ENGINEERING REPORT
FOR THE

RADFORD AAP CLOSURE OF ACID WASTE LAGOONS AND HAZARDOUS WASTE LANDFILL

Radford, Virginia

PREPARED FOR

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
HUNTSVILLE DIVISION
Huntsville, Alabama

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JUNE 1985

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June 1985

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June 14, 1985

Commander
U.S. Army Engineer Division, Huntsville
ATTN: HNDED - PM (Mr. Jack Boswell)
P.O. Box 1600
Huntsville, AL 35807

Subject: Final Engineering Report for Closure of Hazardous Waste Facilities at the Radford Army Ammunition Plant, Contract No. DACA 87-84-C-0079

Gentlemen:

Enclosed for your review are three (3) copies of the Final Engineering Report for the closure of hazardous waste facilities at the Radford Army Ammunition Plant. Copies of the report have also been distributed in accordance with the distribution of submissions in our scope of services. This report incorporates the comments received on the Intermediate Final Report.

It is our understanding that Radford AAP personnel will submit this report to the Commonwealth of Virginia Division of Solid and Hazardous Waste Management. The submission of this Engineering Report would serve as the closure plan submission to the State.

Dr. T.G. Shea, a registered professional engineer with the Commonwealth of Virginia and Manager of Engineering Technology, has reviewed this engineering report.

Sincerely,

ENGINEERING-SCIENCE

Timothy G. Shea, Ph.D., P.E.
Manager, Engineering Technology
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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Radford Army Ammunition Plant (Radford AAP) in Radford, Virginia is a government-owned, contractor-operated military facility. The plant has been operated by Hercules, Inc. since the early 1940's to manufacture propellants, explosives and basic ammunition ingredients. To support the manufacturing operation, the Radford AAP operates several hazardous waste management (HWM) facilities which include surface impoundments and a landfill trench. As a result of several recent studies on these HWM facilities to assess compliance with the Federal and State Hazardous Waste Regulations, it was decided to close the surface impoundments HWM Nos. 5 and 7 and the hazardous waste landfill trench HWM 16.

Engineering-Science (ES) was retained by the U.S. Army Corps of Engineers (USACOE) to provide engineering services for the closure of these facilities (HWM Nos. 5, 7 and 16). The purpose of this Engineering Analysis Report is to present the results of the closure analysis which would lead to the selection of a closure method so that detailed closure plans and specifications could be prepared.

SITE FACILITIES DESCRIPTION

The Radford AAP is located in Pulaski and Montgomery Counties in Southwest Virginia. The plant site is divided into a northern and a southern section by the New River. The Elbrook formation, consisting mainly of shaly dolomite with interspersed strata of limestone, shale and argillaceous limestone, underlies the site. Residual soils, terrace deposits and alluvial soils are found in various geomorphic units in the area. Groundwater in the vicinity of the site occurs at shallow depths primarily in the overburden and near the bedrock. At some locations in the general plant area, the bedrock formation is characterized by sinkholes and solution channels which often allow groundwater to move rapidly.

HWM 5 is a holding lagoon that receives various acid washdown waters and spills from an acid tank farm. The impoundment bottom was lined in 1981 with Hypalon of 60-mil thickness. Because the lagoon was operated without a liner in the past and leakage occurred from the acidic wastewater pipe south of the lagoon, the soils underneath the lagoon and once-leaking pipe have probably been contaminated by acidic liquids. Groundwater samples collected from the monitoring wells at HWM 5 indicate that groundwater degradation has occurred in the vicinity of the site. Specifically, low pH values were found at all of the monitoring wells and elevated nitrate and sulfate levels were observed at the downgradient wells. These results are indicative of contamination caused by wastewater containing nitric and sulfuric acids.

HWM 7 is an unlined holding and neutralization basin that receives spills and cleanings from an acid tank farm and daily production of waste caustic. HWM 7 is located adjacent to the New River and within the 100-year flood boundary. Lime is added to neutralize the liquid when acidic wastes predominate and the neutralized water is pumped to a settling lagoon. Groundwater monitoring results for HWM 7 indicate that groundwater degradation has occurred in the vicinity of the site. Elevated nitrate, sulfate, chloride and manganese concentrations were found in the downgradient wells as compared to the upgradient well. The indicator parameters (pH, specific conductance, TOC and TOX) from the downgradient wells were found to exceed the background levels. Resistivity surveys conducted at HWM 7 also identified several areas where groundwater degradation has possibly occurred.

HWM 16 is a hazardous waste landfill trench located on a terrace in the northern portion of the Radford AAP area. It receives residue from open burning of explosives, various laboratory waste chemicals and lagoon sludges. HWM 16 has a bottom consisting of compacted in-situ soil and began operation in 1980. Groundwater samples collected from monitoring wells in the vicinity of HWM 16 indicate that groundwater degradation has occurred. Further assessment based on additional monitoring wells installed in late 1984 and more extensive analysis indicate that the TNT neutralization sludge disposal site, located about 300 feet upgradient of HWM 16, is a probable source of groundwater contamination. An additional groundwater investigation focusing on this TNT neutralization sludge disposal site is planned.

Due to the known groundwater contamination at all these sites, a Compliance Monitoring program is to be implemented by Radford AAP. It is very likely that the Compliance Monitoring Program will extend several years into the post-closure period of HWM sites 5, 7 and 16.

GENERAL CLOSURE REQUIREMENTS

The Commonwealth of Virginia, Department of Health obtained final authorization of its Hazardous Waste Management Regulations from EPA in December, 1984. Therefore, the closure and post closure of HWM Nos. 5, 7 and 16 will be regulated by the Virginia Regulations. During the planning and initial phase of this closure analysis, it was believed that the standards in Section 9.00 of the Virginia Regulation for Interim Status facilities would be applicable for closure of the HWM facilities. However, the recent amendment to the State Regulations requires that a regulated HWM facility, i.e., one which received wastes after July 26, 1982, must meet the closure and post-closure requirements under Section 10.00 standards. Thus, HWM Nos. 5, 7 and 16 will have to be closed following the relevant Section 10.00 standards. While closure of HWM 16 would not be significantly affected by this amendment, the operational surface impoundments (HWM 5 and HWM 7) will have to satisfy more stringent requirements in Section 10.00 for closure, post-closure care and groundwater protection.

With possible subsoil contamination as inferred from the groundwater quality and operational practices at the Radford site, the general requirements applicable for closure of the surface impoundments include:

- o Remove all the wastes and liquids.
- o Stablilize the bottom sediment and subsoil to the extent needed to support backfill and final cover.
- o Backfill the depressions and provide site drainage.
- o Install a final cover system and provide post-closure care and groundwater monitoring for the 30-year post-closure period, unless it is demonstrated that no hazardous material remains after the final closure.

The general requirements applicable for closure of the hazardous waste landfill (HWM 16) include:

- o Install a final cover system to minimize infiltration of precipitation.
- o Provide post-closure care and groundwater monitoring for the post-closure care period of 30 years.

No final cover system, post-closure care or post-closure groundwater monitoring would be required if all the wastes and the contaminated materials (including contaminated soil) are removed and disposed in an off-site facility.

CLOSURE METHOD

The following were considered in selecting closure methods for the Radford AAP hazardous waste facilities:

- The regulatory requirements in Section 10.00 of the Virginia Hazardous Waste Management Regulations.

- Environmental protection against possible release of contaminants from the closed facilities.

- Technical feasibility of various methodologies to be used in the final closure and their anticipated post-closure performance.

- Cost effectiveness of the method.

Three potential closure alternatives were identified for the closure of the surface impoundments. They are: offsite disposal; treatment; and in-place closure.

The offsite disposal alternative consists of removal and transportation of all waste material and contaminated subsoil to a permitted offsite facility for disposal. This involves an excessive cost at no apparent gain in environmental protection.

The treatment alternative involves removal of surficial wastes, excavation of the contaminated subsoil and mixing with an appropriate agent. Upon treatment, the contaminated soil would be neutralized, solidified and stabilized and the mobility of the contaminants would be significantly reduced. However, the treatment alternative alone is potentially incomplete because demonstration of no contamination potential remaining after treatment is difficult and therefore is viable only as part of other closure alternatives.

The in-place closure alternative consists of removal of surficial wastes and closure with the contaminated subsoil in place. A final cover system and post-closure care would be required for the in-place closure. The in-place closure alternative, at a moderate cost, is environmentally acceptable and technically sound. The majority of the in-place closure costs results from the post-closure groundwater monitoring. Because of the Compliance Monitoring that will be implemented and because of probable groundwater quality improvement within several years after closure of the impoundments, the total groundwater monitoring cost could be significantly less than what is required for a 30-year post-closure period.

The in-place closure alternative is desirable also for the hazardous waste landfill trench (HWM 16). The reasons for in-place closure include: no disturbance of wastes; no known adverse impacts on the environment; and low potential of leachate generation after closure with a final cover system.

Site preparation tasks, such as neutralization of impoundment liquids and flashing of the potentially NC-laden sediments in HWM 5 will be performed by Radford AAP (Hercules, Inc.) because of safety concerns associated with reactive compounds. The closure construction for the surface impoundments (HWM 5 and HWM 7) involves demolition of appurtenant structures, treatment of subsoil and sediments, sampling/analysis, backfilling and cover system installation. The closure construction for the hazardous waste landfill (HWM 16) includes compaction of the remaining bottom section and filled cover area, leachate drain installation, disposal of the final volume of wastes and cover system installation. The final cover system, the most important component in the closure of the hazardous waste facilities with waste in place, consists of: one foot of topsoil with grass cover; one foot of cover soil; 30-mil PVC membrane liner; and compacted soil bedding (secondary liner).

COST, SCHEDULE AND RECOMMENDATIONS

The preliminary estimated cost of closure construction for HWM sites 5, 7 and 16 is approximately $320,000. The annual post-closure cost is estimated at about $28,000, about 90 percent of which is attributable to groundwater monitoring. Since a separate post-closure groundwater monitoring is not necessary during the Compliance Monitoring period and the post-closure groundwater monitoring at the HWM 5 and HWM 7 sites could be curtailed if the groundwater quality is shown to approach background levels, the annual cost of $28,000 may not be needed for the entire 30-year post-closure period. It is estimated that the closure of the Radford AAP hazardous waste facilities (HWM Nos. 5, 7 and 16) can be completed in 10 months following the receipt of appropriate funding.

Two recommendations are made as interim actions prior to the closure of these facilities: minimize filling of interim soil cover in HWM 16; and neutralize acidic liquids in HWM 7 as frequently as practical. The interim soil cover, placed after disposal of a batch of waste material, constitutes a significant portion of the filled material in HWM 16. By disposing of wastes in large batches and thereby reducing the interim soil cover material in HWM 16, the space for the closure-related wastes (e.g., cover sand and liner membrane from HWM 5) can be assured. At the HWM 7 site, surges of acidic liquids leaking out of the impoundment prior to neutralization may cause groundwater degradation (low pH and elevated metal concentrations) in the immediate vicinity of HWM 7. By more frequent neutralization (or adding lime beforehand) and thus minimizing surges of acidic liquid prior to closure of HWM 7, the groundwater quality at the site could stabilize earlier, thereby allowing the possible curtailment of costly groundwater monitoring.

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INTRODUCTION

1.1 BACKGROUND

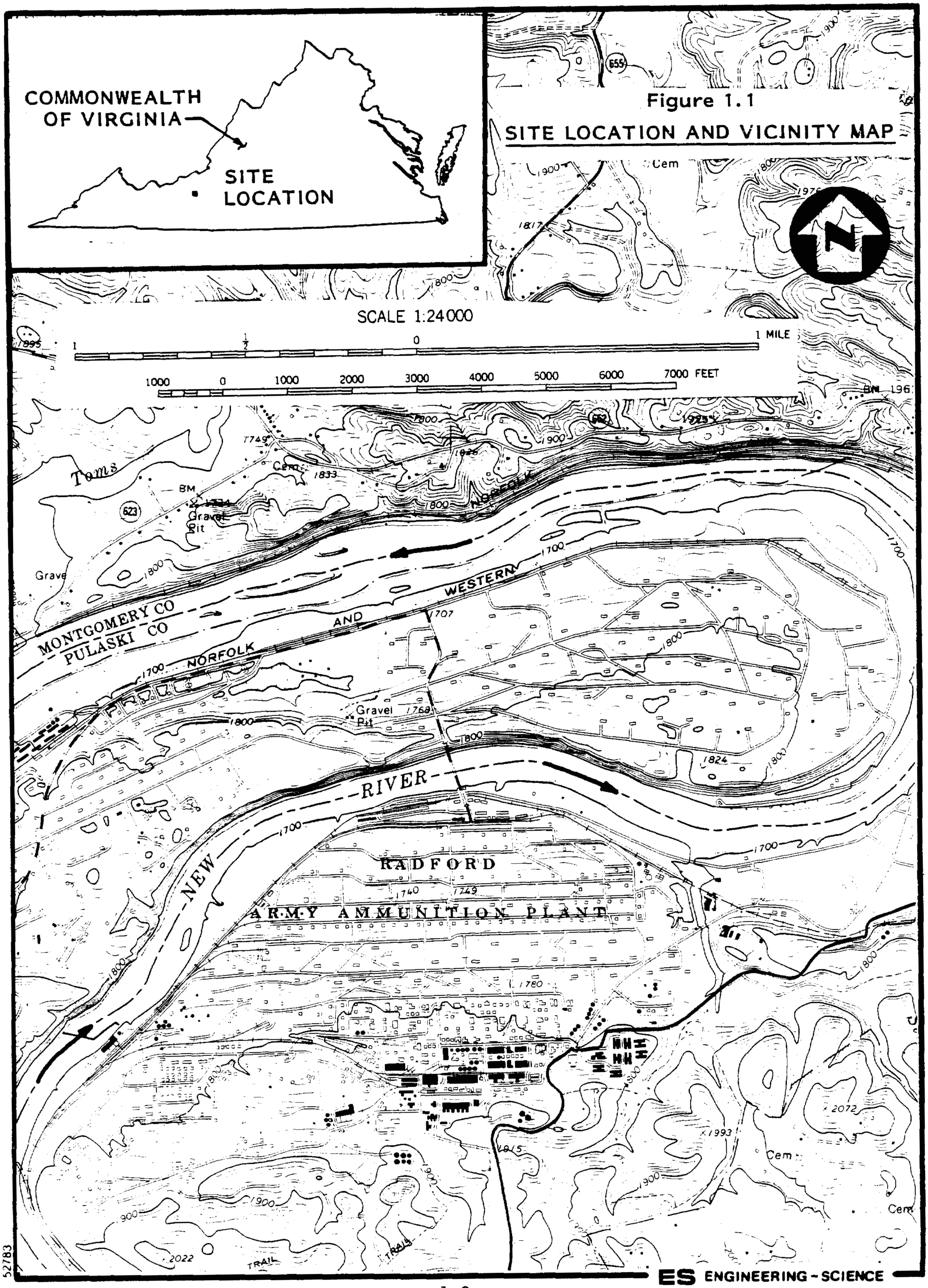
The Radford Army Ammunition Plant (Radford AAP) is located in Pulaski and Montgomery Counties in Southwest Virginia. The Radford AAP is a government-owned, contractor-operator (GOCO) military industrial installation engaged in manufacturing propellants, explosives and basic ammunition ingredients. Other plant activities include power and steam generation and water and wastewater treatment. The main manufacturing area covers 4,145 acres about four miles north of Radford, Virginia, and is separated by the New River into two major areas. Within the Radford AAP area, the New River flows initially to the east, and then forms a horseshoe-shaped area by turning 180 degrees to flow to the west. The northern portion of the Radford AAP, located within this horseshoe area (Pulaski County), is thus enclosed by the river. The southern portion of the plant occupies the area south of the river in Montgomery County (Figure 1.1).

Hercules, Inc., the operator of the Radford AAP, began construction of the plant in 1940 and manufactured smokeless powder in 1941. Construction of various facilities continued until the end of World War II, when the plant was placed on standby status. In 1949, the production of smokeless powder was resumed on a limited scale. In 1950, the Radford AAP was rehabilitated to meet the demands for the Korean conflict and facilities for production of cast propellant charges for rockets and missiles were added from 1952 to 1958. Goodyear Aircraft fabricated missile component parts at the Radford AAP until Hercules took over the operation. The plant was further expanded in 1968 with the construction of three automated continuous TNT lines.

As part of plant production activities, the Radford AAP has several hazardous waste management (HWM) facilities in operation. Surface impoundments are used to receive corrosive wastes from various production waste streams (HWM Nos. 5, and 7) or serve as neutralization/ equalization basins (HWM Nos. 4, 19 and 20). After neutralization, flows are directed to a settling lagoon (SWM Nos. 8 or 9), allowed to settle and then discharged to the New River under National Pollutant Discharge Elimination System (NPDES) permits. Several landfills have been in operation to dispose of solid wastes. These facilities include the fly ash landfills, sanitary landfill trenches and a hazardous waste landfill trench (HWM 16). Wastes received in HWM 16 include ash from open burning of explosive wastes, ash from incineration of waste propellants, waste laboratory chemicals, and lagoon sludge produced by neutralization of acidic wastewater.

A number of studies have been performed on the above listed HWM facilities to assess compliance with the Resource Conservation and Recovery Act (RCRA) and Commonwealth of Virginia Hazardous Waste Management Regulations (COVHWMR). As a result of these previous studies (NUS, January 1981; USAEHA, December 1980 and December 1981; USAEHA, October 1983, BCM, April 1984 and May 1984), the U.S. Army Corps of Engineers decided to construct replacement storage tanks and close existing surface impoundments HWM Nos. 5 and 7. HWM 16, the hazardous waste landfill trench, is also scheduled to be removed from service. Preliminary Closure and Post-Closure Plans for HWM Nos. 5, 7 and HWM 16 were prepared previously (CH2M Hill and PEER consultants, July 1984).

The U.S. Army Corps of Engineers, Huntsville Division (COE), has retained Engineering-Science (ES) to provide engineering services for the closure of HWM facilities Nos. 5, 7 and 16 (Figure 1.2), and the design of replacement tanks for HWM Nos. 5, 6 and 7. HWM 6 was an acidic water holding lagoon that once received spills and washdown


COMMONWEALTH OF VIRGINIA
SITE LOCATION
Figure 1.1
SITE LOCATION AND VICINITY MAP
SCALE 1:24000
1 MILE
7000 FEET
MONTGOMERY CO
PULASKI CO
NORFOLK AND WESTERN
NEW RIVER
RADFORD ARMY AMMUNITION PLANT
Toms
Gravel Pit
Cem
TRAIL
ES ENGINEERING-SCIENCE
52783

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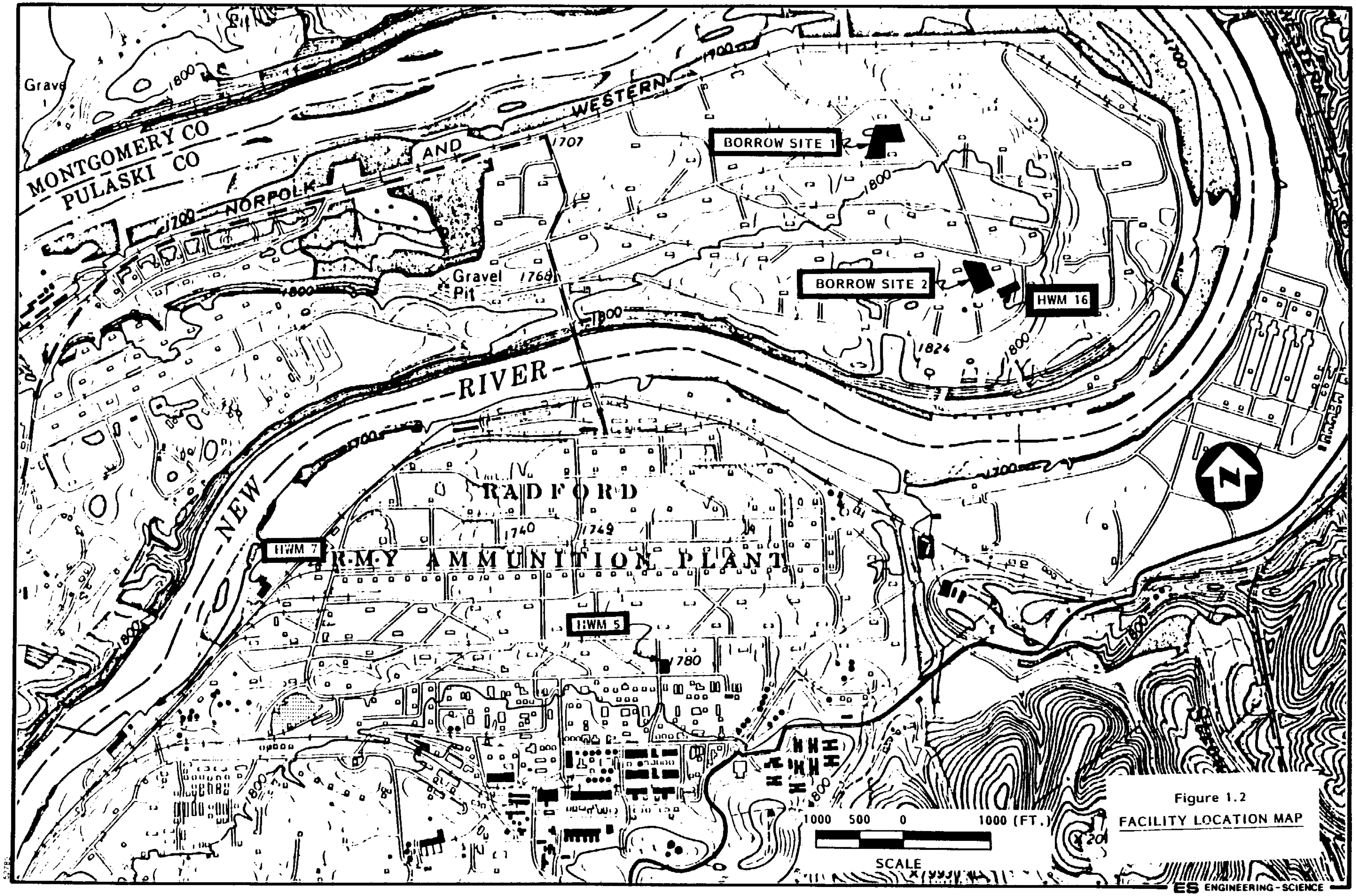


Figure 1.2
FACILITY LOCATION MAP

waters from an acidic tank farm. HWM 6 has not been in service since the RCRA Hazardous Waste Management Regulations came into effect in November, 1980. It, therefore, is not subject to regulations for closure. A replacement tank is needed for HWM 6 because of the likelihood of future operation of facilities in that area which will require temporary storage of acid spills and washdown waters.

Presented herein are the results of engineering and technical analyses required for the final closure of these hazardous waste management facilities. Relevant information provided in the Background and Records Evaluation Report (ES, 1984) is also incorporated into this report.

Since the Commonwealth of Virginia (COV) has obtained Final Authorization of its Hazardous Waste Management Program from the U.S. Environmental Protection Agency (EPA) on 18 December 1984, the closure of the HWM facilities at the Radford AAP will be conducted in compliance with COV regulations. These regulations (COVHWMR) are almost identical to those of the RCRA. The Radford HWM facilities will probably be the first hazardous waste facilities closed under the regulatory approval of the COV.

1.2 OBJECTIVES

The objective of the Engineering Report is to present the results of the closure analysis for HWM facilities Nos. 5, 7 and 16. The closure analysis consisted of a technical and economic review of feasible methods of closure including consideration of applicable regulations. It was intended that the closure analysis would lead to the selection of recommended closure methods and, therefore, allow for the preparation of closure construction documents (specifications and detailed plan drawings). A contractor would then be engaged by the COE to implement the closure plans and specifications.

1.3 REPORT FORMAT

To meet the objective of this report, the existing information relevant to the closure of the hazardous waste management facilities has been reviewed and is presented in subsequent sections of this report. These include: Geohydrologic and Geotechnical Summary (Section 2); Hazardous Waste Characteristics Analysis (Section 3); and Contamination Analysis (Section 4). The Background and Records Evaluation Report (ES, December 1984) and additional data that have recently become available have been utilized to compile this existing information.

Next, general approaches and alternatives for closure of the Radford AAP disposal facilities are presented (Section 5). The analysis presented focused on a review of available closure methods, a preliminary cost analysis, permits and regulations, technical feasibility/practicality, and environmental impacts. Comparisons of these alternatives were made based on three critical factors: technical feasibility, environmental acceptability, and cost. Based on these comparisons a closure method was then selected and a more detailed analysis, is provided in Section 6. Discussion of the post-closure care and groundwater monitoring requirements are provided in Section 7. A cost estimate and closure schedule are presented in Section 8. Finally, a summary of the closure analysis and recommendations are provided in Section 9.

A Health and Safety Plan presenting an overview of the safety concerns associated with the closure methods discussed herein is also provided (Appendix A). This plan will serve as the basis for the development of a detailed site-specific Health and Safety Plan, which will be developed as part of the construction documents. The sampling, analysis and quality control programs will also be part of the construction documents.

SECTION 2

GEOHYDROLOGIC AND GEOTECHNICAL SUMMARY

SECTION 2

GEOHYDROLOGIC AND GEOTECHNICAL SUMMARY

This section presents a summary of relevant information concerning the geology, soils and geohydrology of the sites. A discussion of the general setting, including the physiography, geology and geohydrology, of the Radford AAP is provided. Site-specific subsurface conditions are presented for each of the hazardous waste management sites to facilitate cross-referencing between the geology and geohydrology of each facility.

The information in this section was compiled from various previous studies prepared for the Radford AAP site (NUS, 1981; USAEHA, 1980, 1981 and 1983; BCM, April and May, 1984; and CH_2M Hill and PEER Consultant, 1984).

2.1 GENERAL SETTING

Physiography

The Radford AAP is located in the Valley and Ridge Physiographic Province of the Appalachian Highland Region. The topography of the region is characterized by elongated, narrow, flat-topped ridges consisting of resistant sandstones and dolomites that strike southwest to northeast. Narrow valleys of varying width and length intervene these ridges. These landforms are the result of a complex sequence of thrust faulting and multiple folding over the past hundred million years. The New River originates in the Blue Ridge Plateau of North Carolina and forms the divide between Montgomery and Pulaski Counties in Southwest Virginia (Figure 1.1). The river is characterized by a number of rapids and entrenched meanders. The New River flows through the Radford AAP dividing the plant area into a northern and a southern section. In general, surface water drains to the New River in the vicinity of the Radford AAP. An exception is the southeastern portion of the Radford AAP which is drained by Stroubles Creek, a major tributary to the New River.

Geology

The Radford area is underlain by sedimentary rocks consisting of limestone, dolomite and minor sandstone, which are complexly folded, faulted and fractured. The Radford AAP site is underlain by the Elbrook formation of Cambrian age, consisting mainly of shaly dolomite with interspersed strata of limestone, shale and argillaceous limestone. Common features of dolomite and limestone rocks in this area are sinkholes, solution channels and pinnacled bedrock surface. These rocks are mantled by residual soils consisting of sand, silt and clay derived from the underlying parent rocks. Alluvial deposits are also found along stream valleys and in the terrace and floodplain of the New River. Alluvial soils include micaceous silts and sandy clays underlain by coarser deposits of silty and clayey sands and gravels. Cobbles and boulders, commonly referred to as "riverjack", are scattered in the alluvial strata.

Geohydrology

Groundwater in the vicinity of the Radford AAP occurs at relatively shallow depths (unconfined) in both the overburden and bedrock. The groundwater is recharged by precipitation and streamflows in surrounding hills and terraces, and flows toward the New River and locally toward Stroubles Creek. In areas of terrace deposits, the groundwater surface is encountered near the top of the bedrock. In floodplain areas, the water table occurs in the alluvial material due to the greater depth to bedrock and the area's proximity to the New River. Groundwater in the carbonate bedrock (i.e., dolomite and limestone) is found in fractures and solution channels. This condition often allows groundwater and, therefore, any contaminants in the groundwater, to readily migrate locally.

2.2 SITE-SPECIFIC SUBSURFACE CONDITIONS

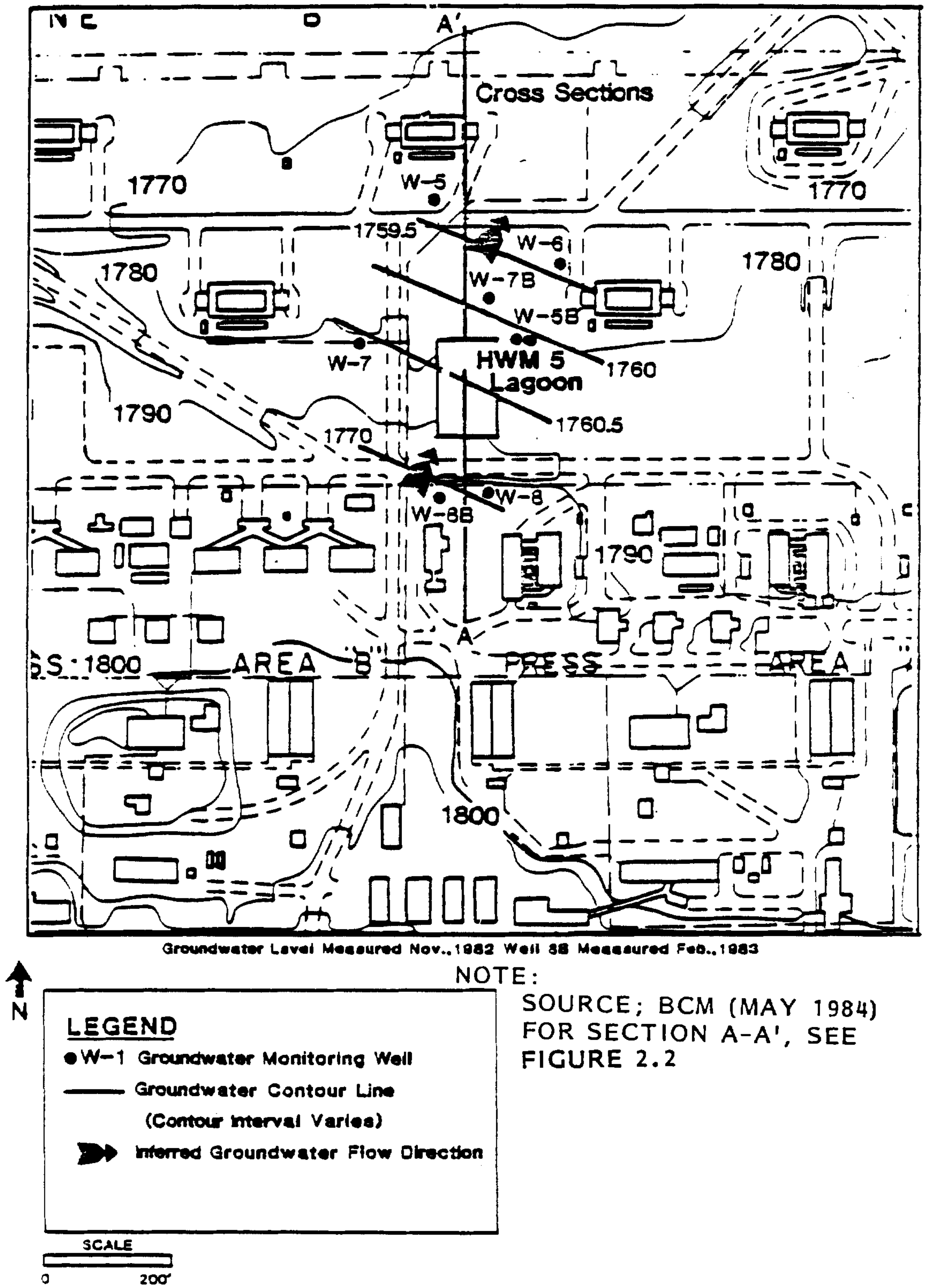
Hazardous Waste Management Site 5

HWM 5 is located on a river terrace which slopes gently to the north toward the New River (Figure 1.2). The overburden at HWM 5 is primarily silty soils and underlain by alluvial silt, sand and gravel. The terrace materials are deposited in discontinuous lenses, probably the result of deposits of former stream channels. The bedrock beneath the site consists of weathered dolomite which slopes gently toward the north following the surface slope. The bedrock was recorded at similar elevations with depths from the surface ranging from 22 to 34 feet. However, the actual bedrock surface may be irregular due to solution channels, original stream erosion and sinkholes.

The groundwater at HWM 5 is shallow and unconfined with depths ranging from 12 to 17 feet. The groundwater elevation to the south of HWM 5 (upgradient) is approximately 1770 feet. To the north and northeast, which is the direction of the groundwater flow at HWM 5 (Figure 2.1), the elevation of the groundwater is approximately 1760 feet. At HWM 5, the groundwater table drops about 10 feet over a short distance between the upgradient well (W-8B) and the lagoon, and flattens between the lagoon and the downgradient wells (Figure 2.2). This variation in gradient is due to the occurrence of permeable but discontinuous sand and gravel lenses in less permeable silty soil.

Figure 2.1

GROUNDWATER CONTOURS IN THE VICINITY OF HWM 5 SITE

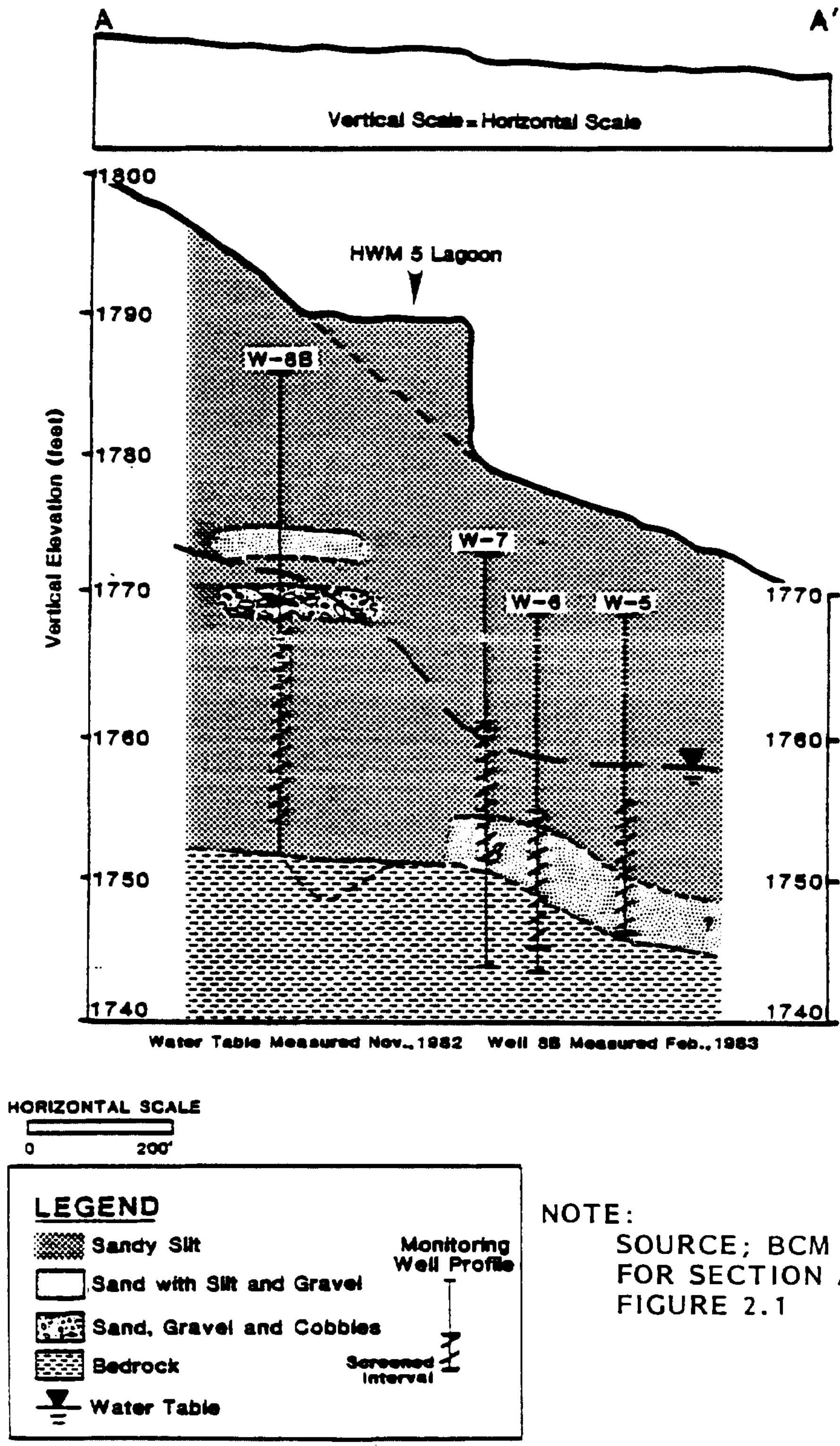


NOTE:

SOURCE; BCM (MAY 1984)
FOR SECTION A-A', SEE
FIGURE 2.2

FIGURE 2.2

GEOLOGIC CROSS-SECTION OF HWM 5 SITE



NOTE:
SOURCE; BCM (MAY 1984)
FOR SECTION A-A', SEE FIGURE 2.1

ES ENGINEERING-SCIENCE

Hazardous Waste Management Site 7

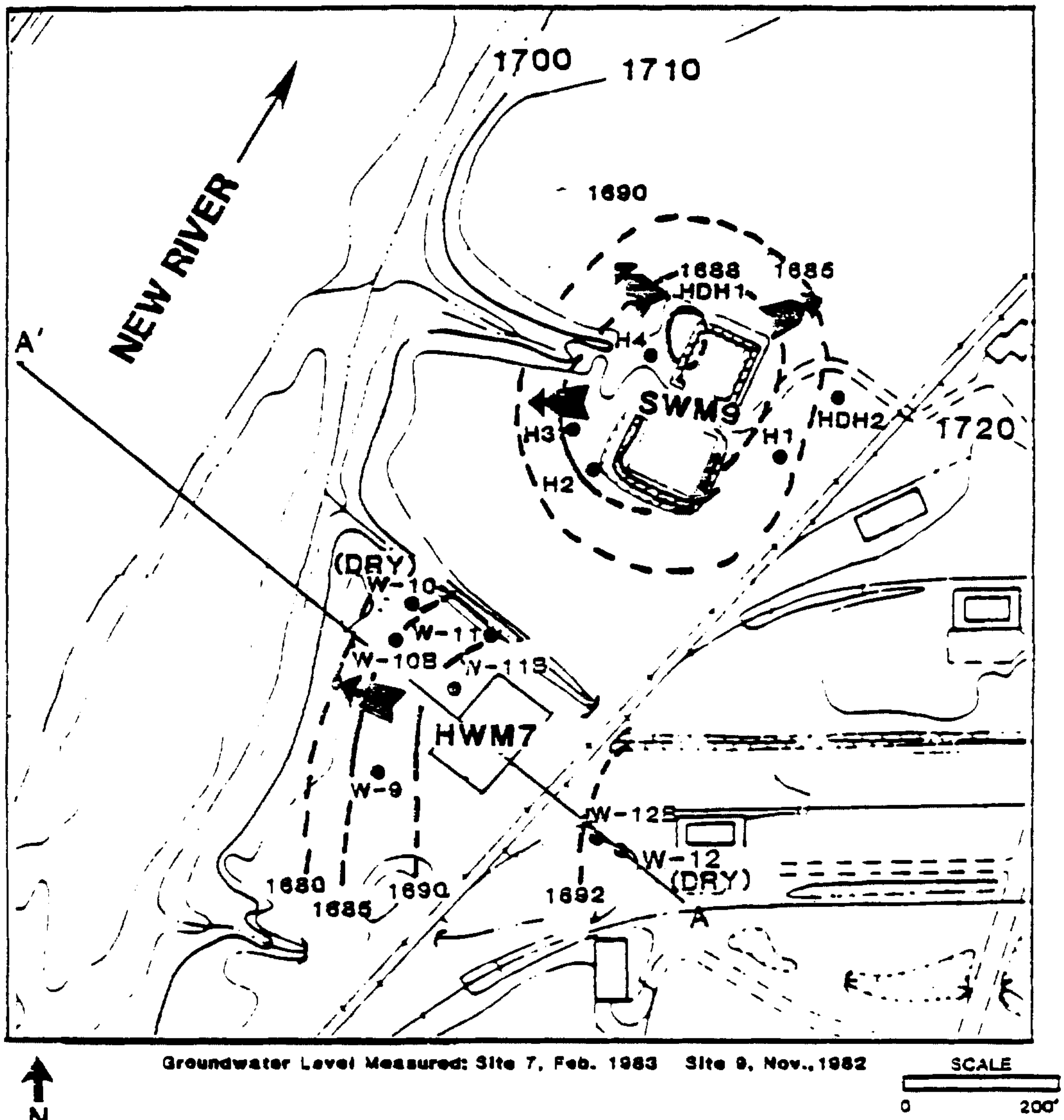
HWM 7 is located within the flood plain about 250 feet from the New River and about 100 feet from the railroad tracks (Figure 1.2). The floodplain in this area is fairly flat with a mild slope toward the New River. The approximate surface elevation of the site is 1715 feet which is about 40 feet above the mean river level. The HWM 7 site is located within the 100-year flood boundary (NUS, 1981), which is one of the principal reasons for closure of the site.

The subsurface material underlying HWM 7 consists of about 25 feet of alluvial deposits overlying dolomite/limestone bedrock. The alluvial soils range from silty sand with clayey silt lenses in the upper part to a mixture of silt, sand and gravel with riverjack toward the base. These alluviums have been deposited by old river channels as well as the recent river channel during periods of flooding. The bedrock consists of gray dolomite and argillaceous limestone of the Elbrook formation. Both the dolomite and limestone formations are moderately weathered and fractured.

The groundwater at HWM 7 is shallow and unconfined. The depth of the water table in the vicinity of HWM 7 ranges from 17 to 26 feet in depth. The direction of the groundwater flow in the vicinity of HWM 7 is toward the New River (Figure 2.3). The geologic cross-section of the HWM 7 site is shown in Figure 2.4. Because of very permeable subsurface material at the base of the alluvial deposits (coarse sand/gravel and fractured bedrock), the groundwater table beneath HWM 7 is virtually flat and readily responds to river level fluctuations (BCM, May 1984).

Figure 2.3

GROUNDWATER CONTOURS IN THE VICINITY OF HWM 7 SITE



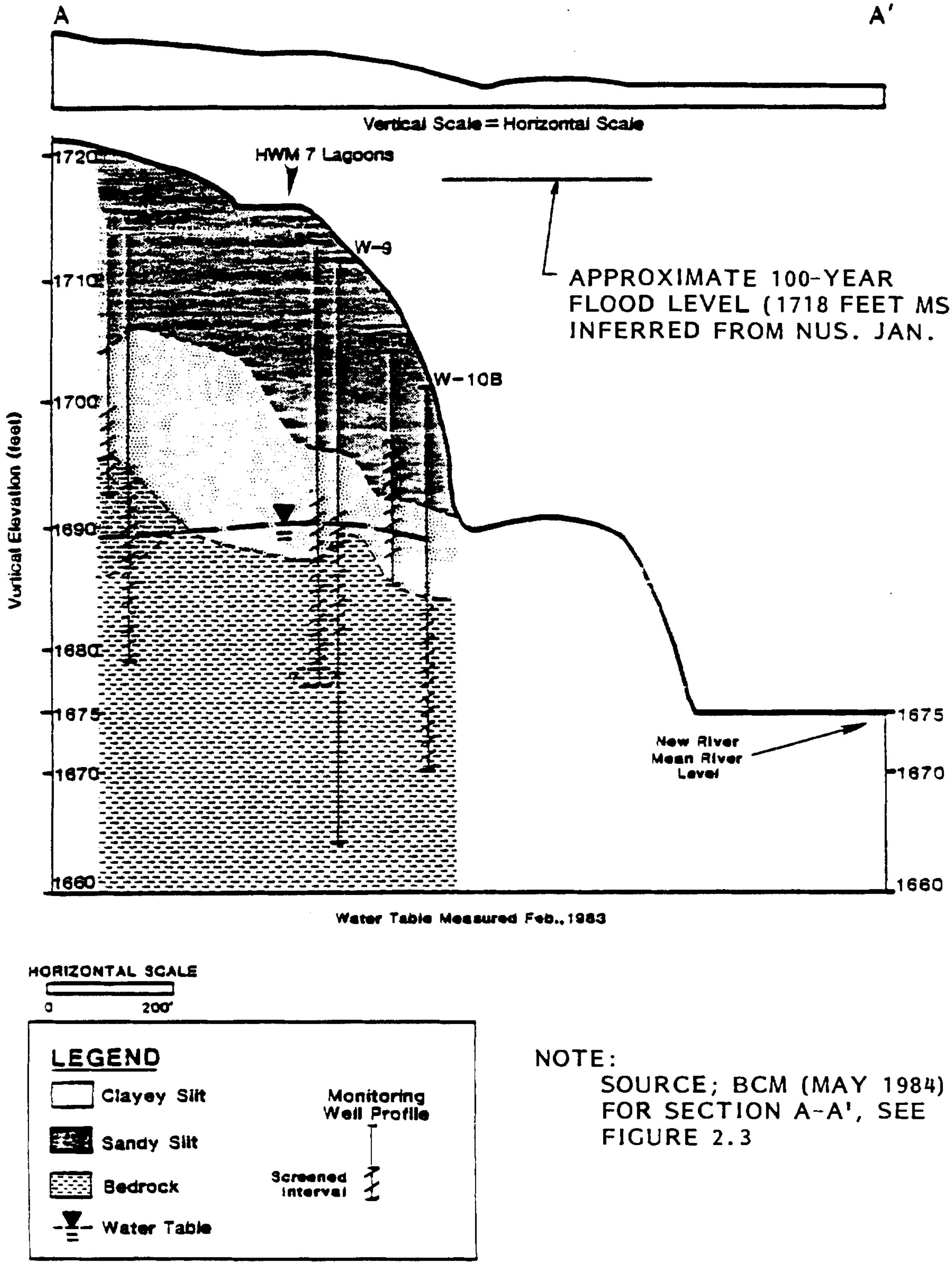
NOTE:

SOURCE; BCM (MAY 1984)
FOR SECTION A-A', SEE
FIGURE 2.4

LEGEND

- ● Groundwater Monitoring Well
- — — — Groundwater Contour Line (Contour Interval Varies)
- Inferred Groundwater Flow Direction

FIGURE 2.4
GEOLOGIC CROSS-SECTION OF HWM 7 SITE



NOTE:
SOURCE; BCM (MAY 1984)
FOR SECTION A-A', SEE FIGURE 2.3

Hazardous Waste Management Site 16

HWM 16 is located near the edge of the upper terrace in the horseshoe section of the Radford AAP (Figure 1.2). A distinct lower terrace approximately 1000 feet wide separates the upper terrace and the New River. The surface topography in the immediate vicinity of HWM 16 forms a mild slope to the east, steepens at the edge of the upper terrace, and then becomes almost flat in the lower terrace. The edge of the lower terrace forms a bluff above the floodplain.

Subsurface materials in the vicinity of HWM 16 consist of clayey to micaceous sandy silt, silty sand and gravel, and limestone/dolomite bedrock. The surface materials consist of clayey to micaceous sandy silt and range in depth from 10 to 40 feet. The pH of soil samples collected within 20 feet of the ground surface, ranges from 4.8 to 6.8 with a typical value of 5.4. Underlying the surface material are terrace deposits of silty sand and gravel with occasional large cobbles (riverjack). Beneath the silty sand and gravel is the gray limestone/dolomite bedrock of the Elbrook formation. The top of the bedrock is 50 to 60 feet below the ground surface to the west of HWM 16 and greater than 70 feet deep to the south and east. The rocks are highly fractured, forming breccia at several locations.

Laboratory permeability values of soil samples collected from the HWM 16 site ranged from 9.0×10^{-4} cm/sec to 4.4×10^{-6} cm/sec. The average permeability of fractured rock, estimated by field permeability tests, is higher at 2.3×10^{-3} cm/sec (NUS, 1981). The depth to the water table is about 50 feet (elevation 1790 feet) to the west of HWM 16 and about 70 feet (Elevation 1743 feet) at the eastern end of HWM 16. In general, the groundwater table is near the top of the bedrock. The groundwater flow direction is toward the east and northeast, roughly parallel to the HWM 16 trench, and the gradient is steep at about eight percent.

Borrow Sites

Two locations, Borrow Sites 1 and 2 (Figure 1.2), are potential sources of borrow material for the cap liner and common fill needed to close the Radford AAP Hazardous Waste Management facilities. Borrow Site 1 is presently being used as a borrow area for sanitary landfill cover material. Borrow Site 1 is located in the northern portion of the upper terrace and about one-half mile northwest of HWM 16. This area is grass-covered and forms a low hill which slopes gently downward to the north. The exposed cut faces of Borrow Site 1 show predominantly micaceous sandy silt to silty sand. Borrow Site 2 is the area to the northwest of the sanitary and hazardous waste landfill trenches. If borrow material were used from Borrow Site 2, the area could be used for future sanitary landfill expansion after the borrow material is removed.

The results of the Borrow Site Investigation are presented in a separate geotechnical report (Schnabel, 1985). It appears that the borrow areas investigated contain material suitable for use as a cap liner. When compacted at three percent above the optimum moisture content, the portions of borrow site material gave laboratory permeability values of less than 10^{-7}cm/sec. Except for 1-2 feet of overlying topsoil, all the subsurface materials in the two borrow sites are judged to be suitable for common fill. Laboratory test results and recommendations for construction are provided in the geotechnical report (Schnabel, 1985).

SECTION 3

HAZARDOUS WASTE CHARACTERISTIC ANALYSIS

SECTION 3

HAZARDOUS WASTE CHARACTERISTIC ANALYSIS

Provided in this section is a general site description and a discussion of the sources of waste for each of the HWM facilities (Nos. 5, 7 and 16). The specific physical and chemical properties of the chemical substances identified at these sites are also presented. A process flow diagram of the HWM facilities at the Radford AAP is presented in Figure 3.1. This figure shows the relationship between HWM facilities Nos. 5 and 7 and other HWM facilities.

3.1 HAZARDOUS WASTE MANAGEMENT SITE NO. 5

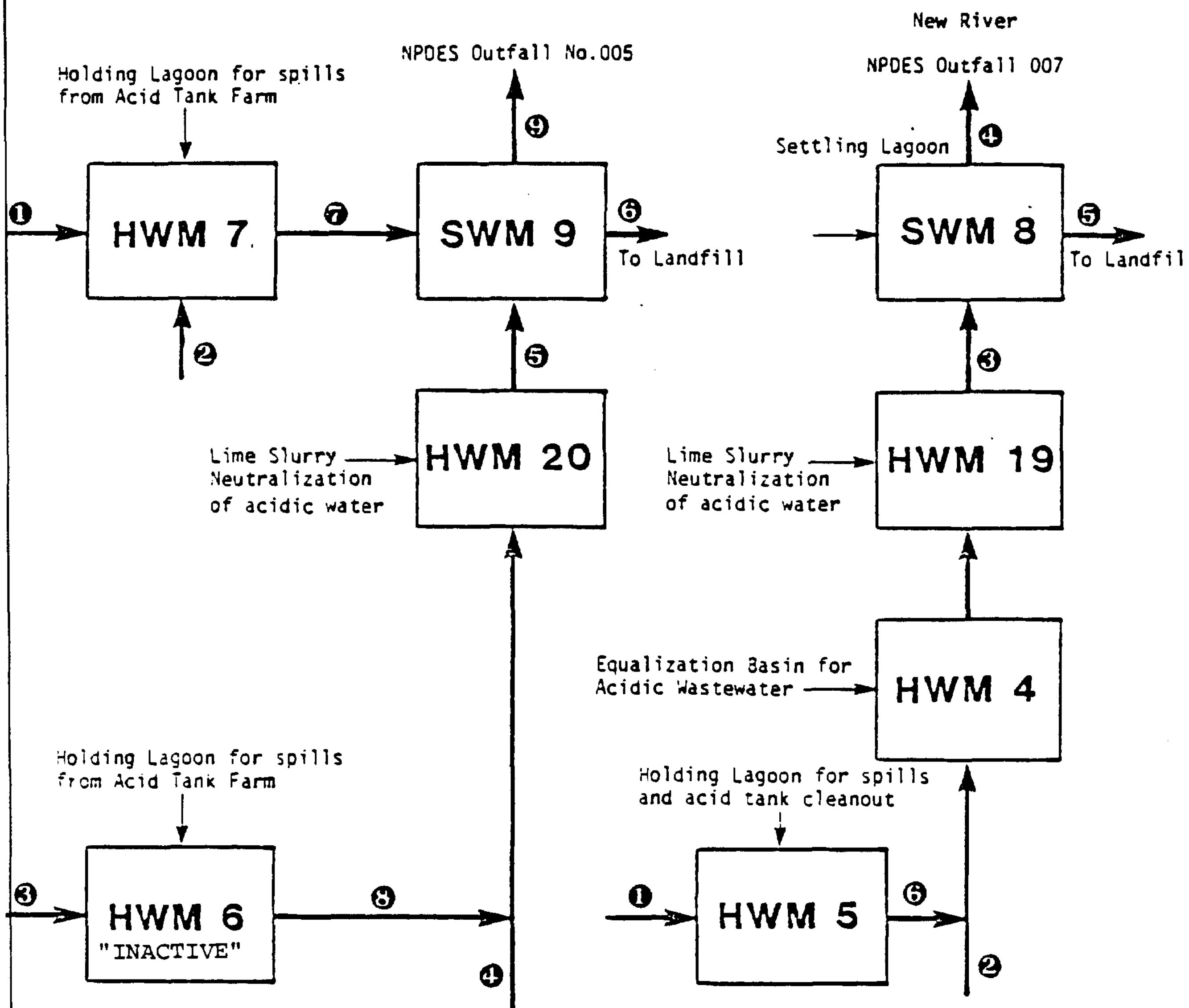
Site Description

HWM 5 is a surface impoundment serving as a holding basin for runoff, spill and washdown waters from an acid tank farm. HWM 5 has been in service since the mid-70's. The dimensions of the impoundment are illustrated in Figure 3.2. The impoundment is approximately 150 feet by 100 feet at the crest elevation of the dike, and is approximately 10 feet deep with side slopes of 30 to 40 degrees. The depth of the acidic water is normally 2 to 4 feet for a total volume of about 140,000 to 300,000 gallons. The bottom of the impoundment was lined in 1981 with Hypalon of 60 mils in thickness. The liner is covered with about 12 inches of sand, and the sides are covered with approximately 6 inches of sand and granite riprap. The compatability of the Hypalon liner with the acidic water has been rated as "good" according to a previous report (Wyss et al, September 1980).

As illustrated in Figure 3.1, the effluent from HWM 5 is discharged to an equalization basin, HWM 4. The effluent is conveyed via a sub-

Figure 3.1

Radford AAP
Process Flows of Existing HWM Facilities



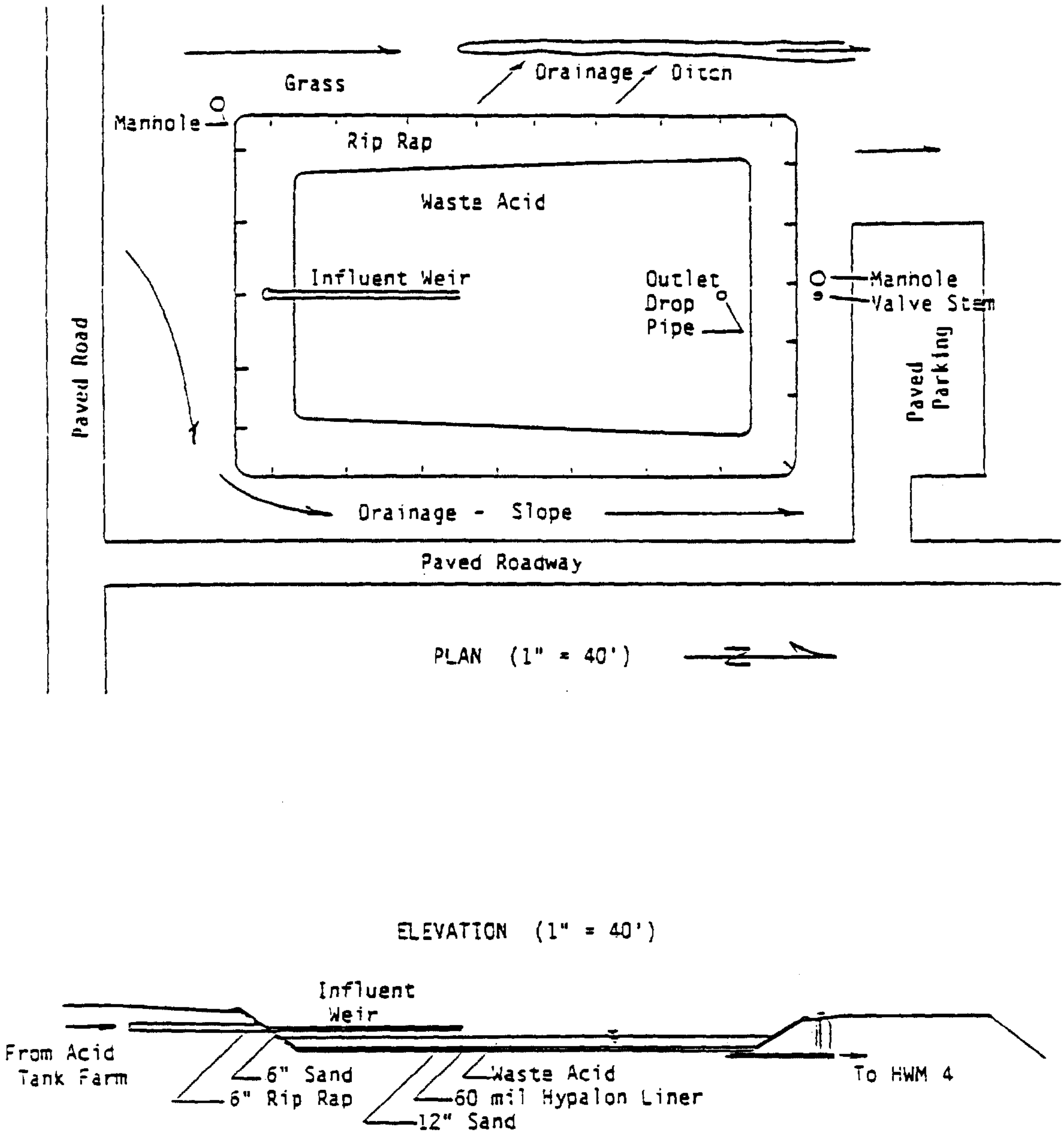
1. Acid spills, variable amount
2. Waste caustic, 4,000 gallons per day
3. Acid spills, variable amount
4. Acidic wastewater, 4,000,000 gallons/day
5. Neutralized acidic wastewater
6. Calcium sulfate sludge containing a small amount (estimated 1 %) of nitrocellulose fines, 400 cu.yds.per year
7. Neutralized wastewater, variable amount
8. Waste acid
9. Neutralized supernatant from settling lagoon 4,000,000 gallons per day plus neutralized wastewater, variable amount

1. Acid spills, variable amount
2. Acidic wastewater, 8,000,000 gallons/day
3. Neutralized acidic wastewater 8,000,000 gallons/day
4. Neutralized supernatant from settling lagoon
5. Calcium sulfate sludge containing a small amount (estimated 1 %) of nitrocellulose fines, 800 cu.yds.per year.
6. Waste acid

SOURCE: BCM, MAY 1984

FIGURE 3.2

Hazardous Waste Management Facility 5



Radford Army Ammunition Plant

surface gravity pipe. The effluent from HWM 4 is treated by lime slurry neutralization (HWM 19) and allowed to settle in SWM 8 prior to discharge to the New River under NPDES permit No. VA0000248.

Waste Characterization

The impoundment's influent consists of rainwater runoff and various strengths and mixtures of nitric and sulfuric acids. An analysis of influent water taken during low flow in 1981 indicated that the influent wastewater contained low concentrations of several heavy metals. These results are presented in Table 3.1.

The lagoon water is classified as a hazardous waste because of its corrosivity. The pH of the lagoon's influent when tested in 1981 was 1.5 which classifies the lagoon water as a corrosive hazardous waste (pH below 2.0 or above 12.5).

Although there are very little solids accumulated on the bottom of HWM 5, no sampling and analysis has been conducted on the accumulated solids. Process wastewater containing low concentrations of nitrocellulose (NC) was previously conveyed to HWM 5 from the acid screen house located on-site at the Radford AAP. In the fall of 1983, this practice was discontinued and the pipe conveying this waste stream was rerouted to the boiling tub settling pit for recycling (Webb, December 1984). During the hydrographic survey conducted by ES in December 1984, a thin layer of dregs (possibly NC fines) was observed throughout the bottom of the lagoon.

Several other acid waste lagoons that receive similar waste streams have been tested to determine the concentration of NC in the accumulated solids. Microscopic examination of sludge samples from these lagoons indicated NC in concentrations of less than one percent. According to test criteria used by the Radford APP laboratory personnel, sludges containing less than 26 percent NC are non-reactive when NC is the only reactive component present. Analyses for other explosive materials including nitroglycerin and dinitroglycerin showed very low

TABLE 3.1

HWM 5

RESULTS OF ANALYSIS OF INFLUENT WASTE SAMPLE TAKEN DURING LOW FLOW
(USAEHA, December 1981)

Parameter	Measurement
pH	1.5
As	Not Detected (ND)
Ba	ND
Cd	0.029 mg/l
Cr	0.20 mg/l
Pb	ND
Hg	0.020 mg/l
Se	ND
Ag	ND

Source: USAEHA, December 1981, sited in CH_2M Hill and Peer Consultants, July 1984.

concentrations of these constituents in the lagoon sludges. These results indicate that it is unlikely that the solids in HWM 5 are reactive due to NC or other explosive materials which may be present.

Since the presence or absence of contaminants (i.e., heavy metals, NC and/or other reactive constituents) in the HWM 5 accumulated solids has not been adequately confirmed to date, the solids in HWM 5 should be handled properly (e.g., flashing to burn explosive compounds and disposal in HWM 16) at closure.

3.2 HAZARDOUS WASTE MANAGEMENT SITE NO. 7

Site Description

HWM 7 is an unlined surface impoundment serving as a holding and neutralization basin for spills and washdown waters from an acid (oleum) tank farm and daily production of waste caustic. The areal dimensions of the lagoon are 160 feet by 90 feet and its depth is 10 feet with side slopes of 45 degrees (Figure 3.3). Lime is added and mixed by two air diffusers to neutralize the acidic wastes.

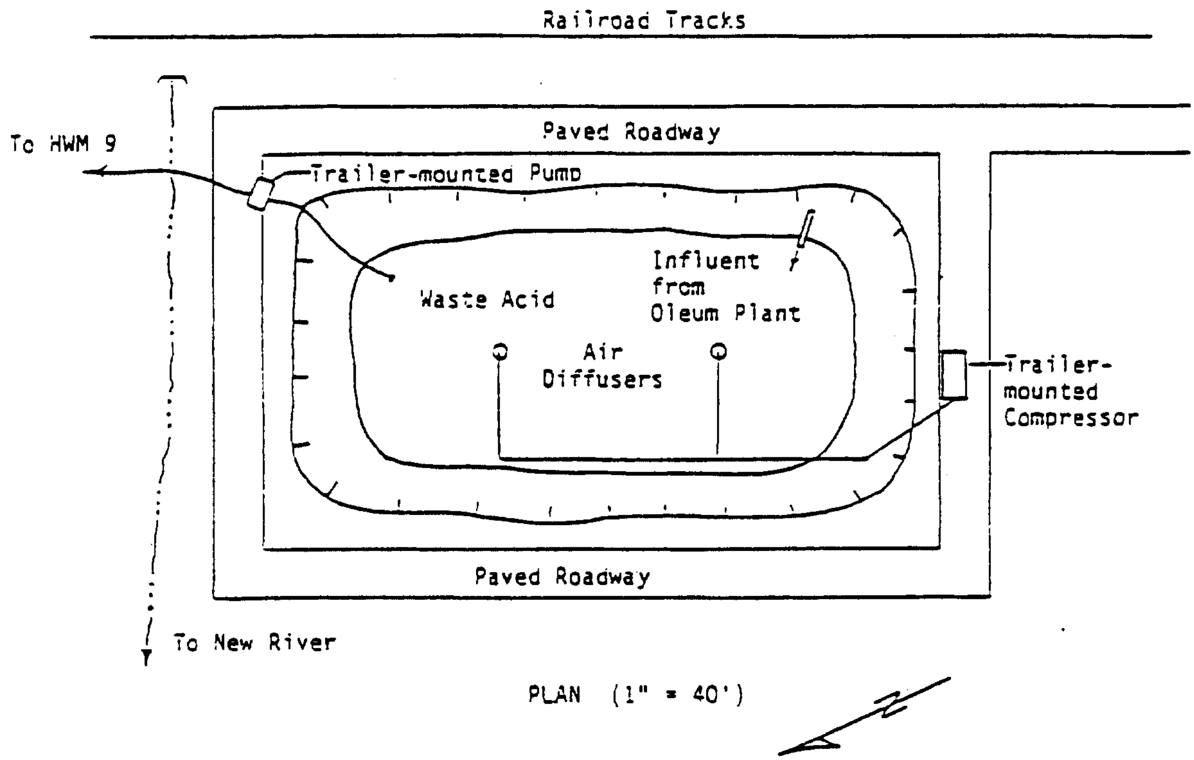
The neutralized effluent from HWM 7 is pumped to an unlined holding basin (No. 7A) prior to being discharged to SWM 9 for settling. In some cases, however, the effluent from HWM 7 is discharged via a temporary surface pipe system directly to SWM 9 (Figure 3.1). After settling, the effluent from SWM 9 is discharged to the New River under NPDES Permit No. VA0000248.

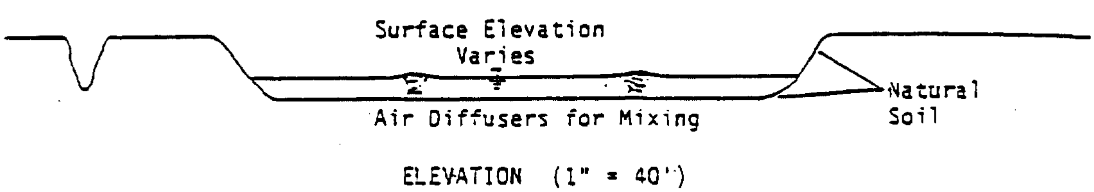
Waste Characterization

The HWM 7 influent contains waste sulfuric acid and caustics from the production of oleum. According to EP toxicity analyses conducted on the lagoon influent water and sediment, several heavy metals were detected but in very low concentrations (i.e., nonhazardous). The pH of the lagoon water was 11.4 when the analysis was conducted, which is also

Figure 3.3

Hazardous Waste Management Facility 7





Radford Army Ammunition Plant

classified as nonhazardous. Since the pH of the lagoon's influent is known to fluctuate (below 2.0 and above 12.5), the wastewater is classified as a corrosive substance. The results of an analysis conducted of the lagoon water and sediment are presented in Table 3.2.

Based on the hydrographic survey conducted by ES in December 1984, the depth of accumulated sediments in HWM 7 is about 5 feet, probably residues of lime precipitation. According to Radford AAP personnel, no waste stream from the NC-line has been discharged to HWM 7 in the past. Therefore, no reactive wastes are likely to be present in HWM 7.

The samples collected from the lagoon water and sediment indicate that heavy metals are not present in concentrations that would classify the wastes as hazardous. However, this determination is based on only one influent and sediment sample.

3.3 HAZARDOUS WASTE MANAGEMENT SITE NO. 16

Site Description

HWM 16 is a hazardous waste landfill located adjacent to a sanitary landfill (Permit No. 401). These disposal facilities began operation in 1980 and 1976, respectively. HWM 16 consists of a trench 400 feet by 60 feet (measured at the surface), as depicted in the plot plan of HWM 16 and the sanitary landfill (Figure 3.4). The depth of the landfill trench ranges between 10 and 14 feet. The capacity of HWM 16 is about 6,000 cubic yards, of which approximately 70 percent is filled as of December, 1984. The bottom of the trench consists of compacted in-situ soil.

Waste Characterization

The Radford AAP generates a variety of wastes that are disposed in the on-site hazardous waste landfill trench (HWM 16). Presented in Table 3.3 is a summary of the wastes disposed in HWM 16. It should be noted that the ash from waste propellant incineration and the residue

TABLE 3.2

RESULTS OF ANALYSIS OF LAGOON WATER
AND SEDIMENT SAMPLES FROM HWM 7

PARAMETER	LAGOON WATER	SEDIMENT
pH	11.4	--
As	Not Detected	ND
Ba	ND	0.33 mg/l
Cd	0.016 mg/l	0.027 mg/l
Cr	ND	0.73 mg/l
Pb	ND	0.58 mg/l
Hg	ND	ND
Se	ND	ND
Ag	ND	0.027 mg/l

Source: USAEHA (December 1981)

TABLE 3.3

SUMMARY DESCRIPTION OF WASTES DISPOSED IN HWM 16

Waste[a]	Rate Of Generation[a] (tons/yr)	Physical[a] Form	Hazard Description	EPA Hazard[a] Number
Ash from waste propellant incineration	unknown	solid	reactive, non-EP toxic[a]	D003
Residue from waste propellant burning	unknown	solid	reactive, EP toxic[a]	D003, D008
Residue from explosive contaminated waste burning	200	solid	reactive[a]	D003
SAR area fume burner ash	0.1	solid	EP toxic[a]	D006, D007
Sludge from neut. of SAR process water	unknown	sludge	nonhazardous[a]	--
Sludge from neut. of nitro-cellulose mfg acid process water	unknown	sludge	nonhazardous[b]	--
Sludges from Bioplant, Building 470, and NG 2 Pretreatment Building 9410	50	sludge	non-hazard-ous[c,d,e]	--

[a] USAEHA (December 1981)
[b] Ewing (15 January 1982)
[c] Everett (19 March 1982)
[d] Everett (10 November 1982)
[e] Jenrette (18 November 1983)

Source: Ch_2M Hill and Peer Consultants, Inc, July 1984 from explosive contaminated waste burning are listed as "reactive wastes." This information is based on the assumption that residues from the treatment of reactive wastes are considered reactive hazardous wastes until proven otherwise (USAEHA, 1981). Since HWM 16 began disposal operations in 1980, wastes characterized as reactive (Table 3.3) were incinerated or open burned prior to disposal in the landfill to render them non-reactive. Reactivity test methods including thermal stability, unconfined burning, No. 8 blasting cap and the impact test were used to analyze potentially reactive sludges prior to disposal in HWM 16. This testing determined that the landfilled sludges were non-reactive (Webb, 1984). Presently, these sludges are not disposed in the landfill. Analysis by the Radford AAP laboratory of ash and residues from the incineration and open burning of waste propellants utilizing the USEPA approved reactivity testing methods (i.e., Bureau of Mines Gap test and Deflagration/Detonation Transition (DOD) test) determined that these materials were non-reactive (Cali, 1985). The ash and residues that were analyzed and found to be non-reactive are similar to the wastes landfilled prior to reactivity testing performed using the EPA approved methods. Table 3.4 lists the wastes open burned prior to disposal in HWM 16.

Presented in Table 3.5 are EP toxicity results for several ash residues disposed in HWM 16. These analytical results indicate that with the exceptions of lead concentrations of the propellant burning ground ash, none of the residues contain concentrations of heavy metals that would classify the waste as hazardous (USAEHA, 1981). However, this determination is based on one sampling event conducted in 1981 and might not be totally representative of the wastes disposed in the landfill.

According to Radford personnel, small quantities of laboratory waste chemicals and materials were also disposed in HWM 16. These include sulfur, nitrodiphenylamine, potassium nitrate, cryolite, diphenylamine, potassium sulfate and other chemicals in bottles. A listing of these laboratory wastes is presented in Appendix B.

TABLE 3.4

SUMMARY DESCRIPTION OF WASTES THAT ARE OPEN-BURNED PRIOR TO DISPOSAL IN HWM 16

WASTE	PHYSICAL FORM	HAZARD DESCRIPTION	EPA HAZARD NUMBER
Nitrocellulose	Solid	Reactive	D003
Laboratory explosive wastes	Solid, Liquid	Corrosive	D002
Waste propellant	Solid	Reactive	D003
NG slums	Sludge	Reactive	D003
Explosive contaminated waste	Solid	Reactive	D003

Source: USAEHA (December 1981)

TABLE 3.5

EP TOXICITY RESULTS FOR WASTES
DISPOSED IN HWM 16

Concentration in mg/l

Parameter	Incinerator Ash from Waste Propellant Incinerator	Contaminated Burning Ground Ash	Propellant Burning Ground Ash	Virginia Maximum
As	ND (Not Detected)	ND	ND	5.0
Ba	ND	0.64	0.76	100
Cd	0.092	0.032	0.012	1.0
Cr	0.148	0.026	0.031	5.0
Pb	3.4	ND	51	5.0
Hg	ND	0.029	ND	0.2
Se	ND	ND	ND	1.0
Ag	0.037	ND	ND	5.0

Source: USAEHA (December 1981)

3.4 SUMMARY

Based on the available information reviewed, the wastes in HWM Nos. 5, 7 and 16 can be characterized as follows:

- HWM 5 and 7 presently receive corrosive washdown waters.
- The concentration of nitrocellulose in HWM 5, should be less than one percent by weight (non-reactive) based on the results of analytical testing of accumulated solids from other Radford AAP surface impoundments.
- Analysis of the lagoon water (HWM 5 and 7) and accumulated solids (HWM 7) determined that only low concentrations (non-hazardous) of heavy metals are present.
- According to Radford personnel, wastes classified as "reactive" were rendered "non-reactive" prior to disposal in the landfill. Various laboratory chemicals were also disposed in HWM 16.

SECTION 4

CONTAMINATION ANALYSIS

SECTION 4

CONTAMINATION ANALYSIS

Provided in this section is a discussion of the groundwater degradation and probable soil contamination that have occurred in the vicinity of the HWM sites (Nos. 5, 7 and 16). The results of the groundwater monitoring work and resistivity surveys conducted at the sites are the basis for assessment of the groundwater quality in the vicinity of the Hazardous Waste Management facilities under study. The presence of contaminants including acidic wastes (pH), heavy metals (EP toxicity) and nitrocelluose (reactivity), is also discussed. A discussion of the groundwater flow and geologic formation of the HWM facilities is provided when these factors influence the groundwater quality.

To comply with the USEPA and Commonwealth of Virginia Hazardous Waste Regulations, groundwater monitoring wells were installed in the vicinity of each of the HWM sites (Nos. 5, 7 and 16). Samples were collected on a quarterly basis and analyzed. The groundwater samples from the HWM Nos. 5 and 7 sites were analyzed for primary and secondary indicator parameters. The groundwater samples from the HWM 16 site were analyzed for National Interim Primary Drinking Water Regulations (NIPDWR) parameters; constituents of groundwater quality, including iron, manganese, sodium, chloride, phenol and sulfate; and indicators of groundwater contamination, including pH, specific conductance, TOC and TOX. The indicator parameter results were then subjected to statistical analysis (Student's t-Test) to compare the baseline data collected during the first year's quarterly monitoring with the data collected during the first quarter of the second year of operation. A discussion of the monitoring and statistical analysis results is provided in the discussion sections for each of the HWM sites.

Resistivity surveys were conducted at each of the surface impoundments (HWM Nos. 5 and 7) to identify areas of low resistivity, thereby indicating more conductive zones. These conductive zones are interpreted to be areas of possible groundwater degradation due to infiltration of waste liquids. The resistivity surveys conducted at the sites can only be used to indicate a general trend only and cannot be used to determine the extent and migration rate of contamined groundwater. The results of the geophysical surveys conducted at these sites are described in the discussion sections for each of the HWM sites.

HWM 5 had been operated without a liner system prior to 1981 and HWM 7 is an unlined surface impoundment. Therefore, it is likely that the subsoils underneath these impoundments have been contaminated by percolating waste liquids. Since no sampling and analysis have been made for subsoils, the nature and extent of soil contamination is inferred from other site characteristics such as liquid wastes, subsoil conditions, operational practice and groundwater quality data.

4.1 HAZARDOUS WASTE MANAGEMENT SITE NO. 5

Groundwater Quality

Locations of the HWM 5 groundwater monitoring wells are shown in Figure 2.1. The Student's t-Test results for the primary indicator parameters indicated a statistically significant difference for at least one of the primary parameters for each of the wells at HWM 5. A summary of the Student's t-Test for HWM 5 using both the Classical and Cochran's Approximation methods is presented in Table 4.1. The results of the Student's t-Test for pH, specific conductance, TOX and TOC from the HWM 5 monitoring wells are presented in Appendix C.

TABLE 4.1

SUMMARY OF GROUNDWATER DATA STATISTICAL ANALYSIS
FOR HWM 5

	Specific Conductance	Total Organic Carbon	Total Organic Halogen	pH
Classical Student's t-Test				
Upgradient Well Comparison				
HWM 5 - Well W-8 (S5W8)		--- Upgradient Well ---		
HWM 5 - Well W-5 (S5W5)	N	SH	N	SH
HWM 5 - Well W-6 (S5W6)	N	N	N	SH
HWM 5 - Well W-7 (S5W7)	N	SH	N	SH
Each Well Compared to Itself				
HWM 5 - Well W-8 (S5W8)	N	SH	N	N
HWM 5 - Well W-5 (S5W5)	N	N	N	SH
HWM 5 - Well W-6 (S5W6)	N	SH	N	SH
HWM 5 - Well W-7 (S5W7)	N	N	N	SH
Cochran's Approximation				
Upgradient Well Comparison				
HWM 5 - Well W-8 (S5W8)		--- Upgradient Well ---		
HWM 5 - Well W-5 (S5W5)	N	SH	N	SH
HWM 5 - Well W-6 (S5W6)	N	N	N	SH
HWM 5 - Well W-7 (S5W7)	N	SH	N	SH
Each Well Compared to Itself				
HWM 5 - Well W-8 (S5W8)	N	SH	N	SL
HWM 5 - Well W-5 (S5W5)	SH	N	N	SH
HWM 5 - Well W-6 (S5W6)	N	SH	N	SH
HWM 5 - Well W-7 (S5W7)	N	N	N	SH

SH - Significantly higher
SL - Significantly lower
N - No significant change

Source: BCM, 1984

The groundwater in the vicinity of the upgradient well (W-8) at HWM 5 was found to be contaminated due to a leaking acid pipe (NUS, 1981; USAEHA, 1981). A new upgradient well (W-8B) was placed approximately 80 feet west of the contaminated upgradient well (W-8). Recent groundwater monitoring results (August 1984) from the new upgradient well showed lower specific conductance, TOC and TOX values as compared to the contaminated upgradient well. However, all of the groundwater samples collected from the monitoring wells in the vicinity of HWM 5, including the new upgradient well, have low pH values. The results shown in Table 4.2 indicate that the groundwater in the vicinity of HWM 5 is degraded.

Groundwater samples collected from the monitoring wells at HWM 5 and analyzed for Primary Drinking Water Standards also indicate that groundwater degradation has occurred. Presented in Table 4.2 are monitoring results indicating groundwater quality at HWM 5. Specifically, the contamination as indicated by high nitrate and sulfate levels at the downgradient wells would be expected since the surface impoundment (HWM 5) receives wastewater containing nitric and sulfuric acids. It is also notable that elevated metal concentrations (arsenic, chromium and mercury) are associated with low pH in Wells W-8, W-5B and W-7B. The groundwater monitoring results for HWM 5 are provided in Appendix D.

Since groundwater degradation was identified at HWM 5, a Groundwater Quality Assessment Plan was prepared and conducted as required by both the Commonwealth of Virginia and Federal Hazardous Waste Regulations. The purpose of the Assessment Plan is to determine if HWM 5 is the source of the groundwater degradation and determine the rate and extent of migration of the hazardous wastes or hazardous waste constituents in the groundwater. The results of the Phase I Groundwater Quality Assessment Program indicated that groundwater degradation has occurred beneath HWM 5 (Nemeth, 1984). As a result, a Compliance Monitoring Program (Virginia Regulation 10.06.10) will be implemented in the

TABLE 4.2

MONITORING RESULTS INDICATING GROUNDWATER QUALITY

AT HWM 5

Groundwater[1] Monitoring Parameter	Upgradient Wells W8B	Upgradient Wells W8	Downgradient Wells W5B	Downgradient Wells W6	Downgradient Wells W7B	Drinking Water Standards
Nitrate mg/l	5.30	285	56	26	104	10
Sulfate mg/l	1.0	2125	100	149	210	250
Chloride mg/l	NC	35	62	14	49	250
Manganese mg/l	0.068	44.2	0.296	0.605	9.090	0.05
pH units	4.9	3.4	5.6	5.0	3.2	6.5-8.5
Spec.Cond.UMC	110	3900	710	493	1825	-
Arsenic[2] mg/l	ND ND	0.174 2.670	ND 0.286	ND ND	0.148 0.156	0.05
Chromium[2] mg/l	ND ND	0.097 0.132	0.002 0.010	0.003 0.004	0.085 0.101	0.05
Mercury[2] UGL	ND ND	0.2 11.8	0.2 0.6	0.2 ND	0.3 ND	2.0

[1] From samples collected 28 August 1984, except for sulphate and chloride analyzed from 26 April 1983 samples.

[2] Results of filtered and unfiltered sample analysis.

NOTES: ND - Not detected
NC - Not collected.
Spec. Cond. - Specific conductance.
UMC - Micromhos per centimeter.
UGL - Microgram per liter

Source: Radford AAP Groundwater Monitoring Data future. The purpose of the Compliance Monitoring Program is to further assess the groundwater contamination in the vicinity of the HWM site.

Resistivity Survey

The resistivity surveys conducted at HWM 5 generally yielded results that may be related to the leakage of acidic wastes. More specifically, groundwater degradation was identified in the area south of the acid waste lagoon, towards the upgradient well. The areas of low resistivity readings also indicate that acidic wastes are present both to the northwest and northeast of the site (BCM, 1984). Other readings taken to the southeast were inconclusive since the results could not differentiate between the potential presence of acidic waste leakage or a filled sinkhole.

According to Radford AAP personnel, acid sewer pipe leakage was a source of groundwater degradation in the vicinity of the upgradient well (W-8) at HWM 5. In March 1984, the sewer pipe was replaced and contamination (acidic water) was noted during the excavation (Webb, 1984). Since the acid pipe had been leaking at least for a few years, the probable contaminated zone in the north of the lagoon (as indicated by resistivity survey) could be either from the pipe leakage or from the lagoon leakage prior to liner installation.

Soil Contamination

No sampling and analysis have been conducted to date to identify the nature and extent of soil contamination underneath the HWM 5 site. Therefore, soil contamination is assessed from other indirect data such as groundwater quality, operational characteristics of the surface impoundment and typical soil contamination known from other similar situations.

Prior to the liner installation in 1981, the acidic water in HWM 5 would have percolated into the subsoil at a slow rate. Acidic liquids (low pH) tend to dissolve and carry various metals in soil. If heavy metals (i.e., arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) are present in the soil, they could be mobilized at higher concentrations than the background levels. This general trend is shown at the HWM 5 site by the recent groundwater quality data (Table 4.2).

The August 1984 data from Wells W-8 and W-7B show low pH values and higher metal (arsenic, chromium and mercury) concentrations than found in the uncontaminated upgradient well. It should be noted that these concentrations are far below the EP toxicity level. They exceed the National Drinking Water Standards, but there are no downgradient water wells from HWM 5. Once the pH approaches a neutral level in the aquifer by dilution, the metal ions would be adsorbed to soil and the impact of any groundwater contamination would be detected only within the limited downgradient area of the Radford AAP property.

HWM 5 has been operated with an impermeable liner system since late 1981 and thus the liklihood of acidic water entering the subsoil after this date is minimal. Any acidic water present that might mobilize any metals from the soil should have already drained by gravity or be reducing in amount. Any further groundwater contamination resulting from low pH water mobilizing metals from the subsoil should not be significant.

Sediments in HWM 5 may contain some NC solids because wastes from the NC process line were previously discharged to HWM 5. However, contamination by the NC solids would be limited to the impoundment bottom sediments since fibrous NC solids cannot migrate into the subsoil. The bottom sediment of HWM 5 should be treated to eliminate possible reactivity caused by NC.

4.2 HAZARDOUS WASTE MANAGEMENT SITE NO. 7

Groundwater Quality

Figure 2.3 shows the locations of the HWM 7 groundwater monitoring wells. Initially, four groundwater monitoring wells were installed in the vicinity of HWM 7. The upgradient well (W-12) was dry during all but one of the quarterly monitoring efforts. A new upgradient well (W-12B) was later installed. Consequently, no upgradient/downgradient well comparisons were possible for HWM 7 using the initial data. Statistical analyses were conducted comparing monitoring data (indicator parameters) from each well to the results obtained previously from that well and the results are presented in Table 4.3. The Student's t-Test results for HWM 7 are presented in Appendix C.

Recent groundwater data (August 1984) include data from the newly installed upgradient monitoring well (W-12B). Comparison of the upgradient and downgradient well data collected during the recent monitoring effort indicates that the groundwater in the vicinity of HWM 7 is degraded. The groundwater contaminants found in higher concentrations in the downgradient wells as compared to the upgradient well include nitrate, sulfate, chloride and manganese. The indicator parameters including pH, specific conductance, total organic carbon (TOC) and total dissolved solids (TDS) at the downgradient wells also exceed the background levels at the upgradient well. The elevated nitrate and sulfate levels would be expected since HWM 7 is unlined and the wastewater contained nitric and sulfuric acids. Also, the cadmium and chromium concentrations in W-11B, probably caused by a low pH, exceed the Drinking Water Standards. The location of the unlined impoundment relative to the monitoring wells indicate that the acid waste lagoon is the likely source of the contamination. A summary of monitoring results indicating groundwater quality in the vicinity of HWM 7 is presented in Table 4.4 The groundwater data for HWM 7 are provided in Appendix D.

TABLE 4.3

SUMMARY OF GROUNDWATER DATA STATISTICAL ANALYSIS

FOR HWM 7

	Specific Conductance	Total Organic Carbon	Total Organic Halogen	pH
Classical Student's t-Test				
Each Well Compared to Itself				
HWM 7 - Well W-9	SH	N	N	N
Cochran's Approximation				
Each Well Compared to Itself				
HWM 7 - Well W-9	SH	N	N	N

SH - Significantly higher
SL - Significantly lower
N - No significant change

Source: Radford AAP Groundwater data compiled by BCM, 1984.

TABLE 4.4

MONITORING RESULTS INDICATING GROUNDWATER QUALITY AT HWM 7

Groundwater[1] Monitoring Parameter		Upgradient Well W-12B	Downgradient Wells W-9	W-10B	W-11B	Drinking Water Standards
Nitrate	mg/l	4.70	138	23	301	10
Sulfate	mg/l	149	1336	1943	2593	250
Chloride	mg/l	6.0	16	-	21	250
Manganese	mg/l	.246	6.05	.625	29.70	.05
pH	units	7.5	6.9	7.0	4.3	6.5-8.5
Spec. Cond.	UMC	740	3000	3400	5200	-
TOC	mg/l	1.5	5.0	6.5	19	-
TDS	mg/l	501	3139	3518	5906	-
Cadmium[2]	UGL	ND	1.0	ND	13.3	10
		ND	1.5	ND	13.7	
Chromium[2]	mg/l	0.005	0.002	0.001	0.078	0.05
		0.008	0.027	0.002	0.080	

[1] From samples collected 29 August 1984, except for chloride analyzed from 2 May 1983 samples.

[2] Results of duplicate sample analysis.

NOTES:
- ND - Not detected
- TOC - Total Organic Carbon
- TDS - Total Dissolved Solids
- UMC - Micromhos per centimeter
- UGL - Microgram per liter

Source: Radford AAP Groundwater Monitoring Data compiled by BCM, 1984

The movement of groundwater should also be a consideration in determining the extent of groundwater degradation in the vicinity of HWM 7. The soils at the base of the alluvial deposits underlying HWM 7 are known to be highly permeable and respond rapidly to rises in the river water level. These water level fluctuations may act to dilute and disperse the groundwater contaminants thereby reducing the contaminant concentrations in the groundwater.

A Groundwater Quality Assessment Plan for HWM 7 was prepared and conducted as required by the Commonwealth of Virginia Hazardous Waste regulations since groundwater degradation has occurred in the vicinity of the site. The purpose of the Assessment Plan is to determine if HWM 7 is the source of the groundwater degradation and determine the rate and extent of migration of the contaminated groundwater. The results of the Phase I Groundwater Quality Assessment Program indicated that groundwater degradation has occurred at HWM 7 (Nemeth, 1984). As a result, a Compliance Monitoring Program will be required in the future.

Resistivity Survey

The resistivity survey conducted at HWM 7 indicates that groundwater degradation has occurred to the immediate south and west of the acid waste lagoon (BCM, 1984). Readings taken further west of the lagoon indicate that groundwater degradation has occurred but to a lesser extent. The proximity of HWM 7 to these contaminated areas supports the possibility that the lagoon is the source of the groundwater degradation. The results of the resistivity survey are supported by the recent groundwater quality data dated August 1984 (Appendix D).

Soil Contamination

HWM 7 is an unlined surface impoundment which receives both acidic wastes (oleum) and waste caustic. With no liner protection, the soil beneath the impoundment could contain free liquid of very low or high pH that may render the soils hazardous. Since HWM 7 serves as a neutralization basin and the pH of the waste stream characteristically fluctuates, any liquid with an extreme pH value in the soil would be neutralized to some extent by subsequent infiltration of neutralized liquids. Thus, soil or groundwater contamination by an extreme pH would be limited only to the immediate vicinity of the impoundment when acidic liquid accumulates for several days before neutralization. This is shown by the August 1984 groundwater data (Table 4.4). Only Well W-11B, the nearest downgradient well, showed a low pH and elevated metal concentrations (cadmium and chromium). Upon further dilution and neutralization toward the downgradient area, the pH should approach the neutral level and metals would be immobilized by adsorption onto soils.

According to Radford personnel, no waste stream from the NC process line has been discharged to HWM 7. Therefore, the sediments and subsurface soil at HWM 7 would not contain any NC.

4.3 HAZARDOUS WASTE MANAGEMENT SITE NO. 16

Groundwater Quality

Groundwater samples were collected quarterly during the first year of the hazardous waste disposal activities at HWM 16 to compile baseline data. Groundwater samples were collected semi-annually during the second year and were statistically (Student's t-Test) compared to the baseline data. The parameters analyzed included National Interim Primary Drinking Water Regulations (NIPDWR) parameters; constituents of groundwater quality, including iron, manganese, sodium, chloride, phenol and sulfate; and indicators of groundwater contamination, including pH, specific conductance, TOC, and TOX.

Based on the statistical analysis of the baseline and second year's semi-annual data, wells CDH2 and C-4 showed significant changes for several of the indicator parameters. Additional samples were collected and analyzed and confirmed these earlier results. A summary of this statistical analysis for HWM 16 is presented in Table 4.5. The results of the statistical analysis are presented in Appendix C.

Analysis for the NIPDWR parameters for the groundwater monitoring wells for HWM 16 indicated that most of the parameters did not show any notable difference in concentration in the downgradient wells. Some slight changes for the NIPDWR parameters that were noted in the downgradient wells were not statistically significant. A summary of the monitoring results indicating groundwater quality at HWM 16 is presented in Table 4.6. As noted in the summary table, the sulfate, specific conductance and TOC values increase and the pH decreases at the downgradient well as compared to the upgradient well. However, the background (upgradient) levels for nitrate and chloride are higher than at the downgradient well. It should also be noted that none of these initial results exceed the Drinking Water Standards. Groundwater data for HWM 16 are presented in Appendix D.

Because of the statistically significant groundwater quality changes at the HWM 16 site, a Groundwater Assessment Program was implemented and the results became available very recently (USAEHA, March 1985). Four additional monitoring wells, 16-1, 16-2, 16-3 and 16-4 were installed as shown in Figure 4.1. Samples were collected from three new wells (16-2, 16-3 and 16-4) and two existing wells (C1 and CDH2) in November 1984 and analyzed for indicator paramaters, inorganic parameters, explosives, pesticides and organic priority pollutants. The results of the organic priority pollutant analysis are summarized in Table 4.7 and the results of analysis for indicator parameters, inorganic parameters and explosives are shown in Appendix D (site 16, run date: March 1, 1985). In addition to compounds listed in Table 4.7, samples from all wells

TABLE 4.5

SUMMARY OF

GROUNDWATER DATA STATISTICAL ANALYSIS FOR HWM 16

	Specific Conductance	Total Organic Carbon	Total Organic Halogen	pH
Classical Student's t-Test				
Each Well Compared to Itself[1]				
HWM 16 - Well C-1	N	N	N	N
HWM 16 - Well C-4	SH	SH	N	N
HWM 16 - Well CDH2	SH	SH	SH	SL
Each Well Compared to Itself[2]				
HWM 16 - Well C-1	N	N	N	SL
HWM 16 - Well C-4	SH	SH	SH	SL
HWM 16 - Well CDH2	SH	SH	N	SL

SH - Significantly Higher
SL - Significantly Lower
N - No Significant Change

[1] Groundwater data from the June 1983 sampling effort.
[2] Groundwater data from the September 1983 sampling effort.

Source: Table compiled by Engineering-Science from information presented in the Closure and Post-Closure Plans prepared by CH_2M Hill and Peer Consultants, July 1984.

TABLE 4.6

MONITORING RESULTS

INDICATING GROUNDWATER QUALITY AT HWM 16

Groundwater Monitoring Parameters		Upgradient Well C-1	Downgradient Wells C-4	CDH2	C-2[1]	Drinking Water Standards
Nitrate[2]	mg/l	6.0	4.0	0.19	-	10
Sulfate[3]	mg/l	ND[5]	7.0	22.0	-	250
Chloride[4]	mg/l	7.0	5.0	4.0	-	250
pH[3]	units	7.6	7.6	7.4	-	6.8-8.5
Spec. Cond.[3]	UMC	245	440	480	-	-
TOC[3]	mg/l	7.0	17	26	-	-

1 Groundwater monitoring well dry during all sampling efforts.
2 Sample collected 12 June 1982.
3 Sample collected 13 June 1983.
4 Sample collected 19 April 1982.
5 Non-detectable.

Note: UMC- micromhos per centimeter

Source: Radford AAP Groundwater Monitoring Data, USAEHA, 1983

Figure 4.1

LOCATIONS OF VARIOUS WASTE DISPOSAL SITES

IN THE VICINITY OF HWM 16

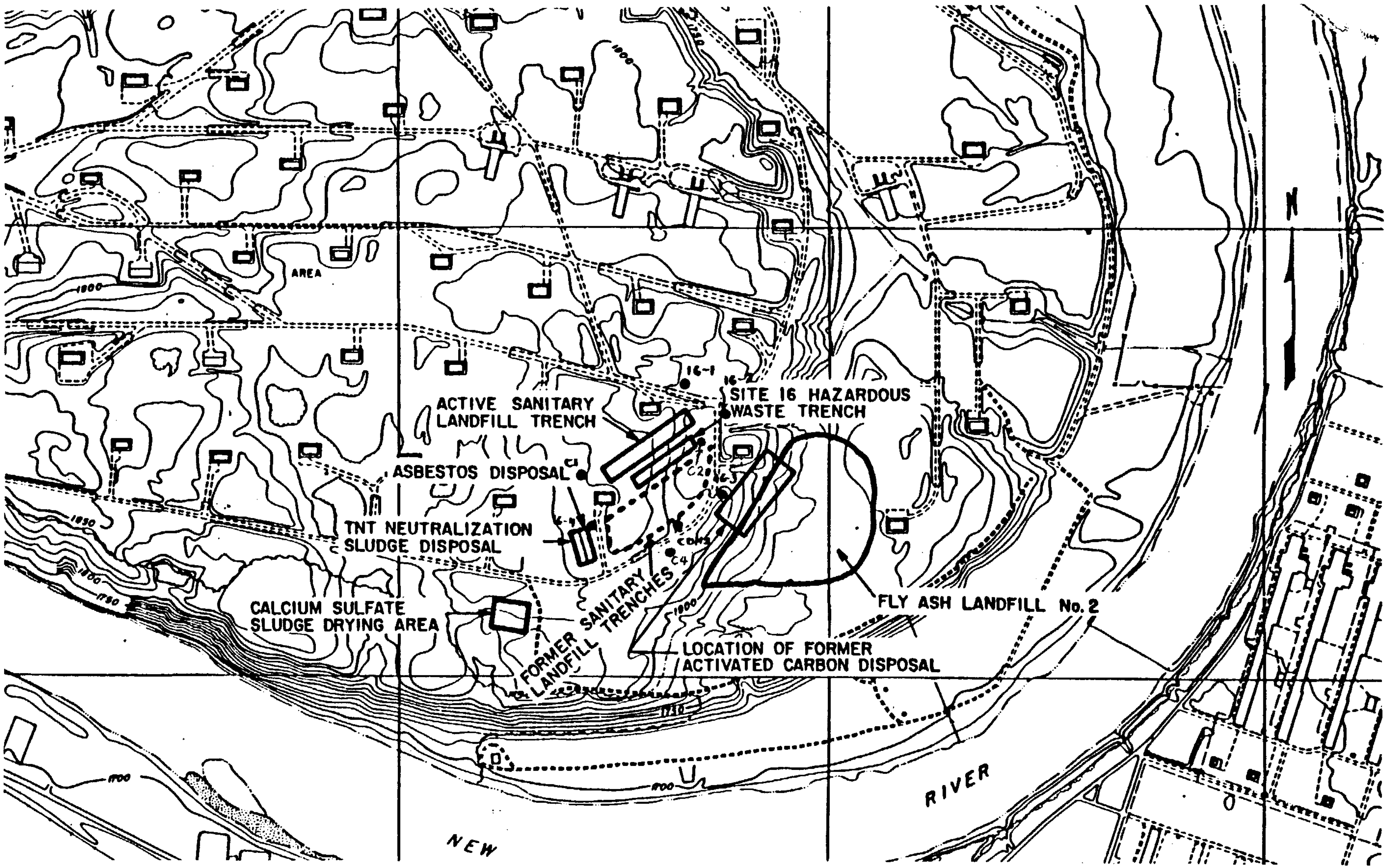


TABLE 4.7

ORGANIC PRIORITY POLLUTANTS DETECTED IN HWM 16 GROUNDWATER MONITORING WELLS[1]

Compound[2]	C1	16-2	16-3	16-4	CDH2
	Unit: Microgram per Liter				
Bromodichloromethane	-	-	-	-	3
Chloroform	-	4	12	32	
Dichlorofluoromethane	-	-	-	-	5-20
Methylene chloride	-	-	-	-	3
Trichlorofluoromethane	-	-	-	-	5
Diethyl phthalate	-	-	14	-	-
2,6-Dinitrotoluene	-	-	-	30	-

[1]Samples collected on November 12, 1984.
[2]Compounds at nondetectable levels are not shown.

contained trace levels (non-quantifiable) of various phthalates including bis (2-ethylhexyl) phthalate, di-n-butyl phthalate, di-n-octyl phthalate, and dimethyl phthalate.

According to the assessment by USAEHA (March, 1985), the groundwater is contaminated with low levels of DNT and halomethane compounds. The contamination of the upgradient well 16-4 suggests that the source of this contamination is not HWM 16. As shown in Figure 4.1, a former disposal trench which received TNT neutralization sludge is close to and upgradient of Well 16-4. Therefore, it is very likely that the TNT neutralization sludge disposal trench is the source of contamination. It is planned by Radford AAP to further investigate this possiblity.

Soil Contamination

Wastes disposed in HWM 16 are mostly solids and therefore, would not be causing soil or groundwater contamination unless a significant amount of leachate is formed. Probable sources of leachate include wastewater and lagoon sludges and infiltration of precipitation. The compacted trench bottom slopes down from the filled section toward the unfilled section. If any leachate were formed, therefore, it could be readily noticed at the toe of the slope. No leachate has been observed to date. Thus, it is unlikely that subsoil is contaminated by leachate generated from the wastes in the trench. With a final cover system provided at closure the potential of leachate generation will be further reduced.

4.4 Summary

HWM 5

Based on the groundwater monitoring data and resistivity surveys, both the acid pipe leak and lagoon prior to liner installation should be considered as sources of groundwater degradation. The leaking sewer pipe was repaired in early 1984. The groundwater degradation identified north of HWM 5 is probably due to leakage from the lagoon (prior to liner installation) which has migrated in the direction of the groundwater flow. The soils beneath the liner system most probably do not contain NC. The soils may contain acidic liquids and elevated concentrations of dissolved metals. Since HWM 5 has been operated with an impermeable liner after 1981, further mobilization of any contaminants in the soil to the groundwater should be minimal or non-existent.

HWM 7

The groundwater data and resistivity surveys indicate that the groundwater is degraded in the vicinity of HWM 7. A limited amount of subsoil may have been contaminated by acidic liquid and metal ions. This contamination should be confined within the immediate vicinity of the impoundment because the lagoon water is frequently neutralized.

HWM 16

Two major issues associated with the closure of HWM 16 are possible disposal of reactive wastes and the source of groundwater contamination in the vicinity of HWM 16. Based on the practice of open burning and incineration of explosive residues, ash residues should no longer be reactive. The recent groundwater assessment program for HWM 16 has identified the TNT neutralization sludge disposal trench as being the probable source of groundwater contamination. Further investigation of this possibility will be conducted. There is no evidence of leachate being generated in significant quantities within the HWM 16 trench. If leachate is, or was, present in small quantities, this should not have caused significant subsoil contamination.

SECTION 5

GENERAL CLOSURE ANALYSIS

SECTION 5

GENERAL CLOSURE ANALYSIS

The objective of this section is to develop general closure concepts and to select a closure method for each of the HWM facilities. Several closure alternatives are identified based on the regulatory requirements for closure of the Radford AAP hazardous waste facilities. A comparative analysis of these alternatives is performed to decide the most effective closure method with respect to environmental protection, cost and practicality. An evaluation of the requirements for cover systems for the HWM sites is also provided.

5.1 GENERAL CLOSURE CRITERIA

Regulatory Overview

Until recently, it was believed that the Radford AAP facilities (HWM Nos. 5, 7 and 16) would be closed following the standards in Section 9.00 for Interim Status facilities of the Virginia Hazardous Waste Regulations. However, the recently amended State Hazardous Waste Management Regulations require that all regulated HWM facilities (hazardous waste disposal facilities that received wastes after July 26, 1982) are to meet the closure and post-closure requirements under Section 10.00 as if they were permitted hazardous waste facilities. Thus, the closure and post-closure of the Radford AAP hazardous waste facilities (HWM Nos. 5, 7 and 16) will be regulated by the Section 10.00 Standards. Although these two sections are similar in framework, the standards in Section 10.00 are more stringent since they are applicable to facilities designed and constructed to meet the regulations under RCRA. The impact of the Section 10 Regulation is especially significant for closure of the surface impoundments as summarized in Table 5.1. In

TABLE 5.1

MAJOR DIFFERENCES IN SECTIONS 9.00 AND 10.00 OF THE VIRGINIA HAZARDOUS WASTE REGULATIONS
AS RELATED TO CLOSURE OF SURFACE IMPOUNDMENTS

	SECTION 9.00		SECTION 10.00	
	Closure Conditions	Closure and Post-Closure Requirements	Closure Conditions	Closure and Post-Closure Requirements
CLOSURE ALTERNATIVES	- No hazardous wastes remain	- None.	- SI with synthetic or clay liner (no leak). Remove or decontaminate all hazardous material including liner.	- None.
	- Hazardous material remains.	- Drying of remaining liquids. Install cover system. Provide post-closure care	- SI with synthetic liner (no leak). Hazardous material remains.	- Stabilize wastes. Install cover system. Provide post-closure care. Conduct groundwater monitoring if the disposal facility is not double-lined and doesn't have a leak detection system.
			- SI with leak or without liner. Remove or decontaminate all hazardous material but not all contaminated subsoils.	- Stabilize wastes/subsoil. Install cover system. Provide post-closure care. Conduct groundwater monitoring.
GROUNDWATER PROTECTION	- SI to be closed. Groundwater Quality Assessment Program in progress. Groundwater contamination has occurred.	- Continue quarterly assessment until facility is closed. Semi-annual groundwater monitoring after closure.	- SI to be closed. Groundwater Quality Assessment Program in progress. Groundwater contamination has occurred.	- Complete the groundwater Quality Assessment Program. Develop/implement a Corrective Action Program. Continue corrective action until groundwater protection standard is met.

this section, the State Hazardous Waste Management Regulations, primarily from Section 10.00, are referenced wherever applicable. These regulations are inlcuded in Appendix E.

Closure Performance Standards

The closure performance standards, as presented in the Virginia Hazardous Waste Regulations (10.07.02), require that the owner or operator of a hazardous waste disposal facility shall close the facility in a manner that:

- o minimizes the need for further maintenance, and

- o controls, minimizes or eliminates to the extent necessary to prevent threats to human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall or waste decomposition products to the ground or surface waters or to the atmosphere.

The escape of contaminants to the environment occurs primarily through migrating water and, to a limited extent, migrating gas. At the Radford AAP hazardous waste management sites, the generation and migration of gas is not expected due to the nature of the wastes disposed. Therefore, the aforementioned closure standards can be met by effectively isolating the hazardous wastes from migrating water in the subsurface environment. Since hazardous waste facilities should be situated above the fluctuating groundwater table, as is the case for the Radford AAP hazardous waste management facilities, the lateral groundwater flow would not be directly responsible for the migration of contaminants in the groundwater. Thus, the primary components of the Closure Plan should include a final cover system to minimize the percolation of rainwater into the waste material and, if applicable, a leachate collection system to prevent the leachate from migrating downward to the groundwater table. Post-closure care requirements emphasize maintaining the integrity of the waste containment system (especially the final cover) and monitoring groundwater (10.07.08(a)(1)).

5.2 CLOSURE ALTERNATIVES FOR SURFACE IMPOUNDMENTS

Regulatory Requirements

The standards for closure and post-closure care of surface impoundments are provided in 10.07 and 10.11.09 of the Virginia Hazardous Waste Regulations. The closure steps vary depending on the original design of the facility, characteristics of wastes after closure, and to a limited extent, the owner's preference as dictated by the facilities' overall Waste Management Program. Figure 5.1 illustrates the general closure requirements and alternatives as defined in the Virginia Hazardous Waste Regulations. Initially, the owner or operator must choose either removal or treatment option. After this initial action there are three possible scenarios for closure sequences:

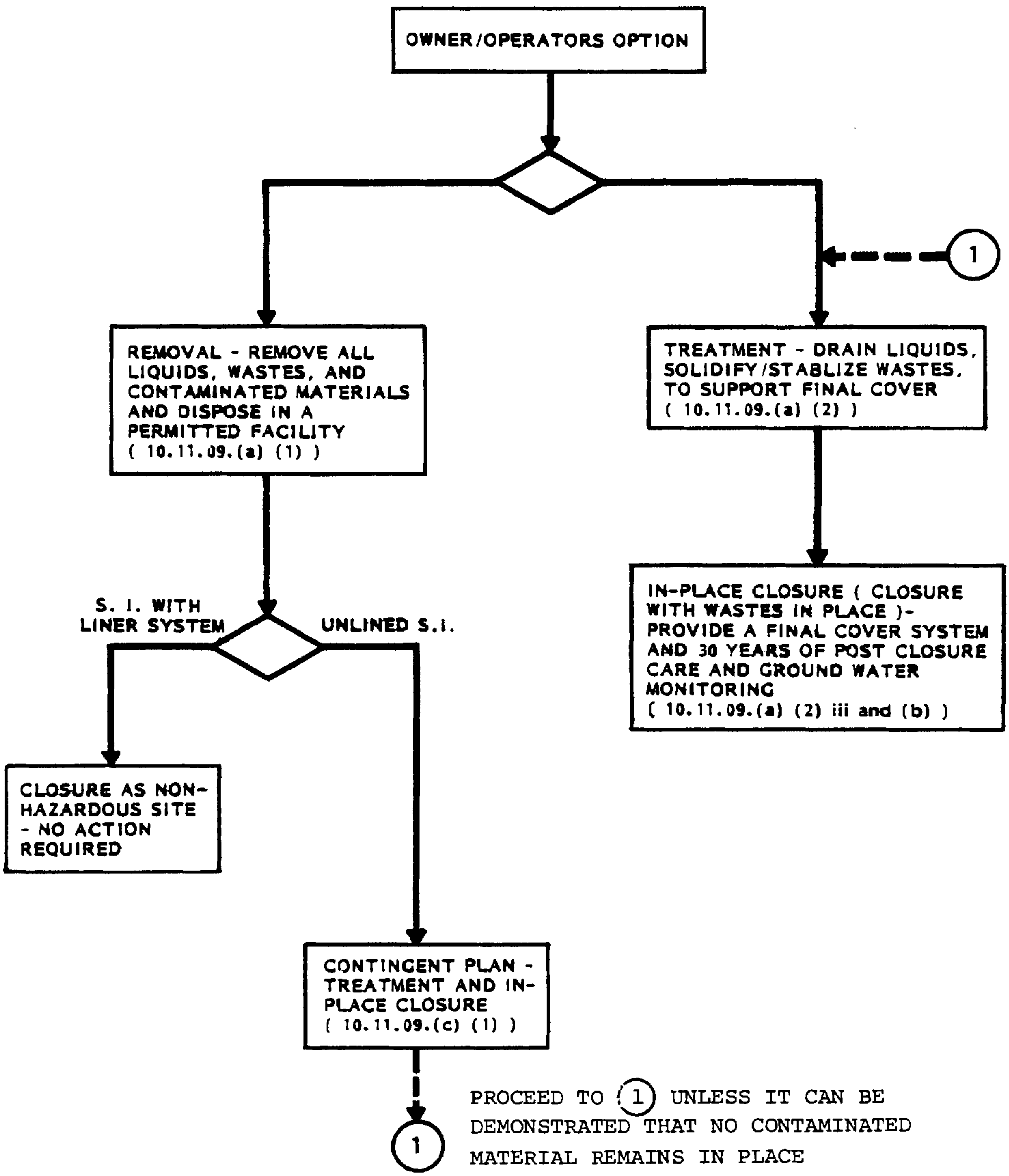
- Treatment of wastes followed by in-place closure (i.e., provide a final cover system, post-closure care and groundwater monitoring).

- Removal and disposal of wastes followed by contingent treatment of remaining wastes/contaminated materials and in-place closure if the surface impoundment is unlined. This contingent action may be exempted if no wastes or contaminated materials (including subsoil) remain in place at closure.

- Removal and disposal of wastes followed by closure of the surface impoundment as a nonhazardous site if no wastes or contaminated materials remain in place at closure of a lined surface impoundment.

Figure 5.1

REGULATORY REQUIREMENTS FOR CLOSURE OF SURFACE IMPOUNDMENTS



General approaches to determine the most desirable closure method can be derived from characteristics of the surface impoundments and impacts of specific methods on the overall waste management program. From an economic standpoint, options requiring long-term post-closure monitoring and maintenance should be avoided if possible since they would entail significant costs over the 30-year post-closure care period. For closure purposes, both HWM 5 and HWM 7 are considered to be unlined surface impoundments: HWM 5 had been operated without a liner until 1981 and HWM 7 is an unlined surface impoundment. Thus, regardless of the initial action whether to remove wastes or not, the closure of the surface impoundments includes possible treatment and in-place closure activities (Figure 5.1). The contingent plan (treatment and in-place closure) is a safeguard against contaminated subsoils which are likely to exist at an unlined surface impoundment site. Since the subsoils at the HWM 5 and HWM 7 sites are probably contaminated to some extent as discussed in Section 4, the contingent plan to deal with the contaminated soil should be implemented. This leads to three possible closure alternatives that meet the State Hazardous Waste Regulations. Since the amount of the surficial wastes (e.g., liner, sediment and cover sand) is insignificant, these alternatives are primarily based on the method of handling the contaminated soils:

- Offsite disposal - Remove and dispose of all wastes and contaminated materials (including subsoil) in a permitted, offsite disposal facility. No additional actions are required if it can be demonstrated that no wastes or contamined materials remain on site at closure.

- Treatment - Decontaminate all wastes and contaminated materials (including subsoil). No additional actions are required if it can be demonstrated that no contaminants remain on site at closure. Naturally, a combination of removal and treatment is also acceptable as an alternative.

- In-Place Closure - Remove and dispose of some wastes, solidify the remaining wastes, and stablize wastes and subsoils to the extent necessary to support final cover. Provide a final cover system. Also provide post-closure care and groundwater monitoring for the 30-year post-closure period.

Comparative Analysis

The results of a comparative analysis for closure of the surface impoundments are summarized in Table 5.2, including the closure activities, preliminary cost estimates and advantages and disadvantages for each of the closure methods. General assumptions and methods of this comparative analysis are:

- Only core tasks for each of the closure alternatives are included for this comparison. Cost items such as site preparation, health and safety, equipment decontamination and contingency are not included in this preliminary analysis.

- For the purpose of cost estimation, the total amount of contaminated soil at HWM Nos. 5 and 7 was assumed to be the volume above the groundwater table and within the lagoon perimeter and estimated to be about 20,000 cubic yards.

- The volume of soil needed to backfill the excavated surface impoundments (HWM Nos. 5 and 7) includes both the excavated volume (20,000 cy) and the volume required to bring the site to grade (8,000 cy).

- Groundwater monitoring at the HWM facilities is not part of the post-closure requirements once all the wastes and contaminated material are removed or decontaminated.

TABLE 5.2

COMPARATIVE ANALYSIS OF SURFACE IMPOUNDMENTS (HWM 5 AND HWM 7) CLOSURE METHODS

Closure Method	Major Activities	Cost Estimate	Advantage	Disadvantage
Off-site Disposal	Excavation/Loading	20,000 CY x $3.00 = $ 60,000	- Wastes Removed off-site	- Very expensive
Disposal site:	Transportation	30,000 ton x $62 = 1,860,000	- No post-closure care	- Interferes with plant operation
Triangle Resource,	Disposal fee	30,000 ton x $60 = 1,800,000		
Pinewood, S.C.	Backfill	28,000 cy x $2.50 = 70,000		- Negative impact along transportation route
		Total $3,790,000		- Unknown long-term liability - Complete removal impractical
Treatment				
Removal of wastes and subsoil treatment	Disposal of HWM 5 Wastes in HWM 16	350 Cy x $20.00 = $ 7,000	- Low potential of contaminant release	- Complete treatment probably impossible
	Treatability Study	Lump Sum 30,000	- Simplest and least expensive if final cover and post-closure care/monitoring are not required	- Uncertain in-situ performance
	Subsoil Treatment	20,000 Cy x $8.00 = 160,000		- Probable Post-closure groundwater monitoring and final cover requirements
	Sampling/Analysis	Lump Sum 35,000		
		Total $ 232,000		
		Additional cost for final cover and post-closure groundwater monitoring may be required.		
In-Place Closure	Disposal of HWM 5 waste in HWM 16	500 cy x $20.00 = $ 10,000	- Possible curtailment of long-term GW monitoring	- Long-term liability - Possible release of
30-years post-closure care and groundwater (GW) monitoring	Other site cleanup	Lump Sum 10,000		
	In-place treatment	1,600 cy x $15.00 = 24,000	- Least interference with plant operation	contaminants at a low rate for a limited period
	Sampling/analysis	Lump Sum 35,000		
	Backfill	8,500 cy x $3.00 = 25,500		
	Cover System	50,000 sf x $1.20 = 60,000		
	Post-closure care	$2,500 x 30 years = 75,000		
	GW monitoring equipment	8 wells x $2,000 = 16,000		
		One-time replacement 16,000		
	GW sampling - labor, equipment	2 x 30 year x $600 = 36,000		
	GW analysis	2 x 8 x 30 yr x $400 = 192,000		
		Total $ 499,500		

Notes: o Cost data are from published data, ES past project experience and contractor/vendor supplied information with minor site-specific adjustments.

o Cost estimates are intended for comparative cost purposes only.

o The total volume of contaminated soil and wastes in HWM 5 and HWM 7 is assumed at 20,000 cubic yards.

o Additional cost items such as site preparation, health/safety and contingency are not included in this comparative analysis.

o Groundwater monitoring for the in-place closure option will be a detection monitoring program.

o It is assumed that post-closure care and groundwater monitoring will be performed by the Radford AAP personnel.

o Costs are in May 1985 dollars. In estimating the present worth of costs, it was assumed that the inflation rate and the discount rate were the same; therefore, the present worth of the annual costs is the current cost estimate times the number of years.

- The groundwater monitoring cost for in-place closure is based on a semi-annual detection monitoring program (minimum level of monitoring required by the regulations) with existing monitoring wells. Because of the confirmed groundwater contamination at the surface impoundment sites (HWM 5 and HWM 7), a Compliance Monitoring Program (expanded monitoring when groundwater contamination is suspected as a result of the detection monitoring program) is to be implemented at these sites. The groundwater monitoring cost for the in-place closure method could be considerably lower than that presented by sharing the data from the Compliance Monitoring for initial years of the post-closure period.

- Unit costs have been compiled based on published cost data with adjustments for the site-specific conditions, quotes form contractors and suppliers and ES' past experience with similar projects. These published data sources include: Matrecon (1983); Lutton, et.al. (1979); Rogoshewski, et. al. (1983); Ehrenfeld and Bass (1983); and Department of the Army (1984).

Offsite Disposal

Presently no commercial hazardous waste landfills are available within the Commonwealth of Virginia for off-site disposal of wastes and contaminated soil. Therefore, a quotation for off-site disposal was obtained from Triangle Resource Industry of Reidsville, North Carolina, the closest disposal facility to the Radford AAP site. For disposal at their Pinewood, South Carolina facility, the unit cost for transportation would be 62 dollars per ton ($1235/load by a 20-ton truck) and the disposal fee would be 60 dollars per ton (3 cents per pound). A similar quotation ($45/ton for transportation and $85/ton for disposal) was obtained from Chemical Waste Management, Inc. for disposal at its Fort Wayne, Indiana facility. Since the quoted disposal fee is typical for soils contaminated by hazardous wastes, the total cost of off-site disposal, even at a much closer facility, would be at least two million dollars. In spite of apparent advantages of the off-site disposal as a "walk away" solution, the high costs of this method preclude off-site disposal from serious consideration. It should also be noted that disposal of wastes at an off-site facility does not necessarily eliminate concerns with long-term liability. If the off-site facility were to be improperly operated or abandoned, then the generators of the wastes stored at the facility could be liable for any ensuing damages. Thus, the long-term liability becomes an unknown and uncontrollable issue. In addition, complete removal of all the contaminted subsoil is probably impossible due to site constraints hindering removal of the probable bell-shaped area of contamination beneath the site.

Treatment

The treatment method involves disposal of the wastes (liner and materials above the liner) from HWM 5, a treatability study to optimize the subsoil treatment program, treatment of the contaminated subsoil and a sampling/analysis program to confirm the effectiveness of treatment. Because of the probable presence of NC fines in HWM 5, the sediment and sand above the liner should be removed and "flashed" (exposed to high temperature) and then the residue disposed in HWM 16. The liner also would be removed and disposed in HWM 16. The sediment in HWM 7 will be treated in-place as part of the subsoil treatment. After proper treatment (neutralization and solidification by hydrating reagents), the amount of free water in the soil interstices would be minimal and groundwater contamination from the treated soil is not likely. Although the estimated cost for this alternative of approximately $230,000 is the lowest of the three alternatives, two major defficiencies are inherent with this alternative: complete treatment of the entire contaminated soil would be practically impossible due to the site constraints; and infiltration of surface water into the treated subsoil should not be allowed to prevent remobilization of the contaminants. Thus, it would be necessary to install a final cover system (to prevent infiltration of surface water) and to provide at least a limited period of groundwater monitoring (to confirm the effectiveness of treatment). As a result, the treatment alternative eventually would involve almost all of the actions required for the in-place closure method described below.

In-Place Closure

The in-place closure method involves disposal of the surficial wastes from HWM 5, limited soil treatment (neutralization and solidification), sampling/analysis, backfilling, cover system installation, post-closure care and groundwater monitoring. Neutralization and solidification of the contaminated soil can be achieved by mixing the in-situ soil with appropriate additives. A discussion of the available additives is presented in Section 6. After confirming the characteristics of the treated material and underlying soils (sampling/analysis), the surface impoundments would be backfilled and a cover system be installed. Potential cover system alternatives are discussed in Section 5.4. The post-closure care requirements consist of integrity inspections and maintenance of the closed site for a 30-year period. Groundwater monitoring is also required for 30 years. The estimated cost for this in-place closure method is about $500,000. For a few to several years after closure, a small amount of acidic water with elevated concentrations of various minerals and metals could be released from the subsurface soils. However, its impact on the groundwater quality would be insignificant since no major source of contaminants will be present after closure of the surface impoundments.

Evaluation of Closure Method

To select a final closure method for the surface impoundments, three factors are considered as screening criteria: environmental protection, technical feasibility/practicality, and cost effectiveness. Each of the available alternatives is reviewed with respect to these criteria.

Also, evaluation of each alternative is focused on the contaminated subsoil since cost of handling other surficial wastes is minor.

Offsite Disposal

Environmental protection - The removal of all wastes and contaminated soil will definitely eliminate further degradation of groundwater at the sites. However, the actual level of groundwater degradation that could be prevented by this alternative would be insignificant since:

- The major source of groundwater contamination, liquids in the surface impoundments, will not be present after closure of these facilities;
- The remaining source of groundwater contamination, the soil interstice water with a low pH and possible elevated concentration of minerals and metals, is very limited in quantity;
- There are no downgradient water supply wells before the groundwater flows into the New River, which may be impacted by contaminants in the subsoil underneath the closed facilities;
- Elevated metals in groundwater would likely be adsorbed to soil once low pH of groundwater is neutralized by dilution and would therefore not be detectable at a great distance from the source; and,
- The groundwater at the Radford AAP site discharges into the New River. Very conservative estimates of dilution upon discharge into the river are about 5×10^5 for HWM 5 and 1×10^4 for HWM 7 (USAEHA, 1985). The resultant water quality degradation would not be at detectable levels.

This option also involves several potential negative impacts such as possible spills and accidents during excavation and the long haul to the disposal site. Long-term liability associated with future environmental degradation due to problems at the offsite disposal facility cannot be completely ruled out. As a result, these potential negative factors offset most of the limited benefits in environmental protection achieved by removal of the on-site contaminated soil.

Technical Feasibility/Practicality - Although some contamination is involved, the site soil can be easily excavated with common excavation equipment. Transportation and redisposal services are often available from a single contractor and do not involve any technical problems. Infiltration of liquids into the unsaturated subsoil typically forms a bell-shaped contaminated zone, i.e., the areal extent of the contamination near the groundwater table is larger than the bottom area of the surface impoundment. For complete removal of the entire contaminated soil, the area of excavation at the ground surface could be much larger than the general area of the surface impoundments. Excavation beyond the areal extent of the facility is not feasible for HWM 5 because of the numerous pipeline networks in the vicinity of HWM 5. Therefore, the practical extent of excavation would be limited within the lagoon perimeter. Considering a slope setback for the depth of excavation, a significant portion of the contaminated soil could remain in place.

Cost Effectiveness - The total cost estimate for the offsite disposal alternative is about $3,790,000 as presented in Table 5.2. Considering the limited benefits achieved for environmental protection and recognizing that complete removal of all contaminated soil may be impractical, the high cost of the offsite disposal alternative cannot be justified.

Treatment

Environmental Protection - The treatment of the contaminated subsoil would involve neutralization of acidic water in soil interstices and solidification of the soil mass to retard leaching of contaminants. This would eliminate most of, if not all, future groundwater contamination by the contaminated subsoil. The enhancement of environmental quality is believed to be marginal based on the following reasons: removal of the major source (lagoon liquid) at closure; very limited quantity of the remaining contamination source (acidic water); no downgradient water supply wells; adsorption of metal ions to downgradient soils; and a large dilution factor by the New River.

Technical Feasibility and Practicality - Several types of treatment methodologies are available for neutralization and solidification of acid-contaminated soils. Most often, lime-based pozzolanic material is mixed into soil to achieve multiple effects: acidic liquid is neutralized by lime; excess moisture is removed by hydration; and the soil mass is solidifed by pozzolanic reaction. Thus, the overall potential of groundwater contamination by the contaminated soil is greatly reduced. Due to the operational characteristics (i.e., excavation and mixing) and site constraints, complete treatment of the entire contaminated subsoil would be impractical and it is likely that some would remain untreated at closure. Also, this type of treatment is intended only to significantly reduce the mobility of contaminants rather than to destroy or remove them. If excess water is allowed to infiltrate, remobilization of contaminants is possible. Therefore, a final cover system and post-closure groundwater monitoring would usually be required unless it is demonstrated that no or little contaminants could migrate into groundwater after closure.

Cost Effectiveness - At an estimated cost of about $230,000 (Table 5.2), the treatment alternative appears to be the least expensive option. As discussed in the previous paragraph, this alternative would probably need a final cover system and post-closure care. Thus, treatment would be part of a more comprehensive closure method such as in-place closure, rather than a complete alternative by itself.

In-Place Closure

Environmental Protection - The potential groundwater contamination by the remaining contaminated subsoil would not present a significant environmental threat. This is based on several factors: removal of the major contamination source (lagoon liquid) at closure; limited quantity of potential contaminant (acidic liquid) in the remaining contaminated soil; no downgradient water supply wells; adsorption of some hazardous constituents (metal ions) to downgradient soil; and dilution upon discharge to the New River. Site-specific evaluations of the contaminated subsoil as related to groundwater quality at the sites are provided herein.

At the HWM 5 site, the major source of contamination was virtually eliminated when a synthetic liner was installed in late 1981. After some lag period, it is expected the groundwater quality would show a generally improving trend. A summary of selected indicator parameters (pH, specific conductance, nitrite and nitrate as N, and sulfate) from the HWM 5 monitoring wells (5, 6, 7 and 8) is presented in Table 5.3. In this table, the downgradient Wells 5, 6 and 7 show a definite trend of improvement in groundwater quality. At Well No. 8, it is believed that the groundwater contamination was caused by a nearby acid pipe leak. The pipe leak was repaired very recently (early 1984) and it appears that the elapsed time is not long enough to reverse the groundwater quality trend. In summary, except for Well No. 8 which was contaminated by a more recent pipe leak, the groundwater quality at the HWM 5 site appears to be improving with a diminishing contaminant release from the soil. This trend would continue, possibly with minor

TABLE 5.3

GROUNDWATER QUALITY TREND AT HWM 5

	April 81	Oct. 82	July 83	Nov. 84
Well 5				
pH	7.0	6.6	6.9	-
Spec. Cond. (UMC)[1]	7,730	1,220	1,200	-
NO_2tNO_3 as N (mg/l)	250	16	-	-
Sulfate (mg/l)	3,200	270	260	-
Well 6				
pH	6.4	5.4	5.6	5.0
Spec. Cond. (UMC)	793	1,260	680	490
No_2+NO_3 as N (mg/l)	6.9	60	-	28
Sulfate (mg/l)	97	330	170	140
Well 7				
pH	6.7	7.1	7.4	-
Spec. Cond. (UMC)	6,800	475	660	-
NO_2+NO_3 as N (mg/l)	420	3	-	-
Sulfate (mg/l)	3,630	64	50	-
WELL 8				
pH	4.5	4.0	3.8	3.4
Spec. Cond. (UMC)	733	4,750	3,700	3,900
NO_2+NO_3 as N (mg/l)	0.53	260	-	285
Sulfate (mg/l)	88	330	2,100	2,370

[1] UMC - Micromhos per centimeter

fluctuations due to the influence of the previous pipe leak, for a few to several years until the local groundwater quality returns to pre-operation conditions.

At the HWM 7 site, the primary source of contamination (acidic water) is routinely neutralized. Although there is some possibility of introducing a slug of acidic water due to the operation schedule, groundwater quality at the HWM 7 site should not present a major concern with respect to low pH and resultant heavy metal problems. This can be seen in the groundwater quality data presented in Table 4.4 and Appendix D. The pH values from the HWM 7 monitoring wells are consistently very close to 7.0. One exception is the November 1984 data from Well No. 11B, which show a low pH of 4.3 and elevated metal concentrations. Because Well No. 11B is the closest downgradient well to the impoundment, it appears that this low pH has resulted from a slug of acidic water before stabilization. Since infiltration of acidic water will not be persistent (i.e., routine neutralization of acidic water in HWM 7), the pH of groundwater at the Well 11B location and further downgradient would return to neutral. As a result, the elevated metal concentrations should attenuate to the background level. In the absence of acidic water infiltration after closure, this temporal groundwater quality problem would quickly disappear.

Technical Feasibility/Practicality - Activities involved in the in-place closure method are relatively simple and straightforward. Most of the closure activities consist of routine earthwork such as excavation, hauling, backfilling, compaction and grading. The design and installation of the cover system also uses well-known, practical technology. With appropriate selection of cover material (see Section 5.4), the infiltration of surface water would be virtually eliminated.

Cost Effectiveness - The total estimated cost for in-place closure of the surface impoundments is about $471,000. Only 29 percent (or

$136,000) would be spent for closure activities such as waste removal, soil treatment, backfill and cover system. Thus, the post-closure groundwater pollution potential would be greatly reduced at a minimal cost. The majority of the in-place closure cost (71 percent) is required for post-closure care and groundwater monitoring. For several years after closure of HWM 5 and HWM 7, groundwater quality data will be available from the Compliance Monitoring Program. This monitoring data can be used to satisfy post-closure care monitoring needs. It is also possible that if it can be shown by improved groundwater quality that in-place closure of the surface impoundments does not present an adverse impact on the environment, the requirements for groundwater monitoring may not have to extend for 30 years. Thus, the total post-closure cost for the in-place closure alternative could be less than that estimated.

Recommended Closure Alternative

The offsite disposal alternative is too costly with no significant benefits from an overall environmental protection point of view. It is uncertain that the treatment alternative alone would completely eliminate future groundwater pollution potential. Therefore, the treatment option is viable only as part of the in-place closure alternative. The in-place closure alternative would be able to minimize future groundwater contamination even though some contaminated subsoil remains in place. It also satisfies the regulatory requirements at a reasonable cost. Therefore, the in-place closure method is recommended for the closure of the surface impoundments at the Radford AAP. Since the long-term groundwater monitoring (Compliance Monitoring) is required anyway at these sites, the additional burden to meet the post-closure requirements does not appear to be excessive. Also, based upon past groundwater monitoring results, there is reason to believe that groundwater quality will continue to improve to background levels. Therefore, after appropriate negotiation with the State, there may be potential for discontinuing groundwater monitoring or significantly reducing its scope. The detailed closure analysis for the selected alternative (i.e., in-place closure) is presented in Section 6.

5.3 CLOSURE ALTERNATIVES FOR LANDFILL

The standards for closure and post-closure care of a hazardous waste landfill as presented in the Virginia Hazardous Waste Regulations are summarized below:

- o A final cover system must be installed and maintained to minimize migration of liquid through the closed landfill (10.14.11(a)).

- o Post-closure care which consists of groundwater monitoring and maintenance of the closed facility must be provided for the 30-year post-closure period (10.07.08(a)(1) and 10.14.11(b)).

Although not specifically stated in the regulations, the wastes and contaminated materials could be removed for disposal in an offsite (or on-site), permitted facility and HWM 16 would no longer be subject to Virginia's Hazardous Waste Management Regulations. Table 5.4 presents a comparative analysis of these closure options. For this preliminary analysis, the total volume of waste in HWM 16 was assumed to be 5,500 cubic yards. This estimate includes 4,200 cubic yards in HWM 16 as of December 1984 plus an estimated volume of 1,300 cubic yards to be disposed before the landfill is closed. Most of the unit cost data compiled for the closure of the surface impoundments is also applicable to the cost estimate for closure of HWM 16.

Based on the same unit costs used for off-site disposal of the wastes from the surface impoundments, the total estimated cost of off-site disposal for HWM 16 is about $1,050,000. As in the case of the surface impoundments, off-site disposal is the most expensive disposal method.

TABLE 5.4

COMPARATIVE ANALYSIS OF LANDFILL (HWM 16) CLOSURE METHODS

CLOSURE METHOD	MAJOR ACTIVITIES	COST ESTIMATE	ADVANTAGE	DISADVANTAGE
Off-site Disposal Disposal site: Triange Resource Pinewood, SC	Mobilization Excavation/loading Transportation Disposal Fee Backfill	Lump Sum = $ 10,000 5,500 cy x $4.00 = 22,000 8,250 ton x $62 = 511,500 8,250 ton x $60 = 495,000 5,500 cy x $2.00 = 11,000 Total 1,049,500	- Waste removed off-site - No post-closure care	- Very expensive - Unknown long-term liability
On-site Disposal A new, on-site disposal facility with double liner leak detection and cover system About 6,000 cy capacity	Design/permitting Construction Excavation/disposal Closure/cover system Post-closure care	Lump Sum $100,000 20,000 sf x $5.50 = 110,000 5,500 cy x $5.00 = 27,500 20,000 sf x $1.50 = 30,000 30 years x $3,000 = 90,000 Total $357,500	- Waste secured on-site - Long-term commitment and part of closure cost absorbed by HWM 5 closure.	- Long-term commitment - Disturbance of wastes - Uncertain permit approval
In-Place Closure Cover system and 30 years post-closure care and groundwater (GW) monitoring	Cover system Post-closure care GW monitoring and equipment GW Sampling - labor GW analysis	40,000 sf x $1.20 = $48,000 $ 2,500 x 30 year = 75,000 4 wells x $2,000 = 8,000 One-time replacement = 8,000 2 x 30 yr x $1,000 = 60,000 2 x 4 x 30 yr x $400 = 96,000 Total $295,000	- Least expensive alternative if HWM 5 cannot be used as an on-site dispoasl facility.	- Long-term liability - Possible release of contaminants. - Probable complication due to impact of sanitary landfill and flyash landfill on groundwater.

Notes:
- o Cost data are from published data, ES past project experience, and contractor/vendor supplied information with minor site-specific adjustments.
- o The total volume of wastes in HWM 16 is assumed at 5,500 cy.
- o Groundwater monitoring program for the in-place closure option will be a detection monitoring program.
- o It is assumed that post-closure care and groundwater monitoring will be performed by the Radford AAP personnel.
- o Health, safety and contingency costs are not included in this comparative analysis.
- o Cost estimates are only intended for comparative cost purposes.
- o Costs are in May 1985 dollars. In estimating the present worth of costs, it was assumed that the inflation rate and the discount rate were the same; therefore, the present worth of the annual costs is the current cost estimate times the number of years.

For on-site disposal, a new disposal facility would have to be built with a double liner and leak detection system. The total cost for on-site disposal at a new on-site facility, sized for a waste volume of 6,000 cubic yards, is estimated at about $360,000.

In-place closure of HWM 16 requires a final cover system and post-closure care and groundwater monitoring for 30 years. The total cost for in-place closure is estimated to be about $300,000.

HWM 16 has a compacted natural soil bottom and is not equipped with a leachate collection system. Consequently, should leachate be generated in HWM 16, it could eventually be released at a slow rate into the subsoil and groundwater beneath the site. Based on the recent Groundwater Quality Assessment Program, it was found that the groundwater in the vicinity of HWM 16 has been degraded. According to the preliminary assessment by the USAEHA (USAEHA, 1985), one source of contamination is traced to the TNT neutralization sludge disposal trench located upgradient of HWM 16 (Figure 4.1).

In the absence of any known or likely adverse impact of HWM 16 on the environment, there is no reason to disturb wastes in HWM 16 for offsite or on-site disposal. With a final cover system installed at closure, the potential of leachate generation and resultant soil and groundwater contamination would be minimized. Therefore, the in-place closure method appears to be the most logical choice for HWM 16 and also meets the general requirements of the State Regulations. The details of the closure method and procedures are discussed in Section 6.

5.4 COVER SYSTEM ALTERNATIVES

Should a hazardous waste disposal site be closed with wastes in place, a final cover system must be installed which meets the following criteria (10.11.09 (a) (2) iii and 10.14.11(a)):

- o Provides long-term minimization of migration of liquids through the closed facility;
- o Functions with minimal maintenance;
- o Promotes drainage and minimizes erosion or abrasion of the cover;
- o Accomodates settling and subsidence so that the cover's integrity is maintained; and
- o Has a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

These criteria can be met by the following provisions:

- o Use of an appropriate liner material to minimize the infiltration of surface water into the contained wastes;
- o Placement of a good grass cover and diversion of surface water flow away from the closed facility to minimize erosion and washout of the cover material;
- o Proper surface grading (slope) and installation of an intermediate drainage layer to promote drainage of precipitation; and
- o Compaction of contained material (waste or backfill) to minimize post-closure settlement. With proper compaction, the amount of post-closure settlement should be minimal. However, a sufficient camber and flexible liner material should be considered to accommodate any post-closure settlement.

Presented in Figures 5.2, 5.3 and 5.4 are three cover system alternatives that could be considered for the closure of the Radford AAP

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Figure 5.2

SOIL LINER COVER SYSTEM

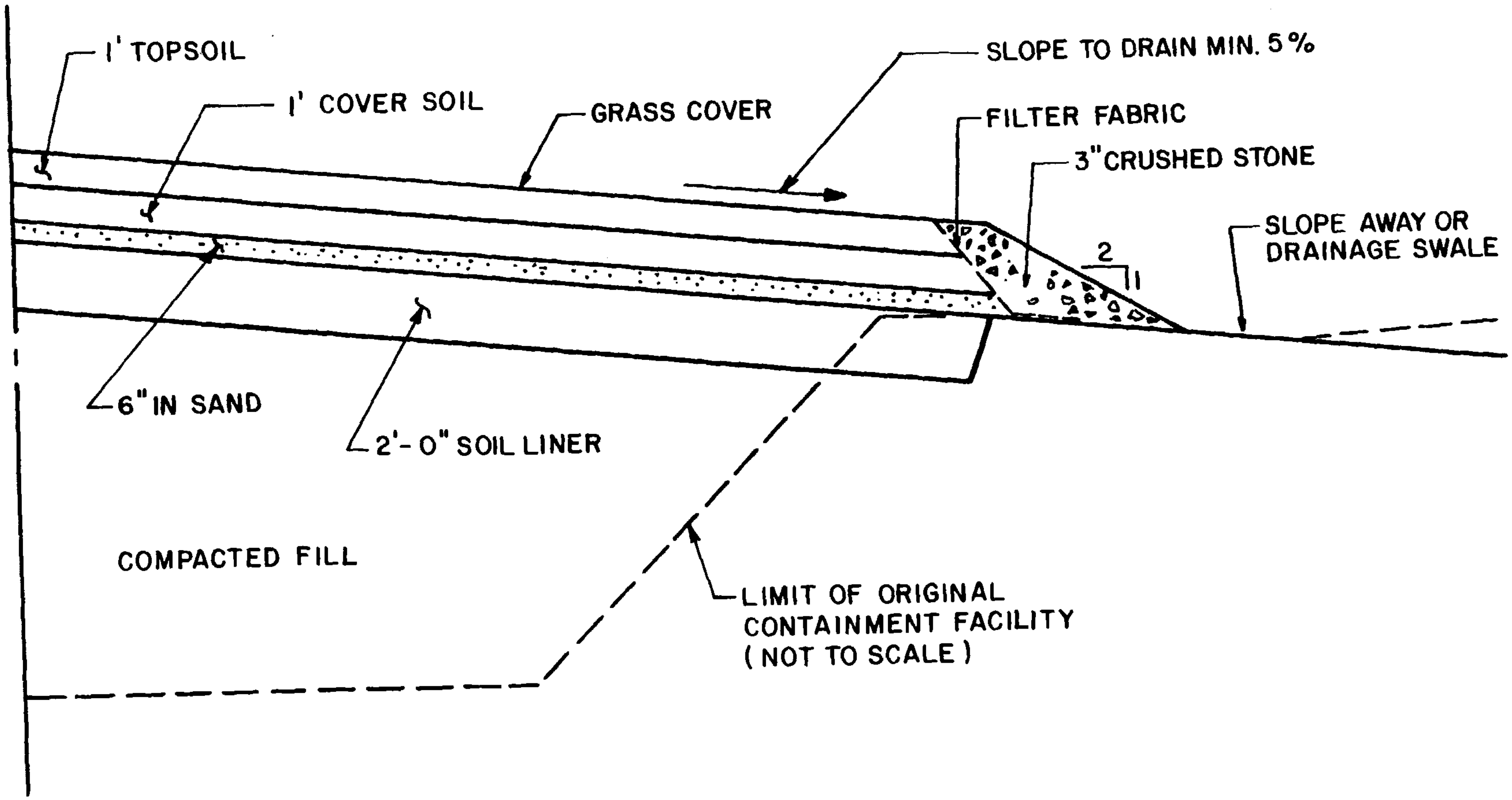

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Figure 5.3

SOIL-BENTONITE LINER COVER SYSTEM

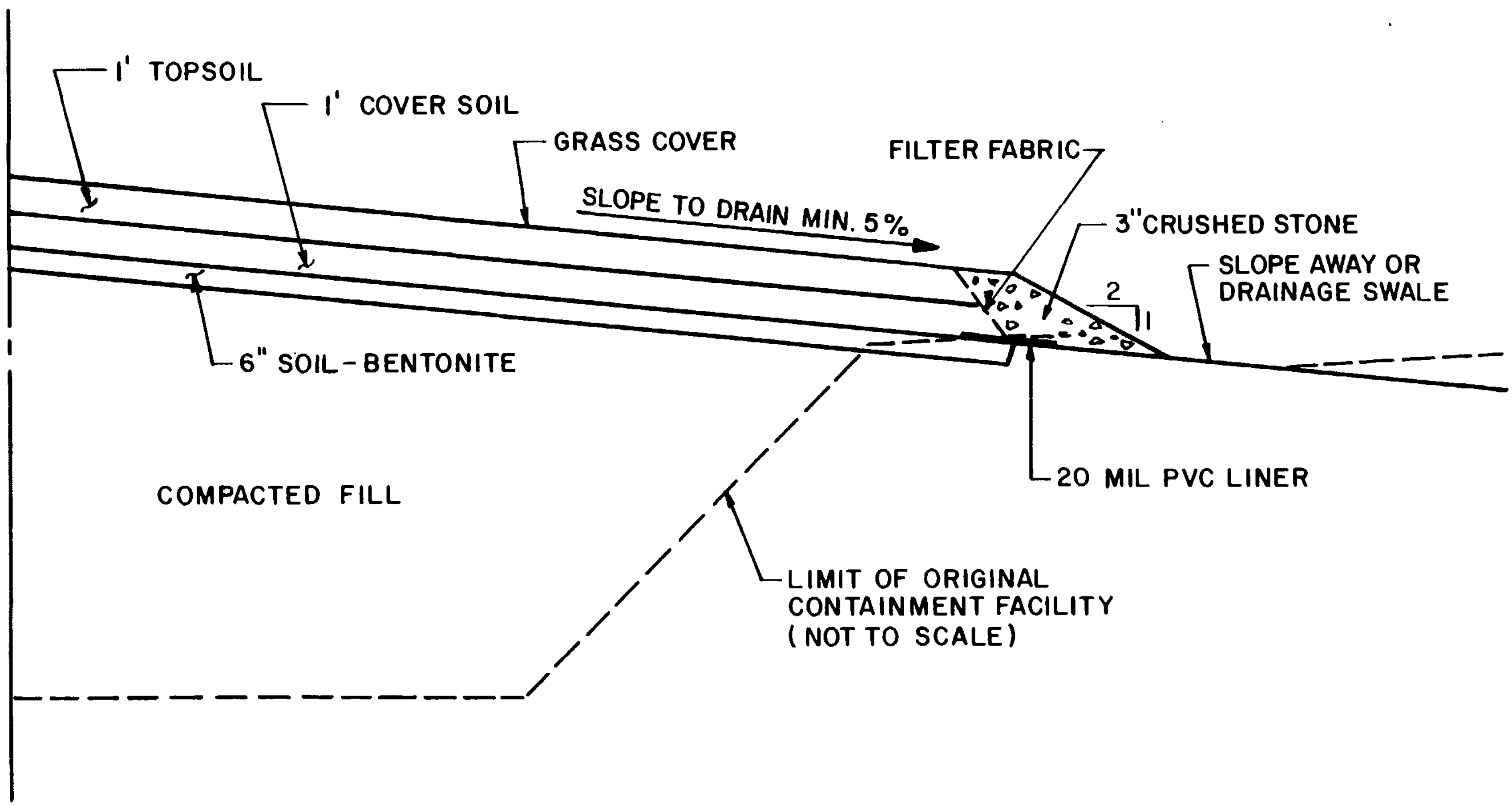

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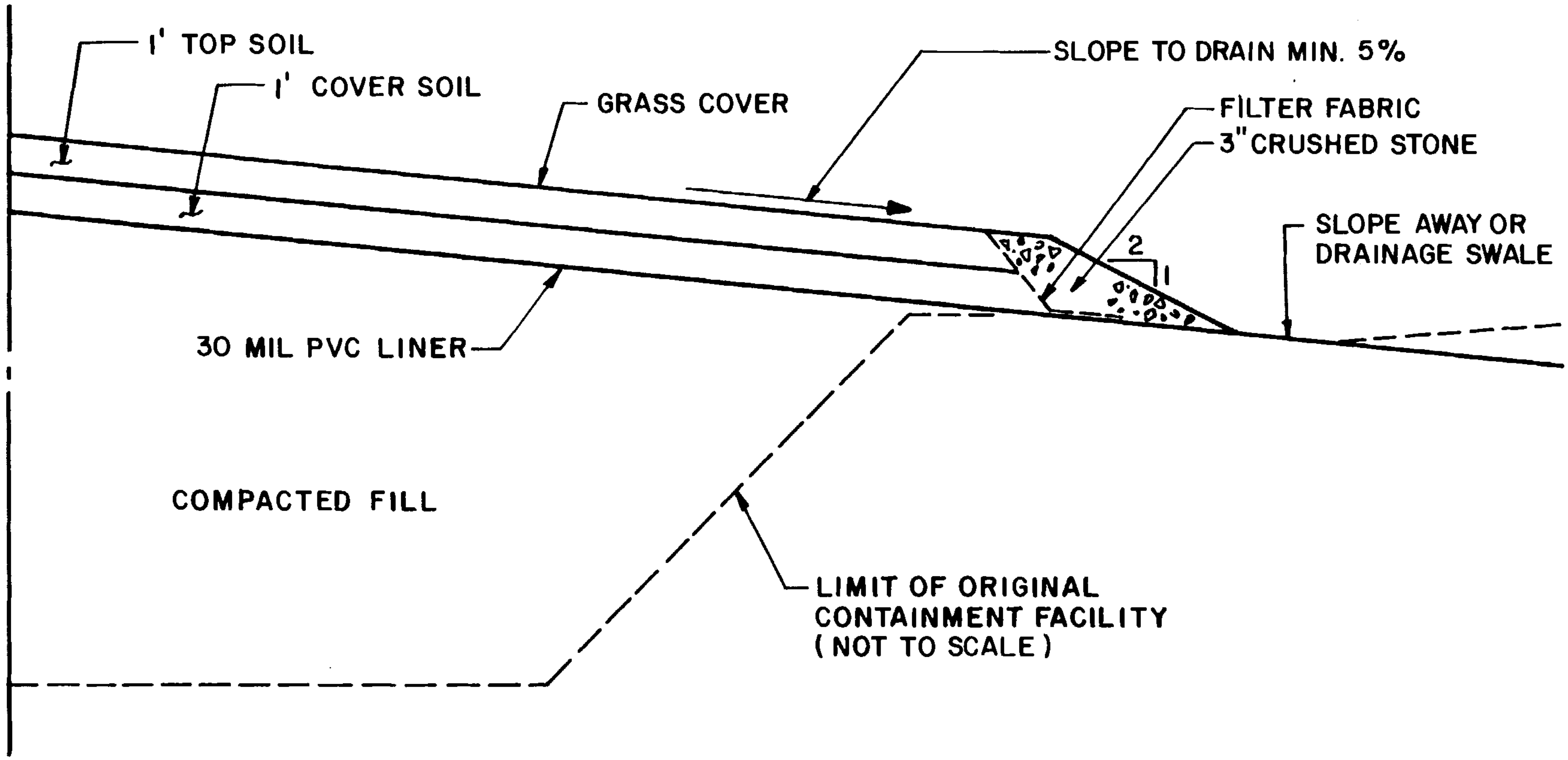
Figure 5.4

SYNTHETIC MEMBRANE LINER COVER SYSTEM



Hazardous Waste Management facilities. These alternatives are based on the review of several technical guidelines (Lutton, et.al., 1979; Lutton, 1980; and Matrecon, 1983) including the recent Army Technical Manual TM 5-814-7 (Department of Army, 1984). The major difference between these cover systems is the low permability liner material: compacted soil liner; soil-bentonite liner; and synthetic membrane liner. Design features and associated cost analyses are summarized in Table 5.5. In most liner applications, synthetic liners are the most expensive whereas soil liners are the least expensive. In this analysis (Table 5.5), however, there are no significant cost differences between the liner systems. One reason for this low cost differential is the small earthwork volume required for the soil liner system. Since the mobilization costs for earth moving equipment is high and the volume of earthwork is small, the unit cost for the soil liner is relatively high. The cost of a sand drainage blanket also contributes to the high cost of the soil liner system. Although a sand drainage blanket is not a mandatory requirement in the Virginia Regulations, it is desirable because of the predominantly silty liner soil at the site and lack of bottom liner or leachate collection system at the site facilities.

Another reason for comparable liner costs is the use of an inexpensive PVC liner. For a cover system, the synthetic liner will be in contact with natural soil and rainwater under a minimum load. Further, the PVC liner is compatible with somewhat acidic site soils. Therefore, a costly liner material is not needed for reason of compatibility. Also, the cost for reinforcement is negated under these cover applications. While the minimum thickness requirement is 20 mils, it is recommended that a 30-mil PVC synthetic liner be used for additional strength and service life.

Soil-bentonite is often used to avoid the high cost of synthetic liners where adequate clay material for a soil liner is not available. However, in addition to not having significant cost advantages over the

TABLE 5.5

COVER SYSTEM ALTERNATIVES

LINER MATERIAL AND DESIGN FEATURE	COST ESTIMATE		
Compacted Soil (Figure 5.3)	Volume for 90,000 ft^2 x 2 ft: 6,700 cy		
o 2-ft compacted soil (clayey silt)	Borrow, haul, compact	6,700 cy x $ 4.00 =	$26,800
o Permeability estimate 10^{-6} cm/sec	Sand drainage blanket	1,670 cy x $15.00 =	25,050
o 6-in sand blanket for drainage	Less common fill in HWM 5 and HWM 7	3,000 cy x $ 2.50 =	-7,500
		Total	$44,350
Soil-Bentonite (Figure 5.4)	Bentonite, delivered	110 ton x $200 =	$22,000
o 6-in soil-bentonite Bentonite-4% by weight	Mixing, handling, compaction	1,750 cy x $10.00 =	17,500
o Permeability estimate 10^{-7} to 10^{-8} cm/sec	20 mil PVC liner	8,000 sf x $ 0.40 =	3,200
o 20-mil PVC liner along perimeter (prevent dryout and cracking)		Total	$42,700
Synthetic Membrane (Figure 5.5)	30 mil PVC liner, installed	90,000 sf x $0.50 =	$45,000
o 30-mil PVC			
o Impermeable			
Common Features	Topsoil	3,300 cy x $12.00 =	$39,600
o 1-ft topsoil and 1-ft cover soil	Cover soil	3,300 cy x $ 2.00 =	6,600
o Vegetation (grass)	Vegetation	L.S. =	2,400
o Riprap, fabric, swale, etc.	Riprap	400 cy x $25.00 =	10,000
	Fabric, swale, etc.	L.S. =	4,000
		Total	$62,600

Notes:
- o Cost estimate is based on a total area of 90,000 square feet for HWM Nos. 5, 7 and 16.
- o Cost data are from published data, ES past project experience and contractor/vendor supplied information with minor site-specific adjustments.
- o Cost estimates are only intended for comparative cost purposes.
- o Unit cost for the entire cover system (including common features) is $1.20/sf as used in Tables 5.2 and 5.4.

PVC liner system, use of a soil-bentonite system generally presents dust control problems. Also, laboratory studies and extensive field quality control are frequently needed for the installation of soil-bentonite cover systems.

In summary, the PVC membrane appears to be the best cover system for the Radford HWM because of its comparable cost and easy field installation. Site-specific aspects of the design and evaluation of the PVC liner cover system are presented in Section 6.

SECTION 6

DETAILED CLOSURE ANALYSIS

SECTION 6
DETAILED CLOSURE ANALYSIS

General approaches and methods for closure of the hazardous waste facilities at the Radford AAP and selection of the most desirable alternative are discussed in Section 5. This section presents a detailed analysis for the selected closure method (in-place closure). In addition to procedural descriptions of site preparation, closure construction and sampling/analysis, an evaluation of the proposed cover system is provided. A summary of site-specific closure related activities is presented in Table 6.1.

6.1 SITE PREPARATION

Site preparation includes all activities to be performed prior to initiation of closure construction by a contractor to be selected by the COE. These activities primarily consist of the handling of liquids and solids in the surface impoundments when the replacement tanks are operational and the surface impoundments can be closed. Radford AAP (Hercules, Inc.) will perform these activities because of the nature of the work. The handling of acidic liquids in the lagoons is a final operation activity and is best conducted by operators familiar with the site. The solids in HWM 5 may contain some NC fines and Hercules is in the best position to handle this material because of the reactive nature of the NC fines and their existing on-site facilities for the destruction of the nitrocellulose. Details of site preparation activities are discussed herein.

TABLE 6.1

SUMMARY OF CLOSURE-RELATED ACTIVITIES

	HWM 5	HWM 7	HWM 16
Site Preparation by Radford AAP	- Replacement tank completed - Divert lagoon inflow to replacement tank - Neutralize liquid - Drain liquid - Wash riprap - Remove and flash bottom sand and sediment and store near HWM 16	- Replacement tank completed - Divert lagoon inflow to replacement tank - Neutralize liquid - Drain liquid	
Closure Construction by Contractor	- Remove and dispose of appurtenant structures - Remove and stockpile riprap - Remove sideslope cover sand and dispose of in HWM 16 - Remove liner and dispose of in HWM 16 - Provide approximately 2' of soil treatment - Conduct sampling/analysis - Provide backfill/grading - Install cover system - Provide final grading and drainage - Install vegetation - Place warning security signs	- Remove and dispose of appurtenant structures - Provide approximately 7' of sediment/soil treatment - Conduct sampling/analysis - Provide backfill/grading - Install cover system - Provide final grading and drainage - Install vegetation - Place warning security signs	- Install leachate drain system - Receive cover sand and liner from HWM 5 - Receive final volume of wastes - Conduct sampling/analysis - Compact wastes and cover soil - Install cover system - Provide grading/drainage - Install vegetation - Place warning security signs
Regulatory Follow-up and Post-Closure Activities by RAAP	For All Facilities: - Obtain approval of the closure plan. - Notify the State at least 180 days prior to beginning of closure work. - Complete site cleanup within 90 days and all other closure work within 180 days after receiving the final volume of wastes. - Provide certification by the owner and an independent professional engineer. - Provide notice to local land authority. - Place notice in deed to property. - Provide for future use restrictions not to disturb the components of the closed facility. - Provide post-closure care (inspection, maintenance and groundwater monitoring).		

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HWM 5

Following the completion of the replacement tank, the acidic water would be diverted to the new tank and the impoundment would be ready for closure. The following site preparation activities will be performed by Radford AAP:

- o Lower the liquid level in HWM 5 to a practical minimum via the existing effluent line.
- o Flush the old influent pipe, manholes, stainless trough and granite riprap on the sideslopes with a weak sodium hydroxide solution and water. By neutralizing acidic residues on these materials and structures and flushing with water, they can be reused, buried in place, or disposed of in the sanitary landfill without the need for costly handling as hazardous material.
- o Allow the sodium hydroxide solution to soak in the sediment and cover sand of the impoundment thereby neutralizing acidic liquids. Additional sodium hydroxide may have to be added if the quantity used for flushing of pipes and other materials is not sufficient.
- o Drain the neutralized liquid and allow excess liquid in low spots to dry.
- o When the cover sand and sediments are still wet, remove and flash all bottom solids (sand and sediments) to burn NC fines. Store near HWM 16 for later disposal and cover with a plastic sheet.

HWM 7

Following the completion of the replacement tank, the acidic water would be diverted to the new tank and the impoundment would be ready for closure. The following will be performed by Radford AAP:

- o Flush the old influent pipe (from the diversion point to the discharge outlet) and manhole with a weak sodium hydroxide solution and water.

- o Add lime slurry to the lagoon wastewater and mix using the air diffusers until the wastewater in the lagoon is neutralized.

- o Remove and flush the air diffuser pipes with water. The pipes may be reused, recycled as scrap metal or disposed of in the sanitary landfill.

- o Drain neutralized wastewater to SWM 9 and allow the bottom of the impoundment to dry.

HWM 16

No site preparation work is needed for HWM 16.

Regulatory Follow-Up

The Virginia Hazardous Waste Management Regulations require certain follow-up activities for closure of hazardous waste management facilities (10.07). These follow-up activities are applicable to all three facilities (HWM Nos. 5, 7 and 16) and will be handled by the COE in cooperation with Radford AAP:

- o Obtain approval of the closure plan from the Commissioner. This engineering report describes the closure plans for the Radford AAP hazardous waste management facilities and its approval of this report will satisfy this requirement.

- o Notify the Commissioner at least 180 days prior to the date actual closure work is to be initiated. Based on the schedule discussed in Section 8 of this report, the closure work would be initiated in June, 1986. The submittal of this report to the State therefore should satisfy this notification requirement.

- The initial cleanup of the site (i.e., site preparation as discussed in Section 6.1) should be completed within 90 days after receiving the final volume of hazardous wastes.

- The closure activities should be completed within 180 days after receiving the final volume of wastes.

- When closure is completed, a certification that the facility has been closed in accordance with the specifications in the approved closure plan should be submitted to the Commissioner. This certification should be issued both by the owner (Radford AAP) and by an independent professional engineer registered by the Commonwealth.

Additional regulatory requirements for post-closure of the facilities are discussed in Section 7.

6.2 CLOSURE CONSTRUCTION

All closure construction activities described in this section will be performed by a contractor selected by COE. A general discussion of site-specific closure activities as summarized in Table 6.1 is presented. Detailed discussions of specific subjects such as soil treatment, sampling/analysis and cover system evaluation are provided in separate subsections.

HWM 5

Closure construction activities for HWM 5 include additional site cleanup, soil treatment, sampling/analysis, backfill and final cover system installation:

- o Remove all the appurtenant structures including the trough, manhole, influent pipe, decant pipe and guard rails. The influent pipe sections not affected by the construction activities at the HWM 5 site may remain in place after plugging both ends with concrete. The concrete and clay pipe will be disposed at the non-combustible dump and the metallic material hauled to the contaminated waste incinerator for handling by Hercules.

- o Remove the riprap on the side slopes of the impoundment and stockpile for later use. This will be used for the stabilization of the high slope for the closure of HWM 16. The estimated volume of riprap from HWM 5 is about 120 cubic yards.

- o Remove the cover sand on the side slopes and dispose of in HWM 16. The cover sand on the side slopes does not need flashing. The total volume of sand from HWM 5 is estimated at about 400 cubic yards. This sand will be placed in HWM 16 so that additional wastes (last batch of hazardous wastes and liner material from HWM 5) can be placed above the sand layer. At closure the sand layer can act as a drainage layer to collect any leachate generated from the wastes.

- o Remove the hypalon liner, cut into pieces and dispose of in HWM 16.

- o Treat approximately two feet of subsoil with lime kiln dust. A discussion of soil treatment is provided in Section 6.3.

- After three days of curing time, perform sampling of the subsoil to identify the nature of the soil contamination. The sampling and analysis program is discussed in Section 6.4.

- Backfill the depression with the soil excavated from the borrow site. The location of the borrow site is shown in Figure 1.2. The fill material should be compacted within three percent of the optimum moisture content to no less than 95 percent of the maximum dry density (ASTM D-698). Details of common fill construction are described in the Geotechnical Report (Schnabel, 1985).

- Install a final cover system in general accordance with the proposed system shown in Figure 5.4. A detailed evaluation of this cover system is provided in Section 6.5.

- Provide final grading for drainage control around the closed facility. The final topography of the HWM 5 site after closure is shown in Figure 6.1.

- Provide vegetation cover on the final cover, drainage swales and other disturbed areas. Discussions on the selection of a grass species for vegetation cover are provided in Section 6.5.

- Install a warning sign to indicate the presence of a closed hazardous waste facility and to prohibit the access of unauthorized personnel or vehicles. Enclosure of the facility by fencing is not neccessary because the entire plant area is under a strict security control and the cover system (crushed stone perimeter) is designed to deter accidental access to the area.

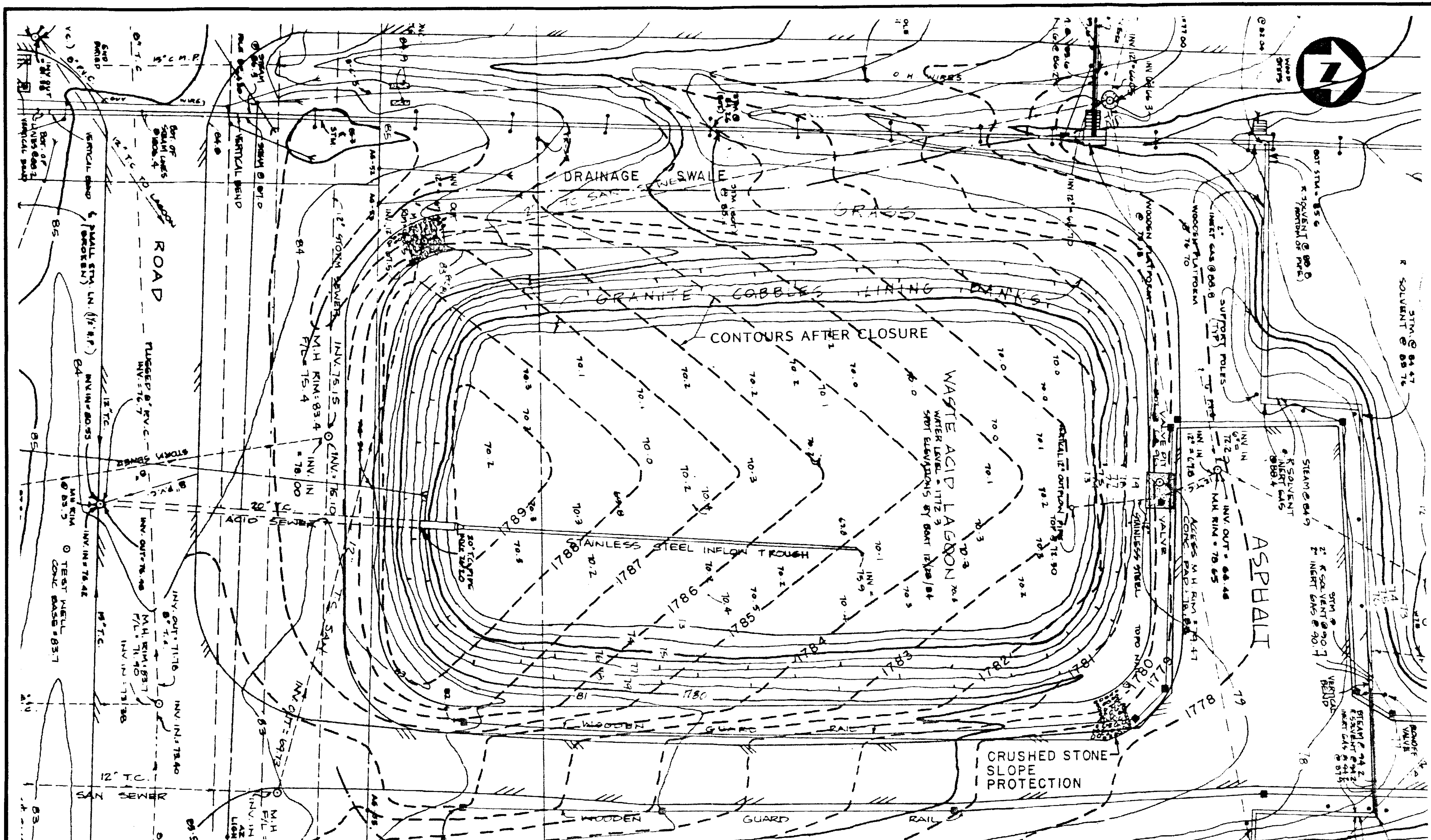

Figure 6.1

HWM 5 SITE AFTER CLOSURE

HWM 7

Closure construction activities for HWM 7 include the following:

- Remove all the appurtenant structures such as guard rails, influent pipe, concrete pad, and effluent (3-inch stainless steel) pipe. The concrete and clay pipe will be disposed at the non-combustible dump and the metallic material hauled to the contaminated waste incinerator for handling by Hercules. The influent pipe outside of the closure construction area may remain in place after plugging both ends with concrete.

- Treat approximately seven feet of sediments and soil (five feet of bottom sediment and additional two feet of subsoil) with lime kiln dust. The treatment procedures are described in Section 6.3.

- Perform subsoil sampling after the treated sediment and soil is cured for three days. Section 6.4 presents further details of the sampling and analysis program.

- Backfill the depression with the soil excavated from the borrow site. Fill material should be compacted within three percent of the optimum moisture content to no less than 95 percent of the maximum dry density. Details of common fill construction are presented in the Geotechnical Report (Schnable, 1985).

- Install a final cover system as proposed in Figure 5.4. The details of liner evaluation are presented in Section 6.5.

- Provide final grading for drainage control around the closed facility. The final topography of the HWM 7 site after closure is shown in Figure 6.2.

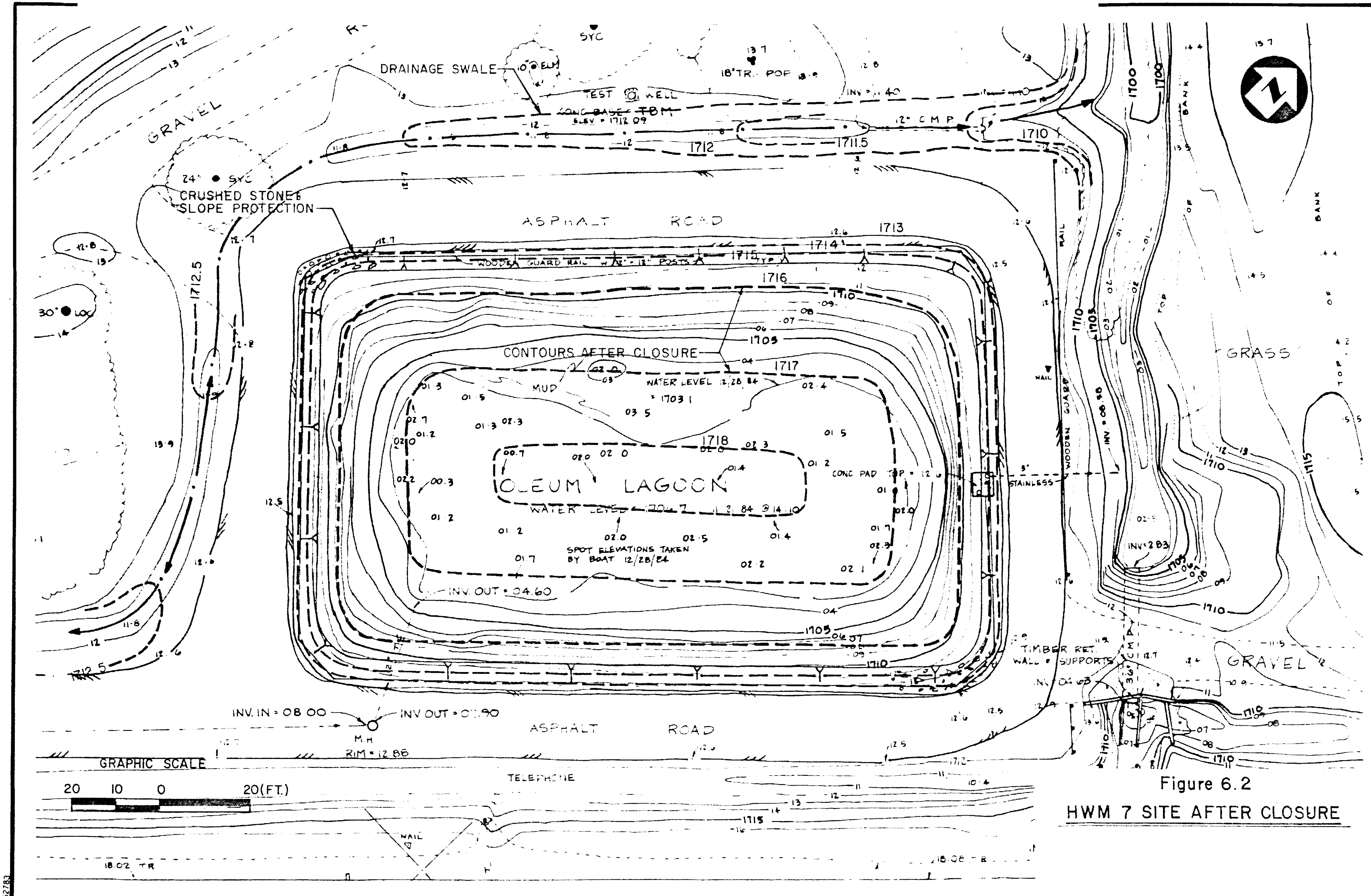

Figure 6.2

HWM 7 SITE AFTER CLOSURE

- o Provide vegetation cover on the final cover, drainage swale and other disturbed areas. Selection of an adequate grass species and seeding method are described in Section 6.5.

- o Install a warning sign.

HWM 16

Closure construction activities for HWM 16 involve installation of a leachate drain system, disposal of the final volume of wastes, sampling of wastes in the trench and subsoil, compaction of the existing cover soil and final cover installation.

- o Install a leachate drain system (Figure 6.3). The compacted trench bottom slopes down toward the unfilled section of the trench and any leachate, if generated, would flow to the toe of the high slope. The leachate drain system is intended to drain this leachate and not allow it to build up or to migrate into the subsoil.

- o Dispose of the cover sand from HWM 5 in HWM 16, covering the bottom of the unfilled section of the trench to promote drainage in conjunction with the leachate drain system.

- o Dispose of the final volume of wastes, including the liner material removed from HWM 5, in HWM 16.

- o Perform sampling of wastes and subsoil in HWM 16. This sampling is to aid the Radford AAP in their groundwater assessment program and may be conducted by Radford AAP prior to closure.

- o Compact the existing cover soil to provide support for a final cover system.

- o Install the final cover system as shown in Figure 6.3.

- o Provide final grading to promote surface drainage around the closed landfill. The final topography of the HWM 16 site after closure is shown in Figure 6.4.

- o Provide vegetation cover on the final cover, drainage swales and other disturbed areas. Selection of a grass species and seeding method are presented in Section 6.5.

- o Install a warning sign.

6.3 SOIL TREATMENT

Selection of Additive

Presented in Table 6.2 are several candidate agents for the neutralization, stabilization and solidification of the impoundment sediments and subsoil. Initially, a mixture of lime and flyash was considered as the appropriate treatment agent since flyash is available at the Radford AAP. After a detailed review, lime kiln dust is favored over the lime/flyash mixture because:

- o Lime kiln dust is a waste material and is available locally.

- o In addition to accomplishing all three required functions (acid neutralization, stabilization, and solidification), lime kiln dust can be applied without the premixing step required for the lime and flyash mixture.

6-12

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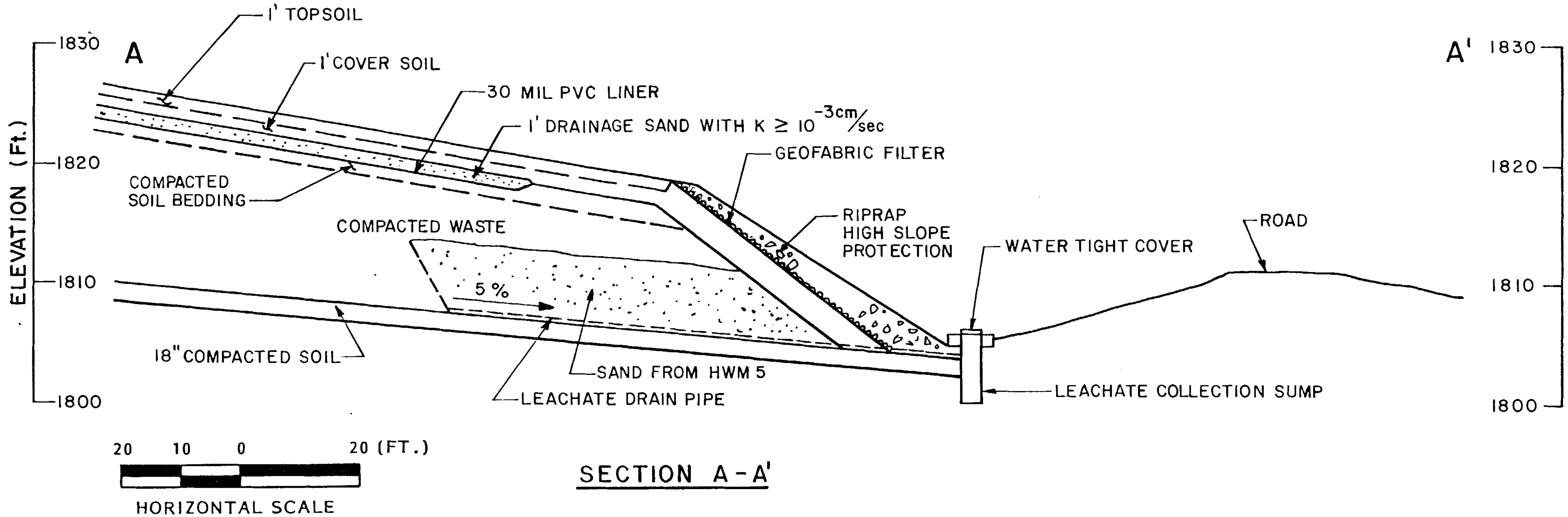
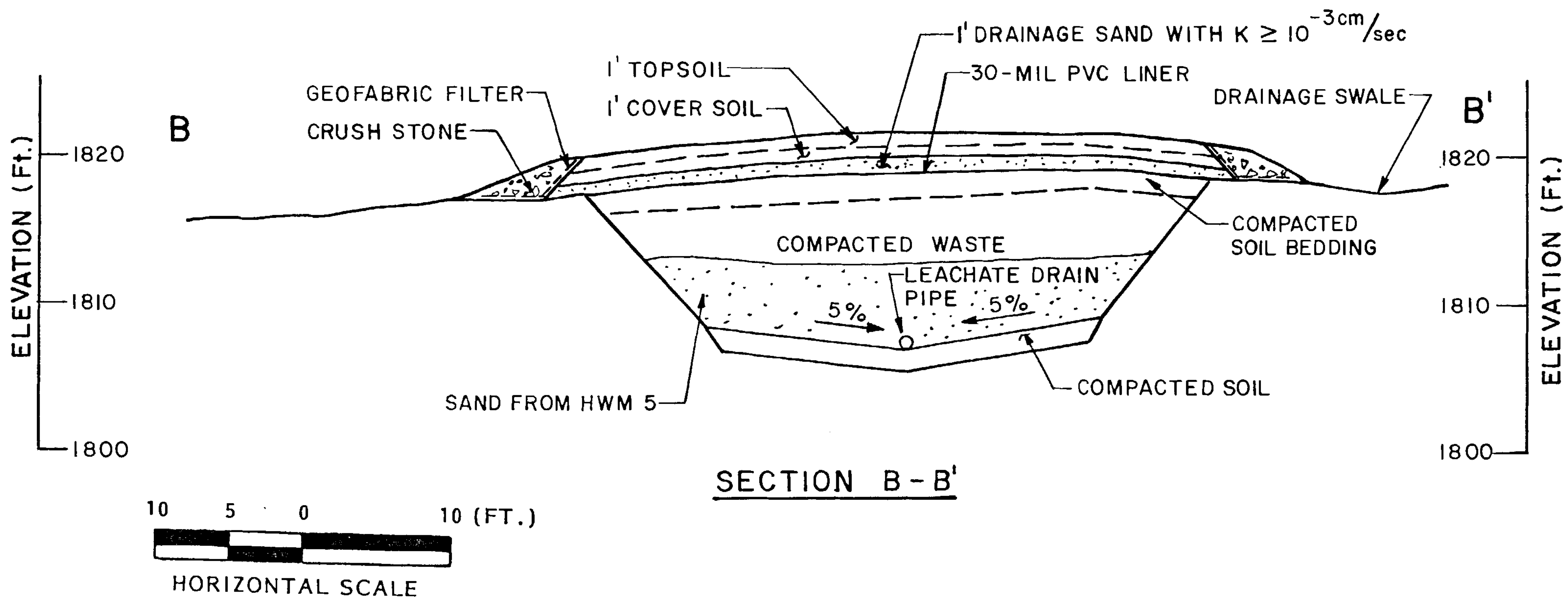


SECTION A-A'



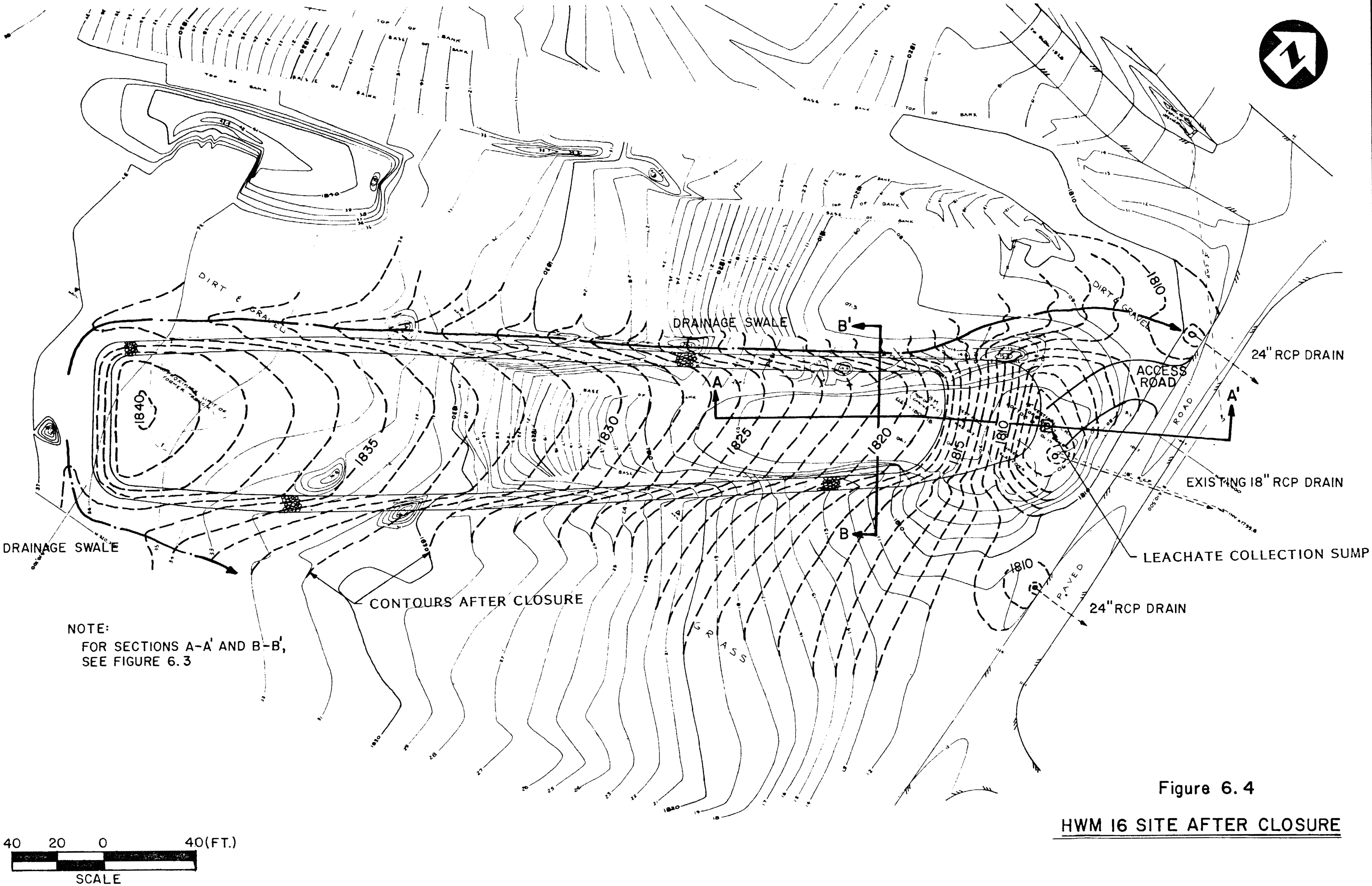
SECTION B-B'

NOTE:
FOR SECTION LOCATIONS, SEE FIGURE 6.4

Figure 6.3

CLOSURE OF HWM 16

CROSS-SECTIONS



NOTE:
FOR SECTIONS A-A' AND B-B', SEE FIGURE 6.3

Figure 6.4

HWM 16 SITE AFTER CLOSURE

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TABLE 6.2

ADVANTAGES AND DISADVANTAGES OF NEUTRALIZATION/SOLIDIFICATION AGENTS

MATERIAL	ADVANTAGES	DISADVANTAGES[1]
Cement	High physical strength Readily available	High Cost Low neutralization power
Lime (Quicklime)	High neutralization power Quick-setting	Low Physical Strength High cost Highly reactive
Lime (Hydrated)	High neutralization power Not as reactive as quicklime	Low physical strength Slow setting
Hydrated Lime and Flyash	Low overall cost ultimately high strength	Requires mixing
Cement Kiln Dust	Low cost Available locally	Low neutralization power Intermediate strength
Lime Kiln Dust	Low cost Quick-setting High neutralization power Available locally	Intermediate physical strength

[1] Dust problem is common to all these materials.

Source of Lime Kiln Dust

U.S. Gypsum at Kimballton, Virginia, which is the supplier of lime to Radford AAP, can supply about 25 tons of lime kiln dust per day delivered in a pneumatic truck. Once unloaded, storing and handling of this type of material would involve many problems (e.g., storage space, dust, and protection from rain and wind). Therefore, it is desirable to plan the soil treatment work in accordance with the material production and delivery schedule. To treat 1,600 cubic yards of sediment and soil (650 cubic yards for HWM 5 and 950 cubic yards for HWM 7) with about 15 percent by volume of lime kiln dust, about 240 cubic yard (or 260 tons) of lime kiln dust is needed. At a typical delivery rate of 22 to 24 tons per truck, the soil treatment work can be scheduled for a period of 12 days. Prior to soil treatment, the contractor should conduct a brief testing program to determine an adequate proportion of lime kiln dust.

Method of Construction

The impoundment bottom of HWM 5 should not be soft and any light equipment (e.g., loader, grader, small bulldozer, tiller, etc.) would be able to work on it to mix lime kiln dust into the soil. At HWM 7, however, the bottom sediments and soil are anticipated to be too soft to support any equipment. To overcome the soft foundation problems and to phase the work progress with the delivery of lime kiln dust, the following procedures are recommended:

- Due to deeper excavation (about 7 feet) and accessibility problem at HWM 7, a backhoe with at least 25 feet of reach would be required.

- Lower the bank level of two short sides to about two feet above the impoundment bottom. The backhoe can start excavation on these lowered banks (working benches).

- The backhoe excavates the sediment and soil to a depth of seven feet and mixes it with lime kiln dust delivered by a pneumatic truck. Considering the delivery rate of lime kiln dust and normal backhoe performance, approximately a 15 foot wide strip a day could be completed.

- Maneuvering on one of the benches, the backhoe would work on the first 15 foot strip of the impoundment bottom during the first day. Next day, the backhoe would move to the other bench and would work on the second 15 foot strip along that bench.

- In two days, the backhoe can continue working on the next strip maneuvering on a new bench (previously treated and hardened strip) and proceed toward the center strip. About two feet of fill would be placed to minimize the contact between the backhoe and the contaminated soil. New work benches could be reinforced with geofabric (placed under the two feet fill) if the treated soil could not support the backhoe.

- Each day's work would consist of two phases: excavation and mixing. During the excavation phase, the pneumatic truck stays on-site and applies the additive on the freshly excavated areas. When excavation is finished, the pneumatic truck leaves the site and the backhoe continues mixing the excavated soil and additive.

- At a rate of a 15 foot strip a day, the entire work for HWM 7 can be completed in eight days assuming there is no interruption. If necessary because of other equipment scheduling or a need for further hardening of the treated soil, the work at HWM 7 can be stopped and the pneumatic truck could be assigned to HWM 5.

6.4 SAMPLING AND ANALYSIS

The objective of the sampling and analysis program is to document the characteristics of wastes (in HWM 16) and subsoils (HWM Nos. 5, 7 and 16) for future reference. This documentation would be very useful should a need arise to trace the source of any future groundwater contamination and to develop a corrective action program. It would also serve as supporting data if groundwater quality stabilizes in several years after closure and the Radford AAP would like to negotiate with the State to cease groundwater monitoring at the surface impoundment sites. If the data collected reveal little or no subsoil contamination, then this information could be used in discussions with the State at closure to better define the necessity or type of post-closure care required.

The sampling program would have to be conducted prior to backfilling and cover system installation. Due to the access problem, sampling at the HWM 5 and HWM 7 sites could be done only after soil treatment, upon which the impoundment bottom would be able to support a drilling rig. Sampling at the HWM 16 site can be done prior to closure construction since no access problem is involved. The USAEHA is investigating the merits and possibility of sampling at HWM 16 prior to closure. Unless an early sampling program at HWM 16 is implemented by the USAEHA, sampling at all three sites will be conducted by the contractor selected for closure construction.

A summary of the sampling and analysis program is to be conducted is provided in Table 6.3. At the surface impoundment sites (HWM 5 and HWM 7), three borings will be drilled within each impoundment. Each boring will be advanced to the groundwater table and three soil samples, the first sample from the treated zone and next samples in the untreated zone, will be collected. Samples will be analyzed for pH and heavy metals. At the HWM 16 site, the borings will be advanced through wastes in the trench and about 10 feet into the subsoil. Continuous waste

TABLE 6.3
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM

	HWM 5	HWM 7	HWM 16[a]
Number of Borings	3	3	6 to 12
Depth of boring (ft)	10 To water table from the impound-ment bottom	12 To water table from the impound-ment bottom	24 10 ft into subsoil
Number of samples per boring and sample depths[b]	3 at 1, 5 and 10 ft	3 at 3, 8 and 12 ft	Continuous waste sampling in landfill and 3 soil samples at 3, 6 and 10 ft
Analysis Parameters	pH and heavy metals	pH and heavy metals	Composite waste: heavy metals, explosives, and purgeable organics; Soil: heavy metals and organics if present in the wastes.

(a) Sampling and analysis for HWM 16 may be conducted by Radford AAP and/or USAEHA prior to initiation of closure construction.

(b) Sample depths from the bottom of the containment system.

samples and three soil samples will be collected from each boring. The waste samples will be composited within each boring and analyzed for heavy metals, explosives and purgeable organics. The soil samples are to be analyzed for heavy metals. If purgeable organics are found in the waste samples, the soil samples will also be subject to purgeable organic analysis to identify possible migration of these compounds into the subsoil.

Specific sampling location, sampling procedure, health and safety requirements and quality control program will be included in the Sampling, Analysis and Quality Control Program to be provided as part of the construction documents.

6.5 COVER SYSTEM EVALUATION

Proposed Cover System

Cross-sections of the proposed cover system are presented in Figure 5.4 (applicable to HWM 5 and HWM 7) and Figure 6.3 (applicable to HWM 16). The basic components of the cover system and their functions are:

- o Grass-covered surface to prevent erosion of the cover soil and to promote evapotranspiration of moisture in soil. The slope of the surface should range from five to ten percent depending on the surrounding topography.

- o One foot of topsoil and one foot of cover soil to support the growth of grass and to protect the underlying PVC liner.

- o A primary liner consisting of 30-mil PVC membrane to prevent infiltration of surface water into the subsoil or wastes within the closed facilities. One foot of drainage sand above the PVC liner will be included for HWM 16 only.

- A compacted soil layer to serve as a bedding layer for the PVC liner and as a secondary liner in case of primary liner failure. The thickness of the compacted soil layer, to be placed on the compacted fill in HWM 5 and HWM 7 and on the compacted existing soil cover at HWM 16, would vary from one to two feet. The thickness of the bedding (and secondary liner) layer will be at least two feet.

Additional features associated with the cover system include:

- A crushed stone perimeter designed to do the following: to protect the slope against erosion; to promote drainage of the cover soil layer; to clearly mark the extent of the closed facility; and to deter accidental vehicle or equipment access.

- A filter fabric between the crushed stone and the cover soil. This is necessary to prevent piping (internal erosion) of the cover soil into the crushed stone zone.

- Drainage swales to divert surface flows around and away from the containment area.

- A leachate drain system (HWM 16 only) consisting of a drainage blanket layer (sand salvaged from HWM 5), a drain pipe and a leachate collection sump. The bottom of the HWM 16 trench will be scarified and recompacted, prior to disposal of the final volume of wastes and sand, to a compacted thickness of 18 inches. The leachate drain system and compacted bottom will minimize escape of hazardous waste constituents should any leachate be formed in the landfill.

- Placing of riprap on the high slope of HWM 16 for protection against erosion and added stability. The riprap available from

HWM 5 will be reused for this purpose. This riprapped area will also be underlain by filter fabric to prevent piping of cover soil.

Vegetation

The factors considered for selection of a vegetation species are:

- o Shallow rooted species to avoid damage of the liner material by plant roots;

- o Fall seeding species assuming that major construction activities will take place in summer months and seeding will follow in the fall.

- o Perennial species for adequate, year around erosion protection; and

- o Species suitable for use in areas of moderate temperatures.

An ideal candidate species for the above conditions is Kentucky blue grass. Since Kentucky blue grass favors alkaline soil as opposed to acidic site soils, pH adjustment will be needed by adding lime in the cover soil and topsoil. To supplement any potential weakness of a single species, it is often desirable to mix some other species (e.g., tall fescue and white clover). A hydroseeder would be the most cost-effective seeding method. Seed, fertilizer, mulch and lime can be sprayed from a hydroseeder. If the construction schedule does not allow the use of fall-seeding species, other species adequate for the given seeding season should be selected.

Design Standards

The general design criteria for the final cover system is contained in the Virginia Hazardous Waste Regulations (10.11.09(a)(2)iii and 10.14.11(a)) as presented in Section 5.4. It is specifically required that the permeability of the cover liner material should be less than or equal to the permeability of any bottom liner system or natural subsoils present. Since there are only natural subsoils (treated with lime kiln dust at the HWM 5 and HWM 7 sites and recompacted to form a soil liner at the HWM 16 site) at these facilities, the minimum requirement for cover liner material with respect to the permeability would be a soil liner compacted out of selected on-site soil. When a synthetic membrane liner is used, the minimum thickness requirement is 20-mil. In the proposed cover system, however, a 30-mil synthetic liner (PVC) on a compacted soil layer is recommended for maximum performance at a reasonable cost.

A sand drainage layer, with a permeability of no less than 10^{-3} cm/sec, is often recommended above the low permeability barrier (Department of Army, 1984). The drainage layer is especially important in the following situations:

- The barrier (low permeability) layer consists of a soil liner and the facility is located in a non-arid region. In this case, portions of precipitation would reach the barrier layer and eventually infiltrate through the barrier into the wastes and subsoil. Provision of a drainage layer would promote internal drainage above the barrier and minimize infiltration of water into the barrier.

- The barrier layer consists of a synthetic membrane liner and there is a potential of a high hydrostatic pressure buildup. The high hydrostatic pressure due to accumulated leachate or water (e.g., bottom of a landfill and cover system with an extra thick cover soil) could damage the liner. The drainage layer would keep the hydrostatic pressure at a minimum to protect the liner.

For cover application at the Radford sites, none of the above conditions applies and therefore, the drainage layer is not recommended. The additional factors considered in recommending the proposed cover system without a drainage layer are:

- o The use of a 30-mil liner which is thicker than the minimum requirement of 20-mil;
- o The relatively steep and short surface slopes which would not allow any substantial infiltration even under an extended wet period; and
- o The fact that the average annual precipitation is moderate (about 40 inches).

However, because of the hazardous waste remaining in place, a drainage sand layer is included for HWM 16 only for additional protection against possible infiltration. With minor variations to incorporate site-specific conditions such as topography, drainage, and size of the facilities, the proposed cover system meets or exceeds all design/performance standards required by the State and the Department of the Army TM 5-814-7.

Performance Evaluation

To more completely determine the adequacy of the proposed cover system, an additional evaluation was made to ensure the performance of the proposed cover system under the various conditions.

Frost Action

If the impermeable liner material is within the depth of frost penetration, the freezing soil could apply a high stress on the liner and cause an excessive deformation of the liner, which eventually might lead to the failure of the liner system. The depth of frost penetration in the Radford area is about 15 inches (Lutton, 1980). Since the thickness of the cover soil (including topsoil) is 24 inches, frost penetration should not reach the soil layer supporting the membrane liner.

Erosion Potential

The erosion potential can be evaluated by the Universal Soil Loss Equation (USLE) which is a convenient and widely accepted method. The USLE gives average annual soil loss as the product of six erosion-related factors. The equation is:

$$A = R\ K\ L\ S\ C\ P$$

where A = average annual soil loss, in tons/acre
R = rainfall and runoff erosivity index
K = soil erodibility factor, tons/acre
L = slope-length factor
S = slope-steepness factor
C = cover/management factor
P = practice factor

The values of these parameters are estimated following the general guildelines in Lutton, et al (1979) and Lutton (1980) and given as follows:

R = 170

K = 0.33 (for silt loam, organic content >4%)

LS= 0.75 (for HWM 16, S=10% and L=30 ft)

LS= 0.75 (for HWM 5, S=8% and L=57 ft)

C = 0.01 (for meadow with grass/legume cover)

P = 1.0

Thus,

$$A = 170 \times 0.33 \times 0.75 \times 0.01 \times 1.0 = 0.42 \text{ tons/acre}$$

This annual erosion estimate is well below the acceptable limit of 2 tons/acre. Even for twice the slopes given above, the annual errosion rate would only be about 1.2 tons/acre.

Drainage Control

At the HWM 5 and HWM 7 sites, external drainage is well controlled by existing features (e.g., roads, ditches, culverts and pipes) and no run-on is anticipated. Runoff from the closed facilities will be routed to periphery drainage swales. Since the drainage areas for these drainage swales are very small (no more than one-half acre), these swales should be able to handle flows without any potential threat to the cover system.

At the HWM 16 site, the natural topography of the area does not allow any drainage path in the vicinity of HWM 16. Runoff from the cover area and immediate vicinity will be routed by drainage swales around the closed facility to the toe area of the high slope and then drained via an existing 18-inch pipe and two new 24-inch pipes.

Secondary Liner

It is recommended by the Army (TM 5-814-7) that a secondary soil liner with a permeability not exceeding 10^{-7} am/sec be provided underneath the primary synthetic liner. Portions of site soils from the borrow areas met this permeability requirement when tested after recompaction in the laboratory. However, it is not likely that this permeability requirement could be met in the field because of: less control in selecting source material; less control in compaction and moisture content; and difficulty with compaction on the waste material for HWM 16. This potential deficiency will be partially compensated by using a thicker (30-mil) PVC liner than the minimum requirement of 20 mil.

6.6 INTERIM ACTIONS

Operation of HWM 16

The total capacity of the HWM 16 trench is estimated at 6,000 cubic yards. About 4,200 cubic yards (70 percent) of this capacity has been filled as of December 1984, leaving a storage capacity of 1,800 cubic yards available. The rate of waste being disposed in HWM 16 is approximately 1,000 cubic yards per year. Assuming the closure of HWM 16 is in June 1986, an additional volume of 1,500 cubic yards is expected to be filled in HWM 16. At closure, about 400 cubic yards of contaminated material from HWM 5 (bottom liner and sand) will be disposed in HWM 16. Thus, the total remaining capacity may not be sufficient to accommodate the wastes that must be disposed in HWM 16 before it is closed.

According to Radford AAP personnel, the future Hazardous Waste Management Program after closure of HWM 16 entails a minimal amount of hazardous waste generation. Under this program, most of the wastes presently disposed in HWM 16 would be incinerated (rendered non-reactive) or reclassified (nonhazardous) for disposal in the sanitary landfill. The remaining amounts will be containerized (55-gallon drums) and disposed in an approved off-site disposal facility. It is recommended that this program be implemented as soon as possible to limit the amount of wastes disposed in HWM 16 prior to closure.

Another way to reduce the volume of wastes in HWM 16 would be the temporary storage of waste either in containers or in waste piles. A significant amount of material in HWM 16 is believed to be interim soil cover. Disposal of wastes in HWM 16 in small volumes would require more interim cover soil than disposal of wastes in larger volumes. Thus, disposal of wastes in larger volumes would reduce the volume of cover soil in HWM 16 and thereby reduce the total volume of material in HWM 16. Temporary storage of wastes for less than 90 days does not require any special permit under the current Virginia Hazardous Waste Regulations. Plastic sheeting may also be used as an interim cover to reduce the volume of the total material.

Operation of HWM 7

Subsurface water with low pH can mobilize heavy metals in the subsoil and may cause groundwater contamination. At the Radford AAP surface impoundment sites, this general relationship is shown in the November 1984 water quality data (See Tables 4.2 and 4.4). At the HWM 5 site, two wells (Nos. 7B and 8) show low pH and elevated arsenic, chromium, and mercury concentrations. At the HWM 7 site, Well No. 11B has low pH and elevated cadmium and chromium concentrations. Although HWM 7 is a neutralization basin, some acidic water may infiltrate into the subsoil during the accumulation period before adding lime and could be detected from an immediate downgradient well. This can be prevented, to a limited degree, by adding lime more frequently or beforehand and not allowing acidic water to accumulate over an extended period.

SECTION 7

POST-CLOSURE CARE AND GROUNDWATER MONITORING

SECTION 7

POST CLOSURE CARE AND GROUNDWATER MONITORING

7.1 HAZARDOUS WASTE SURFACE IMPOUNDMENTS

In accordance with the Virginia Hazardous Waste Regulations, this section presents the post-closure plan for HWM 5 and 7 based on the closure of both sites as hazardous units. Unless otherwise determined by the State Health Commissioner, post-closure care is to extend over a 30-year period (10.07.08(a)(2)). The major components of post-closure care as proposed in this plan are groundwater monitoring, inspection and maintenance. Possible contingency activities are also described in this section.

Groundwater Monitoring

Based on information presented in previous discussions, it does not appear that hazardous constituents present in the subsoils at the impoundment sites will be released to either surface water or air in quantities sufficient to warrant monitoring. Therefore, only groundwater monitoring is considered necessary during the post-closure care period for HWM 5 and HWM 7. Results of the Groundwater Quality Assessment Program conducted at the sites indicate that groundwater contamination has occurred. In response to these monitoring results a Compliance Monitoring program will be instituted under 10.06.02 prior to closure and will continue during the post-closure period as required by 10.06.01(c)(3).

This Compliance Monitoring program will be implemented using a minimum of four wells (one upgradient and three downgradient), constructed in accordance with 10.06.08(a) through (c). The wells to be used will be selected after final review of the Groundwater Quality Assessment Program.

Samples will be collected in accordance with 10.06.08(d) and (e), on a quarterly basis. Background groundwater quality will be determined for each constituent as specified in 10.06.08(g)(1). The water quality parameters that will be analyzed as part of this program include:

- Specific conductance
- Total organic carbon (TOC)
- Total organic halogen (TOX)
- pH
- Any additional parameters as agreed upon by the Commissioner

For quality control purposes, samples will be split into four portions for analysis. Groundwater elevations will be measured for each sampling event and the direction and rate of groundwater flow will be determined on an annual basis (10.06.08(f) and 10.06.10(e)). Additionally, all monitoring wells will be analyzed for Virginia Regulations' Appendix 3.6 hazardous constituents on an annual basis.

It is anticipated that because of the nature of the wastes in the surface impoundments and the closure activities to be conducted as described in Section 6.0, the Radford AAP may elect after several years of groundwater monitoring to discuss with the State the requirement for monitoring over a 30-year priod. It is probable that the groundwater quality at these sites will improve to ambient levels after several years. If monitoring confirms this then groundwater monitoring could be terminated or reduced in scope.

Inspection

In accordance with 10.07.09(a)(1), regular post-closure inspections of the sites will be made to ensure the integrity of the cover system and all associated structures. Inspections will be conducted by qualified personnel on a routine basis, with additional inspections following inclement weather or catastrophic events (e.g., fire or explosion elsewhere at the Radford AAP). To ensure that all items of interest are addressed during the inspection, an inspection log will be used during each inspection. This inspection log will list the potential problems/conditions that the inspector should note while conducting the inspection. The inspector will be asked to identify the existence or absence of each problem and, if present, to address its degree of severity (e.g., low, moderate or high). Table 7.1, discussed in the following paragraphs, provides a listing of all items to be inspected.

Because failure of the soil cover or the underlying PVC liner could result in increased infiltration and leachate generation, it is necessary to inspect the cover for surface erosion, subsidence, or ponding; plant root penetration, or exposure of the liner. The grass cover should be inspected for general health and the presence of undesirable competitive species, particularly deep-rooted plants or shrubs. Vegetation should be kept trimmed to prevent encroachment on access controls, roads and signs. Stormwater drainage controls (i.e., slopes and swales) should be inspected for erosion, subsidence, and in the case of swales, accumulated sediment that might block the flow of stormwater. Locks and caps on groundwater monitoring wells should be inspected for damage.

The need for additional security is expected to be minimal due to the overall secure nature of the Radford plant. Therefore, the installation of warning signs will be the only additional security measure taken during the post-closure care period, as only authorized personnel are allowed to enter the restricted portion of the Radford AAP.

Maintenance

The nature and degree of post-closure maintenance of the site will be primarily determined by observations made during the routine inspections. However, since the Radford AAP will remain in operation, plant personnel will have the opportunity to informally observe the need for maintenance on a more frequent basis. A description of the expected maintenance activities that will be performed in accordance with 10.07.09(a)(2) is discussed below.

TABLE 7.1

INSPECTION CHECKLIST FOR CLOSED ON-SITE FACILITIES

Item	Problem	Problem Exists? (Yes or No)	Degree of Problem? (e.g., Low)
Soil Cover	erosion		
	subsidence		
	ponding		
PVC Liner	exposed		
Grass Cover	inadequate growth/health		
	deep-rooted vegetation		
	presence of undesirable species		
	inadequate trimming		
Stormwater Drainage			
slopes	erosion		
	subsidence		
drainage swale	erosion		
	subsidence		
	vegetation growth		
	accumulated sediment		
Monitoring Wells			
locks	damage		
caps	damage		
Security			
warning signs	missing		
	defaced		
	obscured		
access road	disrepair		

The cover, drainage slopes, and vegetation will be maintained as needed. Damage due to erosion and subsidence will be corrected by adding soil and regrading the site. It is expected that no significant subsidence will occur following closure, and thus only erosion would be the major long term concern. Maintenance of vegetation necessary to control erosion will include removing deep-rooted plants and adding fertilizer to enhance growth as necessary. Overgrowth into drainage swales and access roads will be controlled. Swales will be cleared of any accumulated material.

Security will be maintained by immediately repairing or replacing any damaged signs or access roads. Damaged monitoring wells will be repaired if possible. If it is determined that the integrity of the well has been destroyed, then the well will be replaced. Surveyed benchmarks used to indicate the location of the site (10.07.10) will be protected and maintained as necessary. The general perimeter of the surface impoundment will be easily recognizable due to the presence of riprap for slope protection.

Contingency Activities

In the event of major damage, contingency measures will be promptly taken. Extensive erosion will be repaired by the most appropriate of the following measures: replacement of cover or fill soil; restoration of original grade design or replacement with new grade design; and/or installation of riprap. Any other cover deterioration due to deep-rooted plants, cracking, cold weather, or slope instability will be promptly corrected by filling, regrading and reseeding, as appropriate. Damage to vegetation will be controlled by the addition of nutrients, manual watering (in the event of drought), and/or pest control as appropriate.

Although the groundwater contamination has been confirmed at all of the HWM sites, no significant adverse impacts are anticipated because of: no downgradient water supply wells; removal of the major contamination sources at HWM 5 and HWM 7; and dilution by the New River.

Therefore, Radford AAP is planning to present Alternate Concentration Limits (ACL) to the State for approval as tentative groundwater protection standards. If the detection monitoring program indicates groundwater deterioration beyond the ACLs, remedial steps will be taken to control the migration of contaminants. Potential control measures include groundwater pumping and the construction of barriers (e.g., slurry wall). A complete and thorough evaluation of available control measures will be made prior to initiating any remedial steps.

7.2 HAZARDOUS WASTE LANDFILL TRENCH

Since post-closure care is also required for HWM 16, groundwater monitoring and inspection programs similar to those outlined in Section 7.1 will be implemented. An additional inspection item for HWM 16 would be the leachate collection sump (Figure 6.3). If any leachate is found to have accumulated in the sump, it will be removed for treatment at the wastewater treatment plant and more frequent inspections will be conducted. If it is deemed necessary, a routine leachate removal program will be implemented. As in the case of the surface impoundments, air and surface water monitoring will not be performed, as it is not expected that any gases will be generated within the landfill and there will be no release to surface water from the site. Post-closure care will continue for 30 years, unless otherwise determined by the Commissioner.

7.3 FUTURE USE RESTRICTIONS

In accordance with 10.07.08(c), there will be no use of the disposal areas which would allow any disturbance of the integrity of the final cover, liner(s) or any other components of any containment system, or of the function of the associated monitoring systems. Land use activities that will be prohibited at each facility include:

- On-site construction
- Excavation (except as necessary for major maintenance activities)
- Well construction on or near the site

- Agricultural use
- Silvicultural use
- Water infiltration (run-on, ponding, irrigation)
- Recreational use
- Disposal operations
- Vehicular traffic (except as necessary for major maintenance activities)
- Housing on or near the site.

7.4 NOTICE TO LOCAL LAND AUTHORITY

As required by 10.07.10, the Radford AAP will submit to the local land authority survey plans prepared and certified by a professional land surveyor which show the disposal areas with respect to permanently surveyed benchmarks. These plans shall contain a note stating that there will be no disturbance of the disposal areas by Radford AAP.

7.5 NOTICE IN DEED TO PROPERTY

As required by 10.07.11, a notation will be made on the deed to the facility property that will notify, in perpetuity, any potential purchaser of the property that: (1) the land has been used to manage hazardous waste; (2) its use is restricted to that of open space; and (3) the survey plan and record of the type, location, and quantity of hazardous wastes disposed on site has been filed with the Commissioner and local land authority.

SECTION 8

CLOSURE COST AND SCHEDULE

SECTION 8

CLOSURE COST AND SCHEDULE

Presented in this section are cost and schedule estimates for closure of the Radford AAP hazardous waste management facilities, HWM Nos. 5, 7 and 16. These estimates are based on the closure method discussed in Section 6.

8.1 CLOSURE COST ESTIMATE

Table 8.1 presents a summary of closure cost estimate. This cost estimate is based on the closure method as provided in Section 6, costs as of May 1985, and cost data compiled from various sources. The sources of these cost data include: quotes from material suppliers and contractors; various published cost data (Department of Army, 1984; Lutton, et al, 1979; Lutton, 1980; Ehrenfeld and Bass, 1983; and Matrecon, 1983); and ES' past experience in the similar projects. The total closure cost, including health and safety considerations (10 percent) and contingency (20 percent), is estimated at approximately $320,000. This does not include the cost for site preparation to be conducted by Hercules, Inc. Almost 50 percent of the construction cost is required for cover system installation.

Table 8.2 summarizes the post-closure cost estimates in 1985 dollars. The post-closure cost is estimated on an annual basis because the period of post-closure groundwater monitoring is not certain at this time. Normally, groundwater monitoring is required for the 30-year post-closure period. At the Radford hazardous waste management facilities, however, a Compliance Groundwater Monitoring Program is to be implemented because of known groundwater contamination. It is likely

TABLE 8.1

SUMMARY OF CLOSURE COST ESTIMATE

Site Preparation			0
	To be performed by Hercules, Inc. as part of final phase operations		
Mobilization	Lump Sum		$15,000
Demolition and Soil Treatment			$26,380
Remove appurtenant structures - HWM 5 and 7			
Equipment, labor and material	Lump Sum		$ 4,000
Handle riprap in HWM (disposal of sand/liner not included)			1,000
Soil Treatment			
Material - lime kiln dust 260 ton x $15/ton delivered to the site		=	$ 3,900
Pneumatic truck - site time 12 day x 4 hrs x $60		=	2,880
Backhoe at HWM 7	8 day x $500/day	=	4,000
Loader at HWM 5	4 day x $500/day	=	2,000
Other miscellaneous equipment		=	800
Labor	2 men x 8 hr x 12 days x $25/hr	=	4,800
Supervision with PU truck 60 hrs x $50		=	3,000
Sampling and Analysis			$33,900
Assume HWM 16 is included			
Drill rig	6 days x $1,800	=	$10,800
Geologist and expense	6 days x $ 600	=	3,600
Soil analysis	50 x $ 250	=	12,500
Waste (HWM 16 only) analysis	10 x $ 600	=	6,000
Misc. (container, shipping, etc.)			1,000
Waste Disposal and Backfill			$44,000
Backfill - HWM 5	5,500 cy x $3.00	=	$16,500
HWM 7	5,000 cy x $3.00	=	15,000
Compaction - HWM 16 bottom and cover	Lump Sum	=	3,000
Leachate drain - HWM 16	Lump Sum	=	2,000
Disposal of sand and liner from HWM 5 in HWM 16	350 cy x $20.00	=	7,000
Disposal of other final wastes in HWM 16	100 cy x $ 5.00	=	500

TABLE 8.1 (Continued)

Cover System Installation			$127,700
Bedding soil layer (HWM 16 only)	700 cy x $ 3.00	=	2,100
30-mil PVC liner, installed	90,000 sf x $ 0.50	=	45,000
Drainage sand for HWM 16	800 cy x $20.00	=	16,000
Cover soil	3,300 cy x $ 2.00	=	6,600
Topsoil (mixed with lime)	3,300 cy x $12.00	=	39,600
Seeding/mulching, 4 acres	4 acres x $1,000	=	4,000
High slope riprap - HWM 16 material from HWM 5, placement only	120 cy x $ 5.00	=	600
Perimeter crushed stone, installed	400 cy x $20.00	=	8,000
Perimeter filter fabric, installed	10,000 sf x $ 0.25	=	2,500
Final grading, swales and cleanup	Lump Sum	=	3,000
Warning signs	3 x $100	=	300

Summary

Site preparation		0
Mobilization		$ 15,000
Demolition/Soil Treatment		26,380
Sampling/Analysis		33,900
Waste Disposal/Backfill		44,000
Cover System		127,700
		$246,980
Health/safety considerations (10%)		24,698
Contingency (20%)		49,396
	Total	$321,074

Note: All costs in May 1985 dollars.

TABLE 8.2

SUMMARY OF ANNUAL POST-CLOSURE COST ESTIMATE

Groundwater Monitoring			$25,200
Sampling, Labor	2 x $2,000	=	4,000
Analysis	2 x 12 wells x $800	=	19,200
Data handling/reporting			2,000
Inspection/Maintenance			$ 2,800
Inspection and reporting	2 x $ 500	=	$ 1,000
Grass mowing	2 x 300	=	600
Patching, fertilizer, etc.			1,200
		TOTAL	$28,000/year

NOTES:

- Groundwater sampling and inspection/maintenance to be performed by Radford AAP personnel.
- Groundwater analysis to be performed by an independent or USAEHA laboratory.
- It is assumed that the groundwater monitoring equipment (dedicated well samplers, air compressor, controller, water level indicator, etc.) will be purchased and installed as part of Compliance Monitoring Program.
- During the time period that Compliance Monitoring will be required at the sites, the data from Compliance Monitoring can satisfy the needs for Post-Closure groundwater monitoring. Therefore, the groundwater monitoring costs shown will not be expended during this time period.

that the Compliance Monitoring will be conducted for several years after closure of the facilities. During the Compliance Monitoring period, no additional post-closure groundwater monitoring should be required. Also, Radford AAP may consider the merits of negotiating with the State for cessation of post-closure groundwater monitoring at HWM 5 and HWM 7 once the groundwater quality stabilizes. Since no significant levels of contaminants would be present upon closure of these surface impoundments, soil analysis data (to be available after closure) and improving groundwater quality may demonstrate that no further monitoring is necessary.

The annual post-closure cost is estimated at about $28,000 with about 90 percent of this attributed to groundwater monitoring. When post-closure groundwater monitoring is not required, the annual cost of inspection and maintenance is estimated to be about $3,000.

8.2 CLOSURE SCHEDULE

The closure schedule as currently envisioned, including the engineering and design tasks, is presented in Figure 8.1. The construction documents will be completed by early December 1985 under this plan. A contractor for the construction of the replacement tanks can be selected in two months and the replacement tanks will be ready in five months once the project funding is provided.

Following the completion of the replacement tanks, Radford AAP can complete site preparation in one month. By this time the closure construction documents should have been reviewed by the State, a contractor for closure construction selected, and closure construction equipment mobilized. Thus, the closure construction could be started in six months after the project funding. The total closure construction, including vegetation of the final cover system, would take about four months. The sampling and analysis program may be performed in parallel with other construction activities with little interference with other major activities. This is because the sampling should be performed

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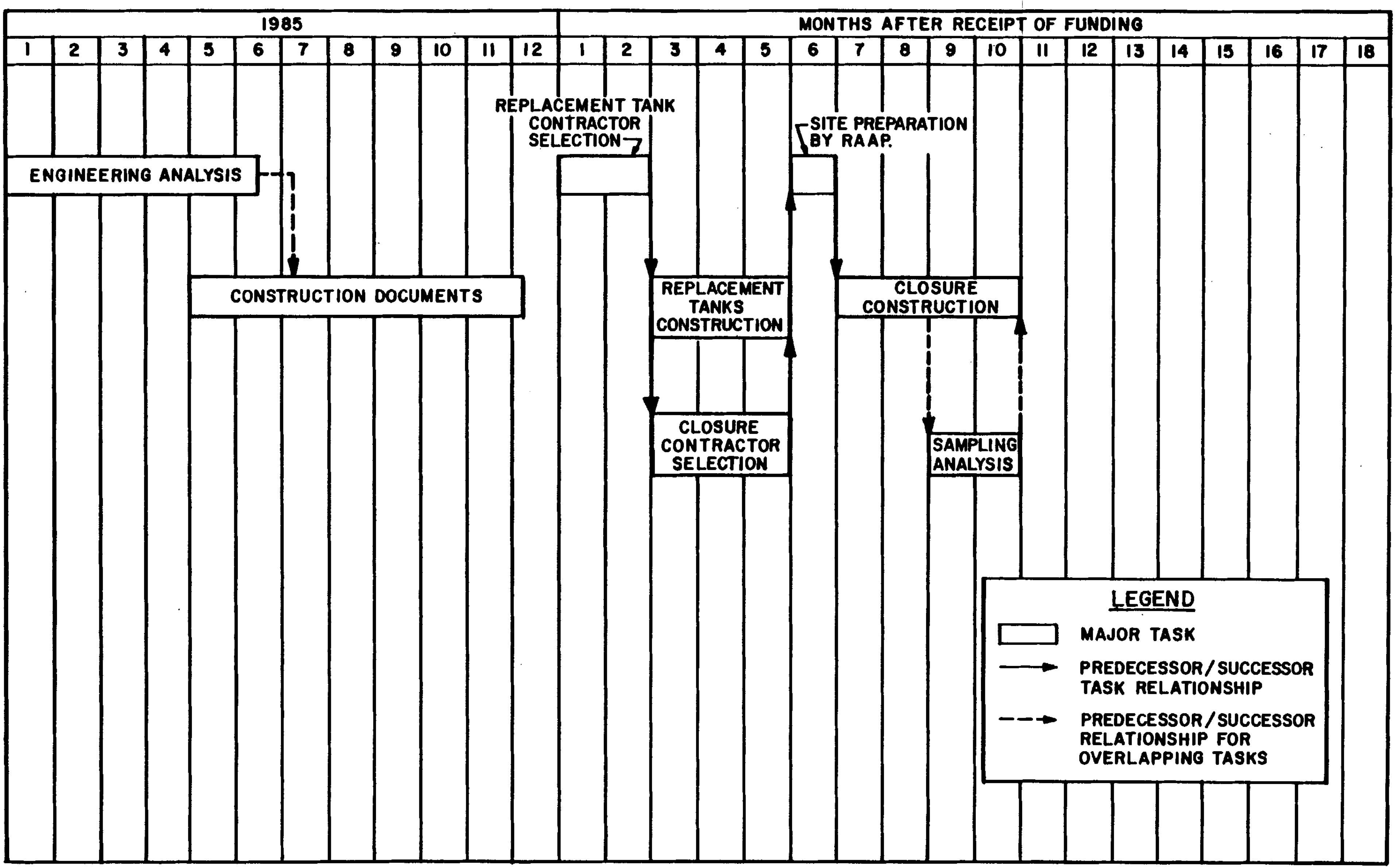
Figure 8.1
CLOSURE SCHEDULE



after the soil treatment and prior to backfilling of the impoundments while the treated soil is being cured. The final activity or seeding of grass will take place in nine months and the overall closure construction can be completed within 10 months after the project funding is provided.

SECTION 9

SUMMARY AND RECOMMENDATIONS

SECTION 9

SUMMARY AND RECOMMENDATIONS

9.1 SUMMARY

Groundwater Assessment

The results of the Phase I Groundwater Quality Assessment Program (under the Section 9 Standards) conducted for the Radford AAP hazardous waste management facilities indicate that groundwaters in the vicinity of HWM Nos. 5, 7 and 16 have been degraded. A Compliance Monitoring Program (under Section 10.6 of the Virginia Regulations) is to be implemented for HWM 5 and HWM 7 to closely monitor the nature and impact of groundwater contamination. An additional groundwater investigation in the vicinity of the TNT neutralization sludge disposal site is also planned. A corrective action program, under the Section 10 Standards, may be required by the State to clean up contaminated groundwater in the future, but the nature and extent of the contamination combined with the fact that there are no downgradient users of the groundwater suggest that this is unlikely. These groundwater protection programs would be conducted independently of closure plans for the Radford AAP hazardous waste management facilities. With known groundwater contamination, it is unlikely that removal of liquid, waste sediment and appurtenant structures from HWM 5 and HWM 7 could warrant the closure of these facilities as nonhazardous.

Closure Method for Surface Impoundments

The waste liquids from HWM 5 and HWM 7 will be neutralized and drained. The surficial wastes in HWM 5 will be removed, dried and disposed in HWM 16. The sediment in HWM 5 will be removed and flashed to destroy possible NC fines prior to disposal. The major issue in closing these sites is focused on the contaminated soil underneath the surface impoundments. Three alternatives are available for the contaminated soil: offsite disposal; treatment; and in-place closure.

Offsite disposal involves an excessively high cost at no substantial benefit in terms of overall environmental protection. Once the source of contamination (acidic wastewater in the impoundments) is removed at closure, the potential of future environmental degradation due to the in-place contaminated soil should be insignificant. Furthermore, major excavation and transportation activities involved in the offsite disposal alternative present negative impacts such as disturbance, spill and potential accidents.

The treatment alternative has merit as part of a disposal option (including in-place closure) because it can reduce the negative impacts on the environment. Because the surface impoundments are unlined (HWM 5 was unlined before 1980) and because of uncertainties involved in the treatment of contaminated soil, it is likely that a final cover system and post-closure groundwater monitoring would be required after treatment. Thus, the treatment alternative would likely include all major activities required for the in-place closure.

The in-place closure alternative involves removal of all surficial wastes and contaminated material in HWM 5 because of the presence of nitrocellulose fines, treatment of sediments and subsoil to the extent necessary to support a cover system, backfilling the impoundment, installation of a final cover system and post-closure care. The impact of the in-place contaminated subsoil on the groundwater quality should be minimal since the major contamination source is removed; the remaining contaminants in the subsoil are limited in quantity; no downgradient water supply wells exist; and the dilution factor provided by the groundwater flowing into the New River is very high. In addition, the nature of the groundwater contamination (i.e., low pH and elevated metals sometimes exceeding the drinking water standards) is not serious at this time and will be improved after closure by adsorption of metals on the subsoil and dilution in the groundwater. The closure construction should be relatively simple and the overall cost, even with post-closure cost considered, is moderate. Thus, it is concluded that the in-place closure method is the most cost-effective and environmentally acceptable solution to the closure of the surface impoundments.

Closure Method for Hazardous Waste Landfill

Although the groundwater in the vicinity of the HWM 16 site is contaminated, there is little evidence that HWM 16 is the source of this contamination. Instead, the TNT neutralization sludge disposal trench appears to be a source for some of the contamination based on the nature of wastes and its location, about 300 feet upgradient from HWM 16. An additional investigation is planned by Radford AAP to confirm this possibility. If it is known that the hazardous waste constituents in a hazardous waste landfill are escaping or likely to escape from the closed facility, redisposal (offsite or on-site) of the waste could be considered as one of the alternatives. Otherwise, in-place closure is normally required by the regulations and is the most cost-effective method. Such is the case at HWM 16 where in-place closure is recommended. The in-place closure of HWM 16 involves installation of a final cover system and providing post-closure care for 30 years.

Cover System

If a hazardous waste facility is closed with some wastes or contaminated material in place (in-place closure), as proposed for the Radford AAP hazardous waste management facilities, a final cover system is required to minimize infiltration of surface water. The proposed cover system consists of one foot of topsoil, one foot of cover soil, a 30-mil PVC membrane liner and a compacted soil bedding layer with a minimum thickness of two feet. Grass cover will be provided to minimize erosion. A multi-purpose crushed stone perimeter will be installed for each of these closed facilities to enhance the performance of the cover system.

Cost and Schedule

The total cost for closure of the Radford AAP hazardous waste facilities (HWM Nos. 5, 7, and 16) is estimated at about $320,000. Nearly one-half of the closure construction cost is associated with final cover installation. The annual post-closure cost is estimated at about $28,000. Approximately 90 percent of the annual post-closure cost is needed for groundwater monitoring. For the first several years of the post-closure period, the Compliance Monitoring Program should suffice for the post-closure groundwater monitoring. Since there are no reasons for persistent groundwater degrdation at HWM 5 and HWM 7 after closure, it is possible that Radford AAP may cease groundwater monitoring through negotiation with the State once the groundwater quality stabilizes. Thus, the total post-closure cost could be significantly less than what is required for the normal 30-year post-closure period.

The current project contract calls for completion of the closure design documents and specifications by early December 1985. The selection of a contractor, and building the replacement tanks for HWM 5 and HWM 7 should require approximately five months. The closure construction will follow the completion of the construction of the replacement tanks and would take another five months. It is estimated that all closure construction can be finished within 10 months after the project funding is provided.

9.2 RECOMMENDATIONS

It is recommended that HWM sites 5, 7, and 16 be closed by an in-place closure method and that post-closure care be provided. To facilitate the closure and post-closure plans as presented in this report, it is recommended that the operation of HWM 7 and HWM 16 be modified slightly between now and closure. At the HWM 7 site, it appears that surges of acidic wastewater between scheduled neutralization may cause some acidic waste to migrate into the immediate surroundings and result in low pH and elevated metal concentrations in groundwater. More frequent neutralization (or adding lime beforehand) is recommended to alleviate the contamination of groundwater, which could lead to a shorter post-closure groundwater monitoring program.

Each time a batch of waste is disposed in HWM 16, an interim soil cover is required to isolate the wastes from the environment. Cover soil, rather than wastes, could consititute a significant portion of the total filled volume in HWM 16. The current closure plan calls for disposal of some closure-related wastes (e.g., cover sand and removed liner from HWM 5) in HWM 16. To assure that all regular and closure-related wastes can be disposed in the limited remaining space of HWM 16, the volume of the cover soil in HWM 16 should be minimized. This can be achieved by disposal of wastes in larger batches (after a certain period of temporary storage) or using a temporary cover (e.g., plastic sheets) at HWM 16.

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APPENDIX A

HEALTH AND SAFETY PLAN

TABLE OF CONTENTS

SECTION 1

PURPOSE

The purpose of this plan is to provide an overview of the critical safety issues associated with the selected in-place closure method as presented in the Engineering Analysis Report. Also provided are general guidelines for establishing personnel protection standards and mandatory safety practices and procedures for the in-place closure method. The specific safety practices and procedures to be used during the closure of Hazardous Waste Management (HWM) facilities Nos. 5, 7 and 16 at the Radford Army Ammunition Plant (Radford AAP) will be provided in detail as part of the Construction Document for closure. Safety practices and procedures required to implement the sampling phase of the closure Program will be addressed in the Sampling Analysis and Quality Control Program Document.

SECTION 2

APPLICABILITY

The provisions of this Safety Plan are mandatory for all on-site investigations and closure actions performed on-site at the Radford Army Ammunition Plant (Radford AAP). All contractors retained to implement the closure plan for the Radford HWM facilities must abide by all safety practices and procedures outlined for their specific project tasks. All personnel who engage in the Hazardous Waste Management Closure Program at the Radford AAP shall be familiar with this plan and comply with its requirements.

SECTION 3

SITE LOCATION

The Radford AAP is located in Pulaski and Montgomery Counties in southwestern Virginia, approximately eight (8) miles northwest of the City of Radford. The plant is a government-owned, contractor-operated (GOCO) ammunition ingredient manufacturing facility.

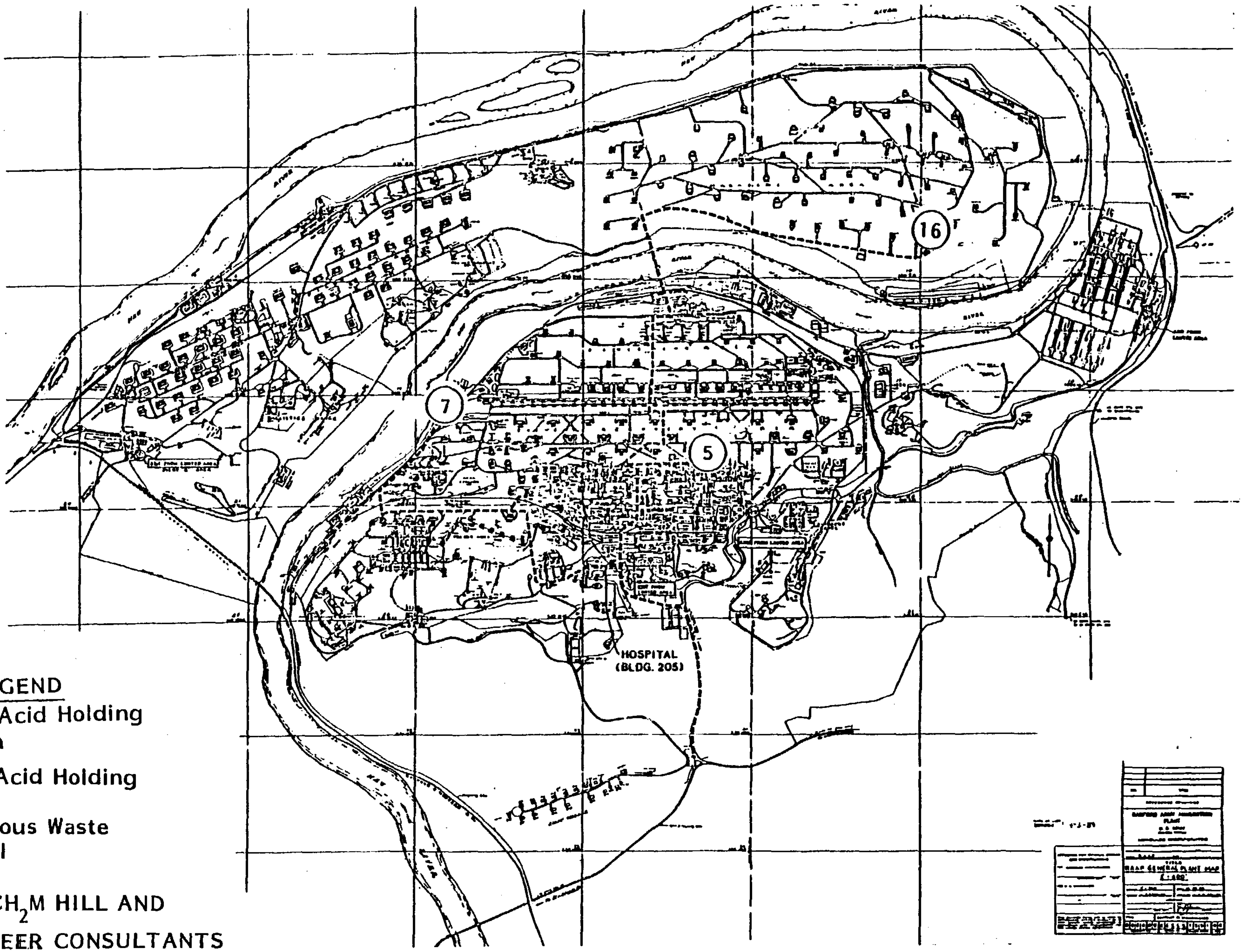
Presented in Figure 3-1 is the facility site plan for the Radford AAP. The location of the Hazardous Waste Management (HWM) facilities (Nos. 5, 7 and 16) that are to be removed from service at the Radford AAP are shown on this plant map. All of these HWM facilities are within the plant's perimeter. It should be noted that the New River bisects the Radford AAP property and HWM 16 is located on the northern portion of the plant property.

The Radford AAP is secured by artificial barriers to prevent unknown or unauthorized entry. The plant perimeter is surrounded by a six-foot chain link fence with a three-strand barbed wire top guard. The access gates and perimeter fencing at the Radford AAP are posted with "No Trespassing" signs. These signs are posted in sufficient number so as to be seen from any approach to the restricted portion of the plant.

The Radford AAP has in effect a security program whereby all visiting personnel must request clearance prior to being admitted on-site. All subcontractors are also required to sign in when entering the restricted portion of the Radford AAP. All subcontractors retained to conduct the closure of the HWM facilities are to adhere to the security procedures that are in use at the Radford AAP.

Figure 3.1

Location Map of Hazardous Waste Management Facilities



LEGEND

5 Waste Acid Holding Lagoon

7 Waste Acid Holding Lagoon

16 Hazardous Waste Landfill

SOURCE: CH_2M HILL AND PEER CONSULTANTS

ES ENGINEERING-SCIENCE

SECTION 4

BACKGROUND

Presented in this section is a general site description for each of the HWM facilities (Nos. 5, 7 and 16) that are to be closed at the Radford AAP. A discussion of the physical, and chemical substances identified at each of these sites are also provided. A process flow diagram of the HWM facilities at the Radford AAP is presented in Figure 4.1. This figure shows the flow relationship between facilities Nos. 5 and 7 and other Radford HWM facilities.

HAZARDOUS WASTE MANAGEMENT SITE NO. 5

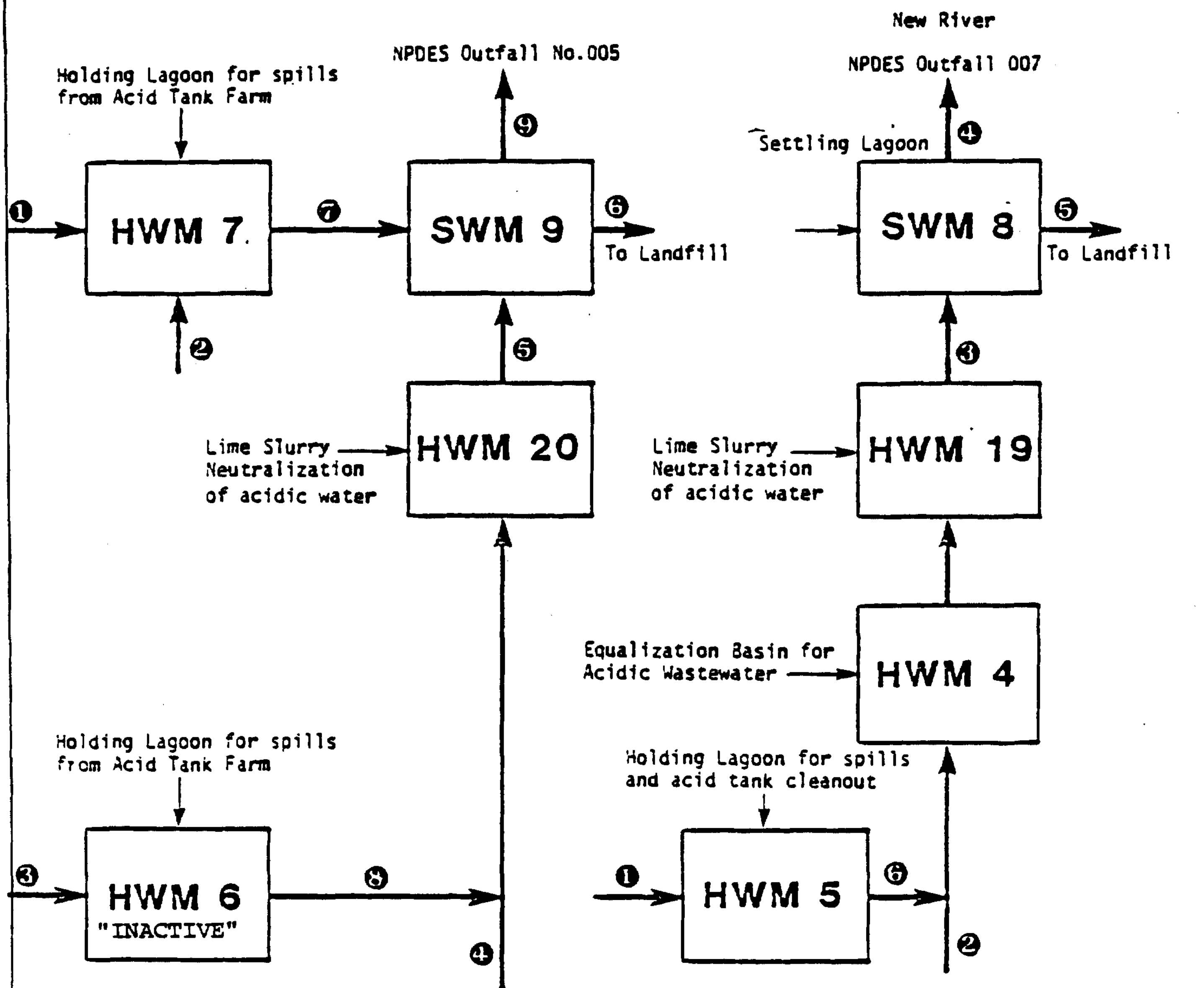
Site Description

HWM 5 is a surface impoundment located within the Radford AAP. HWM 5 serves as a holding basin for runoff, spill and washdown waters from an acid tank farm. The dimensions of the impoundment are shown in Figure 4.2. The impoundment is approximately 150 feet by 100 feet at the crest elevation of the dike, and is approximately 10 feet deep with side slopes of 30 to 40 degrees. The depth of the acidic water is normally 2 to 4 feet for a total volume of about 143,600 to 300,000 gallons. HWM 5 has been in use since the mid-70's. The basin was lined in 1981 with Hypalon of 60 mils in thickness. The bottom liner is covered with about 12 inches of sand, and the sides are covered with approximately 6 inches of sand and granite riprap, respectively (CH_2M Hill, July 1984). The compatability of the Hypalon liner with the acidic water has been rated as "good" according to a previous report (Wyss et al, September 1980).

As illustrated in Figure 4.1, the effluent from HWM 5 is discharged to an equalization basin, HWM 4. The effluent is conveyed via a sub-surface gravity pipe. The effluent from HWM 4 is treated by lime slurry neutralization and a settling lagoon prior to discharge to the New River under NPDES Permit No. VA 0000248.

Figure 4.1

Radford AAP
Process Flows of Existing HWM Facilities



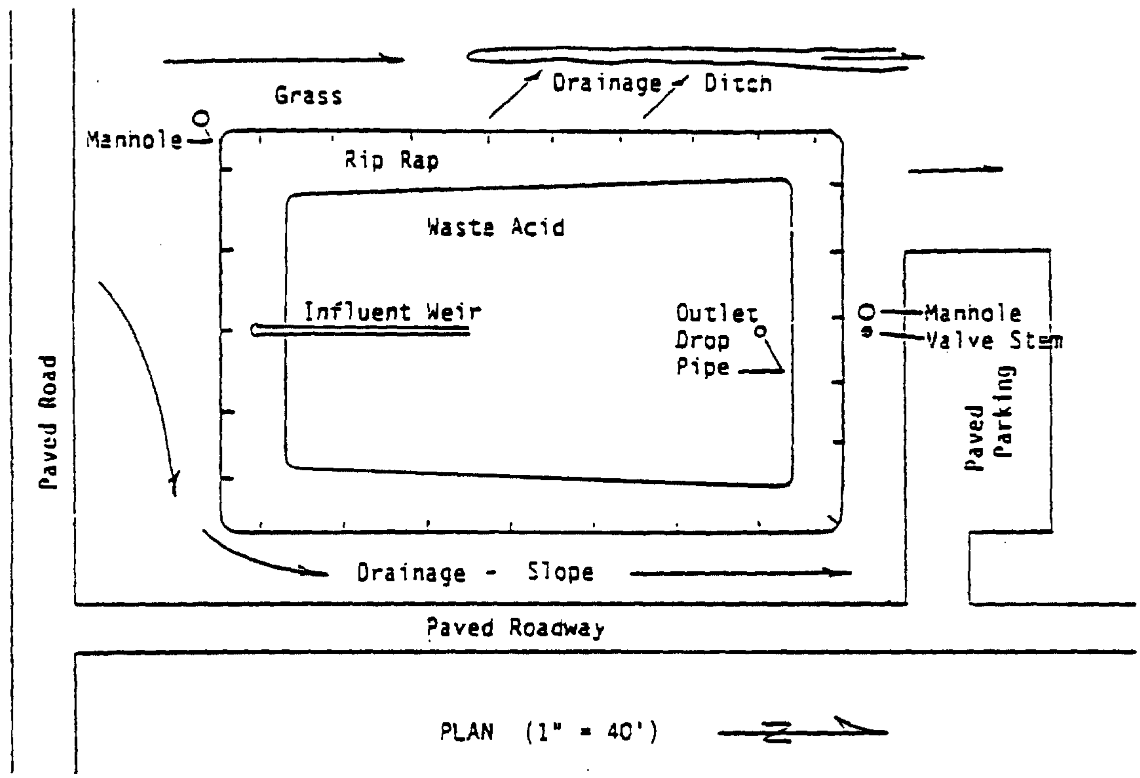
1 Acid spills, variable amount
2 Waste caustic, 4,000 gallons per day
3 Acid spills, variable amount
4 Acidic wastewater, 4,000,000 gallons/day
5 Neutralized acidic wastewater
6 Calcium sulfate sludge containing a small amount (estimated 1 %) of nitrocellulose fines, 400 cu.yds.per year
7 Neutralized wastewater, variable amount
8 Waste acid
9 Neutralized supernatant from settling lagoon 4,000,000 gallons per day plus neutralized wastewater, variable amount

1 Acid spills, variable amount
2 Acidic wastewater, 8,000,000 gallons/day
3 Neutralized acidic wastewater 8,000,000 gallons/day
4 Neutralized supernatant from settling lagoon
5 Calcium sulfate sludge containing a small amount (estimated 1 %) of nitrocellulose fines, 800 cu.yds.per year.
6 Waste acid

SOURCE: BCM, MAY 1984

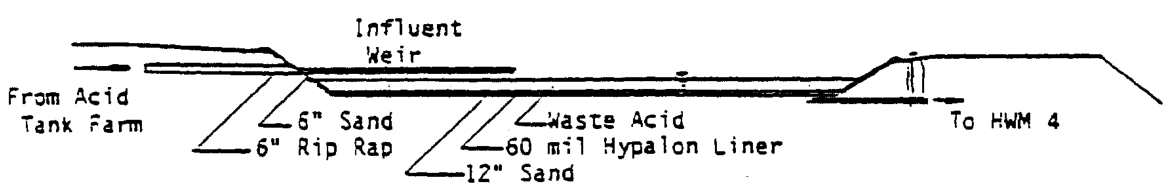
FIGURE 4.2

Hazardous Waste Management Facility 5



PLAN (1" = 40')

ELEVATION (1" = 40')



Radford Army Ammunition Plant

Waste Characterization

The impoundment's influent consists of rainwater runoff and various strengths and mixtures of nitric and sulfuric acids. An analysis of influent water taken during low flow in 1981 indicated that the influent wastewater contained low concentrations of several heavy metals (not hazardous because of EP toxicity).

The lagoon water is classified as a hazardous waste because of its corrosivity. The pH of the lagoon's influent when tested in 1981 was 1.5 which classifies the lagoon's water as a corrosive hazardous waste (pH below 2.0 or above 12.5).

The accumulated solids that have settled above the hypalon liner system in HWM 5 have not been sampled and analyzed to determine if contaminants (heavy metals) are present. Based on the analytical testing (EP toxicity) of lagoon influent previously discussed, the accumulated solids are not likely to contain heavy metals in concentrations that would render the solids hazardous. However, no other data on the lagoon's influent are available to determine the extent of contamination at HWM 5.

Process wastewater containing low concentrations of nitrocellulose (NC) were previously conveyed to HWM 5 from the acid screen house located on-site at the Radford AAP. In the fall of 1983, this practice was discontinued and the pipe conveying this waste stream was relocated. Currently, the waste stream is discharged to the boiling tub settling pit for recycling (Webb, December 1984).

Analytical testing to determine the concentration of NC in the accumulated solids at HWM 5 has not been conducted to date. Several other acid waste lagoons that receive similar waste streams have been tested to determine the concentration of NC in their accumulated solids. Microscopic examination of sludge samples from these lagoons found NC in concentrations of less than one percent. According to reactivity test criteria sludges containing less than 26 percent NC are non-reactive when NC is the only reactive constituent present. Analyses for other explosive materials including nitroglycerin and dinitroglycerin showed very low NC concentrations (nondetectable, or less than one percent) in the lagoon sludges. These results indicate that it is unlikely that the solids in HWM 5 are reactive since very low concentrations of NC were found in other waste lagoons that are used for similar purposes at the Radford AAP.

HAZARDOUS WASTE MANAGEMENT SITE NO. 7

Site Description

HWM 7 is an unlined surface impoundment located within the Radford AAP. HWM 7 serves as a holding and neutralization basin for spills and washdown waters from an acid (oleum) tank farm and daily production of waste caustic. The area dimensions of the lagoon are 160 feet by 90 feet and its depth is 10 feet with side slopes of 45 degrees (Figure 4.3). The lagoon is equipped with two bottom air diffusers to provide mixing when lime is added to render the acidic wastes neutral.

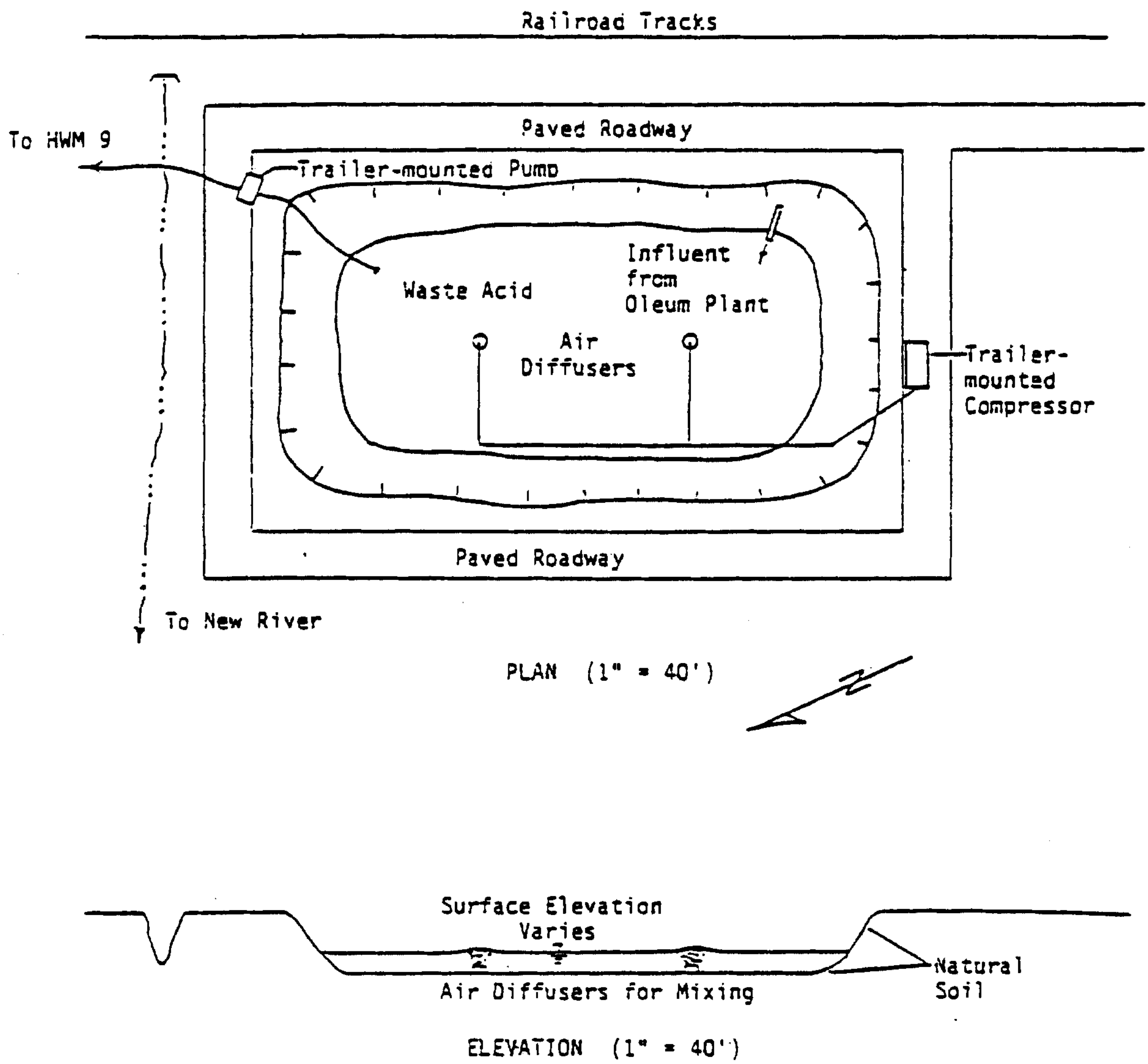
The neutralized effluent from HWM 7 is pumped to an unlined holding basin (No. 7A) prior to being discharged to SWM 9 for settling. In some cases, however, the effluent from HWM 7 is discharged via a temporary surface pipe system directly to SWM 9 (Figure 4.1). After settling, the effluent from SWM 9 is discharged to the New River under NPDES Permit No. VA0000248.

Waste Characterization

The HWM 7 influent contains waste sulfuric acid and caustics from the production of oleum. According to EP toxicity analyses conducted on the lagoon water and sediment, several heavy metals were detected but in very low concentrations (i.e., nonhazardous). The pH of the lagoon water was 11.4 when the analysis was conducted, which is also classified as nonhazardous. However, the pH of the lagoon's influent is known to fluctuate (below 2.0 and above 12.5), thereby classifying the wastewater as a corrosive substance.

FIGURE 4.3

Hazardous Waste Management Facility 7



Radford Army Ammunition Plant

As with HWM site 5, the accumulated solids in HWM 7 have not been analyzed to determine if reactive constituents are present. However, according to Radford AAP personnel, wastewaters discharged to HWM 7 in the past in the form of washdown waters from the acid tank farm did not contain NC (Webb, December 1984). Therefore, it is unlikely that NC is present in concentrations that could render the solids reactive.

HAZARDOUS WASTE MANAGEMENT SITE NO. 16

Site Description

HWM 16 is a hazardous waste landfill trench located adjacent to a sanitary landfill (Permit No. 401) at the Radford AAP. These disposal facilities began operations in 1980 and 1976, respectively. HWM 16 consists of a trench 400 feet by 60 feet (measured at the surface), as depicted in the plot plan of HWM 16 and the sanitary landfill (Figure 4.4). The depth of the landfill trench ranges between 10 and 14 feet. The capacity of HWM 16 is about 6000 cubic yards, of which 70 percent is filled as of December, 1984. The bottom of the trench consists of soil which was compacted to obtain a permeability of no more than 1×10^{-7} cm/sec.

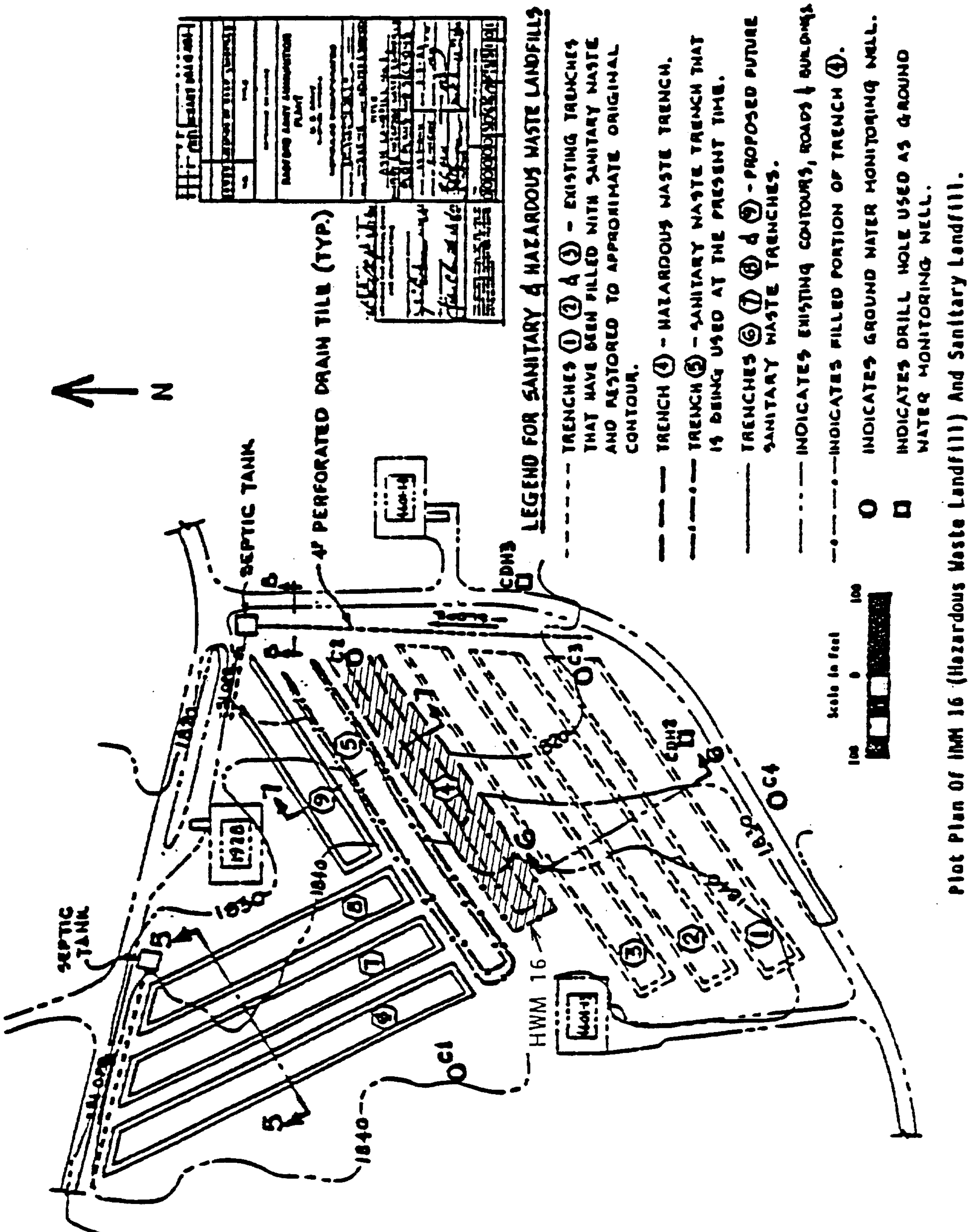
Waste Characterization

The Radford AAP generates a variety of wastes that are disposed in the on-site hazardous waste landfill trench (HWM 16). Presented in Table 4.1 is a list of the reactive and corrosive materials that are ultimately disposed in HWM 16 following treatment. The waste materials presented are generated from Radford AAP activities including the incineration or waste propellants, and disposal of laboratory waste chemicals and materials.

The rate of generation of wastes to be landfilled was approximately 625 cubic yards per year. From 1980, when use of HWM 16 first began, to August 1983, approximately 1270 tons of ash and 684 tons of sludge were placed in HWM 16 (USAEHA, 3-5 October 1983). As of December 1984, approximately 4200 cubic yards of waste had been disposed in the landfill.

Figure 4.4

RADFORD AAP
HAZARDOUS WASTE MANAGEMENT SITE 16



SOURCE: U.S. ARMY ENVIRONMENTAL HYGIENE AGENCY

TABLE 4.1

SUMMARY DESCRIPTION OF WASTES THAT ARE OPEN-BURNED PRIOR TO DISPOSAL IN HWM 16

WASTE	PHYSICAL FORM	HAZARD DESCRIPTION	EPA HAZARD NUMBER
Nitrocellulose	Solid	Reactive	D003
Laboratory explosive wastes	Solid, Liquid	Corrosive	D002
Waste propellant	Solid	Reactive	D003
NG slums	Sludge	Reactive	D003
Explosive contaminated waste	Solid	Reactive	D003

Source: USAEHA (December 1981)

Presented in Table 4.2 is a summary of the wastes disposed in HWM 16. It should be noted that the ash from waste propellant incineration and residue from explosive contaminated waste burning are listed as reactive wastes. This information is based on the assumption that residues from the treatment of reactive wastes are considered reactive hazardous waste until proven otherwise (USAEHA, 1981). Since HWM 16 began disposal operation in 1980, wastes characterized as reactive (Table 4.1) were incinerated or open burned prior to disposal in the landfill to render them non-reactive. Reactivity test methods including thermal stability, unconfined burning, No. 8 blasting cap and the impact test were used to analyze potentially reactive sludges prior to disposal in HWM 16 This testing determined that the landfilled sludges were non-reactive. Presently, these sludges are not disposed in the landfill. Analysis by the Radford AAP laboratory of ash and residues from the incineration and open burning of waste propellants utlizing the USEPA approved reactivity testing methods (i.e., Bureau of Mines Gap Test and Deflagration/Detonation Transition (DOD) Test) determined that these materials were non-reactive. The ash and residues that were analyzed and found to be non-reactive are similar to the wastes landfilled prior to reactivity testing performed using the USEPA approved methods.

Presented in Table 4.3 are EP toxicity results for several ash residues disposed in HWM 16. These analytical results indicate that with the exception of lead concentrations of the propellant burning ground ash, none of the residues contain concentrations of heavy metals that would classify the waste as hazardous (USAEHA, 1981). However, this determination is based on one sampling event conducted in 1981 and may not be representative of the waste residues presently disposed in the landfill. According to Radford personnel, various laboratory waste chemicals and materials were also disposed in HWM 16. A sampling and analysis program will be conducted during the closure of HWM 16 to further document the nature of wastes in HWM 16.

TABLE 4.2

SUMMARY DESCRIPTION OF WASTES DISPOSED IN HWM 16

Waste[a]	Rate Of Generation[a] (tons/yr)	Physical[a] Form	Hazard Description	EPA Hazard[a] Number
Ash from waste propellant incineration	unknown	solid	reactive, non-EP toxic[a]	D003
Residue from waste propellant burning	unknown	solid	reactive, EP toxic[a]	D003, D008
Residue from explosive contaminated waste burning	200	solid	reactive[a]	D003
SAR area fume burner ash	0.1	solid	EP toxic[a]	D006, D007
Sludge from neut. of SAR process water	unknown	sludge	nonhazardous[a]	--
Sludge from neut. of nitro-cellulose mfg acid process water	unknown	sludge	nonhazardous[b]	--
Sludges from Bioplant, Building 470, and NG 2 Pretreatment Building 9410	50	sludge	non-hazardous[c,d,e]	--

a USAEHA (December 1981)
b Ewing (15 January 1982)
c Everett (19 March 1982)
D Everett (10 November 1982)
e Jenrette (18 November 1983)

nsRAD 2:8/585

TABLE 4.3

RESULTS OF ANALYSIS OF SOME WASTES
DISPOSED IN HWM 16

Sample and Measurement (mg/l)

Parameter	Incinerator Ash from Waste Propellant Incinerator	Contaminated Burning Ground Ash	Propellant Burning Ground Ash
As	ND (Not Detected)	ND	ND
Ba	ND	0.64	0.76
Cd	0.092	0.032	0.012
Cr	0.148	0.026	0.031
Pb	3.4	ND	51
Hg	ND	0.029	ND
Se	ND	ND	ND
Ag	0.037	ND	ND

Source: USAEHA (December 1981)

SECTION 5

CLOSURE PROCEDURES

Provided in this section is a brief discussion of the closure procedures that are presented in the Engineering Report. These discussion sections address the closure of the Hazardous Waste Management Facilities (Nos. 5, 7 and 16) that are to be removed from service. The potential exposures and risks associated with these closure methods are presented in Section 6. The closure procedures presented herein include:

- o Site preparation (surface impoundments).
- o Demolition and cleanup (surface impoundments).
- o Sediment and soil treatment (surface impoundments).
- o Sampling, backfilling and cover system installation.

SITE PREPARATION (SURFACE IMPOUNDMENTS)

Site preparation includes activities to be performed prior to initiation of closure construction: diversion of the influent to the new replacement tanks; neutralization of lagoon wastewater and other acid contaminated materials; draining of liquids; and flashing the sediments removed from HWM 5 to render non-reactive NC fines that could be present. Because of the nature of the work, handling of acidic liquids and NC-laden sediments, it was decided that Radford AAP (Hercules, Inc.) would perform these tasks folowing the standard safety procedures required for plant operations.

DEMOLITION AND CLEANUP (SURFACE IMPOUNDMENTS)

As an initial step to close the surface impoundments, the contractor will remove all appurtenant structures such as the pipes, manholes, trough, decant pipes, air diffuser pipes and guard rails. Unless useable, these will be crushed and disposed in the sanitary landfill. The granite riprap from HWM 5 will be salvaged and stored near the HWM 5 or HWM 16 site. The cover sand and Hypalon liner from HWM 5 will be removed and disposed in HWM 16.

SEDIMENT AND SOIL TREATMENT (SURFACE IMPOUNDMENTS)

The insitu treatment step is intended to provide a stable foundation for backfilling and placement of the final cover system within the surface impoundments. This closure step requires the mechanical mixing of lime kiln dust (calcium oxide) with the soils/solids in the surface impoundments. Two feet of material at HWM 5 and seven feet of sediment and soil at HWM 7 will be treated. The lime kiln dust will effectively solidify the soils and sediment in the surface impoundments while also acting as a neutralizing agent. This step will also facilitate access for personnel and equipment to all areas of the surface impoundments to perform sampling and backfilling activities.

SAMPLING, BACKFILLING AND COVER SYSTEM INSTALLATION

Surface Impoundments

Materials in the surface impoundments will be sampled after the treatment step to determine the nature of contamination in the subsoils underlying the impoundments. Samples from three borings to the groundwater table will be collected and analyzed for pH and heavy metals. Following the treatment and sampling steps, the surface impoundments will be backfilled and a cover system provided.

HWM 16 will be closed with wastes in place as a hazardous waste facility. To characterize the landfilled wastes (i.e. residues from burning/incineration and laboratory chemicals) and subsurface soil contamination, a sampling and analysis program will be conducted as part of site closure. This sampling program will include 6 to 12 soil borings, approximately ten (10) feet into the subsoil. The waste material will be sampled continuously, composited and analyzed for heavy metals, explosives and purgeable organics. Three samples of the subsurface soils from each boring will also be collected and analyzed for heavy metals. The sampling program at HWM 16 may be conducted by Radford AAP prior to closure of the facility.

A leachate collection system will be installed underlying the remaining unfilled section of HWM 16. Following the installation of this system, the cover sand and liner material removed from HWM 5 will be disposed in the landfill. The final volume of hazardous wastes from the Radford AAP production operations also should be disposed in HWM 16 prior to closure of the facility. After completion of disposal operations, the existing cover soil in the filled section of HWM 16 will be compacted and a final cover system installed over the entire landfill trench. The riprap salvaged from HWM 5 will be used to stabilize the sloped end (approximately 14 feet high) located at the northeast side of the landfill.

SECTION 6

POTENTIAL EXPOSURES AND RISKS

The potential exposures and risks associated with the closure of the Hazardous Waste Mangement facilities at the Radford AAP are presented herein. The steps required to close the surface impoundments (HWM Nos. 5 and 7) and the hazardous waste landfill (HWM No. 16) are listed below. For each step listed, a discussion section is provided which addresses the exposures and risks associated with each activity.

- o Site Preparation (surface impoundments)
- o Demolition and Cleanup (surface impoundments)
- o Sediment and soil treatment (surface impoundments)
- o Sampling, backfilling and cover system installation

The site preparation work will be conducted by Radford AAP (Hercules, Inc.) following the standard safety procedures required for plant operation. Therefore, safety issues associated with the site preparation work are not addressed in this plan.

Summarized in Table 6.1 are the potential risks and exposures that are associated with the closure methods listed above. The physical and chemical constituents that could potentially be found at the HWM sites during closure are presented in Table 6.2. For each constituent listed, the potential hazard and acute effect associated with direct contact to these constituents are provided.

The acute effects associated with exposure to the waste materials at the Radford HWM facilites are provided since these substances may come in direct contact with skin. The potential exposures while conducting the site closure activities (listed above) are for relatively short periods of time during the closure activities. None of the acute exposures listed in Table 6.2 pose serious life threatening situations.

TABLE 6.1

POTENTIAL EXPOSURES AND RISKS

Activity	Potential Exposures and Risks	Comments
Demolition and cleanup (surface impoundments)	Exposure to potentially corrosive subsoil	Leakage of acidic waste-water from pipe and manhole may have contaminated soils
Sediment and soil treatment (surface impoundments)	Inhalation of lime kiln dust	Lime kiln dust will be mechanically spread and mixed
Sampling and testing (surface impoundments)	Exposure to potentially corrosive subsoil and lime kiln dust	The NC fines will be removed and incinerated prio to beginning the sampling and anaylsis program
Sampling and testing (hazardous waste landfill trench)	Drilling into pockets of chemical wastes	Laboratory wastes were disposed in HWM 16 in the past. Landfill wastes may contain trace quantities of reactive constituents.

TABLE 6.2
POTENTIAL HAZARD AND ACUTE EFFECT OF PHYSICAL OR CHEMICAL CONSTITUENTS AT THE HWM FACILITIES

HWM Site	Physical or Chemical Constituents	Potential Hazard	Potential Acute Effects	Comments
5, 7	Nitrocellulose	Reactive	Burning of skin	Dry NC fines are dangerous when exposed to intense heat; wet somewhat less a threat. To be flashed prior to site work.
5, 7	Solids containing corrosive "free liquids"	Corrosive	Skin irritation	Solids containing free liquids are to be neutralized/solidified as part of Closure Plan.
5, 7	Soils contaminated with heavy metals	EP Toxic	None	Found in concentrations below EP toxicity limits. Heavy metals are not in a form so as to gain entrance into the body or tissues of workman in measurable quantities.
16	Residues containing reactive constituents	Reactive	None	Residues are rendered non-reactive by incineration or open burning prior to disposal.
16	Residues contaminated with heavy metals	EP Toxic	None	Metals are found in concentrations below EP Toxicity Levels. Heavy metals are not in a form so as to gain entrance into the body or tissues of the workman in measurable quantities.
16	Airborne lead dust from propellant burning ground ash	EP Toxic	Accumulation of lead in body tissues via respiratory inhalation	The concentration of lead in propellant burning ground ash has been detected at concentrations of 51 mg/l. Appropriate respiratory protection will be required in the vicinity of HWM 16 during the conduct of site closure.
16	Various laboratory chemicals	Toxic Reactive Ignitable	Skin Irritation eye and respiratory tract irritation	Examples of chemicals are sulfur, cryolite, diphenylamine, tetrahydrofuran and chlorobenzene. Heat, flame, and direct contact should be avoided.

DEMOLITION AND CLEANUP

All surficial structures and materials will be neutralized by a weak sodium hydroxide slurry solution prior to demolition and cleanup activities. These materials, after neutralization, would not present any notable health and safety hazard. Level D worker protection with optional productive equipment including rubber gloves, safety goggles and respiratory protection will be required while conducting this closure task. The subsoil surrounding underground pipes and manholes to be excavated at HWM 5 and 7 may have been contaminated by acid leaks from the impoundments. Direct contacts with subsoil, therefore, should be avoided. The level of personal protection required for the demolition activities is also adequate for the excavation work to be conducted.

SEDIMENT AND SOIL TREATMENT

The potential exposure to lime kiln dust during the spreading and mixing with the soils/solids within the surface impoundments is the potential risk associated with this closure step. All mixing and spreading will be performed using mechanical devices so contractor personnel should not be directly exposed to the lime material. However, the mixing and spreading of the lime kiln dust may generate fugitive dust. In response to this potential hazard, personnel protective equipment affording skin, eye and respiratory protection will be required.

SAMPLING, BACKFILLING AND COVER SYSTEM INSTALLATION

Hazardous Waste Surface Impoundments

The risks associated with conducting the sampling and analysis program at the surface impoundments are exposure to corrosive constituents including acidic water and lime kiln dust in the soil/solids.

Direct contact with soil samples should be avoided. Personal protection affording skin, eye and respiratory protection will be required.

Hazardous Waste Landfill Trench

Collecting samples from HWM 16 by drilling techniques is a major safety concern due to the potential of penetrating small pockets of chemical wastes. The possibility of this occurring may be remote yet it can not be completely dismissed because the wastes have been disposed randomly in the landfill trench. Therefore, personnel protection should be provided to prevent direct contact with chemical waste or soil samples and inhalation of dusts. The generation of heat and/or flames during drilling would present dangerous conditions to workers since the landfilled residues are potentially ignitable and reactive. If any hard material is encountered during drilling, the pressure on the drill stem should be kept at a minimum and water may have to be added to avoid generating excessive heat.

SECTION 7

PERSONNEL PROTECTION

This section presents the general personnel protection standards that will be required to conduct the closure of the hazardous waste facilities (Nos. 5, 7 and 16) at the Radford AAP. Presented in Table 7.1 are the personnel protection requirements for each of the activities that will be conducted as part of the closure plan. The basic equipment required for level C and D are as follows:

Level C Protection

- Full-face piece, air purifying, canister-equipped respirator
- Chemical-resistant clothing, long sleeves (one or two pieces)
- Rubber gloves
- Steel toe and shank boots
- Hard hats
- Options as required
  - Inner chemical-resistant gloves
  - Disposable outer boots
  - Escape mask

Level D Protection

- Coveralls or work clothes
- Leather or chemical-resistant boots or shoes (steel toe and shank)
- Hard hat
- Options as required
  - Rubber gloves
  - Disposable outer boots
  - Safety goggles or chemical splash shield
  - Escape mask or respirator

TABLE 7.1

PERSONNEL PROTECTION REQUIREMENTS

HWM Site	Activity	Level of Protection	Modifications/Comments
5, 7	Site preparation	D	Goggles, full-face splash shield, chemical resistant coveralls, rubber gloves and boots
5, 7	Demolition and cleanup	D	Chemical resistant coverall, eye protection dust mask, chemical resistant rubber gloves and boots
5, 7	Sediment and soil treatment	C	Full-face, canister-equipped respirator capable of filtering lime kiln dust
5, 7	Sampling and testing	D	Goggles, full-face splash shield, chemical resistant coveralls, rubber gloves and boots
5, 7, 16	Backfill and cover system installation	D	Skin, eye and respiratory protection for fugitive dust

It should be noted that each of the HWM facilities to be closed at the Radford AAP will not be segregated into designated work zones including exclusion, contamination reduction and support areas. Designating the Radford AAP sites into zones was not deemed necessary due to the relatively low health and safety risks associated with the closure of these facilities. The surface impoundments are classified as hazardous sites only because they store corrosive wastes. The landfill trench site is classified as hazardous because it contains low concentrations of reactive materials. However, contractor personnel must wear appropriate personal protective equipment while performing activities where direct exposure to these materials could be expected. Additionally, a decontamination station (eyewash, first aid, decontamination hose) will be at each of the sites during the conduct of the closure activities. The decontamination hoses presently exist at the impoundment sites. Prior to initiating the site closure activities, the decontamination hoses will be inspected for operating condition and to ensure that they are of adequate length (within 100 feet of the hazard). Provisions will be made for the collection of water used during decontamination activities. All collected waters will be disposed in accordance with Radford AAP waste disposal practices.

NEUTRALIZATION ACTIVITIES

Level C personnel protective equipment will be required for all on-site closure activities that involve neutralization with caustic materials. These activities include the neutralization of liquid wastes (dry lime) and the spreading and mixing of lime kiln dust. However, if liquid caustic (lime) is used to neutralize the lagoon water, then personnel protective equipment affording skin, eye and respiratory protection is required. Therefore, Level C personnel protection is required only when neutralization activities generate fugitive dust containing lime. In response to this health concern, contractor personnel performing these closure activities will be required to wear personal protective equipment affording skin, eye and respiratory protection.

SECTION 8

STANDARD SAFE WORK PRACTICES

All Contractor personnel retained to conduct the closure of the HWM facilities (nos. 5, 7 and 16) at the Radford AAP are required to abide by the work practices and procedures listed below:

- o Contractor personnel must receive a site orientation from the Radford AAP Safety Office prior to the start-up of closure activities.

- o Contractor personnel will abide by all standard safety and security practices/procedures required by the Radford AAP.

- o Contractor personnel will be required to know and follow the Emergency Contingency Plans that are to be followed in the event of an accident (Section 9).

- o When working in the vicinity of active HWM facilities, contractor personnel are required to wear appropriate personal protective equipment (Section 7) and avoid contact with hazardous materials (reactive and corrosive). Personnel should avoid kneeling on the ground and walking through puddles or mud that may contain contaminated substances while working in the vicinity of active HWM facilities.

- o Contractor personnel shall be familiar with the physical surroundings while conducting work activities, including:
  - accessibility to associates, equipment and vehicles
  - site access
  - nearest water sources (decontamination)
  - location of other active HWM facilities in the vicinity of work being conducted.
  - location of first aid station

- o Eating, drinking, chewing tobacco, smoking, carrying matches or lighters are prohibited while conducting the closure activities

- o Contractor personnel are prohibited from conducting the following activities:
  - driving personal car on site
  - entering unauthorized portions of the Radford AAP
  - taking unauthorized photographs on-site
  - transporting weapons, explosives or ingitable materials on-site.

- o Contractor personnel are required to obtain a security pass and wear an appropriate clearance badge.

CONTAMINANT MONITORING

With the exception of pH samples collected from the subsurface soils (HWM Nos. 5 and 7), no contaminant monitoring will be conducted during the closure of the HWM facilities at the Radford AAP. Monitoring was not deemed necessary since no volatile organic constituents are present at these disposal sites. The surface impoundments and hazardous waste landfill are hazardous because they contain corrosive and reactive wastes, respectively.

SECTION 9

EMERGENCY PROCEDURES

In the event that an emergency develops on-site, the procedures delineated herein are to be immediately followed. Emergency conditions are considered to exist if:

- o Any contractor personnel are involved in an accident or experience any adverse effects or symptoms of exposure while on-site. Adverse exposures or symptoms include danger due to physical, chemical and toxicological properties of the materials present.

- o A condition is discovered that indicates the existence of a situation more hazardous than anticipated.

General Emergency Procedures

The following emergency procedures should be followed:

1. Contractor personnel should work in pairs and the entire work crew should work in the same approximate area to render aid in the event of an emergency.

2. In the event that any member of the work crew has an accident while on-site, the entire crew should halt work immediately and render aid or help in rescue operations according to the instructions provided by the site manager.

3. The discovery of any conditions that would suggest the existence of a situation more hazardous than anticipated should result in the evacuation of the work crew and re-evaluation of level of personnel protection required.

4. In the event that an accident occurs, the site manager is to complete an Accident Report Form for submittal to the ES and Radford AAP safety officers. These safety officers will assure that follow-up action is taken to correct the situation that caused the accident.

Personal Injury

In case of personal injury on-site, the following procedures should be followed:

1. The extent of the injury should be determined prior to moving the worker. If the injury is minor, first aid assistance should be given at that time. If the injury appears to be serious, the worker should be evacuated by the Radford AAP ambulance.

2. For minor injuries, the worker should be taken to the on-site Radford AAP hospital. Seriously injured workers requiring major medical assistance should be evacuated to either the Montgomery County Hospital (Blacksburg) or the Radford Community Hospital. Directions to these medical facilities is presented in Section 11 (Emergency Contacts).

3. The site manager is responsible for making certain that an Accident Report Form is completed and that ES Safety Coordinator and Radford AAP safety officer are notified of the incident.

Emergency Equipment

A list of the emergency/first aid equipment that will be made available to the work crew while working on-site at the Radford AAP includes:

- o Fully stocked industrial size first aid kit
- o Portable eye wash (6 gal. capacity which provides 12 minutes of washing)
- o Hose to be connected to the water faucet at each of the HWM facilities which can be used for decontamination purposes.
- o Portable fire extinguisher
- o Safety equipment listed in Table 7-1

Contact with corrosive water is the primary safety concern while conducting work in the vicinity of the hazardous waste surface impoundments. Personnel protective equipment affording skin and eye protection will be required while the lagoon closure activities including neutralization of liquids and neutralization/solidification of solids are being conducted. A portable eye wash station and water hose will be available at each of the surface impoundments during the conduct of the closure activities. The eye wash station to be used at the Radford AAP holds six (6) gallons of water and delivers the eye wash stream in a fine criss-cross spray. The eye wash will deliver a steady stream of water for about 12 minutes (0.5 gpm). If additional eye wash water is required, the on-site water hose could be used to add water to the eye wash station. The eye wash station can be used while being refilled since the fill port is located on the upper portion of the back side of the eye wash station.

CHEMICAL EXPOSURE (ACIDIC WATER)

If any contractor personnel are exposed to chemicals, or fall into one of the surface impoundments during the closure of the HWM facilities, the procedures outlined below should be followed:

1. Another team member (buddy) should remove the individual from the immediate area of contamination.

2. Precautions should be taken to avoid exposure of other individuals to the chemical. Only support personnel wearing appropriate personnel protective equipment should help in rescue operations and conduct decontamination procedures.

3. If the chemical is on the individual's clothing, the clothing should be removed if it is safe to do so.

4. If the lagoon water has contacted the skin, decontamination procedures should be performed immediately. The exposed skin should be washed with large amounts of water with the hose located at each HWM facility. After thorough washing, the individual should be taken to the Radford on-site hospital for further treatment.

5. In case of eye contact, an emergency eye wash should be used. Eyes should be washed for 10 - 15 minutes. The worker should then be evacuated to the Radford AAP hospital.

6. All chemical exposure incidents must be reported in writing to the ES Safety Coordinator and Radford AAP safety officer.

The water hose provided at each of the surface impoundments will be used for decontamination of personnel who come into contact with corrosive water. Personnel performing work in the vicinity of the surface impoundments will be wearing appropriate personnel protective equipment. Also, the acidic water in the lagoons will be neutralized prior to conducting site closure activities. Therefore, personnel performing the on-site closure activities should not be directly exposed to corrosive materials. In the unlikely event that personnel are exposed to corrosive liquids, the water hose located at each of the impoundments should be more than adequate for personnel decontamination. As was previously stated, provision will be made for the collection of water used during decontamination activities. All collected waters will be disposed of in accordance with Radford AAP waste disposal practices.

Fire or Explosion

A hazard of fire or explosion exists when flammable materials are being used or handled or when there is the possibility that a combustible atmosphere may be generated. No flammable materials will be used by contractor personnel and no smoking is permitted on-site during closure activities because of the potential of explosion at the Radford AAP. If a potential for fire or explosion is observed during the closure activities, the work crew is to immediately leave the area and notify the Radford AAP fire department and safety officer.

A fire extinguisher will be provided to subcontractor personnel upon admittance to the Radford AAP for the purpose of extinguishing small fires. If a small fire does occur, the work crews should use available means (i.e., extinguisher or hose) to put out the fire and immediately contact the Radford AAP fire department.

SECTION 10

TRAINING

Field personnel will have formal or prior on-the-site training for the tasks they are assigned to perform. An on-site orientation session conducted by the Radford AAP safety office will be required for all contractor personnel prior to the start-up of closure activities. The on-site safety orientation will have in attendance the following personnel:

- o Representative from the Radford AAP Safety Office.

- o Representative from the U.S. Army Corps of Engineers. Mr. Lawrence Cali has been the Radford AAP contact during the conduct of this project and would probably be the Corps representative at the on-site safety orientation.

- o Representative from Hercules, Inc. Mr. Robert Webb has been contacted concerning the performance of previous work conducted on-site and would probably be Hercules' representative at the on-site safety orientation.

- o All contractor personnel who will be conducting the closure of the Radford AAP hazardous waste management facilities.

- o Representative from Engineering-Science, Inc. Mr. Robert Steele has been the acting Safety Coordinator for this project and will be in attendance for the on-site safety orientation.

The orientation will address the following issues.

1. Health effects and hazards of the chemicals identified or suspected to be present on-site. The basis of discussion for the

health effects and hazards of the chemicals identified or suspected to be present on-site is Section 6, Potential Exposures and Risks. This discussion section addresses the exposures and risks that contractor personnel should be made aware of, prior to performing work on-site.

2. Personnel Protection
   - o Use and care of personal protective equipment.
   - o Necessity for personal protective equipment for closure activities in the vicinity of active HWM facilities.
   - o Maintenance and fitting of personal protective equipment including respiratory protective equipment (conform to 20 CFR 1910.134 and ANSI Z.88.2 (1980)).

3. Decontamination Procedures
   - o Washdown of contaminated personnel
   - o Washdown of equipment following on-site work

4. Exhibition in areas and zones
   - o Site layout
   - o Standard "safe" work practices

5. Emergency Procedures
   - o Rescue procedures
   - o Routes to on-site and local hospitals

PERSONNEL TRAINING

Contractor personnel selected to conduct the closure of the Radford Hazardous Waste Management facilities (Nos. 5, 7 and 16) will have extensive experience in the work that they are to perform at the Radford AAP. If available, conctrator engineering firms will be selected that have prior experience working on-site at the Radford AAP and are familiar with the safety practices and procedures at the plant. The on-the-site training provided prior to performing assigned tasks will address:

- Specific job assignments of each contractor personnel;
- Personnel protection requirements for each work assignment; and
- Emergency and decontamination procedures to be followed in the event that a accident occurs on-site.

A discussion and a walk-thru for each job assignment required to conduct the closure work will be given at each site as part of the on-site safety orientation.

SECTION 11

EMERGENCY CONTACTS

Should any situation or unplanned occurrence require outside assistance or support services, the appropriate contact from the following list should be made.

Radford AAP Emergency Contacts	Telephone Number
Radford AAP Fire Department	(703) 639-7216
Carl Jesse, Fire Department Chief	(703) 639-7233
Radford AAP Ambulance	(703) 639-7163
Radford AAP Security Police	(703) 639-7325
Captain Les Stranger, Security Police	(703) 639-7125
Hercules Pollution Abatement Coordinator, James Morris	(703) 639-7214
Hercules Safety Manager, Charles Gardner	(703) 639-7524
Government Emergency Contacts	
COR Staff Environmental Coordinator, John Horvath	(703) 639-8641
COR Commander's Office, Col. Gary Curtis	(703) 639-8711
COR Safety Officer, Doug Day	(703) 639-8705
COR Security Officer, James Kennington	(703) 639-8645

ES Emergency Contacts	Work	Home
Andy Kubala, Project Manager	(703) 591-7575	
Joseph Kavanagh, Dpty Project Manager	(703) 591-7575	(703) 591-4564
Bob Steele, Project Safety Coordinator	(703) 591-7575	(703) 455-2814

The Radford AAP has an on-site hospital located in building No. 205 for minor medical emergencies. For emergencies that require major medical assistance, the Radford AAP has mutual aid assistance agreements with local fire departments and Emergency Medical Technician (EMT) services. The Radford AAP also has a verbal agreement with the Radford Community Hospital to provide emergency medical assistance to both Radford AAP and subcontractor personnel. Presently, no formal agreement exists between the Radford AAP and the Montgomery County Hospital. However, an implied agreement with the hospital has been made since the emergency room will render aid to Radford AAP personnel. Directions are provided below to the major medical facilities in the Radford/Blacksburg area.

Montgomery County Hospital, Blacksburg, VA

Take Rt. 114 west to Rt. 460 west. Follow Rt. 460 approximately 3-4 miles. Montgomery County Hospital is located on the left side of Rt. 460 across from the Holiday Inn.

Radford Community Hospital, Radford, VA

Take Rt. 114 east to Rt. 11 north. Follow Rt. 11 north across the river bridge to the traffic light at the intersection of First Street and Rt. 11. Turn right on First Street and proceed to Randloph Street. Turn left on Randolph Street and proceed to Seventh Street. Turn right on Seventh Street and the Hospital emergency room is the first right off of Seventh Street.

APPENDIX 1

ACCIDENT REPORT FORM

ACCIDENT REPORT FORM NO.

PROJECT ______________________________

PERSON FILING ______________ ______________ ______
Name Company Date

DATE OF ACCIDENT ________ / ________ / ________

TIME ______________________________

EXACT LOCATION ______________________________

OF ACCIDENT ______________________________

____

PERSON'S ACTIVITY ______________________________

AT TIME OF ______________________________

ACCIDENT ______________________________

WITNESS TO	Name	Affiliation	Phone No.
ACCIDENT	Name	Affiliation	Phone No.
	Name	Affiliation	Phone No.

NATURE OF ACCIDENT ______________________________

ACTION TAKEN ______________________________

PHYSICIAN'S REPORT ______________________________
Name Number®Date

APPENDIX B

RECORD OF WASTE MATERIAL LANDFILLED IN HWM 16

DEPARTMENT OF THE ARMY
RADFORD ARMY AMMUNITION PLANT
CALLER SERVICE 2
RADFORD VIRGINIA 24141-0298

Mr. Cali/ljm/COMMERCIAL
703-639-8482

REPLY TO
ATTENTION OF:

May 10, 1985

Office of Chief Engineer

Dr. Joseph Kavanagh
Engineering Science
Two Flint Hill
10521 Rosehaven Street
Fairfax, Virginia 22030

Dear Mr. Kavanagh:

Enclosed for your information is a list of items that have been landfilled at Site 16 since September 19, 1980. In addition to these items, 2,168 tons of residue from burning explosives and explosives contaminated waste, 545 tons of wastewater treatment sludges, and 165 tons of spent activated carbon have been landfilled at Site 16. The spent carbon was flashed on the propellant burning ground to insure that it would not be reactive.

Should you have any questions concerning this information, please contact Lawrence Cali, COR Staff Chemical Engineer, at (703) 639-8482. We are pleased to be of assistance in this matter.

Sincerely,

John C Horvath

John C. Horvath
Chief, Engineering
Division

Enclosure

Copy Furnished:
US Army Engineer Division, ATTN: HNDED-PM/Mr. Mike Jones, Huntsville, AL, w/encl
AMC Installations & Services Activity, ATTN: AMCIS-RI-IC/Mr. Jerry Dause, Rock Island, IL, w/encl

P. D. No.	Date	Quantity	Material
80-83	9-19-80	58 lbs.	Lead Salicylate
80-100	11-3-80	550 lbs.	Sulfur
80-108	11-18-80	500 lbs.	Sulfur
81-3	1-7-81	250 lbs.	Nitrodiphenylamine
81-7	2-2-81	76 lbs.	Carbolac
81-7	2-2-81	25 lbs.	Alum. Powder
81-8	2-2-81	100 lbs.	Potassium Nitrate
81-14	2-11-81	400 lbs.	Cryolite
81-34	4-2-81	650 lbs.	Diphenylamine
81-43	4-27-81	15 lbs.	Chromium Nitrate Crystals
81-57	5-27-81	500 lbs.	Sulfur
81-74	7-8-81	450 lbs.	Cryolite, Synthetic
83-07	1-10-83	100 lbs.	Magnesium Oxide
83-10	1-19-83	200 lbs.	Charcoal
83-15	2-3-83	1.1 lbs.	Ferrous Ammonium Sulfate
83-25	2-14-83	1 lb.	Phenolphthalein Powder
		3 Bottles	Ferrous Ammonium Sulfate
83-48	4-15-83	150 lbs.	Ethyl Cellulose Flake
83-72	6-6-83	1.1 lbs.	Ferrous Ammonium Sulfate
83-76	6-13-83	3.0 lbs.	Barium Perchlorate
		0.5 lb.	Lead Dioxide
		0.5 lb.	Lead Nitrate
83-89	7-5-83	21 lbs.	Carbon Black
83-119	9-27-83	220 lbs.	Potassium Sulfate
82-67	8-10-82	3 Bottles	Tetra Bromethane
		17 Bottles	Stabilizer Sol. Ph 4
		11 Bottles	Sodium Methoxide
		9 Bottles	Chlorobenzene ←
82-77	8-26-82	120 Bottles	Yellow Ink
82-86	10-1-82	1095 Each	Combat Meals
82-107	12-8-82	2 Bottles	Alkalinity #1, Reagent #1
"	"	2 Bottles	Alkalinity, #2, Reagent #2
"	"	2 Bottles	Buffer Salt pH 7.2 Mixture
"	"	2 Rolls	Cotton, Aseptic, Absorbent
"	"	54 Gals.	Diubutyl Phthalate ←
"	"	2 Bottles	1, 3-Diphenylguanidine
"	"	2 Each	Mannitol - MP 166-167
"	"	2 Bottles	Mercuric Chloride
"	"	1 Bottle	Morpholine
"	"	2 Bottles	No. 2 Absorbing Reagent
"	"	2 Bottles	Nitrilotriethanol MP 20-22 DEG
"	"	2 Bottles	Sodium Sulfate Anhydrous
"	"	1 Lot	Perchloric Acid 70-72 PC
"	"	3 Pks.	Perfluoroelastomer
"	"	2 Bottles	Phosphorus Pentoxide Powder
"	"	1 lb.	Potassium Sulfate Powder
"	"	3 lbs.	Sodium Acetate, Crystals

P. D. No.	Date	Quantity	Material
82-107	12-8-82	3 Bottles	Sodium Citrate, Crystal
"	"	1 lb.	Sodium Cobaltinitrate Powder
"	"	1 Bottle	Sodium Methoxide
"	"	2 Bottles	Sodium Oxalate Standard
"	"	6 lbs.	Stearic Acid
"	"	1 Lot	Sucrose Rea Cry
"	"	4 Gals.	Tetrahydrofuran
"	"	1 Lot	Thymol Blue B Indicator Solution
"	"	9 Bottles	Triphenyl Phosphate
"	"	1 lb.	Uranyl Acetate
"	"	1 Bottle	Zinc Metal Dust
"	"	4 Pks.	Total Count Millipore Filters

0713b

APPENDIX C

STUDENT'S t-TEST RESULTS

RUN DATE 26 JUL 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL S5W5

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	4.210	4989.937	8.375	.051
BACKGROUND STANDARD DEV	.319	715.505	2.631	.022
BACKGROUND SAMPLE SIZE	20	16	16	16
CALCULATED MEAN	6.850	1200.000	28.250	.032
CALCULATED STANDARD DEV	.058	.000	.500	.003
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	22	18	18	18
REFERENCE/BOOK T-VALUE	2.819	2.552	2.552	2.552
CALCULATED T-VALUE	16.217	-10.380	14.750	-1.645
ACCEPT TEST?	REJECT	OK	REJECT	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 10 APR 83 TO 31 DEC 83 .

RUN DATE 26 JUL 83

INSTALLATION: RADFORD AAP, VA SITE: SITE 5

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL S5W6

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	4.210	4989.937	8.375	.051
BACKGROUND STANDARD DEV	.319	716.505	2.631	.022
BACKGROUND SAMPLE SIZE	20	16	16	16
CALCULATED MEAN	5.575	680.000	8.250	.044
CALCULATED STANDARD DEV	.050	.000	.500	.002
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	22	18	18	18
REFERENCE/BOOK T-VALUE	2.819	2.552	2.552	2.552
CALCULATED T-VALUE	8.390	-11.804	-.093	-.601
ACCEPT TEST?	REJECT	OK	OK	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 10 APR 83 TO 31 DEC 83

RUN DATE 26 JUL 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL S5W7

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	4.210	4989.937	8.375	.051
BACKGROUND STANDARD DEV	.319	715.505	2.631	.022
BACKGROUND SAMPLE SIZE	20	16	16	16
CALCULATED MEAN	7.450	660.000	22.250	.036
CALCULATED STANDARD DEV	.058	.000	.500	.003
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	22	18	18	18
REFERENCE/BOOK T-VALUE	2.819	2.552	2.552	2.552
CALCULATED T-VALUE	19.903	-11.859	10.297	-1.333
ACCEPT TEST?	REJECT	OK	REJECT	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 10 APR 83 TO 31 DEC 83

RUN DATE 26 JUL 83

INSTALLATION: RADFORD AAP, VA SITE: SITE 5

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL SSW8 (BACKGROUND WELL)

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	4.210	4989.937	8.375	.051
BACKGROUND STANDARD DEV	.319	715.505	2.631	.022
BACKGROUND SAMPLE SIZE	20	16	16	16
CALCULATED MEAN	3.800	3712.500	17.750	.054
CALCULATED STANDARD DEV	.000	25.000	.500	.002
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	22	18	18	18
REFERENCE/BOOK T-VALUE	2.819	2.552	2.552	2.552
CALCULATED T-VALUE	2.525	-3.498	6.957	.311
ACCEPT TEST?	OK	OK	REJECT	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 10 APR 83 TO 31 DEC 83 .

THE VALUE OF FINAL IS 0
RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL C1 (BACKGROUND WELL)

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.475	227.500	15.750	.005
CALCULATED STANDARD DEV	.050	5.000	.500	.000
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	4.700	-1.947	1.970	-1.400
ACCEPT TEST?	REJECT	OK	OK	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 07 SEP 83 TO 07 OCT 83 .

THE VALUE OF FINAL IS 0
RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL C1 (BACKGROUND WELL)

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.600	245.000	7.000	.005
CALCULATED STANDARD DEV	.000	.000	.000	.000
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	2.658	.184	-1.029	-1.400
ACCEPT TEST?	OK	OK	OK	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 30 MAY 83 TO 29 JUN 83 .

THE VALUE OF FINAL IS 0
RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL C4

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.475	395.000	30.000	14.545
CALCULATED STANDARD DEV	.050	40.415	4.619	.469
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	4.700	12.317	6.449	134.906
ACCEPT TEST?	REJECT	REJECT	REJECT	REJECT

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 07 SEP 83 TO 07 OCT 83 .

THE VALUE OF FINAL IS O
RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL C4

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.625	439.000	17.500	.046
CALCULATED STANDARD DEV	.050	2.000	.577	.003
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	2.191	23.987	2.569	2.399
ACCEPT TEST?	OK	REJECT	REJECT	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 30 MAY 83 TO 29 JUN 83 .

RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL CDH2

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.500	347.500	33.250	.012
CALCULATED STANDARD DEV	.000	20.616	4.924	.008
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	4.362	11.064	7.439	-.759
ACCEPT TEST?	REJECT	REJECT	REJECT	OK

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 07 SEP 83 TO 07 OCT 83 .

RUN DATE 29 MAR 84

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

GROUND-WATER MONITORING STATISTICAL ANALYSIS

WELL CDH2

	PH	SPEC COND	TOC	TOX
UNITS		UMC	MGL	MGL
BACKGROUND MEAN	7.756	243.500	10.000	.020
BACKGROUND STANDARD DEV	.115	15.946	5.715	.021
BACKGROUND SAMPLE SIZE	16	16	16	16
CALCULATED MEAN	7.400	480.000	26.000	.080
CALCULATED STANDARD DEV	.000	.000	.000	.003
SAMPLE SIZE	4	4	4	4
DEGREES OF FREEDOM	18	18	18	18
REFERENCE/BOOK T-VALUE	2.878	2.552	2.552	2.552
CALCULATED T-VALUE	6.066	29.063	5.486	5.613
ACCEPT TEST?	REJECT	REJECT	REJECT	REJECT

THIS STUDENT'S T-TEST AT THE 0.01 LEVEL OF SIGNIFICANCE IS A TWO-TAILED TEST FOR PH AND A SINGLE-TAILED TEST FOR THE OTHER INDICATOR PARAMETERS. A CALCULATED T-VALUE GREATER THAN THE REFERENCE T-VALUE INDICATES A STATISTICALLY SIGNIFICANT CHANGE OF THE CONCENTRATION OR VALUE OF THE INDICATOR PARAMETER FROM BACKGROUND. THIS TEST IS FOR DATA WITH SAMPLING DATES FROM 30 MAY 83 TO 29 JUN 83 .

APPENDIX D

GROUNDWATER MONITORING RESULTS

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA FACILITY: SITE 5

LEGEND

NOTES: ALL METALS AND OTHER PARAMETERS WHERE APPROPRIATE ARE ON A DISSOLVED (FILTERED) BASIS UNLESS OTHERWISE NOTED. DETECTION LIMITS SHOWN ARE NORMAL LEVELS; ACTUAL LIMITS MAY VARY IN ENVIRONMETAL SAMPLES. ANALYTICAL RESULTS ARE ACCURATE TO EITHER 2 OR 3 SIGNIFICANT FIGURES.

A VALUES SHOWN ARE FOR WATER LEVEL ELEVATION ABOVE A REFERENCE DATUM
B UPGRADIENT SITE
C RESULTS ARE FOR UNFILTERED SAMPLE
* VALUE EXCEEDS A NATIONAL INTERIM PRIMARY DRINKING WATER REGULATION STANDARD
# VALUE EXCEEDS A NATIONAL SECONDARY DRINKING WATER REGULATION CRITERIA
& VALUE EXCEEDS A STATE WATER QUALITY STANDARD OR CRITERIA

MGL - MILLIGRAMS/LITER
UGL - MICROGRAMS/LITER
PCL - PICOCURIES/LITER
UMC - MICROMHOS/CENTIMETER
NTU - NEPHELOMETRIC TURBIDITY UNITS
TON - THRESHOLD ODOR NUMBER
TDN - TASTE DILUTION INDEX NUMBER
CU - COLOR UNITS
PHM - PER 100 MILLILITERS

RUN DATE: 16 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 8

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	8 S5W8	S5W5	S5W6	S5W7
GROSS ALPHA	02 NOV 81	1.30	PCL	28.20	ND	3.18	1.62
GROSS ALPHA	30 NOV 81	1.30	PCL	25.70			
GROSS ALPHA	22 MAR 82	23.70	PCL	<23.70	<4.66	<2.67	<4.41
GROSS ALPHA	07 JUN 82	23.60	PCL	<23.60	<4.11	<3.76	<5.18
RADIUM-228	30 NOV 81	.05	PCL	.71			
RADIUM-226	07 JUN 82	.05	PCL				.27
GROSS BETA	02 NOV 81	1.30	PCL	24.70	2.27	3.38	2.02
GROSS BETA	30 NOV 81	1.30	PCL	35.90			
GROSS BETA	22 MAR 82	1.30	PCL	27.60	3.09	4.30	2.47
GROSS BETA	07 JUN 82	1.30	PCL	18.80	2.73	3.27	1.84
STRONTIUM-90	30 NOV 81	1.7	PCL	ND			
TRITIUM	30 NOV 81	224.	PCL	ND			
URANIUM	11 NOV 81	0.	PCL	8.			
GROSS ALPHA	20 JUL 82	1.3	PCL	49.60			

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 5

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8	S5W5	S5W6	S5W7
WATER LEVELS (A)	07 JUN 82		FT	1772.0	1761.8	1762.4	1764.1
LEVELS (A)	19 JUL 82			1770.0			
ARSENIC	07 JUN 82	.010	MGL	.180*	ND	ND	ND
BARIUM	07 JUN 82	.1	MGL	ND	ND	ND	ND
CADMIUM	07 JUN 82	.005	MGL	ND	ND	ND	ND
CHROMIUM	07 JUN 82	.010	MGL	.020	ND	ND	ND
FLUORIDE	07 JUN 82	.10	MGL	5.00*	.14	.20	.42
LEAD	07 JUN 82	.010	MGL	.010	ND	ND	ND
MERCURY	07 JUN 82	.2	UGL	ND	ND	.4&	.3&
NO2+NO3 AS N	07 JUN 82	.05	MGL	260.00&	16.00&	60.00&	3.00
SELENIUM	07 JUN 82	.005	MGL	.016*	ND	ND	ND
SILVER	07 JUN 82	.01	MGL	.01	ND	ND	ND
ENDRIN	07 JUN 82	.04	UGL	ND	ND	ND	ND
LINDANE	07 JUN 82	.08	UGL	ND	ND	ND	ND
TOXAPHENE	07 JUN 82	1.6	UGL	ND	ND	ND	ND
METHOXYCHLOR	07 JUN 82	1.6	UGL	ND	ND	ND	ND
2,4-D	07 JUN 82	3.8	UGL	ND	ND	ND	ND
SILVEX	07 JUN 82	.5	UGL	ND	ND	ND	ND
GROSS ALPHA	07 JUN 82	23.60	PCL	<23.60	<4.77	<3.76	<5.18
GROSS ALPHA	20 JUL 82	1.30	PCL	49.60			
RADIUM-226	07 JUN 82	.05	PCL				.27
GROSS BETA	07 JUN 82	1.30	PCL	18.80	2.73	3.27	1.84
CHLORIDE	07 JUN 82	1.0	MGL	16.0	64.0	23.0	53.0
IRON	07 JUN 82	.03	MGL	1.06#	ND	ND	.19
MANGANESE	07 JUN 82	.01	MGL	63.00#	.79#	2.28#	ND
PHENOL	07 JUN 82	.01	MGL	.01&	ND	ND	ND
SODIUM	07 JUN 82	1.	MGL	76.	26.	30.	31.
SULFATE	07 JUN 82	5.0	MGL	330.0#	270.0#	330.0#	63.0
PH(FIELD)	07 JUN 82		PH	4.0&	6.6	5.3&	7.2
PH(FIELD)	07 JUN 82		PH	4.0&	6.6	5.3&	7.2
PH(FIELD)	07 JUN 82		PH	4.0&	6.6	5.3&	7.2
PH(FIELD)	07 JUN 82		PH	4.0&	6.6	5.3&	7.2
SPEC COND	07 JUN 82	1.	UMC	4750.	1220.	1260.	742.
SPEC COND	07 JUN 82	1.	UMC	4750.	1220.	1270.	743.
SPEC COND	07 JUN 82	1.	UMC	4750.	1220.	1260.	742.
SPEC COND	07 JUN 82	1.	UMC	4750.	1220.	1260.	743.
TOC	07 JUN 82	1.0	MGL	9.0	37.0	5.0	32.0
TOC	07 JUN 82	1.0	MGL	9.0	37.0	5.0	32.0
TOC	07 JUN 82	1.0	MGL	9.0	37.0	5.0	32.0
TOC	07 JUN 82	1.0	MGL	9.0	37.0	5.0	32.0

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 5

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8		S5W5		S5W6		S5W7	
TOX	07 JUN 82	.010	MGL	.028	C	.014	C	.014	C	.013	C
TOX	07 JUN 82	.010	MGL	.029	C	.041	C	ND		.016	C
TOX	07 JUN 82	.010	MGL	.030	C	.027	C	ND		.020	C
TOX	07 JUN 82	.010	MGL	.027	C	.013	C	.014	C	.013	C

RUN DATE: 14 JAN 83

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 5

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8	S5W5	S5W6	S5W7
GROSS ALPHA	02 NOV 81	1.30	PCL	28.20	ND	3.18	1.62
GROSS ALPHA	30 NOV 81	1.30	PCL	25.70			
GROSS ALPHA	22 MAR 82	23.70	PCL	<23.70	<4.66	<2.67	<4.41
GROSS ALPHA	07 JUN 82	23.60	PCL	<23.60	<4.77	<3.76	<5.18
GROSS ALPHA	20 JUL 82	1.30	PCL	49.60			
GROSS ALPHA	13 SEP 82	11.90	PCL	32.10	<8.23	<11.9	<4.69
RADIUM-226	30 NOV 81	.05	PCL	.71			
RADIUM-226	07 JUN 82	.05	PCL				.27
GROSS BETA	02 NOV 81	1.30	PCL	24.70	2.27	3.36	2.02
GROSS BETA	30 NOV 81	1.30	PCL	35.90			
GROSS BETA	22 MAR 82	1.30	PCL	27.60	3.09	4.30	2.47
GROSS BETA	07 JUN 82	1.30	PCL	18.00	2.73	3.27	1.84
GROSS BETA	13 SEP 82	1.30	PCL	18.10	3.35	3.41	2.47
STRONTIUM-90	30 NOV 81	1.7	PCL	ND			
STRONTIUM-90	20 JUL 82	1.0	PCL	ND			
TRITIUM	30 NOV 81	224.	PCL	ND			
URANIUM	11 NOV 81		PCL	8.			
URANIUM	20 JUL 82		PCL	19.			

RUN DATE: 14 JAN 83

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 5

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	SAMPLING SITES RESULTS B S5W8		S5W5		S5W6		S5W7	
WATER LEVELS (A)	13 SEP 82		FT	1764.5		1758.8		1760.4		1760.1	
ARSENIC	13 SEP 02	.010	MGL	.138*		ND		ND		ND	
BARIUM	13 SEP 82	.1	MGL	ND		.3		ND		.2	
CADMIUM	13 SEP 82	.005	MGL	.010		ND		ND		ND	
CHROMIUM	13 SEP 02	.010	MGL	.160*		ND		.020		ND	
FLUORIDE	13 SEP 02	.10	MGL	3.00*		.16		.20		.52	
LEAD	13 SEP 82	.010	MGL	.014		ND		ND		ND	
MERCURY	13 SEP 02	.2	UGL	ND		ND		.3$		ND	
NO2+NO3 AS N	13 SEP 02	.05	MGL	270.00&		17.00&		88.00$		3.00	
SELENIUM	13 SEP 02	.005	MGL	ND		ND		ND		ND	
SILVER	13 SEP 82	.01	MGL	ND		ND		ND		ND	
ENDRIN	13 SEP 82	.04	UGL	ND		ND		ND		ND	
LINDANE	13 SEP 02	.08	UGL	ND		ND		ND		ND	
TOXAPHENE	13 SEP 02	1.6	UGL	ND		ND		ND		ND	
METHOXYCHLOR	13 SEP 82	1.6	UGL	ND		ND		ND		ND	
2,4-D	13 SEP 82	3.8	UGL	ND		ND		ND		ND	
SILVEX	13 SEP 82	.5	UGL	ND		ND		ND		ND	
GROSS ALPHA	13 SEP 02	11.90	PCL	32.10*		<8.23		<11.9		<4.89	
GROSS BETA	13 SEP 82	1.30	PCL	18.10		3.35		3.41		2.47	
CHLORIDE	13 SEP 82	1.0	MGL	16.0		59.0		30.0		62.0	
IRON	13 SEP 02	.03	MGL	.60#		ND		ND		ND	
MANGANESE	13 SEP 02	.01	MGL	35.00#		.44#		3.80#		.04	
SODIUM	13 SEP 82	1.	MGL	45.		25.		46.		23.	
SULFATE	13 SEP 02	5.0	MGL	2310.0#		290.0#		610.0#		84.0	
PH(FIELD)	13 SEP 82		PH	3.08&		6.7		5.48&		7.1	
PH(FIELD)	13 SEP 02		PH	3.88&		6.6		5.48&		7.1	
PH(FIELD)	13 SEP 82		PH	3.88&		6.7		5.48&		7.1	
PH(FIELD)	13 SEP 82		PH	3.88&		6.7		5.48&		7.1	
SPEC COND	13 SEP 02	1.	UMC	3980.		680.		1900.		475.	
SPEC COND	13 SEP 02	1.	UMC	4000.		600.		1900.		475.	
SPEC COND	13 SEP 02	1.	UMC	4000.		600.		1880.		480.	
SPEC COND	13 SEP 82	1.	UMC	3950.		680.		1900.		475.	
TOC	13 SEP 82	1.0	MGL	7.0		29.0		7.0		20.0	
TOC	13 SEP 82	1.0	MGL	7.0		28.0		7.0		21.0	
TOC	13 SEP 02	1.0	MGL	8.0		30.0		7.0		20.0	
TOC	13 SEP 82	1.0	MGL	8.0		29.0		7.0		20.0	
TOX	13 SEP 82	.010	MGL	.080	C	.029	C	.040	C	.030	C
TOX	13 SEP 82	.010	MGL	.052	C	.032	C	.047	C	.036	C
TOX	13 SEP 82	.010	MGL	.063	C	.028	C	.056	C	.038	C
TOX	13 SEP 82	.010	MGL	.069	C	.027	C	.049	C	.034	C

RUN DATE: 14 JAN 83

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 5

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8	S5W5	S5W6	S5W7
TOC(UNFILT)	13 SEP 82	1.000	MGL	15.000	42.000		24.000
TOC(UNFILT)	13 SEP 82	1.000	MGL	15.000	41.000		22.000
TOC(UNFILT)	13 SEP 82	1.000	MGL	15,000	42.000		23.000
TOC(UNFILT)	13 SEP 82	1.000	MGL	15.000	41.000		23.000

RUN DATE: 26 JUL 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	SAMPLING SITES RESULTS B S5W8	S5W5	S5W6	S5W7
WATER LEVELS (A)	25 APR 83		FT	1767.5	1760.8	1759.4	1761.1
CHLORIDE	26 APR 83	1.0	MGL	35.0	62.0 C	14.0 C	49.0
CHLORIDE	26 APR 83	1.0	MGL	34.0 C	62.0	14.0	50.0 C
IRON	26 APR 83	.03	MGL	.24	23.40# C	12.40# C	ND
IRON	26 APR 83	.03	MGL	56.40# C	ND	ND	63.40# C
MANGANESE	26 APR 83	.01	MGL	40.40# C	.50#	1.59# C	2.60# C
MANGANESE	26 APR 83	.01	MGL	41.00#	.80# C	1.08#	.03
PHENOL	26 APR 83	.01	MGL	.01&	ND	ND	ND
PHENOL	26 APR 83	.01	MGL	.01& C	ND	ND	ND
SODIUM	26 APR 83	1.	MGL	42. C	25.	18. C	21.
SODIUM	26 APR 83	1.	MGL	37.	26. C	17.	21. C
SULFATE	26 APR 83	5.0	MGL	2200.0# C	260.0# C	170.0 C	42.0
SULFATE	26 APR 83	5.0	MGL	2050.0#	260.0#	160.0	54.0 C
PH(FIELD)	26 APR 83		PH	3.8#	6.9	5.6#	7.5
PH(FIELD)	26 APR 83		PH	3.8#	6.9	5.6#	7.4
PH(FIELD)	26 APR 83		PH	3.8#	6.8	5.5#	7.5
PH(FIELD)	26 APR 83		PH	3.8#	6.8	5.6#	7.4
SPEC COND	26 APR 83	1.	UMC	3700.	1200.	680.	660.
SPEC COND	26 APR 83	1.	UMC	3750.	1200.	680.	660.
SPEC COND	26 APR 83	1.	UMC	3700.	1200.	680.	660.
SPEC COND	26 APR 83	1.	UMC	3700.	1200.	680.	660.
TOC	26 APR 83	1.0	MGL	18.0	28.0	8.0	22.0
TOC	26 APR 83	1.0	MGL	17.0	29.0	8.0	22.0
TOC	26 APR 83	1.0	MGL	18.0	28.0	8.0	22.0
TOC	26 APR 83	1.0	MGL	18.0	28.0	9.0	23.0
TOX	26 APR 83	.010	MGL	.052 C	.029 C	.046 C	.034 C
TOX	26 APR 83	.010	MGL	.057 C	.036 C	.042 C	.034 C
TOX	26 APR 83	.010	MGL	.056 C	.034 C	.046 C	.041 C
TOX	26 APR 83	.010	MGL	.053 C	.031 C	.043 C	.035 C
TOC(UNFILT)	26 APR 83	1.000	MGL	15.000	18.000	9.000	14.000
TOC(UNFILT)	26 APR 83	1.000	MGL	14.000	18.000	9.000	15.000
TOC(UNFILT)	26 APR 83	1.000	MGL	15.000	18.000	9.000	15.000
TOC(UNFILT)	26 APR 83	1.000	MGL	14.000	18.000	9.000	15.000
SUSP SOLIDS	26 APR 83	5.	MGL	5.	ND	ND	9.
SUSP SOLIDS	26 APR 83	5.	MGL	2249. C	588. C	468. C	498. C

RUN DATE: 26 SEP 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	D S5W8	S5W5	S5W6	S5W7
WATER LEVELS (A)	01 AUG 83		FT	1761.5	1757.0	1756.4	1758.6
PH(FIELD)	01 AUG 83		PH	3.5#	6.5	5.1#	7.2
PH(FIELD)	01 AUG 83		PH	3.5#	6.5	5.2#	7.1
PH(FIELD)	01 AUG 83		PH	3.5#	6.5	5.1#	7.1
PH(FIELD)	01 AUG 83		PH	3.5#	6.5	5.2#	7.2
PH(LAB)	01 AUG 83		PH		7.3	7.1	7.2
PH(LAB)	01 AUG 83		PH		7.3	7.0	7.1
SPEC COND	01 AUG 83	1.	UMC	470.	1400.	1860.	600.
SPEC COND	01 AUG 83	1.	UMC	470.	1400.	1860.	595.
SPEC COND	01 AUG 83	1.	UMC	470.	1400.	1860.	590.
SPEC COND	01 AUG 83	1.	UMC	470.	1390.	1860.	600.
TOC	01 AUG 83	1.0	MGL	7.0	20.0	9.0	5.0
TOC	01 AUG 83	1.0	MGL	7.0	20.0	9.0	5.0
TOC	01 AUG 83	1.0	MGL	7.0	19.0	9.0	5.0
TOC	01 AUG 83	1.0	MGL	7.0	19.0	8.0	5.0
TOX	01 AUG 83	.010	MGL	.074 C	.058 C	.093 C	.029 C
TOX	01 AUG 83	.010	MGL	.073 C	.060 C	.092 C	.040 C
TOX	01 AUG 83	.010	MGL	.060 C	.062 C	.067 C	.038 C
TOX	01 AUG 83	.010	MGL	.075 C	.065 C	.079 C	.040 C
TOC(UNFILT)	01 AUG 83	1.0	MGL	32.0	68.0	31.0	33.0
TOC(UNFILT)	01 AUG 83	1.0	MGL	32.0	69.0	31.0	32.0
TOC(UNFILT)	01 AUG 83	1.0	MGL	32.0	67.0	31.0	34.0
TOC(UNFILT)	01 AUG 83	1.0	MGL	33.0	68.0	32.0	33.0
SUSP SOLIDS	01 AUG 83	5.	MGL	217.	ND	ND	219.
SUSP SOLIDS	01 AUG 83	5.	MGL	ND	5730.	1611.	ND

RUN DATE: 13 NOV 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8	W8B	W5B	S5W6	W7B
WATER LEVELS (A)	28 AUG 84		FT	1769.9	1774.0	1762.6	1761.4	1763.3
ARSENIC	28 AUG 84	.010	MGL	.174*	ND	ND	ND	.148*
ARSENIC	28 AUG 84	.010	MGL	2.670* C	ND	.286* C	ND	.156* C
BARIUM	28 AUG 84	.30	MGL	ND	.18	ND	ND	ND
BARIUM	28 AUG 84	.30	MGL	ND	.11 C	ND	ND	ND
CADMIUM	28 AUG 84	1.0	UGL	8.9	ND	1.0	ND	2.7
CADMIUM	28 AUG 84	1.0	UGL	8.5 C	ND	1.2 C	ND	2.1 C
CHROMIUM	28 AUG 84	.001	MGL	.097*	ND	.002	.003	.085*
CHROMI M	28 AUG 84	.001	MGL	.132* C	ND	.010 C	.004 C	.101* C
LEAD	28 AUG 84	.005	MGL	.007	ND	ND	ND	.006
LEAD	28 AUG 84	.005	MGL	.026 C	.001 C	.016 C	ND	ND
MERCURY	28 AUG 84	.2	UGL	.2	ND	.2	.2	.3
MERCURY	28 AUG 84	.2	UGL	11.8* C	ND	.6 C	ND	ND
NO2+NO3 AS N	28 AUG 84	.01	MGL	287.00*	5.30	56.00*	26.00*	104.00*
NO2+NO3 AS N	28 AUG 84	.01	MGL	284.00* C	5.50 C	56.00* C	28.00* C	59.00* C
SELENIUM	28 AUG 84	.005	MGL	.013*	ND	.012*	ND	ND
SELENIUM	28 AUG 84	.005	MGL	.015* C	ND	.011* C	ND	ND
SILVER	28 AUG 84	.025	MGL	ND	ND	ND	ND	ND
SILVER	28 AUG 84	.025	MGL	ND	ND	ND	ND	ND
IRON	28 AUG 84	.10	MGL	.20	ND	ND	ND	.31#
IRON	28 AUG 84	.10	MGL	30.50# C	.47# C	9.35# C	ND	.66# C
MANGANESE	28 AUG 84	.001	MGL	46.000#	.068#	.296#	.605#	9.090#
MANGANESE	28 AUG 84	.001	MGL	42.500# C	.072# C	.455# C	1.050# C	8.790# C
SULFATE	28 AUG 84	.1	MGL	2278.0#	1.0	100.0	149.0 C	210.0
SULFATE	28 AUG 84	.1	MGL	2455.0# C	1.0 C	101.0 C	149.0	1060.0# C
PH(FIELD)	28 AUG 84		PH	3.4#	4.9#	5.6#	5.0#	3.2#
PH(FIELD)	28 AUG 84		PH	3.4#	4.9#	5.6#	5.0#	3.2#
PH(FIELD)	28 AUG 84		PH	3.3#	4.9#	5.6#	5.0#	3.2#
PH(FIELD)	28 AUG 84		PH	3.4#	4.9#	5.6#	5.0#	3.2#
SPEC COND	28 AUG 84	1.	UMC	3900.	112.	720.	490.	1800.
SPEC COND	28 AUG 84	1.	UMC	3800.	110.	720.	500.	1900.
SPEC COND	28 AUG 84	1.	UMC	3900.	110.	710.	490.	1800.
SPEC COND	28 AUG 84	1.	UMC	3900.	110.	710.	490.	1800.
TOC	28 AUG 84	.1	MGL	5.0	2.0	2.0	1.0	2.0
TOC	28 AUG 84	.1	MGL	5.0	2.0	2.0	1.0	2.0
TOC	28 AUG 84	.1	MGL	6.0	2.0	2.0	1.0	2.0
TOC	28 AUG 84	.1	MGL	5.0	2.0	2.0	1.0	2.0
TOX	28 AUG 84	.010	MGL	.048 C	.026 C	ND	.013 C	.027 C
TOX	28 AUG 84	.010	MGL	.047 C	.037 C	.013 C	.013 C	.022 C
TOX	28 AUG 84	.010	MGL	.046 C	.024 C	.012 C	.015 C	.024 C

RUN DATE: 13 NOV 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 5

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S5W8		W8B		W5B	S5W6	W7B	
				SAMPLING SITES RESULTS							
TOX	28 AUG 84	.010	MGL	.046	C	.034	C	ND	ND	.019	C
TOC(UNFILT)	28 AUG 84	1.0	MGL	6.0		1.0		3.0	1.0	2.0	
TOC(UNFILT)	28 AUG 84	1.0	MGL	6.0		2.0		3.0	1.0	2.0	
TOC(UNFILT)	28 AUG 84	1.0	MGL	6.0		2.0		3.0	1.0	2.0	
TOC(UNFILT)	28 AUG 84	1.0	MGL	6.0		1.0		3.0	1.0	2.0	
TDS	28 AUG 84	1.	MGL	4529.		50.		597.	406.	1872.	

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 7

LEGEND

NOTES: ALL METALS AND OTHER PARAMETERS WHERE APPROPRIATE ARE ON A DISSOLVED (FILTERED) BASIS UNLESS OTHERWISE NOTED. DETECTION LIMITS SHOWN ARE NORMAL LEVELS; ACTUAL LIMITS MAY VARY IN ENVIRONMETAL SAMPLES. ANALYTICAL RESULTS ARE ACCURATE TO EITHER 2 OR 3 SIGNIFICANT FIGURES.

A   VALUES SHOWN ARE FOR WATER LEVEL ELEVATION ABOVE A REFERENCE DATUM
B   UPGRADIENT SITE
C   RESULTS ARE FOR UNFILTERED SAMPLE
\#   VALUE EXCEEDS A NATIONAL SECONDARY DRINKING WATER REGULATION CRITERIA
&   VALUE EXCEEDS A STATE WATER QUALITY STANDARD OR CRITERIA
D - WELL WAS DRY

MGL - MILLIGRAMS/LITER
UGL - MICROGRAMS/LITER
PCL - PICOCURIES/LITER
UMC - MICROMHOS/CENTIMETER
NTU - NEPHELOMETRIC TURBIDITY UNITS
TON - THRESHOLD ODOR NUMBER
TDN - TASTE DILUTION INDEX NUMBER
CU - COLOR UNITS
PHM - PER 100 MILLILITERS

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 7

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S7W12	S7W9	S7W10	S7W11
				SAMPLING SITES RESULTS			
WATER LEVELS (A)	21 JUN 82		FT	D	1687.5	D	D
ARSENIC	21 JUN 82	.010	MGL		ND		
BARIUM	21 JUN 82	.1	MGL		ND		
CADMIUM	21 JUN 82	.005	MGL		ND		
CHROMIUM	21 JUN 82	.010	MGL		ND		
FLUORIDE	21 JUN 82	.10	MGL		.20		
LEAD	21 JUN 82	.010	MGL		ND		
MERCURY	21 JUN 82	.2	UGL		ND		
NO2+NO3 AS N	21 JUN 82	.05	MGL		10.008		
SELENIUM	21 JUN 82	.005	MGL		ND		
SILVER	21 JUN 82	.01	MGL		ND		
ENDRIN	21 JUN 82	.04	UGL		ND		
LINDANE	21 JUN 82	.08	UGL		ND		
TOXAPHENE	21 JUN 82	1.6	UGL		ND		
METHOXYCHLOR	21 JUN 82	1.6	UGL		ND		
2,4-D	21 JUN 82	3.8	UGL		ND		
SILVEX	21 JUN 82	.5	UGL		ND		
GROSS ALPHA	21 JUN 82	1.30	PCL		8.15		
RADIUM-226	21 JUN 82	.05	PCL		.30		
GROSS BETA	21 JUN 82	1.30	PCL		2.19		
CHLORIDE	21 JUN 82	1.0	MGL		35.0		
IRON	21 JUN 82	.03	MGL		ND		
MANGANESE	21 JUN 82	.01	MGL		.53#		
PHENOL	21 JUN 82	.01	MGL		ND		
SODIUM	21 JUN 82	1.	MGL		[illegible]		
SULFATE	21 JUN 82	5.0	MGL		480.0#		
SPEC COND	21 JUN 82	1.	UMC		1560.		
SPEC COND	21 JUN 82	1.	UMC		1570.		
SPEC COND	21 JUN 82	1.	UMC		1560.		
SPEC COND	21 JUN 82	1.	UMC		1560.		
TOC	21 JUN 82	1.0	MGL		53.0		
TOC	21 JUN 82	1.0	MGL		53.0		
TOC	21 JUN 82	1.0	MGL		53.0		
TOC	21 JUN 82	1.0	MGL		53.0		
TOX	21 JUN 82	.010	MGL		.018 C		
TOX	21 JUN 82	.010	MGL		.018 C		
TOX	21 JUN 82	.010	MGL		.018 C		
TOX	21 JUN 82	.010	MGL		.018 C		

RUN DATE: 29 OCT 82

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 7

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S7W12	S7W9	S7W10	S7W11
GROSS ALPHA	09 NOV 81	2.89	PCL		ND		
GROSS ALPHA	10 NOV 81	1.30	PCL			ND	
GROSS ALPHA	30 MAR 82	22.80	PCL		<7.51	<5.69	<22.80
GROSS ALPHA	21 JUN 82	1.30	PCL		8.15		
RADIUM-226	30 MAR 82	.05	PCL			.17	
RADIUM-226	21 JUN 82	.05	PCL		.30		
GROSS BETA	09 NOV 81	1.30	PCL		2.29		
GROSS BETA	10 NOV 81	1.30	PCL			2.72	
GROSS BETA	30 MAR 82	1.56	PCL		ND	ND	2.09
GROSS BETA	21 JUN 82	1.30	PCL		2.19		
URANIUM	30 MAR 82	0.	PCL				0.

RUN DATE: 14 JAN 83

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 7

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S7W12	S7W9	S7W10	S7W11
				SAMPLING SITES RESULTS			
WATER LEVELS (A)	20 SEP 82	-	FT		1686.5	1693.0	
ARSENIC	20 SEP 82	.010	MGL		ND	ND	
BARIUM	20 SEP 82	.1	MGL		.3	.3	
CADMIUM	20 SEP 82	.005	MGL		ND	ND	
CHROMIUM	20 SEP 82	.010	MGL		ND	ND	
FLUORIDE	20 SEP 82	.10	MGL		.21	.12	
LEAD	20 SEP 82	.010	MGL		ND	ND	
MERCURY	20 SEP 82	.2	UGL		ND	ND	
NO2+NO3 AS N	20 SEP 82	.05	MGL		8.00&	3.00	
SELENIUM	20 SEP 82	.005	MGL		ND	ND	
SILVER	20 SEP 82	.01	MGL		ND	ND	
ENDRIN	20 SEP 82	.04	UGL		ND	ND	
LINDANE	20 SEP 82	.08	UGL		ND	ND	
TOXAPHENE	20 SEP 82	1.6	UGL		ND	ND	
METHOXYCHLOR	20 SEP 82	1.6	UGL		ND	ND	
2,4-D	20 SEP 82	3.8	UGL		ND	ND	
SILVEX	20 SEP 82	.5	UGL		ND	ND	
GROSS ALPHA	20 SEP 82	6.18	PCL		<6.16	<4.41	
GROSS BETA	20 SEP 82	1.71	PCL		1.10	ND	
CHLORIDE	20 SEP 82	1.0	MGL		9.0	7.0	
IRON	20 SEP 82	.03	MGL		ND	ND	
MANGANESE	20 SEP 82	.01	MGL		.51#	.11#	
PHENOL	20 SEP 82	.01	MGL		.01&	.01&	
SODIUM	20 SEP 82	1.	MGL		132.	6.	
SULFATE	20 SEP 82	5.0	MGL		230.0	37.0	
PH(FIELD)	20 SEP 82		PH		7.3	7.2	
PH(FIELD)	20 SEP 82		PH		7.3	7.2	
PH(FIELD)	20 SEP 82		PH		7.3	7.2	
PH(FIELD)	20 SEP 82		PH		7.3	7.2	
SPEC COND	20 SEP 82	1.	UMC		1400.	900.	
SPEC COND	20 SEP 82	1.	UMC		1490.	900.	
SPEC COND	20 SEP 82	1.	UMC		1490.	900.	
SPEC COND	20 SEP 82	1.	UMC		1490.	900.	
TOC	20 SEP 82	1.0	MGL		36.0	25.0	
TOC	20 SEP 82	1.0	MGL		37.0	26.0	
TOC	20 SEP 82	1.0	MGL		40.0	27.0	
TOC	20 SEP 82	1.0	MGL		37.0	27.0	
TOX	20 SEP 82	.010	MGL		ND	.042 C	
TOX	20 SEP 82	.010	MGL		.013 C	ND	
TOX	20 SEP 82	.010	MGL		.010 C	ND	

RUN DATE: 14 JAN 83

INSTALLATION: RADFORD AAP, VA

FACILITY: SITE 7

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S7W12	S7W9	S7W10	S7W11
TOX	20 SEP 82	.010	MGL		ND	ND	
TOC(UNFILT)	20 SEP 82	1.000	MGL		71.000	142.000	
TOC(UNFILT)	20 SEP 82	1.000	MGL		75.000	142.000	
TOC(UNFILT)	20 SEP 82	1.000	MGL		70.000	135.000	
TOC(UNFILT)	20 SEP 82	1.000	MGL		71.000	137.000	

RUN DATE: 26 JUL 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 7

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B S7W12	S7W9	S7W10	S7W11
WATER LEVELS (A)	02 MAY 83		FT	1694.1	1686.5		1700.2
CHLORIDE	02 MAY 83	1.0	MGL	6.0	16.0		23.0 C
CHLORIDE	02 MAY 83	1.0	MGL	6.0 C	16.0 C		21.0
IRON	02 MAY 83	.03	MGL	ND	7.40# C		35.90# C
IRON	02 MAY 83	.03	MGL	22.80# C	.04		.07
MANGANESE	02 MAY 83	.01	MGL	.62# C	.55# C		5.10#
MANGANESE	02 MAY 83	.01	MGL	.13#	.40#		7.50# C
PHENOL	02 MAY 83	.01	MGL	.01& C	.01& C		.03&
PHENOL	02 MAY 83	.01	MGL	.01&	ND		.03& C
SODIUM	02 MAY 83	1.	MGL	7.	160.		1600.& C
SODIUM	02 MAY 83	1.	MGL	7. C	164. C		1540.&
SULFATE	02 MAY 83	5.0	MGL	100.0	710.0# C		4500.0# C
SULFATE	02 MAY 83	5.0	MGL	130.0 C	580.0#		4100.0#
PH(FIELD)	02 MAY 83		PH	7.1	7.4		7.2
PH(FIELD)	02 MAY 83		PH	7.1	7.3		7.1
PH(FIELD)	02 MAY 83		PH	7.1	7.4		7.1
PH(FIELD)	02 MAY 83		PH	7.1	7.4		7.1
SPEC COND	02 MAY 83	1.	UMC	680.	1750.		6800.
SPEC COND	02 MAY 83	1.	UMC	685.	1750.		6800.
SPEC COND	02 MAY 83	1.	UMC	685.	1750.		6750.
SPEC COND	02 MAY 83	1.	UMC	680.	1750.		6800.
TOC	02 MAY 83	1.0	MGL	24.0	26.0		99.0
TOC	02 MAY 83	1.0	MGL	23.0	25.0		99.0
TOC	02 MAY 83	1.0	MGL	24.0	25.0		98.0
TOC	02 MAY 83	1.0	MGL	23.0	25.0		100.0
TOX	02 MAY 83	.010	MGL	.029 C	ND C		.030 C
TOX	02 MAY 83	.010	MGL	.035 C	.015 C		.028 C
TOX	02 MAY 83	.010	MGL	.032 C	.012 C		.029 C
TOX	02 MAY 83	.010	MGL	.037 C	ND C		.016 C
TOC(UNFILT)	02 MAY 83	1.000	MGL	32.000	18.000		65.000
TOC(UNFILT)	02 MAY 83	1.000	MGL	32.000	17.000		66.000
TOC(UNFILT)	02 MAY 83	1.000	MGL	33.000	18.000		66.000
TOC(UNFILT)	02 MAY 83	1.000	MGL	32.000	18.000		65.000
SUSP SOLIDS	02 MAY 83	5.	MGL	ND	429. C		1911. C
SUSP SOLIDS	02 MAY 83	5.	MGL	424. C	5.		12.

RUN DATE: 09 MAY 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 7

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	SAMPLING SITES RESULTS B W12B	S7W9	W10B	W11B
WATER LEVELS (A)	08 AUG 83		FT	1691.3			1687.9
PH(FIELD)	08 AUG 83		PH	7.4			7.5
PH(FIELD)	08 AUG 83		PH	7.4			7.5
PH(FIELD)	08 AUG 83		PH	7.5			7.5
PH(FIELD)	08 AUG 83		PH	7.4			7.5
SPEC COND	08 AUG 83	1.	UMC	1000.			7600.
SPEC COND	08 AUG 83	1.	UMC	1000.			7600.
SPEC COND	08 AUG 83	1.	UMC	1010.			7600.
SPEC COND	08 AUG 83	1.	UMC	1010.			7500.
TOC	08 AUG 83	1.0	MGL	34.0&			156.0&
TOC	08 AUG 83	1.0	MGL	33.0&			156.0&
TOC	08 AUG 83	1.0	MGL	33.0&			155.0&
TOC	08 AUG 83	1.0	MGL	33.0&			154.0&
TOX	08 AUG 83	.010	MGL	.022 C			.038 C
TOX	08 AUG 83	.010	MGL	.025 C			ND
TOX	08 AUG 83	.010	MGL	.035 C			.027 C
TOX	08 AUG 83	.010	MGL	.025 C			.033 C
TOC(UNFILT)	08 AUG 83	1.0	MGL	108.0			178.0
TOC(UNFILT)	08 AUG 83	1.0	MGL	115.0			177.0
TOC(UNFILT)	08 AUG 83	1.0	MGL	110.0			178.0
TOC(UNFILT)	08 AUG 83	1.0	MGL	118.0			175.0
SUSP SOLIDS	08 AUG 83	5.	MGL	2680. C			3040. C
SUSP SOLIDS	08 AUG 83	5.	MGL	ND			ND

RUN DATE: 13 NOV 84

INSTALLATION: RADFORD AAP, VA   SITE: SITE 7

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	SAMPLING SITES RESULTS			
				B W12B	S7W9	W10B	W11B
WATER LEVELS (A)	29 AUG 84		FT	1695.3	1684.0	1682.6	1689.9
ARSENIC	29 AUG 84	.010	MGL	ND	ND	ND	.011
ARSENIC	29 AUG 84	.010	MGL	ND	ND	ND	.017 C
BARIUM	29 AUG 84	.30	MGL	ND	ND	ND	ND
BARIUM	29 AUG 84	.30	MGL	ND	ND	ND	ND
CADMIUM	29 AUG 84	1.0	UGL	ND	1.0	ND	13.3*
CADMIUM	29 AUG 84	1.0	UGL	ND	1.5 C	ND	14.7* C
CHROMIUM	29 AUG 84	.001	MGL	.005	.002	.001	.078*
CHROMIUM	29 AUG 84	.001	MGL	.008 C	.027 C	.002 C	.080* C
LEAD	29 AUG 84	.005	MGL	.007	ND	ND	ND
LEAD	29 AUG 84	.005	MGL	ND	.007 C	ND	ND
MERCURY	29 AUG 84	.2	UGL	.3	ND	.6	.2
MERCURY	29 AUG 84	.2	UGL	1.4 C	.4 C	1.3 C	ND
NO2+NO3 AS N	29 AUG 84	.01	MGL	4.70	138.00*	23.00*	301.00*
NO2+NO3 AS N	29 AUG 84	.01	MGL	4.70 C	116.00* C	25.00* C	277.00* C
SELENIUM	29 AUG 84	.005	MGL	ND	ND	.008	.005
SELENIUM	29 AUG 84	.005	MGL	ND	ND	.007 C	.008 C
SILVER	29 AUG 84	.025	MGL	ND	ND	ND	ND
SILVER	29 AUG 84	.025	MGL	ND	ND	ND	ND
IRON	29 AUG 84	.10	MGL	ND	ND	ND	1.30#
IRON	29 AUG 84	.10	MGL	4.99# C	11.40# C	ND	1.44# C
MANGANESE	29 AUG 84	.001	MGL	.246#	6.050# C	.625#	29.700#
MANGANESE	29 AUG 84	.001	MGL	.341# C	5.600#	.585# C	30.500# C
SULFATE	29 AUG 84	.1	MGL	149.0	1336.0#	1943.0#	2593.0#
SULFATE	29 AUG 84	.1	MGL	151.0 C	1306.0# C	1943.0# C	2652.0# C
PH(FIELD)	29 AUG 84		PH	7.5	6.9	7.1	4.3#
PH(FIELD)	29 AUG 84		PH	7.5	6.9	7.0	4.3#
PH(FIELD)	29 AUG 84		PH	7.5	6.9	7.0	4.3#
PH(FIELD)	29 AUG 84		PH	7.6	6.9	7.0	4.3#
SPEC COND	29 AUG 84	1.	UMC	740.	3000.	3400.	5200.
SPEC COND	29 AUG 84	1.	UMC	740.	3000.	3300.	5200.
SPEC COND	29 AUG 84	1.	UMC	740.	3000.	3400.	5200.
SPEC COND	29 AUG 84	1.	UMC	740.	2950.	3400.	5100.
TOC	29 AUG 84	.1	MGL	2.0	5.0	7.0	19.0
TOC	29 AUG 84	.1	MGL	1.0	5.0	6.0	19.0
TOC	29 AUG 84	.1	MGL	1.0	5.0	7.0	19.0
TOC	29 AUG 84	.1	MGL	2.0	5.0	6.0	19.0
TOX	29 AUG 84	.010	MGL	.039 C	ND	.020 C	.031 C
TOX	29 AUG 84	.010	MGL	.050 C	ND	.017 C	.029 C
TOX	29 AUG 84	.010	MGL	.044 C	ND	.011 C	.030 C

RUN DATE: 13 NOV 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 7

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B W12B		S7W9		W10B		W11B	
TOX	29 AUG 84	.010	MGL	.048	C	.012	C	.016	C	.027	C
TOC(UNFILT)	29 AUG 84	1.0	MGL	1.0		6.0		6.0		19.0	
TOC(UNFILT)	29 AUG 84	1.0	MGL	2.0		5.0		7.0		19.0	
TOC(UNFILT)	29 AUG 84	1.0	MGL	2.0		5.0		6.0		19.0	
TOC(UNFILT)	29 AUG 84	1.0	MGL	2.0		6.0		6.0		19.0	
TDS	29 AUG 84	1.	MGL	501.		3139.		3518.		5906.	

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

LEGEND

NOTES: ALL METALS AND OTHER PARAMETERS WHERE APPROPRIATE ARE ON A DISSOLVED (FILTERED) BASIS UNLESS OTHERWISE NOTED. DETECTION LIMITS SHOWN ARE NORMAL LEVELS; ACTUAL LIMITS MAY VARY IN ENVIRONMENTAL SAMPLES. ANALYTICAL RESULTS ARE ACCURATE TO EITHER 2 OR 3 SIGNIFICANT FIGURES.

A VALUES SHOWN ARE FOR WATER LEVEL ELEVATION ABOVE A REFERENCE DATUM
B UPGRADIENT SITE
@ RESULTS ARE FOR UNFILTERED SAMPLE
# VALUE EXCEEDS A NATIONAL SECONDARY DRINKING WATER REGULATION CRITERIA
& VALUE EXCEEDS A STATE WATER QUALITY STANDARD OR CRITERIA
D - WELL WAS DRY

MGL - MILLIGRAMS/LITER
UGL - MICROGRAMS/LITER
PCL - PICOCURIES/LITER
UMC - MICROMHOS/CENTIMETER
NTU - NEPHELOMETRIC TURBIDITY UNITS
TON - THRESHOLD ODOR NUMBER
TDN - TASTE DILUTION INDEX NUMBER
CU - COLOR UNITS
PHM - PER 100 MILLILITERS

RUN DATE: 13 DEC 83

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4	CDH2	C3	CDH3
WATER LEVELS (A)	12 JUL 82		FT	1790.8	D	1771.6	1771.6	D	
LEVELS (A)	13 JUN 83		FT	1788.8		1769.6	1768.1		
LEVELS (A)	19 SEP 83		FT	1785.8		1809.1	1763.1		
SULFATE	13 JUN 83	5.0	MGL	ND		7.0	6.0		
SULFATE	13 JUN 83	5.0	MGL	ND		ND	22.0 C		
PH(FIELD)	19 SEP 83		PH	7.5		7.5	7.5		
PH(FIELD)	19 SEP 83		PH	7.5		7.5	7.5		
PH(FIELD)	19 SEP 83		PH	7.5		7.4	7.5		
PH(FIELD)	19 SEP 83		PH	7.4		7.5	7.5		
PH(LAB)	19 SEP 83		PH				7.5		
SPEC COND	19 SEP 83	1.	UMC	230.		430.	370.		
SPEC COND	19 SEP 83	1.	UMC	230.		360.	330.		
SPEC COND	19 SEP 83	1.	UMC	230.		360.	360.		
SPEC COND	19 SEP 83	1.	UMC	220.		430.	330.		
TOC	19 SEP 83	1.0	MGL	16.0		34.0	29.0		
TOC	19 SEP 83	1.0	MGL	15.0		26.0	38.0		
TOC	19 SEP 83	1.0	MGL	16.0		34.0	29.0		
TOC	19 SEP 83	1.0	MGL	16.0		26.0	37.0		
TOX	19 SEP 83	.010	MGL	ND		14.430 C	.018 C		
TOX	19 SEP 83	.010	MGL	ND		15.230 C	ND		
TOX	19 SEP 83	.010	MGL	ND		14.170 C	ND		
TOX	19 SEP 83	.010	MGL	ND		14.350 C	.019 C		
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		25.0	36.0		
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		34.0	32.0		
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		33.0	33.0		
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		26.0	35.0		
SUSP SOLIDS	19 SEP 83	5.	MGL	11.		75.	1815.		
SUSP SOLIDS	19 SEP 83	5.	MGL	ND		ND	ND		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	SAMPLING SITES RESULTS B C1	C2	C4	CDH2	C3	CDH3
WATER									
LEVELS (A)	07 DEC 81		FT				1766.6		
LEVELS (A)	19 APR 82		FT	1790.9	D	1772.6	1769.1	D	
LEVELS (A)	12 JUL 82		FT	1790.8	D	1771.6	1771.6	D	
LEVELS (A)	13 JUN 83		FT	1788.8		1769.6	1768.1		
LEVELS (A)	19 SEP 83		FT	1785.8		1809.1	1763.1		
ARSENIC	07 DEC 81	.010	MGL	ND		ND	ND		
ARSENIC	19 APR 82	.010	MGL	ND		ND	ND		
ARSENIC	12 JUL 82	.010	MGL	ND		ND	ND		
ARSENIC	18 OCT 82	.010	MGL	ND		ND	ND		
BARIUM	07 DEC 81	.1	MGL	ND		ND	ND		
BARIUM	19 APR 82	.1	MGL	ND		ND	ND		
BARIUM	12 JUL 82	.1	MGL	ND		ND	ND		
BARIUM	18 OCT 82	.1	MGL	ND		ND	ND		
CADMIUM	07 DEC 81	.005	MGL	ND		ND	ND		
CADMIUM	17 DEC 81	.010	MGL	ND	ND	ND			
CADMIUM	19 APR 82	.005	MGL	ND		ND	ND		
CADMIUM	12 JUL 82	.005	MGL	ND		ND	ND		
CADMIUM	18 OCT 82	.005	MGL	ND		ND	ND		
CHROMIUM	07 DEC 81	.010	MGL	ND		ND	ND		
CHROMIUM	19 APR 82	.010	MGL	ND		ND	ND		
CHROMIUM	12 JUL 82	.010	MGL	ND		ND	ND		
CHROMIUM	18 OCT 82	.010	MGL	ND		ND	ND		
FLUORIDE	07 DEC 81	.10	MGL	.10		.13	ND		
FLUORIDE	19 APR 82	.10	MGL	.13		.15	ND		
FLUORIDE	12 JUL 82	.10	MGL	.10		.14	ND		
FLUORIDE	18 OCT 82	.10	MGL	.12		.14	ND		
LEAD	07 DEC 81	.010	MGL	ND		ND	ND		
LEAD	19 APR 82	.010	MGL	ND		ND	ND		
LEAD	12 JUL 82	.010	MGL	ND		ND	ND		
LEAD	18 OCT 82	.010	MGL	ND		ND	ND		
MERCURY	07 DEC 81	.2	UGL	ND		ND	ND		
MERCURY	19 APR 82	.2	UGL	.5&		ND	ND		
MERCURY	12 JUL 82	.2	UGL	ND		ND	ND		
MERCURY	18 OCT 82	.2	UGL	ND		ND	ND		
NO2+NO3 AS N	07 DEC 81	.01	MGL	6.20&		.19	3.20		
NO2+NO3 AS N	19 APR 82	.01	MGL	7.00&		.14	3.60		
NO2+NO3 AS N	12 JUL 82	.01	MGL	6.00&		4.00	.19		
NO2+NO3 AS N	18 OCT 82	.01	MGL	7.00&		.12	4.00		
SELENIUM	07 DEC 81	.005	MGL	ND		ND	ND		
SELENIUM	19 APR 82	.005	MGL	ND		ND	ND		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4	CDH2	C3	CDH3
SELENIUM	12 JUL 82	.005	MGL	ND		ND	ND		
SELENIUM	18 OCT 82	.005	MGL	ND		ND	ND		
SILVER	07 DEC 81	.010	MGL	ND		ND	ND		
SILVER	19 APR 82	.010	MGL	ND		ND	ND		
SILVER	12 JUL 82	.010	MGL	ND		ND	ND		
SILVER	18 OCT 82	.010	MGL	ND		ND	ND		
ENDRIN	07 DEC 81	.04	UGL	ND		ND	ND		
ENDRIN	19 APR 82	.04	UGL	ND		ND	ND		
ENDRIN	12 JUL 82	.04	UGL	ND		ND	ND		
ENDRIN	18 OCT 82	.04	UGL	ND		ND	ND		
LINDANE	07 DEC 81	.08	UGL	ND		ND	ND		
LINDANE	19 APR 82	.08	UGL	ND		ND	ND		
LINDANE	12 JUL 82	.08	UGL	ND		ND	ND		
LINDANE	18 OCT 82	.08	UGL	ND		ND	ND		
TOXAPHENE	07 DEC 81	1.6	UGL	ND		ND	ND		
TOXAPHENE	19 APR 82	1.6	UGL	ND		ND	ND		
TOXAPHENE	12 JUL 82	1.6	UGL	ND		ND	ND		
TOXAPHENE	18 OCT 82	1.6	UGL	ND		ND	ND		
METHOXYCHLOR	07 DEC 81	1.6	UGL	ND		ND	ND		
METHOXYCHLOR	19 APR 82	1.6	UGL	ND		ND	ND		
METHOXYCHLOR	12 JUL 82	1.6	UGL	ND		ND	ND		
METHOXYCHLOR	18 OCT 82	1.6	UGL	ND		ND	ND		
2,4-D	07 DEC 81	3.8	UGL	ND		ND	ND		
2,4-D	19 APR 82	3.8	UGL	ND		ND	ND		
2,4-D	12 JUL 82	3.8	UGL	ND		ND	ND		
2,4-D	18 OCT 82	3.8	UGL	ND		ND	ND		
SILVEX	07 DEC 81	.5	UGL	ND		ND	ND		
SILVEX	19 APR 82	.5	UGL	ND		ND	ND		
SILVEX	12 JUL 82	.5	UGL	ND		ND	ND		
SILVEX	18 OCT 82	.5	UGL	ND		ND	ND		
GROSS ALPHA	07 DEC 81	1.56	PCL	ND		ND	ND		
GROSS ALPHA	19 APR 82	3.17	PCL	ND		ND	ND		
GROSS ALPHA	12 JUN 82	1.30	PCL			2.61			
GROSS ALPHA	12 JUL 82	2.40	PCL	ND		2.61	ND		
GROSS ALPHA	18 OCT 82	2.56	PCL	ND		ND	ND		
GROSS BETA	07 DEC 81	1.30	PCL	1.72		1.49	1.70		
GROSS BETA	19 APR 82	1.30	PCL	2.67		1.97	1.17		
GROSS BETA	12 JUL 82	1.82	PCL	ND		4.26	ND		
GROSS BETA	18 OCT 82	1.59	PCL	1.94		1.32	ND		
CHLORIDE	07 DEC 81	1.0	MGL	6.5		1.7	2.3		
CHLORIDE	19 APR 82	1.0	MGL	7.0		5.0	4.0		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4	CDH2	C3	CDH3
CHLORIDE	12 JUL 82	1.0	MGL	11.0		9.0	10.0		
CHLORIDE	18 OCT 82	1.0	MGL	6.0		ND	ND		
CHLORIDE	13 JUN 83	1.0	MGL	4.0		5.0 C	1.0		
CHLORIDE	13 JUN 83	1.0	MGL	4.0 C		6.0	1.0 C		
IRON	07 DEC 81	.03	MGL	ND		ND	ND		
IRON	19 APR 82	.10	MGL	.04		.11	.08		
IRON	12 JUL 82	.03	MGL	.08		ND	ND		
IRON	18 OCT 82	.03	MGL	ND		ND	ND		
IRON	13 JUN 83	.03	MGL	.24 C		1.52# C	.23		
IRON	13 JUN 83	.03	MGL	ND		ND	10.70# C		
MANGANESE	07 DEC 81	.01	MGL	.01		.07#	ND		
MANGANESE	17 DEC 81	.03	MGL	ND	ND	.20#			
MANGANESE	19 APR 82	.03	MGL	.05		.11#	.02		
MANGANESE	12 JUL 82	.01	MGL	ND		.19#	.11#		
MANGANESE	18 OCT 82	.01	MGL	ND		.08#	.17#		
MANGANESE	13 JUN 83	.01	MGL	.01 C		.27# C	.01		
MANGANESE	13 JUN 83	.01	MGL	ND		.23#	.11# C		
PHENOL	07 DEC 81	.01	MGL	ND		ND	ND		
PHENOL	19 APR 82	.01	MGL	ND		.01&	ND		
PHENOL	12 JUL 82	.01	MGL	.01&		.01&	.01&		
PHENOL	18 OCT 82	.01	MGL	ND		ND	ND		
PHENOL	13 JUN 83	.01	MGL	.01&		ND	ND		
PHENOL	13 JUN 83	.01	MGL	.01& C		ND	ND		
SODIUM	07 DEC 81	1.	MGL	7.		6.	8.		
SODIUM	19 APR 82	1.	MGL	3.		3.	2.		
SODIUM	12 JUL 82	1.	MGL	2.		2.	2.		
SODIUM	18 OCT 82	1.	MGL	2.		1.	2.		
SODIUM	13 JUN 83	1.	MGL	2.		3.	2.		
SODIUM	13 JUN 83	1.	MGL	2. C		3. C	2. C		
SULFATE	07 DEC 81	5.0	MGL	1.5		16.5	1.2		
SULFATE	19 APR 82	5.0	MGL	ND		15.0	ND		
SULFATE	12 JUL 82	5.0	MGL	ND		ND	18.0		
SULFATE	18 OCT 82	5.0	MGL	ND		6.0	ND		
SULFATE	13 JUN 83	5.0	MGL	ND		ND	22.0 C		
SULFATE	13 JUN 83	5.0	MGL	ND		7.0	22.0 C		
SULFATE	13 JUN 83	5.0	MGL	ND		ND	6.0		
SULFATE	13 JUN 83	5.0	MGL	ND		7.0	6.0		
PH(FIELD)	07 DEC 81		PH	7.9		7.5	7.6		
PH(FIELD)	07 DEC 81		PH	7.9		7.5	7.6		
PH(FIELD)	07 DEC 81		PH	7.9		7.5	7.6		
PH(FIELD)	07 DEC 81		PH	7.9		7.5	7.6		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4	CDH2	C3	CDH3
PH(FIELD)	19 APR 82		PH	7.6		7.6	7.5		
PH(FIELD)	19 APR 82		PH	7.6		7.6	7.5		
PH(FIELD)	19 APR 82		PH	7.6		7.6	7.5		
PH(FIELD)	19 APR 82		PH	7.6		7.6	7.5		
PH(FIELD)	12 JUL 82		PH	7.8		7.6	7.5		
PH(FIELD)	12 JUL 82		PH	7.8		7.6	7.5		
PH(FIELD)	12 JUL 82		PH	7.8		7.6	7.5		
PH(FIELD)	12 JUL 82		PH	7.8		7.6	7.5		
PH(FIELD)	18 OCT 82		PH	7.7		7.8	7.7		
PH(FIELD)	18 OCT 82		PH	7.7		7.8	7.8		
PH(FIELD)	18 OCT 82		PH	7.7		7.8	7.8		
PH(FIELD)	18 OCT 82		PH	7.8		7.8	7.8		
PH(FIELD)	13 JUN 83		PH	7.6		7.7	7.4		
PH(FIELD)	13 JUN 83		PH	7.6		7.6	7.4		
PH(FIELD)	13 JUN 83		PH	7.6		7.6	7.4		
PH(FIELD)	13 JUN 83		PH	7.6		7.6	7.4		
PH(FIELD)	19 SEP 83		PH	7.5		7.5	7.5		
PH(FIELD)	19 SEP 83		PH	7.5		7.4	7.5		
PH(FIELD)	19 SEP 83		PH	7.4		7.5	7.5		
PH(FIELD)	19 SEP 83		PH	7.5		7.5	7.5		
PH(LAB)	19 SEP 83		PH				7.5		
SPEC COND	07 DEC 81	1.	UMC	241.		350.	420.		
SPEC COND	07 DEC 81	1.	UMC	242.		350.	420.		
SPEC COND	07 DEC 81	1.	UMC	241.		350.	420.		
SPEC COND	07 DEC 81	1.	UMC	242.		350.	420.		
SPEC COND	19 APR 82	1.	UMC	225.		339.	480.		
SPEC COND	19 APR 82	1.	UMC	225.		340.	480.		
SPEC COND	19 APR 82	1.	UMC	225.		339.	480.		
SPEC COND	19 APR 82	1.	UMC	225.		339.	480.		
SPEC COND	12 JUL 82	1.	UMC	265.		346.	315.		
SPEC COND	12 JUL 82	1.	UMC	275.		345.	310.		
SPEC COND	12 JUL 82	1.	UMC	265.		348.	308.		
SPEC COND	12 JUL 82	1.	UMC	265.		345.	310.		
SPEC COND	18 OCT 82	1.	UMC	240.		300.	340.		
SPEC COND	18 OCT 82	1.	UMC	240.		300.	340.		
SPEC COND	18 OCT 82	1.	UMC	240.		300.	340.		
SPEC COND	18 OCT 82	1.	UMC	240.		300.	340.		
SPEC COND	13 JUN 83	1.	UMC	245.		440.	480.		
SPEC COND	13 JUN 83	1.	UMC	245.		440.	480.		
SPEC COND	13 JUN 83	1.	UMC	245.		436.	480.		
SPEC COND	13 JUN 83	1.	UMC	245.		440.	480.		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

SAMPLING SITES RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4	CDH2	C3	CDH3
SPEC COND	19 SEP 83	1.	UMC	230.		430.	360.		
SPEC COND	19 SEP 83	1.	UMC	220.		430.	330.		
SPEC COND	19 SEP 83	1.	UMC	230.		360.	330.		
SPEC COND	19 SEP 83	1.	UMC	230.		360.	370.		
TOC	07 DEC 81	1.0	MGL	4.0		8.0	3.0		
TOC	07 DEC 81	1.0	MGL	4.0		8.0	3.0		
TOC	07 DEC 81	1.0	MGL	4.0		8.0	3.0		
TOC	07 DEC 81	1.0	MGL	4.0		8.0	3.0		
TOC	19 APR 82	1.0	MGL	15.0		29.0	31.0		
TOC	19 APR 82	1.0	MGL	15.0		29.0	31.0		
TOC	19 APR 82	1.0	MGL	15.0		29.0	30.0		
TOC	19 APR 82	1.0	MGL	15.0		29.0	30.0		
TOC	12 JUL 82	1.0	MGL	17.0		37.0	35.0		
TOC	12 JUL 82	1.0	MGL	16.0		36.0	35.0		
TOC	12 JUL 82	1.0	MGL	15.0		36.0	36.0		
TOC	12 JUL 82	1.0	MGL	16.0		36.0	35.0		
TOC	18 OCT 82	1.0	MGL	5.0		5.0	4.0		
TOC	18 OCT 82	1.0	MGL	5.0		5.0	4.0		
TOC	18 OCT 82	1.0	MGL	5.0		6.0	4.0		
TOC	18 OCT 82	1.0	MGL	5.0		5.0	4.0		
TOC	13 JUN 83	1.0	MGL	7.0		18.0	26.0		
TOC	13 JUN 83	1.0	MGL	7.0		17.0	26.0		
TOC	13 JUN 83	1.0	MGL	7.0		17.0	26.0		
TOC	13 JUN 83	1.0	MGL	7.0		18.0	26.0		
TOC	19 SEP 83	1.0	MGL	16.0		26.0	37.0		
TOC	19 SEP 83	1.0	MGL	16.0		34.0	29.0		
TOC	19 SEP 83	1.0	MGL	16.0		26.0	29.0		
TOC	19 SEP 83	1.0	MGL	15.0		34.0	38.0		
TOX	07 DEC 81	.010	MGL	.029 C		.085 C	.057 C		
TOX	07 DEC 81	.010	MGL	.036 C		ND	.049 C		
TOX	07 DEC 81	.010	MGL	.014 C		.088 C	.066 C		
TOX	07 DEC 81	.010	MGL	ND		.084 C	ND		
TOX	19 APR 82	.010	MGL	.038 C		.043 C	.023 C		
TOX	19 APR 82	.010	MGL	.073 C		.034 C	.011 C		
TOX	19 APR 82	.010	MGL	.040 C		.038 C	ND		
TOX	19 APR 82	.010	MGL	.045 C		.030 C	ND		
TOX	12 JUL 82	.010	MGL	ND		ND	.012 C		
TOX	12 JUL 82	.010	MGL	ND		ND	ND		
TOX	12 JUL 82	.010	MGL	ND		ND	ND		
TOX	12 JUL 82	.010	MGL	ND		ND	.013 C		
TOX	18 OCT 82	.010	MGL	ND		28.850 C	.710 C		

RUN DATE: 29 MAR 84

INSTALLATION: RADFORD AAP, VA

SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C2	C4		CDH2		C3	CDH3
TOX	18 OCT 82	.010	MGL	ND		26.150	C	.790	C		
TOX	18 OCT 82	.010	MGL	ND		29.950	C	.480	C		
TOX	18 OCT 82	.010	MGL	ND		29.840	C	.580	C		
TOX	13 JUN 83	.010	MGL	ND		.043	C	.084	C		
TOX	13 JUN 83	.010	MGL	ND		.045	C	.079	C		
TOX	13 JUN 83	.010	MGL	ND		.046	C	.078	C		
TOX	13 JUN 83	.010	MGL	ND		.049	C	.080	C		
TOX	19 SEP 83	.010	MGL	ND		14.350	C	.019	C		
TOX	19 SEP 83	.010	MGL	ND		14.430	C	.018	C		
TOX	19 SEP 83	.010	MGL	ND		15.230	C	ND			
TOX	19 SEP 83	.010	MGL	ND		14.170	C	ND			
TOC(UNFILT)	13 JUN 83	1.0	MGL	9.0		22.0		31.0			
TOC(UNFILT)	13 JUN 83	1.0	MGL	9.0		23.0		31.0			
TOC(UNFILT)	13 JUN 83	1.0	MGL	9.0		23.0		32.0			
TOC(UNFILT)	13 JUN 83	1.0	MGL	10.0		24.0		32.0			
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		33.0		33.0			
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		26.0		32.0			
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		25.0		36.0			
TOC(UNFILT)	19 SEP 83	1.0	MGL	13.0		34.0		35.0			
SUSP SOLIDS	13 JUN 83	5.	MGL	ND		26.		ND			
SUSP SOLIDS	13 JUN 83	5.	MGL	8.		ND		238.			
SUSP SOLIDS	19 SEP 83	5.	MGL	ND		75.		1815.			
SUSP SOLIDS	19 SEP 83	5.	MGL	11.		ND		ND			
2,4,6-TNT	17 DEC 81	.020	MGL	ND	ND	ND					
2,4-DNT	17 DEC 81	.020	MGL	ND	ND	ND					
2,6-DNT	17 DEC 81	.020	MGL	ND	ND	ND					
METHANOL	17 DEC 81	40.	UGL	ND	ND	ND					
ETHANOL	17 DEC 81	200.	UGL	ND	ND	ND					
ETHER	17 DEC 81	1.	UGL	4.	8.	5.					
ACETONE	17 DEC 81	5.	UGL	ND	ND	ND					
BENZENE	17 DEC 81	1.	UGL	ND	ND	ND					
TOLUENE	17 DEC 81	5.	UGL	ND	ND	ND					

RUN DATE: 01 MAR 85

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C4	CDH2	16-1	16-2	16-3	16-4
WATER LEVELS (A)	12 NOV 84		FT	1790.3		1770.1		1755.8	1768.8	1788.5
ARSENIC	12 NOV 84	.010	MGL	ND		ND		ND	ND	ND
ARSENIC	12 NOV 84	.010	MGL	ND		ND		ND	ND	ND
BARIUM	12 NOV 84	.30	MGL	ND		ND		ND	ND	ND
BARIUM	12 NOV 84	.30	MGL	ND		ND		.72 C	.81 C	ND
CADMIUM	12 NOV 84	.001	MGL	ND		ND		ND	ND	ND
CADMIUM	12 NOV 84	.001	MGL	ND		ND		ND	ND	ND
CHROMIUM	12 NOV 84	.001	MGL	ND		ND		ND	ND	ND
CHROMIUM	12 NOV 84	.001	MGL	.001 C		.003 C		.009 C	.003 C	.006 C
LEAD	12 NOV 84	.005	MGL	ND		.009		.015	ND	ND
LEAD	12 NOV 84	.005	MGL	ND		.017 C		.016 C	ND	.013 C
MERCURY	12 NOV 84	.2	UGL	ND		ND		ND	ND	ND
MERCURY	12 NOV 84	.2	UGL	ND		ND		ND	.48 C	ND
SELENIUM	12 NOV 84	.005	MGL	ND		ND		ND	ND	ND
SELENIUM	12 NOV 84	.005	MGL	ND		ND		ND	ND	ND
SILVER	12 NOV 84	.025	MGL	ND		ND		ND	ND	ND
SILVER	12 NOV 84	.025	MGL	ND		ND		ND	ND	ND
PH(FIELD)	12 NOV 84		PH	7.8		7.2		7.9	8.0	7.8
PH(FIELD)	12 NOV 84		PH	7.8		7.2		7.8	8.0	7.8
PH(FIELD)	12 NOV 84		PH	7.8		7.2		7.8	8.0	7.9
PH(FIELD)	12 NOV 84		PH	7.8		7.2		7.8	8.0	7.9
SPEC COND	12 NOV 84	1.	UMC	170.		340.		420.	380.	220.
SPEC COND	12 NOV 84	1.	UMC	170.		340.		420.	380.	220.
SPEC COND	12 NOV 84	1.	UMC	170.		350.		420.	380.	200.
SPEC COND	12 NOV 84	1.	UMC	170.		340.		420.	370.	220.
TOC	12 NOV 84	.1	MGL	.8		1.8		.9	1.3	1.5
TOC	12 NOV 84	.1	MGL	.9		1.8		.9	1.3	1.6
TOC	12 NOV 84	.1	MGL	.9		1.8		.9	1.3	1.5
TOC	12 NOV 84	.1	MGL	.9		1.8		1.0	1.4	1.6
TOX	12 NOV 84	.010	MGL	ND		.022		ND	.034	.053
TOX	12 NOV 84	.010	MGL	ND		.018		ND	.033	.054
TOX	12 NOV 84	.010	MGL	ND		.021		ND	.031	.053
TOX	12 NOV 84	.010	MGL	ND		.023		ND	.035	.049
TOC(UNFILT)	12 NOV 84	1.0	MGL	.8		1.3		1.5	3.3	1.6
TOC(UNFILT)	12 NOV 84	1.0	MGL	.6		1.6		1.6	3.2	1.3
TOC(UNFILT)	12 NOV 84	1.0	MGL	.7		1.7		1.4	3.4	1.5
TOC(UNFILT)	12 NOV 84	1.0	MGL	.7		1.8		1.5	3.1	1.2

RUN DATE: 01 MAR 85

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

SAMPLING SITES
RESULTS

PARAMETER	SAMPLING DATE	DETECTION LIMIT	UNITS	B C1	C4	CDH2	16-1	16-2	16-3	16-4
2,4,6-TNT	12 NOV 84	.001	MGL	ND		ND		ND	ND	ND
2,4,6-TNT	12 NOV 84	.001	MGL	ND		ND		ND	ND	ND
2,4-DNT	12 NOV 84	.001	MGL	ND		ND		ND	ND	.015 C
2,4-DNT	12 NOV 84	.001	MGL	ND		ND		ND	ND	.014
2,6-DNT	12 NOV 84	.001	MGL	.001 C		.002 C		.001 C	.002 C	.032 C
2,6-DNT	12 NOV 84	.001	MGL	.001		.002		.001	.002	.028
RDX	12 NOV 84	.030	MGL	ND		ND		ND	ND	ND
RDX	12 NOV 84	.030	MGL	ND		ND		ND	ND	ND
HMX	12 NOV 84	.100	MGL	ND		ND		ND	ND	ND
HMX	12 NOV 84	.100	MGL	ND		ND		ND	ND	ND
TETRYL	12 NOV 84	.010	MGL	ND		ND		ND	ND	ND
TETRYL	12 NOV 84	.010	MGL	ND		ND		ND	ND	ND
NQ	12 NOV 84	.10	MGL	ND		ND		ND	ND	ND

RUN DATE: 01 MAR 85

INSTALLATION: RADFORD AAP, VA SITE: SITE 16(C)

LEGEND

NOTES: ALL METALS AND OTHER PARAMETERS WHERE APPROPRIATE ARE ON A DISSOLVED (FILTERED) BASIS UNLESS OTHERWISE NOTED. DETECTION LIMITS SHOWN ARE NORMAL LEVELS; ACTUAL LIMITS MAY VARY IN ENVIRONMENTAL SAMPLES. ANALYTICAL RESULTS ARE ACCURATE TO EITHER 2 OR 3 SIGNIFICANT FIGURES.

A VALUES SHOWN ARE FOR WATER LEVEL ELEVATION ABOVE A REFERENCE DATUM
B UPGRADIENT SITE
@ RESULTS ARE FOR UNFILTERED SAMPLE
& VALUE EXCEEDS A STATE WATER QUALITY STANDARD OR CRITERIA

MGL - MILLIGRAMS/LITER
UGL - MICROGRAMS/LITER
PCL - PICOCURIES/LITER
UMC - MICROMHOS/CENTIMETER
NTU - NEPHELOMETRIC TURBIDITY UNITS
TON - THRESHOLD ODOR NUMBER
TON - TASTE DILUTION INDEX NUMBER
CU - COLOR UNITS
PHM - PER 100 MILLILITERS

APPENDIX E

COMMONWEALTH OF VIRGINIA HAZARDOUS WASTE REGULATIONS APPLICABLE TO CLOSURE OF RADFORD AAP HAZARDOUS WASTE MANAGEMENT FACILITIES

10.00 Standards For Permitted Hazardous Waste Management Facilities

10.01 Purpose, Scope and Applicability

10.01.01 The purpose of this Section is to establish minimum standards which define the acceptable management of hazardous waste.

10.01.02 The standards in this Section apply to owners or operators of the facilities which treat, store, or dispose of hazardous waste. These standards apply to all treatment, storage, or disposal of hazardous waste at these facilities after the effective date of these regulations, except as specifically provided otherwise. To improve readability, the regulations contained in this Section refer sometimes to the "facility" rather than to the "owner or operator of the facility". Whenever the former word appears the applicability of the regulations to the owner or operator is implied.

10.01.03 The requirements of this Section apply to the following activities only to the extent that they are included in a permit by rule granted under Section 11.08:

(a) Ocean disposal of hazardous waste subject to a permit issued under the Marine Protection, Research and Sanctuaries Act.

(b) A POTW which treats, stores, or disposes of hazardous waste.

10.01.04 The requirements of this Section do not apply to:

(a) A facility permitted, licensed, or registered by the Commonwealth to manage municipal or industrial solid waste, if the only hazardous waste the facility treats, stores, or disposes of is excluded from regulation by Section 3.03;

(b) A facility which treats or stores hazardous waste, which treatment or storage meets the criteria in Section 3.04.01, except to the extent that Section 3.04.02 provides otherwise;

(c) A generator accumulating waste on-site in compliance with Section 6.05.05(a);

(d) A farmer disposing of waste pesticides from his own use in compliance with Section 6.07.02;

(e) A totally enclosed treatment facility;

(f) An elementary neutralization unit or a wastewater treatment unit as defined in Section 2.00;

(g) (1) Except as provided in Section 10.01.04(g)(2), a person engaged in treatment or containment activities during immediate response to any of the following situations:

(i) A discharge or a spill of a hazardous waste;

(ii) An imminent and substantial threat of a discharge or spill of hazardous waste;

(iii) A discharge or a spill of a material which when discharged or spilled, becomes a hazardous waste.

(2) An owner or operator of a facility otherwise regulated by Section 10.00 shall comply with all applicable requirements of Sections 10.03 and 10.04.

(3) Any person who is covered by Section 10.01.04(g)(1) and who continues or initiates hazardous waste treatment or containment after the immediate response is over is subject to all applicable requirements of Section 10.00 (or Section 9.00, if applicable) and 11.00 for those activities.

(h) A transporter storing manifested shipments of hazardous waste in containers approved at a transfer facility for a period of ten days or less.

(i) A facility or portions of a facility operating under interim status standards until such status is terminated.

(j) The addition of absorbent material to waste in a container (as defined in Section 2.32) or the addition of waste to absorbent material in a container, provided that these actions occur at the time waste is first placed in the container and Section 10.02.08(b), 10.09.02 and 10.09.03 are complied with."

10.01.05 Imminent hazard action. Notwithstanding any other provisions of these regulation, enforcement action may be taken as provided for in Section 1.07.03(b).

10.01.06 Effective dates. Regulations contained in this Section have been promulgated as a result of several amendments. Unless otherwise specifically stated the effective dates of the following sections are:

(a) Sections 10.01 through 10.05, 10.07 through 10.10, and 10.15: August 17, 1983 (the date of the receipt of Phase II Interim Authorization);

(b) Sections 10.06 and 10.11 through 10.14: November 1, 1983.

10.01.07 The federal requirements contained in Part 264, Title 40, Code of Federal Regulation (40 CFR 264) will apply to a person who treats, stores or disposes of hazardous waste in the Commonwealth after it receives Final Authorization (see Section 2.67) at a facility which was not covered by the standards under 40 CFR 264 at the time when the Commonwealth obtained authorization, and for which facility EPA promulgates standards after the Commonwealth is authorized. The federal regulations will only apply until the Commonwealth is authorized to permit such facilities under Subpart A of Part 271, Title 40, Code of Federal Regulations.

10.02 General Facility Standards

10.02.01 Applicability

(a) The regulations in Section 10.02 apply to all hazardous waste facilities except as Sections 10.01 and 10.02.01(b) provide otherwise.

(b) Section 10.02.09 applies only to facilities subject to regulations under Sections 10.09 through 10.15 (containers, tanks, surface impoundments, waste piles, land treatment, landfills, and incinerators).

10.02.02 Identification number. Every facility owner or operator shall apply to the EPA for an identification number in accordance with EPA notification procedures.

10.02.03 Required notices

(a) The owner or operator of a facility that has arranged to receive hazardous waste from a foreign source shall notify the Commissioner in writing at least four weeks in advance of the date the waste is expected to arrive at the facility. Notice of subsequent shipments of the same waste from the same foreign source is not required.

(b) The owner or operator of a facility that receives hazardous waste from an off-site source (except where the owner or operator of the facility is also

(g) The most recent closure cost estimate and, for disposal facilities, the most recent post-closure cost estimate; and

(h) The certification signed by the owner or operator of the facility or his authorized representative.

[For the convenience of the regulated community, a copy of BHWM Form 8700-13 is shown in Appendix 10.2.]

10.05.05 Unmanifested waste report. If a facility accepts for treatment, storage or disposal any hazardous waste from an off-site source without an accompanying manifest or shipping paper in case of water (bulk) transporters, and if the waste is not excluded from the manifest requirement by Section 3.03, then the owner or operator shall prepare and submit a single copy of a report to the Commissioner within 15 days after receiving the waste. BHWM Form 8700-13 may be used for this report. The report shall include the following information:

(a) The EPA identification number, name and address of the facility;

(b) The date the facility received the waste;

(c) The EPA identification number, name and address of the generator and the transporter, if available;

(d) A description and the quantity of each unmanifested hazardous waste the facility received;

(e) The method of treatment, storage or disposal for each hazardous waste;

(f) The certification signed by the owner or operator of the facility or his authorized representative; and

(g) A brief explanation of why the waste was unmanifested, if known.

[For the convenience of the regulated community, a copy of BHWM Form 8700-13 is shown in Appendix 10.2.]

10.05.06 Additional reports. In addition to submitting the annual report and unmanifested waste reports, the owner or operator shall also report to the Commissioner:

(a) Releases, fires and explosions as specified in Section 10.04.06.

(b) As otherwise required by Section 10.06 and by Sections 10.11 through 10.14.

(c) Facility closure as specified in Section 10.07.

10.06 Groundwater Protection

10.06.01 Applicability.

(a) Except as provided in Section 10.06.01(b) the regulations in Section 10.06 apply to owners and operators of facilities that treat, store, or dispose of hazardous waste in surface impoundments, waste piles, land treatment units, or landfills. The owner or operator shall satisfy the requirements of this Section for all wastes (or constituents thereof) contained in the regulated unit (see Section 2.155) at the facility. Any waste or waste constituent migrating beyond the waste management area under Section 10.06.06(b) is assumed to originate from a regulated unit unless the Commissioner finds that such waste or waste constituent originated from another source.

(b) The owner or operator is not subject to regulation under Section 10.06 if:

(1) He is exempted under Section 10.01;

(2) He designs and operates a surface impoundment in compliance with Section 10.11.03, a pile in compliance with Sections 10.12.01(c), 10.12.03 or 10.12.04, or a landfill in compliance with Section 10.14.03;

(3) The Commissioner finds, pursuant to Section 10.13.11(d), that the treatment zone of a land treatment unit does not contain levels of hazardous constituents that are above background levels of those constituents by an amount that is statistically significant, and if an unsaturated zone monitoring program meeting the requirements of Section 10.13.09 has not shown a statistically significant increase in hazardous constituents below the treatment zone during the operating life of the unit. An exemption under this Section can only relieve an owner or operator of responsibility to meet the requirements of Section 10.06 during the post-closure period; or

(4) The Commissioner finds that there is no potential for migration of liquid from a regulated unit to the uppermost aquifer during the active life of the regulated unit (including the closure period) and the post-closure care period specified under Section 10.07.08. This demonstration shall be certified by a qualified geologist or geotechnical engineer. In order to provide an adequate margin of safety in the prediction of potential migration of liquid, the owner or operator shall base any predictions made under this Section on assumptions that maximize the rate of liquid migration.

(c) The regulations under Section 10.06 apply during the active life of the regulated unit (including the closure period). After closure of the regulated unit, the regulations in Section 10.06;

(1) Do not apply if all waste, waste residues, contaminated containment system components, and contaminated subsoils are removed or decontaminated at closure;

(2) Apply during the post-closure care period under Section 10.07.08 if the owner or operator is conducting a detection monitoring program under Section 10.06.09; or

(3) Apply during the compliance period under Section 10.06.07 if the owner or operator is conducting a compliance monitoring program under Section 10.06.10 or a corrective action program under Section 10.06.11.

10.06.02 Required programs.

(a) Owners and operators subject to Section 10.06 shall conduct a monitoring and response program as follows:

(1) Whenever hazardous constituents under Section 10.06.04 from a regulated unit are detected at the compliance point under Section 10.06 the owner or operator shall institute a compliance monitoring program under Section 10.06.10;

(2) Whenever the groundwater protection standard under Section 10.06.03 is exceeded, the owner or operator shall institute a corrective action program under Section 10.06.11;

(3) Whenever hazardous constituents under Section 10.06.04 from a regulated unit exceed concentration limits under Section 10.06.05 in groundwater between the compliance point under Section 10.06.06 and the downgradient facility property boundary, the owner or operator shall institute a corrective action program under Section 10.06.11; or

(4) In all other cases, the owner or operator shall institute a detection monitoring program under Section 10.06.09.

(b) The Commissioner will specify in the facility permit the specific elements of the monitoring and response program. The Commissioner may include one or more of the programs identified in Section 10.06.02(a) in the facility permit as may be necessary to protect human health and the environment and will specify the circumstances under which each of the programs will be required. In deciding whether to require the owner or operator to be prepared to institute a particular program, the Commissioner will consider the potential adverse effects on human health and the environment that might occur before final administrative action on a permit modification application to incorporate such a program could be taken.

10.06.03 Groundwater protection standard. The owner or operator shall comply with conditions specified in the facility permit that are designed to ensure that hazardous constituents under Section 10.06.04 entering the groundwater from a regulated unit do not exceed the concentration limits under Section 10.06.05 in the uppermost aquifer underlying the waste management area beyond the point of compliance under Section 10.06.06 during the compliance period under Section 10.06.07. The Commissioner will establish this groundwater protection standard in the facility permit when hazardous constituents have entered the groundwater from a regulated unit.

10.06.04 Hazardous constituents.

(a) The Commissioner will specify in the facility permit the hazardous constituents to which the groundwater protection standard of Section 10.06.03 applies. Hazardous constituents are constituents identified in Appendix 3.6 that have been detected in groundwater in the uppermost aquifer underlying a regulated unit and that are reasonably expected to be in or derived from waste contained in a regulated unit, unless the Commissioner has excluded them under Section 10.06.04(b).

(b) The Commissioner will exclude an Appendix 3.6 constituent from the list of hazardous constituents specified in the facility permit if he finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. In deciding whether to grant an exemption, the Commissioner will consider the following:

(1) Potential adverse effects on groundwater quality, considering:

(i) The physical and chemical characteristics of the waste in the regulated unit, including its potential for migration;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of groundwater and the direction of groundwater flow;

(iv) The proximity and withdrawal rates of groundwater users;

(v) The current and future uses of groundwater in the area;

(vi) The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality;

(vii) The potential for health risks caused by human exposure to waste constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects; and

(2) Potential adverse effects on hydraulically-connected surface water quality, considering:

(i) The volume and physical and chemical characteristics of the waste in the regulated unit;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity and quality of groundwater, and the direction of groundwater flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the regulated unit to surface waters;

(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

(c) In making any determination under Section 10.06.04(b) about the use of groundwater in the area around the facility, the Commissioner will consider any identification of underground sources of drinking water as identified by EPA under 40 CFR 144.7.

10.06.05 Concentration limits.

(a) The Commissioner will specify in the facility permit concentration limits in the groundwater for hazardous constituents established under Section 10.06.04. The concentration of a hazardous constituent:

(1) Shall not exceed the background level of that constituent in the groundwater at the time that limit is specified in the permit; or

(2) For any of the constituents listed in Table 10.06-1, shall not exceed the respective value given in that Table if the background level of the constituent is below the value given in Table 10.06-1; or

(3) Shall not exceed an alternate limit established by the Commissioner under Section 10.06.05(b).

(b) The Commissioner will establish an alternate concentration limit for a hazardous constituent if he finds that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded. In establishing alternate concentration limits, the Commissioner will consider the following factors:

(1) Potential adverse effects on groundwater quality, considering:

(i) The physical and chemical characteristics of the waste in the regulated unit, including its potential for migration;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of groundwater and the direction of groundwater flow;

(iv) The proximity and withdrawal rates of groundwater users;

(v) The current and future uses of groundwater in the area;

(vi) The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality;

(vii) The potential for health risks caused by human exposure to waste constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects; and

Table 10.06-1

Maximum Concentration of Constituents for Groundwater Protection

Constituent	Maximum Concentration (Milligrams per liter)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.0002
Selenium	0.01
Silver	0.05
Endrin (1,2,3,4,10,10-hexachloro-1, 7-epoxy-1,4,4a, 5,6,7,8,9a-octahydro-1, 4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenylethane)	0.1
Toxaphene Technical chlorinated camphene, 67-69 percent chlorine)	0.005
2,4-D (2, 4-Dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01

(2) Potential adverse effects on hydraulically-connected surface water quality, considering:

(i) The volume and physical and chemical characteristics of the waste in the regulated unit;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity and quality of groundwater, and the direction of groundwater flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the regulated unit to surface waters;

(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

(c) In making any determination under Section 10.06.05(b) about the use of groundwater in the area around the facility the Commissioner will consider any identification of underground sources of drinking water as identified by EPA under 40 CFR 144.7.

10.06.06 Point of compliance.

(a) The Commissioner will specify in the facility permit the point of compliance at which the groundwater protection standard of Section 10.06.03 applies and at which monitoring shall be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.

(b) The waste management area is the limit projected in the horizontal plan of the area on which waste will be placed during the active life of a regulated unit.

(1) The waste management area includes horizontal space taken up by any liner, dike, or other barrier designed to contain waste in a regulated unit.

(2) If the facility contains more than one regulated unit, the waste management area is described by an imaginary line circumscribing the several regulated units.

10.06.07 Compliance period.

(a) The Commissioner will specify in the facility permit the compliance period during which the groundwater protection standard of Section 10.06.03 applies. The compliance period is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period).

(b) The compliance period begins when the owner or operator initiates a compliance monitoring program meeting the requirements of Section 10.06.10.

(c) If the owner or operator is engaged in a corrective action program at the end of the compliance period specified in Section 10.06.07(a), the compliance period is extended until the owner or operator can demonstrate that the groundwater protection standard of Section 10.06.03 has not been exceeded for a period of three consecutive years.

10.06.08 General groundwater monitoring requirements. The owner or operator shall comply with the following requirements for any groundwater monitoring program developed to satisfy Sections 10.06.09 to 10.06.11:

(a) The groundwater monitoring system shall consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that:

(1) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit; and

(2) Represent the quality of groundwater passing the point of compliance.

(b) If a facility contains more than one regulated unit, separate groundwater monitoring systems are not required for each regulated unit provided that provisions for sampling the groundwater in the uppermost aquifer will enable detection and measurement at the compliance point of hazardous constituents from the regulated units that have entered the groundwater in the uppermost aquifer.

(c) All monitoring wells shall be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing shall be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (i.e., the space between the bore hole and well casing) above the sampling depth shall be sealed to prevent contamination of samples and the groundwater.

(d) The groundwater monitoring program shall include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide a reliable indication of groundwater quality below the waste management area. At a minimum the program shall include procedures and techniques for:

(1) Sample collection;

(2) Sample preservation and shipment;

(3) Analytical procedures; and

(4) Chain of custody control.

(e) The groundwater monitoring program shall include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure hazardous constituents in groundwater samples.

(f) The groundwater monitoring program shall include a determination of the groundwater surface elevation each time groundwater is sampled.

(g) Where appropriate the groundwater monitoring program shall establish background groundwater quality for each of the hazardous constituents or monitoring parameters or constituents specified in the permit.

(1) In the detection monitoring program under Section 10.06.09, background groundwater quality for a monitoring parameter or constituent shall be based on data from quarterly sampling of wells upgradient from the waste management area for one year.

(2) In the compliance monitoring program under Section 10.06.10 background groundwater quality for a hazardous constituent shall be based on data from upgradient wells that:

(i) Is available before the permit is issued;

(ii) Accounts for measurement errors in sampling and analysis; and

(iii) Accounts, to the extent feasible, for seasonal fluctuations in background groundwater quality if such fluctuations are expected to affect the concentration of the hazardous constituent.

(3) Background quality may be based on sampling of wells that are not upgradient from the waste management area where:

(i) Hydrogeologic conditions do not allow the owner or operator to determine what wells are upgradient; or

(ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells.

(4) In developing the data base used to determine a background value for each parameter or constituent, the owner or operator shall take a minimum of one sample from each well and a minimum of four samples from the entire system used to determine background groundwater quality, each time the system is sampled.

(h) The owner or operator shall use the following statistical procedure in determining whether background values or concentration limits have been exceeded:

(1) If, in a detection monitoring program, the level of a constituent at the compliance point is to be compared to the constituent's background value and that background value has a sample coefficient of variation of less than 1.0:

(i) The owner or operator shall take at least four portions from a sample at each well at the compliance point and determine whether the difference between the mean of the constituent at each well (using all portions taken) and the background value for the constituent is significant at the 0.05 level using the Cochran's Approximation to the Behrens-Fisher Student's t-test as described in Appendix 10.4. If the test indicates that the difference is significant, the owner or operator shall repeat the same procedure (with at least the same number of portions as used in the first test) with a fresh sample from the monitoring well. if this second round of analysis indicates that the difference is significant, the owner or operator shall conclude that a statistically significant change has occurred; or

(ii) The owner or operator may use an equivalent statistical procedure for determining whether a statistically significant change has occurred. The Commissioner will specify such a procedure in the facility permit if he finds that alternative procedure reasonably balances the probability of falsely identifying a noncontaminating regulated unit and the probability of failing to identify a contaminating regulated unit in a manner that is comparable to that of the statistical procedure described in Section 10.06.08(h)(1)(i).

(2) In all other situations in a detection monitoring program and in a compliance monitoring program, the owner or operator shall use a statistical procedure providing reasonable confidence that the migration of hazardous constituents from a regulated unit into and through the aquifer will be indicated. The Commissioner will specify a statistical procedure in the facility permit that he finds:

(i) Is appropriate for the distribution of the data used to establish background values or concentration limits; and

(ii) Provides a reasonable balance between the probability of falsely identifying a noncontaminating regulated unit and the probability of failing to identify a contaminating regulated unit.

10.06.09 Detection monitoring program. An owner or operator required to establish a detection monitoring program under Section 10.06 shall at a minimum, discharge the following responsibilities:

(a) The owner or operator shall monitor for indicator parameters (e.g., specific conductance, total organic carbon, or total organic halogen), waste constituents, or reaction products that provide a reliable indication of the presence of hazardous constituents in groundwater. The Commissioner will specify the parameters or constituents to be monitored in the facility permit, after considering the following factors:

(1) The types, quantities, and concentrations of constituents in wastes managed at the regulated unit;

(2) The mobility, stability, and persistence of waste constituents or their reaction products in the unsaturated zone beneath the waste management area;

(3) The detectability of indicator parameters, waste constituents, and reaction products in groundwater; and

(4) The concentrations or values and coefficients of variation of proposed monitoring parameters or constituents in the groundwater background.

(b) The owner or operator shall install a groundwater monitoring system at the compliance point as specified under Section 10.06.06. The groundwater monitoring system shall comply with Sections 10.06.08(a)(2), 10.06.08(b) and 10.06.08(c).

(c) The owner or operator shall establish a background value for each monitoring parameter or constituent specified in the permit pursuant to Section 10.06.09(a). The permit will specify the background values for each parameter or specify the procedures to be used to calculate the background values.

(1) The owner or operator shall comply with Section 10.06.08(g) in developing the data base used to determine background values.

(2) The owner or operator shall express background values in a form necessary for the determination of statistically significant increases under Section 10.06.08(h).

(3) In taking samples used in the determination of background values, the owner or operator shall use a groundwater monitoring system that complies with Sections 10.06.08(a)(1), 10.06.08(b), and 10.06.08(c).

(d) The owner or operator shall determine groundwater quality at each monitoring well at the compliance point at least semi-annually during the active life of a regulated unit (including the closure period) and the post-closure care period. The owner or operator shall express the groundwater quality at each monitoring well in a form necessary for the determination of statistically significant increases under Section 10.06.08(h).

(e) The owner or operator shall determine the groundwater flow rate and direction in the uppermost aquifer at least annually.

(f) The owner or operator shall use procedures and methods for sampling and analysis that meet the requirements of Section 10.06.08(d) and 10.06.08(e).

(g) The owner or operator shall determine whether there is a statistically significant increase over background values for any parameter or constituent specified in the permt pursuant to Section 10.06.09(a) each time he determines groundwater quality at the compliance point under Section 10.06.09(d).

(1) In determining whether a statistically significant increase has occurred, the owner or operator shall compare the groundwater quality at each monitoring well at the compliance point for each parameter or constituent to the background value for that parameter or constituent, according to the statistical procedure specified in the permit under Section 10.06.08(h).

(2) The owner or operator shall determine whether there has been a statistically significant increase at each monitoring well at the compliance point within a reasonable time period after completion of sampling. The Commissioner will specify that time period in the facility permit, after considering the complexity of the statistical test and the availability of laboratory facilities to perform the analysis of groundwater samples.

(h) If the owner or operator determines, pursuant to Section 10.06.09(g) that there is a statistically significant increase for parameters or constituents specified pursuant to Section 10.06.09(a) at any monitoring well at the compliance point, he shall:

(1) Notify the Commissioner of this finding in writing within seven days. The notification shall indicate what parameters or constituents have shown statistically significant increases;

(2) Immediately sample the groundwater in all monitoring wells and determine the concentration of all constituents identified in Appendix 3.6 that are present in groundwater;

(3) Establish a background value for each Appendix 3.6 constituent that has been found at the compliance point under Section 10.06.09(h)(2), as follows:

(i) The owner or operator shall comply with Section 10.06.08(g) in developing the data base used to determine background values;

(ii) The owner or operator shall express background values in a form necessary for the determination of statistically significant increases under Section 10.06.08(h); and

(iii) In taking samples used in the determination of background values, the owner or operator shall use a groundwater monitoring system that complies with Section 10.06.08(a)(1), 10.06.08(b), and 10.06.08(c)

(4) Within 90 days, submit to the Commissioner an application for a permit modification to establish a compliance monitoring program meeting the requirements of Section 10.06.10. The application shall include the following information:

(i) An identification of the concentration of any Appendix 3.6 constituents found in the groundwater at each monitoring well at the compliance point;

(ii) Any proposed changes to the groundwater monitoring system at the facility necessary to meet the requirements of Section 10.06.10;

(iii) Any proposed changes to the monitoring frequency, sampling and analysis procedures or methods, or statistical procedures used at the facility necessary to meet the requirements of Section 10.06.10;

(iv) For each hazardous constituent found at the compliance point, a proposed concentration limit under Sections 10.06.05(a)(1) and (2) or a notice of intent to seek a variance under Section 10.06.05(b); and

(5) Within 180 days, submit to the Commissioner:

(i) All data necessary to justify any variance sought under Section 10.06.05(b); and

(ii) An engineering feasibility plan for a corrective action program necessary to meet the requirements of Section 10.06.11, unless:

(A) All hazardous constituents identified under Section 10.06.09(h)(2) are listed in Table 10.06-1 and their concentrations do not exceed the respective values given in that Table; or

(B) The owner or operator has sought a variance under Section 10.06.05(b) for every hazardous constituent identified under Section 10.06.09(h)(2).

(i) If the owner or operator determines, pursuant to Section 10.06.09(g), that there is a statistically significant increase of parameters or constituents specified pursuant to Section 10.06.09(a) at any monitoring well at the compliance point, he may demonstrate that a source other than a regulated unit caused the increase or that the increase resulted from error in sampling, analysis, or evaluation. While the owner or operator may make a demonstration under this Section in addition to, or in lieu of, submittimg a permit modification application under Section 10.06.09(h)(4), he is not relieved of the requirement to submit a permit modification application within the time specified in Section 10.06.09(h)(4) unless the demonstration made under this Section successfully shows that a source other than a regulated unit caused the increase or that the increase resulted from error in sampling, analysis, or evaluation. In making a demonstration under this Section, the owner or operator shall:

(1) Notify the Commissioner in writing within seven days of determining a statistically significant increase at the compliance point that he intends to make a demonstration under this Section;

(2) Within 90 days, submit a report to the Commissioner which demonstrates that a source other than a regulated unit caused the increase, or that the increase resulted from error in sampling, analysis, or evaluation;

(3) Within 90 days, submit to the Commissioner an application for a permit modification to make any appropriate changes to the detection monitoring program at the facility; and

(4) Continue to monitor in accordance with the detection monitoring program established under Section 10.06.09.

(j) If the owner or operator determines that the detection monitoring program no longer satisfies the requirements of Section 10.06.09, he shall, within 90 days, submit an application for a permit modification to make any appropriate changes to the program.

(k) The owner or operator shall assure that monitoring and corrective action measures necessary to achieve compliance with the groundwater protection standard under Section 10.06.03 are taken during the term of the permit.

10.06.10 Compliance monitoring program. An owner or operator required to establish a compliance monitoring program under Section 10.06 shall, at a minimum, discharge the following responsibilities:

(a) The owner or operator shall monitor the groundwater to determine whether regulated units are in compliance with the groundwater protection standard under Section 10.06.03. The Commissioner will specify the groundwater protection standard in the facility permit, including:

(1) A list of the hazardous constituents identified under Section 10.06.04.

(2) Concentration limits under Section 10.06.05 for each of those hazardous constituents;

(3) The compliance point under Section 10.06.06; and

(4) The compliance period under Section 10.06.07.

(b) The owner or operator shall install a groundwater monitoring system at the compliance point as specified under Section 10.06.06. The groundwater monitoring system shall comply with Sections 10.06.08(a)(2), (b), and (c).

(c) Where a concentration limit established under Section 10.06.10(a)(2) is based on background groundwater quality, the Commissioner will specify the concentration limit in the permit as follows:

(1) If there is a high temporal correlation between upgradient and compliance point concentrations of the hazardous constituents, the owner or operator may establish the concentration limit through sampling at upgradient wells each time groundwater is sampled at the compliance point. The Commissioner will specity the procedures used for determining the concentration limit in this manner in the permt. In all other cases the concentration limit will be the mean of the pooled data on the concentration of the hazardous constituent.

(2) If a hazardous constituent is identified on Table 10.06-1 and the difference between the respective concentration limit in Table 10.06-1 and the background value of that constituent under Section 10.06.08(g) is not statistically significant, the owner or operator shall use the background value of the constituent as the concentration limit. In determining whether this difference is statistically significant, the owner or operator shall use a statistical procedure providing reasonable confidence that a real difference will be indicated. The statistical procedure shall:

(i) Be appropriate for the distribution of the data used to extablish background values; and

(ii) Provide a reasonable balance between the probability of falsely identifying a significant difference and the probability of failing to identify a significant difference.

(3) The owner or operator shall:

(i) Comply with Section 10.06.08(g) in developing the data base used to determine background values;

(ii) Express background values in a form necessary for the determination of statistically significant increases under Section 10.06.08(h); and

(iii) Use a groundwater monitoring system that complies with Section 10.06.08(a)(1), (b) and (c).

(d) The owner or operator shall determine the concentration of hazardous constituents in groundwater at each monitoring well at the compliance point at least quarterly during the compliance period. The owner or operator shall express the concentration at each monitoring well in a form necessary for the determination of statistically significant increases under Section 10.06.08(h).

(e) The owner or operator shall determine the groundwater flow rate and direction in the uppermost aquifer at least annually.

(f) The owner or operator shall analyze samples from all monitoring wells at the compliance point for all constituents contained in Appendix 3.6 at least annually to determine whether additional hazardous constituents are present in the uppermost aquifer. If the owner or operator finds Appendix 3.6 constituents in the groundwater that are not identified in the permit as hazardous constituents, the owner or operator shall report the concentrations of these additional constituents to the Commissioner within seven days after completion of the analysis.

(g) The owner or operator shall use procedures and methods for sampling and analysis that meet the requirements of Section 10.06.08(d) and (e).

(h) The owner or operator shall determine whether there is a statistically significant increase over the concentration limits for any hazardous constituents specified in the permit pursuant to Section 10.06.10(a) each time he determines the concentration of hazardous constituents in groundwater at the compliance point.

(1) In determining whether a statistically significant increase has occurred, the owner or operator shall compare the groundwater quality at each monitoring well at the compliance point for each hazardous constituent to the concentration limit for that constituent according to the statistical procedures specified in the permit under Section 10.06.08(h).

(2) The owner or operator shall determine whether there has been a statistically significant increase at each monitoring well at the compliance point, within a reasonable time period after completion of sampling. The Commissioner will specify that time period in the facility permit, after considering the complexity of the statistical test and the availability of laboratory facilities to perform the analysis of groundwater samples.

(i) If the owner or operator determines, pursuant to Section 10.06.10(h), that the groundwater protection standard is being exceeded at any monitoring well at the point of compliance, he shall:

(1) Notify the Commissioner of this finding in writing within seven days. The notification shall indicate what concentration limits have been exceeded.

(2) Submit to the Commissioner an application for a permit modification to establish a corrective action program meeting the requirements of Section 10.06.11 within 180 days, or within 90 days if an engineering feasib[illegible] has been previously submitted to the Commissioner under Section [illegible] (h)(5). The application shall at a minimum include the following in[illegible]

(i) A detailed description of corrective actions that will achieve complia[illegible] with the groundwater protection standard specified in the per[illegible] Section 10.06.10(a); and

(ii) A plan for a groundwater monitoring program that will demonstr[illegible] the effectiveness of the corrective action. Such a groundwater monit[illegible] program may be based on a compliance monitoring program developed [illegible] meet the requirements of Section 10.06.10.

(j) If the owner or operator determines, pursuant to Section 10.06.10(h), that the groundwater protection standard is being exceeded at any monitoring well at the point of compliance, he may demonstrate that a source other than a regulated unit caused the increase or that the increase resulted from error in sampling, analysis or evaluation. While the owner or operator may make a demonstration under this Section in addition to, or in lieu of, submitting a permit modification application under Section 10.06.10(i)(2), he is not relieved of the requirement to submit a permit modification application within the time specified in Section 10.06.10(i)(2) unless the demonstration made under this Section successfully shows that a source other than a regulated unit caused the increase or that the increase resulted from error in sampling, analysis, or evaluation. In making a demonstration under this Section, the owner or operator shall:

(1) Notify the Commissioner in writing within seven days that he intends to make a demonstration under this Section;

(2) Within 90 days, submit a report to the Commissioner which demonstrates that a source other than a regulated unit caused the standard to be exceeded or that the apparent noncompliance with the standards resulted from error in sampling, analysis, or evaluation;

(3) Within 90 days, submit to the Commissioner an application for a permit modification to make any appropriate changes to the compliance monitoring program at the facility; and

(4) Continue to monitor in accordance with the compliance monitoring program established under Section 10.06.10.

(k) If the owner or operator determines that the compliance monitoring program no longer satisfies the requirements of Section 10.06.10, he shall, within 90 days, submit an application for permit modification to make any appropriate changes to the program.

(1) The owner or operator shall assure that monitoring and corrective action measures necessary to achieve compliance with the groundwater protection standard under Section 10.06.03 are taken during the term of the permit.

10.06.11 Corrective action program. An owner or operator required to establish a corrective action program under Section 10.06 shall, at a minimum, discharge the following responsibilities:

(a) The owner or operator shall take corrective action to ensure that regulated units are in compliance with the groundwater protection standard under Section 10.06.03. The Commissioner will specify the groundwater protection standard in the facility permit, including:

(1) A list of the hazardous constituents identified under Section 10.06.04.

(2) Concentration limits under Section 10.06.05 for each of those hazardous constituents;

(3) The compliance point under Section 10.06.06; and

(4) The compliance period under Section 10.06.07.

(b) The owner or operator shall implement a corrective action program that prevents hazardous constituents from exceeding their respective concentration limits at the compliance point by removing the hazardous waste constituents or treating them in place. The permit will specify the specific measures that will be taken.

(c) The owner or operator shall begin corrective action within a reasonable time period after the groundwater protection standard is exceeded. The Commissioner will specify that time period in the facility permit. If a facility permit includes a corrective action program in addition to a compliance monitoring program, the permit will specify when the corrective action will begin and such a requirement will operate in lieu of Section 10.06.10(i)(2).

(d) In conjunction with a corrective action program, the owner or operator shall establish and implement a groundwater monitoring program to demonstrate the effectiveness of the corrective action program. Such a monitoring program may be based on the requirements for a compliance monitoring program under Section 10.06.10 and shall be as effective as that program in determining compliance with the groundwater protection standard under Section 10.06.03, and in determining the success of a corrective action program under Section 10.06.11(e) below, where appropriate.

(e) In addition to the other requirements of Section 10.06.11, the owner or operator shall conduct a corrective action program to remove or treat in place any hazardous constituents under Section 10.06.04 that exceed concentration limits under Section 10.06.05 in groundwater between the compliance point under Section 10.06.06 and the downgradient facility property boundary. The permit will specify the measures to be taken.

(1) Corrective action measures under this Section shall be initiated and completed within a reasonable period of time considering the extent of contamination.

(2) Corrective action measures under this Section may be terminated once the concentration of hazardous constituents under Section 10.06.04 is reduced to levels below their respective concentration limits under Section 10.06.05.

(f) The owner or operator shall continue corrective action measures during the compliance period to the extent necessary to ensure that the groundwater protection standard is not exceeded. If the owner or operator is conducting corrective action at the end of the compliance period, he shall continue that corrective action for as long as necessary to achieve compliance with the groundwater protection standard. The owner or operator may terminate corrective action measures taken beyond the period equal to the active life of the waste management area (including the closure period) if he can demonstrate, based on data from the groundwater monitoring program under Section 10.06.11(d), that the groundwater protection standard of Section 10.06.03 has not been exceeded for a period of three consecutive years.

(g) The owner or operator shall report in writing to the Commissioner on the effectiveness of the corrective action program. The owner or operator shall submit these reports semi-annually.

(h) If the owner or operator determines that the corrective action program no longer satisfies the requirements of this Section, he must, within 90 days, submit an application for a permit modification to make any appropriate changes to the program.

10.07 Closure and Post-closure

10.07.01 Applicability. Except as Section 10.01 provides otherwise:

(a) Sections 10.07.02 through 10.07.06 which concern closure apply to all hazardous waste facilities; and

(b) Section 10.07.08 through 10.07.11 which concern post-closure care apply to all owners and operators of:

(1) All hazardous waste disposal facilities; and

(2) Waste piles and surface impoundments from which the owner or operator intends to remove the wastes at closure, to the extent that Sections 10.07.08 through 10.07.11 are made applicable to such facilities in Sections 10.11.09 and 10.12.09.

10.07.02 Closure performance standards. The owner or operator shall close the facility in a manner that:

(a) minimizes the need for further maintenance, and

(b) controls, minimizes or eliminates, to the extent necessary to prevent threats to human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or to the atmosphere.

10.07.03 Closure plan; amendment of plan.

(a) The owner or operator of a hazardous waste management facility shall have a written closure plan. The plan shall be submitted with the permit application, in accordance with provisions of Section 11.00, and approved by the Commissioner as part of the permit issuance proceeding. The approved closure plan will become a condition of any permit. The Commissioner's decision shall assure that the approved closure plan is consistent with the provisions of this Section. A copy of the approved plan and all revisions to the plan shall be kept at the facility until closure is completed and certified. The plan shall identify steps necessary to completely or partially close the facility at any point during its intended operating life and to completely close the facility at the end of its intended operating life. The closure plan shall include, at least:

(1) A description of how and when the facility will be partially closed, if applicable, and finally closed. The description shall identify the maximum extent of the operation which will be unclosed during the life of the facility, and how the requirements of Sections 10.07.02, 10.07.04, 10.07.05, 10.07.06, and the applicable closure requirements of Sections 10.09.09, 10.10.08, 10.11.09, 10.12.09, 10.13.11, 10.14.11, and 10.15.12 will be met;

(2) An estimate of the maximum inventory of wastes in storage and in treatment at any time during life of the facility.

(3) A description of the steps needed to decontaminate facility equipment during closure; and

(4) An estimate of the expected year of closure and a schedule for final closure. The schedule shall include, at a minimum, the total time required to close the facility and the time required for intervening closure activities which will allow tracking of the progress of closure.

(b) The owner or operator may amend his closure plan at any time during the active life of the facility. The owner or operator shall amend the plan whenever changes in operating plans or facility design affect the closure plan, or whenever there is a change in the expected year of closure. When the owner or operator requests a permit modification to authorize a change in operating plans or facility design, he shall request a modification of the closure plan at the same time. If a permit modification is not needed to authorize the change in operating plans or facility design, the request for modification of the closure plan shall be made within 60 days after the change in plans or design occurs.

(c) The owner or operator shall notify the Commissioner at least 180 days prior to the date he expects to begin closure.

10.07.04 Closure; time allowed for closure.

(a) Within 90 days after receiving the final volume of hazardous wastes, the owner or operator shall treat, remove from the site, or dispose of on-site, all hazardous wastes in accordance with the approved closure plan. The Commissioner may approve a longer period if the owner or operator demonstrates that:

(1) (i) The activities required to comply with this paragraph will, of necessity, take longer than 90 days to complete; or

(ii) The facility has the capacity to receive additional wastes; there is a reasonable likelihood that a person other than the owner or operator will recommence operation of the site; and closure of the facility would be incompatible with continued operation of the site.

(2) He has taken and will continue to take all steps to prevent threats to human health and the environment.

(b) The owner or operator shall complete closure activities in accordance with the approved closure plan and within 180 days after receiving the final volume of wastes. The Commissioner may approve a longer closure period if the owner or operator demonstrates that:

(1) (i) The closure activities will, of necessity, take longer than 180 days to complete; or

(ii) The facility has the capacity to receive additional wastes; there is reasonable likelihood that a person other than the owner or operator will recommence operation of the site; and closure of the facility would be incompatible with continued operation of the site.

(2) He has taken and will continue to take all steps to prevent threats to human health and the environment from the unclosed but inactive facility.

10.07.05 Disposal or decontamination of equipment. When closure is completed, all facility equipment and structures shall have been properly disposed of, or decontaminated by removing all hazardous waste and residues.

10.07.06 Certification of closure. When closure is completed, the owner or operator shall submit to the Commissioner certification both by the owner or operator and by an independent professional engineer registered by the Commonwealth that the facility has been closed in accordance with the specifications in the approved closure plan.

10.07.07 [Reserved]

10.07.08 Post-closure care and use of property.

(a) (1) Post-closure care shall continue for 30 years after the date of completing closure and shall consist of at least the following:

(i) Monitoring and reporting in accordance with requirements of Sections 10.06, 10.11, 10.12, 10.13 and 10.14; and

(ii) Maintenance and monitoring of waste containment systems in accordance with the requirements of Sections 10.06, 10.11, 10.12, 10.13 and 10.14.

(2) During the 180-day period preceding closure or at any time thereafter, the Commissioner may reduce the post-closure care period to less than 30 years if he finds that the reduced period is sufficient to protect human health and the environment. Prior to the time that the post-closure care period is due to expire, the Commissioner may extend the post-closure care period if he finds that the extended period is necessary to protect human health and the environment.

(b) The Commissioner may require, at closure, continuation of any of the security requirements during part or all of the post-closure period after the date of completing closure when:

(1) Wastes may remain exposed after completion of closure; or

(2) Access by the public or domestic livestock may pose a hazard to human health.

(c) Post-closure use of property on or in which hazardous wastes remain after closure shall never be allowed to disturb the integrity of the final cover, liner(s), or any other components of any containment system, or the function of the facility's monitoring systems, unless the Commissioner finds that the disturbance:

(1) Is necessary to the proposed use of the property, and will not increase the potential hazard to human health or the environment; or

(2) Is necessary to reduce a threat to human health or the environment.

(d) All post-closure care activities shall be in accordance with the provisions of the approved post-closure plan as specified.

10.07.09 Post-closure plan; amendment of plan.

(a) The owner or operator of a disposal facility shall have a written post-closure plan. In addition, certain wastes piles and certain surface impoundments from which the owner or operator intends to remove the wastes at closure are required by Section 10.11.09 and 10.12.09 to have post-closure plans. The plan shall be submitted with the permit application as part of the permit issuance proceeding. The approved post-closure plan will become a condition of any permit issued. A copy of the proved plan and all revisions to the plan shall be kept at the facility until the post-closure care period begins. This plan shall identify the activities which will be carried on after closure and the frequency of these activities, and include at least:

(1) A description of the planned monitoring activities and frequencies at which they will be performed to comply with Sections 10.06, 10.11, 10.12, 10.13, and 10.14 during the post-closure period;

(2) A description of the planned maintenance activities, and frequencies at which they will be performed, to ensure:

(i) The integrity of the cap and final cover or other containment systems in accordance with requirements of Sections 10.11, 10.12, 10.13, and 10.14; and

(ii) The function of the facility monitoring systems equipment in accordance with the requirements of Sections 10.06, 10.11, 10.12, 10.13 and 10.14; and

(3) The name, address, and phone number of the person or office to contact about the disposal facility during the post-closure period. This person or office shall keep an updated post-closure plan during the post-closure period.

(b) The owner or operator may amend his post-closure plan at any time during the active life of the disposal facility or during the post-closure care period. The owner or operator shall amend his plan whenever changes in operating plans or facility design, or events which occur during the active life of the facility or during the post-closure period, affect his post-closure plan. He shall amend his plan whenever there is a change in the expected year of closure.

(c) When a permit modification is requested during the active life of the facility to authorize a change in operating plans or facility design, modification of the post-closure plan shall be requested at the same time. In all other cases, the request for modification of the post-closure plan shall be made within 60 days after the change in operating plans or facility design or the events which affect his post-closure plan occur.

10.07.10 Notice to local government (County Board of Supervisors or City Council). Within 90 days after closure is completed, the owner or operator of a disposal facility shall submit to the local government or the authority with jurisdiction over local land use and to the Commissioner a survey plan indicating the location and dimensions of landfill cells or other disposal areas with respect to permanently surveyed benchmarks. This plan shall be prepared and certified by a professional land surveyor. The plan filed with the local government or the authority with jurisdiction over local land use shall contain a note, prominently displayed, which states the owner's or operator's obligation to restrict disturbance of the site as specified. In addition, the owner or operator shall submit to the local government or the authority with jurisdiction over local land use and to the Commissioner a record of the type, location and quantity of hazardous waste disposed of within each cell or area of the facility. For wastes disposed of before these regulations were promulgated, the owner or operator shall identify the type, location and quantity of the wastes to the best of his knowledge and in accordance with any records he has kept. Any changes in the type, location, or quantity of hazardous wastes disposed of within each cell or area of the facility that occur after the survey plan and record of wastes have been filed shall be reported to the local government or the authority with jurisdiction over local land use and to the Commissioner.

10.07.11 Notice in deed to property

(a) The owner of the property on which a disposal facility is located shall record a notation on the deed to the facility property—or on some other instrument which is normally examined during title search—that will in perpetuity notify any potential purchaser of the property that:

(1) The land has been used to manage hazardous wastes;

(2) Its use is restricted;

(3) The survey plan and record of the type, location, and quantity of hazardous wastes disposed of within each cell or area of the facility have been filed with the local government or the authority with jurisdiction over local land use and with the Commissioner.

(b) If at any time the owner or operator or any subsequent owner of the land upon which a hazardous waste facility was located removes the waste and waste residues, the liner, if any, and all contaminated underlying and surrounding soil, he may remove the notation on the deed to the facility property or other instrument normally examined during title search, or he may add a notation to the deed or instrument indicating the removal of the waste.

10.08 Financial Requirements

10.08.01 Applicability.

(a) The requirements of Sections 10.08.02, 10.08.03 and 10.08.07 to 10.08.11 apply to owners and operators of all hazardous waste facilities, except as provided otherwise in this section or in Section 10.01.

(b) The requirements of Sections 10.08.04 and 10.08.05 apply only to owners and operators of:

(1) Disposal facilities; and

(2) Piles, and surface impoundments from which the owner or operator intends to remove the wastes at closure, to the extent that these Sections are made applicable to such facilities in Sections 10.11.09 and 10.12.09.

(c) The Commonwealth and federal government which own and operate hazardous waste facilities, and their agencies are exempt from the requirements of Section 10.08.

(d) Common meaning of the terms used in this Section are shown in Appendix 2.1.

(2) The waste is stored or treated in such a way that it is protected from any material or conditions which may cause the waste to ignite or react; or

(3) The tank is used solely for emergencies.

(b) The owner or operator of a facility which treats or stores ignitable or reactive waste in covered tanks shall comply with the National Fire Protection Association's (NFPA's) buffer zone requirements for tanks, contained in Tables 2-1 through 2-6 of the "Flammable and Combustible Code—1977".

10.10.10 Special requirements for incompatible wastes.

(a) Incompatible wastes, or incompatible wastes and materials, shall not be placed in the same tank, unless Section 10.02.08(b) is complied with.

(b) Hazardous waste shall not be placed in an unwashed tank which previously held an incompatible waste or material, unless Section 10.02.08(b) is complied with.

10.11 Surface Impoundments

10.11.01 Applicability. The regulations in this Section apply to owners and operators of facilities that use surface impoundments to dispose, treat or store hazardous waste, except as Section 10.01 provides otherwise.

10.11.02 Design and operating requirements.

(a) A surface impoundment (except for an existing portion of a surface impoundment) shall have a liner that is designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil or groundwater or surface water at any time during the active life (including the closure period) of the impoundment. The liner may be constructed of materials that may allow wastes to migrate into the liner (but not into the adjacent subsurface soil or groundwater or surface water) during the active life of the facility, provided that the impoundment is closed in accordance with Section 10.11.09(a)(1). For impoundments that will be closed in accordance with Section 10.11.09(a)(2), the liner shall be constructed of materials that can prevent wastes from migrating into the liner during the active life of the facility. The liner shall be:

(1) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(2) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(3) Installed to cover all surrounding earth likely to be in contact with the waste or leachate.

(b) The owner or operator will be exempted from the requirements of Section 10.11.02(a) if the Commissioner finds, based on a demonstration by the owner or operator, that alternate design and operating practices, together with location characteristics, will prevent the migration of any hazardous constituents (see Section 10.06.04) into the groundwater or surface water at any future time. In deciding whether to grant an exemption, the Commissioner will consider:

(1) The nature and quantity of the wastes;

(2) The proposed alternate design and operation;

(3) The hydrogeologic setting of the facility, including the attenuative capacity and thickness of the liners and soils present between the impoundment and groundwater or surface water; and

(4) All other factors which would influence the quality and mobility of the leachate produced and the potential for it to migrate to groundwater or surface water.

(c) A surface impoundment shall be designed, constructed, maintained, and operated to prevent overtopping resulting from normal or abnormal operations; overfilling; wind and wave action; rainfall; run-on, malfunctions of level controllers, alarms, and other equipment; and human error.

(d) A surface impoundment shall have dikes that are designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes. In ensuring structural integrity, it shall not be presumed that the liner system will function without leakage during the active life of the unit.

(e) The Commissioner will specify in the permit all design and operating practices that are necessary to ensure that the requirements of Section 10.11.02 are satisfied.

10.11.03 Double-lined surface impoundments

(a) The owner or operator of a double-lined surface impoundment is not subject to regulation under Section 10.06 if the following conditions are met:

(1) The impoundment (including its underlying liners) shall be located entirely above the seasonal high water table.

(2) The impoundment shall be underlain by two liners which are designed and constructed in a manner that prevents the migration of liquids into or out of the space between the liners. Both liners shall meet all the specifications of Section 10.11.02(a).

(3) A leak detection system shall be designed, constructed, maintained, and operated between the liners to detect any migration of liquids into the space between the liners.

(b) If liquid leaks into the leak detection system, the owner or operator shall:

(1) Notify the Commissioner of the leak in writing within seven days after detecting the leak; and

(2) (i) Within a period of time specified in the permit, remove accumulated liquid, repair or replace the liner which is leaking to prevent the migration of liquids through the liner, and obtain a certification from a qualified professional engineer that, to the best of his knowledge and opinion, the leak has been stopped; or

(ii) If detection monitoring program pursuant to Section 10.06.09 has already been established in the permit (to be complied with only if a leak occurs), begin to comply with that program and any other applicable requirements of Section 10.06 within a period of time specified in the permit.

(c) The Commissioner will specify in the permit all design and operating practices that are necessary to ensure that the requirements of Section 10.11.03 are satisfied.

10.11.04-10.11.06 [Reserved]

10.11.07 Monitoring and inspection.

(a) During construction and installation, liners (except in the case of existing portions of surface impoundments exempt from Section 10.11.02(a)) and cover systems (e.g., membranes, sheets, or coatings) shall be inspected for uniformity, damage, and imperfections (e.g., holes, cracks, thin spots, or foreign materials). Immediately after construction or installation:

(1) Synthetic liners and covers shall be inspected to ensure tight seams and joints and the absence of tears, punctures, or blisters; and

(2) Soil-based and admixed liners and covers shall be inspected for imperfections including lenses, cracks, channels, root holes, or other structural non-uniformities that may cause an increase in the permeability of the liner or cover.

(b) While a surface impoundment is in operation, it shall be inspected weekly and after storms to detect evidence of any of the following:

(1) Deterioration, malfunctions, or improper operation of overtopping control systems;

(2) Sudden drops in the level of the impoundment's contents;

(3) The presence of liquids in leak detection systems, where installed to comply with Section 10.11.03; and

(4) Severe erosion or other signs of deterioration in dikes or other containment devices.

(c) Prior to the issuance of a permit, and after any extended period of time (at least six months) during which the impoundment was not in service, the owner or operator shall obtain a certification from a qualified professional engineer that the impoundment's dike, including that portion of any dike which provides freeboard, has structural integrity. The certification shall establish, in particular, that the dike:

(1) Will withstand the stress of the pressure exerted by the types and amounts of wastes to be placed in the impoundment; and

(2) Will not fail due to scouring or piping, without dependence on any liner system included in the surface impoundment construction.

10.11.08 Emergency repairs; contingency plans.

(a) A surface impoundment shall be removed from service in accordance with Section 10.11.08(b) when:

(1) The level of liquids in the impoundment suddenly drops and the drop is not known to be caused by changes in the flows into or out of the impoundment; or

(2) The dike leaks.

(b) When a surface impoundment shall be removed from service as required by Section 10.11.08(a), the owner or operator shall:

(1) Immediately shut off the flow or stop the addition of wastes into the impoundment;

(2) Immediately contain any surface leakage which has occurred or is occurring;

(3) Immediately stop the leak;

(4) Take any other necessary steps to stop or prevent catastrophic failure;

(5) If a leak cannot be stopped by any other means, empty the impoundment; and

(6) Notify the Commissioner of the problem in writing within seven days after detecting the problem.

(c) As part of the contingency plan required in Section 10.04, the owner or operator shall specify a procedure for complying with the requirements of Section 10.11.08(b).

(d) No surface impoundment that has been removed from service in accordance with the requirements of this Section may be restored to service unless the portion of the impoundment which was failing is repaired and the following steps are taken:

(1) If the impoundment was removed from service as the result of actual or imminent dike failure, the dike's structural integrity shall be recertified in accordance with Section 10.11.07(c).

(2) If the impoundment was removed from service as the result of a sudden drop in the liquid level, then:

(i) For any existing portion of the impoundment, a liner shall be installed in compliance with Section 10.11.02(a) or 10.11.03; and

(ii) For any other portion of the impoundment, the repaired liner system shall be certified by a qualified professional engineer as meeting the design specifications approved in the permit.

(e) A surface impoundment that has been removed from service in accordance with the requirements of this Section and that is not being repaired shall be closed in accordance with the provisions of Section 10.11.09.

10.11.09 Closure and post-closure care.

(a) At closure, the owner or operator shall:

(1) Remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated subsoils, and structures and equipment contaminated with waste and leachate, and manage them as hazardous waste unless Section 2.80(d) applies; or

(2) (i) Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues;

(ii) Stabilize remaining wastes to a bearing capacity sufficient to support final cover; and

(iii) Cover the surface impoundment with a final cover designed and constructed to:

(A) Provide long-term minimization of the migration of liquids through the closed impoundment;

(B) Function with minimum maintenance;

(C) Promote drainage and minimize erosion or abrasion of the final cover;

(D) Accommodate settling and subsidence so that the cover's integrity is maintained; and

(E) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

(b) If some waste residues or contaminated materials are left in place at final closure, the owner or operator shall comply with all post-closure requirements contained in Section 10.07.08 through 10.07.11, including maintenance and monitoring throughout the post-closure care period (specified in the permit under Section 10.07.08). The owner or operator shall:

(1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;

(2) Maintain and monitor the leak detection system in accordance with Section 10.11.03, where such a system is present between double liner systems;

(3) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of Section 10.06; and

(4) Prevent run-on and run-off from eroding or otherwise damaging the final cover.

(c) (1) If an owner or operator plans to close a surface impoundment in accordance with Section 10.11.09(a)(1) and the impoundment does not comply with the liner requirements of Section 10.11.02(a) and is not exempt from them in accordance with Section 10.11.02(b), then;

(i) The closure plan for the impoundment under Section 10.07.03 shall include both a plan for complying with Section 10.11.09(a)(1) and a contingent plan for complying with Section 10.11.09(a)(2) in case not all contaminated subsoils can be practicably removed at closure; and

(ii) The owner or operator shall prepare a contingent post-closure plan under Section 10.07.09 for complying with Section 10.11.09(b) in case not all contaminated subsoils can be practicably removed at closure.

(2) The cost estimates calculated under Section 10.08.02 and 10.08.04 for closure and post-closure care of an impoundment subject to this paragraph shall include the cost of complying with the contingent closure plan and the contingent post-closure plan, but are not required to include the cost of expected closure under Section 10.11.09(a)(1).

(d) During the post-closure care period, if liquids leak into a leak detection system installed under Section 10.11.03, the owner or operator shall notify the Commissioner of the leak in writing within seven days after detecting the leak. The Commissioner will modify the permit to require compliance with the requirements of Section 10.06.

10.11.10 Special requirements for ignitable or reactive waste. Ignitable or reactive waste shall not be placed in a surface impoundment, unless:

(a) The waste is treated, rendered, or mixed before or immediately after placement in the impoundment so that:

(1) The resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under Sections 3.07 or 3.09; and

(2) Section 10.02.08 is complied with; or

(b) The waste is managed in such a way that it is protected from any material or conditions which may cause it to ignite or react; or

(c) The surface impoundment is used solely for emergencies.

10.11.11 Special requirements for incompatible wastes. Incompatible wastes, or incompatible wastes and materials (see Appendix 10.5 for examples), shall not be placed in the same surface impoundment, unless Section 10.02.08 is complied with.

10.12 Waste Piles

10.12.01 Applicability.

(a) The regulations in this Section apply to owners and operators of facilities that store or treat hazardous waste in piles, except as Section 10.01 provides otherwise.

(b) The regulations in this Section do not apply to owners or operators of waste piles that are closed with wastes left in place. Such waste piles are subject to regulation under Section 10.14 (Landfills).

(c) The owner or operator of any waste pile that is inside or under a structure that provides protection from precipitation so that neither run-off nor leachate is generated is not subject to regulation under Sections 10.12.02 or under Section 10.06, provided that:

(1) Liquids or materials containing free liquids are not placed in the pile;

(2) The pile is protected from surface water run-on by the structure or in some other manner;

(3) The pile is designed and operated to control dispersal of the waste by wind, where necessary, by means other than wetting; and

(4) The pile will not generate leachate through decomposition or other reactions.

10.12.02 Design and operating requirements.

(a) A waste pile (except for an existing portion of a waste pile) shall have:

(1) A liner that is designed, constructed, and installed to prevent any migration of wastes out of the pile into the adjacent subsurface soil or groundwater or surface water at any time during the active life (including the closure period) of the waste pile. The liner may be constructed of materials that may allow waste to migrate into the liner itself (but not into the adjacent subsurface soil or groundwater or surface water) during the active life of the facility. The liner shall be:

(i) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(ii) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(iii) Installed to cover all surrounding earth likely to be in contact with the waste or leachate; and

(2) A leachate collection and removal system immediately above the liner that is designed, constructed, maintained, and operated to collect and remove leachate from the pile. The Commissioner will specify design and operating conditions in the permit to ensure that the leachate depth over the liner does not exceed 30 cm (one foot). The leachate collection and removal system shall be:

(ii) The owner or operator shall express background values and values for hazardous constituents in the treatment zone in a form necessary for the determination of statistically significant increases under Section 10.13.11(d)(3).

(2) In taking samples used in the determination of background and treatment zone values, the owner or operator shall take samples at a sufficient number of sampling points and at appropriate locations and depths to yield samples that represent the chemical make-up of soil that has not been affected by leakage from the treatment zone and the soil within the treatment zone, respectively.

(3) In determining whether a statistically significant increase has occurred, the owner or operator shall compare the value of each constituent in the treatment zone to the background value for that constituent using a statistical procedure that provides reasonable confidence that constituent presence in the treatment zone will be identified. The owner or operator shall use a statistical procedure that:

(i) Is appropriate for the distribution of the data used to establish background values; and

(ii) Provides a reasonable balance between the probability of falsely identifying hazardous constituent presence in the treatment zone and the probability of failing to identify real presence in the treatment zone.

(e) The owner or operator is not subject to regulation under Section 10.06 if the Commissioner finds that the owner or operator satisfies Section 10.13.11(d) and if unsaturated zone monitoring under Section 10.13.09 indicates that hazardous constituents have not migrated beyond the treatment zone during the active life of the land treatment unit.

10.13.12 Special requirements for ignitable or reactive waste. The owner or operator shall not apply ignitable or reactive waste to the treatment zone unless:

(a) The waste is immediately incorporated into the soil so that:

(1) The resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under Section 3.07 or 3.09; and

(2) Section 10.02.08 is complied with; or

(b) The waste is managed in such a way that it is protected from any material or conditions which may cause it to ignite or react.

10.13.13 Special requirements for incompatible wastes. The owner or operator shall not place incompatible wastes, or incompatible wastes and materials (see Appendix 10.5 for examples), in or on the same treatment zone, unless Section 10.02.08 is complied with.

10.14 Landfills

10.14.01 Applicability. The regulations in Section 10.14 apply to owners and operators of facilities that dispose of hazardous waste in landfills, except as Section 10.1 provides otherwise.

10.14.02 Design and operating requirements.

(a) A landfill (except for an existing portion of a landfill) shall have:

(1) A liner that is designed, constructed, and installed to prevent any migration of wastes out of the landfill to the adjacent subsurface soil or groundwater or sufrace water at anytime during the active life (including the closure period) of the landfill. The liner shall be constructed of materials that prevent wastes from passing into the liner during the active life of the facility. The liner shall be:

(i) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(ii) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(iii) Installed to cover all surrounding earth likely to be in contact with the waste or leachate; and

(2) A leachate collection and removal system immediately above the liner that is designed, constructed, maintained, and operated to collect and remove leachate from the landfill. The Commissioner will specify design and operating conditions in the permit to ensure that the leachate depth over the liner does not exceed 30 cm (one foot). The leachate collection and removal system shall be:

(i) Constructed of materials that are:

(A) Chemically resistant to the waste managed in the landfill and the leachate expected to be generated; and

(B) Of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill; and

(ii) Designed and operated to function without clogging through the scheduled closure of the landfill.

(b) The owner or operator will be exempted from the requirements of Section 10.14.02(a) if the Commissioner finds, based on a demonstration by the owner or operator, that alternative design and operating practices, together with location characteristics, will prevent the migration of any hazardous constituents (see Section 10.06.04) into the groundwater or surface water at any future time. In deciding whether to grant an exemption, the Commissioner will consider:

(1) The nature and quantity of the wastes;

(2) The proposed alternate design and operation;

(3) The hydrogeologic setting of the facility, including the attenuative capacity and thickness of the liners and soils present between the landfill and groundwater or surface water; and

(4) All other factors which would influence the quality and mobility of the leachate produced and the potential for it to migrate to groundwater or surface water.

(c) The owner or operator shall design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the landfill during peak discharge from at least a 25-year storm.

(d) The owner or operator shall design, construct, operate, and maintain a run-off management system to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

(e) Collection and holding facilities (e.g., tanks or basins) associated with run-on and run-off control systems shall be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system.

(f) If the landfill contains any particulate matter which may be subject to wind dispersal, the owner or operator shall cover or otherwise manage the landfill to control wind dispersal.

(g) The Commissioner will specify in the permit all design and operating practices that are necessary to ensure that the requirements of Section 10.14.02 are satisfied.

10.14.03 Double-lined landfills.

(a) The owner or operator of a double-lined landfill is not subject to regulation under Section 10.06 if the following conditions are met:

(1) The landfill (including its underlying liners) shall be located entirely above the seasonal high water table.

(2) The landfill shall be underlain by two liners which are designed and constructed in a manner to prevent the migration of liquids into or out of the space between the liners. Both liners must meet all the specifications of Section 10.14.02(a)(1).

(3) A leak detection system shall be designed, constructed, maintained, and operated between the liners to detect any migration of liquid into the space between the liners.

(4) The landfill shall have a leachate collection and removal system above the top liner that is designed, constructed, maintained, and operated in accordance with Section 10.14.02(a)(2).

(b) If liquid leaks into the leak detection system, the owner or operator shall:

(1) Notify the Commissioner of the leak in writing within seven days after detecting the leak; and

(2) (i) Within a period of time specified in the permit, remove accumulated liquid, repair or replace the liner which is leaking to prevent the migration of liquids through the liner, and obtain a certification from a qualified professional engineer that, to the best of his knowledge and opinion, the leak has been stopped; or

(ii) If a detection monitoring program pursuant to Section 10.06.09 has already been established in the permit (to be complied with only if a leak occurs), begin to comply with that program and any other applicable requirements of Section 10.06 within a period of time specified in the permit.

(c) The Commissioner will specify in the permit all design and operating practices that are necessary to ensure that the requirements of Section 10.14.03 are satisfied.

10.14.04 Monitoring and inspection.

(a) During construction or installation, liners (except in the case of existing portions of landfills exempt from Section 10.14.02(a) and cover systems (e.g., membranes, sheets, or coatings) shall be inspected for uniformity, damage, and imperfections (e.g., holes, cracks, thin spots, or foreign materials).

(b) Immediately after construction or installation:

(1) Synthetic liners and covers shall be inspected to ensure tight seams and joints and the absence of tears, punctures, or blisters; and

(2) Soil-based and admixed liners and covers shall be inspected for imperfections including lenses, cracks, channels, root holes, or other structural non-uniformities that may cause an increase in the permeability of the liner or cover.

(c) While a landfill is in operation, it shall be inspected weekly and after storms to detect evidence of any of the following:

(1) Deterioration, malfunctions, or improper operation of run-on and run-off control systems.

(2) The presence of liquids in leak detection systems, where installed to comply with Section 10.14.03;

(3) Proper functioning of wind dispersal control systems, where present; and

(4) The presence of leachate in and proper functioning of leachate collection and removal systems, where present.

10.14.05—10.14.09 [Reserved]

10.14.10 Surveying and recordkeeping. The owner or operator of a landfill shall maintain the following items in the operating record required under Section 10.05.02:

(a) On a map, the exact location and dimensions, including depth of each cell with respect to permanently surveyed benchmarks; and

(b) The contents of each cell and the approximate location of each hazardous waste type within each cell.

10.14.11 Closure and post-closure care.

(a) At final closure of the landfill or upon closure of any cell, the owner or operator shall cover the landfill or cell with a final cover designed and constructed to:

(1) Provide long-term minimization of migration of liquids through the closed landfill;

(2) Function with minimum maintenance;

(3) Promote drainage and minimize erosion or abrasion of the cover;

(4) Accommodate settling and subsidence so that the cover's integrity is maintained; and

(5) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

(b) After final closure, the owner or operator shall comply with all post-closure requirements contained in Sections 10.07.08 through 10.07.11 including maintenance and monitoring throughout the post-closure care period (specified in the permit under Section 10.07.08). The owner or operator shall:

(1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;

(2) Maintain and monitor the leak detection system in accordance with Section 10.14.03, where such a system is present between double liner systems;

(3) Continue to operate the leachate collection and removal system until leachate is no longer detected;

(4) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of Section 10.06;

(5) Prevent run-on and run-off from eroding or otherwise damaging the final cover; and

(6) Protect and maintain surveyed benchmarks used in complying with Section 10.14.10.

(c) During the post-closure care period, if liquid leaks into a leak detection system installed under Section 10.14.03, the owner or operator shall notify the Commissioner of the leak in writing within seven days after detecting the leak. The Commissioner will modify the permit to require compliance with the requirements of Section 10.06.

10.14.12 [Reserved]

10.14.13 Special requirements for ignitable or reactive waste.

(a) Except as provided in Section 10.14.13(b) and in Section 10.14.17, ignitable or reactive waste shall not be placed in a landfill, unless the waste is treated, rendered, or mixed before or immediately after placement in a landfill so that:

(1) The resulting waste, mixture, or dissolution of material no longer meets the definition of ignitable or reactive waste under Section 3.07 or 3.09; and

(2) Section 10.02.08 is complied with.

(b) Ignitable wastes in containers may be landfilled without meeting the requirements of Section 10.14.13(a), provided that the wastes are disposed of in such a way that they are protected from any material or conditions which may cause them to ignite. At a minimum, ignitable wastes shall be disposed of in nonleaking containers which are carefully handled and placed so as to avoid heat, sparks, rupture, or any other condition that might cause ignition of the wastes; shall be covered daily with soil or other noncombustible material to minimize the potential for ignition of the wastes; and shall not be disposed of in cells that contain or will contain other wastes which may generate heat sufficient to cause ignition of the waste.

10.14.14 Special requirements for incompatible wastes. Incompatible wastes, or incompatible wastes and materials, (see Appendix 10.05 for examples) shall not be placed in the same landfill cell, unless Section 10.02.08 is complied with.

10.14.15 Special requirements for liquid waste.

(a) Bulk or noncontainerized liquid waste or waste containing free liquids shall not be placed in a landfill unless:

(1) The landfill has a liner and leachate collection and removal system that meet the requirements of Section 10.14.02(a); or

(2) Before disposal, the liquid waste or waste containing free liquids is treated or stabilized, chemically or physically (e.g. by mixing with an absorbent solid), so that free liquids are no longer present.

(b) Containers holding free liquids shall not be placed in a landfill unless:

(1) All free-standing liquid has been removed by decanting or other methods; has been mixed with absorbent or solidified so that free-standing liquid is no longer observed; or has been otherwise eliminated; or

(2) The container is very small, such as an ampule; or

(3) The container is designed to hold free liquids for use other than storage, such as a battery or capacitor; or

(4) The container is a lab pack as defined in Section 10.14.17 and is disposed of in accordance with that Section.

10.14.16 Special requirements for containers. Unless they are very small, such as an ampule, containers shall be either:

(a) At least 90 percent full when placed in the landfill; or

(b) Crushed, shredded, or similarly reduced in volume to the maximum practical extent before burial in the landfill.

10.14.17 Disposal of small containers of hazardous waste in overpacked drums (lab packs). Small containers of hazardous waste in overpacked drums (lab packs) may be placed in a landfill if the following requirements are met:

(a) Hazardous waste shall be packed in nonleaking inside containers. The inside containers shall be of a design and constructed of a material that will not react dangerously with, be decomposed by, or be ignited by the contained waste. Inside containers shall be tightly and securely sealed. The inside containers shall be of the size and type specified in the Virginia Regulations Governing the Transportation of Hazardous Materials, (VRGTHM) Sections 3.02 to 3.04, if those regulations specify a particular inside container for the waste.

(b) The inside containers shall be overpacked in an open head DOT-specification metal shipping container (Sections 3.03 and 3.04, VRGTHM) of no more than 416-liter (110 gallon) capacity and surrounded by, at a minimum, a sufficient quantity of absorbent material to completely absorb all of the liquid contents of the inside containers. The metal outer container shall be full after packing with inside containers and absorbent material.

(c) The absorbent material used shall not be capable of reacting dangerously with, being decomposed by, or being ignited by the contents of the inside containers in accordance with Section 10.02.08.

(d) Incompatible wastes, as defined in Section 2.74, shall not be placed in the same outside container.

(e) Reactive wastes, other than cyanide- or sulfide-bearing waste as defined in Section 3.09.01(e), shall be treated or rendered nonreactive prior to packaging in accordance with Sections 10.14.17(a) through (d). Cyanide- and sulfide-bearing reactive waste may be packed in accordance with Sections 10.14.17(a) through (d) without first being treated or rendered nonreactive.

10.15 Incinerators

10.15.01 Applicability.