REPORT
ON
CORRECTIVE ACTION
ALTERNATIVES ANALYSIS
OF SMALL LANDFILL

NAVAL AIR STATION
SOUTH WEYMOUTH, MASSACHUSETTS
CONTRACT NO. N62472-05-D-1403

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TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

List of Tables
(follows text)

List of Figures
(follows tables)

List of Appendices

1.0 INTRODUCTION

1.1 Background

HRP Associates, Inc. (HRP) conducted a Corrective Action Alternatives Analysis (CAAA) for the South Weymouth Naval Air Station Small Landfill on behalf of the Department of the Navy, Engineering Field Activity Northeast (EFANE). This work was performed under Contract Number N62472-05-D-1403.

The purpose of this study was to comply with the Corrective Action Alternatives Analysis requirement for closure of the Small Landfill (SL) under the Massachusetts Department of Environmental Protection's Solid Waste Management Regulations (310 CMR 19.140). The CAAA provides an analysis of applicable closure technologies for closure to determine the most appropriate options that are protective of human health and the environment. It is the intention of the Navy to close the SL under current regulatory requirements.

The SL is located on the eastern portion of the naval base (Figure 1). It was used by the Navy for a period of about five years in the 1980s to dispose of debris, primarily of concrete rubble, tree stumps, and miscellaneous solid waste. Additional materials found at the SL during previous investigations included asphalt, railroad ties, plastic, steel, aluminum, rubber tubing, bottles and cans, electrical wires, and wood debris. The SL covers roughly 0.8 to 1 acre in size, and is characterized by an open grass-covered area with a hummocky surface sloping slightly to the southwest. The area around the SL is wooded. An unpaved road borders the SL to the east.

This CAAA is part of the three-phase landfill closure process required by the Massachusetts Department of Environmental Protection (MADEP) Solid Waste Regulations (310 CMR 19.000) that includes the following:

1. Initial Assessment (ISA)
2. Comprehensive Site Assessment (CSA)
3. Corrective Action Alternatives Analysis (CAAA)

(Note: the ISA and the CSA include Qualitative/Quantitative Risk Assessments for both human health and the environment).

1.2 Previous Investigations

The SL has been investigated previously as part of a base-wide evaluation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The results of these investigations are summarized below.

<u>**Phase I Remedial Investigation – 1998**</u>

In 1998, Brown & Root Environmental conducted a CERCLA Phase I Remedial Investigation (RI) at the South Weymouth Naval Air Station that included the SL area. This study included the collection of soil, ground water, sediment, and surface water samples, as well as soil-vapor and geophysical surveys, immunoassay testing, ecological assessment, and test pit excavation. Low levels of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and metals were detected in soils in the SL area.

This report also included an extensive Risk Characterization for both human health and the environment. All risks were determined to be within the U.S. Environmental Protection Agency's (EPA) acceptable ranges under current site usage. In the event of a possible future residential use scenario, the ground water was determined to have exceedances outside of the acceptable risk range for thallium and zinc. However, as discussed in the Phase I report, the presence of zinc may have been due to the zinc-coated galvanized well point used to collect the ground water sample. Also, thallium was detected in ground water in only one of the monitoring wells, and no thallium was detected in soils in that boring. The reported concentration of thallium was close to the laboratory's lower quantitation limit, thus this detection may potentially have been due to analytical variability. The RI report recommended additional investigation at the Small Landfill.

Phase II Remedial Investigation – 2000

Tetra Tech/NUS conducted a CERCLA Phase II Remedial Investigation (RI) at the Naval Air Station in 2000, including the SL area. The Phase II RI included additional risk assessment, surface soil sampling, and groundwater level gauging. Low levels of soil and ground water contaminants were detected in the SL area similar to those detected during the Phase I investigation. The Remedial Investigation determined that the contaminants detected at the Small Landfill were present at concentrations very close to their analytical detection limits or within the range of background concentrations. The Phase II report concluded that cleanup was not warranted to protect human health or the environment.

The Navy conducted four consecutive quarters of groundwater monitoring around the SL from September 2001 to July 2002. This monitoring involved a comprehensive list of parameters, including potential contaminants and leachate parameters. The results showed no significant impact to groundwater from the SL.

The Navy concluded, based on these investigations, that no further characterization was required for the SL, and that they considered the Remedial Investigation of the SL to be complete. Therefore, the landfill closure requirements for the ISA and CSA (steps # 1 and # 2 in closure process) have been completed, with the exceptions noted in Section 1.3 (below).

1.3 Evaluation of Landfill Closure Requirements

The work completed to date on the SL is considered to have fulfilled the requirements under 310 CMR 19.000 for landfill closure and risk assessment (i.e., the ISA and CSA) except for investigation of landfill gases and risk to human safety. A detailed comparison performed by the Navy of the work completed to date versus specific closure requirements under 310 CMR 19.000 is included in Appendix A.

This CAAA study included an investigative phase during which landfill gas sampling was conducted. The results of that study found trace concentrations of methane and hydrogen sulfide in approximately half of the testing locations, but no widespread generation of significant levels of typical landfill gases. A separate report on landfill gas monitoring and test pit installation was completed (see "Report on Installation of Test Pits and Vapor Survey," HRP Associates, Inc., August 2005)

2.0 REVIEW OF APPLICABLE TECHNOLOGIES

In order to determine the most appropriate closure method for the Small Landfill, a list of applicable technologies used in the control of contamination in each environmental media was evaluated. Following the development of a list of applicable technologies, the list was screened to determine the technologies that best fit the existing conditions at the Small Landfill. Applicable technologies for each media were then selected to provide options for closure. The technology options were then integrated into a comprehensive closure alternative package.

The following sections discuss applicable technologies for each media.

2.1 Groundwater/Leachate

Applicable remedial/containment technologies include:

- Installation of a barrier (slurry wall, reactive barrier, etc.) to prevent migration
- Leachate collection system (subsurface drains or extraction wells)
- Groundwater recovery and treatment (i.e., pump and treat)
- Providing alternative water supply to affected residents

2.2 Air/Landfill Gas

In order to control potential off gases generated from the decomposition or volatilization of wastes in landfills, the following technologies may be utilized:

- Passive gas elimination systems that vent directly to the atmosphere; or
- Active gas elimination systems that mechanically extract gases via vacuum. These may include flaring or collection of gases for energy recovery.

2.3 Surface Water

Treatment of surface water that may come in contact with landfilled materials or be affected by leachate or groundwater contamination emanating from a landfill should be considered if appropriate. Appropriate technologies may include one or more of the following:

- Air stripping for removal of volatile organic compounds
- Neutralization
- Metals precipitation
- Biological treatment
- Removal of contaminated sediment

2.4 Wetlands

In order to remediate the impact of a landfill on wetlands, the following technologies may be utilized:

- Biological and/or chemical treatment of sediment
- Dredging
- Restoration of original form and function of wetlands

2.5 Soils

In the event that on-site soils have been impacted by the landfill activities, one or more of the following technologies may be applicable:

- Hot spot excavation and off-site treatment/disposal
- Soil vapor extraction
- Bioremediation/Bioventing
- Soil flushing
- Solidification/stabilization
- Chemical oxidation
- Injection of substances to enhance bioremediation

3.0 SCREENING OF APPLICABLE TECHNOLOGIES

The screening of each of the technologies listed in Section 2.0 is discussed in the following sections as appropriate in order to determine the applicability and suitability of each option. Each technology was analyzed to determine if it would address the level and extent of any existing contamination at the Small Landfill and whether it was a practical and cost effective long-term solution. Potential adverse impacts from combining technologies were also considered. Any technologies not meeting these criteria were eliminated from further consideration. Also, technologies applicable to specific media or conditions were eliminated based on the need (or lack thereof) for remedial measures for that media.

3.1 Groundwater/Leachate

A review of historical groundwater data in the area of the Small Landfill indicates that the site's groundwater has not been impacted significantly by historical activities at the SL. Previous investigations, including extensive ground water monitoring, have not identified a sustained contamination plume emanating from the SL. In addition, no evidence of leachate breakout has been observed. The previous studies concluded that the sporadic detection of zinc and thallium in ground water in selected monitoring wells around the SL was likely due to sampling methodologies and/or laboratory procedures. Therefore, applicable groundwater treatment or containment technologies are not required at the SL, and were not further evaluated for inclusion in the closure options package. Groundwater remediation would not provide any added protectiveness to the site, and is not required for regulatory compliance. The installation of an impermeable landfill cap would protect the site's groundwater in the future by preventing infiltration into the landfilled wastes. No evidence of leachate has been identified at the SL, thus a leachate collection system is not required.

3.2 Air/Landfill Gas

Landfill gas samples submitted for laboratory analysis contained low concentrations of VOCs, none of which were detected in ground water samples historically collected from monitoring wells in the SL area. No methane or sulfur compounds were detected in the landfill gas samples submitted for laboratory analysis, and only trace concentrations were detected via field measurements.

Technologies Evaluated: Passive Systems

Passive venting systems are designed to eliminate buildup of gases generated by decomposition in the landfill by allowing accumulated gases to be vented to the atmosphere by creating a preferential pathway to induce and control airflow. These systems typically consist of either vertical pipe vents or horizontal trench vents that are constructed of permeable materials (sand/gravel/stone) to create preferential pathways for landfill gases to be directed to the atmosphere through controlled flow paths.

Pipe Vents

Process Description: Piping vents consist of piping within a vertical borehole surrounded by a high permeability material that allows accumulated gases to be vented to the atmosphere by creating a preferential pathway. The subgrade piping sections are typically perforated and the annular space surrounding the piping is filled with pea stone or similar permeable material. Pipe vents can be fitted with flares in the event that any combustible off-gases are required to be flared.

Advantages: Pipe vents are effective at eliminating landfill gases. They are easy to install, inexpensive, and have very low operation and maintenance costs. Pipe vents also can be used as monitoring points for landfill gases.

Disadvantages: Pipe vents have a limited radius of influence, thus gas removal tends to be localized around each vent. Also, depending on the composition of the landfill, odors could be produced. There also could be an explosive hazard around the vents depending on the composition of the landfill gas.

Effectiveness: Pipe vents effectively reduce landfill gas pressures, the volume of gas in the landfill, and the lateral migration of gases. Methane and hydrogen sulfide gases were very low in the SL and are not considered to pose a potential threat to the surrounding area via exposure to potential receptors or from explosion.

Implementability: Pipe vents are easy to construct using standard construction materials and techniques. Installation costs are low, with low long-term operation and maintenance costs.

Trench Vents

Process Description: Trench vents consist of horizontal trenches surrounding the landfill filled with high permeability material. The trenches allow accumulated gases to be vented to the atmosphere by creating a preferential pathway.

Advantages: Trench vents are effective at eliminating landfill gases, and in some cases can be more effective in controlling gases than pipe vents because they cover a larger area. Trench vents are easy and inexpensive to install, and have very low operation and maintenance costs.

Disadvantages: Trench vents can become clogged by sediment carried by runoff. Depending on the composition of the landfill, odors could be produced. Gases could migrate under a trench if it is not keyed into an impervious layer or if the trench is too shallow.

Effectiveness: Trench vents effectively reduce landfill gas pressures, the volume of gas in the landfill, and the lateral migration of gases. Trench vents can be more effective than pipe vents in controlling landfill gases, particularly with respect to migration beyond the landfill area. Methane and hydrogen sulfide gases were very low in the SL and are not considered to pose a potential threat to the surrounding area via exposure to potential receptors or from explosion.

Implementability: Trench vents are easy to construct using standard construction materials and techniques. Installation costs are low, as are long-term operation and maintenance costs.

Technologies Evaluated: Active Systems

Mechanical System

Active venting systems utilize mechanical methods to induce gas flow into piping where it can be recovered and released to the atmosphere with treatment if necessary. Active systems typically consist of vapor extraction wells or trenches that induce a negative pressure via blowers or other type of vacuum system. These systems can be combined with flaring of off-gases if required. Under suitable situations, off-gases could be collected and utilized as an energy source.

Advantages: Active systems have a larger area of influence than passive systems, thus they can provide more effective vapor control than passive systems, and reduce the potential for odors and explosion hazards.

Disadvantages: Installation, operation, and maintenance costs are significantly higher for active systems than for passive ones. Because extraction rates are higher, there is greater potential for settlement of landfill materials over time, which could result in damage to piping.

Effectiveness: Active systems are highly effective in removing landfill gases and preventing migration. They are also more effective than passive systems in eliminating odors and reducing explosive hazards if present.

Implementability: Active systems can be installed using conventional construction equipment and techniques.

3.3 Surface Water

The nearest surface water body, the Old Swamp River, is located approximately 800 feet to the west of the SL. This stream has not been identified as having been impacted by activities at the Small Landfill. Treatment technologies for corrective actions for existing stream impacts were therefore not evaluated as part of the CAAA option package. However, closure alternatives must address the potential impact of closure activities (i.e., grading, drainage, etc.) on the stream during any construction activities.

3.4 Wetlands

Wetlands in the vicinity of the Small Landfill have not been identified as being impacted by the landfill activities. Therefore, the technologies listed in Section 2.0 are not applicable, and these technologies were not further evaluated for inclusion in the CAAA options package. Any construction activities that are incorporated into the final closure package will include appropriate erosion and sediment controls.

3.5 Soils

Low levels of metals, PAHs, and petroleum hydrocarbons have been detected in soils in the area of the Small Landfill. However, based upon the low levels detected, the technologies listed in Section 2.0 were not considered necessary to reduce risk and were therefore not further evaluated. Capping of the landfill as part of the options package to ensure that exposure of the landfilled materials cannot occur will be a sufficient risk reduction method.

4.0 INTEGRATION OF TECHNOLOGIES

In order to address closure of the Site, the following integrated landfill closure alternatives were considered for this project based upon the integration of applicable technologies discussed in Sections 2.0 and 3.0. Some of these alternatives were discussed and agreed to be included in the scope of this report during a meeting with EFAN, the MADEP, and HRP Associates, Inc. in June 2005. The following alternatives are discussed below:

- No Action Alternative
- Standard Closure with Clay Cap/Flexible Membrane Liner (FML)
- Consolidation/Reduced Footprint with Capping (Standard Clay Cap or FML)
- Modified Cap Design
- Complete Removal/Off-Site Disposal
- Consolidation/Reduced Footprint with Modified Cap Design

4.1 No Action Alternative

The No Action Alternative includes leaving the buried waste in its current status.

4.2 Standard Closure with Clay Cap/FML

The Standard Closure design will follow the Minimum Design Requirements listed in Chapter 1 of the Massachusetts Landfill Technical Guidance Manual. The primary objectives of the landfill cover are to prevent human exposure to the buried wastes and to prevent rainwater from percolating into the waste layer.

Under this alternative, the cap (starting with the lowest layer) will consist of a subgrade/gas layer, a low permeability layer consisting of either clay or a flexible membrane layer (FML), a drainage layer, followed by a vegetative support layer. Figures 5 and 6 show cross sections of the Standard Closure Cap design. The subgrade/gas layer is designed to collect potential landfill gases prior to off-gassing via a passive gas control system. The low permeability layer consists of either a 60-mil flexible membrane liner or at least 18 inches of clay with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec. Covering the low permeability layer will be a drainage layer, which consists of 6 inches of material with a hydraulic conductivity of at least $1x10^{-3}$ cm/sec. The purpose of the drainage layer is to direct percolated rainwater away from the low permeability layer. A vegetative support layer, consisting of at least 12 inches of material, overlays the drainage layer. The vegetative support layer provides storage of percolated rainwater for use by vegetation in the cover layer. In order to provide erosion control and to prevent freeze/thaw cracking of the cap, the layer consists of 6 inches of topsoil along with vegetative plantings such as grass.

A passive landfill gas system would be used in either design to allow accumulated landfill gases to be vented to the atmosphere.

4.3 Consolidation/Reduced Footprint with Capping

A third alternative for the closure of the Site is to consolidate wastes in the SL area to limit the amount of capping required. This alternative would utilize one of the Standard Capping alternatives discussed above, but wastes in the outer areas of the landfill would be excavated and moved to the center of the landfill for final capping.

This consolidation of wastes would reduce the landfill footprint and thereby reduce the amount of construction materials used for capping. The approximate extent of the consolidated landfill material is depicted on Figure 4.

4.4 Modified Cap Design

Due to the types of the materials contained in the landfill (asphalt, railroad ties, plastic, steel, aluminum, rubber tubing, bottles and cans, electrical wires, wood debris, etc.) and their relative inert nature, the potential to modify the design of the cap is a viable closure option. Under 310 CMR 19.113, an alternative final cover system design may be proposed if, based upon a site specific assessment, it is demonstrated that an alternate design would adequately protect public health, safety, and the environment. The alternative final cover design must have a maximum hydraulic conductivity of 10^{-5} cm/sec.

4.5 Complete Removal/Off-Site Disposal

Under this alternative, the landfilled waste would be excavated down to native material in the footprint of the existing landfill (Figure 4). The excavated material would need to be shipped off-site for disposal or consolidated in one of two other active landfills at the South Weymouth Naval Air Station. The Small Landfill area would then be backfilled to its original grade with clean material.

5.0 ALTERNATIVES ANALYSIS

The MADEP's Solid Waste Regulations (310 CMR 19.00) and the Landfill Technical Guidance Manual (September 1993) were utilized in developing the evaluation criteria for each of the technologies. The following selection criteria were analyzed for each alternative discussed in Section 4.0 in order to determine the best possible alternative for the conditions at the SL:

Criteria	Synopsis
Protectiveness	An evaluation of the ability of an alternative to provide protection of human health and the environment.
Compliance	The ability of an alternative to comply with 310 CMR 19.00 and other applicable laws.
Effectiveness	The capacity of an alternative to be reliable, permanent, and have a prolonged useful life.
Reduction of Toxicity and Volume	This evaluation is the ability of an alternative to effectively treat waste streams such as groundwater treatment and other in-situ treatment.
Implementability	This evaluation determines the feasibility of selected alternative technologies to be implemented as well as their associated timelines to implement.
Cost	The ability of an alternative to be cost effective in both construction and post-construction implementation.

5.1 No Action Alternative

The No Action Alternative does not meet any of the selection criteria because it does not provide protection of human health and the environment or compliance with all applicable regulations. Therefore, this alternative can be automatically eliminated from further consideration.

5.2 Standard Closure with Clay Cap or Flexible Membrane Liner

Protectiveness

Standard Closure with either a Clay Cap or an FML would be protective of human health and the environment because they prevent human exposure to wastes through ingestion and direct contact and limit infiltration that could leach contaminant to groundwater or. By integrating a passive venting system, this alternative also protects human exposure from the inhalation pathway.

Compliance

The cap design would comply with all applicable regulations because it would satisfy the minimum design requirements as specified in 310 CMR 19.112.

Effectiveness

Clay Caps and Flexible Membrane Liners are reliable and proven technologies. They provide protectiveness to all exposure pathways in both the short and long term.

Reduction of Toxicity and Volume

This alternative does not reduce the toxicity or the volume of wastes at the site, it simply minimizes their mobility. They would, however, limit infiltration of runoff and percolating precipitation. This would reduce or eliminate the potential leaching of substances in the landfill.

Implementability

The implementation of these designs is feasible. However, due to the potential redevelopment of the site, these designs may not be compatible with future use plans. Once implemented, the closed landfill may have to be disturbed in order to accommodate future site conditions. An FML maybe more readily available than clay, and is easier to install vs. a clay cap in most cases.

Cost

The costs associated with the Standard Clay and FML Caps are outlined in Tables 1 and 2.

5.3 Consolidation/Reduced Footprint with Capping

Protectiveness

The reduced footprint alternative involves the consolidation of wastes to a centralized location (Figure 4). Upon consolidation, a Standard Cap (clay or FML) would be constructed. Therefore, this alternative offers the necessary level of protection of human health and the environment.

Compliance

Both the Standard Clay and FML caps are proven technologies that are highly implementable using conventional construction techniques and materials.

Effectiveness

Upon completion, the Standard Cap will be effective in the short and long term.

Reduction of Toxicity and Volume

The consolidation of waste would not reduce the toxicity or volume of waste, but it would reduce the overall footprint of the closed landfill providing for land area available for other future uses.

Implementability

Due to the common nature of both of these technologies, the time frame for installation is expected to be short.

Cost

The costs associated with this alternative are summarized in Table 3. Reduction of the footprint results lowers costs for capping materials

5.4 Modified Cap Design

Protectiveness

In order to accommodate for future beneficial uses of the site as well as to protect human health and the environment, a Modified Cap Design would be an appropriate alternative at this site. This would include installation of a passive gas venting system and a FML liner covered by low permeability asphalt.

Compliance

Compliance with applicable regulations could be achieved because the Comprehensive Site Assessment and Risk Assessments indicated that there is little or no threat or potential threat of contamination emanating from the landfill and there is no threat to public health or the environment by the landfill itself. Data collected to date indicates that there is minimal contamination associated with this site, and there is no evidence of contaminants migrating from the SL via groundwater or leachate.

Effectiveness

The modified cap design is effective because it would provide reliable protection for both the short and long term.

Reduction of Toxicity and Volume

Reducing the volume and toxicity of the wastes would not be achieved under this alternative. However as previously discussed, the characteristics of the wastes do not pose a significant threat to human health or the environment.

Implementability

The reduced cap design alternative would meet the implementability criteria because an appropriate design could be developed to coincide with the proposed future development of the SL. This coordination would prevent future disturbance of a full cap design once it is implemented.

Cost

The costs associated with this alternative are summarized in Table 4.

5.5 Complete Removal/Off-Site Disposal

Protectiveness

The Complete Removal Alternative would be protective to human health and the environment because all landfilled material would be removed and disposed of off-site.

Compliance

This alternative would comply with all applicable laws.

Effectiveness

Completely removing all landfilled wastes would be a reliable and permanent alternative that would allow for beneficial redevelopment and use of the Site.

Reduction of Toxicity and Volume

The complete remediation option would reduce the volume of landfilled material on-site. The material would have to be disposed of at a permitted, off-site location or to another landfill on the Navy base, thus the volume of waste would not be reduced but simply transferred to an alternate location.

Implementability

The implementation of this alternative would require significant effort to remove all of the landfilled material.

Cost

Laboratory analysis as well as supervision would be required to ensure that all of the landfilled material was removed from the Site. Approval for an ultimate disposal site for the waste would also be required. Because of the large amount of material that would be required to be excavated, an extended timeline would be required for implementation.

The costs associated with this alternative are summarized in Table 5. The cost of this alternative is significantly higher than other options due to excavation and disposal costs if the material is taken off the Navy base for disposal. The implementation cost for this option would be considerably less if the material is taken to one of the other existing landfills at the Navy base.

5.6 Consolidation and Modified Cap Design

Protectiveness

Combining the Consolidation and Modified Cap Design Alternatives allows landfilled materials to be utilized for drainage purposes without the import of additional fill to achieve the required grades thereby reducing costs while maintaining protection of human health and the environment. The Modified Cap Design would also be effective at reducing direct exposure to the landfilled materials.

Compliance

Approval for a Modified Cap Design is attainable from the MADEP and would comply with applicable regulations.

Effectiveness

The modified cap design is effective because it would prove reliable protection during both the short and long term.

Reduction of Toxicity and Volume

The toxicity and the volume of the wastes would not be reduced, but the overall footprint of the landfill would be decreased under this alternative.

Implementability

This alternative is highly implementable because it utilizes conventional technologies and construction techniques and materials.

Cost

The costs associated with this alternative are summarized in Table 6.

6.0 RECOMMENDED ALTERNATIVE

The following closure alternatives were evaluated for the Small Landfill at the South Weymouth Naval Air Station:

- No Action Alternative
- Standard Closure with Clay Cap/Flexible Membrane Liner
- Consolidation/Reduced Footprint with Standard Cap (Clay or FML)
- Modified Cap Design
- Complete Removal/Off-Site Disposal
- Consolidation/Reduced Footprint with Modified Cap Design

Each of these alternatives was evaluated with respect to protectiveness, compliance, effectiveness, reduction of toxicity and volume, implementability, and cost. The Total Project Cost was calculated as documented in Tables 1-6. The resulting calculations are summarized below:

OPTION	CONSTRUCTION COST	O&M	TOTAL
Standard Closure with Clay Cap	$ 496,057	$ 356,447	$ 852,504
Standard Closure with FML Liner	$ 667,522	$ 356,447	$1,023,969
Reduced Footprint w/Clay Cap	$ 282,829	$ 356,447	$ 639,276
Modified Cap Design	$1,031,000	$ 356,447	$1,387,447
Complete Removal	$1,770,569	N/A	$1,770,569
Reduced Footprint w/Modified Cap	$ 569,553	$ 356,447	$ 926,000

Based on this evaluation, Consolidation/Reduced Footprint with Standard Cap was selected as the recommended alternative.

The "No Action Alternative" was eliminated from further consideration on the basis that it would not result in compliance with regulatory guidelines and requirements. The "Complete Removal" alternative was the only one that resulted in reduction of the toxicity and volume of waste in the SL area, although it simply relocates the landfill material to another area. That option was eliminated from consideration because of the significantly higher costs resulting from disposal fees if the material were taken off-site. Backfill costs would also be higher for that option. The disposal costs would be eliminated, leaving only excavation, transport, and backfilling costs, if the material can be taken to another existing landfill on the Navy base. However, the feasibility of that option is uncertain at this time, thus it was eliminated from further consideration as the recommended option.

All of the remaining alternatives involve some type of in situ capping and essentially achieve similar levels of compliance, protection, and reduction of toxicity and volume. The various capping options are essentially equally effective and implementable, and all have similar long-term operation and monitoring costs. The most critical factor, therefore, for these options is cost for installation and materials. A Modified Cap may allow more flexibility for future use and development of the area, which might be a consideration, but use of such a cap would not allow unrestricted use. Any future uses under that option would have to consider the potential effect on the integrity and usefulness of the cap.

Based on the criteria evaluated, the recommended option is Consolidation/Reduced Footprint with a Standard Clay Cap.

TABLES

Explanation of Cost Evaluation

Naval Air Station
Small Landfill
South Weymouth, MA

(HRP #NAV2002.SW)

The costs for each alternative were calculated using the following factors:

Construction Costs

- Estimated quantities from preliminary design plans using the site topographic map and the alternate remedial cross sections.
- Unit costs from Means Environmental Remediation Cost Data assemblies, 2004 escalated to 2006 at a rate of 5%/year. 20% Contingency normal at preliminary design stage.
- Normal Contractor Overhead & Profit of 15%, plus 20% for Bonds, Insurances, Mobilization.
- Engineering Fees and Permitting fees of 10% and 5% respectively.

Post Closure Operation & Maintenance Costs

- Groundwater Analyses as detailed in Table 7.
- Labor Costs at $75/hr assuming quarterly sampling.
- Inspections and Land Surface Care based on minimal efforts, as these remedial options require little long term maintenance.

For each alternative a Present Work Volume was calculated assuming an annual escalation rate of 5% and an interest rate of 5%.

The Total Project Cost was calculated using the current Construction Cost including design and permitting and then adding in the Present Worth of the 30-Year O&M costs. The resulting calculations are summarized below:

OPTION	CONSTRUCTION COST	O&M	TOTAL
Standard Closure with Clay Cap	$ 496,057	$ 356,447	$ 852,504
Standard Closure with FML Liner	$ 667,522	$ 356,447	$1,023,969
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Complete Removal	$1,770,569	N/A	$1,770,569
Reduced Footprint w/Modified Cap	$ 569,553	$ 356,447	$ 926,000

Long Term Monitoring Procedures and Costs

Environmental monitoring requirements for landfill closure are outlined in 310 CMR 19.132. Background ground water quality must consist of a minimum of four quarterly sampling rounds for parameters listed in 310 CMR 19.132(1)(h). Previous monitoring conducted around the SL satisfies the requirements for background data collection. Going forward, the various capping scenarios include semi-annual monitoring of the six existing ground water monitoring wells surrounding the SL for the above-referenced parameters for a period of 30 years. Operation and monitoring (O&M) costs for all of the capping options also include evaluation of landfill gases via a combination of field monitoring with at least two backup air samples submitted for laboratory analysis for methane, hydrogen sulfide, and volatile organic compounds via EPA Method TO-15. The costs include a report on each monitoring event.

Landfill Volume Calculations

The volume calculations for the complete removal were determined by an analysis of the test pit logs to determine the depth at which clean material was encountered during test pit installation. Figure 3 is a cross section through the SL using data from the test pits. Using Land Desktop 3, a land development software, HRP was able to compare the existing topography of the SL to the projected surface of clean material (from the test pit data) to determine the total amount of landfilled material in the Small Landfill. Additional volume calculations for the landfill cap alternatives are presented in Tables 1-6.

Table 1

Clay Cap Cost Estimate

Naval Air Station
Small Landfill
South Weymouth, MA

Item	Quantity	Units	Material	Labor	Equipment	Subtotal	Total
Construction							
Rough Grading	1	L.S.				$ 10,000.00	$ 10,000.00
Gas Vent Piping	400	L.F.				$ 8.97	$ 3,588.00
Gas Venting Layer	2437	CY				$ 10.95	$ 26,685.15
Geotextile Filter Fabric	29224	S.Y.				$ 1.27	$ 37,114.48
Low Permeability Clay Layer	3655	C.Y.				$ 21.56	$ 78,801.80
Drainage Layer	1218	C.Y.				$ 10.76	$ 13,105.68
Geotextile Drainage Grid	7311	S.Y.				$ 1.13	$ 8,261.43
Topsoil Layer	1218	CY				$ 26.95	$ 32,825.10
Vegetative Support Layer	2437	CY				$ 10.76	$ 26,222.12
Hydroseed	1.51	ACRE				$ 3,611.00	$ 5,458.20
						SubTotal	$ 242,061.96
						Escalation at 5%/YR 2004-2006	$ 24,206.20
						20% Contingency	$ 53,253.63
						Subtotal	$ 319,521.78
						+ 35% Contractor OH,P,Bonds,Ins, Mobe	$ 111,832.62
						SubTotal Capital Costs	**$ 431,354.41**
Engineering Design							
						10% of Construction Costs	**$ 43,135.44**
Permitting							
						5% of Construction Costs	**$ 21,567.72**
Total Construction/Design Costs						**Subtotal**	**$ 496,057.57**
Post-Closure Operation & Maintenance							
ANNUAL COSTS							
Groundwater/Vapor Analysis	30	Years *				$ 3,200.00	
Sampling Labor/Reporting	30	Years *				$ 6,800.00	
Inspections	30	Years *				$ 1,500.00	
Land Surface Care	30	Years *				$ 2,500.00	
Note: * Based on semi-annual events.							
						Present Worth of 30 years of O&M	**$ 356,447.07**
						Total Present Worth	**$ 852,504.63**

QUANTITIES ESTIMATE

Gas Venting Layer:
65,800 ft2 x 1 ft x (1 CY/27ft3) = 2437 CY

Geotextile Filter Fabric:
65,800 ft2/layer x 4 layers x (1 SY/9ft3) = 29,224 SY

Low Permeability Clay Liner
65,800 ft2 x 1.5 ft x (1 CY/27ft3) = 3655 CY

Drainage Layer:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Topsoil Layer:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Vegetative Support Layer:
65,800 ft2 x 1 ft x (1 CY/27ft3) = 2437 CY

Table 2

FML Cap Cost Estimate
South Weymouth, MA

Naval Air Station
Small Landfill

Item	Quantity	Units	Material	Labor	Equipment	Subtotal	Total
Construction							
Rough Grading	1	L.S.				$ 10,000.00	$ 10,000.00
Gas Vent Piping	400	L.F.				$ 8.97	$ 3,588.00
Gas Venting Layer	2437	CY				$ 10.95	$ 26,685.15
Geotextile Filter Fabric	29224	S.Y.				$ 1.27	$ 37,114.48
FML Liner	65800	S.F.				$ 2.27	$ 149,366.00
FML Sand Layer	1218	C.Y.				$ 10.76	$ 13,105.68
Drainage Layer	1218	C.Y.				$ 10.76	$ 13,105.68
Geotextile Drainage Grid	7311	S.Y.				$ 1.13	$ 8,261.43
Topsoil Layer	1218	CY				$ 26.95	$ 32,825.10
Vegetative Support Layer	2437	CY				$ 10.76	$ 26,222.12
Hydroseed	1.51	ACRE				$ 3,611.00	$ 5,458.20
						SubTotal	$ 325,731.84
						Escalation at 5%/YR 2004-2006	$ 32,573.18
						20% Contingency	$ 71,661.00
						Subtotal	$ 429,966.03
						+ 35% Contractor OH,P,Bonds,Ins, Mob	$ 150,488.11
						SubTotal Capitol Costs	**$ 580,454.13**
Engineering Design							
						10% of Construction Costs	**$ 58,045.41**
Permitting							
						5% of Construction Costs	**$ 29,022.71**
Total Construction/Design Costs							**$ 667,522.25**
Post-Closure Operation & Maintenance							
ANNUAL COSTS							
Groundwater/Vapor Analysis	30	Years *				$ 3,200.00	
Sampling Labor/Reporting	30	Years *				$ 6,800.00	
Inspections	30	Years *				$ 1,500.00	
Land Surface Care	30	Years *				$ 2,500.00	
Note: * Based on semi-annual events.							
						Present Worth of 30 years of O&M	**$ 356,447.07**
						Total Present Worth	**$ 1,023,969.32**

QUANTITIES ESTIMATE

Gas Venting Layer:
65,800 ft2 x 1 ft x (1 CY/27ft3) = 2437 CY

Geotextile Filter Fabric:
65,800 ft2/layer x 4 layers x (1 SY/9ft3) = 29,224 SY

FML Sand Base
65,800 ft2 x 0.5 ft/layer x 2 layers x (1 CY/27ft3) = 1218 CY

Drainage Layer:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Topsoil Layer:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Vegetative Support Layer:
65,800 ft2 x 1 ft x (1 CY/27ft3) = 2437 CY

Table 3

Consolidation Cost Estimate
South Weymouth, MA

Naval Air Station
Small Landfill

Item	Quantity	Units	Material	Labor	Equipment	Subtotal	Total
Construction							
Rough Grading	1	L.S.				$ 10,000.00	$ 10,000.00
Gas Vent Piping	300	L.F.				$ 8.97	$ 2,691.00
Gas Venting Layer	1315	CY				$ 10.95	$ 14,399.25
Geotextile Filter Fabric	15,800	S.Y.				$ 1.27	$ 20,066.00
Low permeability Clay Layer	1980	C.Y.				$ 21.56	$ 42,688.80
Drainage Layer	660	CY				$ 10.76	$ 7,101.60
Geotextile Drainage Grid	5475	S.Y.				$ 1.13	$ 6,186.75
Topsoil Layer	660	CY				$ 26.95	$ 17,787.00
Vegetative Support Layer	1315	CY				$ 10.76	$ 14,149.40
Hydroseed	0.81	ACRE				$ 3,611.00	$ 2,942.85
						SubTotal	$ 138,012.65
						Escalation at 5%/YR 2004-2006	$ 13,801.26
						20% Contingency	$ 30,362.78
						Subtotal	$ 182,176.70
						+ 35% Contractor OH,P;Bonds,Ins, Mobe	$ 63,761.84
						SubTotal Capital Costs	**$ 245,938.54**
Engineering Design							
						10% of Construction Costs	**$ 24,593.85**
Permitting							
						5% of Construction Costs	**$ 12,296.93**
Total Construction/Design Costs						**Subtotal**	**$ 282,829.32**
Post-Closure Operation & Maintenance							
ANNUAL COSTS							
Groundwater/Vapor Analysis	30	Years *				$ 3,200.00	
Sampling Labor/Reporting	30	Years *				$ 6,800.00	
Inspections	30	Years *				$ 1,500.00	
Land Surface Care	30	Years *				$ 2,500.00	
Note: * Based on semi-annual events.							
						Present Worth of 30 years of O&M	**$ 356,447.07**
						Total Present Worth	**$ 639,276.39**

QUANTITIES ESTIMATE

Consolidated Area = 35,500 ft2

Gas Venting Layer:
35,500 ft2 x 1 ft x (1 CY/27ft3) = 1315 CY

Geotextile Filter Fabric:
35,500 ft2/layer x 4 layers x (1 SY/9ft3) = 15,800 SY

Low Permeability Clay Liner
35,500 ft2 x 1.5 ft x (1 CY/27ft3) = 1980 CY

Drainage Layer:
35,500 ft2 x 0.5 ft x (1 CY/27ft3) = 660 CY

Vegetative Support Layer:
35,500 ft2 x 1 ft x (1 CY/27ft3) = 1315 CY

Topsoil Layer:
35,500 ft2 x 0.5 ft x (1 CY/27ft3) = 660 CY

Table 4

Modified Cap Design Cost Estimate
South Weymouth, MA

Naval Air Station
Small Landfill

Item	Quantity	Units	Material	Labor	Equipment	Subtotal	Total
			Construction				
Rough Grading	1	L.S.				$ 10,000.00	$ 10,000.00
Gas Vent Piping	400	L.F.				$ 8.97	$ 3,588.00
Gas Venting Layer	2444	CY				$ 10.95	$ 26,761.80
Geotextile Filter Fabric	29235	S.Y.				$ 1.27	$ 37,128.45
FML Liner	65000	S.F.				$ 2.27	$ 147,550.00
FML Sand Layer	2444	C.Y.				$ 10.76	$ 26,297.44
Drainage Layer	1222	C.Y.				$ 10.76	$ 13,148.72
Geotextile Drainage Grid	7310	S.Y.				$ 1.13	$ 8,260.30
Asphalt Pavement	7310	S.Y.				$ 27.00	$ 197,370.00
Asphalt Base	1222	CY				$ 27.00	$ 32,994.00
						SubTotal	$ 503,098.71
						Escalation at 5%/YR 2004-2006	$ 50,309.87
						20% Contingency	$ 110,681.72
						Subtotal	$ 664,090.30
						+ 35% Contractor OH,P,Bonds,Ins, Mobe	$ 232,431.60
						SubTotal Capital Costs	**$ 896,521.90**
			Engineering Design				
						10% of Construction Costs	**$ 89,652.19**
			Permitting				
						5% of Construction Costs	**$ 44,826.10**
			Total Construction/Design Costs			**Subtotal**	**$ 1,031,000.19**
			Post-Closure Operation & Maintenance				
ANNUAL COSTS							
Groundwater/Vapor Analysis	30	Years *				$ 3,200.00	
Sampling Labor/Reporting	30	Years *				$ 6,800.00	
Inspections	30	Years *				$ 1,500.00	
Land Surface Care	30	Years *				$ 2,500.00	
Note: * Based on semi-annual events.							
						Present Worth of 30 years of O&M	**$ 356,447.07**
						Total Present Worth	**$ 1,387,447.25**

QUANTITIES ESTIMATE

Gas Venting Layer:
65,800 ft2 x 1 ft x (1 CY/27ft3) = 2437 CY

Geotextile Filter Fabric:
65,800 ft2/layer x 4 layers x (1 SY/9ft3) = 29,224 SY

FML Sand Base
65,800 ft2 x 0.5 ft/layer x 2 layers x (1 CY/27ft3) = 1218 CY

Drainage Layer:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Asphalt Pavement
65,800 ft2 x (1 SY/9ft3) = 7311 CY

Pavement Base:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Table 5 **Complete Removal Cost Estimate** South Weymouth, MA Naval Air Station Small Landfill							
Item	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Subtotal**	**Total**
			Construction				
Excavation	7700	C.Y.				$ 10.00	$ 77,000.00
Backfill, 6" lifts w/ Compactior	7700	C.Y.				$ 10.76	$ 82,852.00
Grading	7325.00	S.Y.	$ 0.34	$ 0.61	$ -	$ 0.95	$ 6,958.75
Hyrdroseeding	1.51	ACRE				$ 3,611.00	$ 5,452.61
Soil Disposal	7700	C.Y.				$ 93.50	$ 719,950.00
Transportation	7700	C.Y.				$ 56.50	$ 435,050.00
						SubTotal	$ 1,327,263.36
						+ 35% Contractor OH,P,Bonds,Ins, Mobe	$ 464,542.18
						SubTotal	**$ 1,791,805.54**
			Surveying of Excavation Areas				
						1% of Construction Costs	**$ 17,918.06**
			Permitting				
						5% of Construction Costs	**$ 89,590.28**
			Engineering Design				
						+ 35% Contractor OH,P,Bonds,Ins, Mobe	**$ 179,180.55**
			Post-Closure Operation & Maintenance				
			Not Applicable				
						Total	**$2,078,494.42**

Table 6

Modified Cap - Consolidation Cost Estimate
South Weymouth, MA

Naval Air Station
Small Landfill

Item	Quantity	Units	Bare Costs Material	Labor	Equipment	Subtotal	Total
Construction							
Rough Grading	1	L.S.				$ 10,000.00	$ 10,000.00
Gas Vent Piping	300	L.F.				$ 8.97	$ 2,691.00
Gas Venting Layer	1315	CY				$ 10.95	$ 14,399.25
Geotextile Filter Fabric	15,800	S.Y.				$ 1.27	$ 20,066.00
FML Liner	35500	S.F.				$ 2.27	$ 80,585.00
FML Sand Layer	1315	C.Y.				$ 10.76	$ 14,149.40
Drainage Layer	660	C.Y.				$ 10.76	$ 7,101.60
Geotextile Drainage Grid	3950	S.Y.				$ 1.13	$ 4,463.50
Asphalt Pavement	3950	S.Y.				$ 27.00	$ 106,650.00
Asphalt Base	660	CY				$ 27.00	$ 17,820.00
						SubTotal	$ 277,925.75
						Escalation at 5%/YR 2004-2006	$ 27,792.58
						20% Contingency	$ 61,143.67
						Subtotal	$ 366,861.99
						+ 35% Contractor OH,P,Bonds,Ins, Mobe	$ 128,401.70
						SubTotal Capital Costs	**$ 495,263.69**
Engineering Design							
						10% of Construction Costs	**$ 49,526.37**
Permitting							
						5% of Construction Costs	**$ 24,763.18**
Total Construction/Design Costs						**Subtotal**	**$ 569,553.24**
Post-Closure Operation & Maintenance							
ANNUAL COSTS							
Groundwater/Vapor Analysis	30	Years *				$ 3,200.00	
Sampling Labor/Reporting	30	Years *				$ 6,800.00	
Inspections	30	Years *				$ 1,500.00	
Land Surface Care	30	Years *				$ 2,500.00	
Note: * Based on semi-annual events.							
						Present Worth of 30 years of O&M	**$ 356,447.07**
						Total Present Worth	**$ 926,000.31**

QUANTITIES ESTIMATE

Consolidated Area = 35,500 ft2

Gas Venting Layer:
35,500 ft2 x 1 ft x (1 CY/27ft3) = 1315 CY

Geotextile Filter Fabric:
35,500 ft2/layer x 4 layers x (1 SY/9ft3) = 15,800 SY

FML Sand Base
65,800 ft2 x 0.5 ft/layer x 2 layers x (1 CY/27ft3) = 1218 CY

Drainage Layer:
35,500 ft2 x 0.5 ft x (1 CY/27ft3) = 660 CY

Asphalt Pavement
65,800 ft2 x (1 SY/9ft3) = 7311 CY

Pavement Base:
65,800 ft2 x 0.5 ft x (1 CY/27ft3) = 1218 CY

Table 7

Groundwater/Vapor Sampling Cost Estimate
South Weymouth, MA

Naval Air Station
Small Landfill

Well Sampling				
	LABOR	**Rate**	**Hours**	**Total**
	Two Field Personnel	$ 75	24	$ 1,800
			Subtotal	$ 1,800
	MATERIALS, EXPENSES			
	Item	**Unit Cost**	**No.**	**Total**
	Travel	250	1	$ 250
	Surv. equip.	100	0	$ -
	Bailers, etc.	50	6	$ 300
	Meters	250	1	$ 250
			Subtotal	$ 550
			Total	$ 2,350
Laboratory Analysis				
	Ground Water			
	Test	**Unit Cost**	**No.**	**Total**
	EPA 8260	$ 90.00	6	$ 540
	Alkalinity	$ 8.40	6	$ 50
	Nitrate Nitrogen	$ 8.40	6	$ 50
	TDS	$ 8.40	6	$ 50
	Chloride	$ 8.40	6	$ 50
	Fe	$ 8.40	6	$ 50
	Mn	$ 8.40	6	$ 50
	Sulphate	$ 8.40	6	$ 50
	COD	$ 14.40	6	$ 86
			Total	$ 979
			Use	$ 1,000
	* pH, temp., Specific Conductance, DO measured in situ.			
	Landfill Gases			
	Test	**Unit Cost**	**No.**	**Total**
	TO-15	$ 300	1	$ 300
	Meter	$ 300	1	$ 300
			Total	$ 600
			Use	$ 600
			Total Analytical	$ 1,600
Data Analysis, Report, Project Management			**Total**	$ 1,000
COST SUMMARY				
				Total
Task	**Item**			
1	Sampling			$ 2,350
2	Laboratory			$ 1,600
3	Report			$ 1,000
			Total	$ -
			Say	$ 5,000
				per event
		Per event	**Background (4)**	**30-yr/per yr. cost ***
	Total Labor & Materials	$ 3,400	$ 13,600	$ 6,800
	Analytical	$ 1,600	$ 6,400	$ 3,200
	* based on semi-annual events over 30 yrs.			

FIGURES

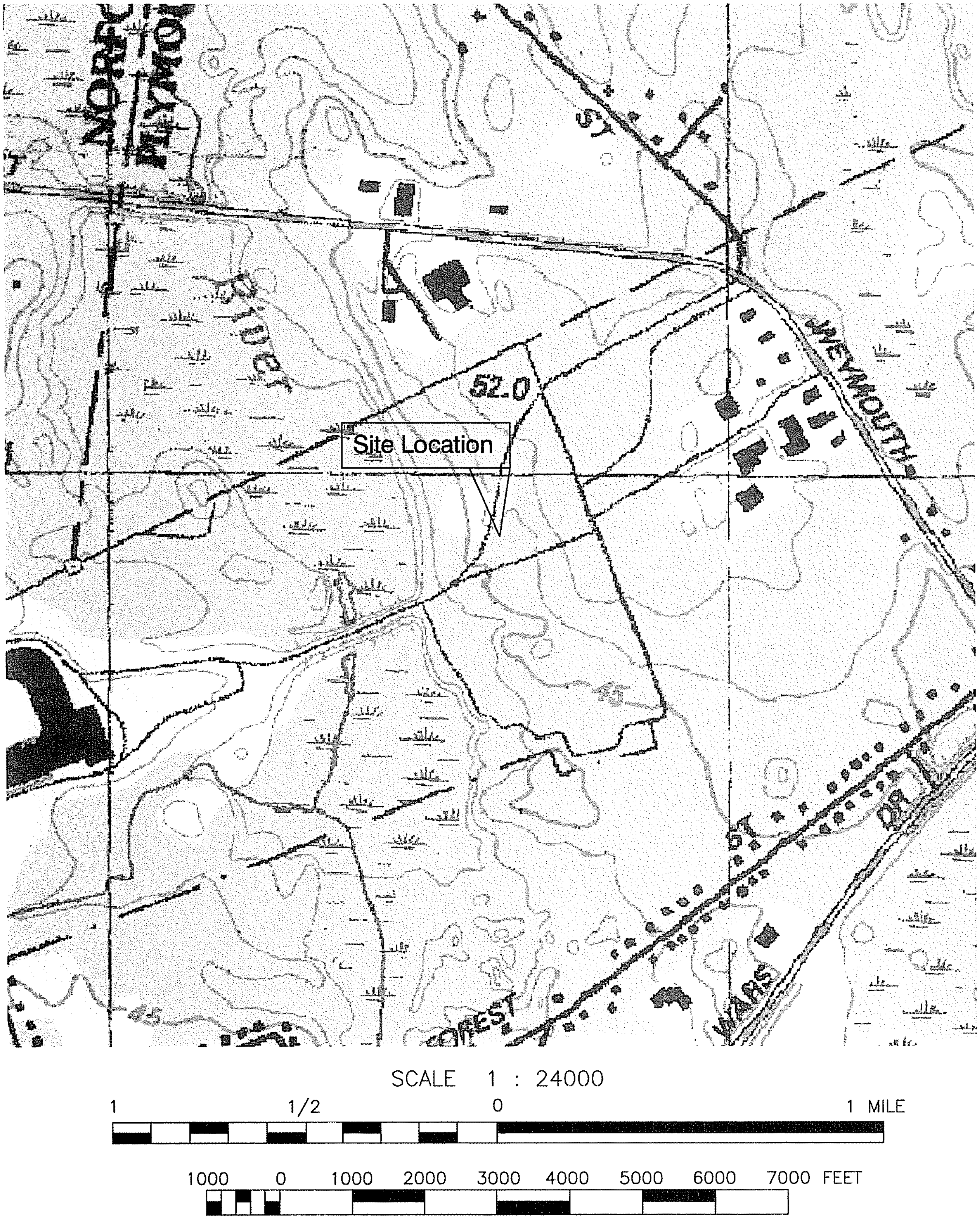

FIGURE 1
SITE LOCATION
SOUTH WEYMOUTH
NAVAL AIR STATION
SOUTH WEYMOUTH, MA
HRP# NAV2002.SW

J:\U\USNAV - USNAVY-EFAN\SOUTH WEYMOUTH, MA\NAV2002SW\CAD\SITE PLAN.dwg, TopoSurvey,
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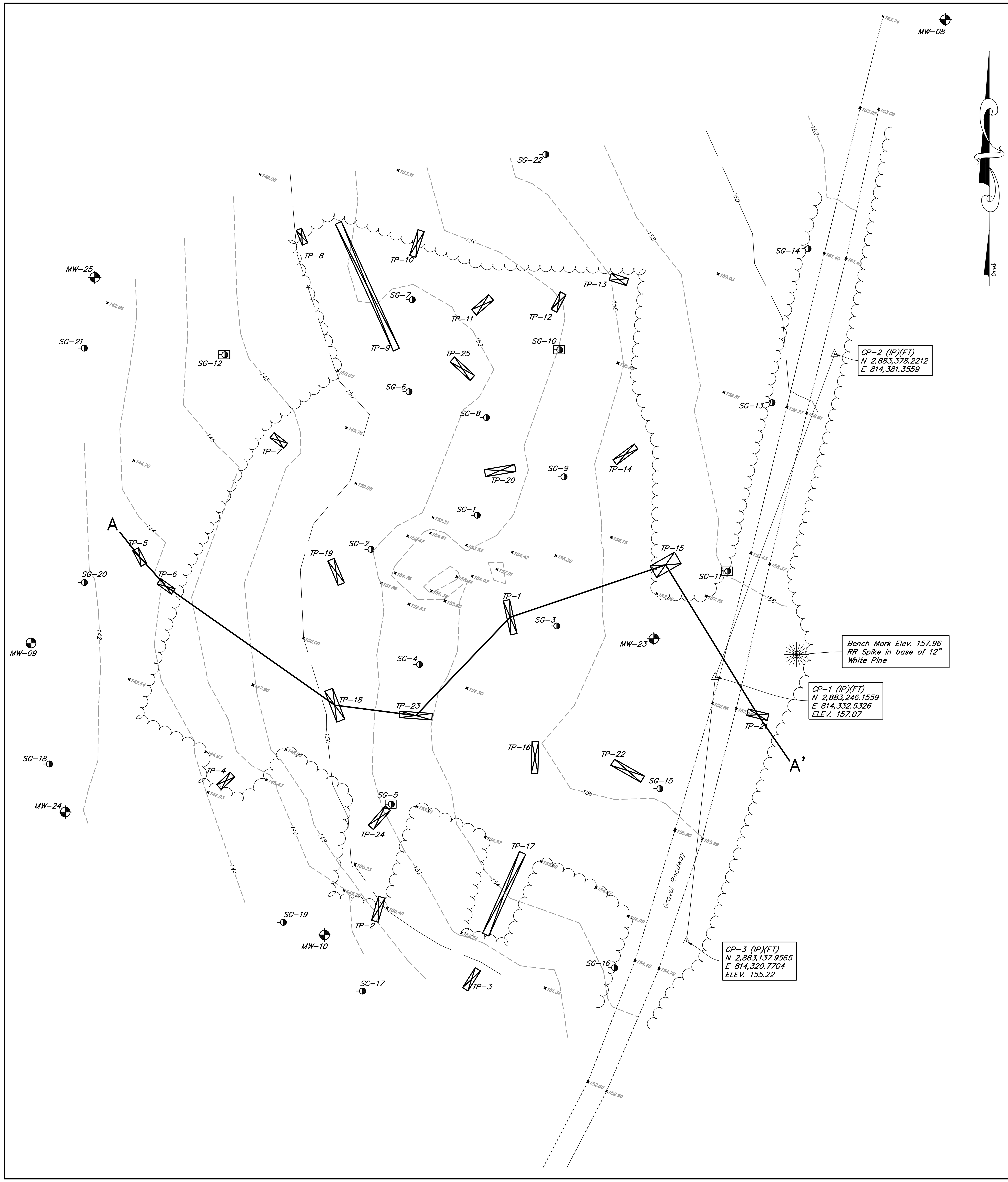

LEGEND

- TEST PIT LOCATIONS
- LANDFILL GAS MONITORING LOCATIONS
- LANDFILL GAS SAMPLING LOCATIONS

A——A' – CROSS SECTION LOCATION

GRAPHIC SCALE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

REVISIONS		
NO.	DATE	DESCRIPTION

SITE PLAN

LOCATION OF TEST PITS & SOIL GAS POINTS
SOUTH WEYMOUTH NAVAL AIR STATION
SMALL LANDFILL
SOUTH WEYMOUTH, MASSACHUSETTS

HRP Associates, Inc.			
Environmental/Civil Engineering & Hydrogeology; Creating the Right Solutions Together; Connecticut, New York, Massachusetts, Pennsylvania, South Carolina; 167 New Britain Avenue; Plainville, Connecticut 06062; Ph:(860)793-6899 Fax:(860)793-6871; www.hrpassociates.com	FMS SURVEYED	WJG APPROVED	1" = 20' SCALE
	FMS DRAWN	JULY 19, 2005 DATE	FIG. 2
	AMS CHECKED	NAV2002.SW PROJECT NO.	SHEET NO.

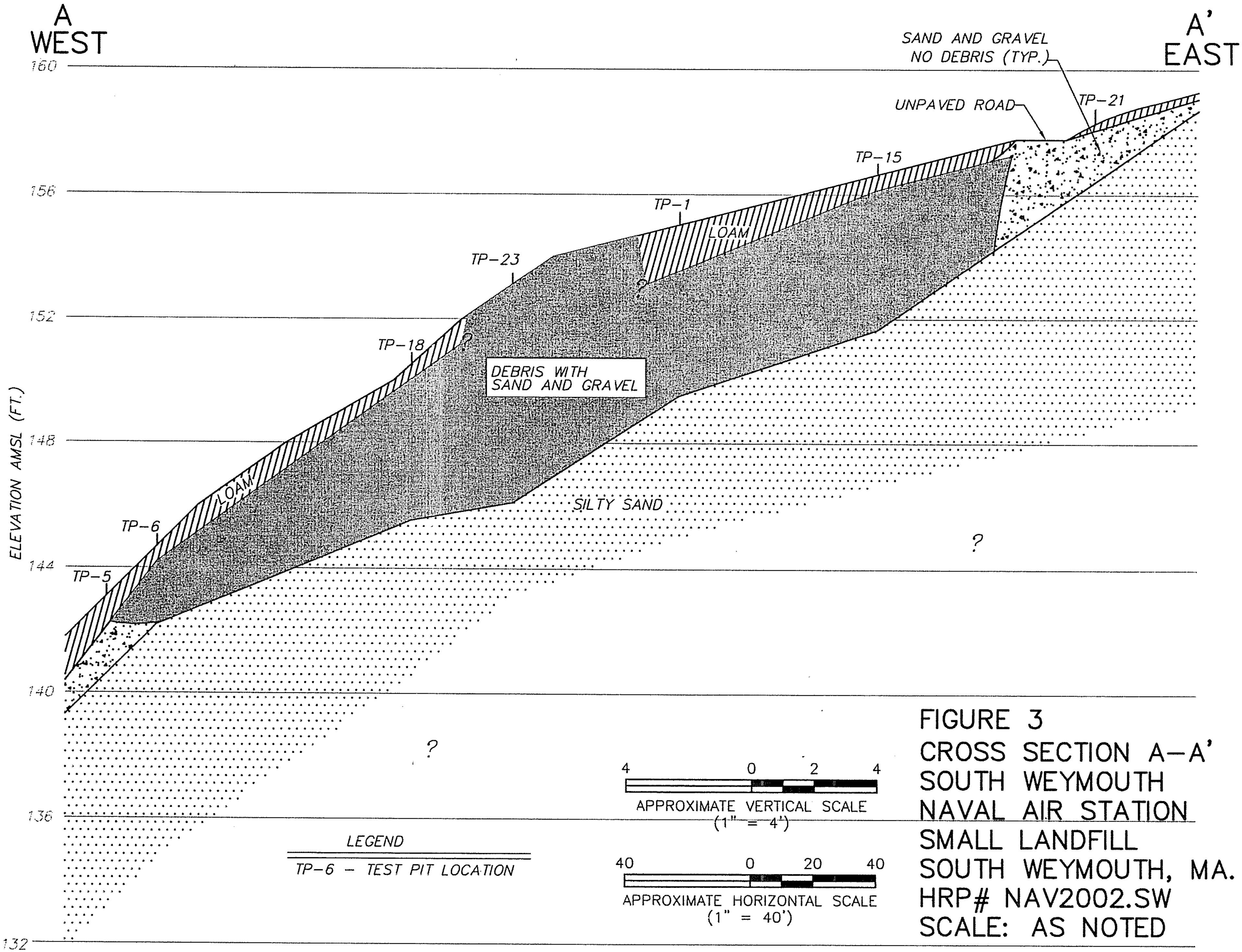

FIGURE 3
CROSS SECTION A-A'
SOUTH WEYMOUTH
NAVAL AIR STATION
SMALL LANDFILL
SOUTH WEYMOUTH, MA.
HRP# NAV2002.SW
SCALE: AS NOTED

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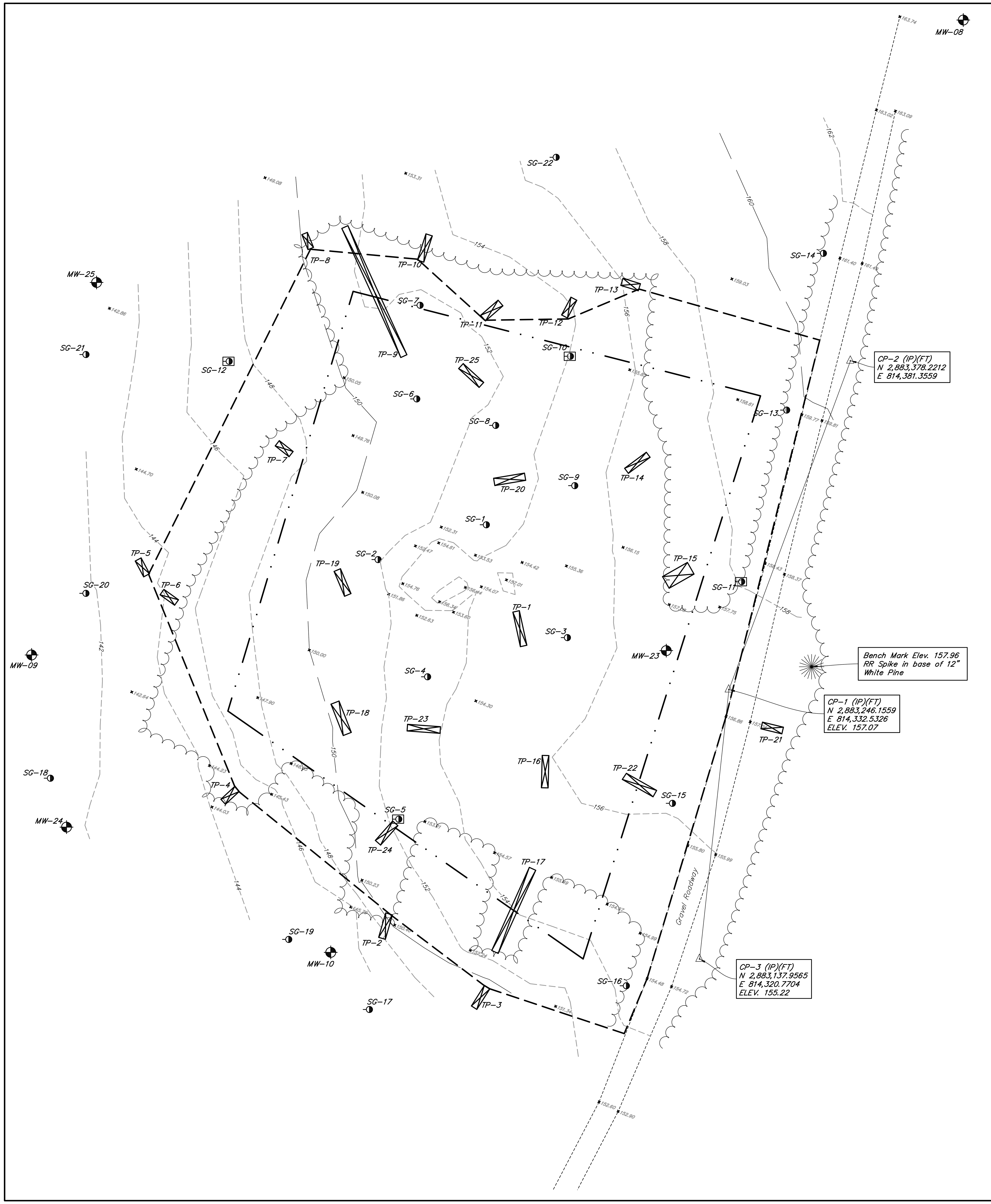

LEGEND

- TEST PIT LOCATIONS (TP-22)
- LANDFILL GAS MONITORING LOCATIONS
- LANDFILL GAS SAMPLING LOCATIONS
- APPROXIMATE EXISTING EXTENT OF DEBRIS
- PROPOSED AREA OF CONSOLIDATED LANDFILL
- MONITORING WELL
- 152 - ELEVATION CONTOURS (AMSL)
  CONTOUR INTERVAL = 2 FEET
- APPROXIMATE TREELINE

GRAPHIC SCALE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

REVISIONS		
NO.	DATE	DESCRIPTION

SITE PLAN WITH LANDFILL FOOTPRINT

SOUTH WEYMOUTH NAVAL AIR STATION
SMALL LANDFILL
SOUTH WEYMOUTH, MASSACHUSETTS

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Ph:(860)793-6899 Fax:(860)793-6871
www.hrpassociates.com

FMS SURVEYED	WJG APPROVED	1" = 20' SCALE	
FMS DRAWN	JULY 19, 2005 DATE		FIG. 4
AMS CHECKED	NAV2002.SW PROJECT NO.		SHEET NO.

FLEXIBLE MEMBRANE LINER (FML) CAP

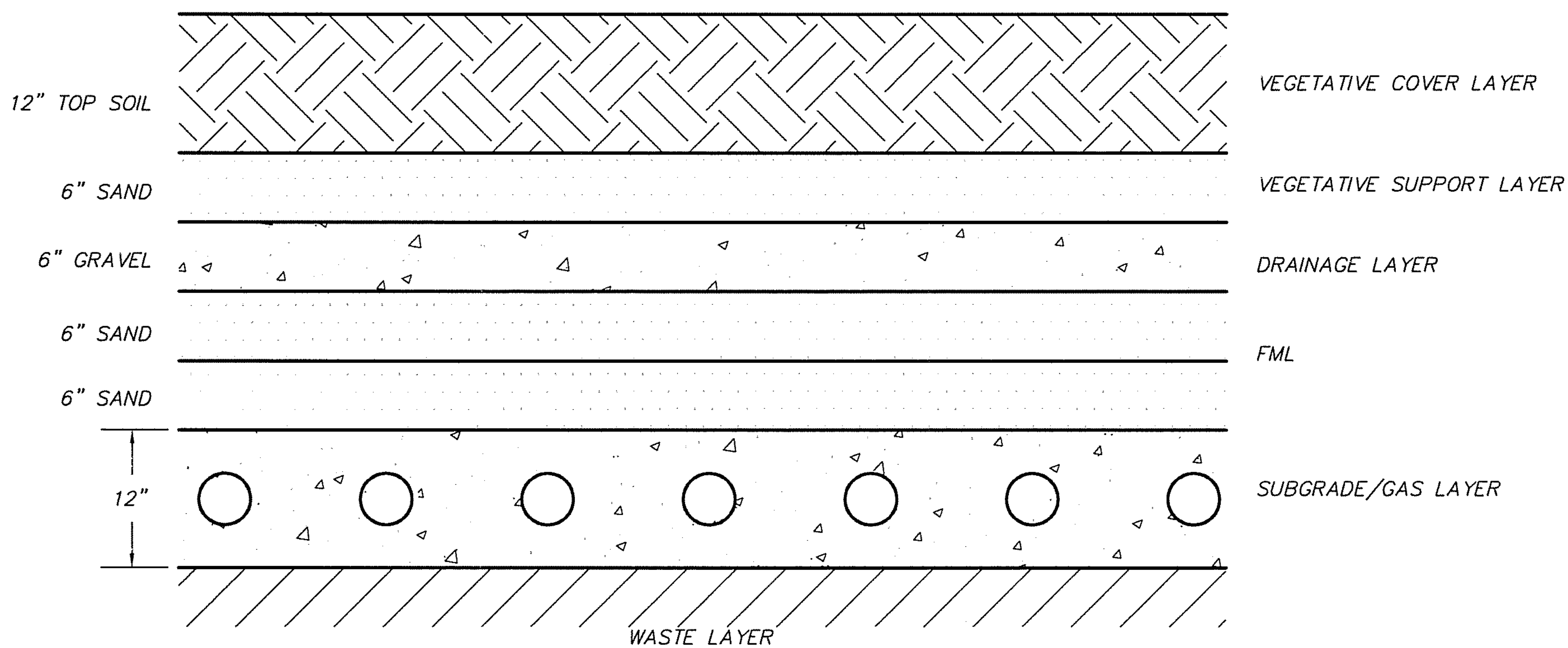

FIGURE 5
FML CROSS SECTION
CAA STUDY OF SMALL LANDFILL
NAVAL AIR STATION
SOUTH WEYMOUTH, MA
HRP# NAV2002.SW

CLAY CAP

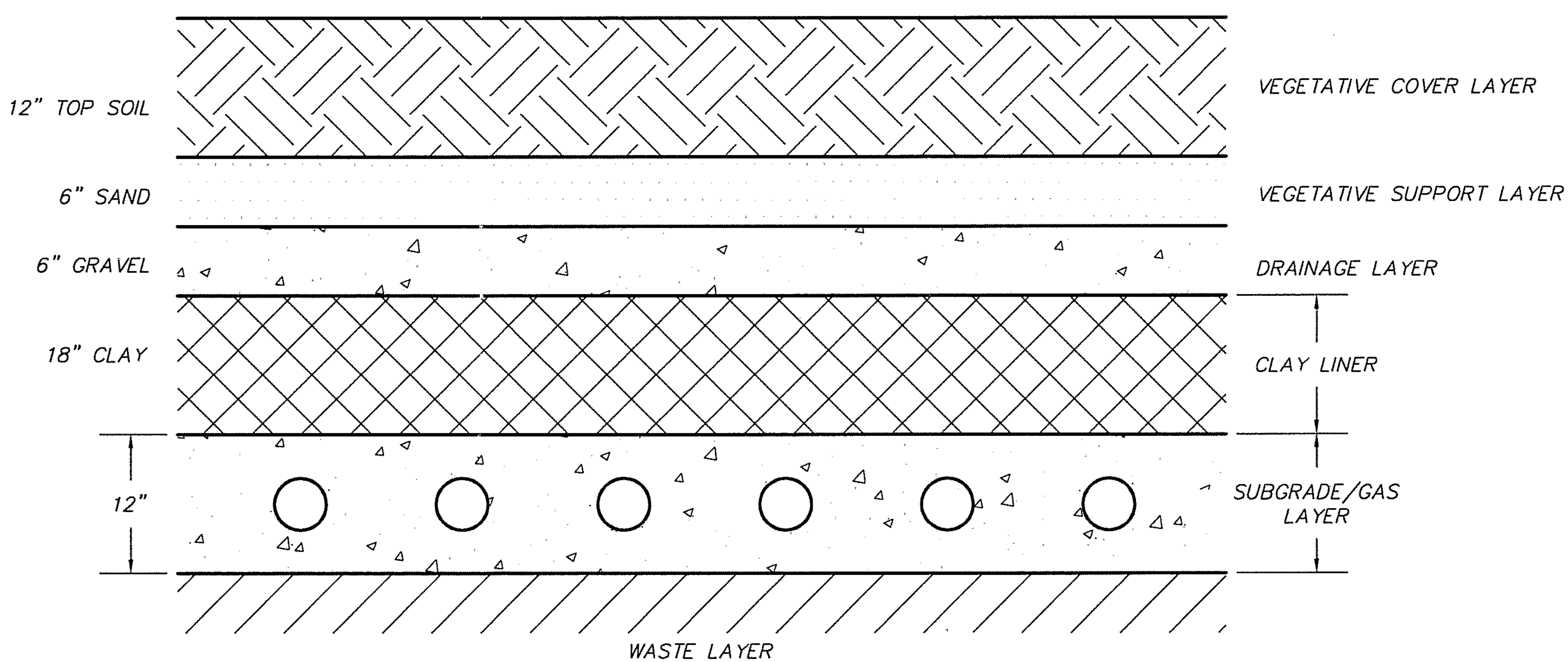

FIGURE 6
CLAY CAP CROSS SECTION
CAA STUDY OF SAMLL LANDFILL
NAVAL AIR STATION
SOUTH WEYMOUTH, MA
HRP# NAV2002.SW

APPENDIX A

EVALUATION OF LANDFILL CLOSURE REQUIREMENTS

SMALL LANDFILL, NAVAL AIR STATION SOUTH WEYMOUTH, CLOSURE ASSESSMENT PROCESS; ANALYSIS OF CERCLA REMEDIAL INVESTIGATION DOCUMENTATION AND STATE REGULATION REQUIREMENTS

The Environmental Department at Engineering Field Activity Northeast (EFANE) has reviewed all Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documentation prepared for the Small Landfill at South Weymouth Naval Air Station (NAS), as it relates to the Massachusetts Department of Environmental Protection (MADEP) solid waste regulations. This review was required to respond to the correspondence received from the MADEP, dated March 21, 2005. MADEP indicated an expectation that the Navy "commence landfill closure as expeditiously as possible". The purpose of this review is to determine if the existing CERCLA information is adequate to satisfy, in part or in whole, the requirements of the Massachusetts Department of Environmental Protection (MADEP) Solid Waste Regulations (310 CMR 19.000) for landfill closure assessment and to identify any additional information required by State regulations. This report presents the findings of this review.

Documents reviewed in making this determination include:

- Final Remedial Investigation Work Plan, South Weymouth Massachusetts, Volumes I and II. November 1995. Prepared by Brown and Root Environmental (Brown and Root, 1995);
- Phase I Remedial Investigation, NAS South Weymouth. Prepared by TtNUS (TtNUS, July 1998);
- Phase II Remedial Investigation Work Plan. Volumes I-III. Prepared by TtNUS (TtNUS, April 1999);
- Phase II Remedial Investigation, Small Landfill, NAS South Weymouth. Prepared by TtNUS (TtNUS, December 2000);
- Record Of Decision, Operable Unit 3, Small Landfill, NAS South Weymouth (January, 2002)
- Health and Safety Plan Naval Air Station South Weymouth CERCLA and MCP Sites. Prepared by TtNUS (TtNUS, December 2002);
- Groundwater Monitoring Program Report, Small Landfill, NAS South Weymouth, Massachusetts. Prepared by ENSE International, October 30, 2002 (ENSR, 2002).
- MADEP Landfill Technical Guidance (MADEP, May 1997)
- Massachusetts Solid Waste Regulations, CMR 19.000 (MADEP, August 2000))
- MADEP Guidance for Disposal Site Risk Characterization in Support of the Massachusetts Contingency Plan. Policy # WSC/ORS-95 141, (MADEP, July 1996)

1.0 INTRODUCTION

The Massachusetts Solid Waste regulations (310 CMR 19.000) require that un-permitted solid waste landfills be assessed prior to closure to determine the landfill's impact on groundwater, surface water, and air quality by characterizing the nature and extent of contamination and assessing the associated risk to public health and the environment. The goals and objectives of the landfill assessment are therefore generally consistent with those of a Remedial Investigation (RI) performed under CERCLA. The data requirements of a CERCLA RI may differ from the landfill closure assessment requirements due to the unique properties of landfills, such as gas generation, that must be addressed during closure, and the fact that most landfills are closed by capping as opposed to the wide variety of remedial actions that may be implemented at CERCLA sites.

2.0 BACKGROUND

The Small Landfill is a 0.8-acre area located at the eastern end of the Weymouth NAS property, to north of the approach end of runway 8-26 that was used for a period of approximately 5 years during the 1980's for the disposal of construction debris primarily consisting of concrete rubble and stumps. Items that have also been identified within the fill materials include aluminum, steel, rubber tubing, metal pipes and rods, bottles and cans, electrical wires, concrete, boulders, asphalt, railroad ties, plastic pipes and materials, and wood debris. A Record of Decision for the Small Landfill was issued under CERCLA in January 2002. The ROD contains a "No Action with Groundwater Monitoring" decision under CERCLA, and states that the "Site will be closed under applicable Massachusetts State Law".

The ROD was based on environmental investigations that were conducted by the Navy under the Installation Restoration Program (IR), including the Small Landfill. These investigations, which were performed on multiple IR sites, included a Preliminary Assessment (PA) performed by Argonne National Laboratories (Argonne) in 1988 (Argonne, 1988), a Site Inspection (SI) performed by Brown and Root Environmental (Brown and Root) in 1990 (Brown and Root, 1990), a Phase I RI performed in 1996 (TtNUS, 1998) and a Phase II RI that was performed specifically on the Small Landfill (TtNUS, 2000).

The PA included a records search, interviews, and a site walkover. Activities conducted during the SI included site walkovers, geophysical surveys, installation of three groundwater monitoring wells, and the collection of soil, sediment, surface water, and groundwater samples. The Phase I RI program activities included a literature search, geophysical (ground penetrating radar) survey, excavation of two test pits, collection and laboratory analysis of surface and subsurface soil samples, monitoring well and piezometer installations, hydraulic conductivity testing, groundwater gauging and water level measurements, stream gauging, and collection and analysis of surface soil, subsurface soil, groundwater sediment, and surface water samples.

The Phase II RI activities included a site walkover investigation, a subsurface investigation consisting of a ground penetrating radar geophysical survey, excavation of two test pits, drilling of three soil borings and installation of three 2-inch inside diameter (I.D.) groundwater monitoring wells, installation of one well point, hydraulic conductivity testing, measurement of groundwater levels, and collection and analysis of surficial and subsurface soil and groundwater samples. Other activities in the Phase II program included an ecological toxicity assessment of soils, and a survey of horizontal and vertical locations of sample locations, monitoring wells, and pertinent site features. All analytical data received Tier III level data validation. The analytical data were used to conduct human health and ecological risk assessments, which were included in the Phase II RI.

3.0 EVALUATION OF CERCLA RI COMPONENTS WITH MADEP LANDFILL CLOSURE ASSESSMENT REQUIREMENTS

This section discusses whether the CERCLA investigations performed for the Small Landfill meet the requirements for landfill closure assessment under 310 CMR 19.000. The approach used to determine if CERCLA investigations performed at the Small Landfill meet the requirements for a landfill closure assessment was to compare the data requirements for landfill closure assessment contained in 310 CMR 19.150 and the Landfill Technical Guidance (MADEP, 1997) with the data presented in the Phase I and Phase II Work Plans, and Phase I and Phase II RI reports. A summary of this comparison is presented in Table 1.

The MADEP landfill closure assessment process includes the following elements each of which are described below:

- Initial Site Assessment (ISA)
- Comprehensive Site Assessment (CSA)
- Qualitative/Quantitative Risk Assessments

3.1 ISA REQUIREMENTS

The ISA consists of a historical and literature review, evaluation of existing data, and the identification of sensitive receptors. The purpose of the ISA is to gather information to develop a Scope of Work for the CSA.

The Landfill Technical Guidance specifies that an ISA must have the following Main Components:

1. Collection and evaluation of all available site data such as historical information and existing technical reports or plans.

2. Conduct a site visit and describe site conditions, including local and regional geology and hydrology and the potential presence of contaminants. Environmental sampling, field screening, or geophysical surveys may be conducted as part of the ISA to facilitate preliminary identification of the extent of waste disposal and the presence of contaminants.

3. Identification and mapping of potential environmental and public health receptors sensitive to contaminate releases

4. Development of a detailed scope of work for activities to be performed during the CSA.

The information obtained during the PA, SI, and Phase I RI comply with or exceed the requirements for an ISA. A summary of this information is contained in Table 1. The PA, SI, and Phase I RI included collection and review of historical site data through a literature review and interviews with knowledgeable individuals, satisfying the requirement for Main Component 1. The SI included collection and screening level analysis of soil and groundwater samples, whereas the Phase I RI included a geophysical survey and additional collection and analysis of soil and groundwater samples. Information contained in the PA, SI, and Phase I RI therefore satisfy the requirements for ISA Main Component 2.

Identification of human and environmental receptors was performed during the Phase I RI. Identification of environmental receptors included delineation and survey location of wetlands, and a survey of terrestrial plant and wildlife communities and species within and adjacent to the Small Landfill. An instrument survey of site features, wetlands, sample locations, and monitoring wells was conducted in 1996 as part of the Phase I RI activities. The survey determined the horizontal coordinates relative to the

Massachusetts State Coordinate System (NAD 1883) to the nearest foot and vertical coordinates relative the National Geodetic Vertical Datum (NGVD) 1983 to the nearest 0.1 foot. The site maps contained in the Phase I RI were created from these surveys. This survey meets the requirements for ISA Main Component 3.

The work plans for the Phase I and Phase II RIs contain a detailed scope of work for the investigation of the Small Landfill. The scopes of work contained in these documents are sufficient to determine if the Small Landfill has an impact on the local environment, to identify and characterize the extent of impact and assess human and environmental risk, and to determine the need for landfill remediation. These work plans therefore satisfy the requirements for ISA Main Component 4. The details of these scopes of work and how they compare with the requirements for a CSA is discussed in Section 3.2.

3.2 CSA DATA REQUIREMENTS

In the CSA, the data necessary to characterize the site's subsurface and evaluate environmental impacts or potential impacts are collected, recorded, and analyzed. The Landfill Technical Guidance (MADEP, 1997) requires that the scope of work for a CSA include the following:

- A summary of the ISA;
- Site mapping;
- A drilling program;
- Determination of hydraulic conductivity;
- A sampling and analysis program;
- A health and safety plan; and
- Project schedule.

These activities were included in the Work Plans and Health and Safety Plans (HASPs) prepared for the Phase I and Phase II RIs (Brown and Root, 1995 and TtNUS 1999, respectively, and TtNUS 2002).

The discussion in this section compares the activities completed in the Phase I and Phase II RI with the seven items noted above that are required to be in the CSA Scope of Work. A comparison of the CSA requirements with site activities performed during the Phase I and Phase II RI is presented in Table 1.

3.2.1 Summary of the ISA

The Landfill technical guidance requires that conclusions drawn and recommendations made in the ISA must be summarized and any important facts or insight relating to the site must be highlighted in the ISA summary.

Section 1.4 of the Phase I RI summarizes the PA and SI investigations, whereas Section 1.1 of the Phase II RI summarizes the findings of the PA, SI, and Phase I investigations. Section 1.4 of the Phase I RI stated that the findings of the PA and SI investigations determined that additional assessment was required at the Site. Section 1.1 of the Phase II RI described the type of waste present in the landfill, and listed the potential contaminants as semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, nutrients, metals, and cyanide, and states that these potential contaminants were included in the parameter list for the Phase I and Phase II RI.

The information contained in PA, SI and the Phase I RI meet or exceed the requirements of an ISA; therefore, the summaries of these documents contained in the Phase I and Phase II RIs meet the requirements for an ISA summary.

3.2.2 Site Mapping

The maps contained in the Phase II RI meet the requirements of the Landfill Technical Guidance for a CSA. Site Mapping that takes place during the CSA is usually limited to updates and correction to the existing base map. A survey performed in 1999 updated the survey of receptors, wetlands, sample locations, and monitoring wells surveyed in 1996. The site maps contained in the Phase II RI were created based on this updated survey.

3.2.3 Drilling Program

The drilling program performed during the SI and Phase I RI meets the requirements of the Landfill Technical Guidance to provide adequate subsurface information for the CSA. A total of six soil borings were drilled at the site to a depth between 14 and 15 feet below ground surface (bgs). Three borings were installed during the SI, and three during the Phase I RI. These borings were used to install 2-inch I.D. groundwater monitoring wells. Each well was developed after completion. One small diameter well point was also installed at the Site during the Phase I RI investigation. Soil samples were collected from each boring for determination of physical properties and for chemical analysis. Soil boring logs were completed to describe subsurface conditions encountered during drilling of each boring. Well completion logs and well development logs were completed to document the construction and development of the monitoring wells. Two test pits were also excavated at the site during the Phase I RI. Test pits logs were completed to describe subsurface conditions. Test pit logs were appended to the Phase I RI.

3.2.4 Determination of Hydraulic Conductivity, Groundwater Elevation and Flow Direction

A determination of hydraulic conductivity is required during the CSA to evaluate the rate at which groundwater flows in the vicinity of the landfill. The determination of hydraulic conductivity and groundwater elevation contouring and flow direction in the RIs meet the requirements of the Landfill Technical Guidance. The hydraulic conductivity of the saturated zone at the Small Landfill was determined through performance of slug tests in the six monitoring wells. The hydraulic conductivity was determined in accordance with methods presented in the Phase I RI Work Plan. The hydraulic conductivity data and calculations are appended to the Phase II RI. In addition to hydraulic conductivity, groundwater elevations were determined at the site by determining the location and elevation of the well risers and groundwater depth gauging. Groundwater contour and flow direction maps were prepared from this data.

3.2.5 Sampling and Analysis Plan

This section compares the sampling and analysis program implemented at the Site during the Phase I and Phase II RI with the CSA requirements. The landfill technical guidance requires that sampling and analytical techniques used in the CSA conform to standard procedures. The Phase I and Phase II RI Work Plans contained a detailed description of the sampling and analysis program that was implemented at the Site. All sample collection methods, sample analytical methods, and data validation methods specified in the Phase I and Phase II RI sampling and analysis plan conformed to standard Environmental Protection Agency (EPA) procedures. A comparison of the CSA sampling and analysis plan requirements with the sampling and analysis program activities performed during the SI, and Phase I and Phase II RIs is presented in Table 2. Major elements of the sampling and analysis programs completed at the site are summarized below.

Soil Samples

Soil samples collected for laboratory analysis during the Phase I RI sampling program included three soil samples from the two test pits, two soil samples from each soil boring, and surficial soil samples. Two

soil samples were collected during the Phase II RI. Soil samples were analyzed for the parameters contained in Table 2.
These analytical parameters are consistent with the requirements of CMR 19.150 and the Landfill Technical Guidance with the exception of total petroleum hydrocarbons (TPH) and dioxins, which were not analyzed for.

Note -
1/ SVOCs/PAHs results were analyzed and showed no exceedances; therefore TPH constituents were not tested.
2/ No exceedances for PCBs were shown in any media of concern; namely groundwater and soils, therefore dioxins were not tested.

Groundwater Samples

Seven groundwater samples were collected with bladder pumps during the Phase I RI using the EPA Low Flow method. No groundwater samples were collected during Phase II. Subsequent to the completion of the Phase II RI, a groundwater monitoring program consisting of four quarterly rounds of groundwater sampling was performed at six groundwater monitoring wells at the site during the period from September 2001 through July 2002. Groundwater samples collected during the Phase I RI and the groundwater monitoring program were analyzed for the parameters contained in Table 2.
These analytical parameters are consistent with the requirements of CMR 19.150 and the Landfill Technical Guidance with the exception of chlorides, sulfates, coliform, TPH, and dioxins which were not analyzed for.

Note -
1/ Chlorides, Sulfates, and Coliform are indicator parameters rather than constituents of concern; therefore they were not tested for under CERCLA.
2/ SVOCs/PAHs results were analyzed and showed no exceedances, thereforeTPH constituents were not tested.
3/ No exceedances for PCBs were shown in any media of concern; namely groundwater and soils, therefore dioxins were not tested. Dioxins have an affinity for soil and not for ground water.

Leachate Sampling

The Phase I RI Work Plan specified collection of leachate samples from the small landfill; however no evidence of leachate or leachate-stained soils were observed during any of the investigations, therefore no samples were collected..

Surface Water and Sediment Sampling

Samples of surface water and sediment were collected from Old Swamp River, French Stream, and other drainage areas during the Phase I RI. Analysis parameters complied with the requirements of CMR 19.150 and the Landfill Technical Guidance with the exception of chloride, sulfate, nitrogen, total dissolved solids, alkalinity, chemical oxygen demand (COD), coliform (surface water only), TPH, and dioxins which were not analyzed for.

Note -
1/ Chloride, sulfate, nitrogen, total dissolved solids, alkalinity, chemical oxygen demand (COD), coliform (surface water only) are indicator parameters rather than constituents of concern therefore they were not tested for under CERCLA.
2/ SVOCs/PAHs results were analyzed and showed no exceedances, thereforeTPH constituents were not tested.

3/ No exceedances for PCBs were shown in any media of concern; namely groundwater and soils, therefore dioxins were not tested. Dioxins have an affinity for soil and not for water.

Landfill Gas Sampling

Landfill gas and soil gas were not sampled during either the Phase I or Phase II RI. This does not conform with the strict requirements of the Landfill Technical Guidance for a CSA scope of work. However, since VOC concentrations detected in soil and groundwater were not elevated, they are not likely to be present in soil gas. Also, the type of materials disposed of in the Small Landfill (concrete, stumps, and assorted metal, glass and plastic/rubber materials) would not generated measurable concentrations of soil gas. Therefore, measurement of landfill gas at this site does not appear to be warranted.

HASP and Project Schedule

A HASP was prepared for the Phase II field investigations (TtNUS 2002). The Phase I and Phase II RI Work Plans (Brown and Root 1995 and TtNUS April 1999, respectively) included a project schedule.

3.3 CSA REPORT

The Phase I and Phase II reports meet the Landfill Technical Guidance requirements for content and data presentation of a CSA report. The CSA report is required to include the following information:

- Data Interpretations and Presentations
- Maps, Plans, and Figures
- Summary Tables and Forms

Extensive and complete discussions of data interpretation and presentation are contained in Section 3.0, 4.0, and 5.0 of the Phase I and Phase II RIs. These documents also contain extensive and detailed maps, plans, and figures depicting site features, groundwater data, sampling locations, and sampling results. Physical and chemical data are summarized in tabular form in both documents. Data forms for soil borings; monitoring well construction and development; hydraulic conductivity testing; groundwater gauging; soil, groundwater, surface water, and sediment sample collection; and laboratory analysis results are attached as appendices to the RI report.

3.4 CSA QUALITATIVE RISK ASSESSMENT

The Landfill Technical Guidance requires that CSA reports include a Qualitative Risk Assessment that identifies the risks to human health, safety, public welfare, and the environment which may have been caused by the landfill. The Qualitative Risk Assessment must identify all potential receptors, list all detected contaminants, including maximum contaminant concentrations and the locations where they were detected and the media they were detected in, and evaluation of potential exposure pathways.

The result of the risk assessment shall be either:

- The existing data are sufficient to indicate there is no significant threat from the landfill;
- The existing date are not sufficient to make a decision of the level or risk posed by the landfill and additional work is necessary; or
- Existing data indicates there may be a significant risk to public health or the environment and a more detailed qualitative risk assessment or remedial measures are required.

The Phase II RI includes a CERCLA human health and ecological risk assessment that meets the requirements of the more detailed Quantitative Risk Assessment, therefore the requirements for including a qualitative risk assessment in the CSA have been exceeded. The CERCLA risk assessment determined that the Small Landfill does not present an unacceptable risk to human health or the environment.

3.5 CSA QUANTITATIVE RISK ASSESSMENT

The Landfill Technical Guidance requirements for a Quantitative Risk Assessment state that "Quantitative Risk Assessment at Solid Waste landfills shall follow the Massachusetts Contingency Plan (310 CMR 40.0000) and associated Guidance for Disposal Site Risk Characterization in support of the MCP (MADEP Policy # WSC/ORS-95-141, July 1996). In order to achieve landfill closure, the risk assessment must demonstrate that a condition of No Significant Risk is achieved at the landfill either under its existing condition or after implementation of corrective action alternatives. The requirements of the MCP apply only to locations outside the boundary of the landfill (beyond the point of compliance). The point of compliance for groundwater is 150 meters from the edge of the system designed to control waste or the property line, which ever is less. The point of compliance for soils is the edge of the area to be capped. The point of compliance for surface water, sediments, and ambient air is the property boundary.

The human health risk assessment performed for the Phase II RI was conducted in accordance with the following state and federal guidance:

- Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual (Parts A, B, C) (EPA 1989a, 1991a, 1991b);
- Dermal Exposure Assessment: Principals and Applications (EPA, 1992a);
- Risk Updates – EPA Region 1;
- Human Health Exposure manual, Supplemental Guidance: Standard Default Exposure Factors OSWER Directive 9285.6-03 (EPA 1991c); and
- Exposure Factors Handbook (EPA 1997a).

The ecological risk assessments performed for the Phase II RI was conducted in accordance with the following state and federal guidance:

- Intermittent "ECO" Update Bulletins of the EPA (published between 1991 and 1996);
- Tri-services Procedural Guidelines for Ecological Risk Assessments; Volume 1 (Wentsal et al., 1996);
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Risk Assessments (Interim Final) (EPA, 1997);
- Guidelines for Ecological Risk Assessment (EPA 1998) and
- Guidance for Disposal Site Risk Characterization under the MCP, Environmental Risk Characterization, Interim Final Policy, April 22, 1996 (MADEP 1996).

The human health and ecological risk assessments performed for the Small Landfill conform with the requirements of Method 3 human health environmental risk characterization (see Table 3) and are therefore consistent with the requirements of the Landfill Technical Guidance for an Quantitative Risk Assessment with the possible exception of characterization of risk to safety from debris protruding from the landfill surface.
Characterization of Risk to Safety is addressed in 310 CMR 40.0960 and includes evaluating the site for the presence of rusted or corroded drums or containers, pits, lagoons, or other dangerous structures. The Navy plans to conduct a site visit with the MADEP Solid Waste Division prior to any field work and address any issues or concerns.

3.6 CONCLUSIONS

The existing CERCLA documents prepared for the Small Landfill substantially comply with the requirements for the landfill closure process under 310 CMR 19.000, including the requirements for an ISA, CSA, and a CSA Qualitative Risk Assessment as shown in the relevant paragraphs of this document.

TABLES

TABLE 1
COMPARISON OF CERCLA INVESTIGATION SITE ACTIVITIES WITH LANDFILL CLOSURE REQUIREMENTS OF 310 CMR 19.000

Activities	Preliminary Assessment	Site Investigation	Phase I Remedial Assessment	Phase II Remedial Assessment
Required ISA Activities				
Background Information		X	X	X
Historical Research		X	X	
Literature/ Data Search		X	X	
Hydrogeological Description			X	X
Site Visit	X	X	X	X
Mapping			X	X
Required CSA Activities				
ISA Summary				X
Mapping Update				X
Drilling Program		X	X	X
Determination of Hydraulic Conductivity			X	
Sampling and Analysis Plan			X	X
Health and Safety Plan			X	X
Project Schedule			X	X

TABLE 2
COMPARISON OF CERCLA INVESTIGATION FIELD ACTIVITIES WITH DATA REQUIRED FOR LANDFILL CLOSURE BY 310 CMR 19.000

Required Analysis Parameters						
Parameters	**Groundwater [1]**	**Soil**	**Surface Water**	**Sediment**	**Landfill Gas**	**Leachate**
Inorganics (Arsenic, Barium, Cadmium, Chromium, Copper, Cyanide, Lead, Mercury, Selenium, Silver, and Zinc)	X	X	X	X	NA	NS
Manganese	X	X	X	X	NA	NS
Iron	X	X	X	X	NA	NS
Chlorides	NS	NS	NS	NS	NA	NS
Sulfate	NS	NS	NS	NS	NA	NS
Nitrate	Nitrate/Nitrite [8]	TKN [8]	NS	NA	NA	NS
TDS	X	NA	NS	NA	NA	NA
Alkalinity	X	NA	NS	NA	NA	NS
COD	X	NA	NS	NA	NA	NS
pH, Specific Conductance, Temperature, and DO	X	NA	X	NA	NA	NS
Purgeable Volatile Organic Compounds	X	X	X	NS	NA	NS
Pesticides	X	X	X	X	NA	NS
PCB's	X	X	X	X	NA	NS
Base/Neutral and Acid Extractable Compounds	X	X	X	X	NA	NS
Polynuclear Aromatic Hydrocarbons (PAHs)	X	X	X	X	NA	NS
Halogenated Volatile Organic Compounds	X	X	X	NS	NA	NS
Coliform	NS	NS	NS	NS	NA	NA
Total Petroleum Hydrocarbons (TPH)	NS	NS	NS	NS	NA	NS
2,3,7,8-TCDD (indicator for Dioxins and Furans)	NS	NS	NS	NS	NA	NS

Notes:

1. Surface and Ground water samples - Quarterly samples were collected from each of the six groundwater monitoring wells at the site during the period from September 2001 to July 2002.
2.
3.
4.
5.

Additional Notes:
TKN = Total Kjeldahl Nitrogen
X = Met Analytical Requirements.
NA = Not Applicable.
NS = Not Sampled.

TABLE 3

COMPARISON OF THE PHASE II RI HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS WITH THE REQUIREMENTS FOR A LANDFILL QUANTITATIVE RISK ASSESSMENT

Human Health Risk Assessment	
Landfill Risk Assessment Requirements	**Included in Small Landfill Risk Assessment**
Hazard Identification	YES
Dose-response Assessment	YES
Exposure Assessment	YES
Consideration of Existing and Future Uses	YES
Risk Characterization	YES
Risk to Safety	NO
Uncertainty Analysis	YES
Environmental Risk Characterization	
Landfill Risk Assessment Requirements	**Included in Small Landfill Risk Assessment**
Identification of Contaminant Fate and Transport	YES
Identification of Exposure Pathways and Receptors of Concern	YES
Evaluating Potential Toxicological Effects	YES
Development of Conceptual Model	YES
Identification of Assessment Endpoints	YES
Risk Characterization	YES