PELA

SCREENING OF REMEDIAL CONTROL MEASURES AND TECHNOLOGIES, INSTALLATION RESTORATION PROGRAM, BUILDING 3001 TINKER AIR FORCE BASE, OKLAHOMA (SITE IDENTIFICATION NO. TINKER OT01)

CONTRACT NO. DACA56-87-M-0034

PROJECT NO. WWYK86-311

(PELA No. 486602)

Prepared for

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May 13, 1988

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Screening remedial alternatives will assist in formulating a remedial action plan for contaminated ground water beneath and in the vicinity of Building 3001 which will assure environmental and public-health protection. The first step of a feasibility study for Building 3001 and the adjacent fuel-contaminated areas is the screening of the possible control measures and technologies. The control measures screened are listed below:

1. Ground-water control technologies
2. Soil and sediment control technologies
3. Surface flow control technologies
4. Air/soil pore space control technologies
5. Drinking water and sewer line control technologies
6. Air pollution control technologies
7. Land disposal/storage technologies
8. In-situ treatment technologies
9. Surface treatment technologies
10. Management methods
11. No-action plan
12. Disposal of treated water.

Ninety control measure technologies were screened. Feasibility, cost, and protection of the environment and public health were the primary criteria used to determine applicability of control technologies.

A control technology passed the screening process for Building 3001 and the adjacent fuel-contaminated areas when it was applicable as

an individual technology or when it could be used in combination with other technologies. Some factors that were considered when evaluating the technologies were: the types of contamination; the areal and vertical extent of contamination; and the presence of Building 3001, parking lots, fuel tanks, runways, and other man-made features.

Based on the screening results, the best remediation plan for the Building 3001 site will include a system of ground-water control, surface treatment of collected ground water, disposal of the treated water, and management controls. The ground-water control will consist of pumping to control the contaminant plumes and collect contaminated water. Several alternative surface treatment methods and systems exist, which are listed below:

Potential Surface Treatment Methods or Systems

Precipitation

Reduction

Ion exchange

Carbon adsorption

Oxidation

Ultra-violet oxidation

Flow equilization

Oil/water separation

Air stripping

Existing industrial waste treatment plan (IWTP)

Modification of IWTP

Combinations of these methods will likely be necessary to treat the variety of organic compounds and heavy metals present in the ground water. Detailed alternatives should be developed from these treatment methods. Treated water should be disposed of by one or more of the following methods:

Potential Methods for Disposal of Treated Water

Discharge into IWTP

Discharge to sanitary sewers

Discharge to storm sewers

Discharge to stream

Aquifer recharge

Industrial use

Irrigation

A detailed feasibility study should be conducted to determine the best disposal method(s). The management methods to employ should consist of land-use controls, alternative water supplies, personnel supervision and training, and coordination with regulatory agencies. Land-use controls have already been implemented since discharges of industrial wastes and solvents have been stopped.

The best remedial action plan for the two fuel-contaminated areas will be the most feasible control measure or combination of control measures from the following:

Potential Control Measures for Fuel-Contaminated Areas

Ground-water control

Soil and sediment control

Surface flow control

Air/soil pore space control

In-situ treatment

Surface treatment of collected ground water

Disposal of treated water

Management controls

Ground-water control would consist of pumping to collect and/or control the contaminants and possibly separating the water and product (oil/water separation). Soil control would consist of excavation; and surface controls would employ grading, capping, and/or surface-water diversion. Gas ventilation could be used for air/soil pore space control, and aeration of the soil will provide a potential in-situ treatment measure. If ground water is collected, the hydrocarbon related organics could be removed by air stripping and as treated water from beneath Building 3001. Management controls consist of proper land use. A detailed feasibility study will determine the most applicable combination of remedial measures.

RECOMMENDATIONS

The next phase of work, in accordance with the Air Force Installation Restoration Program (IRP) and EPA, is the development of detailed alternatives, based on the technologies passing the screening process for each of the control measures listed. The remedial action plan for the Building 3001 site should consist of the following control measures:

Ground-water control

Surface treatment of collected ground water

Disposal of treated water

Management controls

The remedial action plan for the adjacent fuel-contaminated areas should consist of one or more of the following control measures:

Ground-water control

Soil and sediment control

Surface flow control

Air/soil pore space control

In-situ treatment

Surface treatment of collected ground water

Disposal of treated water

Management controls

A feasibility study of detailed alternatives, developed from the various control measures and technologies which passed the screening process, should be conducted. Each detailed alternative should represent a site-specific, comprehensive solution to contamination at Building 3001 and adjacent fuel contaminated areas. The alternatives should be sufficiently detailed to permit completion of the feasibility study, which includes evaluation and selection of an alternative according to engineering, public-health, environmental, cost and regulatory compliance criteria.

Control measures and technologies to be detailed as alternatives for the IRP are:

For Building 3001

1. Ground-water control by pumping
2. Surface treatment methods (one or more of the following)
   a. Precipitation
   b. Ion exchange
   c. Reduction
   d. Carbon absorption
   e. Oxidation
   f. Ultra-violet oxidation
   g. Flow equilization
   h. Filtration
   i. Oil/water separation
   j. Air stripping
   k. Biological treatment
   l. Existing IWTP
   m. Modification of IWTP
   n. Land-use controls
3. Disposal methods
   a. Discharge to IWTP
   b. Discharge to sanitary sewers

c. Discharge to storm sewers

d. Discharge to stream

e. Aquifer recharge

f. Industrial use

g. Irrigation

4. Management methods

a. Land-use controls

b. Alternative water supply

c. Relocation

d. Right-of-way acquisition

e. Personnel supervision and training

f. Coordination with federal, state, and local agencies

<u>For Adjacent Fuel-Contaminated Areas</u>

1. Ground-water control

a. Pumping

b. Oil/water separation

c. Capping

2. Soil and sediment control

a. Excavation

b. Revegetation

3. Surface flow control

a. Grading

b. Capping

c. Surface-water diversion

4. Air/soil pore space control

a. Gas ventilation

5. In-situ treatment

   a. Soil aeration

6. Surface treatment of collected ground water

   a. Air stripping

   b. Oil/water separation

   c. Flow equalization

   d. Existing industrial waste treatment plant (IWTP)

7. Disposal of treated water

   a. Discharge to IWTP

   b. Discharge to sanitary sewers

   c. Discharge to storm sewers

   d. Discharge to stream

   e. Aquifer recharge

   f. Industrial use

   g. Irrigation

8. Management controls

   a. Land-use controls

   b. Alternative water supply

   c. Relocation

   d. Right-of-way acquisition

   e. Personnel supervision and training

   f. Coordination with federal, state, and local agencies

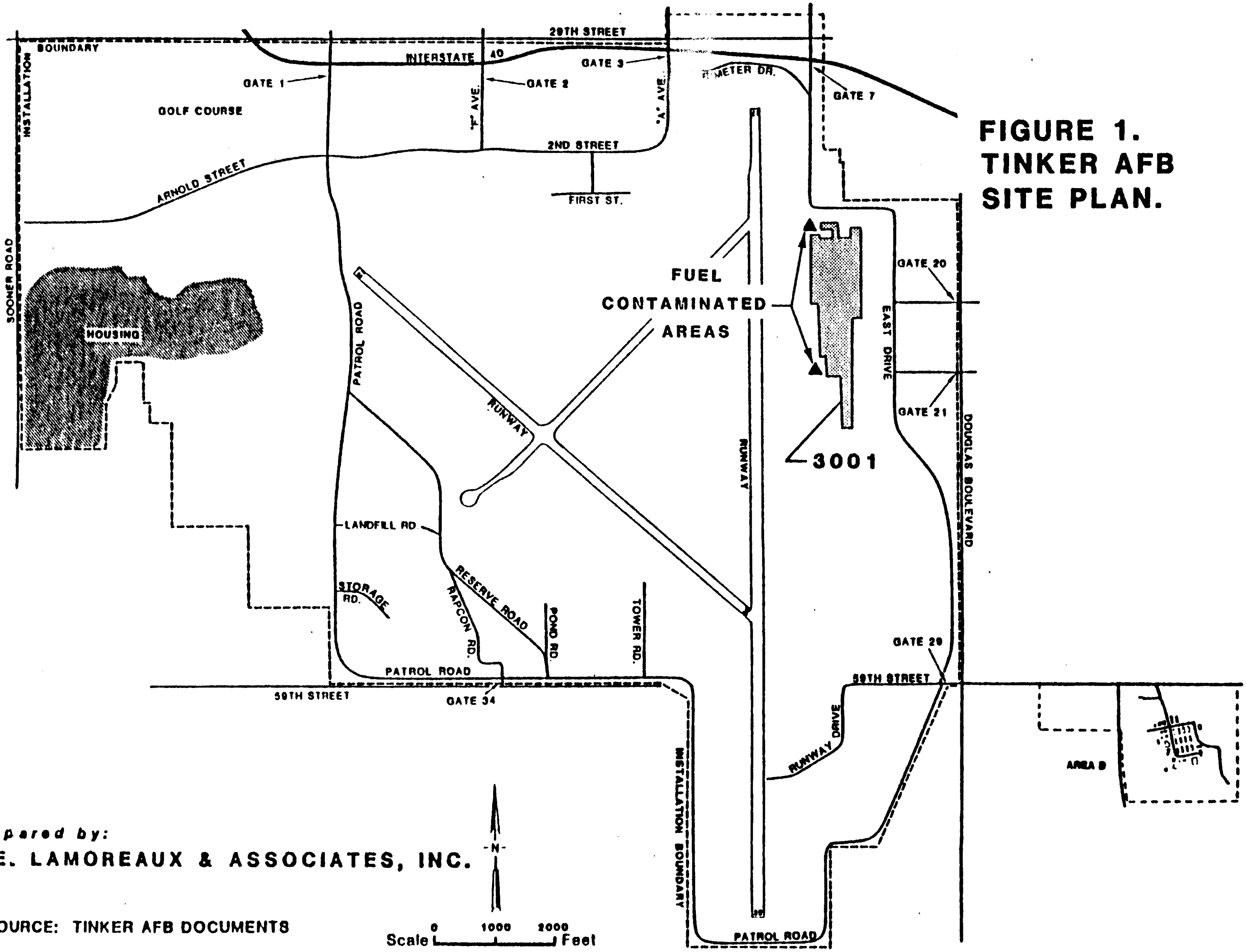
1.0 INTRODUCTION

P. E. LaMoreaux & Associates, Inc. (PELA) was authorized by the Tulsa District Corps of Engineers to review and screen methods and technologies for remedial actions for contaminated ground water in the vicinity of Building 3001, Tinker Air Force Base, Oklahoma. This investigation included review by P. E. LaMoreaux & Associates, Inc. of available data from previous work by Engineering Science; Radian Corporation; A. L. Burke Engineers, Inc.; Dansby & Associates, Inc.; and the Tulsa District Corps of Engineers. Additional information was obtained from published and unpublished data from the U.S. Geological Survey, the Oklahoma Geological Survey, and the Department of the Air Force. The purpose of this review and screening process is to eliminate technologies that are clearly not feasible or appropriate to remediate the contamination problem beneath Building 3001.

1.1 Site Location and Background Information

Tinker Air Force Base is located in the central Redbed Plains section of the Central Lowland physiographic province of Oklahoma. Within Oklahoma County, the Base is adjacent to Oklahoma City, Midwest City, and Del City. The Base lies within a transition zone from residential and commercial land use to the north and west to agricultural land use to the east and south. A general map of Tinker Air Force Base with Building 3001 illustrated is shown in Figure 1.

FIGURE 1. TINKER AFB SITE PLAN.



Prepared by:
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SOURCE: TINKER AFB DOCUMENTS

MODIFIED FROM ENGINEERING SCIENCE 1982

The chronology of activities that follows is based on review of previous studies, memoranda and correspondence, and interpretation of aerial photographs.

Building 3001 has expanded considerably in size since opening in 1942. During its history, numerous hazardous materials were utilized on the premises for refurbishing aircraft and aircraft parts.

At least five investigatory reports on contamination beneath Building 3001 have been prepared since 1982. In 1982, Engineering Science performed a records search. In 1984, Radian Corporation performed an investigation for the Installation Restoration Program. The investigation was a confirmation and quantification of contamination of Tinker Air Force Base. In 1986, A. L. Burke Engineers, Inc. performed an investigation of underground tanks and pits at the Base that included soil sniffer tests. In 1986, Dansby & Associates, Inc. prepared a report on the plugging of Base water supply wells 18 and 19. In 1987, P. E. LaMoreaux & Associates, Inc. prepared a technical review of the Building 3001 remedial investigations performed by the Corps of Engineers.

1.2 Nature and Extent of Problems

Past industrial practices within and in the vicinity of Building 3001 have resulted in ground-water contamination of an underlying perched aquifer and upper zones of the Garber-Wellington aquifer. The Environmental Protection Agency has placed the site on the National Priorities List of hazardous waste sites. Building 3001 houses a large industrial complex where aircraft and jet engines are services, repaired, and/or upgraded. Remedial investigations have been conducted in order to define the extent and magnitude of contamination. The investigations are part of the U.S. Air Force Installation Restoration Program (IRP). The primary contaminants are trichloroethylene (TCE) and chromium (Cr) although other organic compounds and trace metals are present. The maximum area of contaminated ground water covers approximately 220 acres beneath the site and extends to a depth of approximately 175 feet. The highest contaminant concentrations exist beneath the building in the perched aquifer, where 330,000 ug/ℓ of trichloroethylene and 80,000 ug/ℓ of chromium were detected. Two underground storage tank areas, referred to as the north and the southwest tan' areas, were included in the remedial investigations. Fuel product s found floating on the perched ground water at the north tank area and both tank areas contain benzene, toluene, and xylene contamination in the perched ground water.

The remedial investigations included records searching, investigating abandoned solvent pits within the building, investigating the hydrogeological site conditions, installing a ground-water monitoring well network, sampling water supply wells and monitoring wells, and conducting aquifer tests. As a corrective action, two water supply wells were permanently plugged during the course of the investigations. Data were analyzed to define the hydrogeologic conditions and extent of contamination. A ground-water and contaminant transport model was developed to simulate contaminant migration within the aquifer system.

The ground-water contamination, which consists of organic solvents, trace metals, and fuel product, is primarily a result of past industrial operations and storage practices which have now been corrected. Contamination has probably entered the perched aquifer by vertical migration from solvent pits inside the building, storm drains, West Soldier Creek, and underground storage tanks.

The hydrologic and the hydrogeologic systems at the site are complex and interdependent. Runoff is carried to East and West Soldier Creeks by surface drainage and storm drains. Both West Soldier Creek and the storm drain system apparently recharge a perched aquifer beneath the site. In the past, contaminants were discharged into storm drains and later detected in both East and West Soldier Creeks. The contaminants are also present in the perched aquifer. Hydrogeologic investigations indicate that the perched aquifer (beneath the east portion of the building) discharges into East Soldier Creek and therefore some contaminants have the potential of being discharged into East Soldier Creek. The perched aquifer and East Soldier Creek are sources of contamination to the regional aquifer.

The regional aquifer is contaminated in the upper two more permeable zones, referred to as the top of regional and the regional zones. The geologic formations are characterized by very low vertical permeabilities and therefore limited vertical migration has occurred compared to horizontal migration. The horizontal migration has extended beyond water supply well locations in Tinker Air Force Base and has allowed downward migration of contaminants via poorly sealed wells. Two wells have been plugged (wells 18 and 19) and two wells (wells 15 and 16) currently contain trace levels of organic compounds.

The contaminated ground water and the presence of two fuel contaminated sites are primary public health and environmental concerns. Steps need to be taken to select the necessary action required to remedy site problems. A review of potential remedial alternatives has been performed to eliminate those clearly not appropriate to the problems at Building 3001 and the two fuel contaminated areas.

1.3 Objectives of Screening Remedial Technologies

Screening remedial technologies will assist in formulating a remedial action plan for contaminated ground water beneath and in the vicinity of Building 3001 which will assure environmental and public-health protection. A review and screening of all technologies of remediation will require consideration of environmental and public-health protection as established by CERCLA, SARA, RCRA, and NCP.

Engineering feasibility of a remedial technology is determined by the applicability of individual control measures and the degree to which a detailed alternative will perform its intended function. Three elements--performance, reliability, and implementability--are reviewed to determine engineering feasibility and regulatory compliance of federal, state, and local agencies.

Screening of a remedial technology from a cost analysis standpoint considers: 1) the capital cost, which is high when greater than 2 million dollars; 2) the operation and maintenance cost, which is high when greater than .3 million dollars per year; 3) present worth analysis, which is determined by expenditures occurring over different time periods and are evaluated by discounting future costs to a common base year; and 4) sensitivity analysis, which assesses the effects of variations in parameters associated with design, implementation, operation, and effective life that could result in a significant change in overall costs.

Screening of a remedial technology from an environmental standpoint considers the impacts of the technology on hydrology, geology, air quality, flora and fauna, socio-economics, land use, and cultural resources. The technology should be reviewed in detail to determine any adverse environmental impacts and any expected environmental benefits; and then a summary should be prepared to identify the most environmentally beneficial and adverse remedial technologies.

Public health is also considered in the screening of a remedial technology. The technology must be reviewed to determine the degree of short-term and long-term public health protection and the levels at which the technology will reduce adverse long-term effects of residual contamination. The technology will also be screened to determine the threat that the technology will have on workers during construction, operation, and monitoring during the implementation of the technology.

Screening of a remedial technology from a regulatory compliance standpoint considers the capability of the technology to meet design regulations and contaminant discharge requirements of federal, state, and local agencies. The screening should consider individual technologies that may have difficulties in achieving regulatory compliance on an individual basis but would be successful in regulatory compliance when used in combination with other technologies.

The initial screening process may encompass portions of several technologies and will eliminate other technologies that are clearly not feasible or appropriate to the site-specific problem.

2.0 SCREENING OF CONTROL MEASURES AND TECHNOLOGIES

Twelve (12) steps or control measures were reviewed to eliminate those that would not fit the Primary Criteria. Engineering feasibility, cost, environmental impacts, public-health protection, and regulatory compliance (water, soil, and air standards) were the primary criteria for screening the control measures. Each control measure has several technologies that may be potentially utilized to assist with remediation.

Ninety (90) control measure technologies were evaluated to determine their feasibility and applicability to the contamination situation beneath Building 3001 and the adjacent fuel contaminated areas. Most all of the technologies are methods of solving contamination problems. Data provided by the Tulsa Corps of Engineers were reviewed to determine the applicability of each technology. The types of contamination, the areal and vertical extent of contamination, and the presence of Building 3001, parking lots, fuel tanks, runways, and other man-made features were defined through this review. A control technology was eliminated from consideration when the technology would not assist in remediation due to the type of contamination, the areal and vertical extent of contamination, or limited access to the contamination because of existing structures. The ninety (90) control measure technologies that were considered are presented with a brief description of each technology in Table 1.

Each control measure technology is discussed in a section to determine its applicability to the problems at Tinker Air Force Base and is prepared in tabular form (Table 2).

Table 1. Description of Control Measure Technologies

GROUND-WATER CONTROL TECHNOLOGIES

TECHNIQUE: CAPPING

Functions: Indirectly controls ground-water contamination by reducing surface water infiltration (provides impermeable barrier), thereby minimizing leachate generation.

TECHNIQUE: GROUND-WATER PUMPING

Functions: Lowers water table to prevent ground-water contact with buried or impounded wastes; lowers water table to prevent surface discharge of contaminated ground water; contains or collects a leachate plume for delivery to treatment system.

TECHNIQUE: IMPERMEABLE BARRIERS -- Grout curtain; slurry wall; sheet piling

Functions: Upgradient from or around sites, diverts uncontaminated ground-water flow away from wastes; downslope or around sites contains/collects contaminated ground water to limit extent of aquifer pollution or protect off-site wells.

TECHNIQUE: SUBSURFACE COLLECTION DRAINS -- Collection; recirculation; treatment

Functions: Intercepts subsurface leachate before it migrates to ground water; collects and transports leachate to retreatment system or for recirculation.

TECHNIQUE: SURFACE-WATER DIVERSION AND COLLECTION STRUCTURES -- Dikes and berms; ditches, diversions, and waterways; terraces and benches; chutes and downpipes

Functions: Upslope of sites may indirectly control ground-water contamination by intercepting and diverting surface runoff around site, reducing opportunity for runoff infiltration and minimizing leachate generation.

TECHNIQUE: PERMEABLE TREATMENT BEDS

Functions: Adsorpton, precipitation, or neutralization of certain ground-water contaminants downgradient of polluting sources.

TECHNIQUE: GRADING

Functions: Indirectly controls ground-water contamination by promoting surface runoff and reducing infiltration, therefore minimizing leachate generation.

TECHNIQUE: REVEGETATION

Functions: May be used to dry surface layers of filled refuse through root uptake/evapotranspiration, reducing volume of leachate generated, and thereby indirectly controlling ground-water contamination.

TECHNIQUE: BIORECLAMATION

Functions: Bacterial degradation/removal of petrochemical contaminants and other organics as ground water is recycled between pump stations.

Table 1. Description of Control Measure Technologies

SOIL AND SEDIMENT CONTROL TECHNOLOGIES

TECHNIQUE: CAPPING

Functions: Controls off-site transport of contaminated surface soil by capping waste site and stabilizing cover soil; prevents leachate seeps and subsequent contamination.

TECHNIQUE: GRADING AND REVEGETATION

Functions: Controls off-site erosion of cover soil; binds soil particles, protects from wind and rain.

TECHNIQUE: SURFACE-WATER DIVERSION AND COLLECTION -- Diversions; benches/terraces; sediment traps/basins

Functions: Upslope of sites, diverts eroding runoff; downslope or on-site surface, slows runoff, controls soil erosion, channels sediment-laden runoff to collection structures (traps/basins) or stabilization outlets; traps and collects sediments.

TECHNIQUE: LEACHATE CONTROL

Functions: Indirectly functions to prevent soil contamination by collecting and treating leachate that might otherwise migrate off site.

TECHNIQUE: DISPOSAL OF EXCAVATED SEDIMENTS

Functions: Safe disposal of contaminated sediments in secure landfill or by incineration.

SURFACE FLOW CONTROL TECHNOLOGIES

TECHNIQUE: SURFACE SEALING/CAPPING

Functions: Isolates waste from contact with surface runoff and infiltration; stabilizes surface of site, controls off-site transport of contaminated sediments and debris; prevents surface leaks of leachate; supports re-vegetation.

TECHNIQUE: GRADING

Functions: Shapes surface topography to provide for non-erosive runoff and minimize infiltration; supports revegetation.

TECHNIQUE: REVEGETATION

Functions: Stabilizes site surface; controls erosion by wind and water; controls off-site transport of contaminated debris; enhances surface sealing; may prepare site for future re-use.

TECHNIQUE: SURFACE-WATER DIVERSION AND COLLECTION STRUCTURES -- Dikes and berms; ditches, diversions, and waterways; terraces and benches; chutes and downpipes; levees

Functions: Upslope or at perimeter of site, channels runoff around critical areas; downslope or on site, controls off-site erosive transport of contaminated sediments; collects/channels contaminated runoff to basins/traps.

TECHNIQUE: SEEPAGE BASINS

Functions: Collects surface runoff from diversion structures and provides for recharge to ground water.

Table 1. Description of Control Measure Technologies

SURFACE FLOW CONTROL TECHNOLOGIES (continued)

TECHNIQUE: SEDIMENTATION BASINS/TRAPS -- Check dams; sedimentation basins/ponds

Functions: Collects and detains contaminated sediments eroded from disposal site surface; sediment-laden surface runoff intercepted and channeled to these structures; prevents contamination of local water courses by disposal site.

TECHNIQUE: LEACHATE CONTROL -- Collection; recirculation; treatment

Functions: Controls off-site migration of surface leachate seeps (e.g. at base of fill) by collecting and treating or recirculating leachate.

TECHNIQUE: TREATMENT OF CONTAMINATED SURFACE WATERS

Functions: Removal of contaminants by physical, chemical, and/or biological treatment methods.

AIR/SOIL PORE SPACE CONTROL TECHNOLOGIES

TECHNIQUE: CAPPING

Functions: Horizontal sealing provides impermeable barrier to upward migration/surface escape of decomposition gases and volatiles; vertical sealing prevents lateral movement; layered sealing systems may channel gases to vents and treatment structures.

TECHNIQUE: GAS BARRIERS

Functions: Horizontal sealing provides impermeable barrier to upward migration/surface escape of decomposition gases and volatiles; vertical sealing prevents lateral movement; layered sealing systems may channel gases to vents and treatment structures.

TECHNIQUE: GAS VENTILATION SYSTEMS -- Pipe vents; trench vents

Functions: Prevents lateral subsurface migration of gases; safely vents hazardous gases to the atmosphere or to treatment structures.

TECHNIQUE: GAS COLLECTION AND TREATMENT

Functions: For control of volatile toxics, and malodorous decomposition gases, removal or destruction of pollutants by thermal oxidation or adsorption.

DRINKING WATER AND SEWER LINE CONTROL TECHNOLOGIES

TECHNIQUE: PIPELINE REMOVAL AND REPLACEMENT

Functions: Replaces badly damaged sewer lines or contaminated water mains.

TECHNIQUE: LEAK DETECTION AND REPAIR -- Pipeline inspection; grouting; relining

Functions: Allows discovery and repair of leaks, cracks, etc. (points of infiltration/exfiltration).

Table 1. Description of Control Measure Technologies

DRINKING WATER AND SEWER LINE CONTROL TECHNOLOGIES (continued)

TECHNIQUE: IN-SITU CLEANING -- Scouring; flushing; dredging; suction cleaning

Functions: Cleans interiors of municipal sewer and water pipelines infiltrated by contaminated sediments or ground water; removes infiltrated contaminants.

AIR POLLUTION CONTROL TECHNOLOGIES

TECHNIQUE: CAPPING

Functions: Horizontal sealing provides impermeable barrier to upward migration and subsequent release to the atmosphere of decomposition gases and volatiles.

TECHNIQUE: DUST CONTROL

Functions: Method by which dust particles are restrained from becoming airborne.

LAND DISPOSAL/STORAGE TECHNOLOGIES

TECHNIQUE: LANDFILLS

Functions: Disposes of waste materials in impoundments, landfills, and landforms

TECHNIQUE: SURFACE IMPOUNDMENTS

Functions: One of the most common methods for disposal of industrial and municipal wastes.

TECHNIQUE: WASTE PILES

Functions: Piling waste in an area that would be removed from contact with the public and the environment.

TECHNIQUE: DEEP WELL INJECTION

Functions: Utilizing a disposal well by injecting the waste into a zone at depth below potable water.

TECHNIQUE: TEMPORARY STORAGE

Functions: Utilized when a rapid response is necessary. Storing the waste which would be disposed of at a later date in a secure landfill.

TECHNIQUE: LAND APPLICATION

Functions: Mixing or dispersion of wastes into the upper zone of the soil-plant system with the objective of microbial stabilization, adsorption, and immobilization.

IN-SITU TREATMENT TECHNOLOGIES

TECHNIQUE: BIORECLAMATION

Functions: Seeding a waste material with microorganisms to achieve degration.

Table 1. Description of Control Measure Technologies

IN-SITU TREATMENT TECHNOLOGIES (continued)

TECHNIQUE: CHEMICAL DECHLORINATION

Functions: Removing chlorine after treating to reduce the possibility of the chlorine combining with another chemical to form toxic compounds.

TECHNIQUE: HYDROLYSIS

Functions: Chemical decomposition of a substance by water whereby water is also decomposed.

TECHNIQUE: NEUTRALIZATION

Functions: Injecting chemicals into the ground beneath the waste to neutralize the leachate constituents of concern.

TECHNIQUE: OXIDATION

Functions: The direct application of a reactive material to a surface impoundment or to landfilled waste to decontaminate the hazardous components.

TECHNIQUE: PERMEABLE TREATMENT BEDS

Functions: Use of trenches filled with a reactive permeable medium to act as an underground reactor.

TECHNIQUE: POLYMERIZATION

Functions: Treatment of wastes with polymer-forming organic chemicals. The waste is solidified and becomes immobile.

TECHNIQUE: REDUCTION

Functions: Direct application of a reactive material to a surface impoundment or to landfilled waste to decontaminate the hazardous components.

TECHNIQUE: SOIL AERATION

Functions: The process of aerating the soil to assist in the biodegradation process.

TECHNIQUE: SOLVENT FLUSHING

Functions: The application of a solvent to a waste solid or sludge, and collection of the elutriate at well points for the removal and/or treatment of hazardous waste constituents. Typical solvents are water, acids, ammonia, and/or chelating agents.

TECHNIQUE: CHEMICAL PRECIPITATION

Functions: The direct application of a reactive material to a surface impoundment or to landfilled waste to decontaminate the hazardous components.

SURFACE TREATMENT TECHNOLOGIES

TECHNIQUE: INCINERATION

Functions: Incineration combusts or oxidizes organic material at very high temperatures.

Table 1. Description of Control Measure Technologies

SURFACE TREATMENT TECHNOLOGIES (continued)

TECHNIQUE: ACTIVATED CARBON ADSORPTION

Functions: Contaminated gas flowing through the carbon bed is adsorbed on the carbon surface due to Vander Waals attraction and chemical bonding.

TECHNIQUE: AIR STRIPPING

Functions: Removes volatile contaminants from an aqueous waste stream by passing air or steam through the wastes. With air, the volatile, dissolved gases are transferred to the air streams for treatment such as carbon adsorption or thermal oxidation. With steam, the process is a steam distillation of the waste with the volatile contaminants ending up in the distillate for treatment.

TECHNIQUE: STEAM STRIPPING

Functions: Removes volatile contaminants from aqueous waste stream by passing steam through the wastes. The process is a steam distillation of the waste with the volatile contaminants ending up in the distillate for treatment.

TECHNIQUE: AERATED LAGOONS

Functions: Maintains oxygen content in wastewaters to allow for biodegradation.

TECHNIQUE: STABILIZATION PONDS

Functions: Handles wastewater until treatment processing can be identified.

TECHNIQUE: BIOLOGICAL

Functions: Oxidation or hydrolysis of organic compounds in an aerated tank and the remainder removed for disposal. The effluent from the clarifier is discharged. The microorganisms in the activated sludge can acclimate to a wide variety of waste streams.

TECHNIQUE: NEUTRALIZATION

Functions: The adjustment of pH by adding a chemical agent, such as lime or sulfuric acid, to raise or lower pH, respectively.

TECHNIQUE: PRECIPITATION

Functions: A conventional process for removing soluble metals from contaminated ground water or leachate. Chemicals are added to form insoluble forms of the unwanted species.

TECHNIQUE: OXIDATION

Functions: Chemical oxidation is a method which alters the valence state of a waste constituent. Ozone, hydrogen peroxide, and chlorine are the major oxidizing agents used to treat waste. Wet air oxidation processes involve the mixing of air and aqueous waste at high temperature and pressure to the waste.

TECHNIQUE: HYDROLYSIS

Functions: The chemical decomposition of a substance by water whereby the water is also decomposed.

Table 1. Description of Control Measure Technologies

SURFACE TREATMENT TECHNOLOGIES (continued)

TECHNIQUE: REDUCTION

Functions: Chemical reduction is a method which alters the valence state of a waste constituent. It is used with other methods such as precipitation.

TECHNIQUE: ULTRA-VIOLET OXIDATION

Functions: Oxidizes organics by the introduction of ultra-violet rays.

TECHNIQUE: FLOW EQUALIZATION

Functions: Smoothes fluctuations in waste quantity flow or waste composition. Reducing variability in the waste stream to avoid potential upsets of downstream treatment processes and may reduce costs.

TECHNIQUE: FLOCCULATION

Functions: Chemicals are added to the waste stream and change the solubility of the undesired components. The undesirables flocculate and then precipitate.

TECHNIQUE: SEDIMENTATION

Functions: Separates the phases of precipitate by the gravitational settling of the precipitate to the bottom of a sedimentation tank.

TECHNIQUE: FILTRATION

Functions: Separates the precipitate phases by passing the precipitation effluent through a granular or cloth barrier, retaining the particles and allowing the clear effluent to pass.

TECHNIQUE: ION EXCHANGE

Functions: A method to remove inorganic salts from an aqueous solution by typically exchanging a hydrogen ion for a cation or a hydroxide group for an anion.

TECHNIQUE: REVERSE OSMOSIS

Functions: Removes contaminants from aqueous wastes by passing the waste stream, at high pressure, through a semi-permeable membrane. At sufficiently high pressure, clean water passes out through the membrane leaving a concentrated waste stream which must be treated further or disposed of.

TECHNIQUE: LIQUID/LIQUID EXTRACTION

Functions: Utilization of retrievable solvents that would encompass the liquid waste of the waste stream.

TECHNIQUE: OIL/WATER SEPARATION

Functions: Oil having a specific gravity which is less than the specific gravity of water will float on water thus allowing a separation.

Table 1. Description of Control Measure Technologies

SURFACE TREATMENT TECHNOLOGIES (continued)

TECHNIQUE: STEAM DISTILLATION

Functions: Removes volatile contaminants from an aqueous waste stream by passing steam through the wastes. The process is a steam distillation of the waste with the volatile contaminants ending up in the distillate for treatment.

TECHNIQUE: DISSOLVED AIR FLOTATION

Functions: Removes insoluble hazardous components present as suspended fine particles or globules of oils and greases from an aqueous phase. In this technique aqueous waste mixtures are first saturated with air at high pressures and then moved into tanks under atmospheric pressure. The reduction of pressure causes small bubbles of air to form and rise to the surface. The rising bubbles carry the fine particles and small globules of oil or grease to the surface where they are skimmed off.

TECHNIQUE: SOLIDIFICATION

Functions: Reduces leachate production potential by binding waste in a solid matrix by a physical and/or chemical process. Wastes are mixed with a binding agent and subsequently cured to solid form.

TECHNIQUE: STABILIZATION

Functions: Same as SOLIDIFICATION.

TECHNIQUE: FIXATION

Functions: Same as SOLIDIFICATION.

TECHNIQUE: EXISTING INDUSTRIAL WASTE TREATMENT PLANT (IWTP)

Functions: Many technologies are currently employed at the site including reduction, neutralization, biological, clarifiers, and filtration.

MANAGEMENT METHODS

TECHNIQUE: LAND-USE CONTROLS

Functions: Regulation of the land which is contaminated to reduce contact.

TECHNIQUE: ALTERNATIVE WATER SUPPLIES

Functions: The most economical water supply which is removed from the contamination and can provide for the requirements of the existing water supply.

TECHNIQUE: RIGHT-OF-WAY ACQUISITION

Functions: Purchasing a right-of-way to provide for pipelines or ditches to provide for surface runoff or the location of pipelines for alternative water supplies.

Table 1. Description of Control Measure Technologies

MANAGEMENT METHODS (continued)

TECHNIQUE: PERSONNEL SUPERVISION AND TRAINING

Functions: Allows for operation and maintenance of remediation equipment and programs, therefore assists in clean up of the environment.

TECHNIQUE: PERMANENT RELOCATION

Functions: Relocation of the personnel or relocation of facilities.

TECHNIQUE: COORDINATION WITH GOVERNMENT AGENCIES

Functions: Providing all governmental regulatory agencies with information on the contamination and contamination solutions.

NO ACTION PLAN

TECHNIQUE: NO ACTION

Functions: No risk to environment or human health, therefore take no action.

DISPOSAL OF TREATED WATER

TECHNIQUE: DISCHARGE INTO IWTP

Functions: Dispose and treat in the existing wastewater treatment facility.

TECHNIQUE: DISCHARGE TO SANITARY SEWERS

Functions: Removal of treated wastewater from the site via the existing sanitary sewer system.

TECHNIQUE: DISCHARGE TO STORM SEWERS

Functions: Removal of treated wastewater from the site via the existing storm sewer system.

TECHNIQUE: DISCHARGE TO STREAM

Functions: Removal of treated wastewater from the site via an existing stream.

TECHNIQUE: AQUIFER RECHARGE

Functions: Pumping of treated wastewater to an aquifer through a well or a series of wells.

TECHNIQUE: RE-USE FOR INDUSTRIAL PURPOSES

Functions: A recycling of the treated wastewater to be utilized in an industrial process.

TECHNIQUE: IRRIGATION

Functions: The irrigation of a field or crop with the treated wastewater.

Table 2. Screening Control Measures for Primary Criteria

2.1 GROUND-WATER CONTROL TECHNOLOGIES

CAPPING

Engineering Feasibility:	Feasible. Proven technology, but not applicable because most contamination is beneath Building 3001. Potentially applicable to fuel-contaminated areas.
Cost:	Up to $70 thousand/acre with synthetic materials.
Environmental Impacts:	Isolate the underlying contaminated zone and protect it from water infiltration.
Public Health Protection:	Will not remove contamination
Regulatory Compliance:	Complies.
Recommended:	Yes.

GROUND-WATER PUMPING

Engineering Feasibility:	Feasible. Proven technology, feasible control measure.
Cost:	Implementation reasonable, however may require long-term operations/maintenance. Overall cost if variable.
Environmental Impacts:	Removes contaminants from aquifer. Contaminants must be treated upon withdrawal.
Public Health Protection:	Will restrict movement of contaminants or eliminate from aquifer system.
Regulatory Compliance:	Complies.
Recommended:	Yes.

IMPERMEABLE BARRIERS

Engineering Feasibility:	Proven technology, not feasible due to depth and location of contaminants below building and other man-made structures.
Cost:	Due to depth and location of contaminants, it is cost prohibitive.
Environmental Impacts:	Restricts migration of contaminants.
Public Health Protection:	Will not remove contaminants or prevent vertical migration of contamination
Regulatory Compliance:	Non-compliance.
Recommended:	No, can not install barrier below Building 3001 or at necessary depth.

SUBSURFACE COLLECTION DRAINS

Engineering Feasibility:	Proven technology, not feasible or applicable due to depth and location of contamination below building and other man-made structures.
Cost:	Not applicable.

Table 2. Screening Control Measures for Primary Criteria

2.1 GROUND-WATER CONTROL TECHNOLOGIES (continued)

SUBSURFACE COLLECTION DRAINS (continued)	
Environmental Impacts:	Drain contaminated water from very shallow zones, much contamination probably too deep for effective use.
Public Health Protection:	Will not remove contaminants from deeper aquifer.
Regulatory Compliance:	Non-compliance.
Recommended:	No, can not install due to depth of contamination and location of building and other man-made structures.
SURFACE-WATER DIVERSION AND COLLECTION	
Engineering Feasibility:	Proven technology, however not applicable at Building 3001 due to presence of building and other man-made structures.
Cost:	Inexpensive means to control run-on and run-off from area of contaminants.
Environmental Impacts:	Prevents infiltration of water through contaminated zone. Construction of surface drainage limited due to buildings, parking lots, and taxi ways. However, infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed.
Public Health Protection:	No direct contact with contaminants.
Regulatory Compliance:	Non-effective.
Recommended:	No, can not install due to presence of building and other man-made structures.
PERMEABLE TREATMENT BEDS	
Engineering Feasibility:	Feasible. Proven technology.
Cost:	Cost prohibitive in containing contaminants in aquifer at such depths.
Environmental Impacts:	Is not removing contaminants from ground but treating them in place.
Public Health Protection:	Retards or prevents contaminants from entering water-supply system. However, infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed.
Regulatory Compliance:	Non-effective.
Recommended:	No, can not install beds at depth of contamination.
GRADING	
Engineering Feasibility:	Proven technology, however not applicable because of presence of Building 3001.
Cost:	Up to approximately $5,000/acre.

Table 2. Screening Control Measures for Primary Criteria

2.1 GROUND-WATER CONTROL TECHNOLOGIES (continued)

GRADING (continued)	
Environmental Impacts:	Control of run-off to or from contaminated area. Infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed.
Public Health Protection:	Assumes on direct contact or ingestion, no risk.
Regulatory Compliance:	Non-effective.
Recommended:	No, can not perform grading due to presence of building and other man-made structures.
REVEGETATION	
Engineering Feasibility:	Feasible. Proven technology.
Cost:	Inexpensive, due mostly to limited space for surface remedy and revegetation. Less than $7,000/acre.
Environmental Impacts:	Predominantly not applicable because contamination is primarily under building; however, migration of contamination in the ground water would be retarded by restriction of infiltration of water by vegetation.
Public Health Protection:	Restricts dust, thereby resolving likelihood of ingesting contaminants.
Regulatory Compliance:	Complies.
Recommended:	No, contamination is primarily under building.
BIORECLAMATION	
Engineering Feasibility:	Feasible. Proven technology, requires injection of oxygen by spargers, would require installation of wells (spargers).
Cost:	Variable.
Environmental Impacts:	Requires injection of fluid into formation; may cause migration of contaminants; will not remediate metals; oxidation of iron and manganese or other constituents could reduce aquifer permeabilities and increase number of required wells. Transformation of TCE to non-hazardous compound not a certainty. Bacterial action could be inhibited by the metal contaminants. Pilot study required. Transformed products may also be hazardous.
Public Health Protection:	Can remove organic contaminants.
Regulatory Compliance:	Non-compliance.
Recommended:	No, due to too many uncertainties.

Table 2. Screening Control Measures for Primary Criteria

2.2 SOIL AND SEDIMENT CONTROL TECHNOLOGIES

CAPPING	
Engineering Feasibility:	Proven technology but not applicable due to presence of Building 3001. Would be applicable to fuel-contaminated area.
Cost:	Inexpensive. $1.19 to $15.75/yd^3 of capping material up to $70,000/acre.
Environmental Impacts:	Restricts water from percolating through zone of aeration and flushing contamination. However, infiltration and flushing of contaminants can also be desirable.
Public Health Protection:	Will decrease rate of migration.
Regulatory Compliance:	Complies.
Recommended:	No, can not be installed due to presence of building and other man-made structures.
GRADING	
Engineering Feasibility:	Proven technology but not applicable due to presence of Building 3001. Would be applicable to fuel-contaminated area.
Cost:	Inexpensive. Up to $15.75/yd^3.
Environmental Impacts:	Routes water away from contaminated soil thereby reducing the potential of migration of contaminated soil.
Public Health Protection:	Prevents clean water from being contaminated and migration of contaminants to public accessible areas.
Regulatory Compliance:	Complies for fuel-contaminated area.
Recommended:	No, can not perform grading due to presence of Building 3001 and other man-made structures.
REVEGETATION	
Engineering Feasibility:	Proven technology, but limited since most of contaminants are beneath Building 3001.
Cost:	Inexpensive, less than $7,000/acre.
Environmental Impacts:	Not applicable because contamination is predominantly beneath building. However, contamination at the surface would be restricted from becoming mobile. Would be beneficial at fuel-contaminated area.
Public Health Protection:	Reduces dust and therefore mobile contaminants.
Regulatory Compliance:	Complies.
Recommended:	Yes.

Table 2. Screening Control Measures for Primary Criteria

2.2 SOIL AND SEDIMENT CONTROL TECHNOLOGIES (continued)

SURFACE-WATER DIVERSION	
Engineering Feasibility:	Proven technology, some already exists in storm drains.
Cost:	Relatively inexpensive.
Environmental Impacts:	Prevents surface water from infiltrating into contaminated zone and thus promoting migration of contaminants. Will prevent erosion. Will not remove contaminants.
Public Health Protection:	Assumes no contact or ingestion, no risk.
Regulatory Compliance:	Complies.
Recommended:	No, can not install due to presence of Building 3001.
LEACHATE COLLECTION	
Engineering Feasibility:	Proven technology, however not applicable because of depth of contaminants.
Cost:	Not applicable.
Environmental Impacts:	Not applicable.
Public Health Protection:	Not applicable.
Regulatory Compliance:	Not applicable.
Recommended:	No.
EXCAVATION AND REMOVAL	
Engineering Feasibility:	Feasible. Proven technology, however not feasible because contaminants are deep beneath Building 3001. May be applicable to area of fuel contamination.
Cost:	Expensive due to depth of contaminants and presence of Building 3001. Approximately $70/yd^3$ in open areas.
Environmental Impacts:	Exposes contaminants to air and requires disposal elsewhere, however eliminates source of contamination.
Public Health Protection:	Human exposure during excavation, however eliminates source area (fuel contamination).
Regulatory Compliance:	Complies.
Recommended:	Yes, but restricted to areas of fuel contamination.

Table 2. Screening Control Measures for Primary Criteria

2.3 SURFACE FLOW CONTROL TECHNOLOGIES

CAPPING

Engineering Feasibility:	Feasible. Proven technology, limited due to presence of Building 3001, however would be applicable to fuel-contaminated area.
Cost:	Up to $70,000/acre with synthetic materials.
Environmental Impacts:	Prevents infiltration through contamination, however infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

GRADING

Engineering Feasibility:	Feasible. Proven technology, limited due to presence of Building 3001. Would be applicable to fuel-contaminated area.
Cost:	Approximately $2.62/yd^3$.
Environmental Impacts:	Provides runoff away from contaminated areas, however infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

REVEGETATION

Engineering Feasibility:	Feasible. Proven technology, limited area for revegetation.
Cost:	Less than $7,000/acre.
Environmental Impacts:	Prevents erosion. Could prevent contaminants for becoming airborne. Not applicable for Building 3001 because contamination is beneath building. Would be applicable for fuel-contaminated area.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No.

Table 2. Screening Control Measures for Primary Criteria

2.3 SURFACE FLOW CONTROL TECHNOLOGIES (continued)

SURFACE-WATER DIVERSION AND COLLECTION

Engineering Feasibility:	Feasible. Proven technology, some surface water diversion is already present with existing storm drains.
Cost:	Inexpensive.
Environmental Impacts:	Prevents surface water from recharging to contaminated zone; some restrictions because of Building 3001. However, infiltration and flushing of contaminants can also be desirable if the source of contamination has been removed. Would be more applicable to fuel-contaminated area.
Public Health Protection:	Assume no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

SEEPAGE BASINS

Engineering Feasibility:	Proven technology. Seepage basins are used to discharge water collected from surface-water diversions, ground-water pumping, or leachate treatment to ground water.
Cost:	Cost prohibitive due to limited area.
Environmental Impacts:	Will not remove contaminants from soil or ground water, but will recharge aquifer.
Public Health Protection:	The basins are utilized to recharge aquifers with treated water. Would not be protecting the public from contamination.
Regulatory Compliance:	Non-compliance.
Recommended:	No, not effective.

SEDIMENT BASINS

Engineering Feasibility:	Feasible. Proven technology, but there is probably of little use because of limitations on space and low ground-water gradients to surface water.
Cost:	Would not be cost effective.
Environmental Impacts:	Prevents migration of contaminated sediment into Soldier Creek.
Public Health Protection:	Reduces distribution of contaminated sediment, thus reducing potential contact.
Regulatory Compliance:	Not applicable.
Recommended:	No, space limitation and engineering constraints.

Table 2. Screening Control Measures for Primary Criteria

2.3 SURFACE FLOW CONTROL TECHNOLOGIES (continued)

LEACHATE COLLECTION

Engineering Feasibility:	Proven technology, but not applicable because depth of contamination.
Cost:	Not applicable because depth of contaminants prevents the collection of leachate.
Environmental Impacts:	Will not remedy.
Public Health Protection:	Will not remedy.
Regulatory Compliance:	Will not remedy.
Recommended:	No, due to depth of contamination.

SURFACE-WATER TREATMENT

Engineering Feasibility:	Feasible. Proven technology, not applicable as surface water at Building 3001 is not an issue.
Cost:	Moderate.
Environmental Impacts:	Removes contaminants from surface water. Since elevated concentrations of industrial contaminants were found in four of five sampling stations in Soldier Creek, surface-water treatment would be removing contaminants from the environment.
Public Health Protection:	Elimination of contamination.
Regulatory Compliance:	Soldier Creek should be addressed as a separate area, as required.
Recommended:	No, not applicable as surface water at Building 3001 is not an issue.

2.4 AIR/SOIL PORE SPACE CONTROL TECHNOLOGIES

CAPPING

Engineering Feasibility:	Proven technology, not applicable due to Building 3001.
Cost:	\$1.19 to \$15.75/yd^3 of capping material, up to \$70,000/acre with synthetic material.
Environmental Impacts:	Could prevent escape of gas to atmosphere, however TCE has tendency to be absorbed by soils.
Public Health Protection:	Prevents contact with public.
Regulatory Compliance:	Approved.
Recommended:	No, can not install due to Building 3001 and other man-made structures.

Table 2. Screening Control Measures for Primary Criteria

2.4 AIR/SOIL PORE SPACE CONTROL TECHNOLOGIES (continued)

GAS VENTILATION	
Engineering Feasibility:	Proven technology, not applicable to Building 3001. May be applicable to fuel-contaminated area.
Cost:	Approximately $98,000 with $7,360/year operation and maintenance.
Environmental Impacts:	Removes trapped gases from soil zone, would not remove metal contamination.
Public Health Protection:	Releases gases to atmosphere which could provide contact.
Regulatory Compliance:	Complies.
Recommended:	Yes, but only for fuel-contaminated area.
GAS COLLECTION	
Engineering Feasibility:	Proven technology, not applicable at Building 3001. May be beneficial to fuel-contaminated area.
Cost:	TCE readily disperses so it would not be cost efficient for Building 3001 but may be for collection for fuel-contaminated area. Capital $14,230; operation and maintenance $600.
Environmental Impacts:	Removes trapped gases from soil zone, would not remove metal contamination. Gas has not been a problem at Building 3001.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, gas is not a problem.
GAS BARRIERS	
Engineering Feasibility:	Proven technology, not applicable.
Cost:	$0.43 to $8.40/ft^2.
Environmental Impacts:	Free gas has not been a problem at Building 3001.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, gas is not a problem.

Table 2. Screening Control Measures for Primary Criteria

2.5 DRINKING WATER AND SEWER LINE CONTROL TECHNOLOGIES

PIPELINE REMOVAL OR REPLACEMENT

Engineering Feasibility:	Proven technology, but will have to contend with existing building structure. The existing wells that were contaminated have been properly plugged and abandoned. Tinker AFB has recently completed efforts to correct industrial waste pipe connection errors that have caused unpermitted discharges and probably promoted contaminant migration.
Cost:	Less than $119/ft; however would depend on location relative to man-made structures.
Environmental Impacts:	Will not remediate problem. Will potentially stop the flushing of contaminants from the soil and aquifer.
Public Health Protection:	Will remove potential of contamination getting into water supply system.
Regulatory Compliance:	Complies.
Recommended:	No, already remediated.

LEAK DETECTION AND REPAIR

Engineering Feasibility:	Proven technology, but will have to contend with existing building structure. The existing wells which were contaminated have been properly plugged and abandoned.
Cost:	Less than $119/ft; however would depend on relative location to man-made structures.
Environmental Impacts:	If pipeline supplies recharge, then recharge to aquifer mobilizes contaminants. If sewer line leaks, it may be source of contaminants. Maintenance of positive pressure in supply lines would normally preclude contamination of drinking water. Backflow could siphon contaminants into leaking lines. Consequently, pipes conveying drinking water should not pass through contaminants.
Public Health Protection:	Would protect public from contaminated drinking water.
Regulatory Compliance:	Complies.
Recommended:	No.

IN-SITU CLEANING

Engineering Feasibility:	Proven technology, not applicable.
Cost:	May be cost prohibitive due to existence of building. Approximately $119/ft.
Environmental Impacts:	Will still provide fluids or recharge to aquifer and have potential of contamination or mobilizing existing contamination.
Public Health Protection:	Would not be able to treat water supply lines while still utilizing them to convey water.
Regulatory Compliance:	Complies.

Table 2. Screening Control Measures for Primary Criteria

2.5 DRINKING WATER AND SEWER LINE CONTROL TECHNOLOGIES (continued)

IN-SITU CLEANING (continued)

Recommended:	No, may mobilize contaminants and may be cost prohibitive.

2.6 AIR POLLUTION CONTROL TECHNOLOGIES

CAPPING

Engineering Feasibility:	Proven technology, not applicable.
Cost:	Not feasible since Building 3001 is over the contaminated zone.
Environmental Impacts:	Will not remove contamination.
Public Health Protection:	Would prevent contamination from becoming airborne.
Regulatory Compliance:	Complies.
Recommended:	No, can not install due to presence of Building 3001 and other man-made structures.

DUST CONTROL

Engineering Feasibility:	Feasible. Proven technology, not applicable as there will be little dust from contaminated soils due to presence of building, parking lots, and runways.
Cost:	Inexpensive.
Environmental Impacts:	Would not remediate the problem except to retard migration of contaminants associated with dust.
Public Health Protection:	Would prevent contact through atmosphere.
Regulatory Compliance:	Complies.
Recommended:	No, little potential for dust concentration, dust is not an issue.

2.7 LAND DISPOSAL/STORAGE TECHNOLOGIES

LANDFILLS

Engineering Feasibility:	Proven technology, not possible to excavate or landfill at Building 3001.
Cost:	Expensive.
Environmental Impacts:	Would remove soil contamination to a depth, but would not remedy ground-water problem under Building 3001.
Public Health Protection:	Risks of exposure are associated with excavation and transportation.
Regulatory Compliance:	Complies.

Table 2. Screening Control Measures for Primary Criteria

2.7 LAND DISPOSAL/STORAGE TECHNOLOGIES (continued)

LANDFILLS (continued)	
Recommended:	No, not possible to excavate below Building 3001.
SURFACE IMPOUNDMENTS	
Engineering Feasibility:	Proven technology. Not applicable as Building 3001 is over contaminated area.
Cost:	Expensive.
Environmental Impacts:	Not applicable to ground water at site.
Public Health Protection:	Would limit contact with humans.
Regulatory Compliance:	Complies.
Recommended:	No.
WASTE PILES	
Engineering Feasibility:	Proven technology, cannot pile waste in/at Building 3001, would require excavation to obtain waste but cannot excavate because of Building 3001.
Cost:	Not applicable.
Environmental Impacts:	There is no waste to pile, soil would have to be replaced; cannot pile, water is under Building 3001.
Public Health Protection:	Piling the soil would expose contaminants to humans.
Regulatory Compliance:	Complies, but not applicable in this situation.
Recommended:	No, can not excavate or pile due to presence of Building 3001.
DEEP WELL INJECTION	
Engineering Feasibility:	Proven technology, but regulatory status of hazardous waste injection uncertain. No certainty of receiving permit.
Cost:	Expensive.
Environmental Impacts:	Would require permitting and drilling of deep disposal well; would have to get other wells drilled to pump contaminated water; would not clean up chromium.
Public Health Protection:	No human contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, excessive expenditures and uncertainties.

Table 2. Screening Control Measures for Primary Criteria

2.7 LAND DISPOSAL/STORAGE TECHNOLOGIES (continued)

TEMPORARY STORAGE

Engineering Feasibility:	Proven technology, is most beneficial when a rapid response is necessary.
Cost:	Expensive.
Environmental Impacts:	Would require removal of very large volume of water to remove contaminants to acceptable level, would require removal of very large volume of soil to remove contaminants, would require very large storage facility since it is only a temporary solution.
Public Health Protection:	Is not eliminating contamination, assumes no contact.
Regulatory Compliance:	Complies.
Recommended:	No, due to prohibitive size of facility required.

LAND APPLICATION

Engineering Feasibility:	Proven technology, not applicable as no or limited area available for land application.
Cost:	$40 to $240/ton.
Environmental Impacts:	Pretreatment to remove or lower metals or TCE might be required before application.
Public Health Protection:	The contamination would be at the surface, potential for exposure.
Regulatory Compliance:	Complies.
Recommended:	No, can not apply as land areas are very limited.

2.8 IN-SITU TREATMENT TECHNOLOGIES

BIORECLAMATION

Engineering Feasibility:	Research technology, will not clean metals.
Cost:	Approximately $11,000/acre/year.
Environmental Impacts:	Cleans formation in place by injection of fluids (clean oxygenated water and addition of hydrogen peroxide) and water, would require installation of numerous wells. Oxidation of iron and manganese or other constituents could reduce aquifer permeabilities and increase number of wells needed. Transformation of TCE to non-hazardous components not a certainty. Bacterial action could be inhibited by the metal contaminants. Pilot study would be required. Transformed products may also be hazardous. Does not remediate metals.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.

Table 2. Screening Control Measures for Primary Criteria

2.8 IN-SITU TREATMENT TECHNOLOGIES (continued)

BIORECLAMATION (continued)	
Recommended:	No, not effective technology for metals and numerous uncertainties.
CHEMICAL DECHLORINATION	
Engineering Feasibility:	Developmental, not applicable.
Cost:	Developmental, not applicable.
Environmental Impacts:	Developmental, not applicable.
Public Health Protection:	Not applicable.
Regulatory Compliance:	Not applicable.
Recommended:	No, in developmental stages.
HYDROLYSIS	
Engineering Feasibility:	Hydrolysis of TCE and other chemicals approaches zero.
Cost:	Not applicable.
Environmental Impacts:	Not applicable.
Public Health Protection:	Not applicable.
Regulatory Compliance:	Non-compliance.
Recommended:	No.
NEUTRALIZATION	
Engineering Feasibility:	Proven technology; does not remove contaminant and addition of ferrous sulfate can create problems.
Cost:	Capital approximately $1,000,000; operation and maintenance approximately $1,000/million gallons treated.
Environmental Impacts:	Will reduce hexavalent chromium to trivalent, but will not address TCE.
Public Health Protection:	Assumes no contact, safe. Reduces hexavalent chromium to the less toxic trivalent state.
Regulatory Compliance:	Regulatory compliance may be based on total chromium and not just hexavalent chromium.
Recommended:	No, not effective and may create problems.

Table 2. Screening Control Measures for Primary Criteria

2.8 IN-SITU TREATMENT TECHNOLOGIES (continued)

OXIDATION

Engineering Feasibility:	Proven technology, but may not remove or satisfactorily alter contaminants due to depth of contamination.
Cost:	Moderately expensive. Contaminants will be cost prohibitive.
Environmental Impacts:	Chemical oxidation has been used to control organic residues in treatment of wastewater. Oxidation of iron and manganese or other constituents could reduce aquifer permeabilities.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, due to depth of contaminants.

PERMEABLE TREATMENT BEDS

Engineering Feasibility:	Conceptual technology that is applicable, but a temporary solution. Beds can plug or become saturated with contaminants and require replacement. Applicable only to treatment of relatively shallow ground water. Not applicable since contamination is at depth.
Cost:	Expensive. Is only temporary solution.
Environmental Impacts:	Contact times uncertain, prevention of break through uncertain, extent of cleanup uncertain.
Public Health Protection:	Caution required because method is conceptual technology.
Regulatory Compliance:	Uncertain, will not remove contaminants from deep zones.
Recommended:	No.

POLYMERIZATION

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Very expensive.
Environmental Impacts:	Would not remove contaminants, but lock them up in reservoir. Will reduce permeability of reservoir.
Public Health Protection:	Assumes no contact.
Regulatory Compliance:	Complies.
Recommended:	No, adverse environmental impacts may result.

REDUCTION

Engineering Feasibility:	Feasible. Proven technology.

Table 2. Screening Control Measures for Primary Criteria

2.8 IN-SITU TREATMENT TECHNOLOGIES (continued)

REDUCTION (continued)	
Cost:	$0.77 to $3.95/1,000 gallons.
Environmental Impacts:	Long term fate of contaminants uncertain if removed from solution by reduction. Does not remove organics. Reduces hexavalent chromium to less toxic trivalent chromium, however they remain in the formation.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Regulatory compliance may be based on total chromium and not just hexavalent chromium.
Recommended:	No, will not remove contaminants present.
SOIL AERATION	
Engineering Feasibility:	Feasible. Proven technology, but TCE has a fairly strong tendency to sorb to some soils. Not applicable due to depth of contaminants in ground water. May be applicable to fuel-contaminated area.
Cost:	Expensive.
Environmental Impacts:	Can remove organics and hydrocarbons by mechanically drawing or venting air through unsaturated soil layer; will not remove metals. Will assist with biodegradation.
Public Health Protection:	Safe if no contact.
Regulatory Compliance:	Complies.
Recommended:	Yes, but restricted only to fuel-contaminated area.
SOLVENT FLUSHING	
Engineering Feasibility:	Proven technology, but is limited due to depth of contaminants.
Cost:	Expensive.
Environmental Impacts:	Will remove the solvent only if the solvents can be removed from formation; there will be some residual solvents left in formation from flushing solvents. Will not remove metals.
Public Health Protection:	Assumes no contact, safe
Regulatory Compliance:	Non-compliance.
Recommended:	No, will not remove metals.
CHEMICAL PRECIPITATION	
Engineering Feasibility:	Proven technology, in developmental status.

Table 2. Screening Control Measures for Primary Criteria

2.8 IN-SITU TREATMENT TECHNOLOGIES (continued)

CHEMICAL PRECIPITATION (continued)

Cost:	No data available.
Environmental Impacts:	Will precipitate metals, but will not remove them from the formation; also will not remove organics. Chemical used to precipitate metals could create problems.
Public Health Protection:	Potential still exists for contaminants to enter public water supply.
Regulatory Compliance:	Non-compliance.
Recommended:	No, will not remove organics and may create other environmental problems with use of chemicals.

2.9 SURFACE TREATMENT TECHNOLOGIES

INCINERATION

Engineering Feasibility:	Proven technology for organics. Not applicable due to nature of contamination at Building 3001.
Cost:	Capital approximately \$13.60/meters^3; operation and maintenance approximately \$10.30/meters^3.
Environmental Impacts:	Requires removal of contaminated materials from the formation to be placed in incinerator. Requires pretreatment to concentrate the organics prior to incineration.
Public Health Protection:	Produces stack emissions, possible air/ash contamination.
Regulatory Compliance:	Complies, not practical.
Recommended:	No, not applicable to nature of contamination.

ACTIVATED CARBON ABSORPTION

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Estimated investment \$1,944,000. Annual cost approximately \$29/1,000 gallons.
Environmental Impacts:	Removes solvents from solution, will not remove metals. Concentrates solvents on carbon that can be incinerated, regenerated, or disposed (hazardous).
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

AIR STRIPPING

Engineering Feasibility:	Feasible. Proven technology.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

AIR STRIPPING (continued)

Cost:	Approximately $30/1,000 gallons. Capital investment approximately $2,000,000/10 mgal/day.
Environmental Impacts:	May require multiple steps of stripping to reduce high concentrations of TCE to levels acceptable for discharge. Tall stacks may be required. Does not remove metals.
Public Health Protection:	Assumes no contact, safe. Potential for releasing TCE to atmosphere.
Regulatory Compliance:	Complies.
Recommended:	Yes.

STEAM STRIPPING

Engineering Feasibility:	Proven technology.
Cost:	Approximately $22/1,000 gallons. Capital investment approximately $1,377,000.
Environmental Impacts:	Will remove solvents from water after water is removed from ground, but will not separate metal contamination. May require multiple types of stripping to reduce high concentrations of TCE to levels acceptable for discharge.
Public Health Protection:	Assumes no contact, safe. Potential for releasing volatile organics to atmosphere.
Regulatory Compliance:	Complies.
Recommended:	No, due to high concentrations of TCE.

AERATED LAGOONS

Engineering Feasibility:	Feasible. Proven technology. Service life 30 years. Would have problems with limited area at Base.
Cost:	Capital investment $1,828,000. Operation and maintenance $2.65/1,000 gallons.
Environmental Impacts:	Will remove organics from water after removed from ground through photosynthetic reduction; will not remove metals.
Public Health Protection:	Will be collecting material at surface, possible contact.
Regulatory Compliance:	Complies.
Recommended:	No, area for construction of lagoons is very limited.

STABILIZATION PONDS

Engineering Feasibility:	Feasible technology. Proven for some domestic and some waste waters. Pilot study would be required for TCE. Limited space for any new construction.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

STABILIZATION PONDS (continued)

Cost:	Construction $100,000/MGD; operation and maintenance $10,000/year/MGD.
Environmental Impacts:	Large areas required. Must prevent infiltration of contaminated water into underlying soil.
Public Health Protection:	Collecting materials at surface, possible contact.
Regulatory Compliance:	Complies.
Recommended:	No, limited space for any new construction.

BIOLOGICAL

Engineering Feasibility:	Feasible. Proven technology, pilot study would be required for TCE or other organics. Pre-treatment to remove refractory organics might be required. Metals could effect bacteria depending on loading. Existing wastewater treatment plant might be used depending on pilot studies for treatability and evaluation of plant capacity.
Cost:	Approximately $3,000,000 capital cost and $3.50/1,000 gallons treated.
Environmental Impacts:	Does not effectively remediate metals. Pre- or post-treatment could be required for metals depending on effects of metals on bacteria.
Public Health Protection:	Yes.
Regulatory Compliance:	Complies.
Recommended:	Yes.

NEUTRALIZATION

Engineering Feasibility:	Proven technology for waters requiring pH adjustment. Can be used with other methods (for example, precipitation) to alter pH for discharge.
Cost:	Approximately $1,000,000 construction and $1,000/million gallons treated.
Environmental Impacts:	Involves addition of acid to basic contamination and base to acidic contamination to bring pH to acceptable range. Does not directly remove TCE or metals.
Public Health Protection:	Does not remove contaminants.
Regulatory Compliance:	Complies to reduce corrosivity.
Recommended:	No, does not directly remove TCE or metals.

PRECIPITATION

Engineering Feasibility:	Feasible. Proven technology for metals. Does not remove organics.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

PRECIPITATION (continued)

Cost:	$0.77 to $4.00/1,000 gallons.
Environmental Impacts:	A physical/chemical process by which heavy metals in solution will precipitate and settle. Produces a hazardous sludge generally requiring thickening and disposal. Volume of hazardous sludge this process produces must be compared to volumes produced by other treatments (for example, ion exchange). Low or high pH required for precipitation depending on constituent. Pre-treatment or multi-stage treatment might be required. Existing wastewater treatment plant might be used depending on pilot studies for treatability and evaluation of plant capacity.
Public Health Protection:	Assumes no contact, safe. Risks are associated with handling, transporting, and disposing of sludge.
Regulatory Compliance:	Complies.
Recommended:	Yes.

OXIDATION

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Capital investment $2,000,000. Operation and maintenance approximately $14/1,000 gallons.
Environmental Impacts:	Has been utilized in controlling organic residues.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

HYDROLYSIS

Engineering Feasibility:	Feasible. Natural hydrolysis of TCE approaches zero. Does not remove metals.
Cost:	Wide range.
Environmental Impacts:	Effectiveness with use of elevated temperatures and pressures, probably would require pilot study. Not for metals.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, will not remedy metals contamination.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

REDUCTION

Engineering Feasibility:	Feasible. Proven technology in connection with other methods such as precipitation. Existing wastewater treatment plant might be used depending on pilot studies for treatability and evaluation of plant capacity. Pre-treatment and multi-stage treatment might be required.
Cost:	Capital investment for 2,000 gal/day facility $375,000. Operation and maintenance $300/1,000 gallons.
Environmental Impacts:	Will require pumpage of water prior to treatment; will reduce hexavalent chromium to trivalent chromium, but not organics.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

ULTRA-VIOLET OXIDATION

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Inexpensive.
Environmental Impacts:	Provides greater removal of certain toxics or organics than carbon absorption; water must be removed from formation for treatment; will not remove heavy metals.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

FLOW EQUALIZATION

Engineering Feasibility:	Feasible. Conventional demonstrated technology for moderating flows. Use of equalization ponds could enhance use of existing wastewater treatment plant during low inflows (such as weekends). Potential for use should be evaluated after design of remedial action and projection of volume of wastewater to be treated.
Cost:	Inexpensive.
Environmental Impacts:	Equalization smoothes fluctuations in waste quantity flow or waste composition. Reducing variability in the waste stream avoids potential upsets of downstream treatment processes, and may reduce costs.
Public Health Protection:	Potential exposure from storage basins.
Regulatory Compliance:	Complies.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

FLOW EQUALIZATION (continued)

Recommended:	Yes.

FLOCCULATION

Engineering Feasibility:	Feasible. Proven technology for use with precipitation or either methods to improve settling.
Cost:	Can be expensive for large volumes.
Environmental Impacts:	Does not remove contaminants, but assists with other alternatives.
Public Health Protection:	Does not remove contaminants.
Regulatory Compliance:	Complies.
Recommended:	No, will not remove contaminants.

SEDIMENTATION

Engineering Feasibility:	Proven technology for use with flocculation or other methods. Clarifiers are in use at existing wastewater treatment plant. Pilot studies are required to determine whether settling would be adequate for all constituents in treated waters from remedial actions.
Cost:	$0.77 to $3.95/1,000 gallons.
Environmental Impacts:	Will not remove contaminants in solution from water.
Public Health Protection:	Contaminants are going from solution form to solid form with possible exposure.
Regulatory Compliance:	Complies when used with other alternatives.
Recommended:	No, as will not remove contaminants.

FILTRATION

Engineering Feasibility:	Feasible. Proven technology for use with other methods to remove solids from a liquid or drive liquids out of a solid. Filtration is used at existing wastewater treatment plant. Adequacy of filters to treat increased volume must be evaluated.
Cost:	$38 to $107/ton of dry solids.
Environmental Impacts:	Would remove contaminants if they were solids.
Public Health Protection:	Not eliminating problem by itself. Must use in combination with alternatives.
Regulatory Compliance:	Complies when used with other alternatives.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

FILTRATION (continued)

Recommended:	Yes.

ION EXCHANGE

Engineering Feasibility:	Feasible. Conventional demonstrated technology. Excellent for removal of metal ions.
Cost:	Approximately $9.00/10^3 gallons.
Environmental Impacts:	Waste must be treated for organics before ion exchange because organics clog the resin. Will remove 99% of chromium.
Public Health Protection:	Will remove hexavalent chromium from water.
Regulatory Compliance:	Complies.
Recommended:	Yes.

REVERSE OSMOSIS

Engineering Feasibility:	Feasible. Proven technology, but can require pretreatment for suspended solids above 3 to 5 microns, pH adjustment to prevent scaling by calcium carbonate meters, and other various treatments to prevent bonding of membrane.
Cost:	Expensive for large volumes.
Environmental Impacts:	Will remove both organics and heavy metals from fluids after pumping water from ground. Produces a concentrated waste that must be handled, transported, treated, or disposed.
Public Health Protection:	Produces a hazardous brine or resin that must be handled, transported, or treated, and disposed.
Regulatory Compliance:	Complies.
Recommended:	No, expensive and produces hazardous materials.

LIQUID/LIQUID EXTRACTION

Engineering Feasibility:	Proven technology. Would probably require handling of hazardous solvents that could remove TCE.
Cost:	Can be uneconomical.
Environmental Impacts:	Does not extract the metals.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies when combined with other alternatives.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

LIQUID/LIQUID EXTRACTION (continued)

Recommended:	No, could be economically prohibitive and will not remove metals.

OIL/WATER SEPARATION

Engineering Feasibility:	Feasible. Proven technology, but not applicable because TCE soluble in water. May be applicable to fuel-contaminated area. Existing wastewater treatment plant might be used depending on adequacy to treat increased volume of wastewater.
Cost:	Relatively inexpensive.
Environmental Impacts:	Will be removing oil from water and therefore environment.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

STEAM DISTILLATION

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Approximately $21/1,000 gallons.
Environmental Impacts:	Must pump water from ground, heat water, and then liberate organics; solid contaminants and solvents with high boiling points are separated as bottom products. Will remove 99+% of TCE from water. Will not address chromium. Poses potential air pollution problems when volatile organics are present.
Public Health Protection:	TCE readily disperses to the atmosphere, would be removing contaminants from water; assumes no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	No, will not reduce or eliminate chromium and may create elevated air emissions.

DISSOLVED AIR FLOTATION

Engineering Feasibility:	Proven technology, but not applicable as a remediation. Can be used to remove suspended solids or for concentration of sludges by other treatment methods. Also applies to characterization of wastes to assure compatibility with solidification process.
Cost:	Approximately $320/sq ft of surface area for treatment system.
Environmental Impacts:	Removes insoluble hazardous components present as suspended fine particles or globules of oil and grease from an aqueous phase. Would be beneficial to fuel-contaminated area.
Public Health Protection:	Assumes no contact, safe.

Table 2. Screening Control Measures for Primary Criteria

2.9 <u>SURFACE TREATMENT TECHNOLOGIES</u> (continued)

DISSOLVED AIR FLOTATION (continued)

Regulatory Compliance:	Complies.
Recommended:	No, not applicable to site problems.

SOLIDIFICATION

Engineering Feasibility:	Feasible. Proven technology, but pretreatment to concentrate contaminants requires treatment of large volumes of water. Not for in-situ consideration, methods of solidification are waste specific. Thermoplastic solidification is not applicable to organic solvents, for example.
Cost:	Capital cost approximately \$13.60/meters^3; operation and maintenance costs \$0.30/meters^3.
Environmental Impacts:	Used to immobilize contaminants by incorporating them into structure of a stable solid substance that prevents removal of contaminants by leaching.
Public Health Protection:	Would have to contend with contaminated solid after it absorbed any contaminants.
Regulatory Compliance:	Complies when used with other alternatives.
Recommended:	No, due to large volumes of contaminants.

STABILIZATION

Engineering Feasibility:	Feasible. Proven technology, but usually encompasses solidification and encapsulation.
Cost:	Capital cost approximately \$13.60/meters^3; operating and maintenance cost \$0.30/meters^3.
Environmental Impacts:	Used to immobilize contaminants by incorporating them into structure of a stable solid substance that prevents removal of contaminants by leaching. Will require large area to dispose of stabilized contaminants.
Public Health Protection:	
Regulatory Compliance:	Complies when used with other alternatives.
Recommended:	No, would require large area for disposal of contaminants.

FIXATION

Engineering Feasibility:	Feasible. Proven technology, but not applicable to contamination at site.
Cost:	Not applicable.
Environmental Impacts:	No risk.
Public Health Protection:	Not applicable.

Table 2. Screening Control Measures for Primary Criteria

2.9 SURFACE TREATMENT TECHNOLOGIES (continued)

FIXATION (continued)

Regulatory Compliance:	Not applicable.
Recommended:	No, not applicable to problems at site.

EXISTING INDUSTRIAL WASTE TREATMENT PLANT (IWTP)

Engineering Feasibility:	Feasible. Proven technology. Many technologies are currently employed at the site including reduction, neutralization, biological, clarifiers, and filtration. Modification of the IWTP may be necessary to accommodate a change in the quantity and quality of the waste stream.
Cost:	Would depend on the changes that would be required. Inexpensive.
Environmental Impacts:	Would assist in removing contaminants.
Public Health Protection:	Would reduce the chance of contact.
Regulatory Compliance:	Complies.
Recommended:	Yes.

2.10 MANAGEMENT METHODS

LAND-USE CONTROLS

Engineering Feasibility:	Feasible. Proven technology. Completed within Building 3001.
Cost:	Would depend on land use. Inexpensive.
Environmental Impacts:	Use of land would not change. Discharge or introduction of industrial chemicals terminated under Building 3001.
Public Health Protection:	Has had direct effect on introduction of contamination for potential for human contact. Proper management of land use will prevent human contact.
Regulatory Compliance:	Applicable.
Recommended:	Yes.

ALTERNATIVE WATER SUPPLIES

Engineering Feasibility:	Feasible. Proven technology. Alternate water supplies may be applicable, because of proximity of TCE plume to water-supply wells.
Cost:	Expensive.
Environmental Impacts:	Would not clean up existing contamination problem.

Table 2. Screening Control Measures for Primary Criteria

2.10 MANAGEMENT METHODS (continued)

ALTERNATIVE WATER SUPPLIES (continued)

Public Health Protection:	Would insure no contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

RIGHT-OF-WAY ACQUISITION

Engineering Feasibility:	Feasible. Proven technology. Will be applicable if an alternative water supply is required.
Cost:	Expensive.
Environmental Impacts:	Would not clean up existing contamination problem.
Public Health Protection:	Would not effect public health.
Regulatory Compliance:	Complies.
Recommended:	Yes.

PERSONNEL SUPERVISION AND TRAINING

Engineering Feasibility:	Feasible. Proven technology.
Cost:	Relatively inexpensive.
Environmental Impacts:	Would allow for operation and maintenance of remediation equipment and programs, therefore would assist in clean up of environment.
Public Health Protection:	Would result in awareness and education, thus reducing chance of contact.
Regulatory Compliance:	Complies.
Recommended:	Yes.

PERMANENT RELOCATION

Engineering Feasibility:	Not applicable.
Cost:	Cost prohibitive.
Environmental Impacts:	Would not remediate existing contamination problem; would render property useless.
Public Health Protection:	Would remove public from possible contact, safe.
Regulatory Compliance:	Not applicable.

Table 2. Screening Control Measures for Primary Criteria

2.10 MANAGEMENT METHODS (continued)

PERMANENT RELOCATION (continued)

Recommended:	No, would not remediate contamination and would be cost prohibitive.

COORDINATION WITH GOVERNMENT AGENCIES

Engineering Feasibility:	Feasible. Required.
Cost:	Variable.
Environmental Impacts:	Will determine what levels of contamination are acceptable; mandatory.
Public Health Protection:	Would reduce contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

2.11 NO-ACTION PLAN

NO ACTION

Engineering Feasibility:	Feasible alternative.
Cost:	Minimal.
Environmental Impacts:	Would not remedy contamination problem.
Public Health Protection:	Potential exposure to contaminants, not safe.
Regulatory Compliance:	No.
Recommended:	No.

2.12 DISPOSAL OF TREATED WATER

DISCHARGE TO IWTP

Engineering Feasibility:	Feasible. Applicable.
Cost:	Cost would depend on the volume of water that is added to the existing IWTP.
Environmental Impacts:	Would remove contaminants from water, thereby protecting the environment and the public.
Public Health Protection:	Would reduce the potential for contact, safe.
Regulatory Compliance:	Complies.
Recommended:	Yes.

Table 2. Screening Control Measures for Primary Criteria

2.12 DISPOSAL OF TREATED WATER (continued)

DISCHARGE TO SANITARY SEWERS	
Engineering Feasibility:	Feasible technology.
Cost:	Cost would be related to additional volume of water to be treated by sanitary sewer system.
Environmental Impacts:	Would remove some contaminant materials from water, but would have restricted concentrations and volumes.
Public Health Protection:	Assumes no contact, safe.
Regulatory Compliance:	Complies depending on quality of treated water.
Recommended:	Yes.
DISCHARGE TO STORM SEWERS	
Engineering Feasibility:	Feasible technology.
Cost:	Inexpensive.
Environmental Impacts:	Would depend on the quality of the treated water.
Public Health Protection:	Would depend on the quality of the treated water.
Regulatory Compliance:	Would comply depending on the quality of the treated water.
Recommended:	Yes.
DISCHARGE TO STREAM	
Engineering Feasibility:	Proven technology; would have to file an NPDES permit.
Cost:	Inexpensive. Would have periodic sampling charges.
Environmental Impacts:	Would depend on the quality of the discharge water.
Public Health Protection:	Would depend on the quality of the discharge water.
Regulatory Compliance:	Would depend on the quality of the discharge water.
Recommended:	Yes.
AQUIFER RECHARGE	
Engineering Feasibility:	Proven technology.
Cost:	Would depend on the volume of water and the number of wells required to accommodate the volume of water.

Table 2. Screening Control Measures for Primary Criteria

2.12 DISPOSAL OF TREATED WATER (continued)

AQUIFER RECHARGE (continued)	
Environmental Impacts:	Would depend on the quality of the water to be recharged to the aquifer.
Public Health Protection:	Would depend on the quality of the water to be recharged to the aquifer.
Regulatory Compliance:	Would depend on the quality of the water to be recharged to the aquifer.
Recommended:	No, too many uncertainties.
RE-USE FOR INDUSTRIAL PURPOSES	
Engineering Feasibility:	Feasible. Proven technology. Would depend on physical parameters of the water.
Cost:	Inexpensive, readily available.
Environmental Impacts:	Would depend on the quality of the water and the usage of the water.
Public Health Protection:	Would depend on the quality of the water and the usage of the water.
Regulatory Compliance:	Would depend on the quality of the water and the usage of the water.
Recommended:	Yes.
IRRIGATION	
Engineering Feasibility:	Feasible. Proven technology. Easily implemented.
Cost:	Inexpensive. Would depend on the distance of transport.
Environmental Impacts:	Would depend on the quality of the water.
Public Health Protection:	Would depend on the quality of the water and what was being irrigated with the water.
Regulatory Compliance:	Would depend on the quality of the water.
Recommended:	Yes.

Based on the screening results, the best remedial plan for the contamination problem in the vicinity of Building 3001 will be a combination or system of technologies. The control measures and technologies meeting the primary criteria for the Building 3001 vicinity after the initial screening are listed below:

1. Ground-water control
   a. Ground-water pumping
2. Surface treatment methods (one or more of the following)
   a. Precipitation
   b. Ion exchange
   c. Reduction
   d. Carbon adsorption
   e. Oxidation
   f. Ultra-violet oxidation
   g. Flow equalization
   h. Oil/water separation
   i. Air stripping
   j. Biological treatment
   k. Existing IWTP
   l. Modification of IWTP
3. Disposal methods
   a. Discharge to IWTP
   b. Discharge to sanitary sewers
   c. Discharge to storm sewers
   d. Discharge to stream

e. Industrial use

f. Irrigation

4. Management methods

a. Land-use controls

b. Alternative water supply

c. Relocation

d. Right-of-way acquisition

e. Personnel supervision and training

f. Coordination with federal, state, and local agencies

The best remedial plan for the two fuel-contaminated areas will be a combination or system of technologies. The control measures and technologies meeting the primary criteria for the two fuel contaminated areas after the initial screening are listed below:

1. Ground-water control

a. Pumping

b. Oil/water separation

c. Capping

2. Soil and sediment control

a. Excavation

b. Revegetation

3. Surface flow control

a. Grading

b. Capping

c. Surface-water diversion

4. Air/soil pore space control

a. Gas ventilation

5. In-situ treatment
    a. Soil aeration
6. Surface treatment of collected ground water
    a. Air stripping
    b. Biological treatment
    c. Oil/water separation
    d. Flow equalization
    e. Filtration
    f. Existing industrial waste treatment plant (IWTP)
7. Disposal of treated water
    a. Discharge to IWTP
    b. Discharge to sanitary sewers
    c. Discharge to storm sewers
    d. Discharge to stream
    e. Aquifer recharge
    f. Industrial use
    g. Irrigation
8. Management controls
    a. Land-use controls
    b. Alternative water supply
    c. Relocation
    d. Right-of-way acquisition
    e. Personnel supervision and training
    f. Coordination with federal, state, and local agencies

3.0 CONCLUSIONS

Technologies most applicable for remediation at Building 3001 and the two adjacent fuel contaminated areas have been selected through the screening process. Bench and pilot-scale tests may be necessary to develop and utilize the most beneficial technologies. Bench and pilot-scale studies may assist in the determination of the feasibility of utilization of or modification of the existing IWTP, and/or requirements for design of a new facility.

SELECTED BIBLIOGRAPHY

Bennett, Dr. Gary, 1986, Management of unconsolidated hazardous waste sites: Hazardous Materials Control Research Institute, Library of Congress Catalog No. 86-82842.

Burke Engineers, Inc., A. L., 1986, Investigation of underground tanks, Tinker Air Force Base, Oklahoma: Consultant report prepared for Department of Air Force, Air Logistics Center, Tinker Air Force Base, Oklahoma, Contract No. F34650-85-C-0238.

Dansby & Associates, Inc., 1986, Report of plugging procedures water wells 18 and 19: Consultant report prepared for Department of Air Force Directorate of Contracting and Manufacturing: Oklahoma City Air Logistics Center/PM, Tinker Air Force Base, Oklahoma, Contract No. F34650-85-C-0404.

Engineering Science, Inc., 1982, Installation restoration program, phase I, records search, Tinker AFB, Oklahoma: Consultant report prepared for United States Air Force AFESC/DEV Tyndall AFB, Florida.

Hughes, T. H. and others, 1985, A survey of current waste management technologies: Methods of recovery, treatment, disposal, and storage of hazardous wastes: Environmental Institute for Waste Management Studies.

Jacobson, C. L. and Reed, E. W., 1949, Ground-water supplies in the Oklahoma City area, Oklahoma: Oklahoma Geologic Survey Mineral Report 20.

JRB Associates, 1985, Guidance on remedial investigations under CERCLA: US EPA/540/G-85/002.

Mitchell, James K., 1982, Geotechnical and geophysical aspects of hazardous waste containment: Woodward-Clyde Consultants.

Neilson, David M., 1983, Proceedings of the third national symposium on aquifer restoration and ground-water monitoring: National Water Well Association.

Radian Corporation, 1984, Installation restoration program, phase II - confirmation/quantification, stage 2: Consultant report prepared for U.S. Air Force, Occupational and Environmental Health Laboratory (OEHL), Brooks Air Force Base, Texas, Contract No. F33615-83-D-4001.

U.S. Air Force Engineering and Services Center, 1985, Installation Restoration Program, Phase IV, Management Guidance: Tyndall Air Force Base, Florida.

U.S. Army, Corps of Engineers, 1986, Tinker AFB installation restoration program illustrative report: Tulsa District.

U.S. Army, Corps of Engineers, 1987, Draft remedial investigations report: Tulsa District.

U.S. Environmental Protection Agency, 1982, Handbook for Remedial Action at Waste Disposal Sites: EPA-625/6-82-006, Cincinnati, Ohio.

U.S. Environmental Protection Agency, 1983, Handbook for Evaluating Remedial Action Technology Plans: EPA-600/2-83-076, Cincinnati, Ohio.

Warren, Clif, 1986, Personal communication: U.S. Army, Corps of Engineers, Tulsa, Oklahoma.