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INTERIM CORRECTIVE ACTION
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE
CAPPING ALTERNATIVES EVALUATION FOR THE DRMO

Prepared for:
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SECTION 1.0 INTRODUCTION

1.1 Background

The DRMO facility, approximately three (3) acres in size, is used for the segregation and storage of scrap metals for recycling and recovery at the Portsmouth Naval Shipyard located in Kittery, Maine. The DRMO is located at the base of a hill located south of the Quarters S&N and north of the Piscataqua River. Materials are currently stored on either asphalt paving, concrete or bare earth. While there are no surface water run-off control structures on-site to prevent washing of stored scrap materials during precipitation events, there is a stormwater collection system which drains the area.

McLaren/Hart Environmental Engineering Corporation (McLaren/Hart) has previously conducted four (4) separated phases of environmental investigation at the Solid Waste Management Units (SWMUs) and areas of concern at the Portsmouth Naval Shipyard. The DRMO was investigated during Phase I, II, III and IV field activities and the work is summarized in the following documents:

- RCRA Facility Investigation Field Work, Phase I, Portsmouth Naval Shipyard, Kittery, Maine, May 31, 1990.

- RCRA Corrective Action, Portsmouth Naval Shipyard, Kittery, Maine, Phase II Field Work Report and Appendices I & II, April 26, 1991.

- RCRA Corrective Action, Portsmouth Naval Shipyard, Kittery, Maine, Phase III Field Work Report and Appendices I & II, June 5, 1991.

- RCRA Corrective Action, Portsmouth Naval Shipyard, Kittery, Maine, Phase IV Field Work Report and Appendices I & II, December 17, 1991.

The environmental investigations conducted at the DRMO included shallow and deep soil sampling and analyses, and the installation and sampling of groundwater monitoring wells. The investigations of the DRMO indicated that concentrations of metals, specifically lead, to be elevated in both the shallow and deep soil samples collected from the area. The concentration of total petroleum hydrocarbons (TPH) and polychlorinated biphenyls (PCBs) observed in the soil samples suggested that petroleum products are present in the subsurface soils. A soil sample collected from the sediment of the stormwater catch basin had elevated concentrations of the following metal compounds: copper, lead, nickel, and zinc. In addition, several metal compounds were identified to be present at levels exceeding the USEPA National Primary Drinking Water Standards in water samples collected from the groundwater monitoring wells installed around the DRMO perimeter.

As a result of the soil and groundwater analytical findings, McLaren/Hart has recommended that interim corrective measures be implemented to mitigate present environmental impacts from the DRMO. The immediate environmental impacts are mostly related to soil erosion and runoff of the surface soils into the Piscataqua River, and direct contact via dust and other transport mechanisms of the surface soils. There does not appear to be an immediate concern with regard to groundwater in the area.

McLaren/Hart has recommended that interim corrective measures consist of capping the surface soils with the primary objective of preventing erosion and runoff of surface soil. The cap will also provide separation of the surface soils from personnel working at the facility. Prevention of infiltration is a lesser function of the cap since most of the subsurface soils are located beneath the water table. In addition, surface water measures will be implemented which will allow collection and discharge of surface water runoff from the site in a controlled manner.

The long-term remediation technologies will be negotiated with USEPA at some future time. At present, the Navy has decided to take a proactive role at this facility by implementing interim corrective measures. McLaren/Hart and the Navy are optimistic that these interim corrective measures will be consistent with the final corrective measures at this site and that, eventually,

the interim corrective measures can become part of the final long-term remediation of the site.

1.2 Objectives

The primary objectives of this interim corrective measures study is to evaluate several alternatives for capping and controlling surface water runoff at the DRMO site. There are several site features which will dictate the type of cap which may be implemented at the DRMO. Most importantly, the site cap must be consistent with the future continued operation of the site as a scrap yard for the Navy base. The scrap yard activities involve the use of a large capacity hydraulic crane throughout the yard. General operations involve a significant amount of "scraping" of materials from the land surface for the purpose of relocating or disposing of the materials. The cap must be capable of supporting the hydraulic crane while maintaining its structural integrity. These two (2) features will be the most important contributing factors in determining which type of capping system will be recommended at the DRMO site.

In addition, the cap will be consistent with RCRA performance standards for capping so that USEPA could be in a position to approve the cap as a final corrective measure if it is determined that no "intrusive" type of remedial measures (e.g., excavation and removal, solidification, etc.) are required for the DRMO site.

SECTION 2.0 CAP FUNCTIONS

Capping is a process used to cover buried waste materials to prevent their contact with the land surface and groundwater. It is a reliable technology for preventing contamination from the aboveground environment and for significantly reducing the potential for underground migration of contaminants through infiltration and percolation. Capping is a necessary remediation alternative whenever contaminated materials are to be buried or left in place at a site. In general, capping is performed when extensive subsurface contamination at a site precludes excavation and removal of waste materials due to the potential hazards and/or unrealistic associated costs.

A cap may be constructed over most sites in a short period of time given that the ground is not frozen or saturated. The natural materials needed for construction of some caps, such as soil and clay, are readily available in most parts of the country. In addition, synthetic materials which may be needed are manufactured and distributed widely throughout the United States. The equipment used for construction of most capping systems include typical construction equipment; however, in some instances specialized testing equipment must be used by the liner installer or a soil testing company.

The design of modern caps usually conform to the performance standards established for Resource Conservation and Recover Act (RCRA) landfill closure requirements, 40 CFR 264.310. These standards include minimum liquid migration through the waste materials, low cover maintenance requirements, efficient site drainage, significant resistance to damage due to settling or subsidence, and a permeability lower than or equal to the underlying liner system or natural soils.

In evaluating the necessity for capping at the DRMO site, McLaren/Hart has identified four major functions of the capping. Each of these functions will be discussed as it applies to the DRMO site in the following sections.

2.1 Prevent or Minimize Infiltration

The primary function of most caps is to prevent or minimize water infiltration to the land surface and potentially to groundwater. To accomplish this function, a cap must possess a substantial impermeable member and the surface of the cap should be sloped as to minimize water ponding on the cap which may cause leakage through the cap material.

A secondary benefit which is obtained from the cap's ability to prevent or minimize infiltration is that the hydraulic barrier also provides an excellent, reliable, proven method of limiting direct contact and inhalation of the contaminated materials which are capped.

Because of the fact that most of the subsurface soils of the DRMO are located beneath the water table, prevention of infiltration is not as critical a requirement for the DRMO cap as it may be for other capped sites. It is still desirable to prevent infiltration at the DRMO site since this would reduce the potential for leaching of the soils above the water table, however, this is not the most important function of the cap. More importantly, the DRMO cap must provide a method of limiting direct contact and inhalation of the contaminated site soils. In fact, this is one of the most critical environmental concerns which the DRMO cap must address.

2.2 Prevent Surface Erosion and Control Surface Water Runoff

Another important function of capping is to prevent and control surface water runoff and soil erosion. It is important to prevent and control surface runoff of water which has come in contact with contaminated soils. The surface runoff, if not controlled and/or prevented, may contaminate nearby surface water bodies. Surface erosion must be prevented to reduce the potential for infiltration of surface water into the land surface and the groundwater. Erosion is controlled by reducing the slope length, slope steepness, or improving soil management.

Along with preventing direct contact and inhalation of contaminated soils, the prevention of surface erosion and control of surface water runoff is a critical function of the DRMO cap

because of the site's close proximity to the Piscataqua River. At present, there is very little control of erosion of contaminated surface soils and drainage into the River.

2.3 Promote Aesthetics

A surface cap promotes the aesthetics of a site by limiting contact, both visual and physical, with the waste material. A well managed cap system will be aesthetically pleasing to the general public present around the site and to workers on the site by covering the waste material from direct view. In addition, if the waste materials are producing an offensive odor, a cap would reduce the detection of such odors.

Although there are no odors from the soils of the DRMO site, the Navy does plan to continue operation in the yard in the future. Therefore, it is important that the cap have appealing aesthetics, at least to the point where it is consistent with the current yard appearance.

2.4 Promote Site Reclamation

A cap will promote site reclamation by preventing or minimizing the direct contact by site personnel, the surrounding community and surface water runoff with site contaminants. A cap will not remove the source of site contamination, but will minimize the potential for further contamination to other environmental media by minimizing infiltration of surface water into the groundwater and runoff into surface water bodies.

As mentioned, the Navy plans to continue using the DRMO site as a scrap yard. This involves stockpiling of various uncontaminated debris within the yard. As part of the routine operation of the yard, heavy equipment is for the stockpiling and moving materials within the yard. The capping system selected for the DRMO must be capable of maintaining its structural and environmental integrity during yard operations.

SECTION 3.0 INTERIM CAPPING ALTERNATIVES

There are a variety of cap designs and capping materials which are currently available to implement this technology. Most cap designs are multi-layered to conform with the RCRA standards and technical requirements. However, the selection of the capping materials and the cap design are influenced by site-specific factors. The determining factors for the DRMO cap will include the desired functions of the cover materials, the nature of the waste materials being covered, local climate and hydrogeology, the projected future use of the site, and the cost.

The interim capping alternatives for the DRMO site are presented in the following sections. These alternatives have been developed as an interim corrective measure, but all the alternatives are consistent with the RCRA performance requirements for a final cap and could therefore be consistent with any final corrective measure at the site which does not involve any disturbance or excavation of the contaminated soils.

3.1 OPTION 1 - Semi-Permeable Crushed Stone Cap

This capping alternative, shown in Figure 1, would consist of placing approximately one (1) foot of clean imported crushed stone overtop the contaminated soils of the DRMO. A heavy needlepunched geotextile will be placed directly atop the contaminated soils to provide separation between the clean stone and the contaminated soils. The geotextile will prevent the migration of contaminated soil particles into the clean stone towards the surface. Prior to placing the geotextile the site will be graded to promote drainage and prevent ponding. No removal of contaminated soils from the yard is proposed for this capping project.

The crushed stone will be "choked" with stone fines and cement dust to provide a hard working surface. The cap will be semi-permeable due to the presence of void spaces between the soil particles, but the choking with fines will significantly reduce the permeability of the stone as compared to that of a clean stone.

FIGURE 1

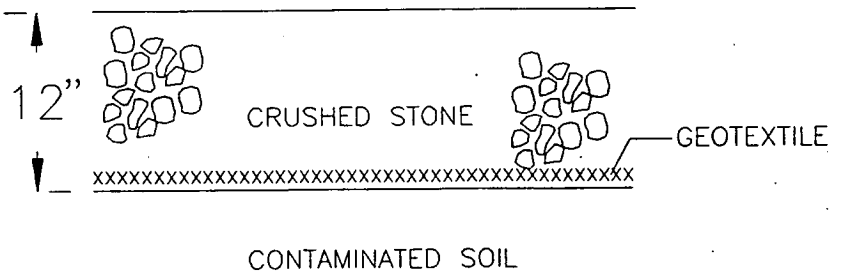

FIGURE 1
SEMI-PERMEABLE CRUSHED STONE CAP

The cap would be constructed using general earthmoving equipment, which are readily available.

3.2 Option 2 - Impermeable Clay Cap

This capping option, shown in Figure 2, consists of constructing 12 inches of compacted clay above the contaminated soils. A heavy needlepunched geotextile will be placed directly atop the contaminated soils to provide separation between the clay and the contaminated soils.

Clay is a less permeable material than crushed stone. This lower permeability would prevent or minimize infiltration of water through the cap more effectively than a crushed stone cap. A six inch vegetative supportive soil layer would be placed above the clay. This layer will support the growth of vegetation which will provide erosion control of the cap.

permeability = 10^{-2}

3.3 OPTION 3 - Geosynthetic Cap

This option, shown in Figure 3, consists of placing a PVC geosynthetic membrane overtop of a heavy needlepunched geotextile. The geotextile is placed over the graded contaminated soils to provide a protective bedding layer for the membrane. Twelve inches of cover soil and vegetation will be placed above the PVC to provide protection of the geomembrane.

There are basically three (3) categories of synthetic membranes which are used in capping: elastomers (rubbers), thermoplastics (plastics), and combination of elastomers and thermoplastics. Butyl rubber, ethylene propylene rubber (ethylene propylene diene monomer, EPDM), and neoprene are the most commonly used rubbers. The most common plastics used in geosynthetic membrane liners or caps are polyethylene (PE), polyvinyl chloride (PVC), and chlorinated polyethylene (CPE). High Density Polyethylene (HDPE) is the most widely used material for landfill liners and caps because of its high chemical compatibility. It is also the

FIGURE 2

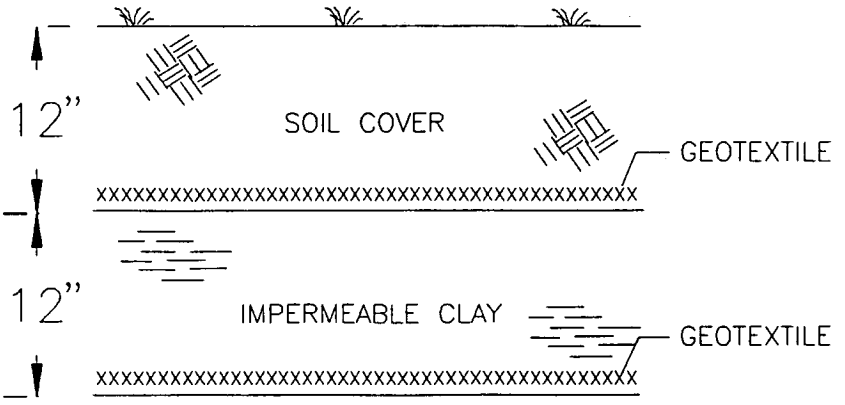

FIGURE 2
IMPERMABLE CLAY CAP

FIGURE 3

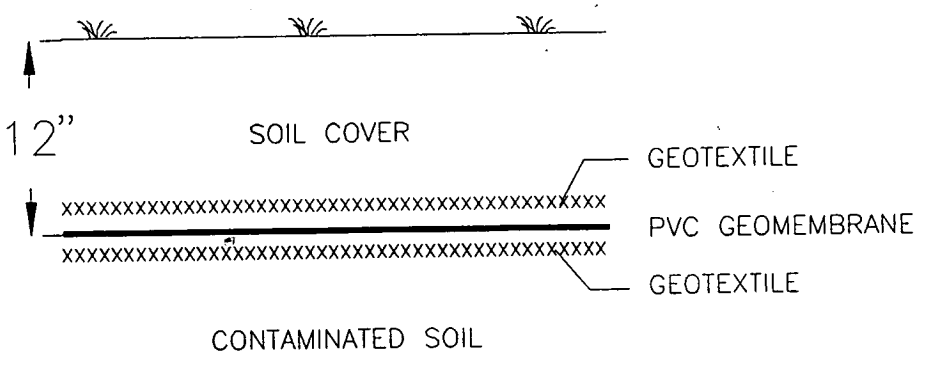

FIGURE 3
GEOSYNTHETIC CAP

most expensive. PVC is proposed for this project since chemical compatibility is not an issue and the only requirement for the geomembrane is that it prevent migration of rainwater through the membrane.

The membrane sheets would be seamed together in the field using either contact adhesives, heat welding, or vulcanization depending on the type of polymeric membrane and the site conditions. The PVC geosynthetic membrane barrier will be isolated from direct contact with the contaminated soil by underlying the membrane with a heavy needle punched geotextile to provide a protective bedding layer for the membrane.

Geotextiles are permeable "fabrics" which are generally used to provide separation of dissimilar soil types or to act as filters between two soils. They also provide a protective bedding layer for geomembrane installations. Generally, geotextiles are placed above and below a geomembrane in a cap to prevent damage to the synthetic membrane.

Because of the problems associated with ultraviolet degradation and durability of PVC membranes, the PVC membranes will be covered with a protective soil layer as part of the capping system. The soil cover also supports vegetation which provides protection against erosion.

3.3.1 OPTION 4 - Claymax® Cap

This option, shown in Figure 4, involves the placement of Claymax above the contaminated soils as an impermeable barrier layer in place of the PVC geomembrane. Claymax is an impermeable geosynthetic which is made by compressing dry bentonite clay between two geotextile fabrics. The total thickness of the geosynthetic is less than 1/4 inch. The bentonite clay becomes hydrated when wet and creates a barrier layer which has a permeability less than 2×10^{-10} cm/sec. The advantage of the Claymax product over the PVC membrane is that the Claymax material is self-healing when punctured.

FIGURE 4

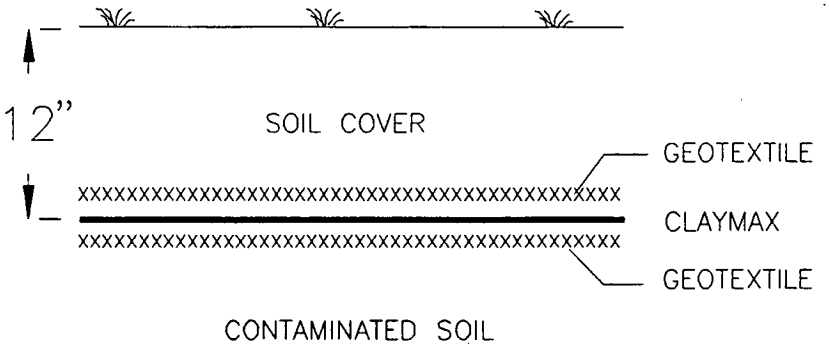

FIGURE 4
CLAYMAX CAP

Like OPTION 3, twelve inches of vegetative supportive soil will be provided to protect the Claymax barrier.

3.4 OPTION 5 - Crushed Stone and Clay Cap Combined

This cap alternative, shown in Figure 5, involves a combination of the crushed stone cap and the impermeable clay cap alternatives with the geosynthetic cap alternative. The geocomposite cap profile would consist of a 12-inch layer of compacted clay and a 12-inche layer of crushed stone. A heavy needlepunched geotextile would be placed above and below the clay layer to provide separation between the materials and prevent intrusion of the clay into both the crushed stone and the contaminated soils. The clay would serve as the hydraulic barrier layer and the crushed stone would provide the protective layer.

3.4.1 OPTION 6 - Crushed Stone and Claymax Combined

This capping option, shown in Figure 6, involves a combination of the crushed stone cap and the Claymax cap. The geocomposite cap profile would consist of a layer of Claymax and 12 inches of crushed stone. A heavy needlepunched geotextile would be placed above and below the Claymax layer for protection. The Claymax would serve as the hydraulic barrier layer and the crushed stone would provide the protective layer.

3.5 OPTION 7 - Full Asphalt Cap

This option, shown in Figure 7, consists of construction of an asphalt cap overtop the contaminated soils in the entire unpaved portions of the DRMO yard. The asphalt will be 6 inches in thickness and will be constructed overtop 12 inches of crushed stone base material. A heavy needlepunched geotextile will be placed between the stone and the contaminated soils.

FIGURE 5

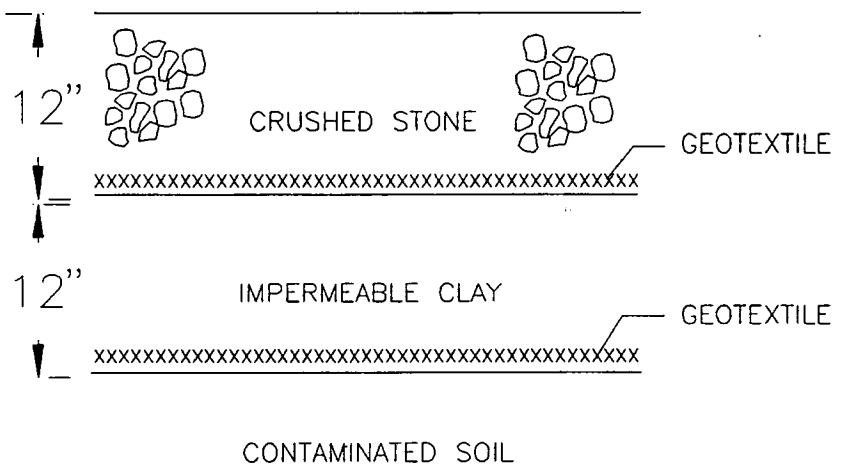

FIGURE 5
CRUSHED STONE AND CLAY CAP

FIGURE 6

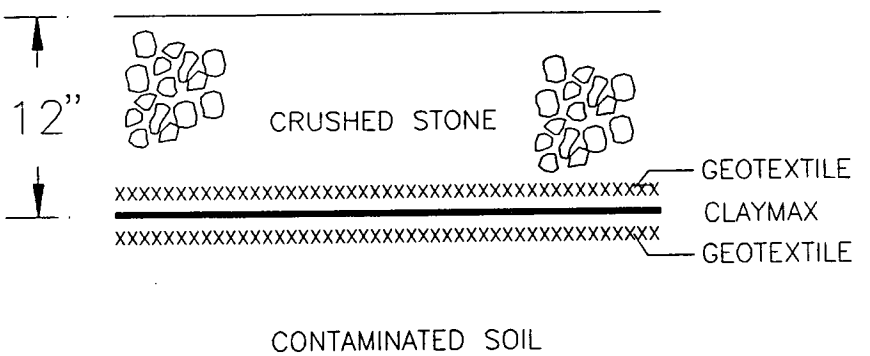

FIGURE 6
CRUSHED STONE AND CLAYMAX

FIGURE 7

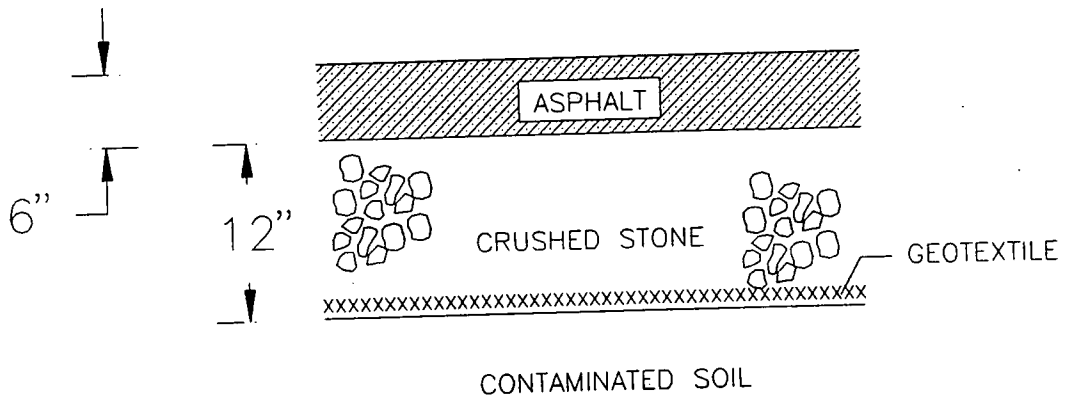

FIGURE 7
ASPHALT CAP

Asphalt is made up of bitumen, which refers to a group of amorphous, colloidal, sticky substances composed principally of complex, high- molecular weight hydrocarbons. Asphalts exhibit strong adhesive and water-repellant characteristics, so that they can be used effectively as cementitious binders or as water-repellent membranes. The most common forms of asphalt used for capping barriers at hazardous waste sites are: (1) hot-sprayed asphalt/tar membranes; (2) asphalt emulsions; (3) reinforced, sprayed asphalt membranes; (4) asphaltic concrete; and (5) prefabricated asphalt lining.

The first form of asphalt is hot-sprayed asphalt membrane, which consists of a relatively tough, high viscosity, high-softening-point asphalt or tar. It usually does not contain any filler or aggregate materials. The asphalt utilized for this application must be ductile enough to conform to the irregularities of the base material and to resist cracking during the asphalt's service lifetime. In addition, it must be strong enough to withstand the stresses imposed upon it. Sprayed asphalt is typically applied to the soil surface using an asphalt distributor. The distributor applies asphalt at an approximate rate of 0.25 gallons per square yard to provide a membrane thickness of 0.04 inches. This cap is not proposed for the DRMO site because it does not posses the durability that is necessary from the cap in the DRMO.

A reinforced, sprayed asphalt membrane consists of a reinforcement material (typically a geotextile membrane), which is placed on the ground surface and sprayed with asphalt cement. This also is not proposed since it does not posses the needed durability.

The fourth type of asphalt used for capping barrier systems is asphaltic concrete. Asphaltic concrete consists of hot asphalt cement and well-graded high-quality aggregate which are compacted to form a uniform, dense mass. The type of asphaltic concrete which would be used a cap would be similar to that used for highway surface courses, but would contain a higher percentage of mineral filler and asphalt cement to increase the water-resistance of the material. This is the type of material which is proposed for the DRMO cap. The asphaltic concrete is necessary to support the traffic and crane operation in the yard.

3.6 OPTION 8 - Full Concrete Cap

This option, shown in Figure 8, involves construction of a six (6) inch reinforced concrete cap at the DRMO site. Six inches of reinforced concrete will be placed above 12 inches of a crushed stone base. A heavy needlepunched geotextile will be placed between the stone and the contaminated soils to provide separation.

Concrete consists of proportions of cement, sand and coarse aggregate which are mixed according to mass. The desired mixture for the concrete cap would be based on the intended the structural loadings of the crane and other operating equipment in the yard. Portland cement concrete is typically used as structural material. A reinforced concrete cap would consist of normal portland concrete with steel rebar to increase its structural integrity. The concrete will be placed above 6 inches of compacted crushed stone base material.

3.7 OPTION 9 - Partial Asphalt Cap and Concrete Cap Combined

This option involves constructing an asphalt cap of the type described in OPTION 7 in the lightly trafficked areas of the DRMO yard. A concrete cap of the type described in OPTION 8 will be constructed in areas of the site where the crane operates.

FIGURE 8

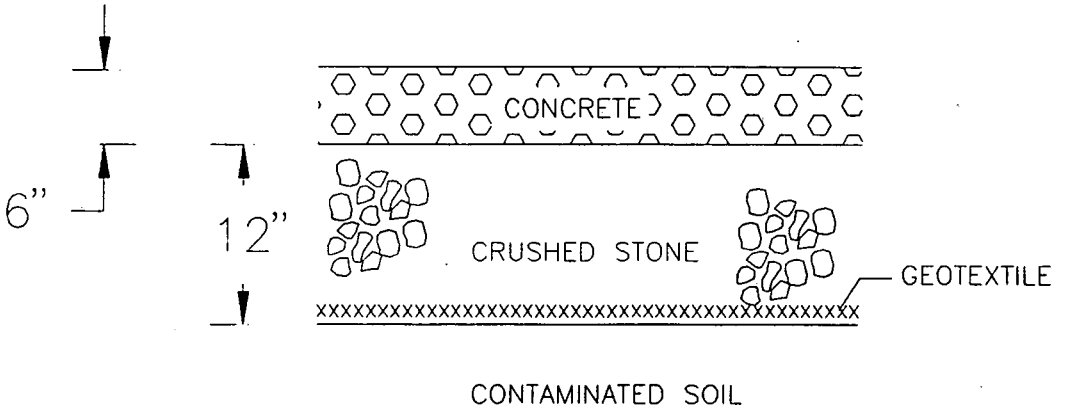

FIGURE 8
CONCRETE CAP

SECTION 5.0 EVALUATION OF CAPPING ALTERNATIVES

The capping alternatives presented in Section 4 will be further evaluated based on their individual advantages and disadvantages as they apply to site-specific conditions and considerations. In addition, a general present worth cost estimate to implement each of the capping methods will be provided for purposes of comparative analysis. The capping alternatives presented in Section 4 are intended specifically for the unpaved area of the DRMO yard where the surface now consists of mostly gravel and debris.

Table 1 presents the cost estimates for each of the capping options which are evaluated in the following sections. All unit costs include both material and labor costs. These unit costs were obtained from various sources such as Means Cost Data and current experience on other related projects.

Quantity estimates for capping areas were made based on the recent survey and investigation of the site performed on September 9 through September 11, 1992. A copy of the site map prepared by Civil Consultants is included as Attachment A. This site map delineates the area where capping is anticipated. By capping or paving the delineated areas the entire site will be "sealed" with a combination of asphalt paving and the selected capping alternative for the scrap yard.

The cost estimates do not include any costs for the disposal of contaminated materials from the DRMO area. It is the intention that this project involve only regrading of the contaminated soils. Each option also contains the cost for constructing curbing along parts of the perimeter of the yard, rehabilitation of the storm inlets and sewers, construction of a small retaining wall at the northern section of the yard, and paving of an approximately 11,000 square foot unpaved area near the site entrance. These activities are proposed as part of the interim corrective activities independent of the specific type of capping system that is implemented in the yard. The recommendation to pave the unpaved area near the entrance with asphalt is based on the fact that

the asphalt can be laid directly atop the surface and can be "feathered" to match the grades of the adjacent existing paving. Excavation of soils in this area is not proposed.

5.1 OPTION 1 - Semi-Permeable Crushed Stone Cap

5.1.1 Advantages

The major advantage to a crushed stone cap is the constructability and availability of the materials used in this type of cap. Most importantly, however is the fact that it is consistent with the operations conducted in the yard. The crushed stone when choked with fines and cement dust will provide a very hard durable surface for operating heavy equipment such as front end loaders and cranes. Scraping of materials from the surface using a front end loader can be accomplished without causing significant damage to the cap. In the event the cap is damaged slightly, it can be repaired relatively easily.

The cap will not be impermeable, but should posses a very low permeability once choked with fines and cement dust minimizing the amount of infiltration into the subsurface. The cap would provide excellent prevention of direct contact with the contaminated soils. Also, surface erosion of the cap would be minimal since the stone surface is very erosion resistant. Another benefit with this cap is that it is only semi-permanent and can easily be removed if EPA requires intrusive remediation actions as part of the final corrective measures at the site. In addition, the capital costs associated with this alternative are relatively inexpensive, the second lowest cost alternative of the seven (7) caps evaluated herein.

5.1.2 Disadvantages

The major disadvantage to this type of cap is that it only minimizes infiltration but does not prevent it. There is no impermeable component to this cap system.

5.1.3 Cost

The capital costs associated with this capping alternative are relatively low when compared to the other alternatives. The estimated capital cost of installing this cap is approximately $280,900. There is only one capping alternative less expensive.

5.2 Option 2 - Impermeable Clay Cap

5.2.1 Advantages

The clay cap alternative would provide a more impermeable cap than OPTION 1. The construction methods used to install a clay cap are similar to those for a soil cover and are currently available for commercial use at the site.

5.2.2 Disadvantages

The disadvantage with this option is that it does posses the surface durability to protect the cap from damage due to equipment operation and is therefore not a valid option for capping of the DRMO. This option is not valid for this site unless operation of the yard is ceased and the yard is permanently closed.

5.2.3 Cost

The cost of this alternative is $382,700.

5.3 OPTION 3- Geosynthetic Cap

5.3.1 Advantages

A significant advantage to the geosynthetic cap is the relatively inexpensive upfront costs. The geotextile cap has the lowest capital cost of the seven (7) alternatives evaluated for use at the site. In addition, the geotextile membranes used for capping systems are impermeable and relatively easy to install. The geotextile membranes provide good surface water and erosion control. The geomembrane sheeting used in the field is produced in a quality controlled factory environment.

5.3.2 Disadvantages

A geomembrane cap will not provide the structural stability needed for the intended use of the site. The traffic and use of the hydraulic crane at the DRMO site will tear and rip the geotextile membrane, which will result in frequent repairs and replacement of geotextile sheeting. This will significantly increase the cost of this alternative over the long term.

5.3.3 Cost

The cost of this alternative is $272,200. This is the cheapest capping option, but this option is not valid for this site unless operation of the yard is ceased and the yard is permanently closed.

5.4 OPTION 4 - Claymax® Cap

5.4.1 Advantages

The advantages of this option are the same as those of OPTION 3 with the additional benefit of the self-healing properties of the Claymax.

5.4.2 Disadvantages

The disadvatanges of this option are the same as those of OPTION 3.

5.4.3 Cost

The cost of this alternative is $288,500. Like OPTION 3, the costs of this option are relatively low compared to the other alternatives, however, this option is not a valid option unless the yard is permanently closed.

5.5 OPTION 5 - Crushed Stone and Clay Cap Combined

5.5.1 Advantages

The advantages to this capping alternative is that it provides the durability the OPTION 1 cap while providing the impermeability of the OPTION 2 cap. Crushed stone will provide a structurally sound surface coarse to support the current operations conducted at the DRMO site and the clay will act as a hydraulic barrier. In addition, this cap would most likely be more agreeable to EPA as a final corrective measure cap because of the addition of the hydraulic barrier layer

5.5.2 Disadvantages

The major disadvantage to this capping alternative is the cost; it is the most expensive cap alternative evaluated for the site. This is due to the additive combined costs of a crushed stone cap and a clay cap. Another disadvantage is that the cap thickness is a total of 24 inches. This will require more grading of the area than some of the other options.

5.5.3 Cost

The estimated capital cost for this option is approximately $ 429,300.

5.6 OPTION 6 - Crushed Stone and Claymax Combined

5.6.1 Advantages

This cap contains all the advantages of OPTION 5 but a lower cost. In addition, by using the Claymax as a substitute for the clay layer, the total thickness of the cap is kept at approximately 12 inches which will allow more grading flexibility of the area. Also, the Claymax liner is proposed in place of a geomembrane since the Claymax has self- healing properties which the geomembrane does not have. Since the Claymax will be placed at a depth of 12 inches it is possible that the liner material could be subjected to stresses which could damage it. The Claymax material is more tolerant of such conditions.

5.6.2 Disadvantages

This option is essentially the same as OPTION 1, but with the addition of an impermeable layer component. There are no significant technical disadvantages with this option.

5.6.3 Cost

The estimated capital cost for this option is approximately $ 335,100.

5.7 OPTION 7 - Full Asphalt Cap

5.7.1 Advantages

The major advantages of asphalt caps are the impermeability to infiltration, and the control of surface water runoff and soil erosion. In addition, a major site-specific advantage is the structurally stability of an asphalt cap to sustain the most of the loads due to current operations conducted in the DRMO. Asphalt provides a better resistance to attack from plant roots and burrowing animals than the crushed stone cap. It is also aesthetically appropriate for the site setting and intended site uses. An asphalt cap will require less maintenance and repairs than the soil, clay, geotextile, geocomposite or soil-cement cap alternatives.

5.7.2 Disadvantages

One major disadvantage to this alternative is the estimate capital cost. Only one other cap alternative had a higher estimated capital cost when compared to an asphalt cap. In addition, the asphalt can be damaged by the cleats of the crane during its operation. The problem is particularly magnified on hot summer days. Also, asphalt requires specialized heating, storing, and construction equipment. Asphalt caps are vulnerable to cracking during cold weather installation and is a relatively stiffer material with regard to subsidence. Also, the concrete is a more permanent type cap most of the other options and would be the most costly to remove if it were not to be considered a permanent remedial measure by EPA.

5.7.3 Cost

The estimated capital cost to install an asphalt cap is approximately $ 525,000.

5.8 OPTION 8 - Full Concrete Cap

5.8.1 Advantages

A concrete cap can be constructed using easily accessible materials and equipment. It will also provide the structural integrity needed to support the hydraulic crane and potential truck traffic in the DRMO area. Concrete provides a means of adequate surface runoff and erosion control. In addition, concrete provides a sufficient hydraulic barrier to infiltration.

5.8.2 Disadvantages

Concrete capping is costly. Concrete is susceptible to cracking and leaking at the construction joints, especially in climates with varying temperatures. The concrete cap will be dependent on a stable substrate, which will require substantial site preparation and grading. Also, the concrete is a more permanent type cap most of the other options and would be the most costly to remove if it were not to be considered a permanent remedial measure by EPA.

5.8.3 Cost

The concrete cap alternative has been estimated to cost approximately $642,900. This is the highest capping option cost evaluated.

5.9 OPTION 9 - Partial Asphalt Cap and Concrete Cap Combined

5.9.1 Advantages

The advantage of this option is that it is less costly than the Full Concrete cap option but provides a cap which will not be damaged by operation of the crane.

5.9.2 Disadvantages

The disadvantages of this option are the same as those of OPTION 7 and OPTION 8 with the exception that the asphalt damage susceptibility is addressed by the addition of concrete areas.

5.9.3 Cost

The estimated capital cost to install a partial asphalt cap and partial concrete cap is approximately $ 584,000. The cost estimate assumes that approximately half of the area will be paved with asphalt and half will be paved with concrete.

NAVFAC PORTSMOUTH NAVAL SHIPYARD
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

TABLE 1

CAPPING OPTION 1:
SEMI-PERMEABLE CRUSHED STONE CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
GEOTEXTILE	5,425	S.Y.	$2.00	$10,900
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 1				$280,900

CAPPING OPTION 2:
CLAY CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CLAY MATERIAL	3,620	C.Y.	$30.00	$108,600
CLAY PLACEMENT AND COMPACTION	3,620	C.Y.	$8.00	$29,000
GEOTEXTILE	10,850	S.Y.	$2.00	$21,700
SOIL COVER (12")	3,620	C.Y.	$15.00	$54,300
SOIL COVER (12") PLACEMENT	3,620	C.Y.	$3.00	$10,900
VEGETATION	5,425	S.Y.	$0.75	$4,100
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 2				$382,700

Notes:
C.Y.-Cubic Yards
EA-Each
L.F.-Linear Feet
S.Y.-Square Yards

NAVFAC PORTSMOUTH NAVAL SHIPYARD TABLE 1 (cont'd)
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

CAPPING OPTION 3:
GEOSYNTHETIC CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
PVC GEOMEMBRANE	5,425	S.Y.	$5.00	$27,100
GEOTEXTILE	10,850	S.Y.	$2.00	$21,700
SOIL COVER (12")	3,620	C.Y.	$15.00	$54,300
SOIL COVER (12") PLACEMENT	3,620	C.Y.	$3.00	$10,900
VEGETATION	5,425	S.Y.	$0.75	$4,100
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 3				$272,200

CAPPING OPTION 4:
CLAYMAX CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CLAYMAX	5,425	S.Y.	$8.00	$43,400
GEOTEXTILE	10,850	S.Y.	$2.00	$21,700
SOIL COVER (12")	3,620	C.Y.	$15.00	$54,300
SOIL COVER (12") PLACEMENT	3,620	C.Y.	$3.00	$10,900
VEGETATION	5,425	S.Y.	$0.75	$4,100
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 4				$288,500

Notes:
C.Y.-Cubic Yards
EA-Each
L.F.-Linear Feet
S.Y.-Square Yards

NAVFAC PORTSMOUTH NAVAL SHIPYARD TABLE 1 (cont'd)
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

CAPPING OPTION 5:
CRUSHED STONE AND CLAY CAP COMBINED

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
CLAY MATERIAL	3,620	C.Y.	$30.00	$108,600
CLAY PLACEMENT AND COMPACTION	3,620	C.Y.	$8.00	$29,000
GEOTEXTILE	10,850	S.Y.	$2.00	$21,700
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 5				$429,300

CAPPING OPTION 6:
CRUSHED STONE AND CLAYMAX COMBINED

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
CLAYMAX	5,425	S.Y.	$8.00	$43,400
GEOTEXTILE	10,850	S.Y.	$2.00	$21,700
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 6				$335,100

Notes:
C.Y.-Cubic Yards
EA-Each
L.F.-Linear Feet
S.Y.-Square Yards

NAVFAC PORTSMOUTH NAVAL SHIPYARD TABLE 1 (cont'd)
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

CAPPING OPTION 7:
FULL ASPHALT CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
ASPHALT (6")	5,425	S.Y.	$45.00	$244,100
GEOTEXTILE	5,425	S.Y.	$2.00	$10,900
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 7				$525,000

CAPPING OPTION 8:
FULL CONCRETE CAP

COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
CONCRETE (6")	3,620	C.Y.	$100.00	$362,000
GEOTEXTILE	5,425	S.Y.	$2.00	$10,900
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 8				$642,900

Notes:
C.Y.-Cubic Yards
EA-Each
L.F.-Linear Feet
S.Y.-Square Yards

NAVFAC PORTSMOUTH NAVAL SHIPYARD TABLE 1 (cont'd)
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

CAPPING OPTION 9: PARTIAL ASPHALT AND CONCRETE CAP COMBINED				
COST ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
MOBILIZATION/DEMOBILIZATION	1	LUMP	$5,000	$5,000
SITE PREPARATION, GRADING	5,425	S.Y.	$6.50	$35,300
CRUSHED STONE MATERIAL	3,620	C.Y.	$28.00	$101,400
CRUSHED STONE PLACEMENT AND COMPACTION	3,620	C.Y.	$4.00	$14,500
ASPHALT (6")	2,713	S.Y.	$45.00	$122,100
CONCRETE (6")	1,810	C.Y.	$100.00	$181,000
GEOTEXTILE	5,425	S.Y.	$2.00	$10,900
CURBING	1,000	L.F.	$15.00	$15,000
STORM WATER INLETS	5	EA.	$5,000	$25,000
RETAINING WALL	150	L.F.	$200	$30,000
PAVE GRAVEL AREA AT ENTRY	1,250	S.Y.	$35.00	$43,800
TOTAL CAPITAL COST OPTION 9				$584,000

Notes:
C.Y.-Cubic Yards
EA-Each
L.F.-Linear Feet
S.Y.-Square Yards

5.10 Summary of Evaluation of Capping Costs

Table 2 presents a summary of the costs of each of the options which were evaluated. The costs range from a low of $272,200 to a high of $642,900. As expected the concrete cap option was the highest priced option. OPTION 3 was the cheapest option but is not really a viable capping option unless the Navy plans to permanently close the yard. OPTION 4, which is another of the relatively lower cost options is also not a viable option for the same reason. OPTION 1 is the second cheapest option, but unlike OPTION 3 and OPTION 4 which are not viable alternatives, a strong argument can be made for the implementation of the OPTION 1 cap. OPTION 5 is a mid-ranged cost of the alternatives evaluated and is a very technically viable option. OPTION 6, also another very technically valid option is only $54,200 more than the lowest viable option evaluated. OPTION 7, the full asphalt cap is the third most costly option at $525,000; and OPTION 9, the partial asphalt and concrete option is the second most costly option at $584,000.

NAVFAC PORTSMOUTH NAVAL SHIPYARD
INTERIM CORRECTIVE MEASURES
COST ESTIMATES FOR CAPPING ALTERNATIVES

TABLE 2

CAPPING OPTION 1: SEMI-PERMEABLE CRUSHED STONE CAP	$280,900
CAPPING OPTION 2: CLAY CAP	$382,700
CAPPING OPTION 3: GEOSYNTHETIC CAP	$272,200
CAPPING OPTION 4: CLAYMAX CAP	$288,500
CAPPING OPTION 5: CRUSHED STONE AND CLAY CAP COMBINED	$429,300
CAPPING OPTION 6: CRUSHED STONE AND CLAYMAX COMBINED	$335,100
CAPPING OPTION 7: FULL ASPHALT CAP	$525,000
CAPPING OPTION 8: FULL CONCRETE CAP	$642,900
CAPPING OPTION 9: PARTIAL ASPHALT AND CONCRETE CAP COMBINED	$584,000

SECTION 6 SELECTION OF CAPPING CONCEPT

6.1 Recommended Design Concept

Based on the technical evaluation of the capping options, the cost of each option, and the regulatory status of this project, McLaren/Hart recommends that the Navy implement the OPTION 6 - Crushed Stone and Claymax Combined. McLaren/Hart makes this recommendation for the following reasons:

- The cap meets all RCRA cap performance requirements. This is a desirable feature given that this interim corrective measure may become the, or part of the, final corrective measure for this site.

- The cost of this option is $335,100. This cost is only $54,200 more than the cheapest viable capping for the site, provided the Navy continues operations in the yard. OPTION 1, the crushed stone cap option cost is estimated to be $280,900, however, OPTION 1 does not contain an impermeable layer component in its profile. A strong argument could be made that an impermeable component is not necessary for the cap of the DRMO since the contaminated soils are located mostly below the groundwater and prevention of infiltration is not really the primary function of the DRMO cap. However, we feel it is advantageous to include an impermeable component for only an additional cost of $54,200. It is particularly prudent to add this layer since it may be likely that EPA will require capping as the final remedial measure at this site. It has been our experience that EPA generally is more favorable to approving capping systems which contain an impermeable component than those that do not.

- The recommended cap can be easily excavated should EPA require some other final remedial corrective measure other than capping. Also, the recommended

cap can be upgraded should EPA require or if the operations of the yard demand. For example, should EPA require a more " permanent" type surface, the crushed stone could always be paved at a later date. Or, if during yard operations, it is noted that a particular area gets heavy activity which causes damage to the surface of the cap, this area could be repaired with crushed stone as part of routine maintenance, or, it if the Navy desires, these heavy trafficked areas could be paved on an as identified basis.

- The asphalt and concrete paving options are permanent options which would be costly to remove should EPA require sub-cap intrusive activities as part of the final corrective measures at this site. As discussed above, should EPA not require such activities, but the Navy require a more durable surface of the cap because of its operations in the yard, the resurfacing could be done at a later date.

ATTACHMENT A

SITE MAP OF DRMO

PREPARED SEPTEMBER, 1992