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Focused Feasibility Study of Forbes Field Air National Guard Base Topeka, Kansas

S. B. Garland II
C. M. Morrissey
T. A. Cronk

Environmental Sciences Division
Publication No. 3401

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Environmental Sciences Division

FOCUSED FEASIBILITY STUDY OF FORBES FIELD AIR NATIONAL GUARD BASE TOPEKA, KANSAS

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EXECUTIVE SUMMARY

This focused feasibility study (FFS) for the Forbes Field Air National Guard Base (ANGB), Topeka, Kansas, has been prepared as part of Phase II of the Installation Restoration Program (IRP) of the U.S. National Guard Bureau (NGB). The Remedial Investigation characterizes the contaminants and recommends remedial action.

The Remedial Investigation Report (RIR) found fuel present in the subsurface environment at Forbes Field ANGB but did not recommend feasibility studies be conducted because the tight clay soils prevent leaching of the fuel to the groundwater or off site. However, the RIR recommended that no excavations take place near the fuel laterals unless a plan is developed to manage the contaminated soil.

The Kansas Air National Guard intends to replace several of the existing fuel laterals. The process will require the excavation of contaminated soil. Therefore, this FFS was prepared to determine how to handle the abandoned fuel lines and the excavated soil. Based on an evaluation of numerous storage, treatment, and disposal alternatives, it is recommended that the excavated soil be stockpiled on a liner with a surrounding berm and be disposed of in the trench as backfill. The decommissioned fuel laterals should be abandoned in place.

ABBREVIATIONS AND ACRONYMS

ANGB	Air National Guard Base
ARAR	Applicable, Relevant, and Appropriate Requirements
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cm/s	centimeters per second
EPA	U.S. Environmental Protection Agency
FFS	Focused Feasibility Study
HMTC	Hazardous Materials Technical Center
IRP	Installation Restoration Program
JP-4	jet fuel
KAL	Kansas Action Levels
KDHE	Kansas Department of Health and Environment
KSANG	Kansas Air National Guard
mg/m^3	milligrams per cubic meter
NGB	National Guard Bureau
ORNL	Oak Ridge National Laboratory
ppm	parts per million
RCL	Recommended Cleanup Level
RI	Remedial Investigation
RIR	Remedial Investigation Report
TSD	Treatment, Storage, and Disposal
$\mu g/kg$	micrograms per kilogram
TWA	Personal exposure limit based on an 8-h time-weighted average (TWA)

1. INTRODUCTION

1.1 BACKGROUND

This focused feasibility study (FFS) for Forbes Field Air National Guard Base (ANGB), Topeka, Kansas, has been prepared as part of the Remedial Investigation (RI) of the Installation Restoration Program (IRP) of the U.S. National Guard Bureau (NGB). The IRP has been implemented to investigate and remediate contaminated sites subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The RI confirms and quantifies hazardous substances at locations identified as potentially contaminated in Phase I (preliminary assessment) of the IRP (HMTC 1986).

The remedial investigation report (RIR) (ORNL 1989) found fuel present in the subsurface environment at Forbes Field ANGB (Fig. 1). The fuel is mostly held within backfill surrounding the fuel laterals under the aircraft ramp and the storm sewers. Fuel also exists in the soil under the tank farm area and in sediments from the drainage ditch. None of these sources of fuel appear to be leaching into the groundwater. Contamination in the fuel lateral trenches appears to be confined by the tight clay soils and, therefore, "pools" at the low point (as if in a bathtub). Since the water table is 3 to 9 ft below the bottom of the lateral trenches, the groundwater will not contact the fuel within the trenches. Because the leaching process is slow, high concentrations of fuel should never reach the water table under the ramp. Therefore, none of the sites were recommended by the RIR for feasibility studies. The RIR recommended that no excavations near the fuel distribution lines or laterals be undertaken without preparations to manage fuel-contaminated soil.

1.2 NATURE OF PROBLEM

The Kansas Air National Guard (KSANG) intends to modify a significant portion of the aircraft parking ramp at the Forbes Field ANGB. Proposed construction plans call for the abandonment and potential removal of existing fuel laterals 5 through 9, the abandonment of fuel hydrant A on lateral 4, and the construction of an underdrain

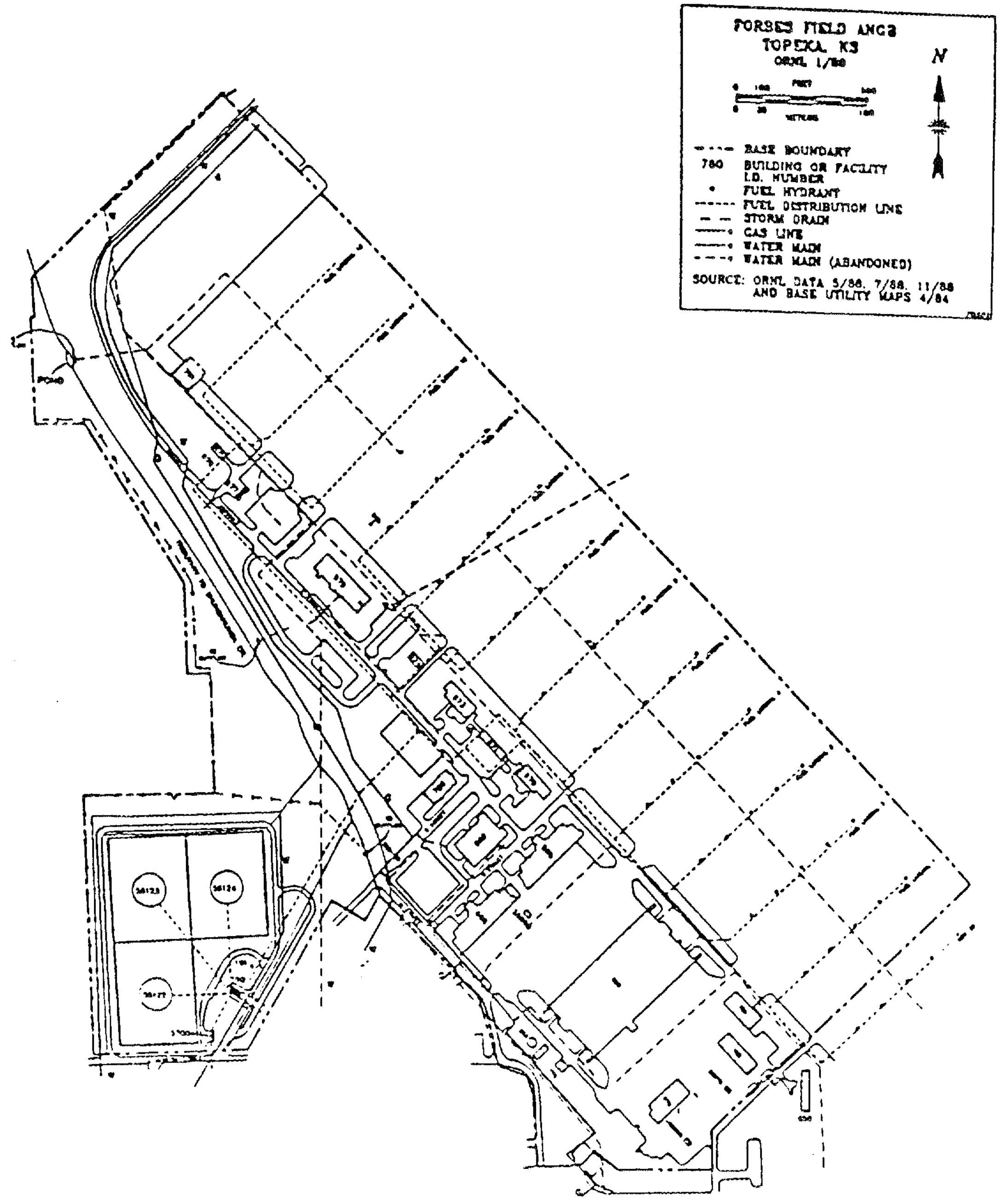


Fig. 1. Map of Forbes Field Air National Guard Base.

system to collect surface infiltration between laterals 5 and 8. In addition, existing fuel laterals 5 through 9 will be replaced by the construction of new laterals 7 through 9. Also, a large section of the aircraft parking ramp will be resurfaced with asphalt paving and concrete. The RIR has indicated that soil excavated during this construction will be contaminated with JP-4 jet fuel. Upon removal, this soil will be exposed to environmental receptor pathways, and provisions must be made to control this exposure in an environmentally safe manner.

Testing conducted during the remedial investigation indicates the majority of underlying JP-4 contamination is concentrated in the sandy backfill of the existing fuel laterals. No soil samples were taken from trench backfill during the remedial investigation because wells and boreholes were specifically placed outside of existing trenches to avoid drilling into underground lines. The maximum concentration of total petroleum hydrocarbons detected in soil outside of the trench areas was 26,000 μg/kg. The Phase I study (HMTC 1986) documents two soil tests conducted on the trench backfill. Results show oil and grease levels of 686,000 μg/kg and 829,000 μg/kg in the vicinity of known spills. These results indicate that it is reasonable to expect soil excavated from areas outside the fuel lateral backfill to contain amounts of JP-4 contamination reaching 20,000 to 30,000 μg/kg. Soil taken from existing trench backfill will contain greater degrees of JP-4, up to 800,000 μg/kg. JP-4 is not a listed hazardous waste. Its hazardous nature is therefore determined by characteristic—specifically, hazardous by flammability. It is believed that the existing contaminant levels do not warrant a classification of hazardous by flammability; hence, excavated soil will be handled as nonhazardous solid waste.

The construction project will require the removal of 2900 yds^3 to 5300 yds^3 of contaminated soil, depending on whether the existing fuel laterals are simply abandoned in place or abandoned and removed.

1.3 PURPOSE OF FFS

This FFS is prepared to determine the means for abandoning existing fuel laterals 5 through 9 and for handling the contaminated soil encountered during installation of the new fuel laterals. First, the general response options applicable to this project are assembled and screened for effectiveness and implementability. Next, remedial response alternatives are formulated as different combinations of the most appropriate general response options. Finally, the remedial response alternatives are evaluated, and a preferred alternative is recommended.

2. STORAGE, TREATMENT, AND DISPOSAL OPTIONS

2.1 INTRODUCTION

2.1.1 Purpose

The excavated soil from new fuel lateral installations will be contaminated with JP-4 and must be handled in an environmentally acceptable manner. The newly constructed fuel laterals will replace several existing fuel laterals that must be decommissioned and abandoned. This section describes the options in abandoning the existing fuel laterals and handling the contaminated soil. Table 1 lists all the options to be considered.

2.1.2 Recommended Cleanup Levels

The treatment, storage, and disposal (TSD) options must comply with appropriate, relevant, and applicable requirements (ARARs). The Kansas Department of Health and Environment (KDHE) has adopted the policy of treating all petroleum-hydrocarbon-contaminated soil in a manner consistent with their policies on leaking underground storage tanks. Because JP-4 is not a listed hazardous waste and the KDHE does not consider petroleum-hydrocarbon-contaminated soil to be hazardous by characteristic (Jean Underwood, Division of Environment, Bureau of Environmental Remediation, Kansas Department of Health, personal communication to T. A. Cronk, ORNL, Grand Junction, Colorado, January 13, 1989), the contaminated soil in question is considered nonhazardous solid waste. The following Recommended Cleanup Levels (RCLs) are applicable.

Soils: The RCL for petroleum-hydrocarbon-contaminated soil is 100 ppm total petroleum hydrocarbons. Contaminated soils will be either treated to reduce contamination to 100 ppm or less or contained in a manner to prevent environmental exposure of 100 ppm or higher.

Groundwater and surface water: The groundwater and surface water protection standard will conform with the policy as set forth in the Kansas Action Levels (KAL).

Table 1.
Focused feasibility study options to be considered, Forbes Field Air National Guard Base

	Handling contaminated soil		
Abandonment of existing fuel laterals	Temporary soil storage	Soil treatment	Soil disposal
Remove landfill	No action	No action	Sanitary
Abandoned in place	Liner/berm	Enhanced volatilization and biodegradation	Permitted landfill
		Landfarm	On-site burial
		Compost	Trench backfill
		Off-site incineration	
		On-site incineration	
		Thermal desorption	
		Vacuum extraction	
		Soil flushing	
		Solidification and immobilization	
		In situ	

Volatile contaminants: Air quality permits are not required for volatile contaminants derived from land treatment of petroleum-hydrocarbon-contaminated soil (Harish Adarwal, Section Chief, Bureau of Air Quality and Radiation Control, Kansas Department of Health, personal communication to T. A. Cronk, ORNL, Grand Junction, Colorado, January 30, 1989). Following are the recommended action levels for personnel involved with construction, as based on the personal exposure limit for an 8-h time-weighted average (TWA) (American Conference of Governmental Industrial Hygienists 1988):

- JP-4, 200 ppm (700 mg/m^3);
- benzene, 1.0 ppm;
- naphthalene, 10.0 ppm;
- toluene, 100 ppm; and
- xylene, 100 ppm.

2.2 DESCRIPTION OF STORAGE, TREATMENT, AND DISPOSAL OPTIONS

2.2.1 Abandonment of Existing Fuel Laterals

The fuel laterals to be abandoned can be either removed and disposed or abandoned in place.

2.2.2 Excavated Soil

2.2.2.1 Temporary Storage

Excavated soil from the trenches must be stockpiled or stored while awaiting disposition. Two alternatives for temporarily storing the soil are the no-action alternative and the liner/berm alternative.

No action: The construction contractor must remove the soil and handle it in a manner consistent with normal construction activities with no regard for contamination.

Liner/berm: The soil is stockpiled on a liner within a bermed area to prevent the runoff of contaminated soil or the leaching and migration of contaminants. The liner can be an existing paved area, a synthetic liner, or an area paved for this purpose, chosen by the NGB and/or Forbes Field ANGB personnel.

2.2.2.2 Treatment

The 11 treatment alternatives listed in Table 1 are described below.

No action: Excavated soil is stored or disposed of with no effort to treat it. During soil removal, a large percentage of the volatile organics escapes to the atmosphere, causing a decrease in the concentration of total organics in the soil. This volatilization occurs because of the excavation activity and not any intentional treatment.

Enhanced volatilization and natural biodegradation: Approximately 6 in. of soil is spread on an unused, paved, or lined area. Periodically the soil is turned over to enhance the volatilization of organics. It is probable that some natural biodegradation of organics also occurs, but nothing is done to promote biodegradation.

Landfarm: A landfarm uses biodegradation for the treatment of the contaminated soil. The excavated soil is spread onto native soil and tilled initially and periodically thereafter. Water and nutrients can be added by a water truck to achieve proper soil conditions. If sufficient land is unavailable, the landfarm can be constructed on top of an unused portion of the airstrip. A landfarm stimulates the growth of naturally occurring or seeded microorganisms to degrade organic compounds. This is a natural metabolic process in which soil conditions, such as nutrients, oxygen, pH, moisture, and temperature, are optimized to maximize the metabolic processes. Figure 2 is a conceptual layout for a landfarm.

Compost: The static-pile composting method would be used. In this approach, the contaminated soil is mixed with a bulking agent, mounded over an air distribution system, and aerated with a forced-air system. Figure 3 is a conceptual layout for a static-pile compost facility (EPA 1985).

Off-site incinerator: Contaminated soil would be transported and fed to an off-site incinerator, and the organic matter is burned off. A device to control air pollution may be required to remove contaminants in the air emissions, and the resulting ash residual may be contained in a landfill.

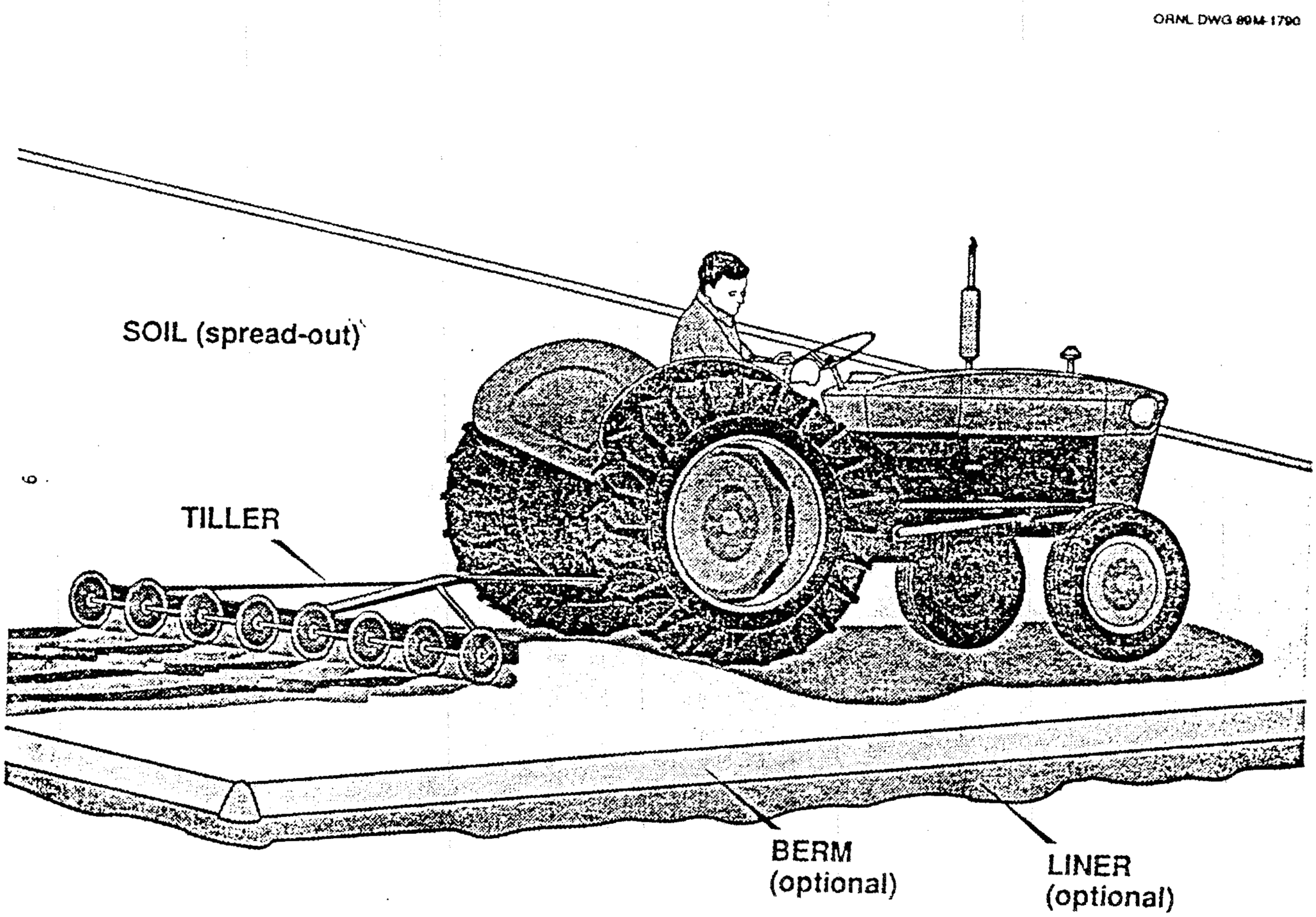
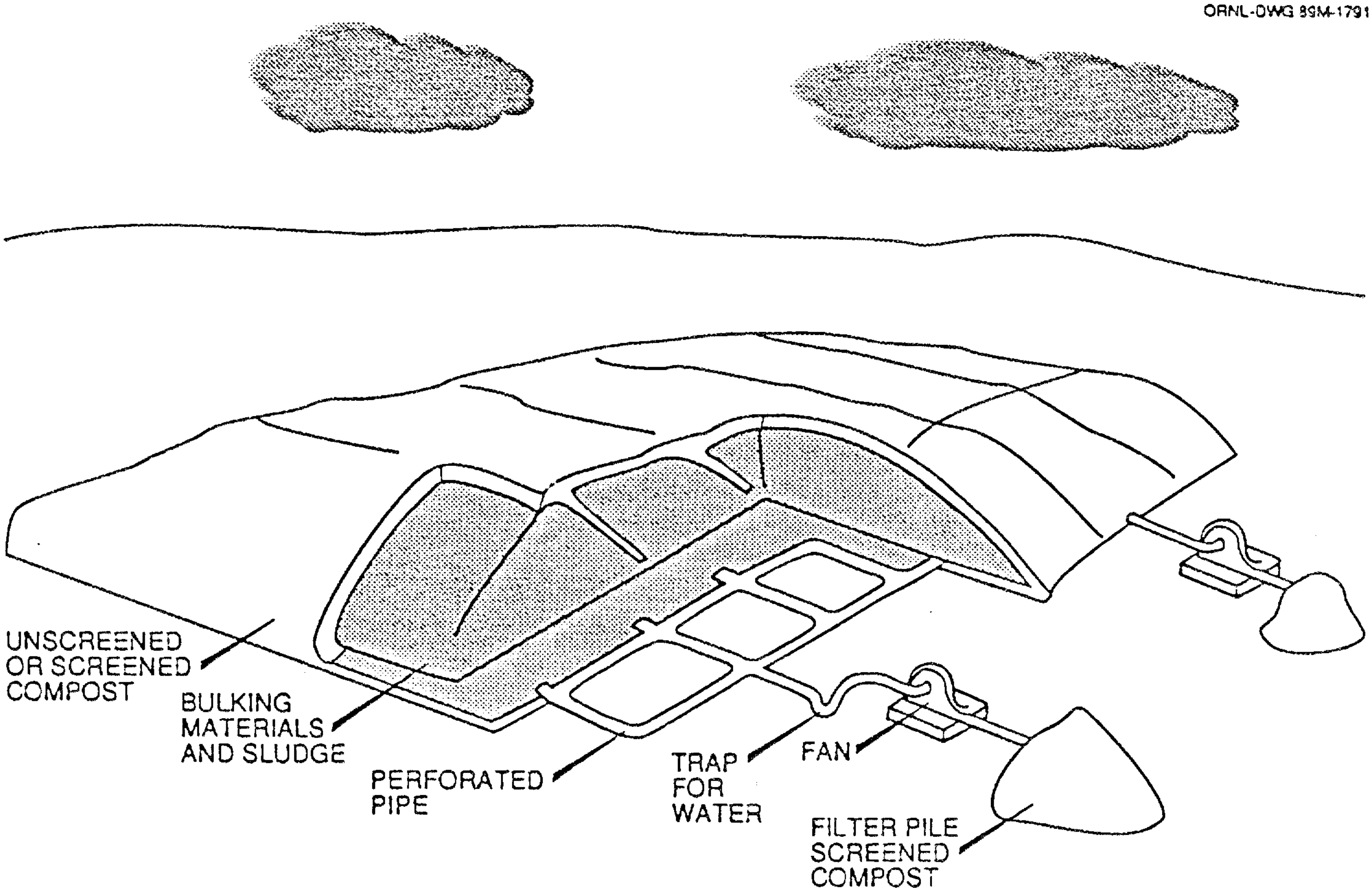


Fig. 2. Conceptual layout for a landfarm.

ORNL-DWG 89M-1791



COMPOSTING EXTENDED PILES WITH FORCED AERATION

Fig. 3. Conceptual layout for a static-pile compost facility.

On-site incinerator: This is identical to the off-site incinerator method, except the incinerator would be brought on site.

Thermal desorption: Contaminated soil would be put into a reaction chamber and sufficiently heated to drive off the organics without incinerating the soil. The released gases containing the contaminants are condensed and incinerated, and the soil can be used or disposed of as needed.

Vacuum extraction: This method is based on the principle that various hydrocarbons have vapor pressures high enough to enable volatilization at ambient temperatures under a reduced atmospheric pressure. Typically, the volatilization of the hydrocarbon is accomplished with a vacuum pump in conjunction with extraction wells drilled into the contaminated soil. However, in this project vacuum extraction would be accomplished by either drilling extraction wells into the stockpiled soil following excavation or by stockpiling the soil over a preconstructed, manifold extraction system. Typically, activated carbon is used to remove the hydrocarbons from the air prior to discharge. Figure 4 shows a conceptual layout for a vacuum extraction system.

Soil-flushing: Soil-flushing uses surfactants, dilute acids and bases, or water to mobilize and flush out the contaminants from the contaminated soil. The flushing solution is sprayed onto the stockpiled soil and allowed to infiltrate through it, mobilizing and transporting the contaminants to a collection network. The flushing solution is collected for recirculation and/or treatment. Figure 5 is a conceptual layout for a soil-flushing system.

Solidification/immobilization: This method requires a thorough mixing of the solidification/immobilization agent and the soil to prevent the contaminants from leaching from the soil. Solidification results in a waste form with a high structural integrity. Immobilization limits the solubility of the contaminants. In either case the contaminant is not expected to leach and migrate into the environment. Typical solidification/immobilization agents are portland cement, pozzolanic cements, thermoplastics, and organic polymers.

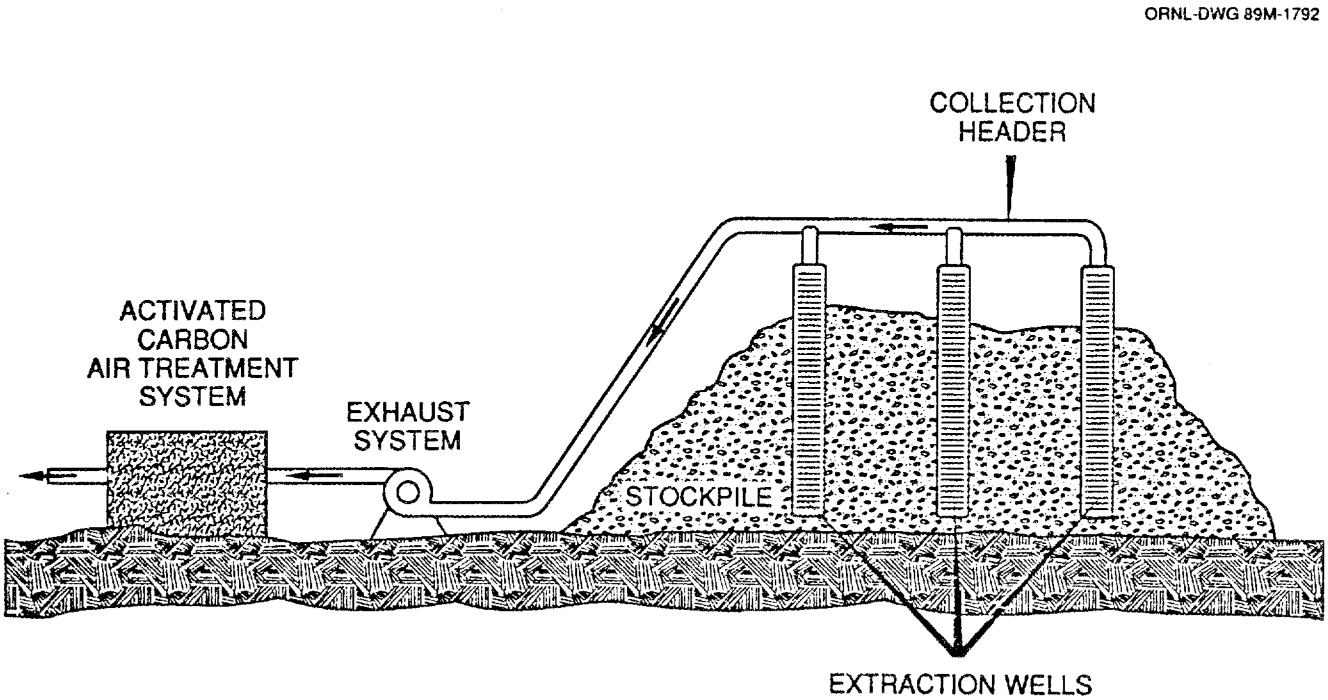


Fig. 4. Conceptual layout for a vacuum extraction system.

ORNL-DWG 89M-1793

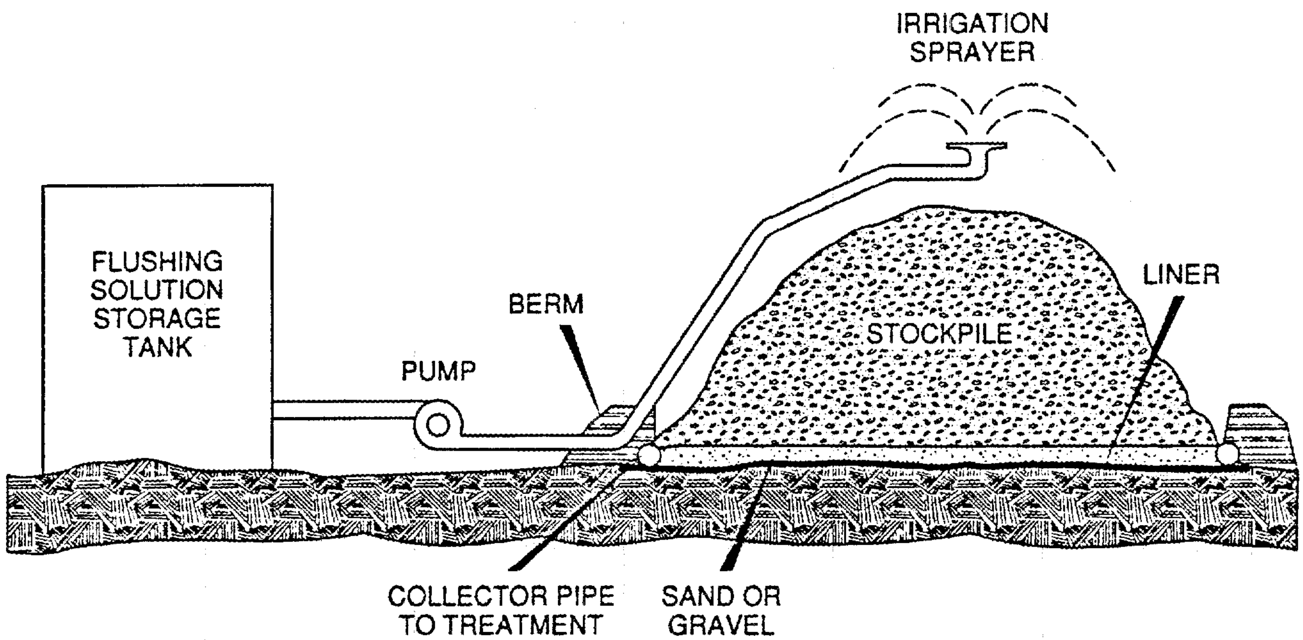


Fig. 5. Conceptual layout for a soil-flushing system.

In situ: After the soil is excavated, it can be backfilled into the trench and treated in situ by a variety of methods, such as vacuum extraction, steam stripping, bioremediation, soil flushing, or a combination of these. For vacuum extraction, pipes, a vacuum system, and exhaust air treatment would be necessary. Steam stripping requires the generation of steam; possibly a solvent to assist in desorbing the JP-4; and a delivery, recovery, and treatment system. Bioremediation would require above-ground mixing, tanks, air blowers, and an injection system. Soil flushing is similar to the system described in this section, adapted for an in situ application. All of these alternatives would require a monitoring program to evaluate performance.

2.2.2.3 Disposal

The four disposal alternatives listed in Table 1 are described below.

Sanitary landfill: The excavated soil is disposed of in a nearby municipal sanitary landfill. A landfill provides long-term containment of the waste to minimize the release of contaminants. A conceptual design for a landfill is shown in Fig. 6.

Permitted landfill: An existing landfill already permitted for hazardous wastes is used. Similar to the sanitary landfill (Fig. 6), a permitted landfill has stricter lining and monitoring requirements.

On-site burial: A sanitary or a permitted landfill is constructed at the site rather than using an existing off-site landfill.

Trench backfill: The excavated soil is put back into the trench for disposal.

ORNL DWG 89M-1794

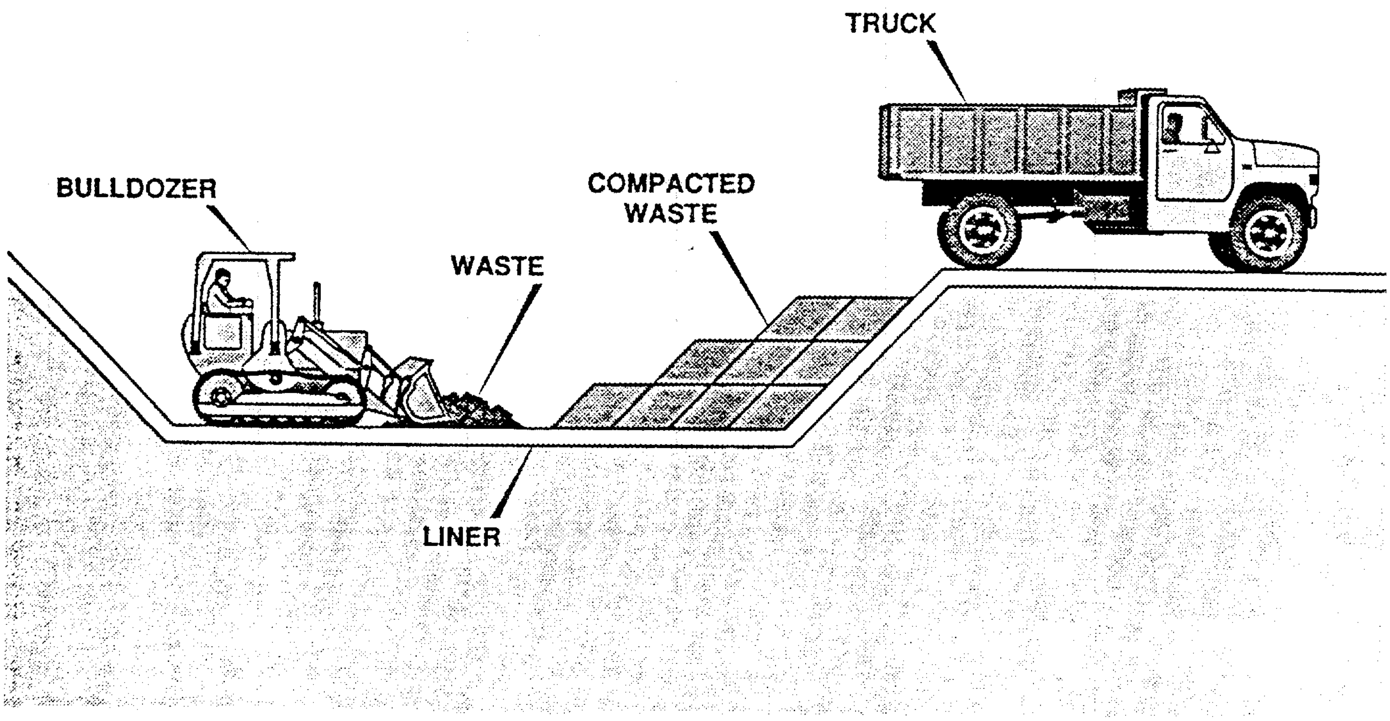


Fig. 6. Conceptual layout for a landfill.

3. SCREENING OF STORAGE, TREATMENT, AND DISPOSAL OPTIONS

3.1 INTRODUCTION

In this section the TSD options previously described are screened for feasibility, cost, and environmental and public health impacts to determine which ones should be subjected to a more detailed evaluation.

3.2 EVALUATION OF OPTIONS

3.2.1 Abandonment of Existing Fuel Laterals

The fuel laterals to be abandoned can be removed or abandoned in place. The removal of the abandoned fuel laterals is not recommended for several reasons. First, there is no environmentally motivated reason. The leaking fuel laterals themselves are the source of soil contamination; when the existing fuel laterals are decommissioned, the leaks will no longer add fuel to the trenches. Also, the remedial investigation found no evidence of contaminant migration away from the trenches; the abandoned fuel laterals will not provide conduits for contaminant transport. Second, the soil in the trenches of the abandoned fuel laterals is probably contaminated. To remove the fuel laterals, this soil would have to be excavated, which would lead to worker exposure, additional waste for disposal, and additional construction costs. Finally, there is no structural reason to remove the laterals; the void space caused by the fuel laterals is not sufficient to cause subsidence of the runway if the laterals collapsed. Therefore, the abandoned fuel laterals should be left in place, disconnected from the fuel system, capped, and located on utility maps as abandoned lines. Removal of decommissioned fuel laterals will no longer be considered as a viable option.

3.2.2 Excavated Soil

3.2.2.1 Storage

Because the soil is contaminated with JP-4, it must be stockpiled to prevent runoff and the leaching of contaminants. Therefore, the liner/berm alternative is preferred, using an existing paved area. The stockpiled soil should be covered with plastic to minimize runoff.

Otherwise, the runoff will have to be removed and disposed of or continually mixed with the stockpiled soil. No action, in regards to temporary storage, will no longer be considered a viable option.

3.2.2.2 Treatment

No action: If there is a need to excavate the soil, some reduction in hydrocarbons will take place from volatilization. The amount of contaminant reduction is directly proportional to the degree of initial contamination that the excavated soil contains and the mix of contaminants present. There is no way of ensuring at the present time that this method of indirect treatment will achieve the RCL of 100 ppm or less. If the excavated soil contains excessive levels of contamination, other forms of treatment may be required. Conversely, if actual contaminant concentrations are as anticipated, this is the preferred method of treatment. This is the least expensive treatment alternative and poses no significant environmental or public health threat. Because actual contaminant concentrations are unknown, a worst case scenario must be assumed, and justification for using the no-action treatment alternative rests entirely on the protectiveness afforded by the preferred soil disposal option. If it can be shown that the preferred soil disposal option ensures environmental protection in itself, then no action should be the preferred treatment option.

Enhanced volatilization and natural biodegradation: This method requires that the soil be turned over periodically to enhance volatilization. Tilling is difficult because of the depth of the stockpile, so the soil must be spread over a large area underlain by a liner or paved area. This aeration of the soil allows natural biodegradation to occur. This alternative uses the natural removal of contaminants, and it should be reasonably reliable. Treatment time required for completion is, however, impossible to quantify at the present time. Estimates will require pilot studies to assess treatment effectiveness on native soils at actual levels of contaminant concentrations.

This alternative has two potential environmental impacts. First, material treated in an open area releases volatile contaminants directly to the atmosphere. Second, turning the soil over can release contaminated soil via wind dispersion. This alternative is acceptable regardless of the degree of soil contamination encountered; however, if the soil contamination levels are excessive, some of the following alternatives offer quicker means of treatment and are preferable.

Landfarm: A landfarm consists of laboratory studies, optimization of soil conditions, seeding of microorganisms, and cultivation. Laboratory or pilot studies should be conducted prior to landfarming to confirm the degradability of the organic contaminants and to determine the optimum environmental parameters for biodegradation. However, this task is not essential, and the optimization can occur during full-scale operation with very little risk.

Previous biodegradation projects have shown the optimum environmental conditions: a pH of 7.0 to 8.5, a temperature of 15 to 35°C (59 to 95°F), and a 10 to 80% moisture content (by weight) (Environmental Research & Technology, Inc. 1983; Brown et al. 1983; EPA 1989). Additionally, sufficient oxygen, nitrogen, and phosphorus are required. These conditions can be achieved and maintained by normal agricultural practices.

Many landfarms of petroleum hydrocarbons have been successful without microbial seeding; however, if the laboratory studies or full-scale operation indicates that an insufficient microbial population exists for biodegradation, microbial seeding may be required.

After site conditions have been optimized for landfarming, these conditions must be maintained for the duration of the project. Monitoring and adjustment of the environmental parameters must be continued throughout the project until sufficient biodegradation has occurred.

Biodegradation is a proven technology that is feasible for the contaminants of concern. A review of the biodegradability of the constituents of JP-4 is shown in Table 2. The largest uncertainty is the time required for treatment, since there have been no documented cases of landfarming soil contaminated with JP-4. Minimal environmental impact is expected.

Table 2.
Biodegradability of JP-4 constituents

Constituent	Biodegradability
Nonane	The straight-chain nonsubstituted hydrocarbon should biodegrade easily
Ethyl benzene	The substituted aromatic hydrocarbon is less biodegradable than aliphatic compounds. There may be some volatilization, particularly at elevated temperatures
Tetradecane	Since biodegradation decreases with chain length, it will be less biodegradable than nonane. The literature is not in agreement on the biodegradability
Methyl naphthalene	Biodegradation decreases with the number of rings, so it will be less degradable than ethyl benzene. Acclimated bacteria should degrade the compounds
Benzene	Benzene should volatilize rapidly and not be subject to biodegradation

Source: From P. T. McMullen, "Evaluation of Composting as a Means of Reclaiming Soil Contaminated with a JP-4 Mixture," Masters thesis, Pennsylvania State University, August 1988.

Composting: The previous evaluation of landfarming is also applicable for composting; however, composting requires the injection of air into the pile. It also should be effective, but the time required for treatment is unknown. There are no documented instances of composting soil contaminated by JP-4, but it has been successfully demonstrated in the laboratory (McMullen 1988). Composting is acceptable for further consideration.

Off-site incineration: Off-site incineration is an effective treatment for the removal of organic contaminants. It can quickly treat the waste once it is delivered. Incinerator systems have applicable mechanical controls to minimize a release to the atmosphere. A large amount of material handling is required, including loading, transporting to the incinerator, removing from the incinerator, and transporting and disposing of ash. This alternative is suitable for wastes with excessive contaminant concentrations but is expensive ($7 to 8 million for 2900 yd^3).

On-site incineration: This method varies from off-site incineration only in that the incinerator is transported rather than the waste.

Thermal desorption: This method has been successful at the pilot scale for several organic contaminants, but no full-scale plant exists at this time. The capital cost to construct a thermal desorption facility on site is $5 to 6 million, and the quantity of soil to be generated at Forbes Field ANGB is not sufficient to justify this expense; therefore, it is eliminated from further consideration.

Vacuum extraction: Vacuum extraction is a reliable and effective way to reduce the concentration of organic contaminants. Since some of the contaminants in the soil are hydrocarbons with relatively low vapor pressures, additional time is required for removal. In addition, the process may have to be enhanced with microbial action, a process not documented for soil contaminated by JP-4. An exhaust air treatment system (probably activated carbon) prevents the release of contaminants to the atmosphere from the blower. Material handling is limited to installing the vacuum wells in the soil mound or stockpiling the excavated soil over an existing extraction manifold. The cost of this system depends on the time required to treat the soil. Therefore, this alternative is suitable.

Soil flushing: Soil flushing is still in the conceptual stage of development. Prior to field application of soil flushing, a pilot study should be conducted to determine the optimum surfactant or flushing agent to be used. The time required for the process depends on the specific flushing agent and the flushing efficiency. After flushing the soil, the flushing solution requires collection through an underdrain system. Since the flushing solution will probably be unsuitable for treatment in a municipal wastewater treatment plant, it will have to be treated on site or shipped off site. A possible environmental risk is the release of the flushing liquid to the groundwater or a spill in transfer. Based on the above considerations, soil flushing is eliminated from further consideration.

Solidification/immobilization: This method binds the contaminated soil into a solid matrix to eliminate leaching. A mixing station would have to be set up on site to mix soil with the solidifying agent. Because the technology is not proven, an extensive amount of leach testing would be required, or the solidified soil would have to be disposed of at a permitted landfill. Existing solidification agents are not specifically designed to bind petroleum hydrocarbons. Therefore, this alternative is eliminated from further consideration.

In situ: The application of vacuum extraction, steam stripping, bioremediation, or soil flushing in situ is subject to the same concerns as when applied aboveground. A combination of vacuum extraction and bioremediation would be feasible because several of the components of JP-4 have low vapor pressures. Serious problems with an in situ technique exist: it must be employed at an active aircraft parking ramp; the techniques have not been demonstrated on JP-4 in situ; and process modification, optimization, and monitoring are difficult because of the runway. These problems are reduced with aboveground treatment. Because the soil will be excavated anyway, it is more practical to treat it after removal than to wait for it to be backfilled. For these reasons this alternative is eliminated from further consideration.

3.2.2.3 Disposal

The four disposal options are evaluated below.

Sanitary landfill: This method is acceptable if the contaminant concentrations of the excavated soil either meet or are reducible to the RCL. In either case, this option is not as attractive as trench backfill.

Permitted landfill: This option is necessary only if environmental protection cannot be ensured through treatment or trench backfill.

On-site burial: On-site burial is appropriate regardless of the contaminant concentrations encountered. However, trench backfill or off-site disposal are both preferable to this option because they are less expensive and easier to implement. The possible exception to the above statement is landfarming. In this case, it may be less expensive to close the landfarm on site as a landfill than to excavate and transport the residual waste to an off-site disposal facility.

Trench backfill: This method is the preferred disposal option. The RIR has sufficiently documented the containment capabilities of the subsoil system and recommends no remedial action because JP-4 in the trenches is not migrating. Thus, replacing the excavated soil into the trench is an acceptable means of ensuring environmental protection in compliance with the RCL.

3.3 SUMMARY

Based on the above screening, several options were eliminated, and several were found to be applicable only in certain situations. The general response options used to formulate remedial response alternatives are listed in Table 3. The next section develops remedial alternatives as a combination of the retained TSD options.

Table 3.
Focused feasibility study options remaining after screening
Forbes Field Air National Guard Base

	Handling Contaminated Soil		
Abandonment of existing fuel laterals	Temporary soil storage	Soil treatment	Soil disposal
Abandon in-place	Liner/berm	No action	Sanitary landfill
		Enhanced volatilization and natural biodegradation	Permitted landfill
			On-site burial
		Landfarm	Trench backfill
		Compost	
		Off-site incineration	
		On-site incineration	
		Vacuum extraction	

4. DEVELOPMENT OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

Remedial alternatives are assembled as various combinations of the TSD options, shown in Table 3. The circumstances surrounding the two phases of construction that may encounter contaminated soil are very different and demand different remedial alternatives. As a result, development of remedial alternatives for abandonment of the existing fuel laterals and for handling contaminated soil in the installation of the new fuel laterals are addressed as two separate sections (Sects. 4.2 and 4.3).

4.2 ABANDONMENT OF EXISTING FUEL LATERALS

As shown in Table 3, the only option considered feasible for the abandonment of existing fuel laterals is abandonment in place. Implementation of this alternative includes disconnecting the laterals decommissioned from the supply trunk line, draining residual fuel, capping the abandoned lines, and noting the location of the abandoned lines on utility maps.

4.3 HANDLING CONTAMINATED SOILS

4.3.1 Alternative I: Enhanced Volatilization and Natural Biodegradation

Alternative I consists of treating the excavated soil through enhanced volatilization and natural biodegradation. Implementation of this alternative consists of temporary storage of excavated soil at a liner/berm storage area pending disposition to the treatment facility. At the earliest possible time, the excavated soil is moved from temporary storage to the on-site treatment facility and treatment begins. Treatment continues until the RCL is achieved or until the soil is acceptable for placement in a sanitary landfill. After treatment is complete, the soil is disposed of at the Airport Authority sanitary landfill. Even though initial screening indicated that trench backfill is the preferred soil disposal option, disposal in the adjacent sanitary landfill is coupled with the volatilization and natural biodegradation treatment option, because the time period required for treatment may exceed the time period required for the installation of the new fuel lateral system. Thus, the treated soil is unavailable for use when trench backfill is required.

4.3.2 Alternative II: Landfarming

Alternative II consists of treating the excavated soil by landfarming. Implementation of this alternative consists of temporary storage of excavated soil at a liner/berm storage area pending disposition to the treatment facility. At the earliest possible time, the excavated soil is moved from interim storage to the on-site treatment facility, and treatment begins. Treatment continues until the RCL is achieved, until the soil is acceptable for placement in the sanitary landfill, or until on-site closure is acceptable. After treatment is complete, either the soil is disposed of at the Airport Authority sanitary landfill or the landfarm is closed on site. Even though initial screening has indicated that trench backfill is the preferred soil disposal option, disposal in the adjacent sanitary landfill or on-site closure is coupled with the landfarming treatment option, because the time period required for treatment may exceed the time period required for the installation of the new fuel lateral system. Thus, the treated soil is unavailable for use when trench backfill is required.

4.3.3 Alternative III: Composting

Alternative III consists of treating the excavated soil by composting. Implementation of this alternative consists of temporarily storing excavated soil at a liner/berm storage area. At the earliest possible time, the excavated soil is moved from interim storage to the on-site treatment facility, and treatment begins. Treatment continues until the RCL is achieved or until the soil is acceptable for placement in the sanitary landfill. After treatment is complete, the soil is disposed of at the Airport Authority sanitary landfill. Even though initial screening has indicated that trench backfill is the preferred soil disposal option, disposal in the adjacent sanitary landfill is coupled with the composting treatment option, because the time period required for treatment may exceed the time period required for the installation of the new fuel lateral system. Thus, the treated soil is unavailable for use when trench backfill is required.

4.3.4 Alternative IV: Off-site Incineration

Alternative IV consists of treating the contaminated soil through off-site incineration. In this alternative, the excavated soil is transported to an incinerator and incinerated, and the residual ash is disposed of at a permitted landfill near the off-site incinerator.

4.3.5 Alternative V: On-site Incineration

Alternative V consists of treating the excavated soil through on-site incineration. Implementation of this alternative consists of temporary storage of excavated soil at a liner/berm storage area until the incinerator can be assembled on site. At the earliest possible time, the excavated soil is moved from interim storage to the on-site treatment facility, and treatment begins. Treatment continues until the RCL is achieved or until the soil is acceptable for placement in the sanitary landfill adjacent to the ANGB on Airport Authority property. After treatment is complete, the soil is disposed of at the Airport Authority sanitary landfill.

4.3.6 Alternative VI: Vacuum Extraction

Alternative VI consists of treating the excavated soil by vacuum extraction. Implementation of this alternative consists of temporary storage of excavated soil at a liner/berm storage area. At the earliest possible time, the excavated soil is moved from interim storage to the on-site treatment facility, and treatment begins. Treatment continues until the RCL is achieved or until the soil is acceptable for placement in the sanitary landfill adjacent to the ANGB on Airport Authority property. After treatment is complete, the soil is disposed of at the Airport Authority sanitary landfill. Even though initial screening has indicated that trench backfill is the preferred soil disposal option, disposal in the adjacent sanitary landfill is coupled with the vacuum extraction treatment option, because the time period required for treatment may exceed the time period required for the installation of the new fuel lateral system. Thus, the treated soil is unavailable for use when trench backfill is required.

4.3.7 Alternative VII: No Action and Trench Backfill

Alternative VII consists of the no-action treatment option followed by disposal through trench backfill. Implementation of this alternative consists of temporary storage of the excavated soil at a liner/berm storage area during the interim period between initial excavation and installation of the new fuel lateral system. After the new fuel lateral system is installed, the contaminated soil is replaced in the trenches as backfill.

5. DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

5.1 EVALUATION CRITERIA

Remedial options will be evaluated with five screening criteria. These criteria facilitate additional alternative development and discrimination. This provides a justifiable methodology to select the preferred alternative.

The seven alternatives developed for handling contaminated soil encountered in the installation of the new fuel lateral system are included in the additional detailed evaluation. Obviously, the single method developed for abandoning the existing fuel lateral system is the preferred alternative and needs no additional screening or evaluation.

The EPA guidance document (EPA 1988) recommends nine evaluation criteria be addressed during detailed analysis:

- short-term effectiveness;
- long-term effectiveness;
- reduction of toxicity, mobility, and volume;
- implementability;
- costs;
- compliance with ARARs, RCLs, or appropriateness for waiver;
- overall protection of human health and the environment;
- state acceptance; and
- local acceptance.

The uniqueness of this site combined with the focused approach utilized by this feasibility study warrant evaluating remedial alternatives with five evaluation criteria:

- performance (effectiveness) and reliability,
- implementability and ease of undertaking additional corrective action,
- environmental and public health impact,
- compliance with regulations or guidelines, and
- cost.

The following sections describe the five evaluation criteria. In addition, they address how each criterion includes the above-mentioned nine EPA criteria.

5.1.1 Performance (Effectiveness) and Reliability

This criterion addresses the concerns of short-term effectiveness; long-term effectiveness; and reduction of toxicity, mobility, and volume. Effectiveness is evaluated for each remedial alternative by its efficiency in supplying environmental protection from contaminant exposure. Reducing contaminant exposure to acceptable levels may be achieved by treatment, containment, or elimination of exposure pathways. Effectiveness is also defined by the time required for each alternative to attain the RCL.

Reliability addresses the degree that each alternative reduces contaminant toxicity, mobility, and volume. An alternative involving destruction provides a more reliable and permanent solution than one employing containment or elimination of exposure pathways.

Reliability also assesses the degree that each alternative can be expected to provide continued ensurance of environmental protection. This criterion assesses the amount of contaminant that still exists after remedial action is complete. It also assesses the degree that the alternative satisfies any necessary post remedial action monitoring and its potential to prevent any future liability by the KSANG. The sensitivity of each alternative's performance to any pertinent parameter uncertainties (i.e., different waste volume and concentrations, cost, institutional permitting and acceptance) is also addressed in the reliability assessment.

5.1.2 Implementability and Ease of Undertaking Additional Corrective Action

This criterion addresses the potential for implementation of each alternative. All alternatives are technically feasible and can be implemented. To further discriminate between them, each is assessed as to how well it facilitates the implementation of any additional corrective action.

5.1.3 Cost

Cost is evaluated as a comparative estimate among alternatives. Cost evaluation includes not only the capital cost of actual remedial facility construction but also those costs involved in facility operation, post remedial monitoring, disposal fees, and administrative expenses.

5.1.4 Environmental and Public Health Impact

Overall protection of human health and the environment as well as state and local acceptance is addressed by this criterion. Long-term environmental impact is considered as well as the impact the alternative has during implementation.

5.1.5 Compliance with Regulations and Guidelines

Each alternative's compliance with appropriate guidance documents and RCLs is considered. If an alternative cannot be shown to be in compliance, it will be evaluated for its appropriateness for a waiver under the six options offered under Section 121(d)(4) of the CERCLA statutes.

5.2 CRITERIA WEIGHTING

Each alternative is rated according to the five evaluation criteria described. The evaluation criteria are not, however, considered to be of equal importance in determining the preferred treatment alternative. The relative importance of each of the evaluation criteria follows:

- performance (effectiveness) and reliability (30%),
- environmental and public health impact (25%),
- cost (25%),
- implementability and ease of undertaking additional corrective action (10%), and
- compliance with regulations and guidelines (10%).

The primary objective of this FFS is to select a remedy that supplies environmental protection in a cost-effective manner. This objective dictates the importance of the evaluation criteria of performance (effectiveness) and reliability, environmental and public health impact, and cost. The evaluation of performance (effectiveness) and reliability includes implicit considerations of how well each alternative complies with regulations and guidelines as well as the need for additional corrective action. Therefore, the weighting criteria for compliance with regulations and guidelines and implementability and ease of undertaking additional corrective action are reduced in importance proportionately.

5.3 COLLECTIVE EVALUATION OF TREATMENT ALTERNATIVES

Each of the remedial alternatives developed for handling contaminated soil is evaluated individually against the five evaluation criteria specified in Sect. 5.1. The alternative is assigned a ranking score on a scale from 0 to 10 (0, poor compliance; 10, excellent compliance) for each criterion. The ranking score is then adjusted by the appropriate weighting coefficient to determine the impact the criterion will have on the overall preference of the alternative. Finally, after the alternatives are fully evaluated individually, they are evaluated collectively in Table 4, which shows the summed, weighted scores for each evaluation criterion. This weighted sum is then used to indicate the order of preference of each alternative (largest score, most preferred; smallest score, least preferred). Preference rankings for the alternatives are shown at the bottom of Table 4. The appendix contains the detailed analysis for each of the alternatives of the five evaluation criteria.

5.4 PREFERRED REMEDIAL ALTERNATIVE

As shown in Table 4, the preferred remedial alternative for handling the contaminated soil from the installation of new fuel laterals is no action and trench backfill. Landfarming, composting, and enhanced volatilization and natural biodegradation follow in descending order of preference.

Table 4.
Collective evaluation of alternatives

Evaluation criteria	Alternative Ratings (weighted)[a]						
	(1) Enhanced volatilization/ natural	(2) Landfarming	(3) Composting	(4) Incineration (off site)	5) Incineration (on site)	(6) Vacuum extraction	(7) No action/ trench backfill
Effectiveness, permanence, reliability	1.5	2.4	2.4	2.7	3.0	1.8	2.1
Implementation/ease of undertaking additional corrective action	0.9	0.9	0.8	0.6	0.6	0.8	0.9
Cost	2.0	1.8	1.5	0.0	0.3	1.5	2.5
Environmental impact	1.5	2.0	2.0	1.3	1.5	1.3	2.0
Compliance with regulations or guidelines	0.7	0.0	0.0	1.0	1.0	0.7	0.7
Total weighted score	6.6	8.0	7.6	5.6	6.4	6.6	8.2
Relative preference of each alternative (1-most preferred) (7-least preferred)	4	2	3	7	6	5	1

[a]Relative preference of each alternative: 1 = most preferred and 7 = least preferred.

6. RECOMMENDATIONS FOR PREFERRED ALTERNATIVE

6.1 PREFERRED ALTERNATIVE DESCRIPTION

6.1.1 Abandonment of Existing Fuel Laterals

It is recommended that the decommissioned fuel laterals be abandoned in place.

6.1.2 Handling Contaminated Soil

The preferred alternative for dealing with contaminated soil encountered during the installation of the new fuel lateral system is no action and trench backfill. The no-action treatment option is warranted because subsurface hydrological characteristics at the site provide the degree of containment necessary to ensure environmental protection. These containment characteristics are substantiated by the findings of the RIR (ORNL 1989), which indicates contaminants are not migrating off site. Thus, replacing the soil in the excavated trenches is an environmentally sound procedure consistent with established site characteristics. During the interim period between initial excavation and final trench backfill, the contaminated soil is stockpiled on a liner surrounded by a berm.

6.1.3 Summary

The preferred remedial alternative is summarized in Table 5.

6.2 HEALTH AND SAFETY CONSIDERATIONS

The construction contractor needs to be notified of the potential health risks involved with excavating contaminated soil so that proper protective equipment is available and monitoring is conducted.

6.3 REGULATORY ACTIONS

Because no treatment of the soil is required, no permits are necessary. Discussions with the state of Kansas indicate no air quality permits are needed for the release of volatiles during soil excavation

Table 5
Focused feasibility study preferred remedial alternative,
Forbes Field Air National Guard Base

Abandonment of existing fuel laterals	Handling Contaminated Soil		
	Temporary soil storage	Soil treatment	Soil disposal
Abandoned in place	Liner/berm	No action	Trench backfill

and stockpiling (Harish Adarwal, Section Chief, Bureau of Air Quality and Radiation Control, Kansas Department of Health, personal communication, January 30, 1989).

7. ENVIRONMENTAL ASSESSMENT

7.1 INTRODUCTION

This section of the FFS provides a brief assessment of the environmental impacts of construction activity and the preferred alternative: abandon fuel laterals in place; store excavated soil at a covered, bermed, lined location; and use the excavated soil as trench backfill.

The sites identified in the RIR that may be impacted by the construction activity are sites 5, 7, 8, 9, and the "hot spot" along lateral 6. There is no indication of contamination in the construction area by chemicals other than those associated with JP-4. Approximately 35 acres will be affected by the construction activity and a total of about 2900 yds^3 of soil will be excavated.

7.2 IMPACTS OF CONSTRUCTION AND THE PREFERRED ALTERNATIVE

7.2.1 Impacts on Air Quality

Routine air monitoring conducted during the drilling of the monitoring wells for the RI indicated that volatilization of JP-4 components to the atmosphere under the conditions of drilling was insignificant. The drilling, however, purposely avoided the trenches, which are the sites of heaviest contamination. Construction activity involving the trenches has the potential to release quantities of volatile fuel components to the atmosphere.

Air quality in the region is good, and prevailing winds tend to quickly disperse and dilute any volatile contaminants or dust released as a result of the construction activities; no detrimental effects to the ambient air quality standards of the region are expected.

7.2.2 Impacts on Groundwater Resources

The groundwater in the area is associated with unconsolidated alluvial glacial deposits. Measured values of hydraulic conductivity for the area indicate low values of 3.5 x $^{10-5}$ to 7.1 x 10^{-4} cm/s. Additionally, there is no indication of contaminant plumes migrating from the area, and the aquifer is 3 to 9 ft below the effected fuel laterals. The aquifer underlying the Forbes Field ANGB is not utilized as a water source in the immediate area of the base.

The large distances between the base and any well fields in the area and the impermeable nature of the aquifer provide a reliable means of containment for any contaminants exposed during remedial action. Therefore, it is anticipated that the proposed activities will have no adverse effects on groundwater resources in the area.

7.2.3 Impacts on Surface Water

7.2.3.1 Hydrology

Soil excavated during construction and stockpiled on the aircraft parking ramp while awaiting return to the trenches as backfill (in accordance with the preferred remedial alternative) can create runoff problems if not properly contained. The aircraft parking is drained by grated catchment basins set flush with the surface. These are attached to the storm sewer system, which drains into the small pond associated with the drainage ditch. Fuel from the excavated soil could drain to the storm drainage system and then to the surface drainage ditch, which flows into the South Branch of Shunganunga Creek, about 1.5 miles from the base. This should not be a problem because the excavated soil will be stockpiled in a properly lined, bermed, and covered area.

7.2.3.2 Water Quality

The quality of water in the area streams is generally too poor for domestic or irrigation use. Proper storage and containment of the excavated soil before the preferred remedial action is undertaken will ensure that there will be no impacts upon water quality in the area.

7.2.3.3 Sediment Quality

The RIR data showed that some sediment samples from the drainage ditch are contaminated with fuel-related compounds, polynuclear aromatic compounds, and pesticides. Proper containment of the excavated soil will prevent any runoff from reaching the ditch. Therefore, the construction activity and the preferred remedial action will have no adverse effect on sediment quality in the drainage ditch.

7.2.4 Impacts on Soils

The tight clay in the area inhibits leaching of contaminants from the trenches into surrounding soils. Hydraulic conductivity values for the clay soils are very low. All data in the RIR indicate that JP-4 spills have remained in the sandy backfill of the fuel lateral trenches with very little migration into the surrounding, undisturbed silty clay. Based on the analytical results from the RIR, the maximum concentration of total petroleum hydrocarbons expected to be encountered in the soil within the trench areas is 800,000 μg/kg. Outside the trench area soil concentration of 20,000 to 30,000 μg/kg can be expected. The construction activity and the preferred remedial alternative will have a positive impact on the fuel-contaminated soils because the release of volatile components will lower the level of contamination in the soil.

7.2.5 Impacts on Ecological Resources

Section 2.2.9 in Vol. 1 of the RIR describes the general ecology of the area. The construction activities and the implementation of the proposed remedial alternative are not anticipated to have any impacts upon the ecological resources (aquatic or terrestrial) described in the RIR, nor will there be any impacts upon endangered or threatened species or floodplains and wetlands. Proper containment and handling of the fuel-contaminated soil will prevent any runoff to the drainage ditch that joins the South Branch of the Shunganunga Creek 1.5 miles downstream.

7.2.6 Impacts on Socioeconomic Resources

7.2.6.1 Land Use and Transportation

Increased traffic will result from construction activity, but this is not anticipated to have any adverse impacts on the environment or the area's transportation system.

7.2.6.2 Employment

The relatively small work force involved in the remedial activities indicates there will be no impact on socioeconomic resources.

7.2.6.3 Public Perceptions

The public will be assured that surface water and groundwater have very little chance of being contaminated as a result of the construction activity and the preferred remedial action. Moreover, there is no potential for human exposure to fuel-related contaminants beyond the Forbes Field ANGB area.

The possibility of dust caused by the construction activities blowing toward the day-care center that borders the Forbes Field ANGB to the west near the tank farm area is the only public concern that may warrant investigation.

7.2.7 Impacts on Archaeological and Historic Resources

The construction activity and preferred remedial action will occur entirely on Forbes Field ANGB near the runway; there will not be any impacts on any archaeological or historic resources.

7.2.8 Impacts on Worker Health and Safety

When excavating there is a potential risk for exposure of workers to explosive hazards or contaminants through inhalation or skin contact. No excavations should be undertaken without workers preparing to encounter and manage fuel-contaminated soil. It is recommended that a qualified industrial hygienist be on site to monitor air exposure. Recommended action levels for personnel involved with construction are stated in Sect. 2.1.2 of the FFS.

Workers must be aware of procedures to alleviate hazards, must have adequate training, and must be properly warned of potential hazards. The implementation of health and safety measures should be monitored by appropriate personnel.

Forbes Field ANGB is a restricted area; therefore, any direct contact with contaminant pathways is confined to trained personnel.

7.3 CONCLUSIONS

The construction activity and preferred remedial action will not have any significant short-term or long-term environmental impacts.

8. CONCLUSIONS AND RECOMMENDATIONS

Following is a summary of the conclusions and recommendations contained in this FFS.

1. The abandoned fuel laterals should be left in place, disconnected from the fuel system, capped, and located on utility maps as abandoned lines.

2. The excavated soil should be stockpiled on a liner or existing paved area, surrounded with a berm, and covered with plastic.

3. The excavated soil should be disposed of in the trench as backfill.

4. The construction activity and preferred remedial action should not have significant short-term or long-term environmental impacts.

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APPENDIX

DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

Table A-1.
Evaluation of remedial alternatives

Alternative	Comments	Raw score	Weighted score
A. Performance (effectiveness) and reliability			
Alternative I: Enhanced volatilization and natural biodegradation	Minimal unenhanced reduction	5	1.5
	Potential for wind and dust exposure		
	Long treatment time		
Alternative II: Landfarming	Contaminant reduction	8	2.4
	Potential for wind and dust exposure		
	Unknown treatment time		
Alternative III: Composting	Contaminant reduction	8	2.4
	Potential for enhanced volatile exposure		
	Unknown treatment time		
Alternative IV: Incineration (off site)	Contaminant reduction	9	2.7
	Potential for exposure during off-site transport		
	Short treatment time		
Alternative V: Incineration (on site)	Contaminant reduction	10	3.0
	Short treatment time		
Alternative VI: Vacuum extraction	No contaminant reduction	6	1.8
	Enhanced volatilization		

Table A-1 (continued)

Alternative	Comments	Raw score	Weighted score
Alternative VII: No action and trench backfill	No contaminant reduction	7	2.1
	Short treatment time		
B. Implementability/ease of undertaking additional corrective action			
Alternative I: Enhanced volatilization and natural biodegradation	Easily accessible during interim storage	9	0.9
	Susceptible to other forms of treatment		
Alternative II: Landfarming	Easily accessible during treatment and interim storage	9	0.9
	Susceptible to other forms of treatment		
Alternative III: Composting	Easily accessible during treatment and interim storage	8	0.8
	Manifold system may hamper access		
	Susceptible to other forms of treatment		
Alternative IV: Incineration (off site)	Not susceptible to other forms of treatment	6	0.6
Alternative V: Incineration (on site)	Not susceptible to other forms of treatment	6	0.6

Table A-1 (continued)

Alternative	Comments	Raw score	Weighted score
Alternative VI: Vacuum extraction	Easily accessible during treatment and interim storage	8	0.8
	Manifold system may hamper access		
	Susceptible to other forms of treatment		
Alternative VII: No action and trench backfill	Easily accessible during treatment and interim storage	9	0.9
	Susceptible to other forms of treatment		
	C. Cost		
Alternative I: Enhanced volatilization and natural biodegradation	Unknown treatment time	8	2.0
	Disposal fees		
Alternative II: Landfarming	Unknown treatment time	7	1.75
	Disposal fees		
	Monitoring costs		
Alternative III: Composting	Unknown treatment time	6	1.5
	Disposal fees		
	Monitoring costs		
	Cost of air manifold system		
Alternative IV: Incineration (off site)	Cost intensive	0	0.0
	Cost of off-site transport		

Table A-1 (continued)

Alternative	Comments	Raw score	Weighted score
Alternative V: Incineration (on site)	Cost intensive	1	0.25
Alternative VI: Vacuum extraction	Long treatment time Disposal fees Monitoring Costs Cost of air manifold system	6	1.5
Alternative VII: No action and trench backfill	Cost of temporary storage only	10	2.5
	D. Environmental and public health impacts		
Alternative I: Enhanced volatilization and natural biodegradation	Creation of wind/dust exposure Exposure to workers during implementation Minimal unenhanced reduction	6	1.5
Alternative II: Landfarming	Creation of wind and dust exposure Exposure to workers during implementation Contaminant reduction	8	2.0

Table A-1 (continued)

Alternative	Comments	Raw score	Weighted score
Alternative III: Composting	Potential for enhanced volatile exposure Exposure to workers during implementation Contaminant reduction	8	2.0
Alternative IV: Incineration (off site)	Potential exposure pathway from accidental spill during off-site transport Potential for poor public acceptance Contaminant reduction Residual ash disposal Air emissions	5	1.25
Alternative V: Incineration (on site)	Potential for poor public acceptance Contaminant reduction Residual ash disposal Air emissions	6	1.5
Alternative VI: Vacuum extraction	Exposure to workers during implementation No contaminant reduction Air emissions	7	1.75

Table A-1 (continued)

Alternative	Comments	Raw score	Weighted score
Alternative VII: No action and trench backfill	Minimal exposure to workers No contaminant reduction	8	2.0
	E. Compliance with regulations and guidelines		
Alternative I: Enhanced volatilization and natural biodegradation	Minimal unenhanced contaminant reduction anticipated but unproven[a]	7	0.7
Alternative II: Landfarming	Contaminant reduction anticipated but unproven[b]	9	0.9
Alternative III: Composting	Contaminant reduction anticipated but unproven[b]	9	0.9
Alternative IV: Incineration (off site)	Contaminant reductionc	10	1.0
Alternative V: Incineration (on site)	Contaminant reductionc	10	1.0
Alternative VI: Vacuum extraction	No contaminant reduction[a]	7	0.7
Alternative VII: No action and trench backfill	No contaminant reduction[a]	7	0.7

Table A-1 (continued)

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[a]Environmental protection ensured to RCL of 100 ppm (Sect. 2.1.2) through containment only. Offers the least amount of satisfaction for the CERCLA statutory requirement that the remedial action utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

[b]Environmental protection to the RCL of 100 ppm (Sect. 2.1.2) achieved by anticipated contaminant reduction and ensured by final containment. Offers a higher degree of satisfaction for the CERCLA statutory requirement that the remedial action utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

[c]Environmental protection ensured to the RCL of 100 ppm (Sect. 2.1.2) through substantial contaminant reduction and final containment of residual ash. Offers the highest degree of satisfaction for the CERCLA statutory requirement that the remedial action utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

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