that of Alternative 4.

Risk to workers would also be reduced through the use of safety protocols, inspections, and surveys similar to those discussed in Alternative 4 (e.g., personal protective equipment, environmental monitoring, and access restrictions to contaminated areas). As calculated in Appendix C, the dose to an individual worker over the project duration was estimated to be approximately 150 mrem. The total project dose was estimated to be 0.91 person-rem (or 0.42 person-rem/year) based on potential exposure to six remediation workers. The total transportation dose for all drivers would be 10.4 mrem (see Appendix C). Waste transportation activities would also possess accident-related risk of $1 \times 10^{-3}$ fatalities (calculation based on information from DOE, 2002 CAIRS). In total, these added doses and risks would not be significant, and no unusual occupational or safety concerns would prevent implementation of this alternative.

This alternative could adversely affect the environment; however, precautions similar to those outlined in Alternative 4 would be included in this alternative as well (e.g., dewatering techniques, dust control measures, erosion control measures, etc.). The assessment of the short-term effectiveness of this alternative with regards to biotic resources, threatened or endangered species, floodplains, wetlands, and noise impacts is comparable to that of Alternative 4.

The estimated time to complete Alternative 5 is approximately 32 months.

#### 4.3.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

The volume of contaminated material would be minimized through the on-site physical treatment processes included as part of this alternative (physical separation, size reduction, and radiological sorting). Since the waste was historically placed in a non-uniform, non-homogeneous manner, it is expected that there would be a reduction in the volume of soil requiring transportation to the LLW facility as a result of on-site physical treatment. Although some of this material may still require off-site disposal at a solid waste facility, the associated cost would be significantly lower than that at a LLW facility. It should be reiterated that the USACE only has the authority to remediate radioactive wastes and chemical wastes that are commingled with radioactive wastes.

#### 4.3.3.6 Implementability

Alternative 5 would be technically feasible. Many of the services and materials to be utilized in this alternative are similar to those of Alternative 4 and are equally available. The primary differences between Alternatives 4 and 5 are the absence of an on-site disposal cell and the additional labor required for on-site characterization activities. However, the additional labor and any necessary instrumentation would also be readily available and commonly implemented. The on-site treatment building to be used for physical treatment, profiling, packaging, and shipping of the excavated materials would be the same size as the covered structure used for Alternative 4.

This alternative's administrative feasibility differs from Alternative 4's in that approval of governmental agencies may be easier for Alternative 5 since it would permanently remove radiologically contaminated materials off site. The administrative feasibility of Alternative 5 could, however, be affected by requirements for transport and disposal of contaminated materials. Obtaining the approvals and permits necessary to coordinate these activities with the receiving facility and regulatory agencies could be cumbersome and time consuming. The USDOT regulates the transport of most radioactive and hazardous material, and some states and other regulatory agencies have their own special requirements. Therefore, depending on the levels of contamination in the waste, the number of requirements and time and effort to meet them could vary significantly.

#### 4.3.3.7 Cost

As shown in Table 4-4, the total present worth cost to implement the Excavation, Treatment, and Off-site Disposal alternative is estimated to be approximately $35.5 million. Details of this cost estimate are presented in Appendix B. Included in this cost are infrastructure improvements; excavation, physical treatment, profiling, transportation, and disposal of materials; post-excavation confirmation sampling; backfilling activities; and all labor and equipment to conduct the work.

## 4.4 Comparative Analysis of Alternatives

This section presents the comparative analysis of the remedial alternatives for the SLDA site. The purpose of this analysis is to identify the advantages and disadvantages of the alternatives retained from Section 3.0 when compared to each other. The comparative analysis allows identification of items that can be compared and contrasted to aid in the final selection of a preferred alternative. The results of this analysis are summarized in Table 4-5. The alternatives evaluated in the detailed analysis include:

- Alternative 1: No Action
- Alternative 4: Excavation, Treatment, and On-site Disposal
- Alternative 5: Excavation, Treatment, and Off-site Disposal

### 4.4.1 Overall Protection of Human Health and the Environment

The No Action alternative (Alternative 1) is not considered protective of human health and the environment because this alternative would not include any remedial action to reduce exposure to contaminated soil or waste. Under this scenario, potential impacts would be the same as those identified in the BRA screening-level calculation of risks and doses. Therefore, the ARARs for unrestricted and restricted use would not be met for the site.

The Excavation, Treatment, and On-site Disposal alternative (Alternative 4) would provide a high level of protection to human health and the environment. Under this alternative, radionuclides above approved cleanup criteria would be removed from within and around the disposal trenches. However, this alternative would also carry greater short-term risk to remediation workers and the general public than the No Action alternative due to potential construction accidents and exposure to contaminants. Subsequent to remediation, however, the potential for future human contact with elevated levels of contaminants would be significantly reduced.

Excavation, Treatment, and Off-site Disposal (Alternative 5) would also provide a high level of protection to human health and the environment (similar to that of Alternative 4). Overall short-term risks to human health could be considered incrementally higher than those of Alternative 4 as a result of a higher degree of treatment activities, longer remediation duration, and waste transportation activities. However, these risks could be offset due to higher long-term level of protection to human health and the environment because of the complete removal of all radioactive contamination above cleanup levels to an established off-site disposal facility that has been optimally sited in arid, rural area to minimize the possibility of a release and exposure incident.

### 4.4.2 Compliance with ARARs

Alternative 1 (No Action) would not meet the ARAR requirements specified in 10 CFR 20.1402 for unrestricted use. Alternative 4 (Excavation, Treatment, and On-site Disposal) would comply with the ARAR identified for restricted conditions at the SLDA site (i.e., 10 CFR 20.1403). Impacted soils and waste present at the SLDA site would be effectively removed and disposed of in an on-site disposal cell. Following completion of this remedial technology, the SLDA site would be suitable for future use under restricted conditions. Alternative 5 (Excavation, Treatment, and Off-site Disposal) would comply with the ARAR identified for unrestricted conditions (i.e., 10 CFR 20.1402). Activities performed under Alternative 5 would satisfy the requirements of 10 CFR 20.1402 since the impacted soils and wastes would be removed from the site and disposed of off site. It is expected that the level of site cleanup under Alternative 4 (10 CFR 20.1403) would be less than that anticipated under Alternative 5 (10 CFR 20.1402), as institutional controls would be used to limit the radiation dose to potential receptors.

### 4.4.3 Long-Term Effectiveness and Permanence

Since no remedial actions or controls would be implemented under Alternative 1, this alternative would not be effective in achieving long-term effectiveness and permanence.

Alternatives 4 and 5 would achieve both long-term effectiveness and permanence. Both alternatives involve removal of soils and waste with ROC activities exceeding approved cleanup criteria and, with respect to the disposal trench areas, there would be no long-term post-remediation monitoring, maintenance, or land-use controls. Although Alternative 4 would have an on-site disposal cell that would need security, operation, monitoring, maintenance, and land use controls, this alternative would meet the dose criteria presented in 10 CFR 20.1403 (the ARAR for restricted site use). Alternative 5 would meet the dose criteria for 10 CFR 20.1402 (the ARAR for unrestricted site use). Alternative 5 would achieve a higher degree of long-term effectiveness and permanence since the impacted soils and debris would be removed from the site to an established facility that would be suitable for LLW disposal based on its climate and proximity of receptors should a future release occur.

### 4.4.4 Short-Term Effectiveness

Although Alternative 1 would not be effective in achieving the RAOs (either in the short or long term), there would be no increase in worker and public exposure to contaminants during implementation since no remedial activities would occur.

Alternatives 4 and 5 would involve excavation, loading, sorting, and transportation activities, all of which would involve significant soil disturbance. There would be increased short-term risk and the potential for elevated dose rates to workers and the public from these activities; however, implementing proven engineering controls and proper safety protocols would mitigate them.

Alternative 5 could potentially entail a higher short-term risk or exposure component than Alternative 4 due to a longer project duration, greater number of workers likely exposed to radioactive materials, and transportation of contaminated materials off site. As calculated in Appendix C, the total occupational dose for Alternatives 4 and 5 were estimated to be 0.33 and 0.91 person-rem, respectively. Accident-related risks from waste transportation that would only be applicable to Alternative 5 would be approximately 1 x $10^{-3}$ fatalities (calculation based on information from DOE, 2002 CAIRS). There would also exist risks associated with waste handling and construction activities involved with construction, filling, and closure of the disposal cell that would only be applicable to Alternative 4, the fatalities were calculated to be slightly less at approximately 8 x $10^{-4}$ (calculation based on information from NUREG 1496, Volume 2).

Both of these alternatives would be effective immediately following removal of the waste from the impacted areas and disposal either in the on-site disposal cell (Alternative 4) or off site in a permitted facility licensed to accept such wastes. Alternative 4 would require a long-term O&M program, while Alternative 5 would not.

### 4.4.5 <u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u>

Implementation of Alternative 1 would not result in reduction of contaminant toxicity, mobility, or volume. This alternative would allow the contamination to remain on site and rely upon the long-term processes of radioactive decay and degradation for contaminant mass reduction, which could take thousands of years to occur.

Under Alternative 4, treatment of excavated soils and debris would be performed to reduce the volume of ROCs. To a much lesser degree, the mobility of selected wastes would be reduced from stabilization. As a result, this alternative would satisfy the statutory preference for treatment as a principle element of the remedial alternative. The toxicity would not be reduced in Alternative 4. In contrast to Alternative 1, elevated levels of contamination would be placed into the disposal cell to reduce exposure risk and Alternative 4 would not rely on the slow processes of decay and degradation to reduce toxicity, mobility, and volume. As a result, Alternative 4 is ranked significantly higher than Alternative 1.

Alternative 5 would include a higher degree of effort for physical separation and radiological sorting to reduce the volume of contamination than Alternative 4. Thus, the volume of excavated material requiring off-site transport and disposal could be kept to a minimum. Soils or debris found to contain radioactivity at levels acceptable for disposal at a solid waste disposal facility would further reduce the volume (and associated cost) of material requiring disposal at the LLW facility. Alternatives 4 and 5 are essentially ranked equally for this criterion.

### 4.4.6 Implementability

Alternative 1 would be the most easily implemented alternative, as it would involve no remedial action. For Alternatives 4 and 5, excavation and physical treatment activities are common and proven methods for site remediation at similar FUSRAP sites and would be generally implementable. The areas to be excavated would be easily accessible, and it is anticipated that the treatment would be completed using conventional equipment. It is currently anticipated that, for Alternative 5, disposal facilities also would be readily available, although space in some LLW facilities may be unavailable or become much more costly if remediation is delayed. The timeframe for these alternatives would be dependent upon the volume of material to be removed, depth of excavation, method of excavation, and other factors such as the presence and control of groundwater. The construction, closure, and maintenance of an on-site disposal cell for Alternative 4 would also be technically feasible; however, administrative feasibility could be problematic since all of the contamination identified would remain on site, and an on-site remedial alternative could be viewed as unfavorable by the governing agencies. Furthermore, a long-term operation and maintenance program (including environmental monitoring) would only be required for Alternative 4 due to the on-site disposal cell. Although Alternative 5 would include a higher degree of on-site physical treatment, Alternative 4 would be more difficult to implement over the long term due to the presence of the on-site disposal cell.

### 4.4.7 Cost

Table 4-5 presents the estimated costs for each alternative. A breakdown of these costs is presented in Table 4-4. Due to the relatively short project duration, it was assumed that any effect of cost escalation resulting from inflation would be minimal and was considered part of the contingency. A discussion of how these costs were generated, including a listing of individual cost components, assumptions, and back-up information, is provided in Appendix B.

The cost for Alternative 1 was estimated to be $0 since no remedial actions will be conducted. Alternatives 4 and 5 would cost approximately $20.2 and $35.5 million, respectively.

#### 4.4.8 State Acceptance

This criterion evaluates the State's position and key concerns the State may have about the preferred alternative, ARARs, and other related matters. This criterion will not be evaluated formally until comments on the RI/FS and Proposed Plan are received and incorporated into the ROD.

#### 4.4.9 Community Acceptance

This criterion addresses the issues and concerns the public may have regarding each of the alternatives. This criterion will not be formally evaluated until comments on the RI/FS and Proposed Plan are received and incorporated into the ROD.

#### 4.4.10 Findings

The comparative analysis of alternatives based on the above criteria provides the basis for the selection of the preferred alternative. The selected preferred alternative must meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs, but the balancing and modifying criteria should also be considered in the selection process.

The results of the detailed analysis presented in Section 4.0 report that Alternative 1 would not meet the CERCLA threshold criteria. Alternatives 4 and 5 would be protective of human health and the environment over the performance period and would satisfy the applicable RAOs established for the SLDA site. However, it is expected that the level of site cleanup under Alternative 4 (10 CFR 20.1403) would be less than that anticipated under Alternative 5 (10 CFR

20.1402), as institutional controls would be used to limit the radiation dose to potential receptors.

The preferred alternative will be described in the Proposed Plan. In accordance with the NCP, the preferred alternative will be presented to the public for review and comment. Public input on the preferred alternative is paramount in the selection process. Based on the comments received, the preferred remedy may be modified. The final remedy will be selected, presented, and formalized in the ROD.

## 5.0 RESULTS OF PARTNERING AND PUBLIC INVOLVEMENT ACTIVITIES

The SLDA site is located between the communities of Vandergrift and Leechburg in Parks Township, Armstrong County, Pennsylvania. The small community of Kiskimere is also located adjacent to the SLDA site. Many of the residents living in and around these communities are familiar with the SLDA site as a result of their association with the former Apollo and Parks nuclear fabrication facilities where several hundred local people were employed as late as the 1990s. The local public is also knowledgeable of the SLDA site from public outreach associated with previous environmental investigations.

Public participation throughout the RI/FS process has been encouraged by the USACE in conformance with Section 117 of CERCLA. Confidential citizen interviews were conducted in January 2003 to gather additional information for development of the RI work plans. Notification to the community of the planned citizen interviews was conducted through advertisement in the local newspaper, the Valley News Dispatch, and through mailings to interested individuals.

In addition to the citizen interviews, three public information sessions were conducted between May 2002 and April 2004. The intent of holding public information sessions was to inform the community of the status of the site remediation effort and to solicit both positive and negative feedback. The public information sessions were held at the Parks Township Fire Hall located approximately one mile south of the site. Notification to the community of the planned public information sessions was also through advertisement in the Valley News Dispatch and through mailings to interested individuals.

The purpose of the first public information session (May 2002) was to notify the public that, in accordance with Section 8143 of Public Law 107-117, the USACE would investigate the SLDA site, evaluate the data collected, and evaluate remedial action alternatives. In addition, the USACE provided an overview of the CERCLA process that would be followed in accordance with the public law. The second public information session (August 2003) presented details of the proposed RI field investigations planned for that fall. In addition to the particulars of the actual scope of work, the rationale for characterizing each media was provided along with the specifics of the sampling program, such as the number of soil borings, monitoring wells, etc. The preliminary results of the RI were presented during the third public information session (April 2004). Since, at that time, the project was moving from the RI to the FS stage, a review of the CERCLA process and the project schedule was also provided.

In addition to the public information sessions, the USACE hosted two TPP meetings to bring together the project stakeholders and to discuss key issues. Elected officials of Parks Township attended the TPP meetings as well as representatives of the NRC, PADEP, EPA, ARCO, and BWXT. The subject of the first TPP meeting (August 2002) was the proposed RI scope of work. The second TPP meeting (March 2004) discussed preliminary RI sampling results and potential remedial action objectives, general response actions, and remedial technologies to be considered for the FS.

Input from community representatives during the public information sessions and TPP meetings was considered important, was evaluated, and, when appropriate, initiated modifications to the work. Additional public information sessions will be conducted at future key stages of the project to maintain a cooperative relationship between the USACE and the community.

Information regarding the project has been made available to the general public at the Vandergrift public library and through the USACE-established website, www.lrp.usace.army.mil/fusrap/slda.htm. The administrative record established for the project will be available to the public at a location near the SLDA site in the near future.

## 6.0 CONCLUSIONS

The purpose of this FS was to evaluate potential remedial alternatives in order to determine the feasibility of each in regards to alleviating the potential risk to human health and the environment posed by the on-site radiological contamination. To achieve this objective, GRAs were initially identified to address the impacted site media: surface soils, sediments, subsurface soils, and debris contaminated with radionuclides at levels above the PRGs presented in Table 1-3 and discussed in Sections 1.2.5 and 2.2.3. The GRAs developed for the SLDA site included No Action, Limited Action, Containment, Removal, Treatment, and Disposal.

Technology types and process options were identified for each GRA based on research performed by the DOE, USACE, and EPA on remediation of radiological wastes and previous CERCLA and FUSRAP remediation projects. The process options examined included conventional, emerging, and innovative technologies. The remedial technologies and process options were initially screened based on the technical implementability of the technology or process option and its ability to satisfy the remedial action objectives.

Remedial technologies and process options that were considered technically implementable were subjected to a more detailed screening based on their effectiveness, implementability, and cost. Of these criteria, effectiveness was considered the most important. Implementability and cost were factored into the assessment only to determine the final screening decision as to whether the technology or process option was to be retained for refinement into remedial alternatives.

Five preliminary remedial action alternatives were developed from the technologies and process options that passed the initial screening and evaluation. The remedial alternatives were based on NCP and CERCLA requirements and included “no action” and “limited action” alternatives. The five preliminary remedial action alternatives were:

- Alternative 1: No Action
- Alternative 2: Limited Action
- Alternative 3: Containment
- Alternative 4: Excavation, Treatment, and On-site Disposal
- Alternative 5: Excavation, Treatment, and Off-site Disposal

The performance period used for evaluation of the remedial alternatives was 1,000 years based on the provision in 10 CFR 1401(d) that the expected peak annual TEDE shall be determined for the first 1,000 years after decommissioning. Each remedial alternative was analyzed based on its effectiveness, implementability, and cost. On the basis of this screening evaluation, Alternatives 2 and 3 were eliminated from further consideration because Alternative 4 was considered the most protective on-site restricted use alternative. That is, Alternative 4 would provide a more reasonable assurance that the criteria set forth in 10 CFR 20.1403 would be met. Alternative 5 was retained for further analysis since it would meet the criteria set forth in 10 CFR 20.1402. The No Action alternative (Alternative 1) was retained for detailed evaluation consistent with EPA guidance and the NCP.

Remedial action Alternatives 1, 4, and 5 were subsequently subjected to a detailed analysis to identify a likely preferred alternative. This analysis primarily consisted of a comparison against the nine CERCLA criteria, grouped into three categories based on their level of relative importance: Threshold, Balancing, and Modifying criteria. Threshold criteria (Overall Protection of Human Health and the Environment and Compliance with ARARs) had to be satisfied for a remedial alternative to be considered a viable remedy. The five Balancing criteria (Long-term Effectiveness and Permanence; Short-term Effectiveness; Reduction of Toxicity, Mobility, and Volume Through Treatment; Implementability; and Cost) represented the primary criteria upon which the detailed analysis was based. Modifying criteria (State Acceptance and Community Acceptance) are typically evaluated following comment on the RI/FS and PP and will be addressed during preparation of the ROD.

The detailed analysis required additional alternative development to allow preparation of a FS-level cost estimate as well as conceptual level design figures illustrating the anticipated site improvements and proposed work. Table 4-3 summarizes the detailed evaluation of each alternative against the nine CERCLA criteria and Table 4-5 identifies the level of satisfaction of the evaluation criteria when compared to each other. For Alternatives 4 and 5, volumes of cover soils, soils generated from excavation cutbacks, and subsurface soils/debris targeted for remediation were estimated and summarized in Table 4-1.

Both alternatives would involve treatment to separate uncontaminated soils and to better characterize the impacted materials. For Alternative 4, treatment activities would include physical separation, size reduction, radiological sorting, and ex situ grouting (select wastes would be stabilized as necessary). Contaminated soils and debris generated from treatment activities would be placed into an on-site disposal cell. A long term operation and maintenance program including environmental monitoring would be implemented once the disposal cell is capped.

Treatment activities for Alternative 5 would be more intensive and would be focused on meeting the requirements of the disposal facility's WAC; ex situ grouting is not included. Contaminated soils and debris would be profiled, packaged, and transported off site for disposal at either a solid waste or LLW facility. Uncontaminated soils identified during completion of Alternatives 4 or 5 would be used as clean backfill on-site. It is important to note that Public Law 107-117 specifically directs the USACE to remediate radioactive waste at SLDA. Therefore, this FS is focused on evaluation of remedial actions to address radioactive wastes and does not address any chemical contamination unless it is commingled with radioactive wastes.

The cost for Alternative 1 was estimated to be $0 since no remedial actions would be conducted under this alternative. Alternatives 4 and 5 would cost approximately $20.2 and $35.5 million, respectively.

The comparative analysis of alternatives based on the above criteria provides the basis for the selection of the preferred alternative. The preferred alternative must meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs, but the balancing and modifying criteria should also be considered in the selection process.

The results of the detailed analysis presented in Section 4.0 report that Alternative 1 would not meet the CERCLA threshold criteria. Alternatives 4 and 5 would be protective of human health and the environment over the performance period and would satisfy the ARARs identified for the site. Alternative 4 would be less costly than Alternative 5; however, this benefit would be offset by the anticipated difficulty in obtaining regulatory concurrence for an on-site disposal cell and by the need for a long-term operation and maintenance program. Alternative 5 would be more costly than Alternative 4, but once the remediation work is completed the site would be suitable for unrestricted use.

The preferred remedial alternative will be presented in the Proposed Plan. In accordance with the NCP, the preferred alternative will be presented to the public for review and comment. Public input on the remedial alternatives is paramount in the selection process. Based on the comments received, the preferred remedy may be modified. The final remedy will be formalized in a ROD.

## 7.0 REFERENCES

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# TABLES

# TABLE 1-1
# DESCRIPTION OF MATERIALS PLACED IN SLDA TRENCHES

| Trench # | Dates of Activity | Description from the Site Characterization Report | Reported[1] Radiological Content | Description from ARCO Memo to Department of Justice (DOJ) (March 2000)[2] |
|---|---|---|---|---|
| Trench # 1 | 1961 | 61 drums and 5 bags of process waste<br><br>23 drums and 17 bags of trash<br>4 drums of beryllium waste<br><br>miscellaneous debris | 141.7 g U-235<br><br>Total Uranium = 4,526 g | Approximately 125,000 cubic feet (ft$^3$) of contaminated soil and/or waste including process wastes, beryllium wastes, and scrap protective clothing (e.g. "dry active waste" DAW) |
| Trench # 2 | 1962 | 15,668 grams (g) of metal oxide powder<br>142.8 kilograms (kg) vapor blast [i.e. sand]<br>25 drums containing 1,075 kg of organic liquid<br>Leached solids, including 399 pounds (lbs.) ash and 160 lbs. miscellaneous residue<br>Leached residue<br><br>In 1965 Trench #2 also received liquids during the exhumation of Trenches 4 & 5 | 4.41 g Uranium<br>156 g Uranium<br>152 g Uranium<br><br>616 g Uranium; 564 g U-235<br>289 g Uranium<br>564 g U-235<br>Total Uranium = 1,217.41 g | Approximately 110,000 cubic feet (ft$^3$) of contaminated soil and/or waste including scrap metallic oxide powders, contaminated sand, process ash and residues, contaminated organic liquids, and DAW. |
| Trench # 3 | 1965<br>(best estimate) | ARCO/B&W believed this trench never received solid or liquid waste. Trench 3 is however thought to have functioned as a "catch basin" that received run-off from Trenches 2 and 4 when they were exhumed in 1965. | | Excavated as a settling pond during 1965 exhumation. Approximately 5,000 ft$^3$ of contaminated soil exists in this area. |
| Trenches # 4<br><br>and #5 | 1963 - 1965<br><br>burial in 1963<br>no burial reported in 1964<br>exhumed in 1965 | 270 kg of scrap "solutions" ($UO_2$-BeO)<br><br>175 "birdcages" (shipping containers) used for UO2-BeO wastes<br><br>52 truck-loads of assorted process wastes, debris, and contaminated equipment<br>The roof from the Apollo facility (burned in pit in early 1963)<br>metal drums, stanchions, shipping container liners, strapping material, combustibles, etc. | 37 g Uranium | Approximately 85,000 ft3 of waste (55,000 and 30,000 respectively). Materials from both trenches included uranium-beryllium scrap solutions, empty "birdcages" , assorted process wastes, debris, contaminated equipment, roof of Apollo facility, and DAW (Dry Active Waste). |
| Trench # 6 | 1965 - 1967<br>1965<br><br>1966<br><br><br><br><br>1967 | 150 drums each containing 5 g Th02<br><br>593 2-quart (qt) bottles of leached solids<br>75 2-qt bottles calcined filters<br>14 55-gallon drums containing 1,811 g U-235<br>200 to 300 drums and air filters from "Blue Building" at Apollo<br>40 55-gal drums containing scrap recovery wastes, including leached ashes and solids<br>leached poly buckets and vials, scap metal, glass, and debris<br>22 drums process waste from CP-1<br><br><br><br><br>1 drum of 8-OH filter cake | 750 g Th02 estimated, not previously reported<br><br><br>1,811 g U-235<br><br>3,162 g U-235;<br>Total Uranium = 3,660.6 g<br><br>1,720 g U-235;<br>Total Uranium = 787,800 g<br><br>570 g U-235;<br>Total Uranium = 258,700 g<br><br>Total U-235 = 7,263 g<br>Total Uranium = 1,051,618 g | Approximately 110,000 cubic feet (ft$^3$) of scrap thorium oxide, scrap recovery waste such as ash and residues, filter cakes, DAW and zircalloy wastes. |
| Trench # 7 | 1968 - 1970<br>1968 | large vacuum chamber<br>one drum of zirc[onium]-beryllium<br>208,456.5 (units not specified) of raffinate, condensate, and filtrate from the high-enriched scrap recovery line<br>33 filters<br><br>97 55-gal drums of scrap recovery wastes and misc. wastes, including leached solids, vials, poly buckets, filter frames, residues and misc. scrap.<br>Disposal boxes containing filter papers and 8-OH filter cake | 913.5 g U 235<br><br>Total Uranium = 982.8 g<br><br><br>148.5 g U-235<br>Total Uranium = 152 g<br>2,301.5 g U-235<br>Total Uranium = 2,553 g<br><br>230 g U-235<br>Total Uranium = 130,000 g<br>Total U-235 = 3690 g<br>Total Uranium = 133690 g | Approximately 100,000 cubic feet (ft$^3$) of zirc-beryllium waste, scrap recovery wastes, filter paper, filter frames, 8-hydroxyquinoline filter cake, DAW, spent organic solutions, and a large vacuum chamber. |

## TABLE 1-1
## DESCRIPTION OF MATERIALS PLACED IN SLDA TRENCHES

| Trench # | Dates of Activity | Description from the Site Characterization Report | Reported[1] Radiological Content | Description from ARCO Memo to Department of Justice (DOJ) (March 2000)[2] |
|---|---|---|---|---|
| Trench # 7 (cont.) | 1969 | contaminated waste drums and filters, 14 truckloads of contaminated waste and filters<br>45 drums of leached samples, filters, debris, vials, buckets, and misc. scrap<br>154 liters of stripped organic solution<br>697 drums (C, D, E, and F series) | 586 g U-235<br>Total Uranium = 608 g<br>2.37 g U-235<br>Total Uranium = 2.43 g<br>14,238 g U-235<br>Total Uranium = 15,310 g | |
| | | | Total U-235 = 14830 g<br>Total Uranium: "not ascertained" | |
| | 1970 | 14 boxes, 11 2-qt bottles, 66 buckets containing 231.933 kg scrap, and 2 filters - "shaken out"<br>25 drums of leached residues, miscellaneous scrap<br>70 liters stripped organic solution<br>198,385 (no units specified) aqueous waste and contaminated oil<br>210 boxes, 27 drums containing "relatively large quantity of U-235" | 1,058 g U-235<br>Total Uranium = 2,404 g<br>91 g U-235<br>Total Uranium = 2,833 g | |
| | | | Total U-235 = 1150 g<br>Total Uranium = 5240 g | |
| Trench # 8 | 1970 | Discarded filtrate from ADU recovery, raffinates from scrap recovery and leached dissolver residues<br>22 drums of contaminated soil from sewer project at Apollo<br>25 drums of leached residues and scrap | 543 g U-235<br>Total Uranium = 18,512 g<br>322.1 g U-235<br>Total Uranium = 2,747.6 g | Approximately 30,000 cubic feet ($ft^3$) of scrap recovery wastes, contaminated soil, leached residues, scrap and DAW. |
| | | | Total U-235 = 865.1 g<br>Total Uranium = 21260 g | |
| Trench # 9 | 1968-1970 | Contaminated soil from Trench #2<br>17 pieces of equipment<br>several pieces of plywood from "Plutonium Facility drum field" | not listed | Approximately 55,000 cubic feet ($ft^3$) of contaminated soil, leached residues, scrap and DAW. |
| Trench # 10 | 1960-1971<br>1960<br>1968<br>1971 | Electrodes, kimwipes and other lab waste, pipes, valves, tygon tubing, fuel tubing, feed sacks, and filter cake<br>Slaughter house demolition waste, a barn foundation and quantities of soil from excavation work<br>uncontaminated scrap (primarily old equipment) from an equipment storage and laydown area near Trench 10.<br>contaminated truck likely used for waste transport reportedly also placed in the trench | 308.2 g U-235<br>Total Uranium = 3,815 g<br>Thorium: 0.03 g | Approximately 370,000 cubic feet ($ft^3$) of material including, electrodes, DAW, filter cakes, barn debris, lightly contaminated equipment, and a truck. Much of the equipment placed in the trench was "uncontaminated ( a barn, construction/demolition waste) |

[1]Descriptions of the waste and dates of activity were obtained from SLDA Site Characterization Report prepared by ARCO, Section 4.5, May 19, 1995.
[2]Memo to the Department of Justice was issued by ARCO March 2000.

**TABLE 1-2**

**BACKGROUND ACTIVITIES OF THE PRIMARY AND SECONDARY ROPCS AT THE SLDA[A]**

| Radionuclide | Soil Activity (pCi/g) | | |
|---|---|---|---|
| | Surface | Subsurface | Composite |
| ***Primary ROPCs*** | | | |
| Americium-241[b] | 0.0 | 0.0 | 0.0 |
| Plutonium-239[b] | 0.0 | 0.0 | 0.0 |
| Plutonium-241[b] | 0.0 | 0.0 | 0.0 |
| Radium-228 | 1.42 | 1.66 | 1.61 |
| Thorium-232 | 1.31 | 1.77 | 1.68 |
| Uranium-234 | 1.32 | 1.28 | 1.29 |
| Uranium-235 | 0.19 | 0.27 | 0.25 |
| Uranium-238 | 1.25 | 1.41 | 1.38 |
| ***Secondary ROPCs*** | | | |
| Cesium-137[b] | 0.79 | 0.0 | 0.16 |
| Cobalt-60[b] | 0.0 | 0.0 | 0.0 |
| Plutonium-238[b] | 0.0 | 0.0 | 0.0 |
| Plutonium-240[b, c] | 0.0 | 0.0 | 0.0 |
| Plutonium-242[b] | 0.0 | 0.0 | 0.0 |
| Radium-226 | 1.32 | 1.32 | 1.32 |
| Thorium-230 | 1.24 | 1.16 | 1.18 |

[a] The background soil activities for surface and subsurface soil are the maximum measured values, as these values exceeded the 95% UTL with 95% coverage of the measured activities as described in the text. The background soil samples were collected from 18 locations at Gilpin/Leechburg Community Park. The surface value represents the activity in the top 15 cm (6 in.) of soil, and the subsurface value represents the value from 60 cm (2 ft) to 1.2 m (4 ft) below the surface. The composite represents the weighted average value for surface and subsurface soil. All values were rounded to two decimal places.

[b] The activities of these radionuclides (which are not naturally occurring) were below the minimum detectable activities. The background values for these radionuclides were taken to be 0.0 pCi/g. The surface soil activity for cesium-137 represents the fallout contribution from previous atmospheric tests of nuclear weapons.

[c] Pu-240 was not reported separately by the analytical laboratory, but was combined with Pu-239 and reported as Pu-239/240. Since the reported background values for Pu-239/240 were zero, the background activity of Pu-240 is zero.

## TABLE 1-3

## PRELIMINARY REMEDIATION GOALS (PRGS) FOR THE PRIMARY ROCS AT THE SLDA

| Radionuclide | PRG (pCi/g) [a] |
|---|---|
| Americium-241 | 27.7 |
| Plutonium-239 | 32.6 |
| Plutonium-241 | 892 |
| Radium-228 | 1.69 |
| Thorium-232 | 1.35 |
| Uranium-234 | 96.4 |
| Uranium-235 | 34.6 |
| Uranium-238 | 123 |

[a] The PRGs represent radionuclide activities in soil in excess of background levels.

**TABLE 1-4**

**ESTIMATED CARCINOGENIC RISKS, RADIATION DOSES, AND HAZARD INDEXES AT THE SLDA (EXCLUDING TRENCH WASTE SAMPLING DATA) [A]**

| Scenario | Radiological Risk | Radiation Dose (mrem) | Annual Dose (mrem/yr) | Hazard Index |
|---|---|---|---|---|
| ***Exposure Unit 1*** | | | | |
| Maintenance Worker | 1.E-07 | 3.E-01 | 3.E-02 | 6.E-05 |
| Adolescent Trespasser | 1.E-08 | 3.E-02 | 6.E-03 | 2.E-05 |
| Construction Worker | 8.E-08 | 3.E-01 | 3.E-01 | 1.E-03 |
| Subsistence Farmer | 1.E-05 | 4.E+01 | 1.E+00 | 1.E-02 |
| ***Exposure Unit 2*** | | | | |
| Maintenance Worker | 3.E-06 | 4.E+01 | 4.E+00 | 1.E-05 |
| Adolescent Trespasser | 3.E-07 | 5.E+00 | 1.E+00 | 4.E-06 |
| Construction Worker | 9.E-08 | 2.E+00 | 2.E+00 | 1.E-09 |
| Subsistence Farmer | 7.E-06 | 1.E+02 | 5.E+00 | 1.E-08 |
| ***Exposure Unit 3*** | | | | |
| Maintenance Worker | 1.E-07 | 3.E-01 | 3.E-02 | 1.E-05 |
| Adolescent Trespasser | 2.E-08 | 3.E-02 | 7.E-03 | 5.E-06 |
| Construction Worker | 9.E-09 | 3.E-02 | 3.E-02 | 1.E-07 |
| Subsistence Farmer | 2.E-06 | 6.E+00 | 2.E-01 | 1.E-06 |
| ***Site-Wide*** | | | | |
| Maintenance Worker | 8.E-08 | 4.E-01 | 4.E-02 | 3.E-05 |
| Adolescent Trespasser | 9.E-09 | 4.E-02 | 9.E-03 | 1.E-05 |
| Construction Worker | 3.E-08 | 2.E-01 | 2.E-01 | 1.E-04 |
| Subsistence Farmer | 6.E-06 | 3.E+01 | 1.E+00 | 1.E-03 |

[a] The radiological carcinogenic risk estimates represent the probability that an individual will develop cancer during their lifetime as a result of exposures to the radioactive constituents at the SLDA site. The radiation doses are the 50-year TEDE and represent the total dose over the duration of the exposure period. The hazard indexes represent the potential for adverse health effects other than cancer and were calculated from the oral intakes of uranium. A hazard index less than 1 indicates little potential for the occurrence of adverse health effects. All values are given to one significant figure.

**TABLE 2-1**

**SUMMARY OF VOLUME ESTIMATES PREPARED FOR THE SLDA SITE**

| Author | Year | Description | Volume Estimate (cubic yards) |
|---|---|---|---|
| BWXT[1] | 1971 | Prepared an estimate of the volume of soils and debris requiring excavation based on BWXT's knowledge of the disposal trench dimensions. | 30,778 |
| ARCO/BWXT[2] | 1995 | Prepared an estimate of the volume of the disposal trenches based on the geophysical anomalies plus a limited quantity of contaminated subsurface soils and debris adjacent to the trenches. | 23,493 |
| ARCO/BWXT[3] | 2000 | Prepared an estimate of the volume of contaminated trench soil and debris requiring remediation based on operational records of the Apollo nuclear fabrication facility. | 36,667 |
| USACE[4] | 2004 | Prepared an estimate of the volume of materials disposed of in the trenches at the SLDA site based on waste disposal documentation provided to USACE by ARCO in 2003. | 4,000 |
| USACE[5] | 2005 | Prepared an estimate of surface soils and subsurface soil/debris requiring remediation based strictly on environmental sampling data collected to date. The remediation criterion was based on a sum of ratios greater than one. | 5,817 – 12,631 |

1. The volume estimate prepared by BWXT in 1971 was based on their knowledge of the disposal area dimensions.
2. The volume estimate prepared by BWXT in 1995 consisted of the estimated volume of the disposal trenches and a limited quantity of contaminated soil encountered adjacent to the trenches based on a clean up criterion of 30 pCi/g uranium.
3. The volume estimate prepared by BWXT in 2000 was based on operational records of the Apollo facility and a uranium cleanup criterion of 30 pCi/g.
4. The volume estimate prepared by USACE in 2004 was based on the volume of radioactive waste materials disposed of at the SLDA site as reported in waste disposal documentation provided by ARCO in 2003.
5. The volume estimate prepared by USACE in 2005 was determined using environmental sampling and PRGs developed as part of the USACE RI. The PRGs were derived from a maximum dose of 25 millirem/yr.

Note: See Appendix A for more detail on the volume estimates.

## TABLE 2-2
## Initial Screening of Remedial Technologies and Process Options
## Shallow Land Disposal Area - Feasibility Study

| General Response Action | Technology | Process Option | Description | Initial Screening Comments* |
|---|---|---|---|---|
| No Action | None | None | No technologies or process options are employed. Could include basic monitoring. | Required by NCP/CERCLA for baseline comparison. |
| Limited Action | Institutional Controls | Deed Restrictions/Zoning | Controls and restrictions placed on future land use and site activities. | Applicable since future use controls are necessary. |
| Limited Action | Monitoring | Groundwater Monitoring | Sampling of groundwater to evaluate migration of radionuclides. | Applicable to verify contamination migration in groundwater. |
| Limited Action | Monitoring | Surface Water Monitoring | Sampling of surface water to verify the level of contaminants leaving the site. | Applicable to verify potential exposure and off-site migration of contaminants. |
| Limited Action | Monitoring | Radiation Exposure Monitoring | Radiation surveys to identify level of radioactivity being released to the environment. May also involve soil sampling. | Applicable to verify exposure to radionuclides. |
| Limited Action | Access Restrictions | Fencing/Barriers | Installation of signage and fencing to prevent unauthorized entry onto the site. | Applicable to control access to the site. |
| Containment | Surface or Sub-Surface Controls | Grading, Grouting | Surface controls include the use of altering site grades, reconstruction of drainage channels, and installation of new drainage swales. Subsurface controls considered for SLDA include injection of grout to fill the mine voids beneath the site to reduce potential mine subsidance. | Applicable to minimize exposure or migration of radionuclides from erosion or in the case of subsurface controls, migration by groundwater transport. Subsurface controls will also reduce the likelihood of mine subsidance. |
| Containment | Capping | Single or Multiple Layer Cap | Placing a combination of one or more cover materials on contaminated areas to reduce migration or contaminants and exposure to radionuclides. | Applicable to control water infiltration into the subsurface and provide a barrier from exposure to contaminants. |
| Containment | Vertical Barriers | Slurry Wall, Grout Curtain | Vertical barriers such as slurry walls or grout curtains are commonly used to reduce the flow of groundwater into or radionuclides out of the remediation area. Slurry walls are typically installed in the overburden soils while grout curtains are installed into bedrock. | Applicable to minimize migration of radionuclides laterally from the remediation area but will not effect the volume or toxicity of the waste. |
| Containment | Mine Stabilization | Mine Grouting | Injection of grout into the mine void would reduce the potential for mine subsidence. | Applicable to minimize migration of radionuclides vertically and laterally from the remediation area in the event of mine subsidence but will not effect the volume or toxicity of the waste. |

*Comments based on the following aspects of technical implementability:
1. Effective at removing or treating radionuclides of concern.
2. Interference from co-located elements is not a concern.
3. Site conditions are optimal for technology.
4. Effectiveness has been demonstrated "in the field."
5. Focuses on remediation of soil and debris.
6. Effective in a reasonable time.

**BOLD = Technology/process option retained for further consideration.**

# TABLE 2-2 (continued)
## Initial Screening of Remedial Technologies and Process Options
## Shallow Land Disposal Area - Feasibility Study

| General Response Action | Technology | Process Option | Description | Initial Screening Comments* |
|---|---|---|---|---|
| **Removal** | **Excavation** | **Conventional Soil Excavation** | **Excavation of soil via conventional construction equipment. Radionuclide migration and leachate/outflow controls commonly used.** | **Applicable as the technology is commonly and successfully used on soil and debris at similar CERCLA sites.** |
| **Ex-Situ Treatment** | **Physical Processes** | **Separation/Size Reduction** | **Precursor step that sorts soil/debris by size, ultimately reducing amount of waste to be disposed or treated.** | **Potentially applicable based on the wide range of media sizes at SLDA.** |
| | | **Radiological Sorting** | **Soils are segregated based upon the level of radioactivity.** | **Potentially applicable based on the soil types at SLDA (mine spoils and clayey silt with sand) and the hetergeneous distribution of waste.** |
| | | Soil Washing | Uses a water solution of surfactants and chelators to remove contaminants from soil by separating fines from coarse particles. | Not applicable due to the homogeneous nature of silty clay-like soils at SLDA. |
| | Chemical Processes | Oxidation/Reduction | Removes inorganics through chemical conversion with the use of oxidizing agents. | Not applicable as a stand-alone process and typically addresses heavy metals in liquid waste streams. |
| | | Solvent Extraction | Uses an organic chemical as a washing solvent to remove organic contaminants from soil. | Not applicable, because of limited effectiveness in removing radionuclides from silty clay-like soils. |
| | **Solidification/ Stabilization** | **Grouting** | **Soil is mixed with binding material and water to form monolith, that is resistant to leaching and possesses high structural integrity.** | **Applicable as a well demonstrated and widely accepted method for stabilizing radionuclides in soils.** |
| | | **Polyethylene Encapsulation** | **Soil is mixed with polyethylene binder and pored into a mold which, after curing, is disposed.** | **Potentially applicable innovative technique to immobilize radionuclides in soil.** |
| | | **Vitrification** | **Employs high heat to convert soil and crystalline additives into solid matrix.** | **Potentially applicable due to ability to reduce gamma dose and form unleachable product.** |
| **In-Situ Treatment** | Chemical Processes | Soil Flushing | Soil flushing uses a washing solution and water extraction system to recover the contaminants. | Not applicable due to the likelihood of flushing solutions migrating into groundwater or off-site. |
| | | Acid Leaching | Removes metals from soil by converting them to a more soluble form in presence of an acid leaching solution. | Not applicable due to regulatory issues with the addition of hazardous materials to subsurface soil and impact on groundwater. |
| | Solidification/ Stabilization | Solidification/Stabilization | In-situ formation of a non-leachable monolith, similar to the ex-situ process. | Not applicable due to difficulty in producing a homogeneous matrix in the field. |
| | | Encapsulation | In-situ grouting by injection of $CaCO_3$ precipitating solutions into contaminated soil area forming a monolith resistant to water migration. | Not applicable due to difficulty in producing a homogeneous matrix in the field. |

*Comments based on the following aspects of technical implementability:
1. Effective at removing or treating radionuclides of concern.
2. Interference from co-located elements is not a concern.
3. Site conditions are optimal for technology.
4. Effectiveness has been demonstrated "in the field."
5. Focuses on remediation of soil and debris.
6. Effective in a reasonable time.

**BOLD = Technology/process option retained for further consideration.**

# TABLE 2-2 (continued)
## Initial Screening of Remedial Technologies and Process Options
## Shallow Land Disposal Area - Feasibility Study

| General Response Action | Technology | Process Option | Description | Initial Screening Comments* |
|---|---|---|---|---|
| **Disposal** | **Offsite Soil/ Debris** | **RCRA Subtitle C Facility** | **Subtitle C facilities are licensed to accept listed and characteristic hazardous waste in compliance with land disposal regulations.** | **Applicable for disposal of non-radiological soil and debris that are classified as hazardous.** |
| | | **RCRA Subtitle D Facility** | **Subtitle D landfills are licensed to accept non-hazardous waste with some low-levels of radioactivity.** | **Applicable for disposal of non-hazardous soil and debris which may also include very low-levels of radioactive contamination.** |
| | | **Radiological Waste Facility** | **Radioactive waste facilities are licensed to accept hazardous and non-hazardous LLW.** | **Applicable for disposal of many types of radioactive wastes; may also accept non-hazardous and hazardous constituents commingled with radiological waste.** |
| | **Onsite Soil/ Debris** | **Onsite Disposal** | **Use of engineered cell or encapsulation facility that would be constructed onsite.** | **Applicable as a means of controlling the mobility of radionuclides. May also reduce the toxicity and volume when used with various treatment processes.** |
| | **Offsite Residual Water** | **Disposal to Treatment Facility** | **Offsite treatment of contaminated water by a commercial facility or local publicly owned treatment works.** | **Applicable, effective, and readily implementable in districts that have waste water treatment capacity.** |
| | **Onsite Residual Water** | **Onsite Discharge** | **Through testing, confirm that residual water meets surface water criteria, and discharge to surface water stream or groundwater.** | **Applicable, effective, and readily implementable.** |

*Comments based on the following aspects of technical implementability:
1. Effective at removing or treating radionuclides of concern.
2. Interference from co-located elements is not a concern.
3. Site conditions are optimal for technology.
4. Effectiveness has been demonstrated “in the field.”
5. Focuses on remediation of soil and debris.
6. Effective in a reasonable time.

**BOLD = Technology/process option retained for further consideration.**

## TABLE 2-3
## Evaluation of Remedial Technologies and Process Options
## Shallow Land Disposal Area - Feasibility Study

| General Response Action | Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|
| **No Action** | **None** | **None** | Does not reduce toxicity, mobility, or volume of radioactive waste. | Easily Implementable. | Only minimal costs associated with five year and optional monitoring. |
| **Limited Action** | **Institutional Controls** | **Deed Restriction/Zoning** | Can be used in combination with other technologies and process options, not typically a stand alone technology. Process options under the limited action response provide the same level of protection to public health and environment; considered effective in limiting exposure. | Technically implementable as a stand alone option and in combination with other actions. Administrative feasibility is considered difficult due to anticipated problems with obtaining regulatory approval of Limited Action and would be subject to NRC control through the existing license. | Low capital and moderate operation and maintenance cost. |
| | **Monitoring** | **Groundwater Monitoring** | | | |
| | | **Surface Water Monitoring** | | | |
| | | **Radiation Exposure Monitoring** | | | |
| | **Access Restrictions** | **Fencing/Barriers** | | | |
| **Containment** | **Surface or Sub-Surface Controls** | **Grading/Grouting** | Effective in directing surface water flow to reduce infiltration and erosion. | Easily implementable. | Low capital and operation and maintenance cost. |
| | **Capping** | **Single or Multiple Layer Cap** | Effective in reducing contaminant exposure levels, eliminating direct radiation, inhalation, and dermal exposure, and inhibiting migration of contaminants. | Implementable, but faces difficult administrative challenges due to leaving contamination in place complicating future land use. Would be subject to NRC control through the existing license. | Low capital and operation and maintenance cost. |
| | **Vertical Barriers** | **Slurry Wall/Grout Curtain** | Effective in minimizing groundwater flow into or impacted groundwater from contaminated areas. | Implementable, but the long-term performance of these barriers is difficult to assess. | Moderate capital and low operation and maintenance costs. |
| | **Mine Stabilization** | **Mine Grouting** | Effective in reducing the potential for mine subsidence and the subsequent migration of radionuclides from contaminated areas. | Implementable, but the long-term performance of these barriers is difficult to assess. | Moderate capital and low operation and maintenance costs. |
| **Removal** | **Excavation** | **Conventional Soil Excavation** | Effective in removing radionuclides of concern thus reducing concentrations and exposure levels to public and environment. | Implementable but use of dust suppression and residual water control techniques would be necessary. | Moderate capital and moderate operation and maintenance cost. |

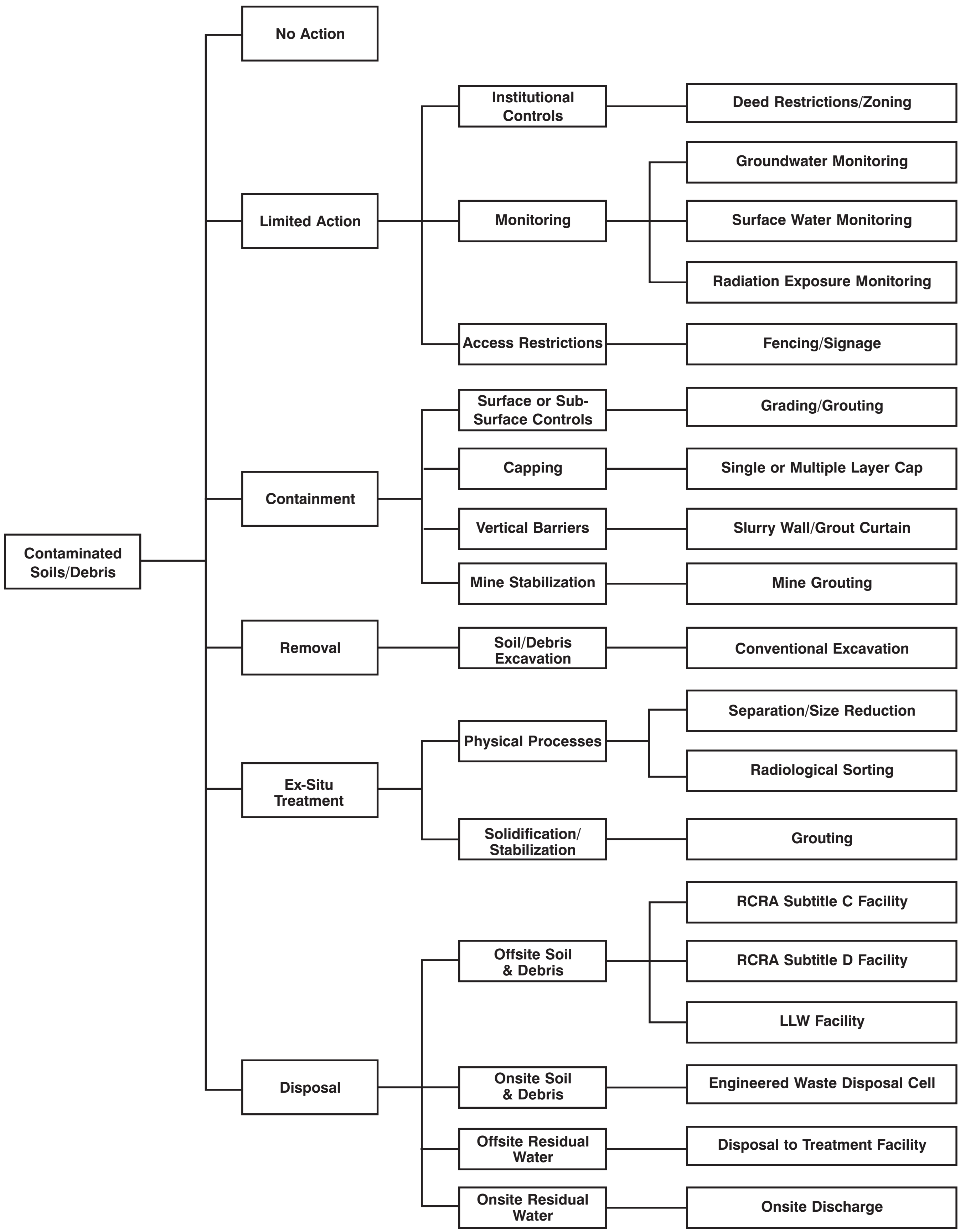
**BOLD** = Technology/process option retained for alternative development.

# TABLE 2-3 (continued)
## Evaluation of Remedial Technologies and Process Options
## Shallow Land Disposal Area - Feasibility Study

| General Response Action | Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|
| **Ex Situ Treatment** | **Physical Processes** | **Separation/Size Reduction** | **Sieving and physical separation are effective in reducing volume or waste to be disposed.** | **Easily Implementable.** | **Low capital and moderate operation and maintenance cost.** |
| | | **Radiological Sorting** | **Radiological Sorting can be effective in reducing the volume of waste to be disposed.** | **Implementable but would likely increase the time to achieve site remediation.** | **Although the equipment is typically rented for a high cost and has a moderate operation and maintenance cost, there would be a significant savings in disposal cost.** |
| | **Solidification/ Stabilization** | **Grouting** | **Effective in immobilizing radionuclides.** | **Implementable but regulatory approval could be difficult as it could be viewed as an unnecessary step. Also increases disposal volume.** | **Moderate capital and operation and maintenance cost.** |
| | | Polyethylene Encapsulation | Effective in immobilizing radionuclides. | Implementable but regulatory approval could be tough as it could be viewed as an unnecessary step. Increased complexity and disposal volume. | Moderate capital and operation and maintenance cost. |
| | | Vitrification | Effective in immobilizing radionuclides. | Implementable but regulatory approval could be tough as it could be viewed as an unnecessary step. Increased complexity and disposal volume. | Moderate capital and operation and maintenance cost. |
| **Disposal** | **Offsite Soil/Debris** | **RCRA Subtitle C Facility**<br>**RCRA Subtitle D Facility**<br>**Radiological Waste Facility** | **Effective in removing contamination from site, but requires transportation of radionuclides off-site.** | **Implementable but faces difficult administrative challenges related to off-site transportation through nearby communities.** | **High capital and low operation and maintenance cost.** |
| | **Disposal On-Site** | **Disposal in Engineered Waste Cell** | **Effective in reducing containment exposure levels, eliminating direct radiation, inhalation, and dermal exposure, and inhibiting migration of contaminants.** | **Implementable but faces difficult administrative challenges resulting from constructing a waste disposal cell complicating future land use.** | **High capital and moderate operation and maintenance costs.** |
| | **Offsite Residual Water** | **Disposal to Treatment Facility** | **Effective in removing contaminated residual water from site. Requires treatment and transportation.** | **Readily implementable.** | **Low capital and low operation and maintenance cost.** |
| | **Offsite Residual Water** | **Onsite Discharge** | **Effective in removing "clean" waters from the site.** | **Implementable but many requirements exist from regulatory control.** | **Low capital and operation and maintenance cost.** |

**BOLD = Technology/process option retained for alternative development.**

**TABLE 2-4**
**Remedial Technologies/Process Options Retained for Alternative Development**
**Shallow Land Disposal Area - Feasibility Study**



## TABLE 3-1

## SUMMARY OF PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES
## SHALLOW LAND DISPOSAL AREA – FEASIBILITY STUDY

| Remedial Action Alternative | Effectiveness | Implementability | Cost | Retained for Detailed Analysis in Section 4 |
|---|---|---|---|---|
| Alternative 1 – No Action | Not protective of human health and the environment; does not meet unrestricted or restricted use criteria | Technically and administratively feasible; availability of equipment and services is not applicable | Low | Yes, as required by the NCP |
| Alternative 2 – Limited Action | Protects human health and partially protects the environment; does not meet unrestricted use criteria and may meet restricted use criteria | Technically implementable, although administrative feasibility could be difficult | High | No |
| Alternative 3 – Containment | Protects human health and partially protects the environment; will meet restricted use criteria | Technically implementable, although administrative feasibility could be difficult | Very high | No |
| Alternative 4 – Excavation, Treatment, and On-Site Disposal | Protects human health and the environment; will meet restricted use criteria | Technically implementable, although administrative feasibility could be difficult | Very high | Yes |
| Alternative 5 – Excavation, Treatment, and Off-Site Disposal | Meets remedial action objectives (restricted and unrestricted use criteria) | Excavation, treatment, and off-site disposal is fully implementable | Very high | Yes |

**TABLE 4-1**

**ESTIMATED VOLUMES - SUBSURFACE SOIL/DEBRIS REMEDIATION**
**SHALLOW LAND DISPOSAL AREA - FEASIBILITY STUDY**

| Trench Number | Average Depth to Bedrock (ft bgs) | Trench Surface Area ($ft^2$) | Trench Volume ($ft^3$) | Trench and Impacted Soils Surface Area[1] ($ft^2$) | Trench and Impacted Soils Volume[2] ($ft^3$) | Volume of Cover Soils[3] ($ft^3$) | Excavation Cutback Distance[4] (ft) | Volume of Cutbacks[5] ($ft^3$) |
|---|---|---|---|---|---|---|---|---|
| **1** | 12 | 10,000 | 100,000 | 30,000 | 300,000 | 60,000 | 18 | 350,000 |
| **2** | 14 | 7,800 | 94,000 | included in Trench 1 area | included in Trench 1 volume | included in Trench 1 volume | 21 | included in Trench 1 volume |
| **3** | 11 | 790 | 6,900 | 4,700 | 41,000 | 9,400 | 16 | included in Trench 1 volume |
| **4** | 15 | 2,000 | 26,000 | 25,000 | 320,000 | 50,000 | 22 | included in Trench 1 volume |
| **5** | 14 | 3,500 | 43,000 | included in Trench 4 area | included in Trench 4 volume | included in Trench 4 volume | 22 | included in Trench 1 volume |
| **6** | 16 | 5,400 | 73,000 | included in Trench 4 area | included in Trench 4 volume | included in Trench 4 volume | 23 | included in Trench 1 volume |
| **7** | 15 | 4,400 | 56,000 | included in Trench 4 area | included in Trench 4 volume | included in Trench 4 volume | 22 | included in Trench 1 volume |
| **8** | 15 | 1,300 | 17,000 | 1,300 | 17,000 | 2,600 | 23 | included in Trench 1 volume |
| **9** | 14 | 2,700 | 32,000 | included in Trench 3 area | included in Trench 3 volume | included in Trench 3 volume | 21 | included in Trench 1 volume |
| **10** | 21 | 12,000 | 230,000 | 14,000 | 270,000 | 28,000 | 43 | 280,000 |
| **Total Volume ($ft^3$)** | -- | -- | 680,000 | -- | 950,000 | 150,000 | -- | 630,000 |
| **Total Volume ($yd^3$)** | -- | -- | 25,000 | -- | 35,000 | 5,600 | -- | 23,000 |
| **Total Volume ($yd^3$) with 20% over-excavation factor** | -- | -- | 30,000 | -- | 42,000 | 6,700 | -- | 28,000 |
| **Total Volume ($yd^3$) with 30% bulking factor** | -- | -- | 39,000 | -- | 55,000 | 8,700 | -- | 36,000 |

1 - Trench and impacted soils surface areas were based on both the trench surface area PLUS the impacted areas outside the disposal trenches identified from the RI.
2 - Trench and impacted soils volumes do NOT include the top two feet of cover soil.
3 - Cover soil volumes include the soils that lie above the trench and impacted soil areas ONLY, and therefore, do not include cutbacks.
4 - Excavation cutback distances were based on the average depth to bedrock and 1:1.5 side slopes for Trenches 1 - 9 and 1:2 side slope for Trench 10.
5 - Cutback volume for Trenches 1 - 9 was based on an *average* depth to bedrock, an *average* excavation cut-back distance, and a linear length of 2,400 feet. The cutback volume for Trench 10 was based on a linear length of 610 feet

## TABLE 4-2

## COMPARISON OF KEY ASPECTS OF REMEDIAL ALTERNATIVES 4 AND 5

## SHALLOW LAND DISPOSAL AREA – FEASIBILITY STUDY

| Item | Alternative No. 4<br>Excavation, Treatment, and On-Site Disposal | Alternative 5<br>Excavation, Treatment, and Off-Site Disposal |
|---|---|---|
| Soil/Debris Processing Rate | 160 Cubic Yards/Day | 96 Cubic Yards/Day |
| Relative Risk to Remediation Workers | Low/Moderate | Low/Moderate |
| Duration to Construct Infrastructure Improvements | 6 Months | 6 Months |
| Duration for Site Remediation and Demobilization | 23 Months | 26 Months |
| Total Project Duration | 29 Months | 32 Months |
| Remediation Cost | $20.2 Million | $35.5 Million |

**TABLE 4-3**
**Detailed Evaluation of Remedial Alternatives**
**Shallow Land Disposal Area – Feasibility Study**

| Criteria | Alternative 1 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| | **No Action** | **Excavation, Treatment, and On-site Disposal** | **Excavation, Treatment, and Off-site Disposal** |
| **Overall Protection of Human Health and the Environment** | Not considered protective of human health and the environment because it does nothing to reduce exposure to radionuclides. | Meets the remedial objectives for protection of human health and the environment. | Meets the remedial objectives for protection of human health and the environment. |
| **Compliance with ARARs** | This alternative would not satisfy the ARARs established for the site. | Satisfies the ARARs established for the site. | Satisfies the ARARs established for the site. |
| **Long-term Effectiveness and Permanence** | This alternative does not provide long-term effectiveness and permanence and current and potential future risks and doses would remain. | Provides long-term effectiveness and permanence by placing contaminated soil and debris materials into an on-site disposal cell. | Provides long-term effectiveness and permanence by removing contaminated soil and debris materials from the SLDA site. |
| **Reduction of Toxicity, Mobility, and/or Volume through Treatment** | Under this alternative there would be no reduction in the toxicity, mobility, or volume of ROCs. | This alternative reduces the volume of contaminated media and to a much lesser extent the mobility of contaminants through treatment. There is no reduction of the toxicity of contaminants. | The volume of contaminated material requiring disposal would be reduced through on-site physical treatment. The mobility and toxicity of contaminants are not reduced through treatment. |
| **Short-term Effectiveness** | There would be no short-term hazards to site workers and the community since no remedial actions would be implemented. | Low to moderate risk to remedial workers during implementation due to intrusive and disposal activities. The risk would be mitigated through a health and safety plan. | Low to moderate risk to remedial workers and community during implementation. The risk would be mitigated through a health and safety plan. |
| **Implementability** | This alternative is readily implementable in terms of administrative and technical feasibility since no remedial actions would be undertaken. | There are no technical implementability issues; services and materials are readily available. Administrative feasibility could be problematic. | There are no technical or implementability issues; services and materials are readily available. |
| **Cost** | $0 | $20.2 Million | $35.5 Million |
| **Volume of contaminated soil and waste material remediated** | 0 $yd^3$ | 24,300 bank $yd^3$ | 24,300 bank $yd^3$ |
| **State Acceptance** | To be evaluated following regulatory review of the FS and proposed plan. | To be evaluated following regulatory review of the FS and proposed plan. | To be evaluated following regulatory review of the FS and proposed plan. |
| **Community Acceptance** | To be evaluated following review of the FS and proposed plan. | To be evaluated following review of the FS and proposed plan. | To be evaluated following review of the FS and proposed plan. |

## TABLE 4-4

## SUMMARY OF ESTIMATED PRESENT WORTH COSTS FOR REMEDIAL ALTERNATIVES
## SHALLOW LAND DISPOSAL AREA - FEASIBILITY STUDY

| Activity | Alternative 1<br>No Action | Alternative 4<br>Excavation, Treatment, and On-Site Disposal | Alternative 5<br>Excavation, Treatment, and Off-Site Disposal |
|---|---|---|---|
| Site Preparation | N/A | $660,805 | $540,515 |
| Site Supervision and Support Facilities | N/A | $2,540,184 | $1,720,295 |
| Remediation Activities | N/A | $9,497,686 | $12,963,098 |
| Environmental Sampling and Analysis | N/A | $1,193,451 | $1,541,515 |
| Disposal Cell Construction | N/A | $3,414,388 | N/A |
| Operation and Maintenance | N/A | $1,042,600 | N/A |
| Waste Transportation and Disposal | N/A | N/A | $14,880,200 |
| **Alternative Subtotal** | **$0** | **$18,349,114** | **$31,645,623** |
| Contingency - 10% | $0 | $1,834,911 | $3,164,562 |
| **Alternative Total** | **$0** | **$20,184,025** | **$34,810,185** |

N/A -- Not Applicable.

## TABLE 4-5

## COMPARATIVE EVALUATION OF REMEDIAL ALTERNATIVES

## SHALLOW LAND DISPOSAL AREA – FEASIBILITY STUDY

| Alternative | Overall Protection of Human Health and the Environment | Compliance with ARARs | Long-Term Effectiveness and Permanence | Short-Term Effectiveness | Reduction of Toxicity, Mobility, or Volume through Treatment | Implementability | Cost (millions) |
|---|---|---|---|---|---|---|---|
| Alternative 1<br>No Action | Low | Low | Low | High[1] | Low | High | $0 |
| Alternative 4<br>Excavation, Treatment, and On-site Disposal | Medium/High | High | Medium/High | Medium | Low/Medium | Low | $20.2 |
| Alternative 5<br>Excavation, Treatment, and Off-site Disposal | High | High | High | Low/Medium | Low/Medium | Medium | $35.5 |

**Notes:**

1 Not effective in achieving RAOs; however, no "increased" impact to workers or community

High - most favorable ranking

Medium - average favorable ranking

Low - least favorable ranking

# FIGURES

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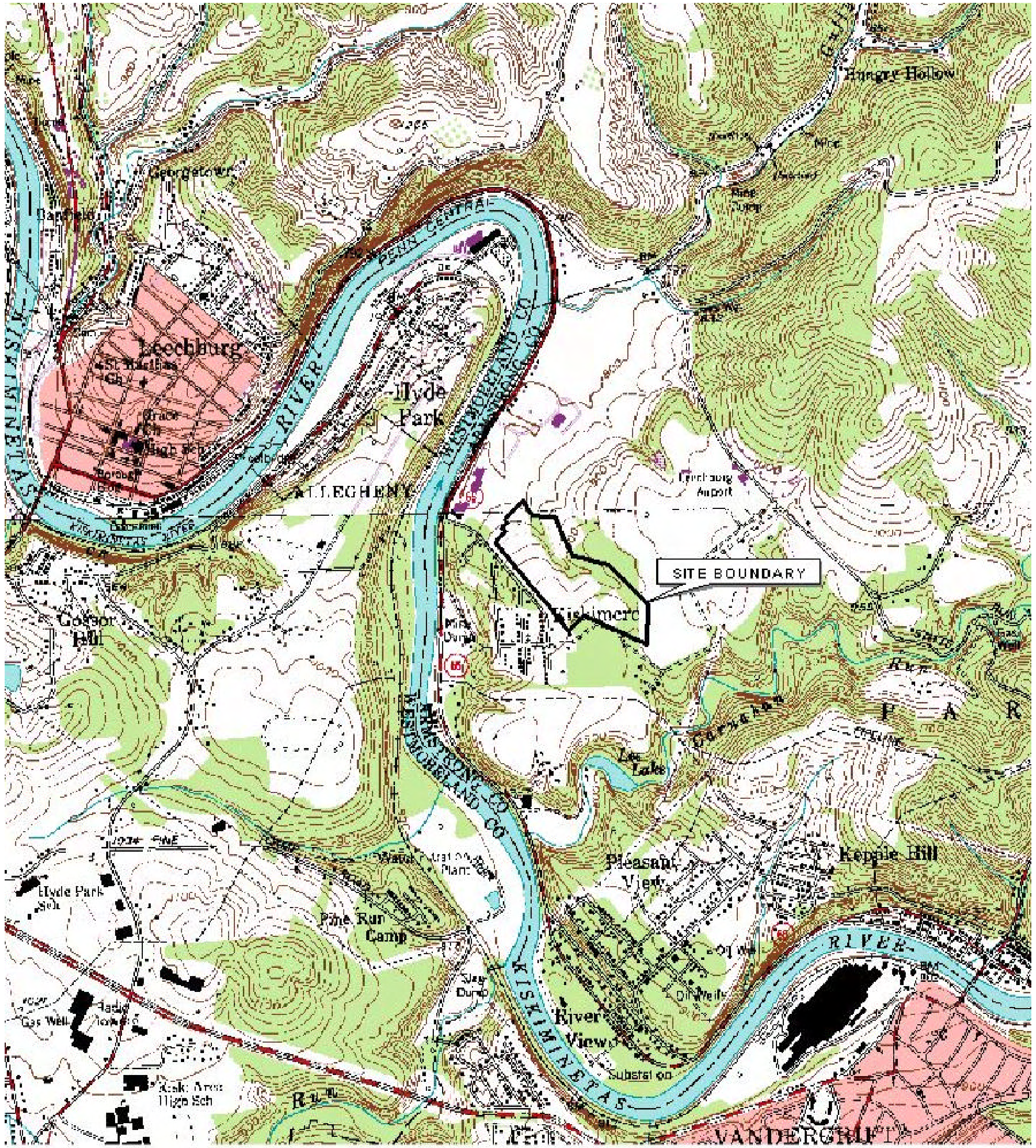
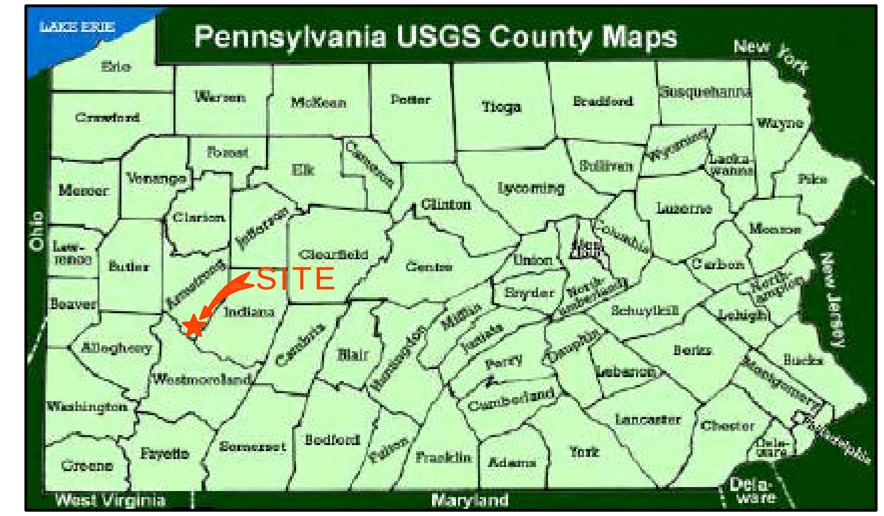
N




Source: USGS 7.5' Topographic Quadrangles
Vandergrift, PA, 1953 (revised 1979)
Leechburg, PA, 1954 (revised 1969)

2000 0 2000 Feet

SITE LOCATION MAP




STATE KEY MAP


SITE ADDRESS:
1105 MARY STREET
VANDERGRIFT, PA 15690

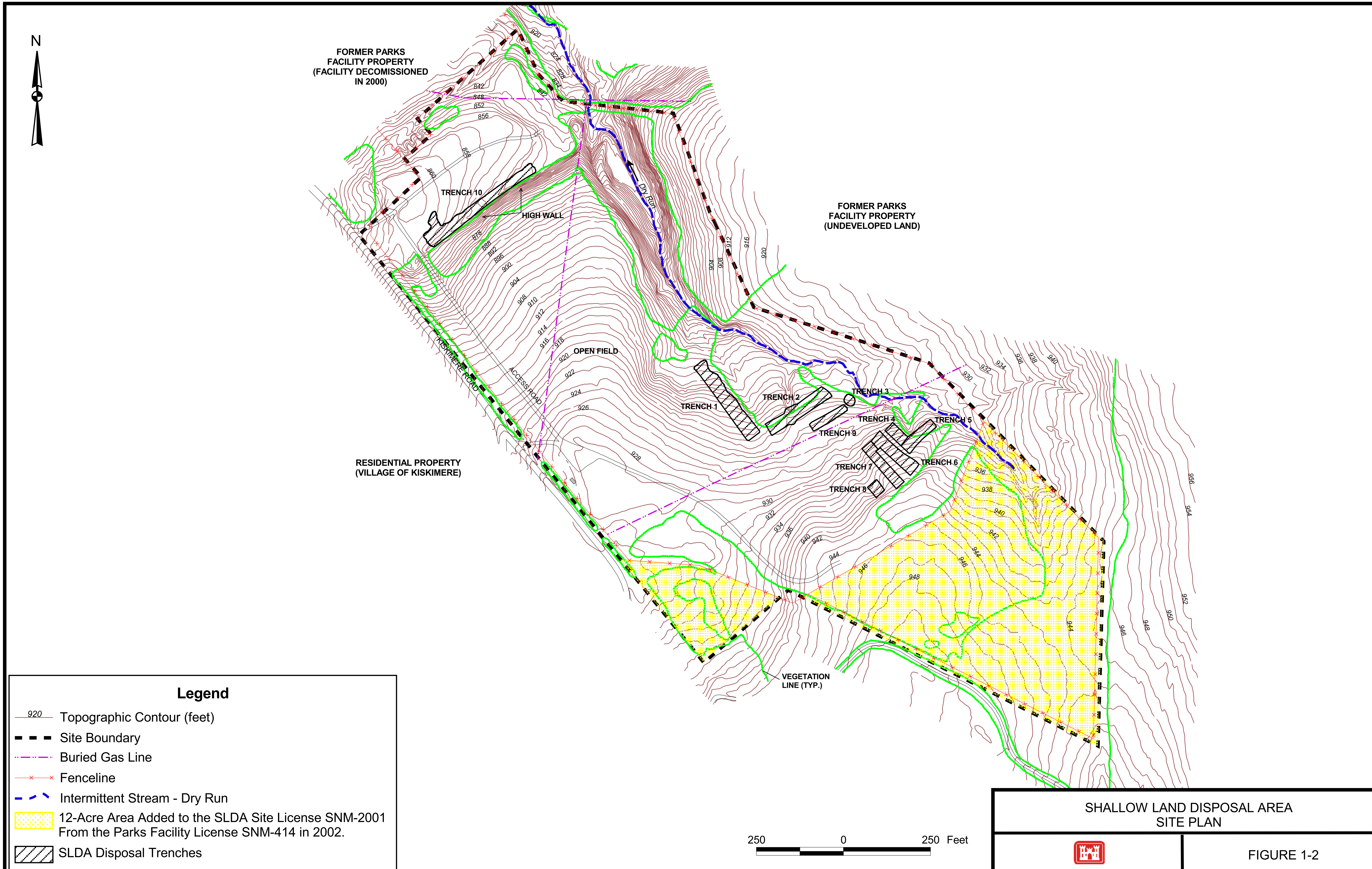
VICINITY MAP

SHALLOW LAND DISPOSAL AREA
SITE LOCATION MAP

URS

FIGURE 1–1

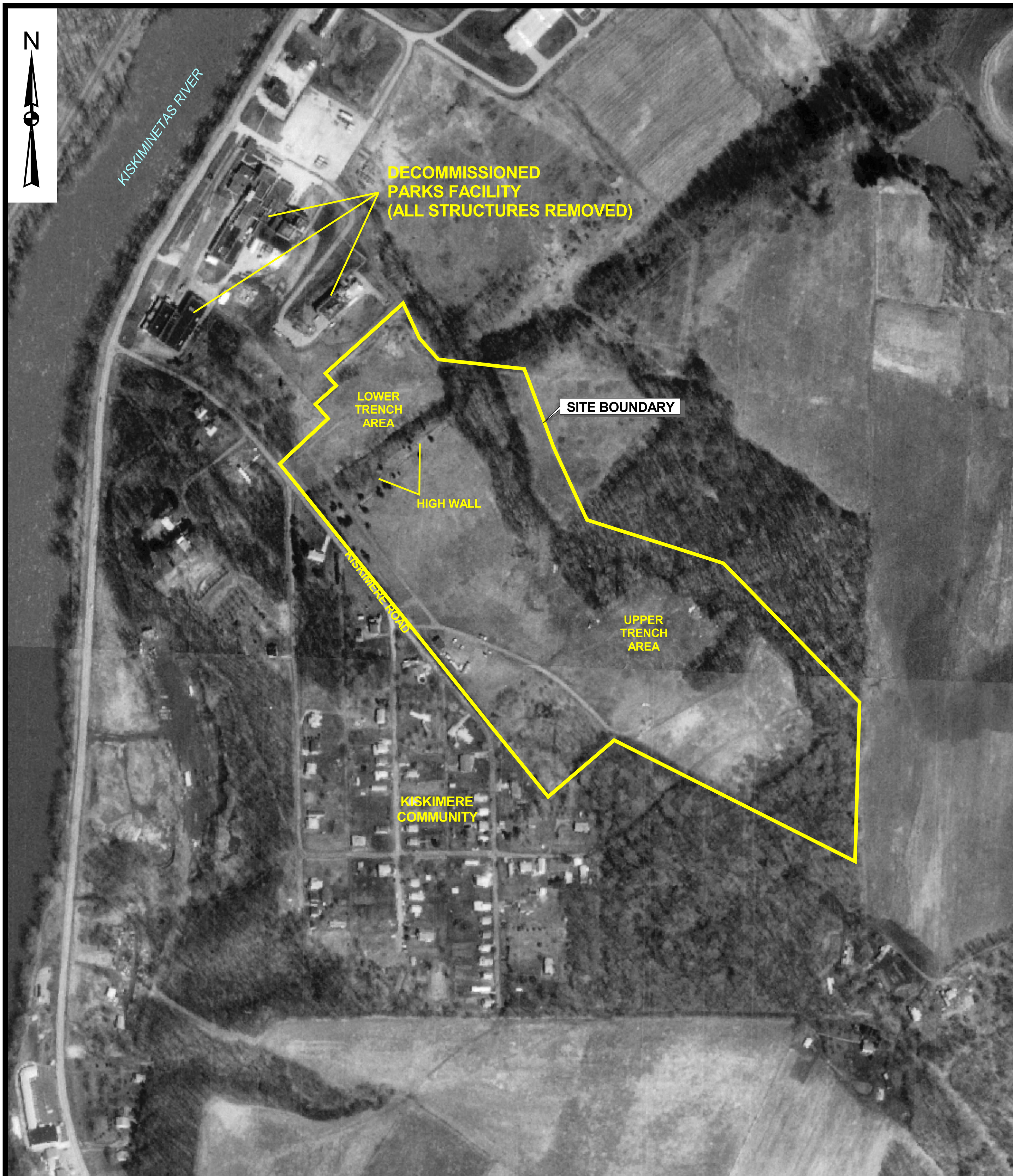
FIGURE 1–1.dwg




SHALLOW LAND DISPOSAL AREA
SITE PLAN

FIGURE 1-2

N:\11171431.00000\GIS\ArcView\geology.apr SITE PLAN
10/13/2004

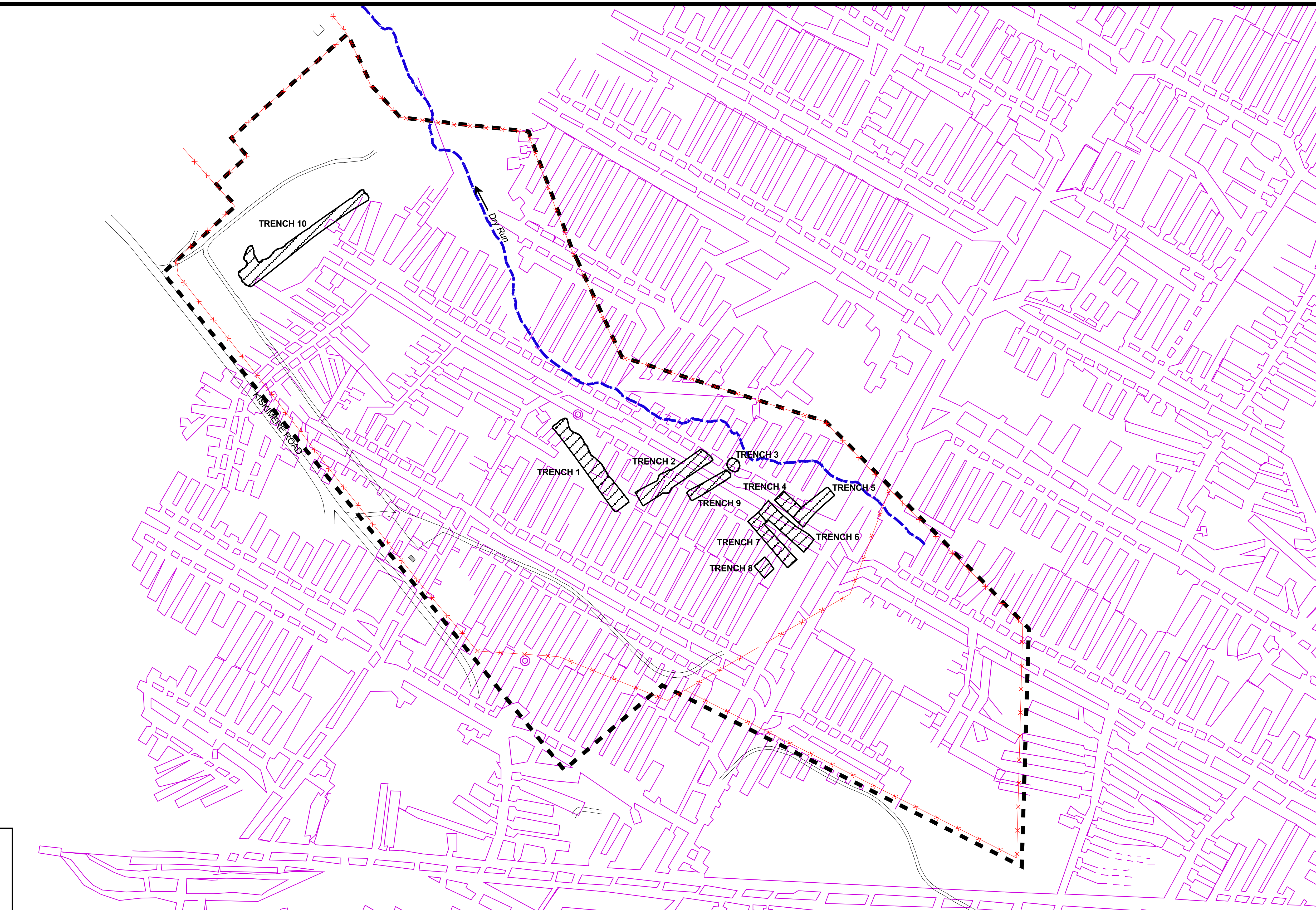



SOURCE: Leechburg and Vandergrift, PA
Digital Orthophotos, 1993.

500 0 500 Feet

| | | |
|---|---|---|
| | SHALLOW LAND DISPOSAL AREA<br>DIGITAL ORTHOPHOTOGRAPH | FIGURE 1-3 |

N:\11171431.00000\GIS\ArcView\sitelocation.apr DIGITAL ORTHOPHOTO
10/13/2004




**Legend**

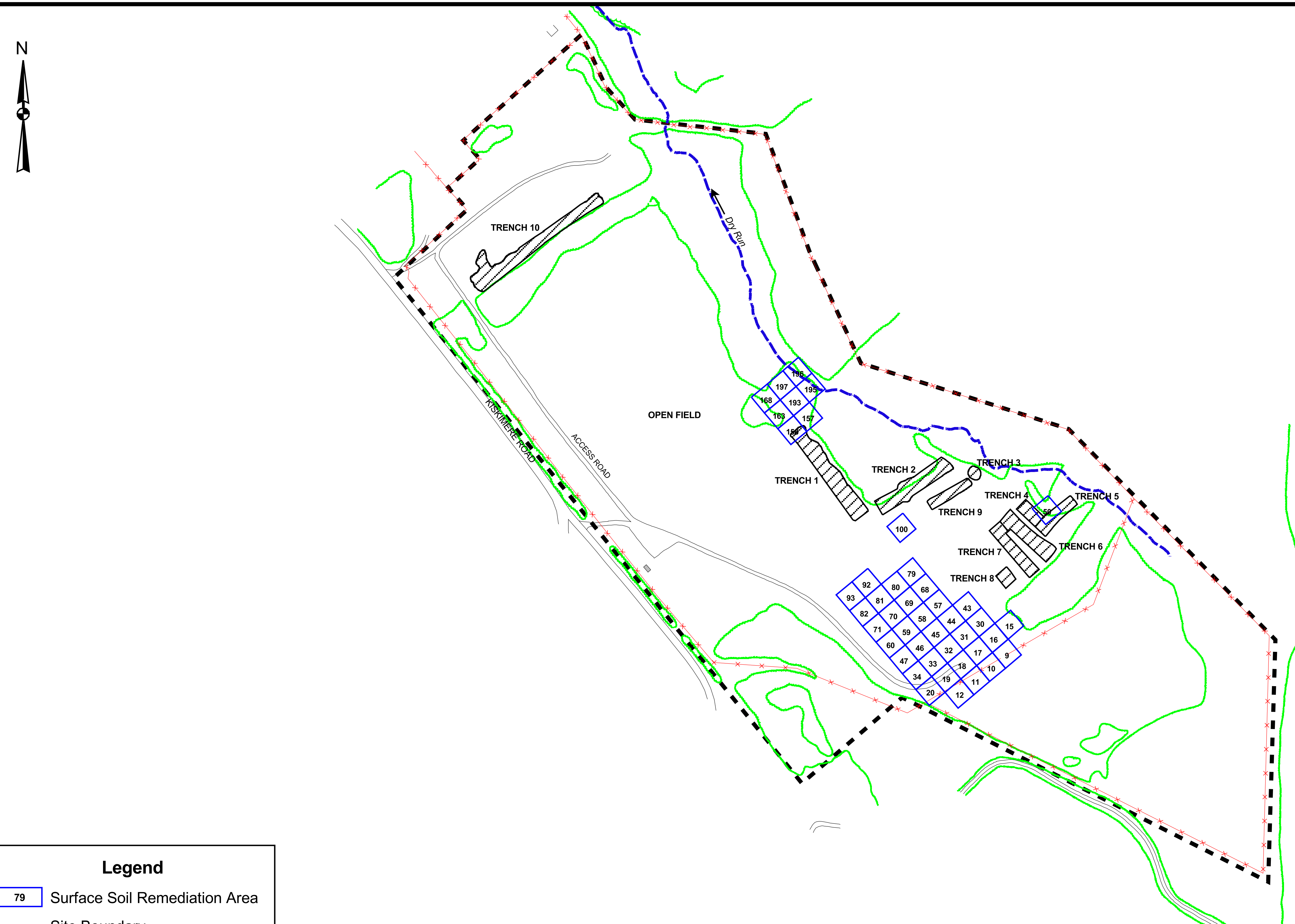
- Deep Mine Workings
- Site Boundary
- Fenceline
- Intermittent Stream - Dry Run
- SLDA Disposal Trenches

NOTE: Mine Workings Map Provided by ARCO.

SHALLOW LAND DISPOSAL AREA
DEEP MINE WORKINGS BENEATH SLDA

FIGURE 1-4

N:\11171431.00000\GIS\ArcView\geology.apr MINEWORKINGS BENEATH SLDA SITE
10/13/2004




**Legend**

- 79 Surface Soil Remediation Area
- Site Boundary
- Fenceline
- Intermittent Stream - Dry Run
- SLDA Disposal Trenches

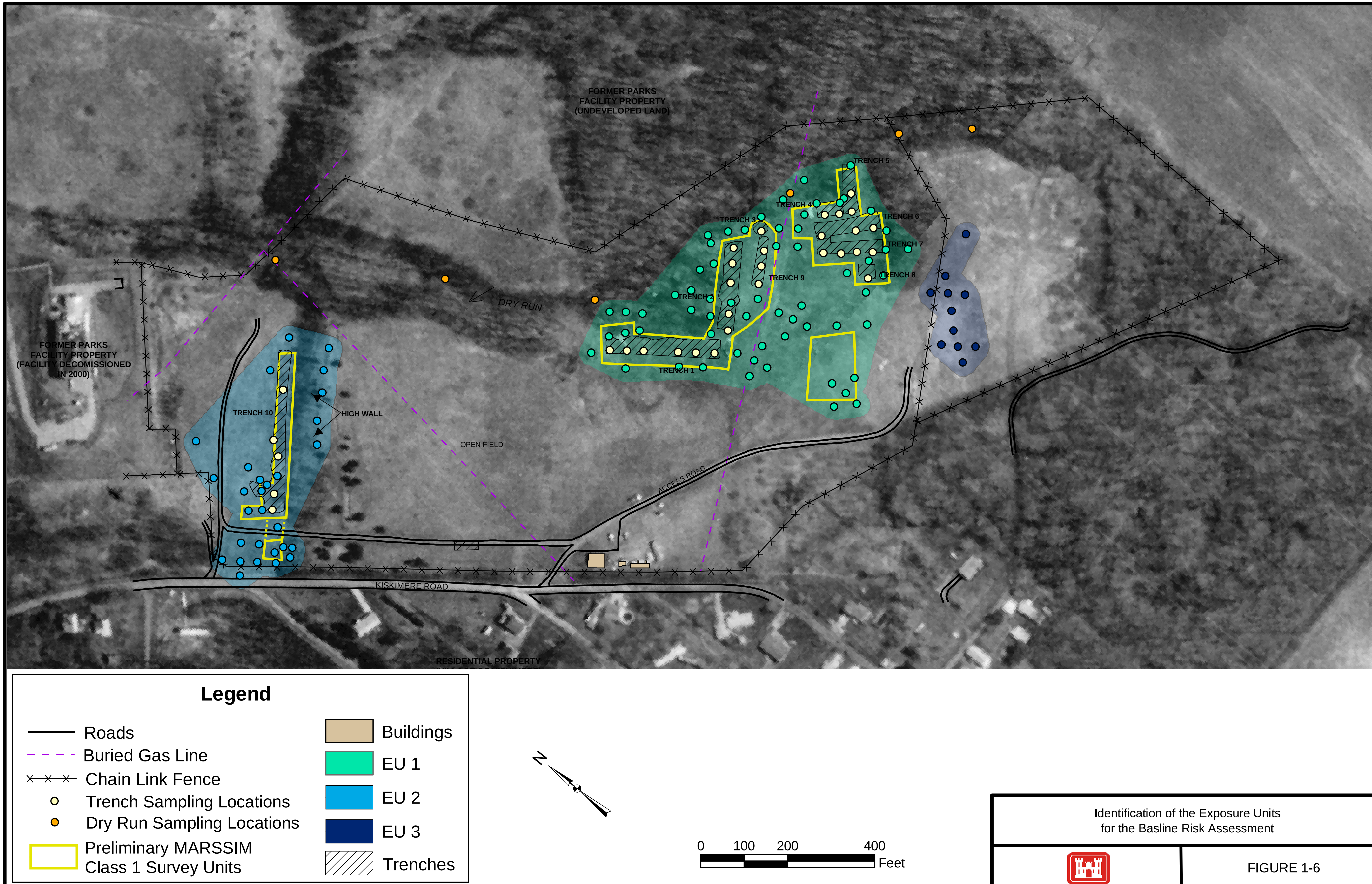
NOTE: Soil Remediation Areas were Located in Accordance with ORAU 1987, 1990.

250 0 250 Feet

SHALLOW LAND DISPOSAL AREA
LIMITS OF SURFACE SOIL REMEDIATION
COMPLETED BY B&W IN 1986 AND 1989

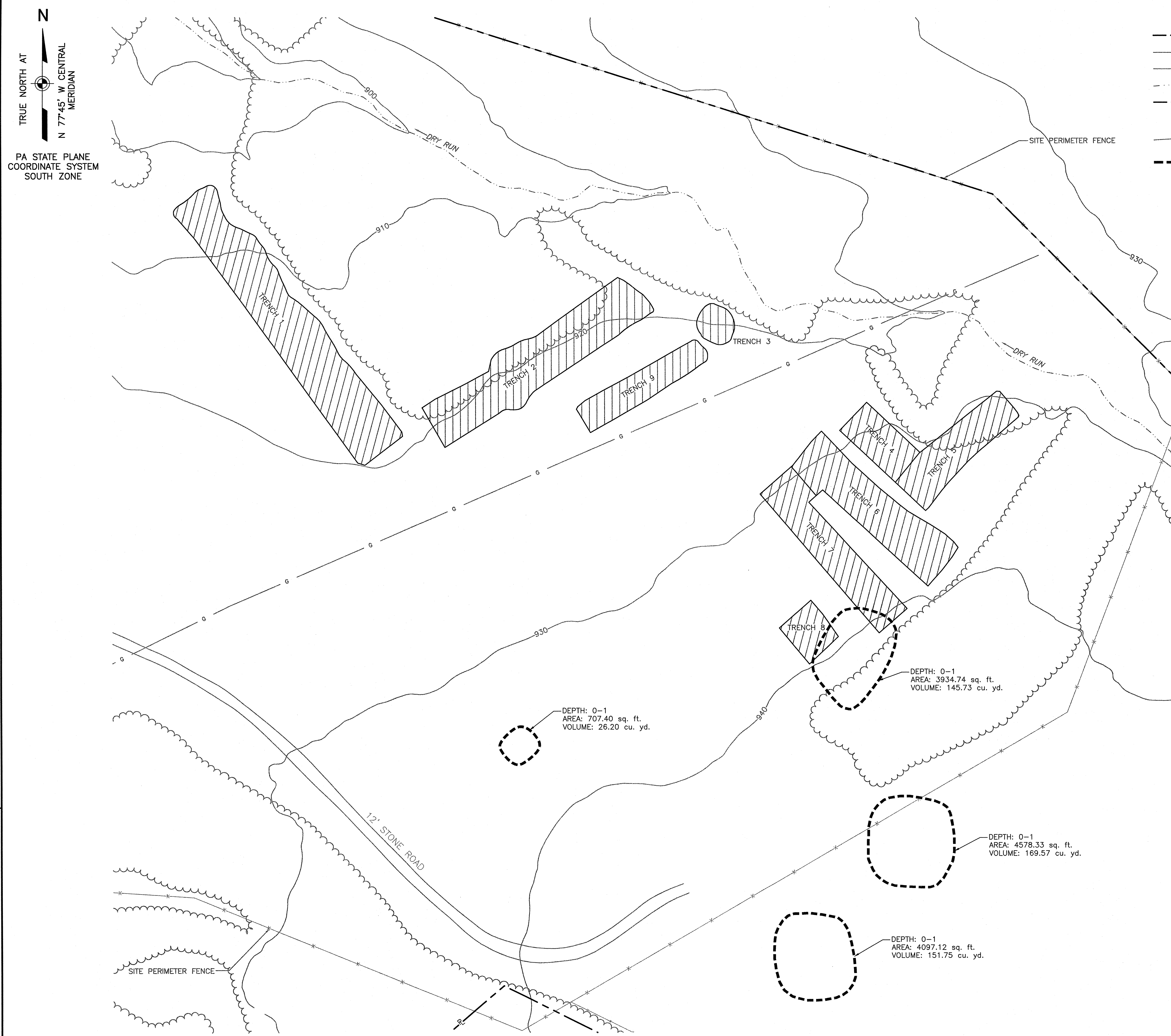
FIGURE 1-5

N:\11171431.00000\GIS\ArcView\geology.apr LIMITS OF SURFACE SOIL REMEDIATION
10/13/2004




Identification of the Exposure Units for the Basline Risk Assessment

FIGURE 1-6




## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- LIMIT OF REMEDIAL SURFACE SOIL EXCAVATION
- TRENCH 9 — APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY

**NOTE:**

1. THE VERTICAL EXTENT OF SURFACE SOIL REMEDIATION WILL BE FROM GROUND SURFACE TO ONE FOOT BELOW GROUND SURFACE.
2. A TOTAL OF 493 CUBIC YARDS OF SURFACE SOILS HAVE BEEN DESIGNATED FOR REMEDIATION.

DRAFT

40' 0 40'
SCALE: 1"= 40'

US Army Corps of Engineers
Pittsburgh District

| Mark | Description | Date | Appr. |
|---|---|---|---|

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1000 LIBERTY AVE., PITTSBURGH, PA 15222

U.S. ARMY CORPS. OF ENGINEERS
BUFFALO DISTRICT
1176 NIAGARA ST., BUFFALO, NY 14207

Designed by: KJS
Dwn by: RAL
Ckd by: TAF
Reviewed by: DDH
Submitted by:
Chief, Arch. Branch
Date: MAY 2005
Rev.
Design file no. 11173327.00000
Drawing code:
File name: FIGURE 4–2
Plot date: 5/23/05
Plot scale: 1=1

SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

UPPER TRENCH AREA
SURFACE SOILS
REQUIRING REMEDIATION

Sheet reference number:
4–1
Sheet 1 of 9

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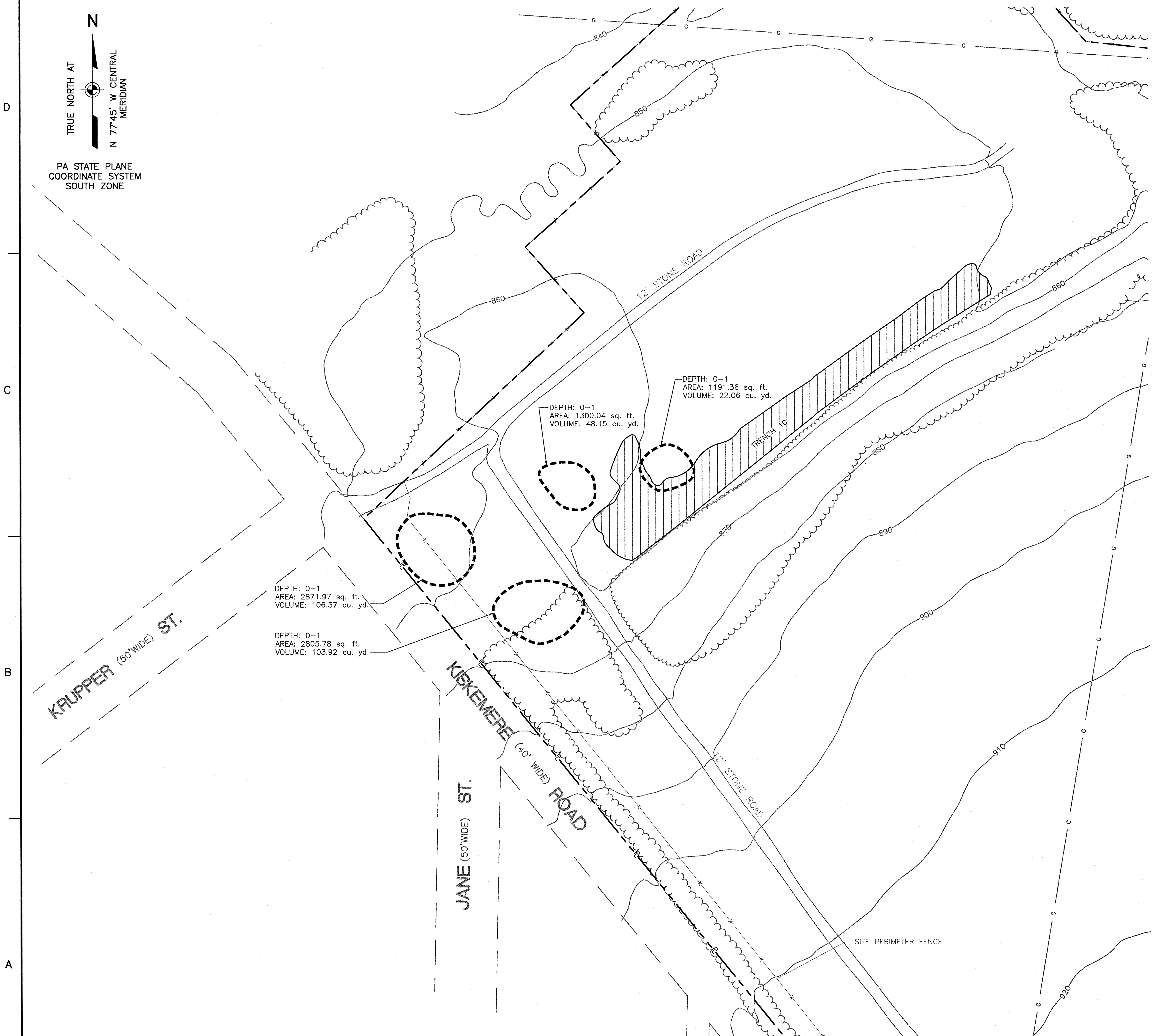


## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- LIMIT OF REMEDIAL SURFACE SOIL EXCAVATION
- TRENCH 9 — APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY

NOTE:

1. THE VERTICAL EXTENT OF SURFACE SOIL REMEDIATION WILL BE FROM GROUND SURFACE TO ONE FOOT BELOW GROUND SURFACE.
2. A TOTAL OF 303 CUBIC YARDS OF SURFACE SOILS HAVE BEEN DESIGNATED FOR REMEDIATION.

DRAFT

SCALE: 1"= 40'

US Army Corps of Engineers
Pittsburgh District

Designed by: KJS
Dwn by: RAL
Ckd by: TAF
Reviewed by: DDH
Submitted by: Chief, Arch. Branch
Date: MAY 2005
Design file no. 11173327.00000
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File name: FIGURE 4-3
Plot date: 5/23/05
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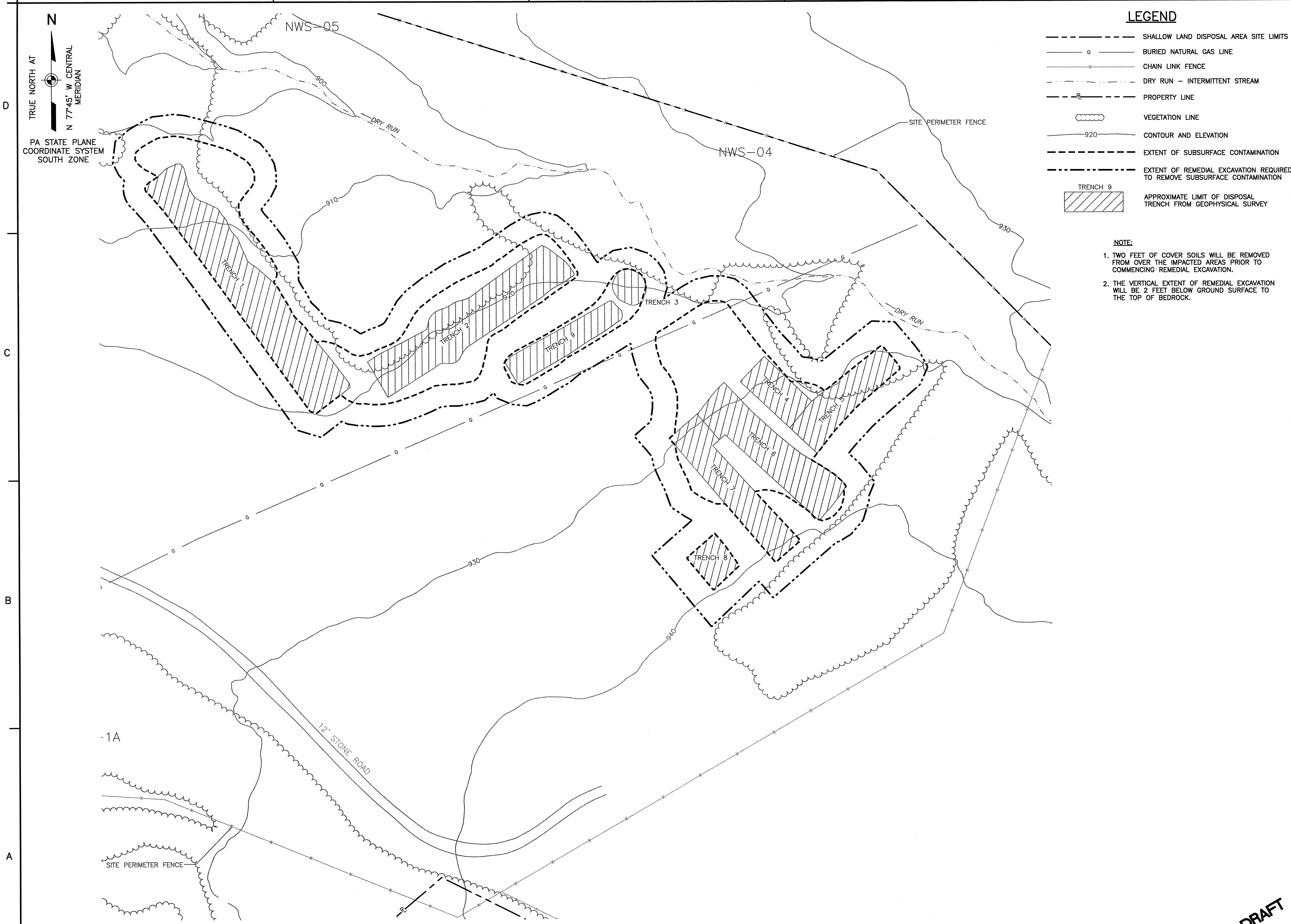
SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

LOWER TRENCH AREA
SURFACE SOILS
REQUIRING REMEDIATION

Sheet reference number: 4–2
Sheet 2 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-2.dwg 1=1 7/7/05-7 RAL




## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- EXTENT OF SUBSURFACE CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION REQUIRED TO REMOVE SUBSURFACE CONTAMINATION
- TRENCH 9 — APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY

NOTE:

1. TWO FEET OF COVER SOILS WILL BE REMOVED FROM OVER THE IMPACTED AREAS PRIOR TO COMMENCING REMEDIAL EXCAVATION.
2. THE VERTICAL EXTENT OF REMEDIAL EXCAVATION WILL BE 2 FEET BELOW GROUND SURFACE TO THE TOP OF BEDROCK.

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Pittsburgh District

| Mark | Description | Date | Appr. |
|---|---|---|---|
| | | | |

| Mark | Description | Date | Appr. |
|---|---|---|---|
| | | | |

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| Reviewed by: DDH | | Drawing code: | |
| Submitted by: Chief, Arch. Branch | | File name: FIGURE 4-4 Plot date: 5/23/05 Plot scale: 1=1 | |

SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

UPPER TRENCH AREA
SUBSURFACE SOILS/DEBRIS
REQUIRING REMEDIATION

Sheet reference number:
4-3
Sheet 3 of 9

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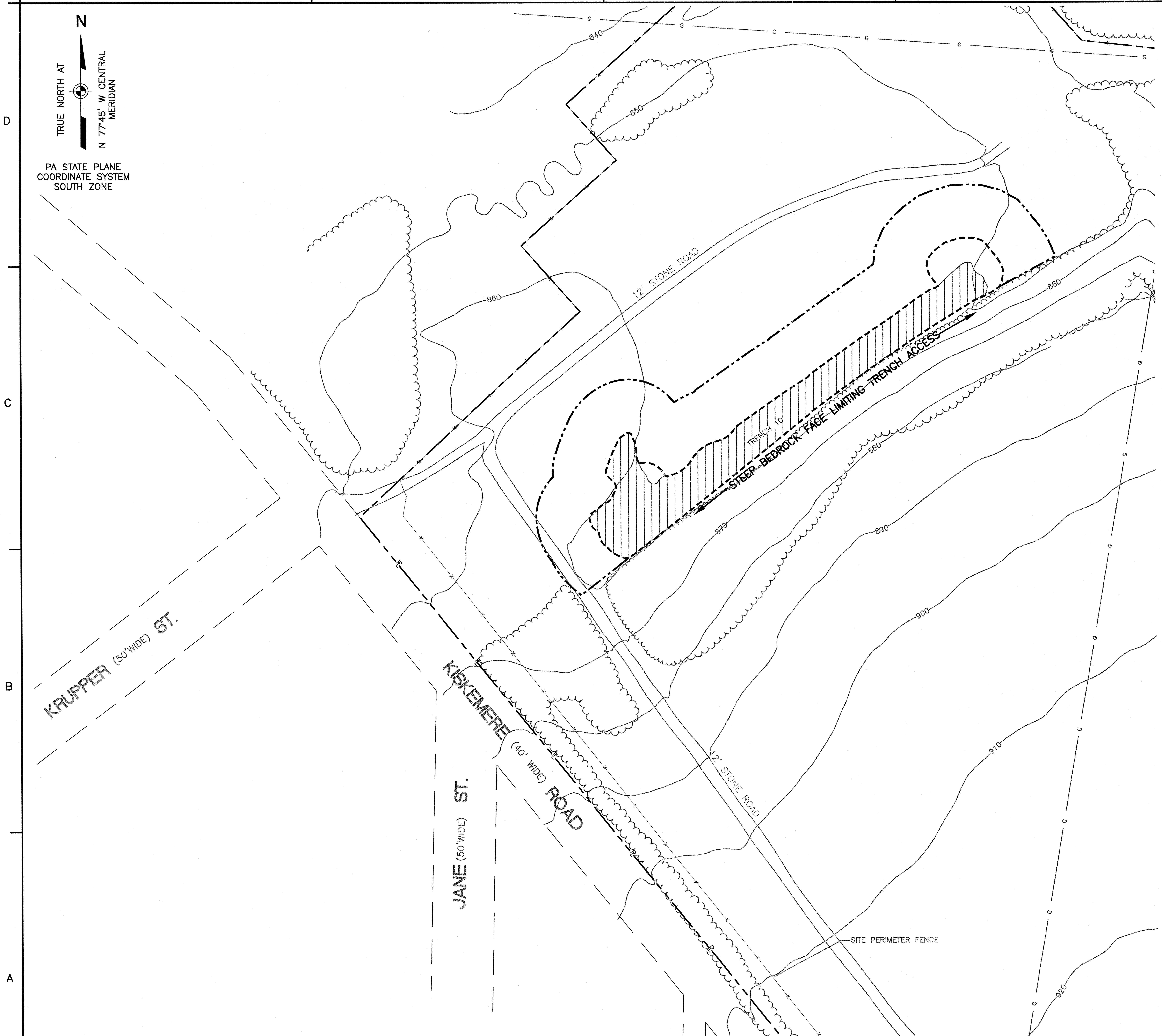


## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- EXTENT OF SUBSURFACE CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION REQUIRED TO REMOVE SUBSURFACE CONTAMINATION
- TRENCH 9 — APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY

**NOTE:**

1. TWO FEET OF COVER SOILS WILL BE REMOVED FROM OVER THE IMPACTED AREAS PRIOR TO COMMENCING REMEDIAL EXCAVATION.
2. THE VERTICAL EXTENT OF REMEDIAL EXCAVATION WILL BE 2 FEET BELOW GROUND SURFACE TO THE TOP OF BEDROCK.

SCALE: 1"= 40'

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|---|---|---|---|

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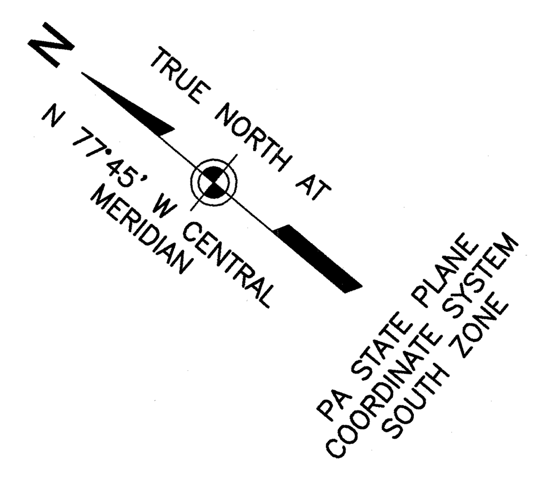
SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

**LOWER TRENCH AREA SUBSURFACE SOILS/DEBRIS REQUIRING REMEDIATION**

Sheet reference number: 4-4
Sheet 4 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-4.dwg 1=1 7/7/05-8 RAL

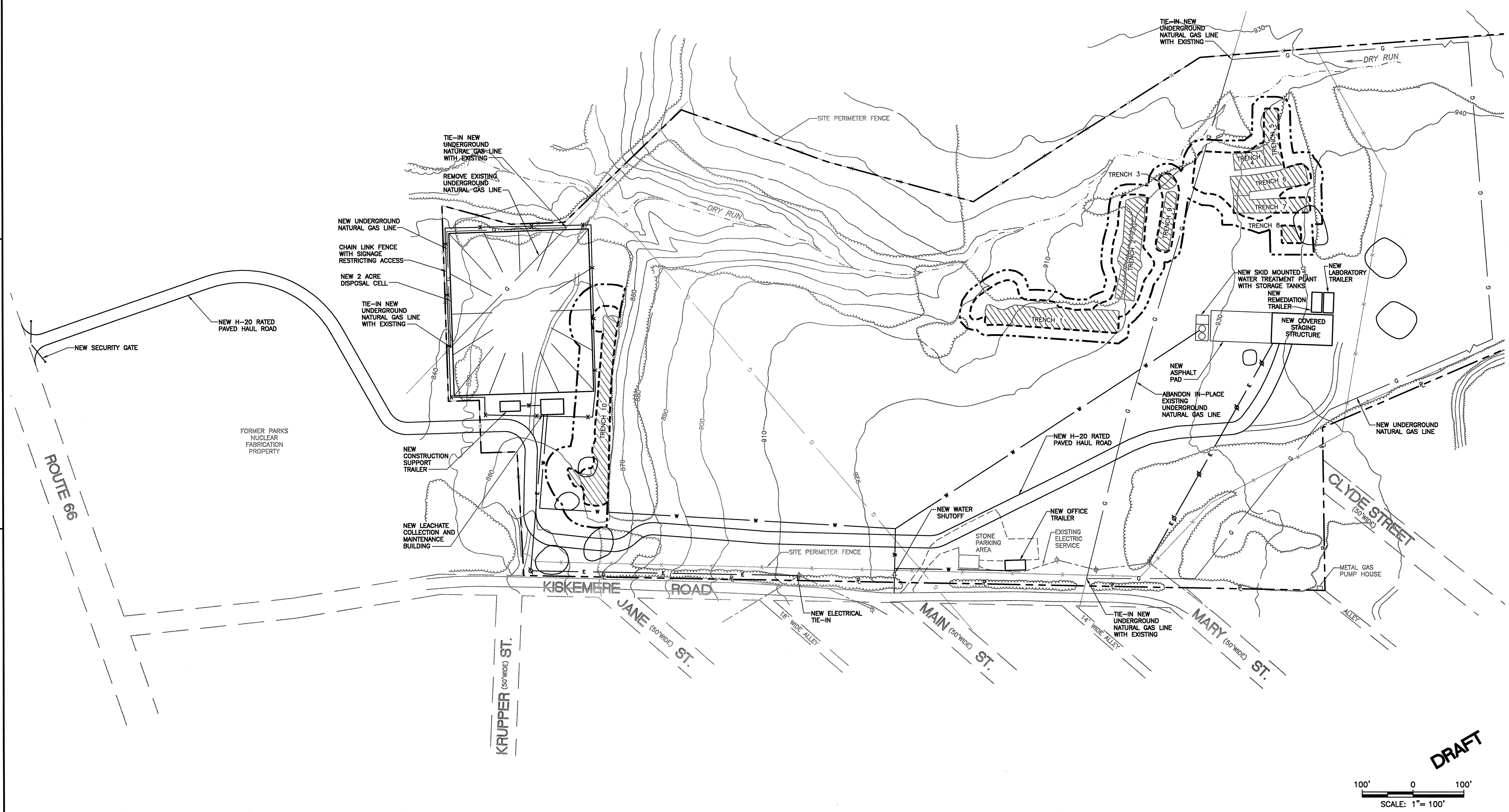



NOTE:

1. LAND BALANCING WILL BE REQUIRED AS NECESSARY TO ENSURE A 7 PERCENT MAXIMUM GRADE.
2. THE EXCLUSION ZONE, CONTAMINANT REDUCTION ZONE, AND SUPPORT ZONE WILL BE DELINEATED DURING FINAL DESIGN.

## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- EXTENT OF CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION
- APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY (TRENCH 9)
- NEW UNDERGROUND WATER SERVICE
- NEW OVERHEAD POWERLINE
- NEW UTILITY POLE
- LIMIT OF SURFACE SOIL REMEDIATION

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U.S. ARMY CORPS. OF ENGINEERS
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1176 NIAGARA ST., BUFFALO, NY 14207

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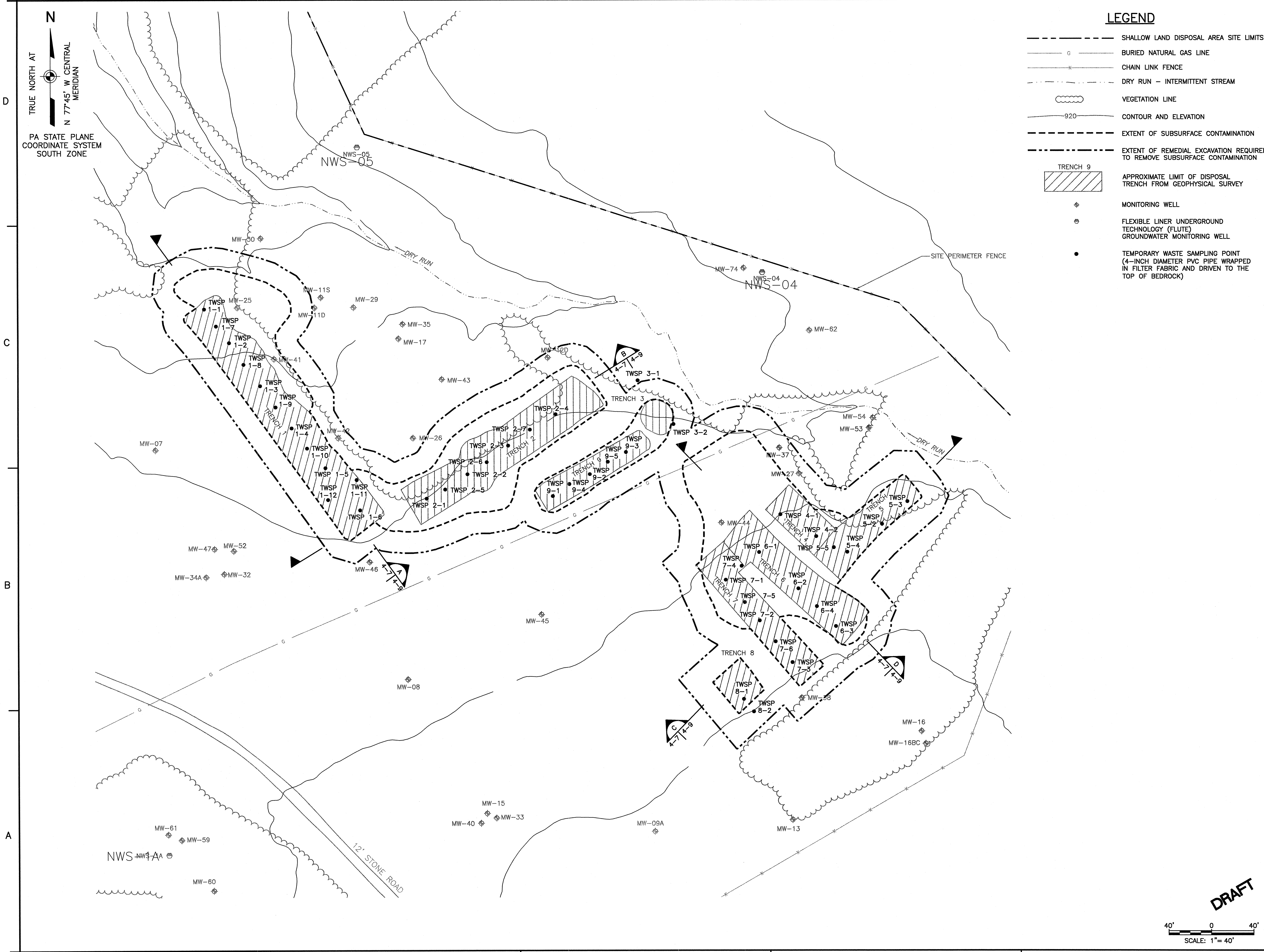
| Designed by: KJS | Date: JANUARY 2006 | Rev. |
| Dwn by: RAL | Ckd by: TAF | Design file no. 11173327.00000 |
| Reviewed by: DDH | | Drawing code: |
| Submitted by: Chief, Arch. Branch | | File name: FIGURE 4-5; Plot date: 5/23/05; Plot scale: 1=1 |

SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

CONCEPTUAL LAYOUT FOR ALTERNATIVE 4: EXCAVATION, TREATMENT, AND ON-SITE DISPOSAL

Sheet reference number:
4–5
Sheet 5 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-5.dwg 1=1 3/3/06-6 RAL

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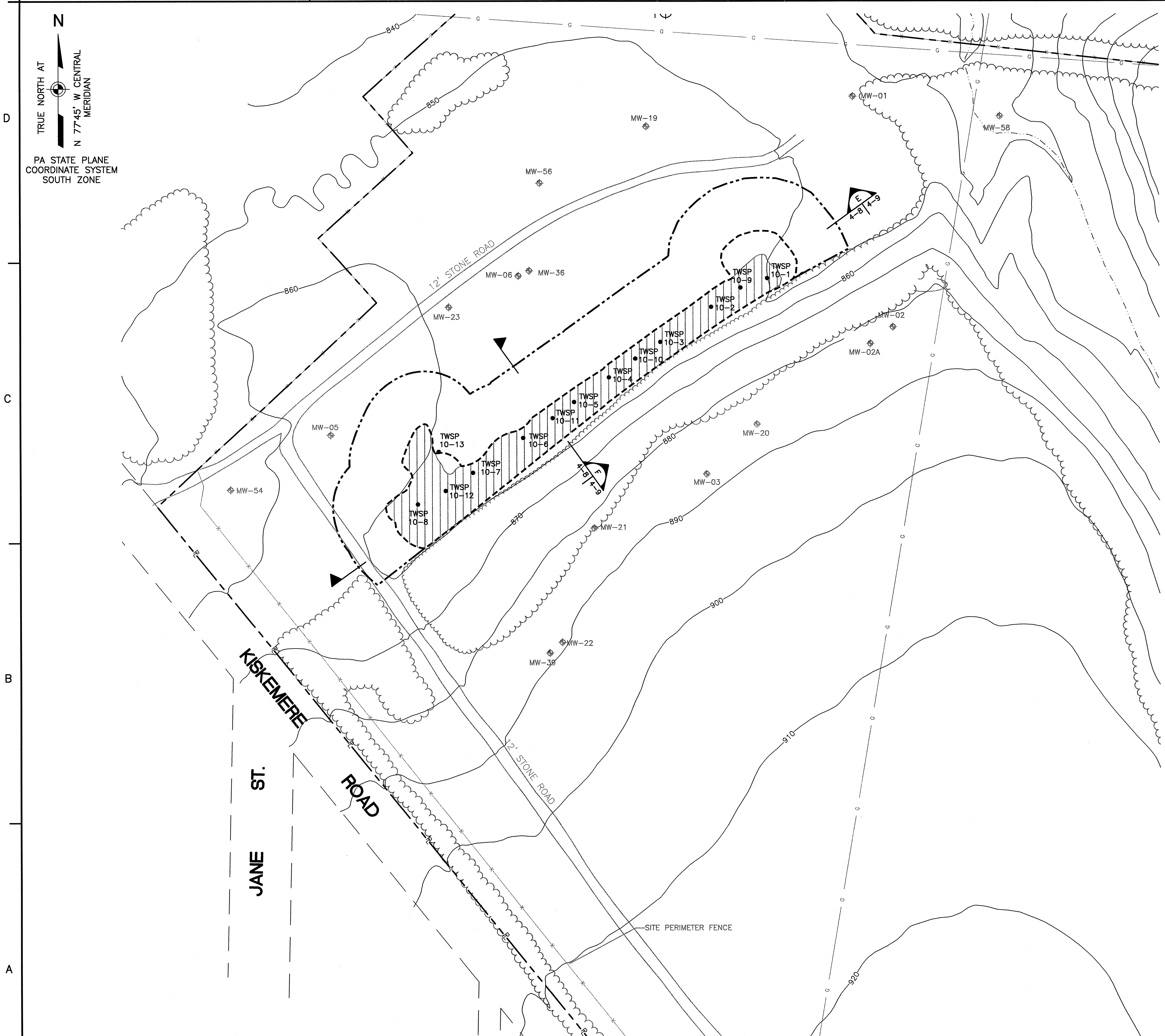
Date: MAY 2005 | Design file no. 11173327.00000 | Drawing code: | File name: FIGURE 4-7 | Plot date: 5/18/05 | Plot scale: 1=1

SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

UPPER TRENCH AREA
CROSS SECTION LOCATIONS

Sheet reference number:
4-6
Sheet 6 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-6.dwg 1=1 7/7/05-9 RAL




# LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- EXTENT OF SUBSURFACE CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION REQUIRED TO REMOVE SUBSURFACE CONTAMINATION
- TRENCH 9 — APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY
- MONITORING WELL
- FLEXIBLE LINER UNDERGROUND TECHNOLOGY (FLUTE) GROUNDWATER MONITORING WELL
- TEMPORARY WASTE SAMPLING POINT (4-INCH DIAMETER PVC PIPE WRAPPED IN FILTER FABRIC AND DRIVEN TO THE TOP OF BEDROCK)

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| Reviewed by: DDH | Design file no. 11173327.00000 |
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| | File name: FIGURE 4-8 Plot date: 5/18/05 Plot scale: 1=1 |

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SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

LOWER TRENCH AREA
CROSS SECTION LOCATIONS

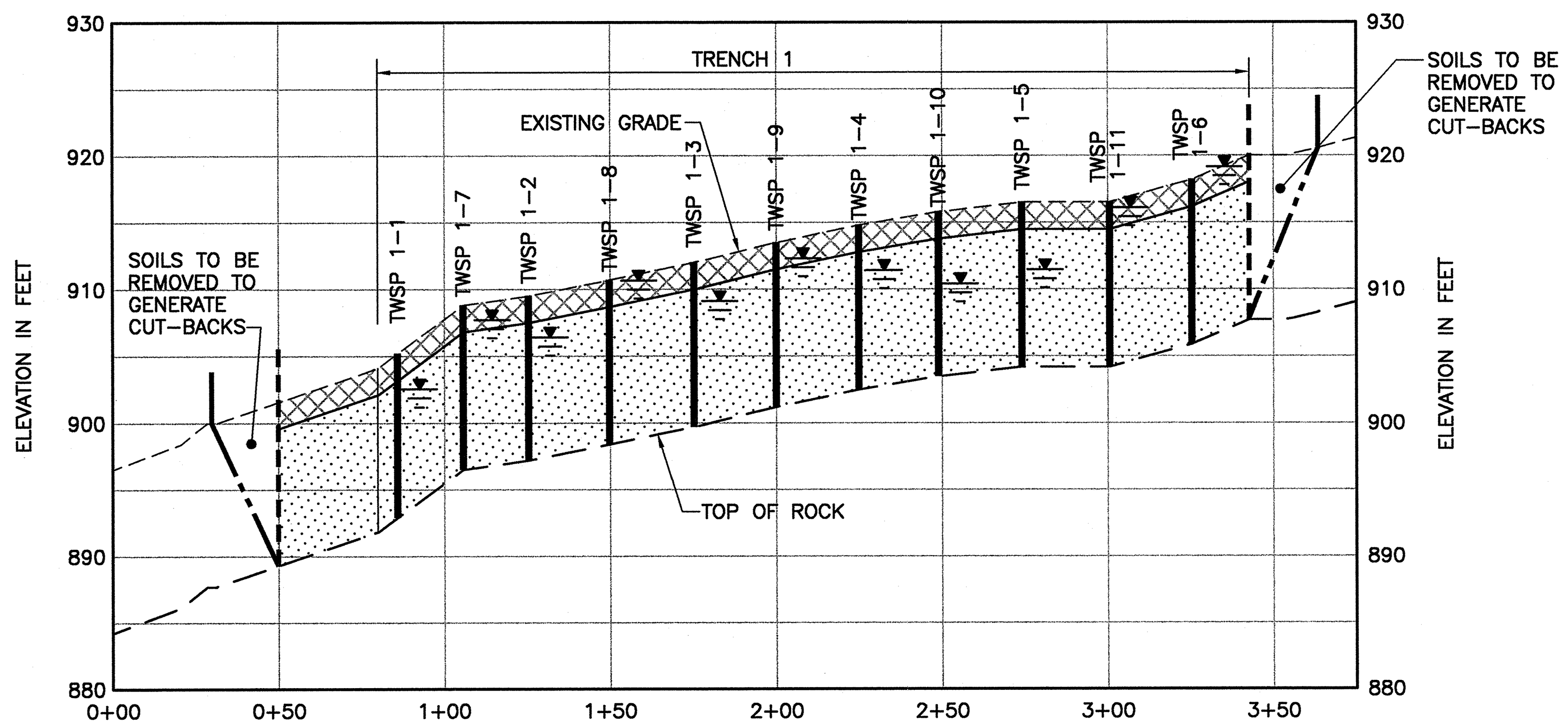
DRAFT

40' 0 40'
SCALE: 1"= 40'

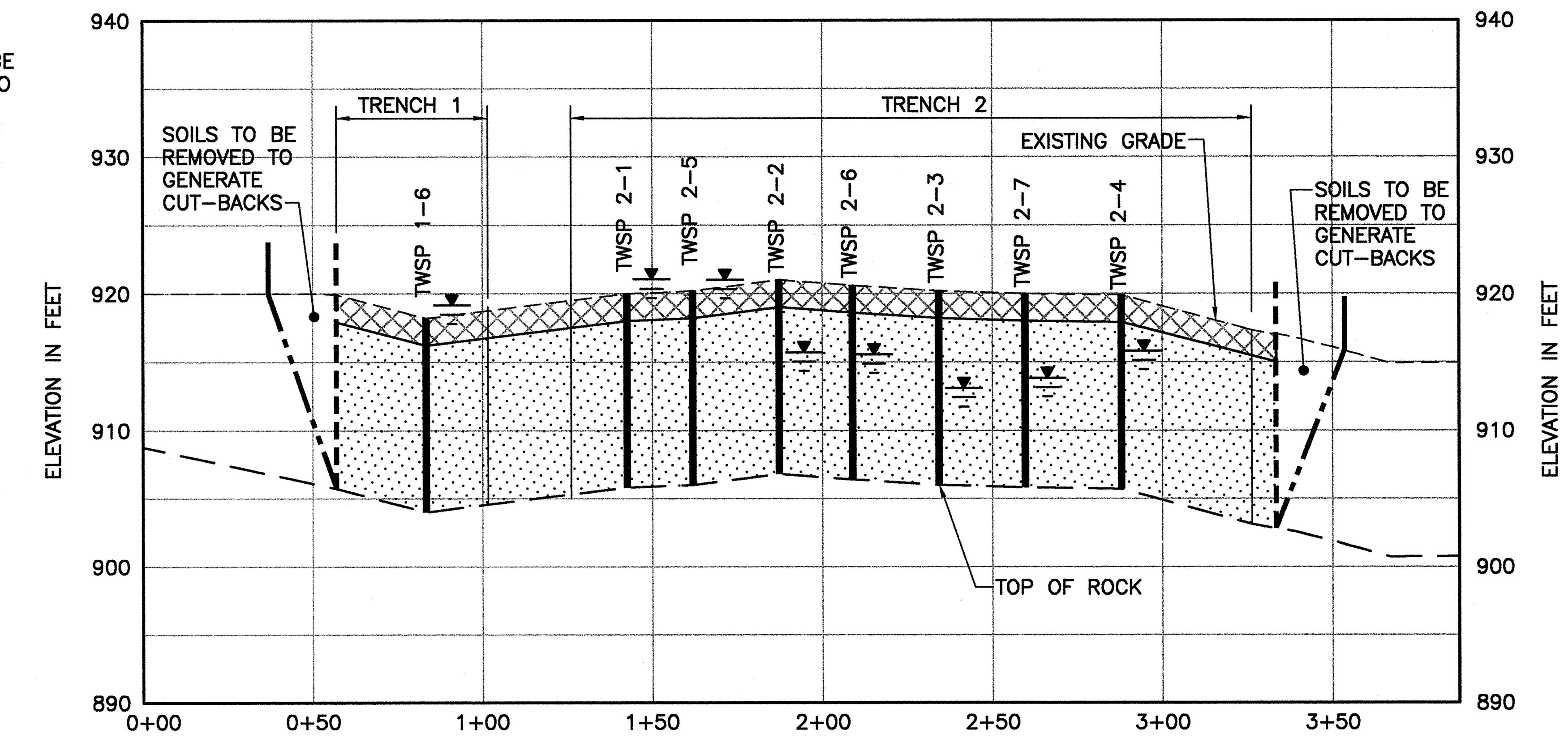
Sheet reference number: 4-7
Sheet 7 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-7.dwg 1=1 7/7/05-6 RAL

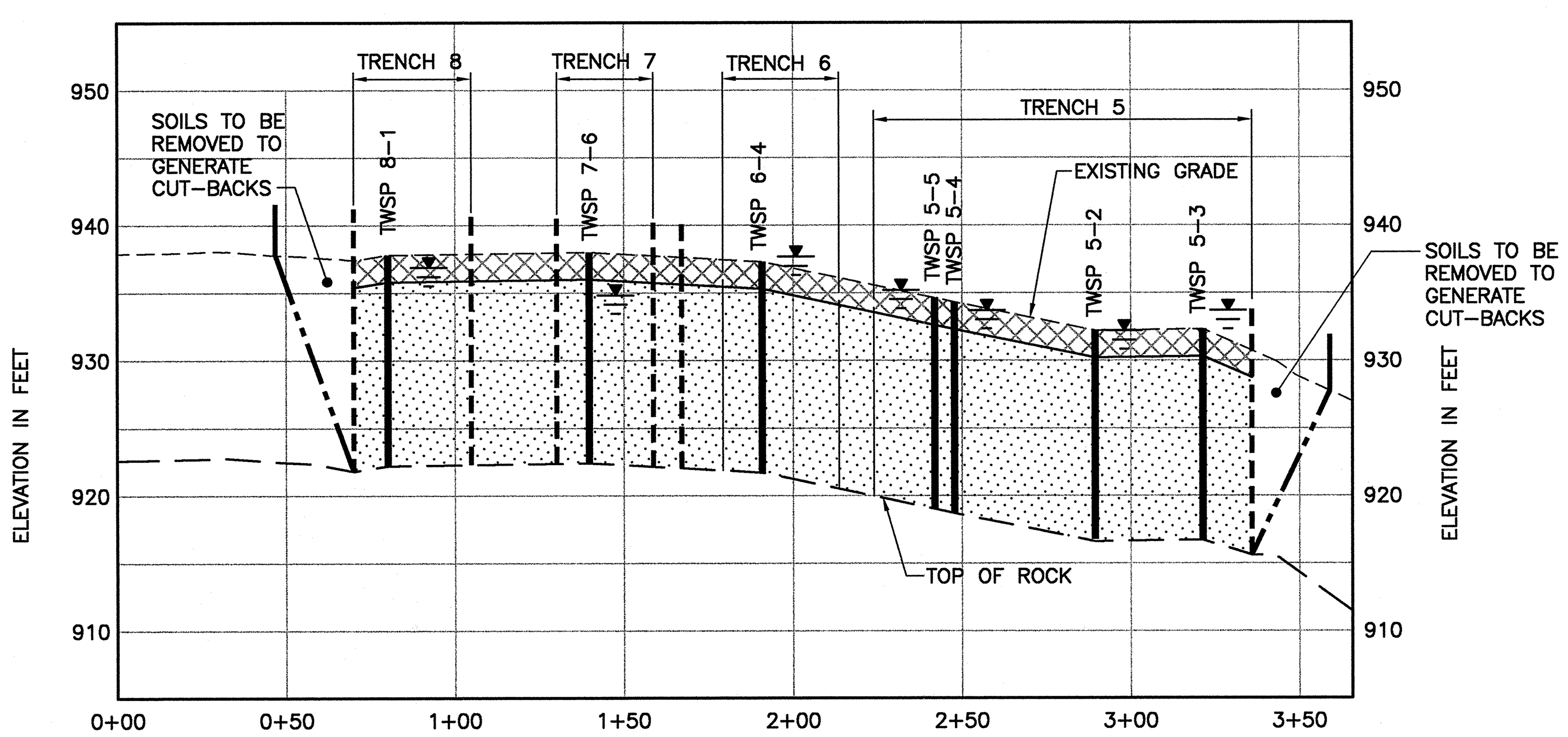
1 2 3 4 5



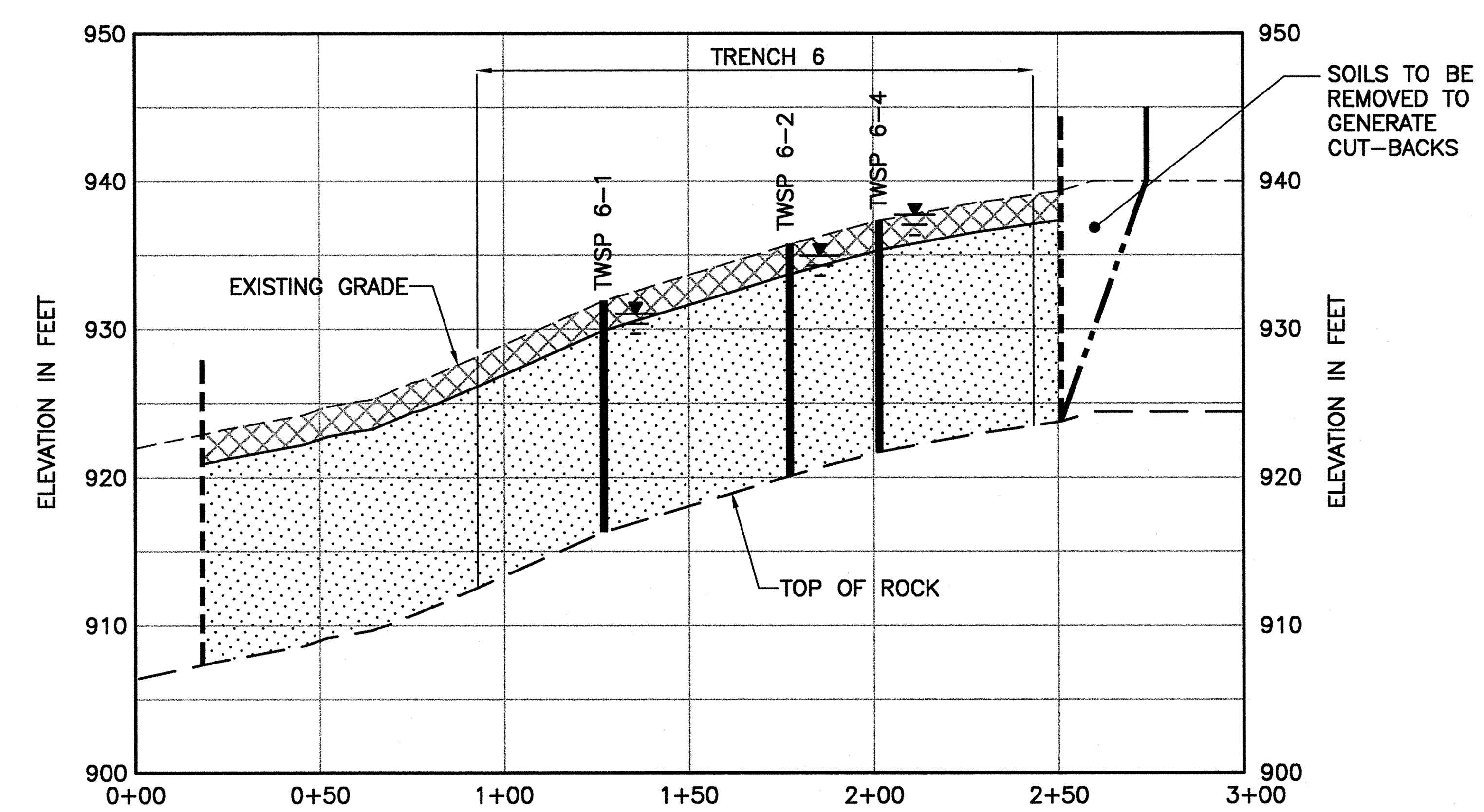

SECTION A 4-7 | 4-9



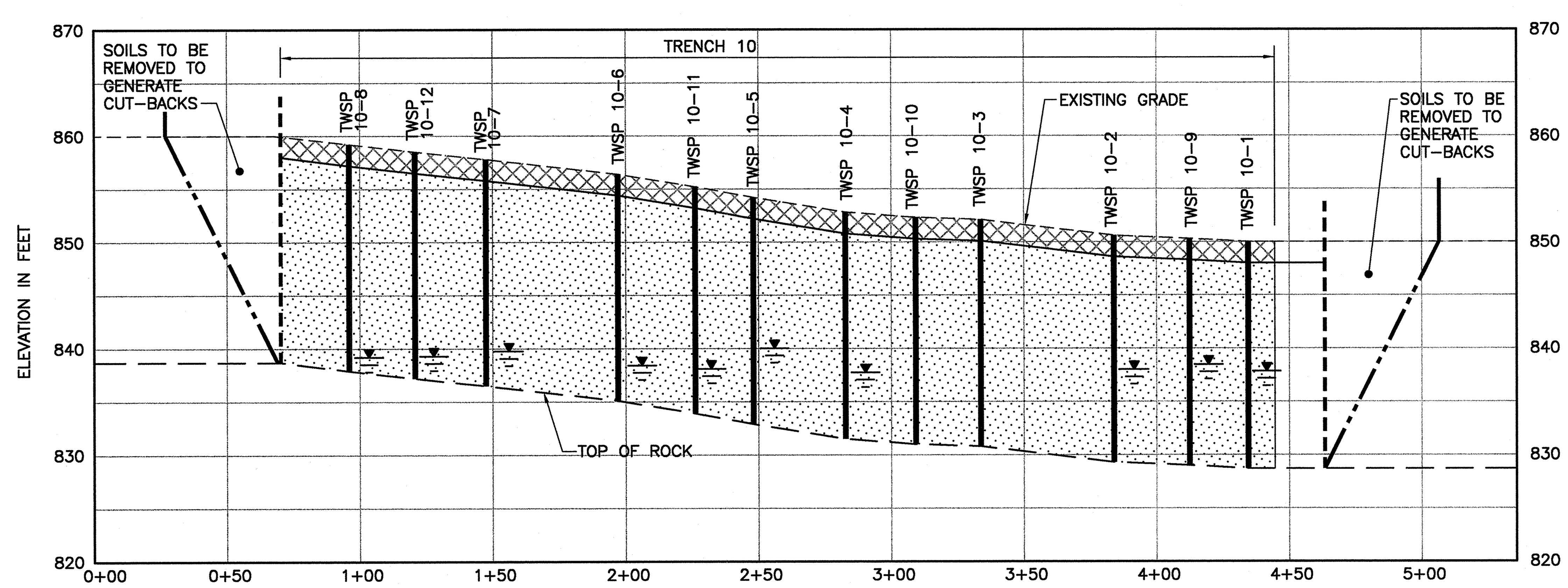

SECTION B 4-7 | 4-9



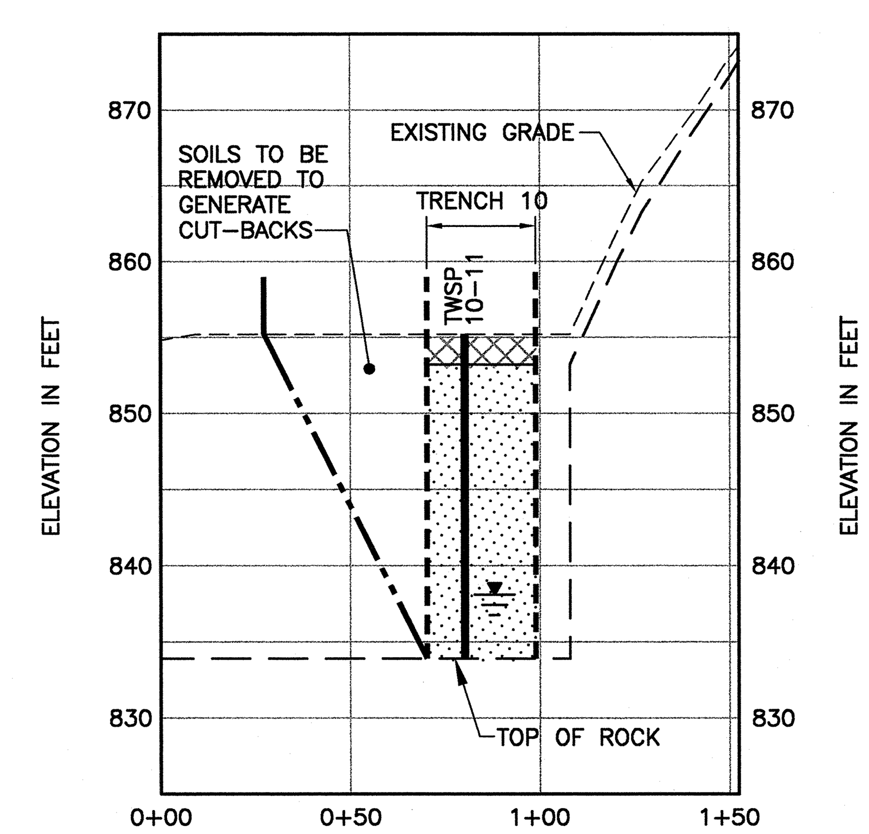

SECTION C 4-7 | 4-9




SECTION D 4-7 | 4-9




SECTION E 4-8 | 4-9




SECTION F 4-8 | 4-9

## LEGEND

- EXTENT OF CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION
- TWO FEET OF COVER SOILS TO BE REMOVED TO ACCESS IMPACTED SOILS/DEBRIS
- POTENTIAL AREA OF WASTE DISPOSAL
- WATER LEVEL MEASURED ON NOVEMBER 25, 2003.
- TWSP 10-12 — TEMPORARY WASTE SAMPLING POINT (SLOTTED 4-INCH DIAMETER PVC PIPE WRAPPED IN FILTER FABRIC DRIVEN INTO TRENCHES TO TOP OF BEDROCK, ABOVE-GRADE PROTECTIVE CASING IS NOT SHOWN)

NOTES:

1. COVER AND CUT-BACK SOILS WILL BE FIELD SCREENED DURING EXCAVATION, STOCKPILED, SAMPLED, AND EITHER RE-USED ON-SITE OR TRANSPORTED OFF-SITE FOR DISPOSAL AT AN APPROPRIATE DISPOSAL FACILITY.
2. CUT-BACKS FOR TRENCHES 1 THROUGH 9 WERE BASED ON A 1:1.5 SLOPE DUE TO THE PRESENCE OF COHESIVE SOILS. CUT-BACKS FOR TRENCH 10 WERE BASED ON A 1:2 SLOPE DUE TO THE PRESENCE OF MINE SPOILS.
3. ACCORDING TO WASTE DISPOSAL RECORDS AND CITIZEN INTERVIEWS, RADIOLOGICAL AND CHEMICAL WASTES WERE DISPOSED OF INTO A SERIES OF LINEAR PITS ALONG THE DISPOSAL TRENCHES AND IN MANY CASES UNCONTAMINATED SOILS SEPARATED WASTES (NON-HOMOGENEOUS DISTRIBUTION).

10' 0 10'
VERT. SCALE: 1"= 10'

40' 0 40'
HORIZ. SCALE: 1"= 40'

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Dwn by: RAL
Ckd by: TAF
Reviewed by: DDH
Submitted by: Chief, Arch. Branch

Date: JANUARY 2006
Design file no. 11173327.00000
Drawing code:
File name: FIGURE 4-9
Plot date: 5/18/05
Plot scale: 1=1

SHALLOW LAND DISPOSAL AREA
PARKS TOWNSHIP, PENNSYLVANIA
FEASIBILITY STUDY

TRENCH AREA
CROSS SECTIONS

Sheet reference number:
4-8
Sheet 8 of 9

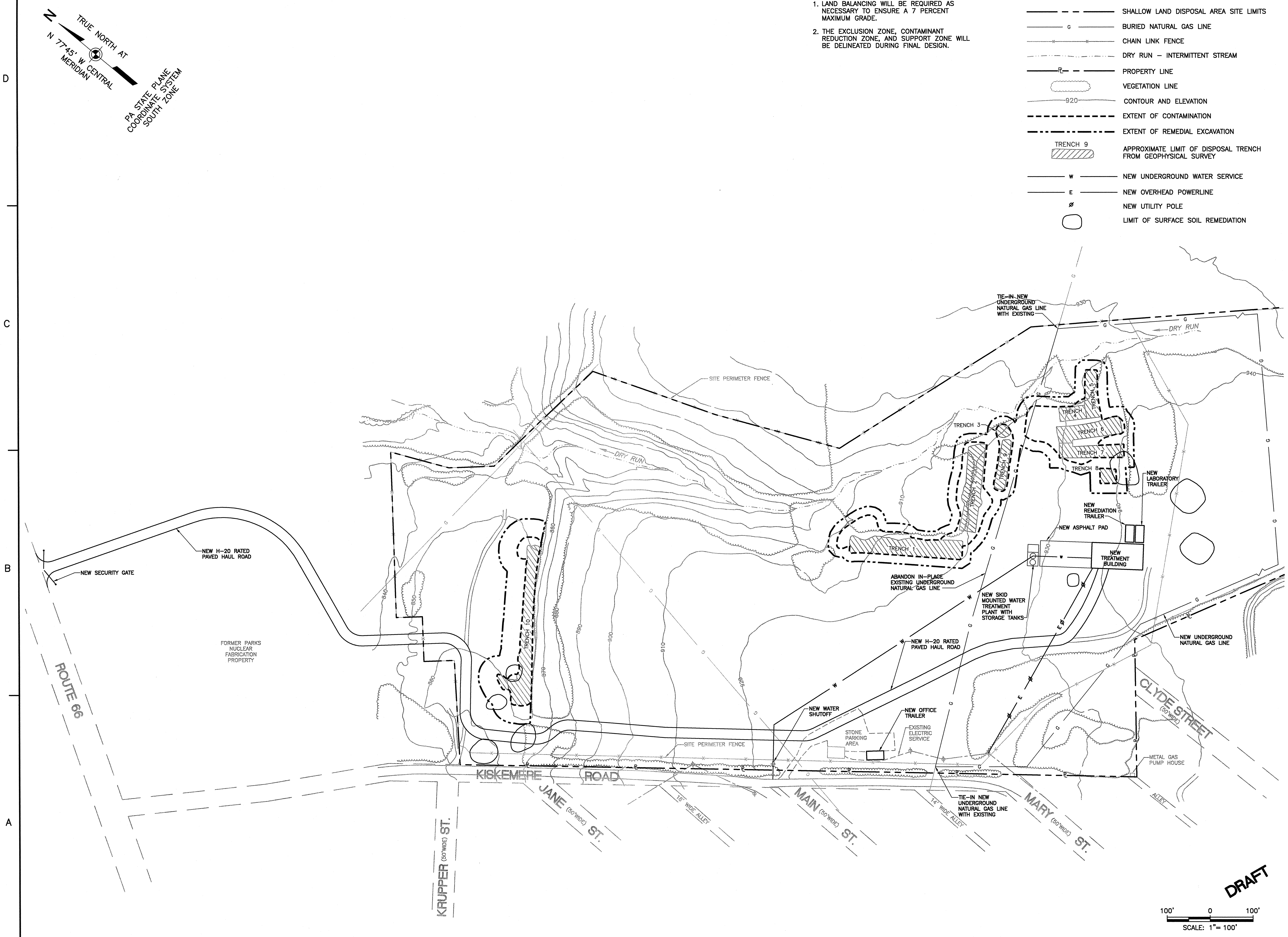
N:\11173327.00000\CAD\DRAFT\ FIGURE 4-8.dwg 1=1 1/9/06-10 RAL

NOTE:

1. LAND BALANCING WILL BE REQUIRED AS NECESSARY TO ENSURE A 7 PERCENT MAXIMUM GRADE.
2. THE EXCLUSION ZONE, CONTAMINANT REDUCTION ZONE, AND SUPPORT ZONE WILL BE DELINEATED DURING FINAL DESIGN.

## LEGEND

- SHALLOW LAND DISPOSAL AREA SITE LIMITS
- BURIED NATURAL GAS LINE
- CHAIN LINK FENCE
- DRY RUN – INTERMITTENT STREAM
- PROPERTY LINE
- VEGETATION LINE
- CONTOUR AND ELEVATION (920)
- EXTENT OF CONTAMINATION
- EXTENT OF REMEDIAL EXCAVATION
- APPROXIMATE LIMIT OF DISPOSAL TRENCH FROM GEOPHYSICAL SURVEY (TRENCH 9)
- NEW UNDERGROUND WATER SERVICE
- NEW OVERHEAD POWERLINE
- NEW UTILITY POLE
- LIMIT OF SURFACE SOIL REMEDIATION

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Design file no. 11173327.00000
Drawing code:
File name: FIGURE 4-10 | Plot date: 5/23/06 | Plot scale: 1=1

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FEASIBILITY STUDY

CONCEPTUAL LAYOUT FOR ALTERNATIVE 5: EXCAVATION, TREATMENT, AND OFF-SITE DISPOSAL

Sheet reference number: 4–9
Sheet 9 of 9

N:\11173327.00000\CAD\DRAFT\ FIGURE 4-9.dwg 1=1 3/3/06-9 RAL