WASTE→ENERGY
TECHNOLOGY CORPORATION

Carolina Coastal Zone Mgmt Program

A Study for the Disposal of Fossil-Fuel-Contaminated Materials

Prepared for

CHARLESTON COUNTY
Charleston, South Carolina

AUGUST 1982

ENERGY SYSTEMS
WASTE PROCESSING SYSTEMS
CONSULTING & TECHNICAL SERVICES

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1.0 EXECUTIVE SUMMARY

o PROGRAM BACKGROUND

In December of 1980, Charleston County submitted a request for funding to conduct a study of disposal methods available for fossil fuel contaminated materials generated in the Charleston area, specifically Charleston Harbor. County officials were concerned that increased energy related activities associated with the transport, transfer, storage and processing of fossil fuels in the area would increase the probability of oil spills and consequently the amount of fossil fuel contamninated materials requiring clean-up and ultimately disposal.

The County was interested in evaluating the various disposal and transfer techniques available and determining the most cost effective method for disposal of fossil fuel contaminated materials. The County was also interested in evaluating the effect of cronic fossil fuel pollution on it's area beaches, estuaries, marshland and waters, as Charleston's tourist/resort and fishing industries are very important to their economy. Funding was made available through Coastal Energy Impact Program (CEIP) grant 308B monies, and in February of 1982, Charleston County retained the services of Waste Energy Technology Corporation [WETCO] and its sub-contractor, Energy Resources Company [ERCO] to conduct the study.

o SPILL RESPONSE PROTOCOL

Pursuant to the Federal Clean Water Act of 1977 (PL 95-217), and Section 48-43-550 of the South Carolina Code of Laws, 1976 (S.C. Oil and Gas Act), contingency plans for oil and hazardous material spills have been developed. The objective of these plans are to provide for efficient, coordinated action to minimize damage from oil and hazardous material discharges, including containment, clean-up and disposal. These plans are intended to provide for:

1. Establishment of a simple, effective procedure for reporting spills.

2. A procedure to designate individuals who have responsibility to alert and coordinate manpower, equipment and material resources and to supervise the control, containment and clean-up of spills.

3. Procedures for reimbursement of reasonable costs incurred in the containment, clean-up and disposal of such discharge by the spiller.

Such plans include an inventory of oil spill equipment and it's location, identification of each person responsible for implementing each phase of the plan, and a designation of priority zones to determine the sequence and methods of clean-up.

o SPILL RESPONSE CAPABILITY

Oil spill equipment in the Charleston area is considered adequate for responding to spills up to 500 - 1000 gallons each. Spills larger than this generally require the assistance of private contractors located outside the State. Most spill response contractors are able to respond to a spill within 24 hours.

Under normal circumstances, spills up to 300 gallons can be effectively responded too by local contractors.

o DISPOSAL OF FOSSIL-FUEL-CONTAMINATED MATERIALS

The disposal methods employed to date have principally included co-disposal with municipal solid waste and burial at a secured landfill. Co-disposal is conducted at existing sanitary landfills where the oil-spill debris is incorporated into the solid waste received, using traditional disposal techniques. This mixing action increases the chance for any oil or water to be absorbed and thereby impedes possible leachate migration.

Small quantities of non-contaminated oil-spill debris may be disposed of at Charleston County Sanitary Landfills, while large quantities of debris which contain more than one hundred (100) gallons of virgin oil are generally disposed of at the Dorchester and/or Berkley County Sanitary Landfills. Oil-spill debris which contains contaminated oils (e.g., heavy metal) must be disposed of at a secure landfill. A secured landfill is specifically designed for hazardous wastes. The closest secured landfill is located in Sumter County (Pinewood, South Carolina) approximately 90 miles one way.

The evaluation of current disposal methods would indicate that the state regulatory agency responsible for disposal of fossil fuel contaminated materials (DHEC Bureau of Solid and

Hazardous Waste Management), exercises good engineering judgement and that which is consistent with existing state and federal regulations.

The evaluation of alternative disposal methods available to Charleston County with respect to: technical feasibility, economics, and compatibility with existing state and federal regulations, indicate that existing disposal practices are adequate. DHEC makes effective use of existing operating facilities. Developing a secondary site to accomodate only fossil fuel contaminated materials would not be justified based on the quantity of material generated in the Charleston area. However, if the County were to experience a marked increase in the magnitude and/or frequency of spills in the Charleston area, consideration should be given to either landspreading or local incineration as a long-term disposal option.

- SPILL RESPONSE FINANCING

Experience to date for fossil fuel related spills which occur within the navigable waters of Charleston County, has demonstrated that the cost recovery mechanisms available to the public and private sector for reimbursement of costs incurred in the conduct of containment, clean-up, disposal and restoration/replacement activities associated with these spills, are adequate.

2.0 INTRODUCTION

Charleston County has traditionally accounted for the greatest number of spills within the state. The main oil and hazardous substance storage and transfer facilities are located in Charleston as well as a large number of recreational boats. However, to put these facts in the proper perspective, the quantity of materials involved in these spills have been relatively small in comparison to other states (less than 100 gallons). This distinction may be attributed to the unique characteristics of Charleston Harbor. Unlike other major seaports which may have numerous vessels a short distance from shore (2 miles), Charleton's shipping lanes originated approximately 8 miles offshore, thereby reducing traffic and consequently potential for collisions in and around the harbor.

The majority of spills which occur in the Charleston area are generally restricted to storage and transfer facilities which are located principally on the western shore of the Cooper River. Available data indicates that twenty-six (26) spills have occured in the harbor since 1980, not counting spills resulting from pleasure boats or spills which may have occurred at the Navy Shipyard. The materials most frequently spilled are diesel, diesel mixtures, #6 oil, #6 oil mixtures and waste oil. Additionally, the size of these spills have generally been less than 100 gallons.

Section 3.0, "Potential Problems Associated With Fossil-Fuel-Contaminated Materials" presents information on the type and quantity of petroleum based products transported through the Charleston Harbor and identifies the location of principal oil transfer, storage, and/or processing facilities thereof. This section also provides a discussion of the ecological systems found within the Harbor and their environmental sensitivity to potential spills.

The primary emphasis of this report has been on reviewing current disposal methods for fossil fuel contaminated materials employed to date, and on evaluating alternative, environmentally sound, disposal methods which may offer a more cost effective solution.

Section 4.0 identifies current disposal practices and their associated costs. An evaluation of alternate disposal methods available to Charleston County is presented in Section 5.0. Each disposal method is evaluated with respect to technical feasibility, economics, and compatibility with federal and state regulations.

In Section 6.0, regulations which enable state and federal agencies to react to a spill situation and to recover cost incurred in the performance of such activities deemed appropriate are identifed. These activities may include: containment, clean-up, disposal, and restoration/replacement.

3.0 POTENTIAL PROBLEMS ASSOCIATED WITH FOSSIL-FUEL-CONTAMINATED MATERIALS

3.1 INTRODUCTION

To be able to develop viable methods for the disposal of oily wastes that may be recovered from the Charleston Harbor area after an oil spill, various background information is required. This section presents information on the type and amount of petroleum based products transported through Charleston Harbor, and transport routes through and transfer points within the harbor. This information gives an indication of the likelihood of a severe spill, the most likely locations of such a spill, and the likelihood of various materials being spilled. Secondly, information on the ecological systems found within the harbor and their enviromnental sensitivity has been included.

Information which can be used to determine the likely dispersion pattern of spilled oil is provided in Appendix A. This includes tidal current projections and prevailing wind patterns in the harbor area. Also affecting dispersion are the physical and chemical characteristics of the spilled oil. A brief discussion of these factors is also included in Appendix A.

It is not the intent of this project to produce an oil spill contingency plan; indeed, plans have already been formulated for the Charleston Harbor area. However, when planning for the disposal of oily wastes it should be realized that different ecological systems (eg. marsh or rocky beach) require that different disposal options be employed.

3.2 PETROLEUM PRODUCT TRANSPORT AND TRANSFER OPERATIONS

From the Army Corps of Engineers publication Waterborne Commerce of the United States [1], information on the type and quantities of petroleum products transported through Charleston Harbor have been compiled. Table 3-1 lists quantities of petroleum products passing through the harbor in the year 1979 (the most recent year for which these statistics have been compiled) and Table 3-2 lists the type and draft of the vessels entering and leaving Charleston Harbor.

Approximately 1.5 million tons of gasoline and close to 2.5 million tons of residual fuel oil were transported through the Charleston Harbor in 1979. These two products make up the largest quantity of petroleum related products passing through the harbor. Also transported through the harbor in significant quantities is distillate fuel oil (0.6 million tons in 1979). These three materials, because they are transported in such large quantities, are the most likely to be spilled; and, because they are primarily transported by tankers, they are also the most likely to spill in a large volume.

The sites of the greatest danger of an oil spill are the various cargo transfer points within Charleston Harbor. The Captain of the Port, Charleston Pollution Contingency Plan prepared by the U.S. Coast Guard, has identified 18 oil transfer, storage, and/or processing facilities located on the Harbor. The location of these facilities are identified on Figure 3-1. From the map it is clear that the location of greatest danger of a spill occurring during transfer operations is on the west bank of the Cooper River in the North Charleston area, some 6 miles up river from the city of Charleston. The river is quite narrow is this area so any large spill would quickly spread along both the east and west shorelines. The east bank of the river across from North Charleston is primarily marsh land and is thus very vulnerable to damage by an oil spill. Tidal currents are strong enough

Table 3-1 Transport of petroleum-related products through Charleston Harbor, South Carolina (Freight Traffic, 1979)

PETROLEUM PRODUCT	TOTAL (SHORT TONS)
crude, tar, oil, and gas	249
gasoline	1,463,812
jet fuel	335,013
kerosene	25,980
distillate fuel oil	607,292
residual fuel oil	2,433,280
lubricating oils and greases	276,216
naphtha, petroleum solvents	80,375
asphalt, tar, pitches	210,222
coke, petroleum coke	16,634
liquified gases	28
petroleum and coal products	2,117

Source: Department of the Army, Corps of Engineers, 1979 "Waterborne Commerce of the United States".

Table 3-2 Trips and drafts of vessels in Charleston Harbor, South Carolina, 1979

	INBOUND						OUTBOUND					
	SELF-PROPELLED VESSELS			NON-SELF-PROPELLED VESSELS			SELF-PROPELLED VESSELS			NON-SELF-PROPELLED VESSELS		
DRAFT (FEET)	PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER	TOTAL	PASSENGER AND DRY CARGO	TANKER	TOWBOAT OR TUGBOAT	DRY CARGO	TANKER	TOTAL
38		1				1						
37			8			8			9			9
36	4	3	1		2	10	1		1			2
35	9	37	2		3	51	17	2				19
34	24	12				36	22	3				25
33	27	22				49	48	2				50
32	41	14				55	49	4			1	54
31	52	19				71	66	4			2	72
30	85	16			1	102	91	6			1	98
29	85	15			12	112	110	4			1	115
28	88	22	1	1	8	120	135	7			1	143
27	103	18			3	124	117	11	1	1	3	133
26	110	15	4		9	138	124	15	4		8	151
25	173	14			4	191	129	24			2	155
24	155	17				172	97	28			1	126
23	139	8			8	155	107	18			1	126
22	143	5			6	154	111	26				137
21	109	4			2	115	124	13				137
20	86	4	1		5	96	87	15	1		2	105
19	48	2	3		11	64	70	17	3			90
18 and less	5,497	11	437	368	629	6,942	5,484	52	439	391	690	7,056
TOTAL	6,978	259	457	369	703	8,766	6,989	251	458	392	713	8,803

Source: Department of the Army, Corps of Engineers, 1979
"Waterborne Commerce of the United States".

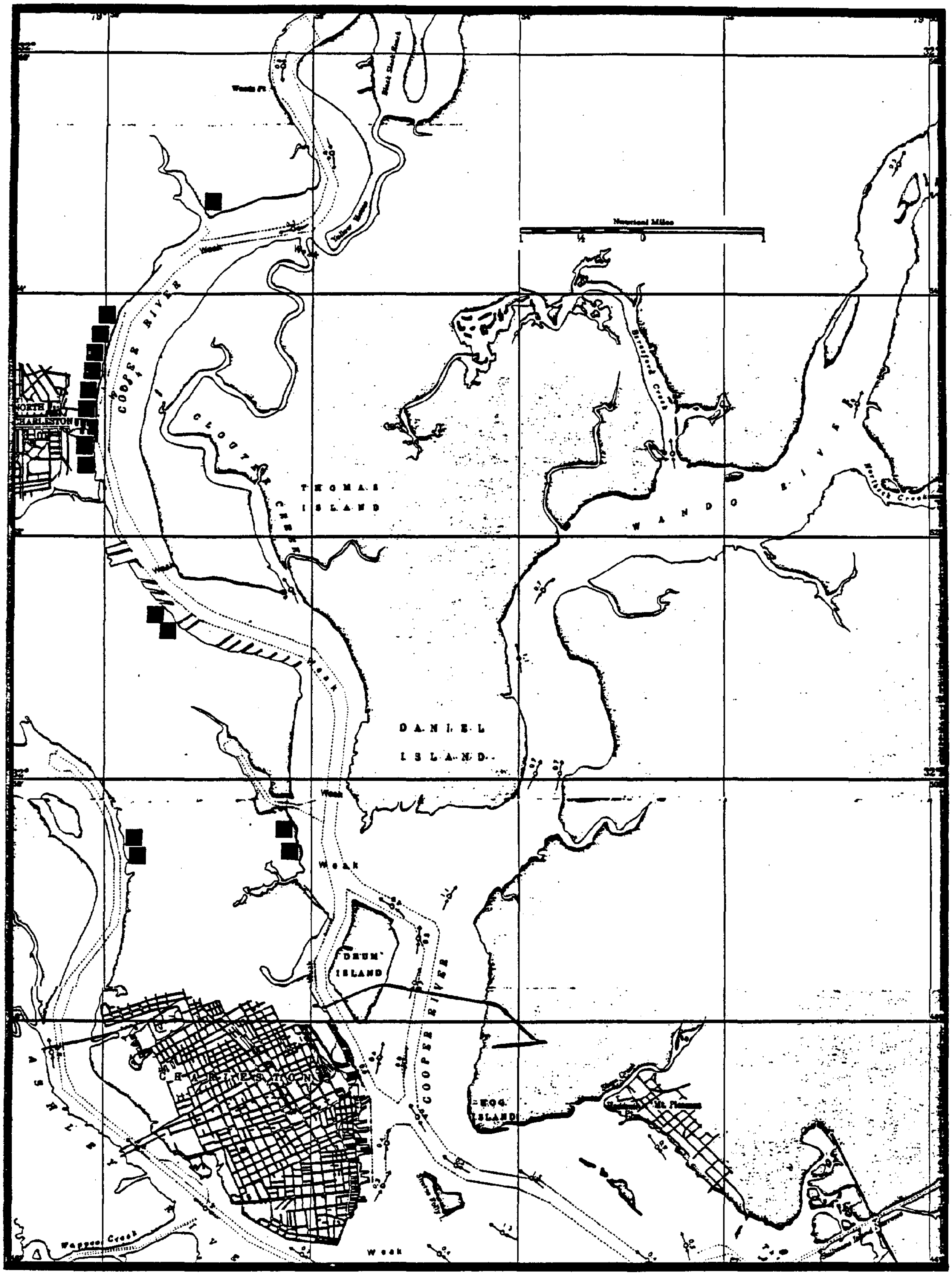


Figure 3-1 Petroleum Transfer, Storage, and Processing Facilities on Charleston Harbor, South Carolina (Map does not show 2 facilities which are north of Woods Point on the Cooper River).

to reverse the river flow several miles further up-stream than North Charleston so the north/south flow of the spilled oil would be dependent on the tidal cycle as well as the prevailing wind direction.

Shipping lanes through the harbor are marked on the Coast Guard tidal charts and on Figure 3-1. Because of the narrow width of most of Charleston Harbor and realizing that within harbors most spills take place at points of transfer, knowing exactly where the shipping lanes are is not of great importance.

3.3 ENVIRONMENTAL SENSITIVITY

From a review of the available literature on the nature and type of shipping traffic in Charleston harbor and the physical and environmentl conditions of the harbor and adjacent rivers, the following conclusions can be drawn.

The greatest concentration of shipping traffic carrying petroleum products is through the harbor channels and up the western side of the Cooper River. The transfer terminals along this river run from lower Charleston up to the terminals in North Charleston. From this very heavy concentration of terminals and transfer points and the associated river traffic, it can be assumed that the probability of a spill of petroleum products taking place is greater along the Cooper than in any other part of the harbor.

In preparing for the clean up and disposal of oil products from such a spill, the physical and environmental factors must be considered. If a spill occurred during ebb tide or during periods of heavy rain and heavy outflow of the Cooper and Wando Rivers, then clean-up activity will be concentrated down river of the spill. If on the other hand an accident occurred during slack or flood tide, especially during periods of spring tides (new moon and full moon), the movement of oil may be up river of the spill. This same phenomenon might occur during periods of low water and slow discharge of both rivers.

In addition to the tidal flow and height of the river, the velocity and direction of the wind must be taken into account before an assessment of the potential damage can be made. During the spring and summer the major wind roses are in a SW direction, thus moving floating petroleum products out of the river and into the lower portions of Charleston and James Island. The general prevailing wind pattern during fall and winter would be in the northerly and/or easterly direction, forcing the spilled material up the Cooper and Wando Rivers.

A careful review of the Environmental Sensitivity Index (ESI) maps for the harbor give an excellent idea of what the potential damage to various environments in the harbor might be. The ESI evolved from a series of indices which were developed to classify the expected vulnerability of the ecological environment to oil spills. Earlier indices were based primarily on physical characteristics and associated response to spills. The ESI incorporates the geomorphic components as well as biological and socioeconomic factors in determining environmental sensitivity. The use of the ESI in mapping has been applied to a variety of coastlines including those of six other states.

The area on the western side of the harbor and up the Cooper River is mostly sheltered coastal structures (ESI No. 8). These would include docks, piers, bulkheads and other man made structures. Generally, these areas have limited marine life, oysters being the dominant species. In the event of a heavy spill, clean up of a floating oil contained within the piers and pilings might be effected with sucton equipment or floating sorbents. The structures themselves might be cleaned with high-pressure spraying or any natural washing of the area.

Greater environmental damage and more costly and damaging clean up efforts will result from contamination of the eastern side of the Cooper river. From the U.S. Naval Reservation across from North Charleston terminals down along Thomas and Daniel Islands, much of the shore line is either sheltered tidal flats and oyster beds (ESI No. 9) or marshes (ESI No. 10). Moderate to heavy oiling of tidal flats and marshes causes severe damage to the epifauna and infauna. The large shore bird population which feed in these areas would be affected by ingestion of contaminated food and general exposure to the oily residues on the beaches.

Cleanup of tidal flats could be effected manually or by mechanical means where the shoreline was accessible to equipment and the contamination was great enough to warrant it. Clean up of the marsh area would be much more difficult due to the fragile nature of the marsh ecosystem and the inability to use machinery. In cases of high oiling, the best practice is to allow the marsh to recover naturally. Heavy contamination may require scrapping the substrate and replanting the primary species.

The lower portion of the harbor would be, in some areas, environmentally less sensitive to an oil spill. Both Drum Island and Shutes Folly Island have exposed riprap which would have to be cleaned by high pressure spraying if the contamination were heavy enough to justify clean up. This would involve the logistical problem of moving men and equipment to the islands. The western shore of the harbor along the Mount Pleasant peninsula, and the southern portion of the harbor, along James Island, both have marshes and oyster beds which would be difficult to clean up. In the case of light oiling, many of these areas would probably be best left to natural decontamination and cleanup.

As previously mentioned, the tidal marshes along the intercoastal waterway behind the barrier islands represent the most sensitive areas. Additionally, the fact that they are sanctuaries for commercially valuable species of both fin and shell fish, makes their protection extremely important. The use of booms and skimmers to prevent the movement of spilled material into these areas is the recommended approach to protection.

4.0 CURRENT DISPOSAL METHODS/COSTS OF FOSSIL-FUEL-CONTAMINATED MATERIALS

4.1 GENERAL

The disposal methods employed to date for fossil fuel contaminated materials generated within Charleston County (primarily oil spill debris), have principally included: co-disposal with municipal solid waste, and burial at secure land-fills. Open burning and recovery have been utilized, but on a limited basis. Disposal of these materials is regulated by the Bureau of Solid and Hazardous Waste Management, S.C. Department of Health and Environmental Control (DHEC). DHEC identifies method(s) available for disposal to those individual(s) responsible for the spill, including any special handling and/or disposal techniques required, and provides supervision to ensure that disposal is conducted in accordance with the recommended procedures. In the past, the quantity of oil spill debris requiring disposal has not been substantial. Available data indicates that twenty-six (26) spills have occured in the Charleston Harbor since 1980, excluding spills which may have occured at the Navy shipyard or from pleasure boats. Additionally, the size of these spills have generally been less than 100 gallons.

4.2 SPILL RESPONSE MECHANISMS

Perhaps the most effective act of legislation available to the County of Charleston and other State and Federal agencies, with respect to responding to emergency oil or other hazardous substance spills which may occur within the Charleston Harbor, is the Federal Clean Water Act of 1977 (P.L. 95-217). This act assures the County that appropriate actions will be implemented to effectively contain and remove the spill from it's waters, and that if public or private assistance is required to conduct these activities, such costs shall be reimbursed. For example, if the individual(s) responsible for the spill is not identified or if said individual(s), in the opinion of the federal administrator, have not responded to the spill in a reasonable manner, then the federal administrator may implement whatever means deemed appropriate (i.e., manpower and/or equipment) for the removal of the oil or hazardous substances discharged and to minimize environmental damage.

In the Charleston area, provisions of the Clean Water Act, in particular, Section 311. "Oil and Hazardous Substance Liability" is administered by the United States Coast Guard. Existing State regulations which are particularily effective regarding the required response to an oil or hazardous substance spill are the S.C. Oil and Gas Act, and the S.C. Pollution Control Act, Article 3. and Chapter 1. of the South Carolina Code of Laws, 1976, respectively. The S.C. Oil and Gas Act was enacted as a means to protect the interests of the State with respect to spills, discharges and escapes of pollutants occurring as a result of procedures in the transfer, storage, and transportation of products which pose a threat of danger and damage to the environment of the State. This Act is not intended to supercede the Federal Clean Water Act, but rather to support and complement it.

The S.C. Pollution Control Act, which was enacted to protect the interest of the State with respect to maintaining reasonable standards of purity of air and water resources, allows for the implementation of whatever action necessary or appropriate to secure for the State the benefits of the Federal Clean Water Act and Federal Clean Air Act. State officials consider the S.C. Pollution Control Act to be more effective in providing statewide jurisdiction over air and water resources.

Provisions of each of these State regulations are administered by the Department of Health and Environmental Control (DHEC).

4.3 SELECTION CRITERIA

There are several State and Federal regulations which pertain to the disposal of fossil fuel contaminated materials in South Carolina. These are:

(1) Regulation Requiring Minimum Standards For Sanitary Landfill Design, Construction and Operation.

(2) Regulation Requiring Minimum Standards for Industrial Solid Waste Disposal.

(3) The South Carolina Hazardous Waste Management Act.

(4) The Resource Conservation and Recovery Act (PL 94-580)

The regulations identified in items 3 and 4, regulate the disposal of fossil fuel contaminated materials in those instances where the material cannot be satisfactorily incorporated into an existing sanitary landfill. The primary considerations in determining if these materials can be incorporated into an existing landfill are: (a) if the material to be disposed of is classified as a hazardous material under the South Carolina Hazardous Waste Act, and (b) that disposal of such material does not pose a threat to the quality of ground water underlying the landfill or adjacent surface water impoundments.

Experience to date with fossil fuel related spills within the navigable waters of Charleston County, have indicated that the material spilled is normally a "virgin" oil (eg. non-contaminated diesel or #6 fuel oil). Where these spills have been cleaned up with sorbents, such as straw, Ekoperl or other commercially available sorbent, the spill debris remaining for disposal will exist in solid bulk form and, under normal circumstances, can be incorporated into an existing sanitary landfill. Fossil fuel contaminated materials which meet this requirement may still be considered unsatisfactory for disposal at sanitary landfills if, in the opinion of DHEC officials, the quantity of waste to be disposed, may contribute to the pollution of the ground water or surface waters. In those instances where the origin of the spill and/or the characteristics of the material spilled is unknown, a complete analysis is performed prior to recommending a disposal method.

Under normal conditions, approval must be obtained from DHEC prior to disposal of any fossil fuel contaminated materials. To avoid unnecessary delays in implementing the disposal process, DHEC must react to a request for disposal within fifteen (15) days. It is important to note, that in spill situations these regulations can be waived if necessary to protect the health and safety of the public, health of living organisms, and the environment. Therefore, the selection of an appropriate disposal method is predicated on good engineering judgement, whereby an effort is made to conform to applicable State and Federal regulation while giving proper consideration to the actual circumstances surrounding the spill.

4.4 CURRENT DISPOSAL TECHNIQUES

Prior to initiating any disposal action for fossil fuel contaminated materials, the local solid waste consultant is contacted. The solid waste consultant acts as a liason between DHEC's district office in Columbia, S.C., and coordinates the disposal effort. The consultant is intimately familiar with the physical characteristic of both public and private operated landfills located within Charleston, Berkeley and Dorchester Counties, and has a working knowledge of existing facility operating practices, i.e. personnel, equipment, etc. After DHEC has determined that disposal of a particular quantity of fossil fuel contaminated materials can be incorporated into a sanitary landfill, the local solid waste consultant is normally called upon to make a recommendation as what landfill(s) should be utilized for disposal. A listing of the local solid waste consultants for each of the State's districts is provided in the S.C. oil and hazardous substance spill contingency plan.

As previously indicated, the disposal method ultimately employed is dependent on the quality and quantity of material requiring disposal, and in addition, is influenced by those circumstances surrounding the spill at a given time. As a result no one disposal method can be stereotyped for a particular spill situation. For example, if a spill of #6 fuel oil were to wash up on a Charleston beach, the type of material which would require disposal would likely be a combination of sand and oil. The quantity of material would depend on to what extent the oil dispersed prior to washing ashore and the method of clean-up. The greater the extent of oil dispersion, the greater the area of beach contaminated by an oil spill. Secondly, the equipment used to remove the contaminated material from the beach area directly affects the disposal quantities. For example, a front- end loader is likely to underscore the contaminated material at a greater depth than a scraper pan.

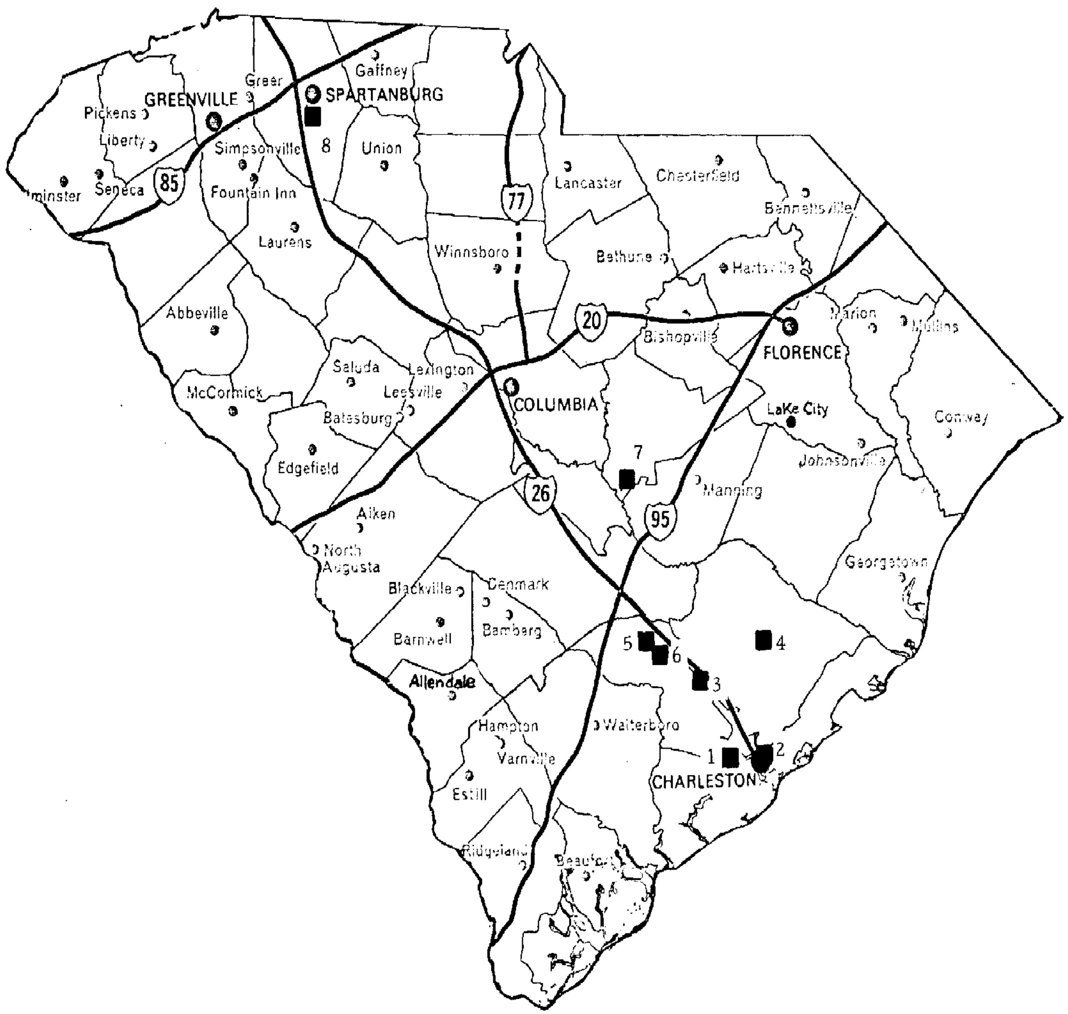
Assuming the oil is virgin oil (eg. had not been contaminated with heavy metals), the material may be suitable for disposal at one of Charleston County's landfills provided, such landfill was in the process of applying a final cover. Existing oil spill debris disposal practice at the County landfills, has been to incorporate the debris with the soil brought in for final cover. This practice is basically a land application technique which relys on microbes present in the soil to consume the oil, and consequently the quantity of oil which can be accommodated is limited.

The County landfills do not apply final cover on a daily basis. If this activity were not being conducted at the time of the spill, or in the opinion of DHEC officials the quantity of oil associated with the debris is too great, the oil spill debris would not be allowed to be disposed of at a County landfill, and would likely be directed to one of four (4) sanitary landfills located in Dorchester or Berkeley county.

Under normal circumstances, if the quantity of oil associated with the oil spill debris is in excess of 50-100 gallons, DHEC will not approve its disposal at either of the Charleston County landfills. However, quantities of oil in excess of 50-100 gallons may be accommodated at the Berkeley or Dorchester County landfills. Disposal practices at these landfills require that oil spill debris be mixed with residential and/or commercial waste prior to disposal and immediately covered. This practice enables disposal of greater quantities of oil than allowed at Charleston's landfills. The amount which can be disposed of is again, predicated on DHEC's assessment of the spill material and present operating conditions at the subject landfill.

If it is determined that fossil fuel contaminated materials cannot be satisfactorily incorporated in any of the existing landfills identified above, the individual(s) responsible for the spill must dispose of the material at a secured landfill. A secured landfill is one that is designed specifically for the disposal hazardous wastes. The closest secured landfill to Charleston county is located in Sumter county (Pinewood, S.C.), approximately 90 miles one way.

A description of the facilities available to Charleston County to conduct the disposal methods described is provided in the following sub-sections. Figure 4.1 identifies the location of these facilities with respect to Charleston County.



LEGEND:

1. Bee's Ferry Landfill
2. Romney Street Landfill
3. BFI Landfill
4. Berkeley County Landfill
5. SCA Landfill
6. Dorchester County Landfill
7. SCA Pinewood Landfill
8. ABCO Industries Incinerator

FIGURE 4-1 LOCATION OF CURRENT DISPOSAL FACILITIES

4.4.1 Charleston County, South Carolina

Disposal of fossil fuel contaminated materials at the Charleston County landfills are normally limited to small quantities (less than 50-100 gallons of oil) and during those periods when the landfill is installing a final cover. South Carolina regulations mandate that any surface which represents a final grade of the sanitary landfill shall be covered with a minimum of two (2) feet well graded soil. As adequate quantities of cover material are not available at either of the County landfills, cover material must be trucked in large quantities. If disposal of fossil fuel contaminated material is permitted, the material is incorporated into the final cover at very low concentrations.

Both of the facilities located within Charleston County are operated by the County Department of Public Works (DPW).

4.4.1.1 Bees Ferry Landfill

Bees Ferry Landfill is located off of Route 17 on St. John's Island approximately 17 miles from downtown Charleston. The landfill consists of two tracts of land: a 50 acre tract which is nearing completion; and a recently permitted 60 acre tract. Landfill operations employ a modified trench method whereby only a portion of the total trench depth is attained through excavation. Depth of excavation is predicated on the location of the ground water table. South Carolina regulations require that a minimum of two (2) feet be maintained between the bottom of any elevation and the seasonal high water level.

The equipment available for facility operations is substantial and includes: crawler tractor (2); scraper pans (2); a dump truck and a compactor. Additional equipment is available as required from the Department of Public Works. Based on existing operating data, County officials estimate that the landfill has adequate capacity to accommodate solid waste through 1985.

Note: The majority of landfills described in this study utilize the trench method for disposal of solid waste. Trenches or "cells" are constructed of various lengths and widths and, depending on the physical characteristics of a particular site, a minimum 2 feet above seasonal high water level. Solid waste is compacted in 2 foot lifts with a 6-inch cover provided at the completion of each day's activities. Once an elevation is attained which represents the final grade a two foot cover is provided. Adjacent cells are normally separated by 10 feet of virgin soil.

4.4.1.2 Romney Street Landfill

The Romney Street Landfill is located adjacent to the Cooper River approximately one mile due north of the Cooper River Bridge. The landfill currently operates under a restricted permit which allows for the disposal of only shredded solid waste. The County operates a shredding facility adjacent to the landfill which reduces the solid waste, primarily residential and commercial, to a minimum (90% by weight passing) 4 inch particle size. Because of a relatively high ground water table, facility operations require the construction of a perimeter dike to create a pit in which the shredded material is deposited. The landfill as originally permitted consists of a 60 acre tract which is developed in 10 acre increments. Landfill equipment is limited to to a single compactor. Support equipment, on an as required basis, is obtained from the Department of Public Works. In some instances the installation of a final cover may be sub-contracted to a local contractor. Based on existing operating data, County officials estimate that the landfill has sufficient capacity to accomodate shredded solid waste into 1984.

A more complete description of the Charleston County solid waste disposal facilities is presented in Appendix B.

4.4.2 Berkeley County, South Carolina

Berkeley County currently has two sanitary landfills, one privately operated by Browning-Ferris Industries (BFI), and the second by the Berkeley County Department of Public Works. In those instances where fossil fuel contaminated materials (oil spill debris) have been approved for disposal by DHEC, the material is normally mixed with residential and/or commercial waste and immediately covered. Mixing the oil spill debris with solid waste provides an opportunity for any free oil present to be absorbed, and thus minimize the potential for pollution.

4.4.2.1 Browning-Ferris Industries (BFI) Landfill

BFI's Landfill is located adjacent to the County Airport in Jedburg, South Carolina, approximately 27 miles northwest of Charleston. The landfill consists of a 110 acre tract of land, 90 of which are available for disposal operations. Landfill operations employ the trench disposal method utilizing a D6 tractor for compaction, daily cover, and if appropriate, final cover operations. Trench excavation, and, on occasion, installation of a final cover is performed by local contractor.

Since October of 1981, the quantity of waste received on a monthly basis has increased threefold. This was primarily due to a change in permit status which allowed BFI to accept residential solid waste. Assuming the quantity of solid waste handled continues at its present rate, BFI officials estimate the landfill has sufficient capacity to accomodate solid waste for an additional 10 years.

4.4.2.2 Berkeley County Landfill

The Berkeley County Landfill is located in Monck's Corner, South Carolina, east of Route 17A approximately 27 miles north of Charleston. The landfill extension, which was permitted in 1975, consists of a 125 acre tract of land. Disposal operations are conducted by the Berkeley County Department of Public Works (DPW), with four personnel: a manager, clerk, and two operators; and four equipment items: two commpactors and two draglines, one of which is loaned among other divisions of the DPW. As with other county operated landfills, additional equipment is readily available upon request. The landfill employs the trench method for disposal operations.

Available information would indicate that the Berkeley County Landfill will be available to accomodate solid waste for an additional 3-4 years. However, Berkeley County is currently experiencing an influx of new industry which may impact this estimate considerably. The DPW is presently conducting a study to better define its current and projected disposal requirements.

4.4.3 Dorchester County, South Carolina

Like Berkeley County, Dorchester County has two sanitary landfills, one privately operated and one County operated. To date, fossil fuel contaminated materials (oil spill debris) approved for disposal at these landfills have been subject to basically the same disposal criteria imposed on Berkeley County landfills.

4.4.3.1 SCA Services Landfill

The SCA Landfill is located in Dorchester, South Carolina approximately 38 miles northwest of Charleston. The landfill consists of a single tract of land, approximately 140 acres in size. Daily operations are conducted by a single employee utilizing a 977L truck loader for compactions and daily cover. The landfill uses the trench method for disposal whereby the trenches, which on the average do not exceed ten (10) feet, are excavated by a local contractor. When appropriate, a local contractor may also install the final cover. The access road to the landfill is maintained by Dorchester County personnel who operate the adjacent sanitary landfill (see Section 4.4.3.2). Based on existing operating data, SCA officials estimate that their landfill will be available to accommodate solid waste for an additional 20 years.

4.4.3.2 Dorchester County Landfill

The Dorchester County landfill is located adjacent to SCA's and consists of a 50 acre tract of land. Facility operations employ the trench method whereby one employee equipped with a single compactor is responsible for performing routine landfill activities. Additional manpower and equipment is available from the Department of Public Works. These support services normally include: trench excavation, final cover and access road maintenance. Based on existing operating data, County officials estimate that the Dorchester landfill will have adequate capacity to accommodate solid waste for an additional 6 years.

4.4.4 Sumter County, South Carolina

SCA Chemical Services operates one of the few secure landfills approved for disposal of hazardous wastes in the United States. Industries, municipalities and the like from all areas of the country, utilize this facility for disposal of materials classified as hazardous wastes under the Resource Conservation and Recovery Act and/or applicable State hazardous waste regulations. SCA's landfill is located in Pinewood, South Carolina approximately 90 miles northwest of Charleston. The 128 acre site is located on a deposit of opalite clay commonly known as Fuller's earth, which has a permeability of 10^{-8} cm/sec. Disposal activities are conducted in cells which are constructed on an individual basis, by mining the opalite clay to a depth of about 50 feet. Each of these cells consumes approximately three acres of available land area and are consumed at a rate of about one per nine month period. A minimum buffer zone of 20 feet is maintained from the bottom of the cell to the ground water table.

The mined clay, which when kiln-dried has substantial absorptive capacity (0.5-1.0 lb water/lb clay), is used in the disposal practice to absorb any leachate which may develop within the cell. Each cell is equipped with a leachate collection system to recover any leachate which may develop for subsequent treatment. State and Federal regulations also require that all liquid hazardous waste be solidified prior to disposal. This is accomplished by mechanically mixing the waste with the dry opalite clay. The excess clay is sold as an industrial absorbent and kitty litter.

The equipment available for operations is significant, including: scraper pans, loaders, graders, back hoes, dump trucks, etc. To conduct the various activities required under normal operations, the facility employs approximately 80 people. Discussions with SCA officials estimate that if the quantity of material requiring disposal continues at its present rate, the Pinewood Landfill could accommodate such materials through the year 2000. The facility currently handles about 135,000 cubic yards of waste per year.

4.4.5 Spartanburg County, South Carolina

In addition to the secure landfill identified in Section 4.4.4, there is a hazardous waste incinerator located in Robuck, South Carolina, approximately 200 miles northwest of Charleston. This facility was constructed specifically for the disposal of liquid hazardous wastes and sludges. Operated by ABCO Industries, the facility utilizes a high temperature incinerator (2000-2300°F), to thermally oxidize the waste. The incinerator is capable of processing up to 120 lbs/per minute of waste at design capacity. ABCO's incinerator system, which only recently began continuous operations, currently operates at about 80% capacity (approximately 95 lb/hr).

Information on the ABCO hazardous waste incinerator is presented for information only. Although incineration of fossil fuel contaminated materials at this facility may be a viable disposal alternative in the future, the high cost of transportation renders it an uneconomical disposal alternative.

Table 4-1 presents a summary of current disposal methods employed by Charleston County for fossil fuel contaminated materials, current operator, haul distance and estimated life. Caution should be exercised in using the estimated life data reported. Only the Charleston County landfills and the hazardous waste disposal facilities are capable of providing accurate data on the quantity of waste handled via weigh scales. The four sanitary landfills described in Sections 4.4.2 and 4.4.3 do not

TABLE 4-1

CURRENT DISPOSAL METHODS: FOSSIL FUEL CONTAMINATED MATERIAL

Disposal Technique	Operator	Location	Haul Distance (Miles: One-way)	Estimated Life (Years)
Land Application	- Charleston County DPW	Charleston County (Bee's Ferry)	17	3 - 5
	- Charleston County DPW	Charleston County (Romney Street)	5	1 - 1.5 [A]
Co-Disposal	- BFI	Berkeley County	27	10
	- Berkeley County DPW	Berkeley County	36	3 - 4
	- SCA	Dorchester County	38	20
	- Dorchester County DPW	Dorchester County	38	6
Burial (Secure Landfill)	- SCA	Sumter County (Pinewood, S.C.)	90	20
Incineration	- ABCO Industries	Spartanburg County (Robuck, S.C.)	200	NA

[A] From date Charleston County shredding facility resumes operations at design capacity.

have these provisions and base their disposal quantities on a per truck/unit volume basis.

4.5 CURRENT DISPOSAL COSTS

In developing costs associated with each of the disposal methods identified in Section 4.4, emphasis was placed on obtaining actual cost data from each of the facility operators. The total cost of disposal for a particular spill will consist of two primary elements: 1) disposal fee and 2) transportation cost.

The disposal fee will vary depending on the disposal method employed, quantity of material and material characteristics. In those instances where the recovery method can be employed, a fee of 10-15 cents per gallon of oil will be paid by the waste oil hauler depending upon the quality of oil recovered from the spill. To illustrate the variations which may be experienced for fossil fuel contaminated materials, the following discussion is provided:

- Charleston County Landfills:

  Charleston County requires a disposal fee of $8.06 per ton of solid wastes disposed of at each of its landfills (approximately $1.40 per cubic yard). However, because they will accept only that quantity of material which can be incorporated into the final cover, the disposal fee is normally waived.

- Private Landfills (BFI/SCA):

  BFI and SCA could not commit to a fixed disposal fee without knowing the disposal quantity or what special handling and/or disposal techniques may be required by DHEC. BFI estimates that a range of $2.00 - $8.00 per cubic yard (cy) could be expected, with an average disposal fee of about $5.00/cy. This estimate is also consistent with those provided by SCA. BFI currently charges $1.25/cy of typical solid waste at their facility; SCA $1.00/cy.

- Dorchester/Berkeley County Operated Landfills:

The disposal fee at both these landfills for typical solid waste is $.90/cy. It is expected that these fees would not increase, at least not appreciably, regardless of the quantity or characteristics of the material approved for disposal.

- SCA Chemical Services, Pinewood, South Carolina:

As would be expected with a disposal facility which handles large quantities of hazardous materials on a routine basis, the disposal fee at the Pinewood landfill are fairly well established. Their disposal fee schedule as of May, 1982, is as follows:

Bulk:	Solid	3.5--4.0 cents/lb ($70 - $80/ton)
	Liquid	7.0 cents/lb ($140/ton)
Drum:	Solid	$26.50--$27.00/drum
	Semi-solid	$34.00/drum
	Liquid	$38.00--$39.00/drum

The difference in disposal costs reported for solids, semisolids, and liquids reflect the facility requirement to solidify prior to disposal.

- ABCO Industries, Robuck, South Carolina:

  Disposal fees vary considerably (5 cents to 20 cents/gallon) depending upon the physical and chemical characteristics of the waste. The actual disposal fee employed is generally a function of of the quantity of waste remaining after incineration. This material must be disposed of at a secure landfill. ABCO estimates a range of 5 cents to 10 cents/lb ($100 - $200/ton) would be indicative of the disposal fee for our particular application.

The second component in determining costs associated with disposal of fossil fuel contaminated material is transportation cost. Transportation cost will vary considerably depending on facility location and waste characteristics. Materials disposed of at a hazardous waste disposal facility must be transported in permitted vehicles which contribute significantly to the cost of transportation. State regulations require that each transporter of hazardous waste maintain financial responsibility for sudden and accidental occurrences in a minimum amount of one million dollars ($1,000,000) with an annual aggregate of two million dollars ($2,000,000). Transportation costs obtained from officials at SCA Chemical Services (Pinewood Landfill) indicate that transportation of a typical load (20 tons) of fossil fuel contaminated materials originating in the Charleston area would cost between $500 and $550. Transportation costs to ABCO Industries is estimated at $850.00 based on a twelve hour turn-around time, at $70.00/hour. The hourly rate reported was obtained from ABCO operating personnel.

Table 4-2 summarizes the estimated transportation costs for each of the disposal methods identified in Section 4.4. The transportation costs reported for sanitary landfills were developed on dollar per mile rate of $0.09 per cubic yard. This is a typical rate used by bulk haulers in estimating transportation costs.

To utilize the information presented in Table 4-2 for estimating the "expected" disposal cost for a particular spill situation, the following bulk densities should be used where applicable:

	Per CU-FT	Per CU-YD
A. Bulk Solid:		
1. Oil/straw	50 #/ft^3	1350 #/yd^3
2. Oil/sand or dirt	100 #/ft^3	2700 #/yd^3
B. Bulk Liquid	60 #/ft^3	1620 #/yd^3

To illustrate the impact of disposal method and facility location on disposal cost, a sample calculation was performed, assuming 200 cubic yards of oil spill debris consisting primarily of oil and straw. The results of these calculations are presented in Table 4-2.

4.6 FUTURE DISPOSAL COSTS

In estimating future costs of disposal for fossil fuel contaminated materials, an inflation rate of eight percent (8%) per annum is recommended for each of the disposal methods described on Secton 4.4. Recent economic trends with respect to wage rates, fuel and equipment costs have tended to decrease the rate at which disposal and transportation costs have historically escalated. However, because the unpredictability of the U.S. economy, care should be exercised in using this or any inflation

TABLE 4-2

CURRENT DISPOSAL COSTS: FOSSIL FUEL CONTAMINATED MATERIAL

(1982 DOLLARS)

Disposal Technique	Operator	Disposal Fee	Transportation Cost	Total Disposl Cost [A]
Land Application	- Charleston County DPW	NA	$3.10/CY	$ 620
	- Charleston County DPW	NA	$1.00/CY	$ 200
Co-Disposal	- BFI	$5.00/CY	$4.90/CY	$1,980
	- Berkeley County DPW	$1.00/CY	$6.50/CY	$1,500
	- SCA	$5.00/CY	$6.90/CY	$2,380
	- Dorchester County DPW	$1.00/CY	$6.90/CY	$1,580
Burial (Secure Landfill)	- SCA	Solid: $.04/lb Liquid: $.07/lb	$550 $550	$14,650 NA
Incineration	- ABCO Industries	$0.07/lb [B]	$850	NA

[A] Assumes 200 CY of oil spill debris consisting primarily of oil and straw.
[B] Waste Oil Haulers will pay for oil, if such oil can be reprocessed.

rate in predicting disposal and/or transportation costs several years in the future.

4.7 ASSESSMENT OF CURRENT DISPOSAL TECHNIQUES

The approach used by the Department of Health and Environmental Control (DHEC) in determining the method of disposal and/or location whereby the disposal of fossil fuel contaminated materials can be conducted, exercises good engineering judgement and is consistent with existing State and Federal regulations. DHEC makes good use of existing disposal facilities - a practice which is encouraged to be continued. Developing a secondary site to accommodate only fossil fuel contaminated materials would not be justified based on the limited quantity generated within the Charleston area. Such a facility would require a considerable investment and monitoring on a continuous basis.

From a disposal cost perspective, Charleston would be considered fortunate to have two (2) of the few approved hazardous waste disposal facilities located within the state (SCA, Pinewood and ABCO Industries). Under normal circumstances, if debris resulting from a spill is classified as a hazardous waste under State or Federal regulations, it must be disposed of at a hazardous waste facility. Consequently, Charleston County would experience a lower overall disposal fee due to a cost savings on transportation.

One alternative which may be considered in those instances where co-disposal at a sanitary landfill would be appropriate if the quantity of material for disposal was not substantial, would be to distribute the material to the various sanitary landfills identified in Section 4.4. This could appreciably reduce or eliminate the quantity of material disposed of at SCA's Pinewood landfill. Additionally, fossil fuel contaminated materials may be stockpiled in a prepared dike area. This would allow disposal activities to be conducted over an extended period of time. The quantity of material disposed of at a particular landfill would be limited to that which is consistent with present operational constraints (i.e., equipment, site conditions, etc.). The sample calculation presented in Section 4.5, indicates a substantial cost increase in disposal costs when material is disposed of at a secure landfill. Although existing State and Federal regulations require those individuals responsible for the spill to pay all costs associated with abatement, clean-up and disposal of said spill (reference Section 6.0), it may be prudent to employ this alternative if DHEC determines that no detrimental environmental effects will result.

5.0 ALTERNATIVE DISPOSAL TECHNIQUES FOR DISPOSAL OF FOSSIL FUEL CONTAMINATED MATERIALS

5.1 INTRODUCTION

In addition to current disposal techniques described in Section 4.0, the options of controlled burning, lagooning, burial, landspreading, and composting deserve consideration as options for the disposal of fossil fuel contaminated materials. Each disposal technique has its own advantages and disadvantages based on technical feasibility, costs of both transportation and disposal, compatibility with federal and state regulations and with local ordinances and public concerns. These considerations are discussed below for each technique. Once the legal and technical feasibility of each has been established, cost becomes the principal evaluation criteria for selecting the best disposal technique. Disposal costs for feasible alternatives are compared in the final part of this section.

The feasibility of any disposal option depends in large part on the form in which the oily waste is found when it is ready for disposal, i.e., after emergency measures have been taken. In rare cases, virgin oil can be recovered from a spill and re-used directly as fuel or lubricant. In some cases oil-contaminated debris can be pumped into tankers and returned to the refinery for blending with feedstock. In other cases, oil-contaminated sand, gravel and shingle can be used for projects such as local highway foundations. Such direct uses of spilled oil and oil-contaminated materials decrease the quantity of fossil fuel contaminated wastes and should be sought wherever possible. However, the principle concern of this report is the disposal of fossil fuel contaminated materials which can not be used directly as either fuel or building material, and which require disposal.

Often, the oil from a spill will be contaminated with straw, hay, or other substances which have been used as sorbents. These materials contain a high level of water and require an inordinate amount of fuel for complete incineration. Moreover, special permits are required to burn the waste because of the resulting smoke, fumes, secondary combustion, and unburned products. If the waste is burned, a highland area is better than a marsh area.

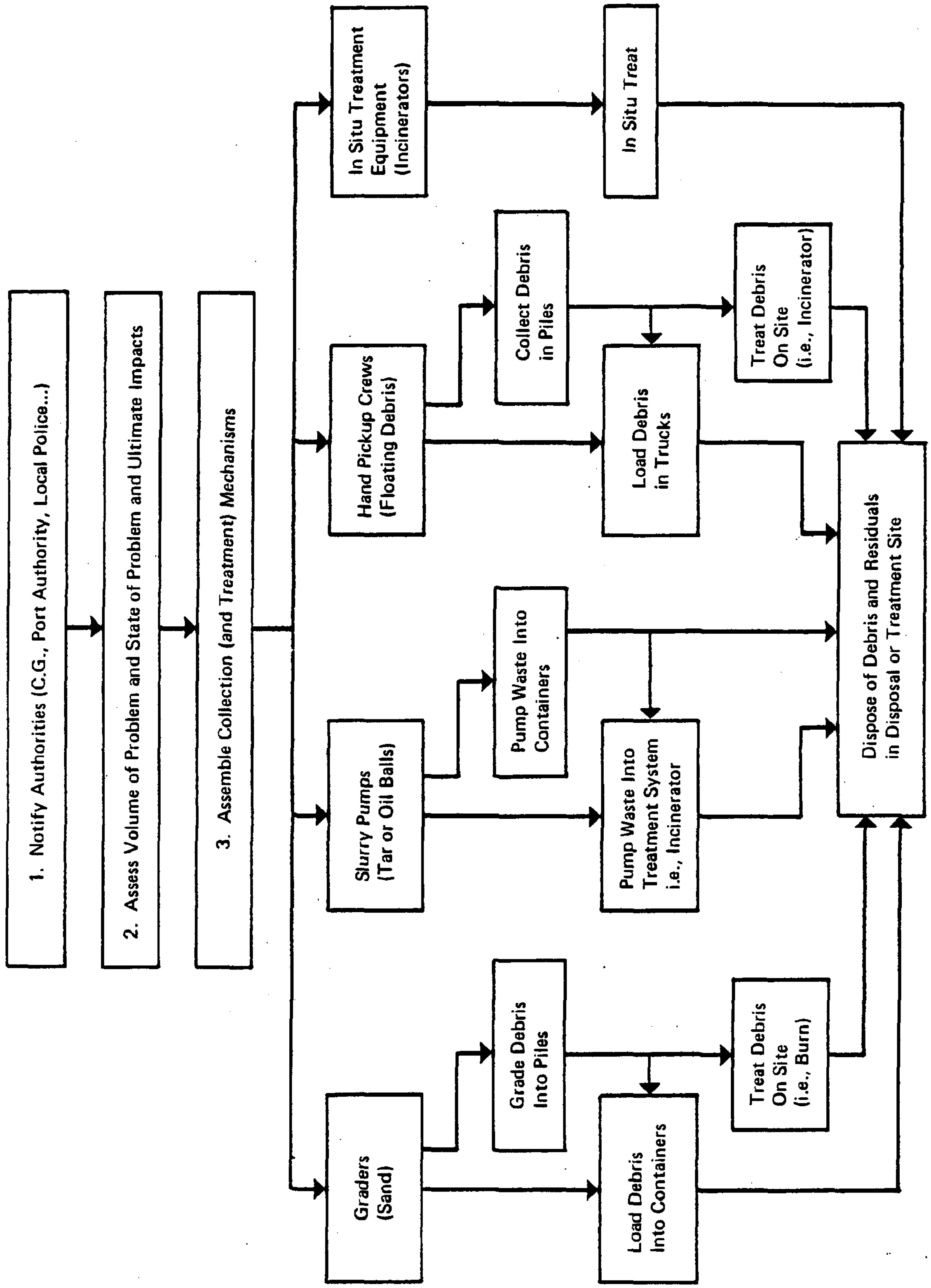
Where an oil spill has reached land, it will be mixed with sand and dirt from the shore. In this case, much of the waste can be recovered using bulldozers and other earth moving equipment, but some will remain unrecovered. Relatively small quantities of oily sand may be allowed at the Charleston County landfills if it is incorporated into the landfill as a daily or final cover so aerobic degradation can take place.

Harbor debris, such as seaweed, discarded wood, and trash, can also contaminate oil from a spill and can hamper cleanup operations and complicate disposal efforts. Harbor debris may include organic material such as seaweed, driftwood, floating trees, the carcasses of birds, animals and fish, and biodegradable trash, as well as natural or manmade inorganic material such as mud, sand, gravel, shingle, cobbles, boulders, and non-biodegradable manufactured trash. Most debris, however, consists of wood. Debris material is normally located under docks, under wharves, or along the shoreline. The quantity of debris and of oil in the debris can vary tremendously. The upper limit on the quantity of oily debris generated at a spill is about 10,000 dumptruck loads at Santa Barbara, and for the east coast about 200 railroad gondola carloads from Hurricane Agnes [2]. The debris volume from a single spill ranges from several cubic meters to over 40,000 cubic meters [3]. Although a spill of this size is unlikely to occur in Charleston because of its climate, size, and traffic patterns, it does point out that Charleston County must be prepared for a range in quantity as well as quality of oil spill debris.

The quantity of debris present when a spill occurs varies with the season, the weather, the tides, and the wind. Spring thaw and increased seasonal rainfall cause high water which floats debris that is stranded above high water during the rest of the year. In addition, annual defoliation causes local increases in the quantity of leaves on the water surface.

Finally, the oil from a spill can emulsify in the water, reaching a semi-solid state, Emulsified oils require very high temperatures in order to burn, and are therefore unlikely candidates for the controlled burning or incineration disposal options.

The disposal options discussed below fall into two broad categories: burning, either by incineration or controlled open burning, and land disposal. The latter includes burial, land-spreading, co-disposal with municipal solid wastes and composting. These techniques rely on the more or less rapid biodegradation of hydrocarbons under specific temperature, moisture, and other conditions. Figure 5-1 presents in flow chart form the way in which several disposal options can fit into the overall oil spill cleanup process. Several techniques can be used to dispose of the debris from one spill, depending on the type of oil and debris, and on the quantity of debris compared to the capacity of, for example, a particular incinerator or sanitary landfill. A description of the technical feasibility of each option for Charleston oily waste is presented below, followed by a discussion of state and federal regulations, and an evaluation of the costs of practical disposal options. Special problems such as the presence of heavy metals or PCBs will be addressed after the practical and legal feasibility of each technique for handling "normal" oily waste has been discussed.



Source: "Combustion: An Oil Spill Mitigation Tool," Battelle Pacific Northwest Labs, Richland, WA, November 1979.

Figure 5-1. Options and Actions for Oil-Contaminated Debris Disposal.

5.2 EVALUATION OF ALTERNATIVE DISPOSAL METHODS

5.2.1 Technical Feasibility of Disposal Methods

5.2.1.1 Controlled Burning

Controlled open burning is one of the fastest methods of disposing of fossil fuel contaminated wastes, though it is only applicable under specific circumstances. Very little transportation is required as open burning usually takes place wherever the oil is collected. Fire control equipment must be provided at the site, and smoke and fumes must be monitored and controlled.

Before burning, information must be gathered about the type of oil which has been spilled, and about the soil and vegetation found in the site. Open burning is not hot enough for emulsified oil. Nor can it be used if the oil is contaminated with PCB's or other toxic organic or inorganic compounds. If the oil is mixed with straw, incomplete combustion takes place and the resulting smoke, fumes and other products require special attention.

In the South Carolina Industrial Solid Waste Disposal Site Regualtion, open burning is defined as:

> "Any fire or smoke producing process not conducted in a boiler plant, furnace, high temperature processing unit, incinerator or flame, or in any such equipment primarily designed for the combustion of fuel or waste material."

As defined by the South Carolina Hazardous Waste Management Regulations, open burning means the combustion of any material without the following characteristics:

(a) control of combustion air to maintain adequate temperature for efficient combusting,

(b) containment of the combustion reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion; and

(c) emission of the gaseous combustion products through a stack, duct, or vent, adequate for both visual monitoring and point source sampling.

Current land and air pollution regulations, then, do not permit the open burning of oily materials. In particular, DHEC Regulation No. 62-2 "Prohibition of Open Burning" prohibits the burning of material containing heavy oils, asphaltic materials other than plant growth which produce smoke in excess of forty (40) percent opacity. Although DHEC has made exceptions to these regulations in the past it cannot be assumed that they will in the future. Prior to initiating open burning as a disposal alternative, a one-time variance must be secured from DHEC's Division of Air Quality Control, Columbia, S.C. Open burning is normally restricted to isolated areas, generally greater than 1/2-mile from a residential area. Depending on the location of the debris, DHEC may require that the debris be relocated prior to burning.

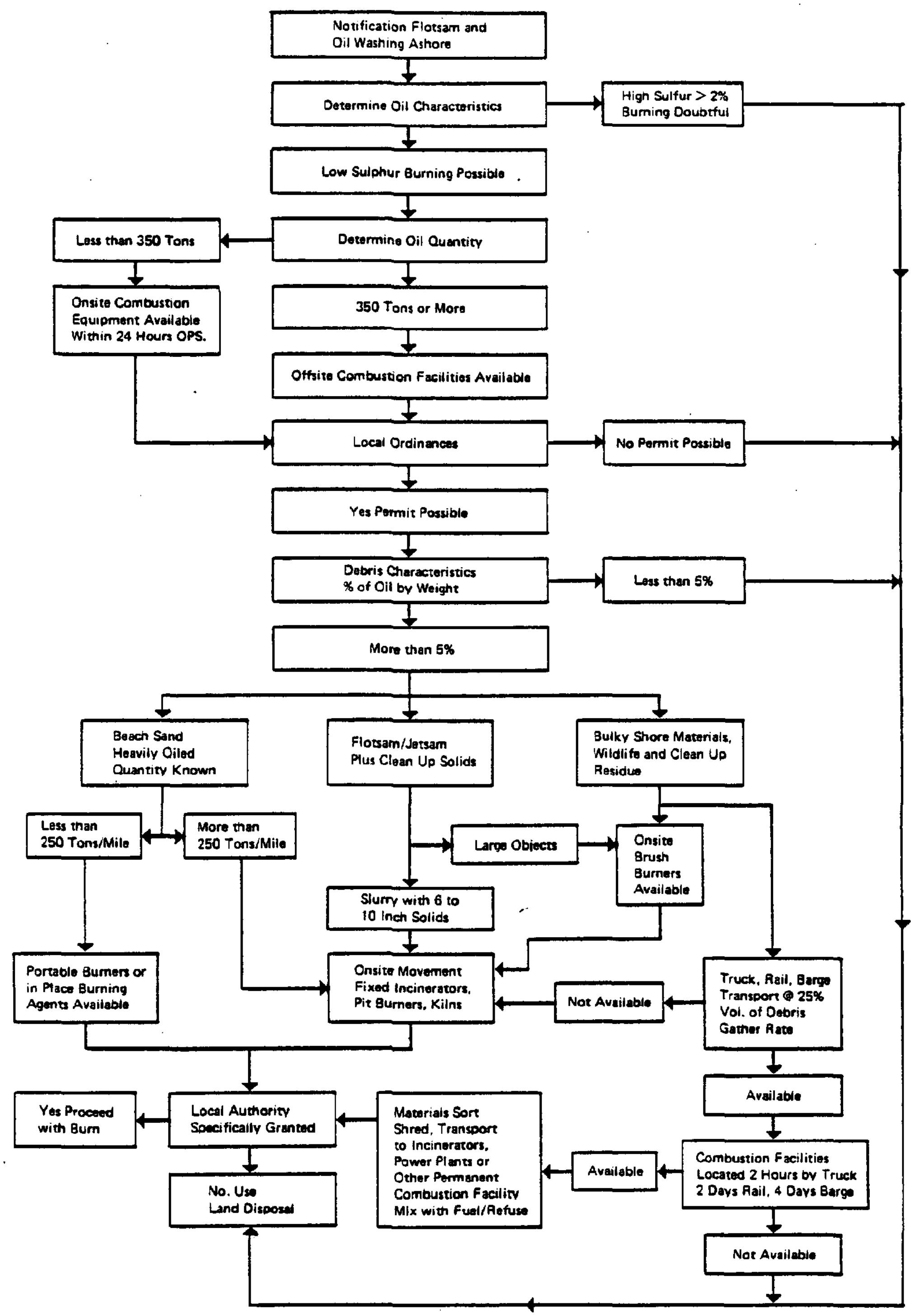
If special approval is obtained, i.e., if fumes and smoke can be adequately controlled, then open burning provides an efficient means of disposing of fossil fuel contaminated waste, It may be especially desirable if the oil has already destroyed the vegetation in an area, in which case the affected areas should be cultivated after the burning in order to aerate the soil and reestablish soil nutrient and pH levels. Establishing windrows such as those described in the "composting" section below can be particularly effective for encouraging new vegetation.

Figure 5-2 and Table 5-1 present conditions under which the burning of oil-contaminated debris might be considered the best option. However, because of current air pollution standards in South Carolina, for the purposes of this report open burning is not thought to be a practical disposal option.

5.2.1.2 Incineration

Incineration is an excellent disposal alternative for most fossil fuel contaminated wastes, if an adequate incinerator is located near the wastes. Unfortunately, the nearest incinerator to Charleston harbor is in Spartanburg, in the northern part of the state, and would therefore involve high transportation costs. The City of Charleston is presently considering the installation of an incinerator as a long-term solution to their existing solid waste disposal problem (reference Appendix B). If the oil spill debris generated in the Charleston area is compatible with the incinerator constructed, transportation costs will be dramatically reduced. To handle waste from oil spills, the incinerator should be capable of accommodating bulk quantities (eg. 5-10 million Btu/hr), and have scrubbers and/or other air pollution control devices to remove partially combusted materials and secondary combustion products from the stack gas.

In order to burn oil, an incinerator should also have a design which can keep the high temperatures of the burning oil at a safe level. A list of incinerators which can handle oil spill debris appears in Table 5-3.



Source: "Combustion: An Oil Spill Mitigation Tool," Battelle Pacific Northwest Labs, Richland, WA, November 1979.

Figure 5-2 Oil-Contaminated Debris Burning Evaluation.

TABLE 5-1

CONDITIONS MOST FAVORABLE TO BURNING OIL CONTAMINATED DEBRIS

CONSIDER CONDITION OR CIRCUMSTANCES	OPTION A OTHER OPTIONS	OPTION B BURNING
Land Availability	Requires extensive preparation land area for farming or burial and restricted access upon completion	Small site required can be existing facilities
High Ground Water Table	Burial unacceptable in some areas	Debris can be burned on site
Heavy Precipitation	Earth moving slow and difficult	Once burning is initiated only most severe would hamper disposal
Permanent Solution Needed	Land farming with time can be permanent disposal, but burial is potentially just storage	Regarded by all authorities as most permanent
Health and Safety	Odors, erosion, leaching, flooding or other changes can endanger health	Dead wildlife, other disease vectors, are handled and
Energy Recovery	Only if oil is recovered and separated at much cost	Used as coal pile additive or in recovery incinerator advantages known
Bulky Debris	Not amenable to burial or land farming without preparation	With limited preparation can be handled even with portable equipment
Limited Transportation	Delays in reaching suitable burial or farming areas	Can be conducted on site
Beach Sand Needed in Place	Detergents can be used but aquatic toxicity increased	Manual or automated equipment has been used to process sand on site

Source: "Combustion: An Oil Spil Mitigation Tool" (Battelle Pacific Northwest Labs, November 1979).

TABLE 5-2

INCINERATORS AND BURNERS

NAME	MANUFACTURER/OWNER	COMMENTS
Portable Beach Incinerator	Not commercially available	Could be manufactured locally - mounts on standard 22 l. drum.
Brush Burner	Fleco	High capacity air supply and fuel oil sprayer.
Elijah	Not commercially available	Draws oil from water surface and sprays it up into combustion chamber.
Floating Furnace	Not commercially available	Closed burning chamber burns smoke free.
Self-Propelled Skimmer Incinerator	Not commercially available	Skims oil from the surface and incinerates it.
Homemade Incinerator	Not commercially available	55-gal drum fitted with propane burner.
Open Pit Burner	Kenting Oil Field Services Canada	Rectangular pit with high velocity over fire air supply.
Mobile Incinerator	Not commercially available	Operates similar to packer garbage truck but with self-contained incinerator.
Environmental Restoration Incinerator Complex	NB Associates San Ramon, CA	Truck mounted incinerator complex. Requires three tractor-trailer units.
Rotary Kiln Sand Cleaner	Envirogenics Co.	Designed for cleaning oil soaked beach sand.
Waste Paper Incinerator	Not commerically available	Smoke free sheet metal incinerator.
Mobil Oil Burner	Conceptual Design	Natural draft burner utilizing a hot air supply.
Vulcanus	Ocean Combustion Services The Netherlands	High efficiency incinerator ship - handles liquids only - up to 25 MT/hr.
LD 60	United Corp. Topeka, KS	Burns liquid wastes at 400 to 6000 gal/hr.
CAM Shipboard Incinerator	Vent-O-Matic North Quincy, MA	Burns liquid wastes up to 150 gal/day.
Trash Burners	U.S. Smelting Furnace Co. Belleville, IL	Will handle solid waste - batch type.
Enviro-O-Pak	Sunbeam Equipment Corp. Lunsdale, PA	Complete self-contained mobile incinerator system.
Open Flame Liquid Oil Burners	Otis Engineering Co. Dallas, TX Baker Oil Tools Co. Houston, TX	Requires large area to operate in, burn relatively smoke free up to 12,000 barrels/day of liquid oil.

Source: "Combustion: An Oil Spill Mitigation Tool" (Battelle Pacific Northwest Labs, November 1979.

Heavy metals which remain with the ash resulting from incineration of fossil fuel contaminated wastes present a secondary disposal problem when incineration is used as an option. The problem of disposing of heavy metals is discussed in Section 5.2.3 "Special Problems."

Until an incinerator which can handle oily wastes is built near Charleston, incineration does not appear to be a practical alternative.

5.2.1.3 Composting

Composting is the biological decompostion of organic materials into a semi-stable product. Naturally occurring microbes are used in a controlled enviroment to break down potentially toxic organic substances into non-toxic by-products.

Composting as an alternative for the disposal of fossil fuel contaminated wastes is technically practical but very expensive. A large capital investment would be required in order to procure a composting site and install a leachate control system. Once the site is setup, however, oil will biodegrade much more rapidly at a composting site than at a municipal private landfill.

In order to implement composting as an alternative, the availability of land, equipment, and bulking material must be assessed, and a leachate control system must be designed and implemented. Composting usually requires mixture of wastes with a bulking agent to ensure proper moisture content (40 to 60 percent) and porosity. The compost pile must then be aerated and kept at a suitable temperature (about 40-60^{o} C), usually by insulating the pile with a cover of previously manufactured compost, or with additonal bulking material. The amount of time required for composting depends on the particular waste in question, and must be determined empirically. Composting of sewage sludge usually takes 21 days. Curing involves the stacking of the material for several weeks after composting to allow for further stabilization. During the 21 days, only the most volatile organic components break down. Curing allows for further decompostion of the organic matter and the prevention of odors [4].

ERCO conducted a "Study of Rapid Biodegradation of Oily Wastes through Composting" for the U.S. Department of Transportation in 1979 [5]; this report demonstrated that composting does accelerate the biodegradation of crude and No. 6 oils on a laboratory scale. The following presentation of basic concepts in composting can be found in that report:

Composting is the biological decompostion of organic materials into a semi-stable product. Organic matter is composed of various constituents. Some of those (such as sugars and carbohydrates) are easily biodegraded, whereas others (waxes, lignins, cellulose) are more resistant to microbial decomposition. Normally, biological degradation is slow. However, by optimizing and manipulating the various parameters and insulating the mass, it is possible to greatly accelerate the process. Processes currently used in composting are considerably more rapid than natural biological degradation.

Microbial decompostion of the organic compounds is carried out primarily by three groups - bacteria, fungi, and actinomycetes. Over 75 different species have been identified in various composting materials. During the composting process, changes in the microbial population occurs as a result of temperature increases. Gray et al., identify four stages in the process: mesophilic (ambient to 40^{o} C), thermophilic (45 to 64^{o} C), cooling, and maturing [6]. Although the greatest activity takes place in the 40 to 60° C range, Spohn reported that thermophilic fungi and actinomycetes were present at temperatures exceeding 80° C [7].

The primary consideration in composting is that the waste material be well aerated. Aerobic decomposition - occurring in the presence of oxygen - is much more rapid and develops higher temperatures than anaerobic decompostion. Different composting systems use different methods to ensure sufficient aeration. The windrow system consists of long, low (3 to 4 feet) piles which are turned periodically. Convective air and frequent turning serve to maintain aerobic conditions.

Several mechanical systems, consisting of either a rotating drum, multistage tower silos, moving elevators, or other devices, have been used to mix and aerate for composting. Some of these systems are in use in Europe, primarily for composting of refuse or combined refuse and sludge.

The static-pile, forced aeration method, which was developed by the U.S. Department of Agriculture (USDA) at Beltsville, Maryland, in 1974, consists of a stationary compost pile constructed over an aeration system. Aerobic conditions are maintained by a suction system which draws air through the pile. This system offers the advantages of low capital investment and low energy costs, and is becoming widely accepted as an economic and effective method for large-scale composting of organic wastes.

Different composting methods have been in use throughout Europe, particularly in Holland. Most have been government-subsidized operations which are concerned with replenishing limited land area with necessary nutrients. Compost made from hydrocarbon wastes has not and probably will not be a very marketable item until more research is done into its effect on plants growing in it. Because compost is not likely to be in much demand, especially in the United States, and because it is expensive compared to other land disposal methods, composting is not thought a practical disposal option.

5.2.1.4 Codisposal

The codisposal of oily wastes with municipal garbage at a garbage-to-oil ratio of about 10:1 is the most practical disposal alternative for Charleston's oily wastes in the medium term (i.e., before an incinerator is built). Biological decay occurs quickly, oil-contaminated soils can be used as a spreading layer, and municipal and private landfills already exist near the harbor. The current limit for the municipal landfills within Charleston County is only 50-100 gallons of oil.

Since sanitary landfills are already in operation all across the United States, codisposal of oily wastes with existing municipal and industrial solid wastes is widely practiced in the U.S. Appropriate landfills must be able to monitor possible contamination from leachate and must cover the wastes with a minimum of six inches of suitable soil each day. Fine-grained soils should line the lifts containing oily debris, and the complete portion should have an impermeable cap to prevent rain from soaking in and oil from floating out. Table 5-3 summarizes solutions to other possible problems.

In general, oil spill debris is handled similarly to all other solid waste materials once approval to deliver it is secured. Dumptrucks loaded with debris are directed where to deposit the waste, then landfill equipment spreads the pile. Any mixing with existing refuse increases the chances of any oil and water being absorbed and thereby impedes

TABLE 5-3

SANITARY LANDFILLING OF OIL SPILL DEBRIS:
POSSIBLE OPERATIONAL PROBLEMS AND SOLUTIONS

POSSIBLE PROBLEM	SOLUTION
Oil not absorbed by refuse (over-saturated or under-saturated)	More mixing with refuse until adequate mix is secured
Ignition of oil debris/refuse	Extinguish flame: prevent by installing spark arrestors on equipment and assuring they have mufflers above equipment
Leaching of oil into ground-water (vertical infiltration of water from surface)	Reduce percolation by improving cover material; slope surface to encourage runoff
Leaching of oil into ground-water (vertical migration down through bottom)	Dig up landfill and reseal bottom
Leaching of oil into ground-water (groundwater flow through refuse)	Reduce groundwater level through pumping; excavate material and install liner
Erosion of cover soil	Place more cover soil; sow with grasses and protect until grass grows

Source: Stearns, et al., 1977, "Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

possible leachate migration. As with municipal waste, oil spill debris must be covered daily in order to discourage flies and rodents attracted to seaweed, to prevent the penetration of precipitation, and to minimize exposure to site users.

Despite its widspread use as a disposal method, codisposal has not been well studied with respect to degradation rates of oil spill debris. it is known that since anaerobic conditions prevail in most landfills most degradation will be anaerobic, and thus slower than if the debris were exposed to more oxygen. Estimates of the time for total decomposition range from 5 to 100 years or more.

Codisposal has proved to be a successful disposal technique in the United Kingdom, When the liquid/solid ratio and other factors (e.g., pH, oxygen content) are carefully established and monitored, chemical and physiochemical reactions within the landfill can completely prevent or partially reduce the potential hazard of oily wastes. At Rainhan and Ingham landfills, for example, domestic waste has been shown to absorb oil by measuring oil concentrations of 2 to 7 percent (weight of liquid per weight solid) while concentration is decreased by about ten-fold within the two meters below [8].

One problem with codisposal can be that of pooling within the landfill. Pooling occurs when there is an uneven mixture of the oil with other wastes, or when the municipal waste is over-saturated with oil. This happened at the Ingham and Wildmore landfills where oil was found to have migrated to the unsaturated zones beneath the landfill. The ratio of the annual volume of liquid disposal to the volume of solid wastes present immediately beneath the sites of lagoons excavated into the landfill materials was estimated to have reached a possible maximum value of 1.25:1 at Ingham during the period 1970 to 1972 and a value 0.08:1 at Rainham during the period 1967 to 1973. However, lateral movement of liquids from the lagoons into the wastes has been expected to reduce the ratios to the limited values of 0.17:1 and 0.016:1 respectively, under the assumption that the whole volume of solid waste was active in absorbing the liquids [8].

Because the liquid/solid ratio was not monitored carefully at Ingham, liquids broke through the surface, especially during a heavy rain. By contrast, the same ratio was controlled at Rainham using excavated trenches or lagoons.

The two municipal landfills in Charleston County are Bee's Ferry and Romney Street. Municipal landfills also exist in Berkeley and Dorchester County. In addition, there are two private landfills located in Berkeley and Dorchester County which are operated by BFI and SCA, respectively. A description of each of these facilities is present in Section 4.0.

In order to evaluate the feasibilty of the disposal of fossil fuel contaminated wastes at each of these sanitary landfills, the following data is required:

- makeup of the waste in each landfill
- landfill cover
- amount of compaction
- activity of biological material
- soil structure under the landfill
- thickness of the landfill
- use rate
- capacity
- hydrogeology
- term of landfill use

Once these factors have been evaluated, the quantity and quality of oily waste which each landfill can safely accept can be determined.

Experimental and actual data from the United Kingdom, indicate that oil spill debris can be placed in domestic sanitary landfills at a 20:1, solid waste:oil ratio, by weight. Based on these data, the number of gallons of oil which can be accepted under ideal conditions can be calculated based on the quantities of waste disposed of at sanitary landfills in the Charleston area. These quantities have been calculated and are presented in Table 5-4. Quantities of oil per month reported for Charleston County landfills are considerably greater than the 50-100 gallons currently accepted. In the event of a major spill, the recovered debris could be stockpiled in an area where it would not be endangering groundwater by leachate or runoff, and added to the sanitary landfills until it has all been disposed.

5.2.1.5 Burial

Burial should be one of the last disposal techniques considered as it involves the slowest rate of degradation of the oily wastes, taking perhaps centuries. It must take place at a geohydrologically secure site (e.g., one which has a clay bottom), as light materials may filter down and contaminate the groundwater. Wastes would be sent to, say, Pinewood Hazardous Waste Disposal site, located 90 miles from Charleston harbor. As previously discussed, the costs of disposal and transportation are therefore very high and make burial even more unpractical if other disposal options are available. However, if other disposal techniques cannot be used for regulatory, political or technical reasons, burial must be kept in mind as one of the last resorts for disposing of fossil fuel contaminated wastes, particularly

TABLE 5-4

GALLONS OF OIL WHICH MAY BE ACCEPTED BY LANDFILLS IN THE CHARLESTON AREA

LANDFILL	[A] TONS OF WASTE DISPOSED PER MONTH	[B] GALLONS OF OIL PER MONTH
Bee's Ferry	6,875	98,200
Romney Street	6,650	95,200
BFI (Berkeley County)	6,125	87,500
SCA (Dorchester County)	4,000	57,100
Dorchester County Municipal Landfill	6,000	85,700
Berkeley County Municipal Landfill	5,650	80,700

[A] Estimated quantities based on best available data.
[B] Average quantities based on tons of waste disposed of per and solid waste: oil ratio of 20:1, by weight.

those contaminated with biocides, PCB's or heavy metals. These would need to be containerized before disposal.

Burial relies on the completely anaerobic degradation of oily wastes. As with codisposal, data is required concerning the landfill cover, the amount of compaction at the site, the activity of biolgical material, the soil structure beneath the site, and the hydrogeology. Long-term monitoring of the site is required, though at many sites it is not currently practiced. Usually 1- or 2-ft layers of debris and fine-grained soils are alternated and compacted, except where unusually bulky debris is present. This type of disposal can take place above or below grade. Above-grade disposal has the advantage of easy detection of leakage. In either case, all portions of the site exposed to the atmosphere are covered with a layer of fine-grained soil and then with a final cover 2 or 3 ft thick. Grasses are then planted to inhibit erosion, though slopes greater than about 4 percent may erode anyway. Table 5-5 summarizes solutions to other possible problems.

The advantages of burial as a disposal technique include the fact that is encapsulates the oil, which minimizes volatilization, that there are few limitations on the size or type of oily debris, that on-site operations are completed relatively quickly, and that, is desired, the land surface can be returned to its pre-disposal appearance. However, the long-term pollution potential and subsequent monitoring requirements are serious.

5.2.1.6 Lagooning

Lagooning is an undesirable disposal option under all but special circumstances. It requires a special liner which is impermeable to oils, which then contains liquid wastes in a specially built pit or trench. Lagooning can be smelly and

TABLE 5-5

DIRECT BURIAL OF OIL SPILL DEBRIS:
POSSIBLE OPERATIONAL PROBLEMS AND SOLUTIONS

POSSIBLE PROBLEM	SOLUTION
Groundwater contamination	Define the extent of the contamination and institute the necessary corrective measures, e.g. pumping, installing groundwater interceptor trenches, excavating point-source materials
Surface water contamination	Determine the source (groundwater or surface waters) and institute remedial measures, i.e., if source is groundwater, use corrective measures as in "groundwater contamination," above; if surface water over the site is becoming polluted, then the area where surface water comes into contact with debris must be defined and corrected by covering the debris with soil and/or diverting surface waters
Slumping of fill	Placement and compaction of additional cover soils
Cover grasses not germinating	Re-sow and evaluate choice of grass and reason for failure; fertilization or chemical soil adjustment may be required

Source: Stearns, et al., 1977, "Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

involves expensive maintenance. A lagoon should be mechanically aerated, and, if possible, seeded with bacteria to encourage degradation which would otherwise be practically non-existent. Data required for setting up a lagoon include the soil type and hydrogeology of available land, which natural and artificial liner types are available, and what construction and transportation equipment are available.

As a temporary storage measure, lagooning can be an expensive but feasible option if certain precautionary measures are taken. A cover for the lagoon should be installed to minimize water infiltration, yet the cover should have vents which allow enough ventilation to prevent spontaneous combustion. Lagooning has not been reported as a method of disposing of oily wastes permanently, although it has been used to dispose of spent drilling muds and other oilfield wastes.

5.2.1.7 Landspreading

Landspreading, also known as land farming, land cultivation, or land treatment, is a disposal option which lies between composting and co-disposal with respect to both cost and rate of biodegradation. It requires a suitable landsite, approximately 23 square feet per gallon of oil, and equipment to turn the debris. Like composting, it relies largely on aerobic degradation, though accomplished in a much more crude fashion. If land is available, landspreading is a good disposal option for debris which contains roughly 1.5-10 percent of the total volume of oil spilled, and which does not contain non-biodegradable materials or excessively large or bulky solids (i.e., debris chunks over six inches in diameter, which might damage equipment).

Since 1959, landspreading has been used to dispose of industrial organic wastes and refinery wastes such as oil refinery tank bottoms and American Petroleum Institute separator sludge wastes. It has been used at least twice for oil spill clean-up debris in Utah and California [3]. The process involves spreading oily wastes thinly over land and then mixing them with soil to expose as much oil as possible to both air and soil microbes. Suitable bacteria are present in virtually all soils, and can multiply to sufficient numbers to convert most of the oil into carbon dioxide and water. In fact, more than 100 species and 30 genera of bacteria, actinomycetes, and water fungi are reported able to metabolize one or more fractions of crude oil. Pseudomonas bacteria series are thought to be the most common. All these microorganisms require oxygen, water, and nutrients (mainly nitrogen and phosphorus), in addition to the hydrocarbon source [2].

Although it is more expensive than co-disposal of oily wastes with municipal and industrial waste, landspreading has the advantage that the land can eventually be used as a building site or for growing trees or grass. Meanwhile, it looks like a plowed field rather than a dump. Landspreading can increase the humus content of the soil. (In addition, landspreading involves little danger to the groundwater if runoff is controlled and no odor or spontaneous combustion problems.) Its main advantage over co-disposal, though, as well as its porosity, nutrient level, and waterholding capacity, is that the oily waste degrades faster. The rate of biodegradation depends on such factors as climates, waste to soil ratio, tilling frequency, and fertilization, but will always be faster than co-disposal. In many cases, aerobic decomposition of oily debris is largely completed in three growing seasons or less. After this period the water pollution potential is nonexistent [2].

Some of the disadvantages to landspreading include the following: volatilization may occur and increase air pollution; stockpiling at a disposal site may be necessary since every 23 square feet of land should only take one gallon of oil; and inclement weather may make it impractical. Other problems and their solutions are outlined in Table 5-6. Equipment needs include a tractor and a rototiller, disc, harrow. or plow. Depending on the site chosen, an access road may be required the following excerpt from Frandsen, "Landfarming Disposes of Organic Wastes" [9], describes how to select a site:

> The area required for safe and efficient disposal of wastes of refineries depends primarily on the amount of included organic material to be biodegraded, whether the landfarming practiced is intensive or not, and the biodegradtion rate. The bioderadation rate, in turn, depends upon the interplay of such factors as climate, amount of waste spread per square foot of soil, waste composition, frequency of tilling, and fertilization.
>
> The site should have a gentle slope to prevent surface ponding, and should be free of rocks, tree stumps, and other materials to facilitate soil tillage, The subsurface conditions which must be evaluated include soil type, groundwater depth, proximity of wells, quality and potential use of groundwater, and groundwater flow direction. Once selected, the site should be dedicated to landfarming and, like any commercially developed land, should not be intended for future agricultural farming. It should be systematically prepared for landfarming and runoff of surface water. While the runoff water can be reapplied if practicable, any discharges must meet EPA and state permit conditions.
>
> The site may be divided into segements for systematic rotation of landfarming operations. If it is divided, roads must be provided for the access of heavy trucks

TABLE 5-6

LANDSPREADING OF OIL SPILL DEBRIS:
POSSIBLE OPERATONAL PROBLEMS AND SOLUTIONS

POSSIBLE PROBLEM	SOLUTION
Inclement weather hindering site preparation and/or mixing	Stockpile debris in prepared, diked area until weather improves.
Difficulty in scarifying soils	Rip soils with track dozer, pulling double or single ripper blades prior to rototilling.
Slow oil decomposition	Till the oil/soil mixture more frequently.
	Add fertilizers (such as urea and phosphates) or water.
Erosion of landspread surface	Regrade the surface to maintain no more than a 1 to 2 percent slope.
Runoff of oily material	Regrade the surface.
	Construct berms.
	Construct runoff catch basin downstream from the area.

Source: Stearns, et al., 1977, "Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

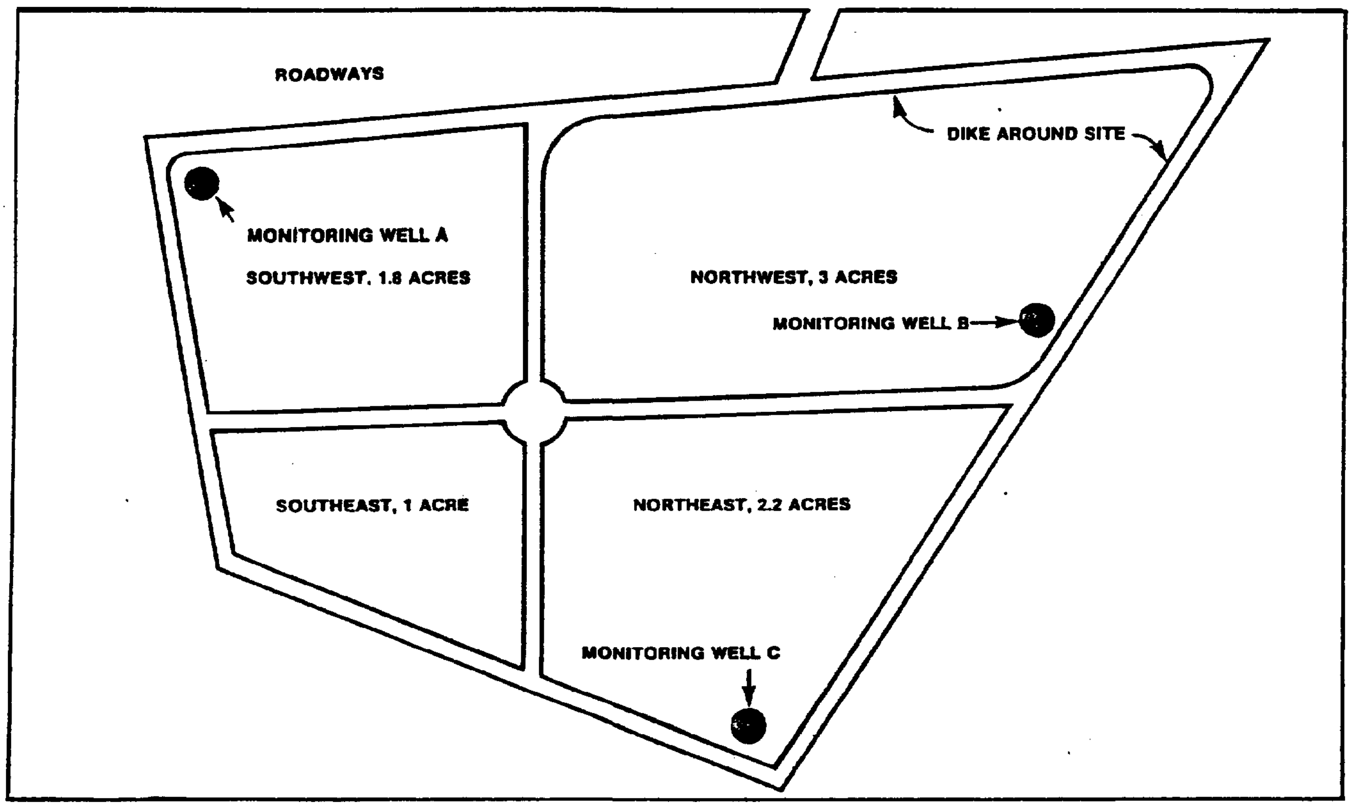
to the individual segements. The whole landfarming site must be fenced to assure entry only of authorized personnel. In cases where the landfarm is not on a potable aquifer, monitoring wells may not be required.

Nutrients should be added to increase the organic oxidation rate, depending on the type of soil involved and the biodegradation rate required. The pH must be maintained between 6 and 9 to prevent leaching of heavy metals and to maintain a high biodegradation rate.

Figure 5-3 shows the layout for a typical intensive refinery landfarm, with roads dividing inot segements for systematic rotation of operations. The roads are elevated and serve as dikes to catch any surface runoff.

Drainage in each quadrant is toward the dikes. Three monitoring wells are located inside this facility and others, not shown, are outside. Landfarm sites where oily sludge is spread only infrequently may simply be flat fields with minimum gradients, dikes, and monitoring wells, with no roads.

Specific landfarming sites such as those used by Continental Oil Company in Ponca City, Oklahoma, by Sun Company, in Marcus Hook, Pennsylvania, and by Exxon in Bayway, New Jersey are also described in Reference 9. These companies have had successful results when they used landspreading to dispose of their refinery wastes, mainly pumpable sludges. Although applications to oil spill debris are few, landspreading is thought to be a promising disposal option for organic wastes contaminated with fossil fuels, if a site can be found ahead of time.



Source: Frandsen, C.F., *Landfarming Disposes of Organic Wastes,* Pollution Engineering, Feb. 1980.

Figure 5-3. Layout of landfarm used by refinery to dispose of oily waste.

Landfarming has been found to be a viable disposal method in nearly every soil type because oil degrading bacteria and fungi are ubiquitous. The only concern in the Charleston area is the water table level. Because Charleston is on the ocean and there are a considerable number of marshes in the surrounding areas, landfarming may not be an environmentally soud method for disposal of oil spill debris. It's compatibility as an acceptable disposal method will depend on the physical characteristics of the actual site secured to conduct landfarming activities.

5.2.2 State and Federal Regulations

State and federal regulations pertaining to the disposal of fossil-fuel-contaminated wastes include the following:

- Federal Clean Air Act
- Federal Water Pollution Control Act, as amended by the Clean Water Act
- Federal Resource Conservation and Recovery Act (RCRA) and Regulations
- Coast Guard Regulations of Oil Spills
- EPA Regulations on Oil Pollution Prevention
- EPA Regulations on Criteria for State, Local and Regional
- Oil Removal Contingency Plans
- South Carolina Oil and Gas Act
- South Carolina Coastal Management Program
- South Carolina Hazardous Waste Management Regulations
- South Carolina Guidelines for Waste Disposal Permits
- South Carolina Landfill Regulations
- South Carolina Industrial Solid Waste Disposal Site Regulations
- Local zoning and/or land use plans

South Carolina state regulations are, in general, more stringent than corresponding federal regulations, although efforts are currently being made to change state laws to be more consistent with current federal standards. South Carolina based their hazardous waste regulations on an EPA draft of RCRA regulations, which were subsequently changed. RCRA regulations concerning the disposal of oily wastes are currently in preparation, and therefore are not yet in effect. If oil or waste oils is designated as hazardous waste, then it must be disposed at a permitted facility.

South Carolina Hazardous Waste Regulations are comprised of the following:

R.61-79	Definitions and General Provisions
R.61-79.1	Criteria, Identification, and Listing of Hazardous Waste
R.61-79.2	Notification of Hazardous Waste Activities
R.61-79.3	Manifest System, Record Keeping and Reporting
R.61-79.4	Spills
R.61-79.5	Financial Responsibility
R.61-79.6	Generators of Hazardous Waste
R.61-79.7	Transporters of Hazardous Waste
R.61-79.8	Standards for Treatment, Storage, or Disposal Facilities
R.61-79.9	Transport Permits
R.61-79.10	Treatment Storage and Disposal Facility Permits
R.61-79.11	Interim Status, Standards for Treatment, Storage, and Disposal Facilities

The state agency concerned with these matters is the Department of Health and Environmental Control (DHEC).

Of the disposal methods under consideration, burning and incineration concern mainly air pollution rergulations, while the land disposal methods are more concerned with groundwater contamination regulations. To the extent that volatiles are still present in the waste, air pollution regulations will apply. If transportation of the waste to a facility is required, then Department of Transportation regulations will apply to that movement.

5.2.3 Special Problems

This section deals with special disposal problems which arise when the spilled oil contains chlorine, heavy metals, polychlorinated biphenyls (PCBs) or biocides. These highly toxic substances are often added to lubricating oils to prevent biological degradation while in use. Unfortunately, the biological toxicity makes these oils particularly difficult to get rid of when they are spilled or ready for disposal.

One of the few ways to dispose of toxic oily debris occurring near the Charleston Harbor is to transport it to the Pinewood hazardous waste disposal site. The other municipal and private landfills in the area are not equipped to handle these substances and are not allowed to receive them. Incineration is also difficult because of the temperatures and scrubbers required. In fact, there are only two incinerators licensed in the U.S. for disposal of PCB-contaminated materials. Located in Arkansas and Texas, these are run by ENSCO and Rollins International, respectively.

Waste chlorinated hydrocarbons have been successfully burned in a rotary cement kiln with destruction of 99.98 percent efficiency. No emissions of high molecular weight chlorinated hydrocarbons were detected, and light chlorinated hydrocarbons were measured only in the parts-per-billion levels in the emissions.

Presently, the only practical way to dispose of chlorinated oily waste, or oily waste containing heavy metals or biocide is to containerize them and transport them to the Pinewood hazardous waste disposal site. The only practical way to dispose of PCB-contaminated wastes is at the secure landfill located in Alabama, operated by Waste Management Chemical Services

5.3 DISPOSAL COSTS

Disposal costs for the options described above depend on the transportation costs to a disposal site, the disposal fee at the site, and the type and quantity of oil spilled at one time. The cost elements for each disposal method are as follows:

- o Codisposal
  - transportation from spill site
  - dumping fee
- o Incineration
  - transportation cost
  - capital cost, if a new facility is required
  - maintenance
  - operating cost
- o Pinewood hazardous disposal site
  - high transportation cost
  - container cost
  - disposal fee

o Landspreading

- transportation from spill site
- equipment and operating costs
- maintenance

Because compost is not currently practiced in the area and therefore could not be employed quickly enough, and because composting is more expensive but otherwise similiar to landspreading, costs have not been developed for composting as a disposal option. This is based on the assumption that the compost from hydrocarbons is not marketable. Secondly, because Spartanburg is so far away, incineration was considered unfeasible and costs have not been estimated. Finally, since current air pollution regulations do not permit open burning of heavy oils, this option has not been costed.

Codisposal costs at private and municipal sanitary landfills have already been presented in Section 4.0.

It is difficult to evaluate landspreading costs before a site has been chosen. Tables 5-7 and 5-8, taken from Reference 3, give "Estimated Unit Costs for Oil Spill Debris Disposal Operations" and an "Example Cost Estimate for a Hypothetical Oil Spill Debris Land Cultivation Operation". These estimates can be used once potential landspreading sites have been selected.

5.4 SUMMARY

This evaluation indicates that at present, codisposal at the Charleston County sanitary landfills is the best option for relatively small quantities of non-contaminated oil spill debris, while quantities of debris which contain more than one hundred (100) gallons of virgin oil should be deposited in either the Dorchester and/or Berkeley County sanitary landfills. However,

Table 5-7

ESTIMATED UNIT COSTS FOR OIL SPILL DEBRIS DISPOSAL OPERATIONS

ITEM	UNIT COST[7] ($/UNIT)
Site geophysical and engineering studies	10 to 12% of site development costs
Access road construction[1] (if needed)	4.50 to 5.00 per ft
Site preparation (clearing, scarifying, grading, where necessary)	600 to 700 per acre
Excavation and covering of trenches (for burial)	1.00 to 1.30 per yd^3
Application of fertilizer, other soil amendments (for landspreading only, if necessary)	180 to 200 per acre per application
Transportation of debris to site[2]	0.05 to 0.07 per yd^3 per mile
Mixing debris with soil (initial and periodic mixing of debris with soil)[3]	80 to 100 per acre per mixing period
Monitoring well installation[4]	180 to 250 or more per well
Seeding surface of disposal area	180 per acre
Laboratory sample analysis:	
pH	5 to 7
Oil content	25 to 50
Organic acid	10 to 20
Disposal gate charge at sanitary landfill[5]	50 to 100 per day
Sanitary facilities, water, and communications (at remote landspreading and burial sites)	50 to 100 per day
Drainage channels[6]	0.5 per ft
Contingencies	12 to 15% of site development costs

[1]20 ft wide, gravel road.

[2]Assumes dump truck or tractor-trailer rig.

[3]Assumes a D-7 size track dozer pulling a rototiller covering five acres per day.

[4]Depends on many variables, including a soil type, depth to groundwater (if any), and drill rig used.

[5]Charge varies significantly depending on geographic area.

[6]Dirt trench.

[7]All costs in 1976 dollars.

Source: Stearns, et al., 1977, :Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

TABLE 5-8

EXAMPLE COST ESTIMATE FOR HYPOTHETICAL OIL SPILL DEBRIS LAND CULTIVATION OPERATION

ITEM	UNITS	UNIT COST ($)	EXTENSION
Access road	800 ft	8.50	$ 6,803
Site preparation	5 ac	1,152.00	5,758
Drainage	170 ft	0.89	159
Landspreading	5 ac	159.00	797
Geophysical and engineering studies	$13,463	10%	1,346
Miscellaneous facilities			266
Disposal operation contingencies			2,268
Subtotal, Disposal Operations			$ 17,397
Transportation of debris from point of collection to disposal site	1,000 cy	$0.11 per cy per mi	850
Total Cost to Transport and Dispose of Debris			$ 18,247

Source: Stearns, et al., 1977, "Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

Note: Costs have been converted from 1976 dollars to 1980 dollars using an inflation rate of 10% per year.

landspreading should be considered as longer term options which require more detailed investigation.

Therefore it is recommended that a search be initiated, and preliminary lease agreements secured for potential disposal sites which are condusive to landspreading. Criteria for these sites are listed in Table 5-9 and have been described in subsection 5.2.1.7.

Additionally, if Charleston County were to implement a full-scale resource recovery program which incorporates an incinerator to convert it's solid waste into steam and/or electricity, such a facility may also provide a long-term, environmentally sound solution for disposal of fossil fuel contaminated materials generated in the area.

TABLE 5-9

SUMMARY OF OIL SPILL DEBRIS DISPOSAL SITE SELECTION CRITERIA

FACTOR	CRITERION
Land use	Planned use of the site for debris disposal should be compatible with on-site and adjacent land use. Disposal at a sanitary landfill would meet this criterion fully. Debris disposal in a residential area may not be compatible.
Water quality	The site should not be a source of water pollution by oil. Disposal on porous soil overly potable groundwater or in an area subject to flooding would not meet this criterion. Sites that do not overlie groundwater (or, if they do, have a clay layer in between) are likely to offer the best protection for groundwater.
Location	Sites should be situated as closely as practical to the point(s) where oil spill debris is (or might be) collected or stockpiled.
Access	Existing access roads into the site should be of all-weather construction or such roads should be constructable in an emergency situation. A site that cannot be readily accessed is of little use. Access into a muddy farm may be temporarily facilitated by placement of a gravel road or military landing mats.

Source: Stearns, et al., 1977, "Oil Spill Decisions for Debris Disposal, Vol. II: Literature Review".

6.0 FINANCING METHODS FOR LOCAL DISPOSAL OF FOSSIL-FUEL-CONTAMINATED MATERIALS

6.1 GENERAL

Prior to the Torrey Canyon incident of 1967 which discharged approximately 36 million gallons of oil off the coast of Great Britian, no adequate national or international regimes existed to compensate victims of oil pollution damage or to enable governments to recover costs for the cleanup of oil spills. As a result of this and other major incidents, several state and federal regulations have been established to assure compensation for costs incurred by victims of oil spills. Those costs which are recoverable include: containment and clean-up of the oil spill; disposal of oil spill debris associated with these activities; and the restoration or replacement of natural resources damaged or destroyed as a result of the oil spill.

6.2 RESPONSIBILITY OF PAYMENT

Existing state and federal regulations mandate that it is the responsibility of those individuals responsible for a spill of fossil fuel and other hazardous substances to immediately notify the appropriate agencies while simultaneously initiating efforts to contain and clean-up the spill. Further, the spiller is responsible for the disposal of all fossil fuel contaminated materials resulting from spill containment and clean-up activities in a manner consistent with existing regulations. Under most circumstances, the spiller is liable for all costs associated with these activities including the restoration or replacement of natural resources damaged or destroyed as a result of the discharge of oil of other hazardous substance.

A description of applicable state and federal requlations, including cost recovery mechanisms, degree of financial responsibility, civil/criminal penalities imposed, availability of funds, etc., is presented in the following paragraphs.

6.2.1 CLEAN WATER ACT (P.L. 95-217)

Perhaps the most effective act of legislation available to the County of Charleston and other State and Federal agencies, with respect to responding to emergency oil or other hazardous substance spills which may occur within the Charleston Harbor, is the Federal Clean Water Act of 1977 (P.L. 95-217). Section 311 of this Act, entitled " Oil or Hazardous Substance Liability", was enacted to protect the navigable waters and ajoining shorelines of the United States and waters of it's contiguous zone, from oil and hazardous substances discharged by the owners and operators of any vessel, and onshore or offshore facility. This act assures the County that appropriate actions will be implemented to effectively contain and remove the spill from it's waters, and that if public or private assistance is required to conduct these activities, such costs shall be reimbursed.

In the Charleston area, provisions of this Act are administered by the U.S. Coast Guard. A provision of the Act which is of paramount importance in protecting the health and welfare of the United States, is that if the individual(s) responsible for the spill is not identified or if said individual(s), in the opinion of the federal administrator, have not responded to the spill in a reasonable manner, then the federal administrator (Coast Guard) may implement whatever means deemed appropriate (i.e., manpower and/or equipment) for the removal of the oil or hazardous substances discharged and to minimize environmental damage. All costs incurred in the performance of these activities by both the public and private sector, are considered costs incurred by the United States Government and are reimbursable under provisions of this Act. Such costs shall include, but not be limited to, containment and clean-up of the substance spilled, disposal of the accumulated debris associated with these activities, and the restoration or replacement of natural resources damaged or destroyed as a result of the discharge.

Except where the owner or operator of a vessel, offshore or onshore facility can prove that the discharge of oil or hazardous substance was caused soley by; (A) act of God, (B) act of war, (C) negligence on the part of the government, or (D) an act of omission on a third party, the owner or operator shall be liable for all costs incurred by the United States Government in an amount not to exceed:

- $125 per gross ton, or $125,000, whichever is greater for an inland oil barge.
- $150 per gross ton, or $250,000, whichever is greater for vessels carrying oil or hazardous substances.
- $50,000,000 for onshore and offshore facilities.

The Act attempts to allow for compliance of this provision by requiring any vessel over three hundred gross tons, including barges of equivalent size, that make use of any port or place in the United States or navigable waters thereof, to establish and maintain evidence of financial responsibility in the amounts identified above. Any vessel which, upon request cannot produce such evidence, may be denied entry to any port or place in the United States or it's navigable waters by the Coast Guard. The level of financial responsibility for onshore and offshore facilities shall be established and maintained at a level not more than $50,000,000, but not less than $8,000,000. Financial responsibility may be demonstrated by any one, or a combination of, the following means: evidence of insurance; surety bonds; qualification as a self-insurer; or other evidence of financial responsibility.

If the owner or operator liabiliy limits identified above are not sufficient to cover all costs incurred by the U.S. Government, additional monies can be made available through a federal "revolving fund". Section 311(k) of the Clean Water Act established a "revolving fund" to be maintained at a level of $35,000,000 for the purpose of implementing the provisions of this Act. However, if it can be shown that such discharge was the result of willful neglect or misconduct within the privity and knowledge of the owner, then the owner or operator will be liable to the United States Government for the full amount of such costs.

In the Charleston area, access to the revolving fund is gained through the Coast Guard, once it has been demonstrated that Federal clean-up action is required. The Captain of the Port, USCG Marine Safety Office, can obtain an informal commitment of up to $50,000 from this fund to initiate clean-up operations under emergency situations. It should be noted, that only those costs incurred in the performance of activities approved by, or are conducted under the direction of, the Coast Guard, are reimbursable by the revolving fund.

In those instances where the discharge of an oil or hazardous substances is caused soley by the act or omission of a third party, the owner or operator is still responsible for all costs incurred by the United States Government. This provision was incorporated to avoid unnecessary delays in responding to a spill while the responsibility for payment is still being debated. Once the spill has been resolved and the responsible party identified, costs incurred by the owner or operator in responding to the spill are recoverable. The owner or operator is entitled to all rights available to the United States Government under this Act to recover costs from a third party. The liability of the third party is equivalent to that which would have been applicable to the owner or operator of a vessel or onshore or offshore facility from which the discharge actually occurred , if the owner or operator had been liable.

In those instances where the discharge of an oil or hazardous substance is caused solely by an act of God, act of war, or negligence on the part of the United States Government, the United States Government shall be responsible for reimbursement of all costs incurred in response to the spill, including those incurred by the owner or operator of a vessel or an onshore or offshore facility from which the discharge occurred.

Under Section 504 of the Clean Water Act, entitled "Emergency Powers", the federal government has established a contingency fund for those instances where a pollution source presents an imminent and substantial endangerment to the health and welfare of the United States. The level of the fund has been established at $10,000,000 and is intended to augment the provisions of the revolving fund, particularly in those situations where the owner or operator of a vessel, onshore or offshore facility is not liable for the discharge of oil or hazardous substance.

In order to insure that owners or operators of any vessels, onshore or offshore facilities comply with the provisions of this Act, the following fines and civil penalities have been provided:

- o Any person(s) who has knowledge of any discharge of oil or hazardous substance of a quantity determined to be harmful under these regulations, and fails to notify the appropriate agency of the United States Government (Coast Guard), then that person(s) shall be fined, upon conviction, not more that $10,000, or imprisoned for not more than one year, or both.

- A civil penality of not more than $5,000 shall be assessed for each offense, whereby the discharge of an oil or hazardous substances was discharged in quantities determined harmful by these regulations.

- A civil penality of not more than $5,000 shall be assessed for each offense, whereby any provision of this Act has not been complied with.

To eliminate confusion in determining the quantity of "oil" harmful under these regulations, (verifying the quantity of oil associated with a particular spill is impossible at best) an oil spill is considered harmful if it produces a sheen. "Oil" as defined herein, is oil of any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil. In the Charleston area, the actual cash amount for each fine and/or civil penality imposed, is determined by the Coast Guard.

6.2.2 ARTICLE 3: S.C. CODE OF LAWS, 1976 - POLLUTION CONTROL (S.C. OIL & GAS ACT)

Article 3. of the S.C. Code of Laws, was enacted as a means to protect the interests of the State with respect to spills, discharges and escapes of pollutants occurring as a result of procedures in the transfer, storage, and transportation of products which pose a threat of danger and damage to the environment of the State, particularily in those instances where Federal regulations are not applicable or are inadequate. This article is not intended to supercede any Federal regulations, but rather to support and complement them. Consequently, several provisions of this article are similiar in context to those of the Federal Clean Water Act, specifically Section 311.

The authority to administer this article has been conferred to the Department of Health and Environmental Control. Similiar to those powers available to the U.S. Coast Guard to administer provisions of the Clean Waste Act, DHEC can authorize the use of private contractors to assist in, or conduct, those activities deemed appropriate to effectively contain, clean-up or dispose of, any oil or hazardous substance discharged, in those cases where the scource of the spill is unknown or the spill is not being responded to in a reasonable manner. In addition, the State Department of Highway and Public Transportation, the Water Resources Commission, and any other State agency shall cooperate and lend assistance to DHEC upon request.

In accordance with the provisions of this article, it is the responsibility of any person(s) discharging an oil or hazardous substance, to immediately implement appropriate action to contain, remove and abate the discharge to DHEC's approval. All costs incurred by DHEC in their efforts to enforce this provision, shall be reimbursed by the spiller, including those incurred by private contractors and other state agencies, unless such discharge was caused soley by; (a) an act of God, (b) act of war, (c) negligence on part of the U.S. Government or State, or (d) act or omission of a third party,

Unlike the Clean Water Act which requires "potential" spillers of oil and other hazardous sustances to establish and maintain substantial limits of financial responsibility, this article does not impose such requirements, and consequently, DHEC is not assured of recovering <u>all</u> costs associated with containment, removal and abatement of oil or hazardous substances discharged upon the land or waters of the State. This article only requires that owners or operators of terminal facilities furnish evidence of financial responsibility ($14,000,000) to meet all liabilities caused by their operation. Terminal facilities as defined herein, include any waterfront or offshore facility, and any related appurtenances used for the purpose of drilling for, pumping, storing, handling, transferring, processing, or refining pollutants.

Although this article allows for the establishment of a fund to cover the cost of such activities which may be required to contain, remove and abate a discharge of oil or hazardous substance, to date the State legislature has not appropriated any monies for the fund. However, it is important to note, that spills which are the subject of this study, i.e., the discharge of fossil fuel material in the Charleston Harbor, are subject to the provisions of the Clean Water Act, Section 311, and therefor are likely to be recovered.

In order in insure that the provisions of this article are complyed with, the following penalities are provided:

- Any person making false statement in response to any provision of this article with a fradulent intent, shall be deemed guilty of a felony, and upon conviction, shall be imprisoned for two (2) years or fined $5,000 or both.

- A civil penality up to $10,000 per day per violation shall be assessed by DHEC, whereby any provision of this article has not been complyed with. This penality shall be the only penalty assessed by the State, and the assessed person(s) shall be excused from any other water pollution related penalty for the same occurrance. The penalty shall not apply if the discharge of oil or hazardous substance is promptly reported and removed in accordance with the rules and regulations of DHEC.

6.2.3 CHAPTER 1: S.C. CODE OF LAWS, 1976 - POLLUTION CONTROL ACT.

Chapter 1. of the S.C. Code of Laws, was enacted to protect the interest of the State with respect to maintaining reasonable standards of purity of air and water resources. Provisions of the chapter are administered by the Department of Health and Environmental Control (DHEC), and allows the Department to take whatever action necessary or appropriate to secure for the State the benefits of the Federal Clean Water Act and Federal Clean Air Act. The primary difference between this regulation and those described in Sections 6.2.1 and 6.2.2, is that, although this chapter allows the State to implement actions necessary to abate, control and prevent air and water pollution, it does not provide a means by which costs incurred in the performance of these activities can be recovered, particularily those incurred in emergency response situations. This chapter does however, allow for the assessment of substantial penalities in those instances where it's provisions are violated, unless such act was caused by an act of God, war, strike, riot or other catastrophe. The penalities provided for under this chapter are as follows:

- Any person who willfully or negligently violates any provision of this chapter, shall be deemed guilty of a misdemeanor and upon conviction shall be fined not less than \$500 nor more than \$25,000 for each day's violation or be imprisoned for not more than two (2) years, or both.

- o A civil penality not to exceed $10,000 per day per violation shall be assessed by DHEC, whereby any provision of this chapter has not been complyed with.

6.3 ADEQUACY OF COMPENSATION

Experience to date for fossil fuel related spills (eg. diesel, #6 oil, waste oil, etc.), which occur within the navigable waters of Charleston County, has demonstrated that the cost recovery mechanisms available to the public and private sector for reimbursement of costs incurred in the conduct of containment, clean-up, disposal and restoration/replacement activities associated with these spills, are adequate. Furthermore, experience would indicate that the requirements of those regulations described herein, and the penalities imposed therein, are of sufficient magnitude to insure that individual(s) responsible for the discharge of fossil fuel materials will respond to a spill in a manner consistent with the requirements of the U.S. Coast Guard and appropriate State agencies. Spills which occur within the navigable waters of Charleston County are subject to the provisions of Section 311 of the Federal Clean Water Act, as described in Section 6.2.1.

In the past, the majority of spills have been small in size, generally less than 200 gallons, and relatively infrequent. Available data would indicate that the number of spills of significance which have occurred since 1980 are less than 15 in number, not counting spills resulting from pleasure boats or those which may have occurred at the Navy shipyard. The majority of these spills have been responded to by Seahol Contracting Co., a local firm specializing in spill containment and clean-up. Seahol maintains and operates oil spill equipment owned by the Charleston Industry Liquid Spillage Control Committee. This committee was instituted by members of the American Petroleum Institute. One of the committee's objectives was to create a single task force as a co-operative to share the cost for oil spill equipment. Members of the committee pay only for labor to operate the equipment and materials consumed, i.e., gasoline, absorbents, etc. Non-members who elect to use the committee's equipment pay a scheduled rental rate in addition to those costs required of members.

To date, Seahol has experienced success in recovering costs associated with these activities, however, they did indicate that in those instances where an international vessel utilizing the Charleston Harbor was the responsible party, reimbursement could be delayed due to time lost working through diplomatic channels and/or through foreign insurance companies.

Based on a review of Federal and State regulations applicable to fossil fuel spills which occur in the navigable waters of Charleston County; available data on the reimbursement of recoverable costs to date; and the professional opinion of individuals who are active in the spill response network, it would appear that the financing of those activities associated with containment, clean-up, disposal and restoration/replacement resulting from fossil fuel spills, are adequate regardless of the responsible party.

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APPENDIX A-1

CHARLESTON HARBOR: BACKGROUND INFORMATION

PREDICTING SPILL DISPERSION

Spill dispersion depends on a number of factors including prevailing tidal and other currents, prevailing wind patterns, and the nature of the spilled material. A spill response team should be made aware of all of these factors as an accurate prediction of surface oil movements will enable clean-up operations to be most efficient and effective.

Tidal current charts for the harbor of Charleston, SC are available from the U.S. Coast Guard. The currents in Charleston Harbor have been well mapped both for direction and velocity.

Generally, Charleston Harbor proper is affected by river currents from the Ashley, Cooper, Wando, and other smaller rivers flowing in approximately a southerly direction and tidal currents moving through the mouth of the harbor to the south and somewhat east of the harbor proper. The tidal currents are quite strong at the mouth of the harbor, up to 2.5 knots at maximum flood tide and up to 4.0 knots at maximum ebb tide. These currents are strong enough to reverse the flow of the Cooper and Wando Rivers up to 15 nautical miles upstream from the mouth of the harbor. The height of high tide above mean low water varies from 0.75 feet to 5.75 feet depending on the moon's position in relation to the Fort Sumter meridian.

During ebb tide the water takes the most direct route to the mouth of the harbor but during flood tide there are a number of reverse flow eddies that small boat navigators and parties interested in tracking surface water movements (as during an oil spill) should be aware of. For example, there is a small gyre that circles an island northwest of Cummings Point. This gyre occurs between one hour before maximum flood tide and two hours following maximum flood tide. Another example is a reversal of the tidal flow along the eastern shore of the Cooper River, just across from Charleston and north of Hog Island Point. From one hour before maximum flood tide to one hour following maximum flood tide, the current moves in a southerly direction along the shore, in the opposite direction of the current midchannel. Because there are oil transfer operations on the west side of the Cooper River in Charleston, this reverse flow eddy has potential significance to oil spill clean-up operations.

As mentioned in Section 3.0, most oil spills occur at the site of transfer operations. In the Charleston Harbor, though most of the oil transfer points are on the Cooper River between Charleston and Bushy Point, there are some located on the eastern shore of the Ashley River as well. Except at approximately two hours after maximum flood tide when the tidal current is beginning to change direction and the current pattern is more random, in both of these immediate areas current direction and approximate velocity can be easily predicted if the time of the tidal cycle is known.

In the Charleston Harbor area the prevailing winds are northerly in the fall and winter and southerly in the spring and summer. Wind is a significant factor in the determination of surface water currents. If both the wind and the tide are moving in the same direction, the velocity of the surface water would be greatly increased. Conversely, if the tidal currents are moving in the opposite direction from the wind there will be a lot of chop on the water surface, any oil spilled on the surface would be broken up and would disperse more readily, making clean-up operations more difficult.

Although the prevailing winds, currents, and waves are important in determining the dispersion on an oil spill, the most important factors are the chemical and physical characteristics of the spilled material. The viscosity and pour point of the oil will determine the rate of spreading. Viscous crude or Bunker C oil with high viscosity (~ 500 centipoises) and high pour point (> 50°F) will spread much more slowly than gasoline. The physical properties affecting oil spill dispersion are evaporation, solution, and absorption; the chemical properties are biological oxidation and auto-oxidation. These are discussed below.

The less viscous and the lower the pour point of a given spilled oil, the more rapidly spreading on the water surface will occur. In turn more spreading means more surface area which allows evaporation to take place more rapidly. As shown in the Table 1, the number of carbon atoms in the various hydrocarbon compounds making up the petroleum determines the rate of evaporation. Table 2 gives the hydrocarbon composition of various petroleum products. Using these two tables, it is easy to predict, for example, that gasoline or kerosene spilled on the water surface would evaporate rapidly. Fifty percent of the average crude oil (composed of 30 percent gasoline, 10 percent kerosene, 15 percent light distallate oil, 25 percent heavy distallate oil, and 20 percent extremely heavy residual oil) is removed by evaporation. Of course crude oils vary substantailly in composition and thus so would the percent of material removed by evaporation. In contrast, 75 percent of diesel and #2 fuel oil is removed by evaporation; and nearly 100 percent of any gasoline or kerosene is removed by evaporation. On the other end of the spectrum, only 10 percent of Bunker C or #6 fuel oil will be lost to volatilization. Rough seas, because of bubbles and spray, will increase the exposed surface area, and will act to increase the rate of evaporation.

The low molecular weight and highly polar components of petroleum are the most soluble and are rapidly lost from the

Table 1.

NUMBER OF CARBON/ATOMS	BOILING POINT	EVAPORATION LOSS
$< C_{15}$	$> 250° C$	Rapid
$C_{15}-C_{25}$	$250° C - 400° C$	Limited
$> C_{25}$	$> 400° C$	Almost none

Source: Koons, C.B., 1973, "Chemical Composition: A Control on the Physical and Chemical Processes Acting on Petroleum in the Marine Environment".

Table 2.

TYPE	COMPOSITION
Gasoline	$C_5 - C_{10}$
Kerosene	$C_{10} - C_{12}$
Light distillate oil	$C_{12} - C_{20}$
Heavy distillate oil	$C_{20} - C_{40}$
Extremely heavy residual oil	$> C_{40}$

Source: See Table 1., above.

Table 3.

COMPOUND	SOLUBILITY IN DISTILLED WATER (ppm)
$n-C_5$	400
$n-C_6$	10
$n-C_7$	3
$n-C_8$	1
$n-C_{12}$	0.01
$n-C_{30}$	0.002

Source: McAuliffe, et al., 1966, 1969, "Solubility in Water of Parrafin, Cycloparrifin, Olefin, Acetylene, Cycloolefin, and Aromatic Hydrocarbons".

surface slick to the water column below. Water solubility decreases substantially as the carbon number increases. Table 3 shows the solubility of distilled water of a variety of normal alkanes. For example benzene (C_6) has a solubility of 1800 ppm vs. the normal C_6 alkane which has a solubilty of 10 ppm. As stated above, the very polar compounds dissolve rapidly. In addition, as oxidation takes place, polar compounds are formed. These are dissolved as they form. In general, oxidation produces compounds with greater solubilities than the original compounds. For example, the oxidation of n-octane with a solubility of 1 ppm, produces n-octanol which has a solubility of 400 ppm [10]. This large difference in solubilities between the parent and oxidized compounds is generally found only in the lower molecular weight hydrocarbons. High molecular weight NSO compounds are structurally similiar to high molecular weight hydrocarbons, often with only a single nitrogen, sulfur, or oxygen molecule present [11].

Adsorption may be an important dispersion mechanism for petroleum products, especially those with specific gravities close to 1.000. If the seas are rough, the oil may rapidly form an oil and water emulsion with sand, silt, or shell fragments entrained as well. If the oil is heavy, it may take only a small amount of foreign material to increase the specific gravity to more than 1.025 (the specific gravity of seawater) allowing the materials to sink.

In general, the physical processes affecting spill dispersion (evaporation, solution, and absorption) are most important immediately after the spill occurs, while the chemical processes (biological oxidation and auto-oxidation) become more important as time passes.

The major chemical process affecting spilled oil is oxidation, although reduction may occur if the oil sinks to the bottom and there is very little oxygen present. Auto-oxidation is the spontaneous reaction of the hydrocarbon molecules with molecular oxygen. This process will occur at temperatures greater than 70^{o}F and is aided by sunlight. Variable valance metals will catalyze auto-oxidation while any sulphur compounds in the oil will inhibit the process. The structure of the hydrocarbons affect the rate of auto-oxidation; tertiary hydrogens are auto-oxidized more rapidly than primary or secondary hydrogens. Therefore alkyl substituted napthenes and isoprenoid paraffins are oxidized more slowly than are normal alkanes.

Zobell found that in well oxygenated water, biological oxidation will range from .02 to 2.0 g/m^2 per day at 25^{o} C [12]. This is as much as 10 times the rate of auto-oxidation of hydrocarbon compounds [13]. Complete microbial oxidation of hydrocarbons yields carbon dioxide, water, nitrates and sulfates. However, the oxidation reactions are not always taken to completion. End products of incomplete oxidation, which are soluble in water, are acids, aldehydes, ketones, alcohols, peroxides, and sulfoxides. Jobson, Cook and Westlake found that the rate of biological oxidation was greatest for saturated compounds, less for aromatic compounds, and least for the asphaltene compounds found in petroleum [13]. In addition, n-alkanes are microbially oxidized more rapidly than isoprenoid alkanes.

APPENDIX A-2

CHARLESTON HARBOR: BACKGROUND INFORMATION

ENVIRONMENTAL SENSITIVITY

The process of determining the environmental sensitivity of various ecological areas within Charleston Harbor could be a very expensive study, complete with detailed mapping of the sensitivity of the South Carolina coastline, has been conducted by the Research Planning Institute for the South Carolina Department of Health and Enviromental Control.

The field work for this study was carried out between January and June of 1981. The South Carolina coastline was broken down into 50 maps (1:24,000 scale; 7.5-minute quadrangles) which covered the entire coastline of the state. These maps, known as Environmental Sensitivity Index (ESI) maps, classify the various coastal habitats as to their sensitivity to oil spills and subsequent contamination.

The Environmental Sensitivity Index (ESI) evolved from a series of indices which were developed to classify the expected vulnerability of the ecological environment to oil spills. Earlier indices were based primarily on physical characteristics and associated response to spills. The ESI incorporates the geomorphic components as well as biological and socioeconomic factors in determining environmental sensitivity. The use of the ESI in mapping has been applied to a variety of coastlines including those of six other states.

The ESI classifies coastal environments on a scale of 1 to 10 with 1 (vertical sea walls) being the least sensitive to oil spills and 10 (marshes) being the most susceptible to serious damage. The index has been developed from a careful study of literature reports of previous major oil spills, classical ecological studies and direct field research. The 14 different coastal environments classifed in the Index are given below with their assigned numbers:

1) Exposed vertical seawalls
2) Not present in South Carolina
3) Fine-grained sand beaches
4) Medium- to coarse-grained sand beaches
5) Exposed tidal flats (low biomass)
5a) Mixed sand and shell beaches
5b) Sheltered erosional scarps
6) Shell beaches
6a) Exposed riprap
7) Exposed tidal flats (moderate biomass)
7a) Erosional scarps in marsh
8) Sheltered coastal structures
9) Sheltered tidal flats (high biomass) and oyster beds
10) Marshes

Detailed descriptions of each of these environmental classifications are provided herein. This information has been excerpted directly from the handbook "Sensitivity of Coastal Environmental and Wildlife to Spilled Oil, State of South Carolina" prepared for the South Carolina Department of Health and Environmental Control, Contract No. EQC-1-197, by Research Planning Institute, Inc., in 1981. This book should be used as reference for listing of wildlife found in the state.

"1) <u>Exposed Vertical Seawalls</u>

<u>Description</u>

o Physical
- Man-made structures with little to no beach face at all tidal levels.
- Exposed to strong waves and currents along open ocean shorelines.

o Plants
- Dominant plants are attached green algae such as <u>Ulva</u> and <u>Enteromorpha</u>.

o Animals
- Barnacles are dominant animals.
- Barnacles have maximum densities in the upper intertidal zone.
- Infauna are minimal due to solid substrate.
- Low diversity, moderate to high density, and low species richness.

<u>Predicted Oil Behavior</u>

o Along vertical seawalls:
- Most oil would be held offshore by reflected waves.
- Deposited oil would be removed rapidly by waves.
- Some oil splash or overtopping may occur.

<u>Potential Biological Damages</u>

o Greatest exposure would be to upper intertidal organisms.

o Impact to fauna and flora would be low due to short-term oil persistence.

o Mortalities may be caused by smothering in cases of heavy oiling.

<u>Recommended Cleanup Activity</u>

o In general, little or no cleanup would be necessary; however, high-pressure spraying would be effective and convenient in most areas where exposed vertical seawalls are present.

o Cleanup recommended for aesthetic reasons only, since most seawalls are located in high recreational-use areas.

"2) Not Present in South Carolina

Note: ESI #2 is exposed wavecut or rocky platforms which are common in techonically active shorelines such as Alaska; or along tropical coasts where cemented carbonate beach sands form rocky intertidal terraces.

3) Fine-grained Sand Beaches

Description

o Physical
- Usually gentle slope with broad, flat profile.
- Often exposed to moderate and high wave energy.
- Shell accumulations may be present in lower intertidal zone or back beach area.

o Plants
- Scattered beach grasses and plants growing at base of matural dunes.
- Beach wrack composed of decaying Spartina grasses.

o Animals
- Insects and amphipods associated with beach wrack are present.
- Burrowing amphipods and polychaete worms are present in the upper and mid intertidal zones.
- Some burrowing clams are present in the lower intertidal to subtidal zones.

- Diversity, density, and species richness low to moderate
- Ghost crabs are common at base of dunes along back beach areas.

Predicted Oil Behavior

o Large accumulations would cover entire beach face.
o Small accumulations would be deposited primarily along high-tide swash lines.
o The compact sediments of this beach type prevent deep penetration of oil.
o Oil may be buried to a maximum of 10-20 cm along the upper beach face.

Potential Biological Damages

o Biological damages would be limited.
o Intertidal organisms would have short-term exposure because oil would be deposited over berm crest; impact may

" occur to supratidal organisms such as beach hoppers (Talorchestian amphipods).

Recommended Cleanup Activity

- o Cleanup should begin only after majority of oil is deposited onshore.
- o Cleanup should concentrate on removal of oil from upper swash zone.
- o Mechanical methods should be used cautiously, but fine-grained sand beaches are generally among the easiest to clean mechanically because of their hard, compact sudstrate.
- o Removal of sand should be minimized.

4) Medium- to Coarse-Grained Sand Beaches

Description

o Physical
- Usually displays a short, steep beach face with a wide back shore or washover terrace.
- Sediments are loosely compacted.
- Beach morphology responds rapidly to changing wave and tidal conditions.

o Plants
- Beach wrack is predominantly decomposing Spartina.

o Animals
- Low species diversity, density, richness.
- A few polychaetes, amphipods, and clams are found at or between low and mid intertidal zones.
- Beach wrack provides habitat for amphipods and insects.

Predicted Oil Behavior

- o Large accumulations would cover entire beach face.
- o Small accumulations would be deposited primarily along high-tide swash lines.
- o Oil may be buried along berm and berm runnel.

Potential Biological Damages

- o Biological damages would be minimal.
- o Supratidal organisms would suffer only short-term exposure unless oil penetrates substrate.
- o Where oil penetrates substrate, some die-offs of infauna would be expected.

" Recommended Cleanup Activity

- o Cleanup should commence only after majority of oil is deposited onshore.
- o Cleanup should concentrate on removal of oil from swash zones.
- o Mechanical methods should be used cautiously.
- o Sediment removal should be minized.

5) Exposed Tidal Flats (Low Biomass)

Description

o Physical
-Sediments are generally fine-grained sand.
-Sediments are very mobile due to waves and tidal currents.
-Associated with tidal deltas and, in some areas, front sand or mixed sand and shell beaches.

o Plants
-Very little flora present.
-Mobile substrate prevents attachment of algae.

o Animals
-When present, bethic infauna are dominant organisms.
-Species diversity, density, and richness vary with substrate.
-Clams, polychaetes, and burrowing crustaceans are the most common macroorganisms.
-Faunal density is lowest at high intertidal zone, increasing at mid and low intertidal zones.
-In sand-bottom flats exposed to high wave energy, deep-burrowing clams dominate simple benthic communities.
-Birds utilize exposed flats as roosting and foraging areas.

Predicted Oil Behavior

- o Most oil would be pushed across tidal flat surface onto adjacent shores by wave and tidal activity.
- o Mobile sediments in coarser-grained flats would prohibit long-term accumulation.
- o Light fractions of oil may contamiante the intertidal waters.

Potential Biological Damages

- o Oil would impact organisms at high-tide swash zones and in pools left during receding tide.

"
- Oil left on substrate during receding tide would:
  - Penetrate burrows of clams and other burrowers.
  - Come in contact with or be ingested by these organisms.
  - Be incorporated into the sediments.
- Birds foraging on the flats would be exposed to oil by:
  - Feather oiling.
  - Ingestion of immobilized or weakened organisms resulting from oil contamination.

Recommended Cleanup Activity

- No cleanup usually necessary in areas where oil accumulation is low.
- Removal of sediment should be avoided.

5a) Mixed Sand and Shell Beaches

Description

- Physical
  - Sediments may be either dominantly mobile or stable, dependent on location of beach with respect to wind and wave conditions.
  - Generally composed of medium sand and broken shell.
  - Natural sorting processes may form sand "stringers" at lower intertidal zones.

- Plants
  - Because of scouring action from active movement of beach sediments due to waves, plants are unable to survive.

- Animals
  - Few macrofaunal organisms are able to survive in mobile sand/shell beaches.
  - Low species diversity, density, and richness.

Predicted Oil Behavior

- Oil would be deposited primarily high on the beach face.
- Only under heavy accumulations would oil be deposited over the lower beach face.
- Burial may be deep along berm.
- Long-term persistence of oil is dependent on incoming wave energy; in sheltered areas, oil would remain for several years.

" Potential Biological Damages

- o Roosting birds would be affected by oiled feathers and possible ingestion of contaminated prey.

Recommended Cleanup Activity

- o Oil should be removed primarily from upper swash lines.
- o High-pressure spraying may be necessary.
- o Mechanical reworking of sediment into the surf zones effective if oil accumulations are heavy enough to require it.
- o Removal of sediment should be restricted.

5b) Sheltered Erosional Scarps

Description

- o Physical
  - Occur along tidal creek environments where erosion is occurring to relict (mostly Pleistocene) sediments.
  - Includes dredged channel escarpments along the Intracoastal Waterway.
- o Plants
  - Terrigenous non-marine detritus, trees, roots, and grasses exposed along shorelinne due to slumping of land along erosional scarp.
- o Animals
  - Infaunal diversity, density, and richness are very low - only a few insect larvae were found.

Predicted Oil Behavior

- o Oil would be deposited on detritus and at base of scarp.
- o Long-term persistence is dependent on incoming wave energy and erosion rates.

Potential Biological Damages

- o Biological damages would be minimal.

" Recommended Cleanup Activity

- o High-pressure spraying may be effective.
- o Good place to corral oil if adjacent areas are higher in sensitivity.

6) Shell Beaches

Description

- o Physical
  - Sediments may be either dominantly mobile or stable, dependent on location of shoreline with respect to wind and wave activity.
  - Composed mostly of oyster and/or quahog shells; generally less than ten percent sand.
  - Common along banks of dredged channels including the Intracoastal Waterway; reworked spoil banks.

- o Plants
  - Shell beaches are generally devoid of vegetation.

- o Animals
  - Shell beaches are generally devoid of fauna.

Predicted Oil Behavior

- o Oil would be deposited primarily on the upper beach face.
- o Oil would percolate easily into the sediments.
- o Burial may be exceptionally deep along the berm.

Potential Biological Damages

- o Damages would be minimal.
- o Chronic leaching of oil after percolation into the beach would continue to affect adjacent, more sensitive environments.

Recommended Cleanup Activity

- o Most shell beaches are formed from dredged spoil material and are generally of limited extent and quite narrow, aligning with channels.
- o Since they are generally associated with more sensitive marsh and tidal flat areas, they would provide a preferred zone to beach incoming oil.
- o Cleanup may require removal of oiled shell to minimize oil leaching into adjacent salt marshes.

"6a) Exposed Riprap

Description

- Physical
  - Predominantly gravel to boulder-sized riprap revetments.
  - Riprap is composed generally of quarried Piedmont granite or high-grade metamorphic rocks (e.g., gneiss).
  - Most common along back beach areas as shore protection for developed property.

- Plants
  - Green filamentous algae and Ulva observed on some riprap in the tidal zone.

- Animals
  - Infaunal densities are moderate to high.
  - Barnacles are patchy with densities ranging as high as 19,500 individuals/m^2 (based on 1/25 m^2 sample).

Predicted Oil Behavior

- Oil would percolate easily between gravel and boulder elements of riprap.
- Heavy oils would adhere to irregular surfaces of boulders, whereas light oils would be removed by wave action.

Potential Biological Damages

- Barnacle community would have short-term impact, primarily from smothering.
- Recolonization would occur relatively quickly after boulders are naturally cleaned of oil.

Recommended Cleanup Activity

- May require high-pressure spraying:
  - to remove oil.
  - to prepare substrate for recolonization of barnacle and oyster communities.
  - for aesthetic reasons.
- Since riprap is often associated with developed, recreational beaches, cleanup would be advisable to minimize chronic leaching of oil trapped in the rocks.

"7) <u>Exposed Tidal Flats (Moderate Biomass)</u>

<u>Description</u>

- o Physical
  - Sediments range from mud to coarse shell.
  - Generally, sediments are less mobile than those of ESI=5.
  - Associated with tidal deltas and prograding spits.

- o Plants
  - Very few flora are present.

- o Animals
  - Benthic infauna are dominant organisms.
  - Species diversity and density vary with substrate, which ranges from mud to mixed sand and shell.
  - As in ESI=5, clams, polychaetes, and burrowing crustaceans are most common macroorganisms, but are found in greater abundance.
  - Faunal density is lowest at high intertidal zones, increasing at mid and lower intertidal zones.
  - Species diversity is low and richness is moderate to high.
  - Deep-burrowing clams dominate simple benthic communities.
  - Birds utilize exposed flats as roosting and foraging areas.

<u>Predicted Oil Behavior</u>

- o Most oil would be pushed across tidal flat surfaces onto adjacent shores by wave and tidal activity.
- o Mobile sediments in coarser grained flats would prohibit accumulation.

<u>Potential Biological Damages</u>

- o Oil would impact organisms at high-tide swash zones and in pools left during receding tide.
- o Oil laid down on substrate by receding tide would:
  - penetrate burrows of clams and other burrowers.
  - come in contact with or be ingested by these organisms.
  - be incorporated into the sediments.
- o Birds foraging on flats during low-tide would be exposed to oil by:
  - Feather oiling
  - Ingestion of oil from preening of contaminated feathers.

"

- Ingestion of organisms which have been immobilized or weakened by oil contamination.

Recommended Cleanup Activity

- o No cleanup usually necessary where oil accumulation is low.
- o Removal of sediment should be avoided.
- o Use of heavy machinery would tend to mix oil into sediments; however, in areas where fine-grained, compacted sand occurs, heavy machinery can be used.
- o In cases of heavy oiling, the beach side of the flats should be cleaned of oil.

7a) Erosional Scarps in Marsh

Description

- o Physical
  - Eroding scarps along tidal creeks and rivers in cohesive marsh sediments; sometimes a combination of a narrow tidal flat, a narrow beach, and an erosional scarp.
  - Commonly associated with less saturated (with water), high marsh sediments and dredge-spoil deposits.
  - Most common on the southern half of the coast.

- o Plants
  - Roots and rhizomes of Spartina alterniflora would be exposed and eventually slump into the water.

- o Animals
  - Would be similar to organisms in ESI=7 tidal flats.
  - Few organisms would be found in erosional scarps, but Ulva burrows would be exposed by the erosion.

Predicted Oil Behavior

- o Little oil would penetrate cohesive, fine-grained sediments, but would affect intertidal communities or animals.
- o Erosion processes would naturally remove oil.

Potential Biological Damages

- o Damage to erosional scarps would be minimal.
- o Oil coating exposed roots and rhizomes of S. alteniflora might kill off fringe plants.
- o Some impact may occur to organisms in sheltered tidal flats fronting scarps.

" Recommended Cleanup Activity

- Erosional scarps in high marsh sediments would provide a better location to corral oil due to lower sensitivity than adjacent marshes and tidal flats.
- Cleaning and removal may be necessary to protect adjacent, more sensitive areas.

8) Sheltered Coastal Structures

Description

- Physical
  - Includes bulkheads, riprap, piers, and docks.
  - Typically a low-energy environment, dependent on seasonal storm activity.
  - Generally associated with more sensitive, back-barrier environments.
- Plants
  - Low to moderate growths of Enteromorpha and Ulva.
- Animals
  - Intertidal zones contain moderate to heavy populations of oysters and their biota.

Predicted Oil Behavior

- Long-term (1-2 years) persistence of oil, especially between rocks and boulders.
- Oil would penetrate more deeply into porous structures.

Potential Biological Damages

- Oysters would be impacted by oiling; mortalities would be high in heavy oiling.
- Oil persistence would be long-term because of low wave energy. In cases of heavy oiling, mortalities would be great throughout the intertidal zone.

Recommended Cleanup Activity

- High-pressure spraying may be effective in removing oil and cleaning substrate for recolonization.

"9) Sheltered Tidal Flats (High Biomass) and Oyster Beds

Description

- Physical
  - Composed of mud or silty sand.
  - Sheltered from major wave and tidal activity.
  - Usually located in back barrier areas.
  - Occur with extensive oyster colonies in many areas.

- Plants
  - Mud flats are generally devoid of vegetation.

- Animals
  - Macroinfauna species diversity, density, and richness high.
  - Extensive clam and oyster populations are present.
  - At high tide, these flats support a large epibenthic community of blue crabs, flounder, channel bass, spotted sea trout, and other vertebrate and invertebrate species.
  - At low tide, many species of birds feed on tidal flats.

Predicted Oil Behavior

- Long-term (several years) persistence of oil due to lack of wave and tidal activity.
- Long-term oil incorporation into sediments is common.
- Oil would be deposited primarily along high-tide swash zones.

Potential Biological Damages

- Extensive die-offs of infauna would be expected.
- Mortalities would be caused by smothering and ingestion.
- Oil would penetrate burrows, mixing in with sediment several centimeters below the surface.
- Recovery would be slow; oil persistence would be long-term.
- Stressed clams move to the surface, attracting birds and other scavengers who can become affected.
- Impact to birds through ingestion of contaminated food or through preening of oiled feathers.

Recommended Cleanup Activity

- Where sediment is compact, manual and mechanical cleanup may be effective for massive accumulations.

- Traffic over the flat should be limited.

10) Marshes

Description

- Physical
  - Over 500,000 acres of coastal marsh of which 334,000 are considered salt marsh.
  - Occur as broad areas between barrier islands and the mainland.
  - Generally fronted by a sheltered tidal flat.
  - Well sheltered from extreme wave and current action.
  - By far, the most common shoreline type in South Carolina.

- Plants
  - Three types of coastal marshes present
    1) Low marsh - predominantly *Spartina alterniflora* occurs in the mid to upper intertidal zones.
    2) High marsh - occurs in the upper intertidal to supralittoral zones; some common high marsh plants are *Spartina patens*, *Salicornia virginica*, *S. bigelovii*, *Batis maritima*, *Limonium carolineanum*, *Sporobolus virginica*, and *Distichlis spicata*.
    3) Brackish freshwater marsh - dominated by *Juncus roemerianus* and *Spartina cynasuriodes*.

- Animals
  - Associated with invertebrates include marsh periwinkles, fiddler crabs, pulmonate snails, polychaetes, amphipods, clams, and mussels.
  - Densities of both epifauna and infauna range from moderate to high.
  - Marshes utilized by numerous birds, alligators, raccoons, and rodents for feeding and reproductive habitat.

Predicted Oil Behavior

- Long-term (5-10+ years) persistence of oil is common with heavy accumulations.
- Oil in small quantities would be deposited along outer fringe.
- Oil in large quantities may cover entire marsh.

Potential Biological Damages

- Oil would be persistent in sheltered marsh areas.

"
- o Long-term exposure to oil would damage marsh plants.
- o Epifauna and infauna would be affected by long-term exposure.

Recommended Cleanup Activity

- o Under light oiling, the best practice is to let the marsh recover naturally.
- o Cutting of oiled fringing grasses or low-pressure flushing may be effective.
- o Vehicles and cleanup crews should avoid activity on marsh surface, where possible.
- o Under heavy oiling, complete scraping of the impacted marsh followed by soil renourishment, replanting, and fertilization may be necessary."

The Charleston Harbor area is detailed in maps #22, 23, 24, and 25. Starting from the southwest and working clockwise to the northeast, the following waterways associated with the harbor area and their adjacent environmental areas should be considered.

The Stono River

The Stono River is an important waterway as it connects with the intercoastal waterway leading in a southwesterly direction from the harbor. While there is limited commercial traffic carrying oil and petroleum products on the intercoastal canal, there is sufficient barge traffic to warrant planning for a spill in this area. The limited depth, 12 feet, and the narrow channel and sharp turns greatly limit the type of ship traffic in the waterway. No heavy tankers or transport ships use the intercoastal waterway and the width and numerous turns limit barge traffic to two barges and a tug.

The intercoastal waterway, because of its position behind the barrier islands, is surrounded by sheltered tidal flats and marshes. Both of these environments are extremely sensitive to oil spills and thus should be protected as much as possible. Booms and skimmers at the mouth of the waterway will help prevent the contamination of this area in the event of a major spill in the harbor. However, in the event of a spill within the waterway, little in the way of preventive measures other than containment can be employed.

The river supports a variety of fish including herring, shad, sturgeon, and striped bass. There are no major shellfish beds or bind rookeries in the area.

The Ashley River

The Ashley River does not present a major concern in planning for oil spill contingencies. There is only a very small amount of tanker and barge traffic on the river. The major traffic on the Ashley is the transport of fuel oil which is carried to the power plant across from Duck Island. The upper reaches of the river support populations of herring, shad, sturgeon, and striped bass, but there are no major shell fish beds or bird breeding and nesting areas. Pelicans and bottlenose dolphins visit the lower river on a year-round basis. The mouth of the river is considerably wider than the intercoastal waterway, but still an effort should be made to use booms and barricades to prevent oil spilled in the harbor from moving up the Ashley River.

The Cooper River

The Cooper River has by far the greatest amount of tanker and barge traffic in the harbor area. As illustrated in Section

1.1, all of the major terminals and transfer points for petroleum products moved through the harbor are on the Cooper.

The mouth of the Cooper and the upper reaches of the harbor support a large variety of wildlife. The same species of fish, herring, shad, sturgeon and bass, move up the Cooper as well as the adjoining Wando River. Drum Island is an important sanctuary for heron - Little Blue, Black-Crowned, Louisiana, Green, and Great White; egret - Great, Cattle, and Snowy; Glossy Ibis; and Roseate Spoonbills. All of these are wading birds and quite susceptible to damage from oil spills. Shutes Folly Island, further down into the harbor, is also the home of seasonal visitors including Red-throated loons and White Ibis. Pelicans and dolphins are found in the mouth of the river.

The development of the western (Charleston) bank of the river would limit the amount of ecological damage which might be done in the event of a major spill. However, the cost of cleaning up and the damage to commercial docks and structures could be considerable. On the eastern shore, the southern portions of Daniel Island are mostly shell beaches and sheltered tidal flats which present a greater environmental risk.

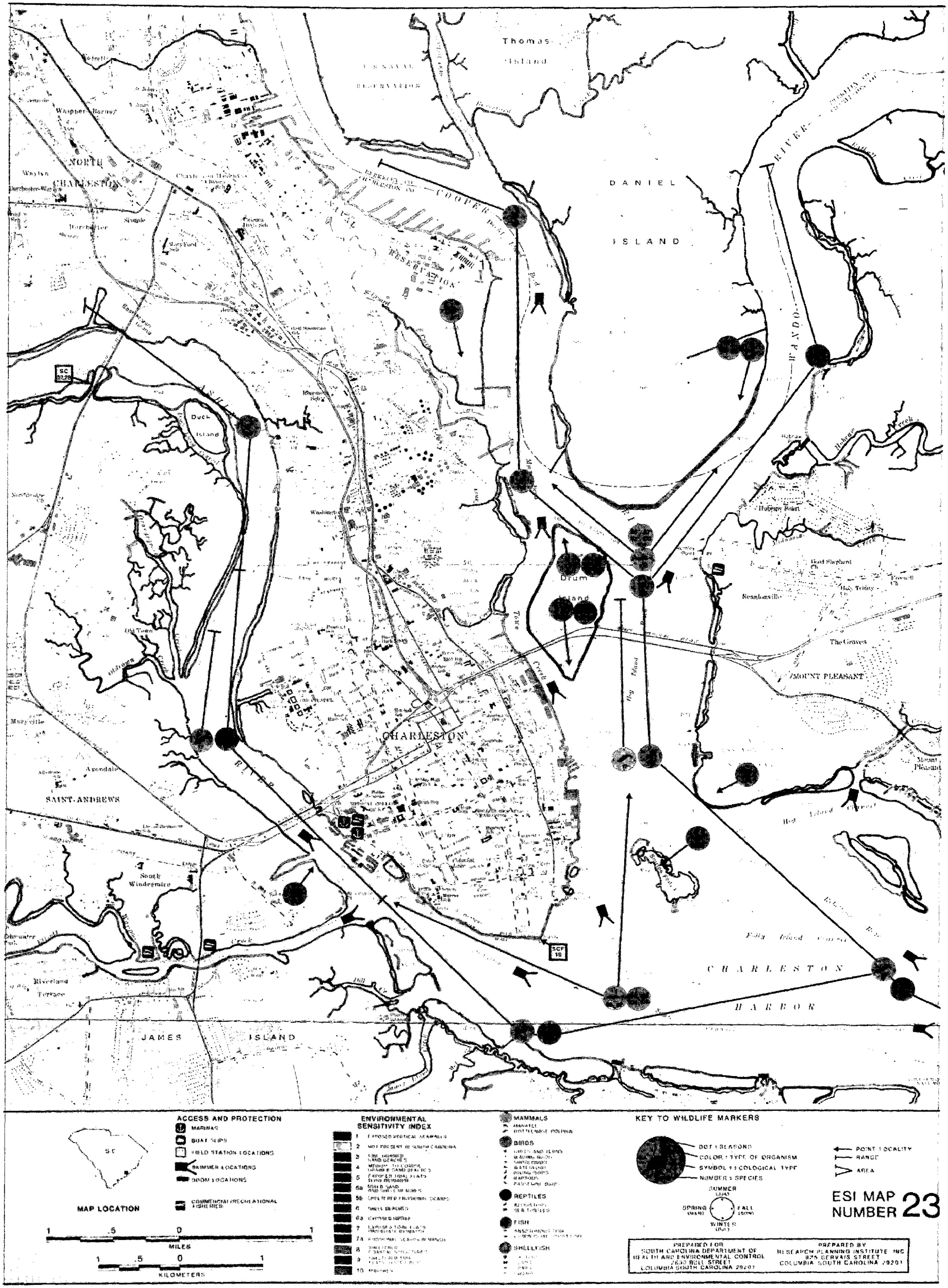
Wando River

Commercial ship traffic up the Wando River consists only of container ships headed to the SPA Wando Terminal. No petroleum products are transported to this terminal. The wildlife density is similar in diversity and greater in number to that in the Cooper and in the event of a spill, precautions should be taken to limit the movement of oil into the river by barricading the mouth of the Wando at Hobcaw Point.

The Intercoastal Waterway

The Intercoastal Waterway behind the Isle of Palms represents the most enviromentally sensitive area in Charleston Harbor. The waterway drains an extensive collection of marshes and associated creeks and bays. This marsh system is an important breeding ground for a number of economically important species of shellfish, among them oysters, quahogs, blue crabs, and both brown and white shrimp. The marsh also represent the most difficult coastal environment to clean up. For these reasons it should be given the highest priority for protection in the case of oil spills.

As was discussed earlier, the chances of contamination from spills occurring within the waterway are considerably less than from those occurring in the harbor. Therefore a barrier system should be established to prevent the entrance of spilled oil in the area of The Cove. For spills occurring along the coast and invading the outer beaches, barriers should be established at Breach Inlet and other entrances to the Intercostal Waterway.


Thomas Island
DANIEL ISLAND
NORTH CHARLESTON
COOPER
WANDO
RIVER
Duck Island
Drum Island
CHARLESTON
MOUNT PLEASANT
SAINT ANDREWS
JAMES ISLAND
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DOT = SEASONS
COLOR = TYPE OF ORGANISM
SYMBOL = ECOLOGICAL TYPE
NUMBER = SPECIES
SUMMER
SPRING
FALL
WINTER
POINT LOCALITY
RANGE
AREA
ESI MAP NUMBER 23
PREPARED FOR
SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
2600 BULL STREET
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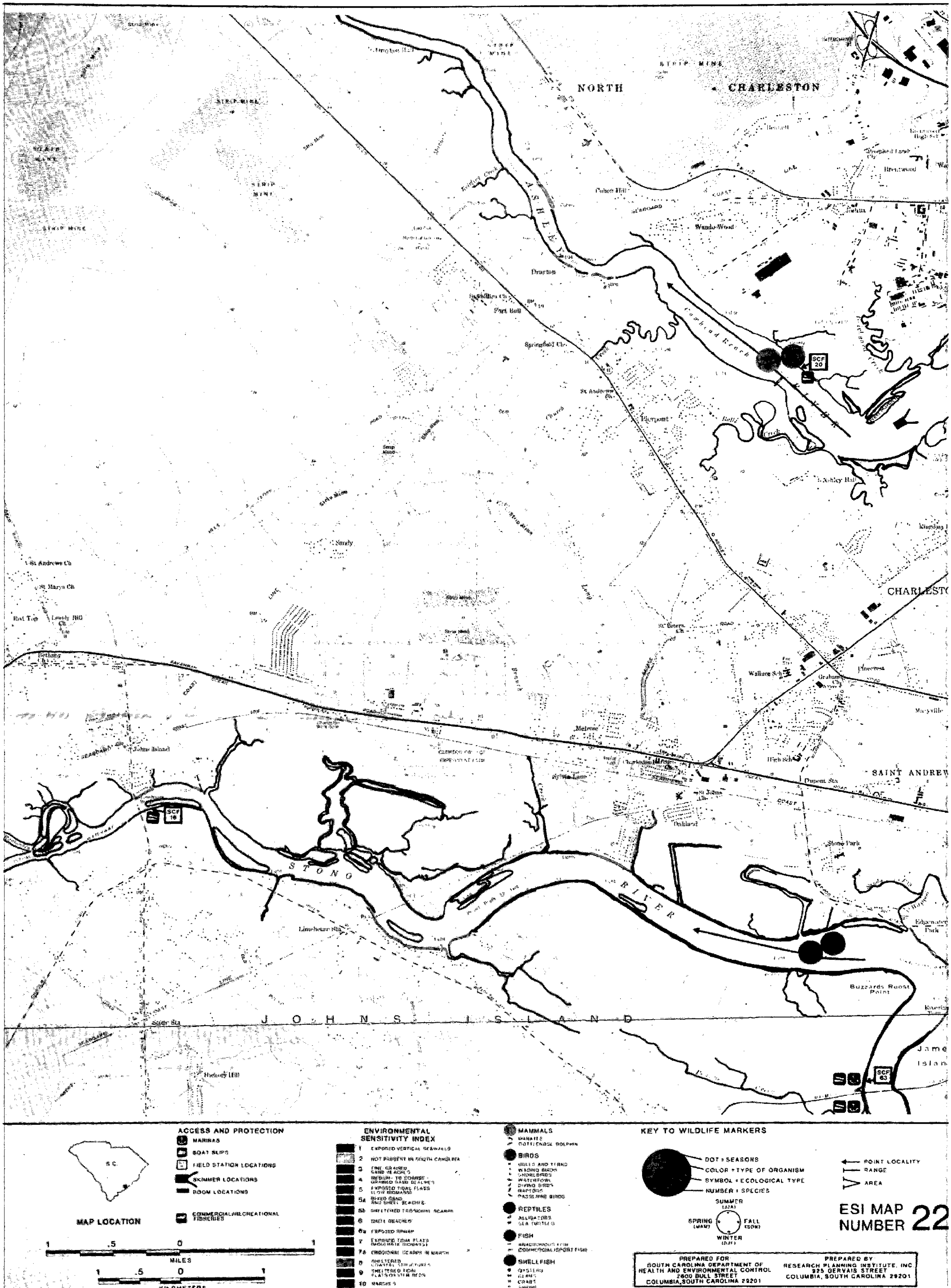

NORTH CHARLESTON
STRIP MINE
ASHLEY
Drayton
Springfield Ch
St Andrews Ch
Ashley Hall
CHARLESTON
Wallace Sch
Melrose
Johns Island
SCF 16
SCF 20
SCF 63
STONO RIVER
Limehouse Sta
Buzzards Roost Point
JOHNS ISLAND
Hickory Hill
SAINT ANDREWS
Stone Park
Edgewater Park
Oakland
Pinecrest
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DIVING BIRDS
RAPTORS
PASSERINE BIRDS
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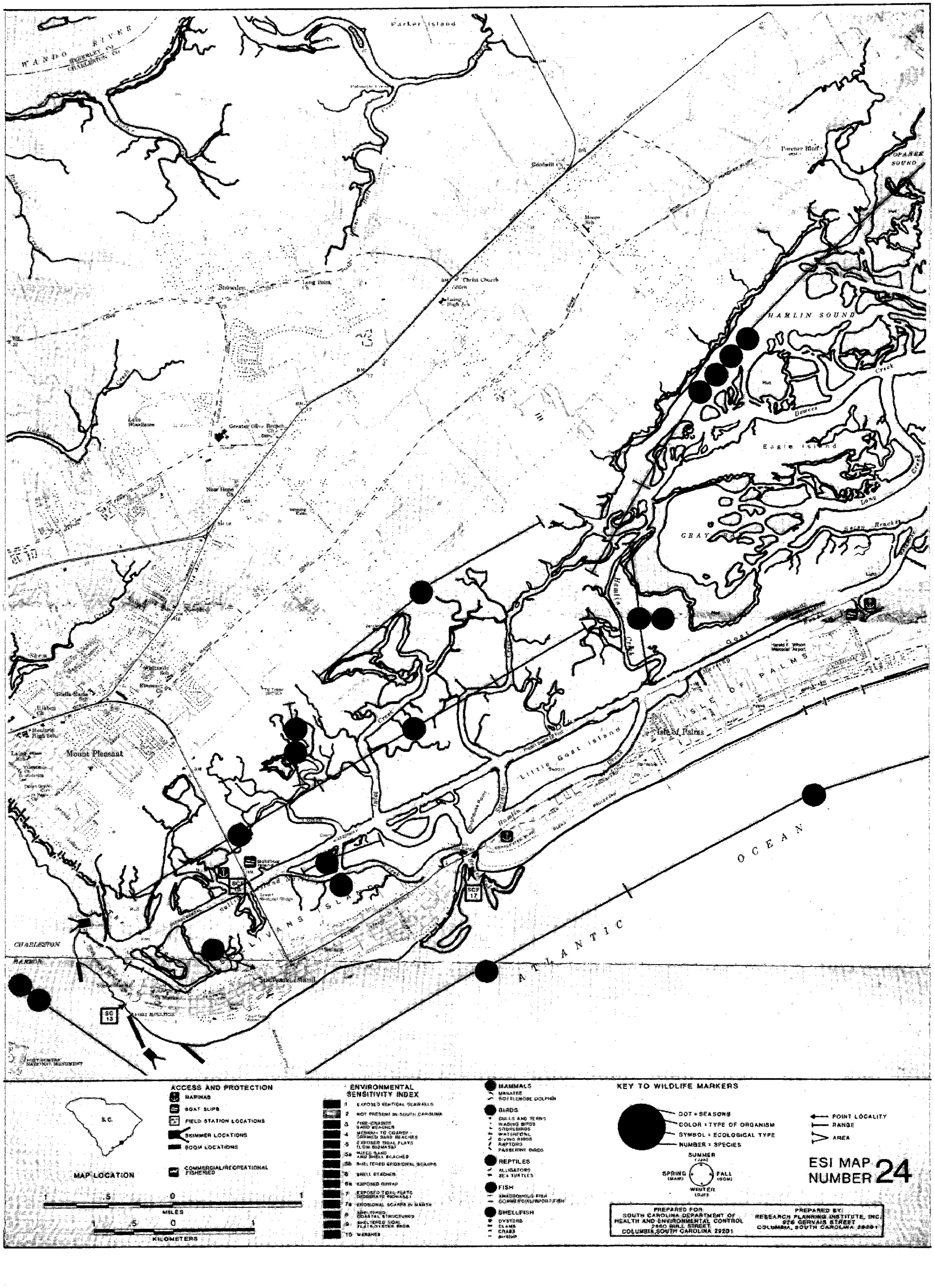
WANDO RIVER
Parker Island
Snowden
Christ Church
HAMLIN SOUND
Eagle Island
Mount Pleasant
Little Goat Island
Isle of Palms
I S L E   O F   P A L M S
Sullivans Island
S U L L I V A N S   I S L A N D
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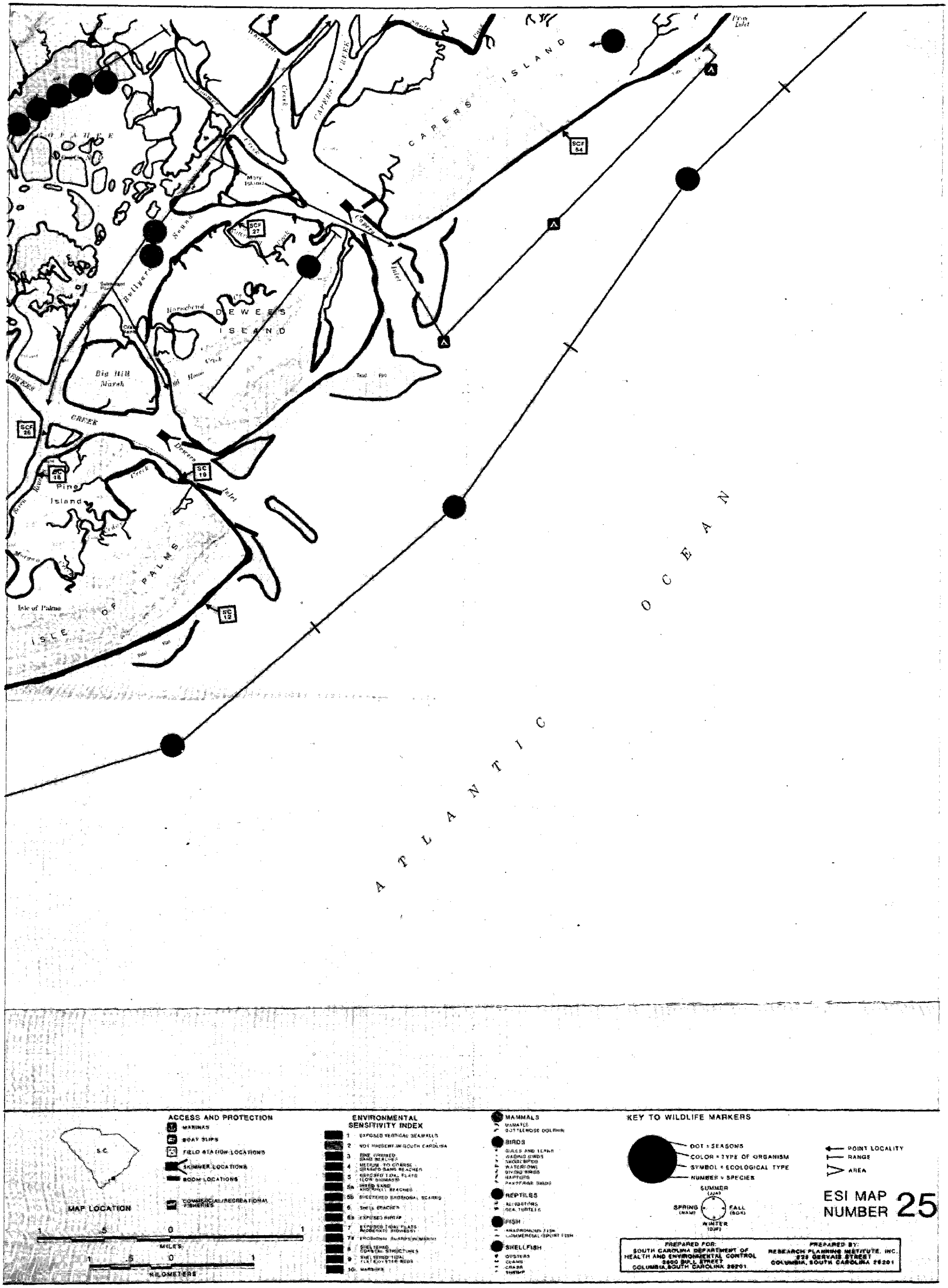

CAPERS ISLAND
DEWEES ISLAND
Big Hill Marsh
Pine Island
ISLE OF PALMS
Isle of Palms
Horsebend
Mary Island
Capers Inlet
Dewees Inlet
DEWEES CREEK
Bullyard Sound
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DOT = SEASONS
COLOR = TYPE OF ORGANISM
SYMBOL = ECOLOGICAL TYPE
NUMBER = SPECIES
SUMMER (JJA)
SPRING (MAM)
FALL (SON)
WINTER (DJF)
POINT LOCALITY
RANGE
AREA
ESI MAP NUMBER 25
PREPARED FOR:
SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
2600 BULL STREET
COLUMBIA, SOUTH CAROLINA 29201
PREPARED BY:
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APPENDIX B

COSTS ASSOCIATED WITH OPERATION OF COUNTY LANDFILLS

GENERAL

Charleston County is currently responsible for the disposal of approximately 165,000 tons per year (TPY) of residential, commercial and industrial solid waste. The majority of solid waste collected within the County is disposed of at County operated processing/disposal facilities. A small quantity of solid waste which originates primarily at the County's northern periphery, is disposed of at privately operated landfills located in Dorchester and Berkley County.

FACILITY DESCRIPTION

The County operates three separate processing/disposal facilities. Two of the County's facilities, the Solid Waste Reduction Center [SWRC] and Romney Street Landfill, operate in tandem. The SWRC receives acceptable solid waste for processing i.e., shred for size reduction. The Romney Street Landfill which is located adjacent to the SWRC receives all the solid waste material shredded for ultimate disposal. The County's third disposal facility, Bee's Ferry Landfill, accepts solid waste not processed at the Solid Waste Reduction Center and will accommodate all the waste disposed of within the County during those periods when the SWRC is inoperable. A detailed description of these facilities is presented in the following paragraphs.

1. Solid Waste Reduction Center

The Charleston County Solid Waste Reduction Center was designed to process all the residential, commercial and industrial (less demolition) solid waste generated within the County. The County elected to expend the additional monies required to construct and operate the facility because of the savings in landfill volume, cover material and hauling costs they derive through its utilization. Existing State regulations permit the County to dispose of shredded solid waste without providing a daily cover. The ability to landfill without daily cover coupled with the ability to attain a higher compaction density than normally experienced with non-shredded waste, substantially increases the usefull life of conventional landfills (i.e. more waste disposed per unit area). This enables the County to realize significant savings through reduced landfill operating costs and future landfill development costs.

The Solid Waste Reduction Center was originally equipped with three vertical shaft shredders which could process up to 70 tons per hour (TPH) of acceptable solid waste. The shredding equipment includes one Heil 92A (Mill#1;500HP) and two Heil 42Fs' (Mills #2 and #3;250HP ea.). Each shredder is fed by a steel apron conveyor which receives solid waste discharged onto the tipping floor by refuse vehicles via a rubber-tired, front-end loader. All waste delivered to the facility is preweighed by a pit-type scale prior to being discharged on the tipping floor. Solid waste is then shredded to a nominal (90% by weight passing) 6-inch partical size. The shredded material is then mechanically conveyed to one of two stationary compactors where it is loaded into transfer trailers for transport to the Romney Street Landfill.

Facility operations have been limited due to equipment break-downs resulting from hard-to-shred materials and insufficient time to adequately perform routine maintenance. The County has since restricted the composition of waste to the facility to residential and light commercial waste. Since

1977, the facility has processed an average of approximately 80,000 TPY while operating 8 hours per day, 5 days per week. Waste delivered to the facility on Wednesdays of each week is minimal.

In October 1981, an explosion occured at the SWRC which caused extensive damage to both building and structure. This explosion demonstrated an urgent need to incorporate safety improvements necessary to reduce potential for personnel injury and property damage during operations. The County is presently landfilling all the waste collected and disposed of within the County at Bee's Ferry Landfill. Safety improvements to the two (2) Heil 42-F shredders are being implemented. These units should be operational by July 1982. In February 1982, a decision was made to remove the Heil 92A and install a "shear-type" shredder of equivalent capacity. The shear shredder reportedly offers additional benefits to conventional hammermill shredders by reducing their susceptability to explosions, and in their ability to process oversize bulky waste (OBW). It is anticipated that by September 1982, the shredding facility will be fully operational.

2. Romney Street Landfill

The Romney Street Landfill which is located adjacent to the SWRC is operated under a restricted permit which allows the disposal of shredded material. Operating personnel at the landfill are responsible for transporting material shredded at the SWRC and for its disposal. Because shredded material does not require daily cover, landfill equipment, excluding that utilized for material transport, is limited to one compactor. Supplementary equipment for site grading and final cover is made available from the Bee's Ferry operation or other County departments, or alternatively, subcontracted to a local contractor.

The County has four tractors and six transfer trailers available for transportation of shredded material. These vehicles discharge the material at one of two permitted areas where it is spread and compacted. Once the active disposal area has reached the maximum allowable elevation, a final cover of topsoil is applied. Based on existing operating data, it is estimated that the Romney Street landfill has sufficient capacity to accommodate waste processed at the SWRC into 1984. This projection is predicated on the SWRC achieving its previous processing rate once facility operations resume. The actual landfill life will vary depending on the processing capability of the new shredding equipment and what avenue the County elects to proceed with respect to implementing a full-scale resource recovery program.

The Romney Street Landfill operates 8 hours per day, 5 days per week. As expected, the landfill operating schedule is compatible with that of the SWRC.

3. Bee's Ferry Landfill

The Bee's Ferry Landfill was acquired by the County in 1978 to receive solid waste which could not be processed at the SWRC and which was by-passed when the shredding facility was inoperable. Since the closing of the County operated Rosemount Landfill in mid-1981, the Bee's Ferry Landfill has been receiving its waste, primarily un-shreddable material such as demolition and excavation debris, brush and trees, furniture and other bulky items, on a continuous basis. An above ground scale system was recently installed to weigh all incoming waste prior to disposal. The landfill consists of two tracts of land; a 50 acre tract which is nearing completion, and a recently permitted 60 acre tract. Prior to the October 1981 explosion at the SWRC, disposal operations were consuming 15 to 20 acres per year of landfill area (82,500 TPY). County officials estimate that at that rate the landfill will have reached its maximum capacity by 1985-86. With the shredding facility inoperable, available landfill area is being consumed at an alarming rate. The Department of Health and Environmental Control and County officials are aware of the impending situation and are actively pursuing an accelerated campaign to reinitiate operation of the SWRC, and to implement a full-scale resource recovery program.

CURRENT OPERATING COSTS

A summary of the operating personnel and equipment provided to operate the County's solid waste processing/disposal facilities is presented in Tables 1 and 2. In addition, operations and maintenance cost data for these facilities have been prepared and are presented in Tables 3 and 4. The majority of these costs were obtained from the Charleston County 1981-1982 Operating Budget. Estimates for employee fringe benefits and general administrative overhead were provided by County officials. These costs do not include amortization of capital facilities, depreciation, or landfill closure costs. Tables 5 and 5A summarize the labor and non-labor operations and maintenance costs for the SWRC/Romney Street Landfill and the Bee's Ferry Landfill on a $/year and $/ton basis. Table 5A was developed to demonstrate the impact of providing cover material on each facility's operating budget. Information obtained from County official and facility operating personnel indicate that the annual cost for cover material at the Bee's Ferry and Romney Street Landfill are approximately $600,000 and $200,000, respectively.

TABLE 1.

OPERATIONS PERSONNEL: COUNTY SOLID WASTE DISPOSAL SYSTSEMS

DESCRIPTION	NUMBER OF POSITIONS SWRC/ROMNEYSTREET	BEE'S FERRY
Administrative:		
Operations Manager	1	-
Supervisor	1	1
Admin. Assistant	1	-
Operations:		
Scale Clerk	1	1
Control Rm. Opr.	2	-
Mechanic	3	1
Equip. Opr. (I)	1	2
Equip. Opr. (III)	1	8
Equip. Opr. (IV)	3	-
Gen. Helper	8	1
TOTAL	22	14

TABLE 2.

OPERATIONS EQUIPMENT: COUNTY SOLID WASTE DISPOSAL SYSTEMS

DESCRIPTION	NUMBER OF EQUIPMENT ITEMS SWRC/ROMNEYSTREET	BEE'S FERRY
Front-End Loader (Rubber Tire)	2	-
Crawler Tractor w/ Landfill Blade	-	2
Compactor	1	1
Scraper Pans	-	2
Dump Truck (12 CY)	2	1
Tractor Trucks	4	-
Transfer Trailers (65 CY)	6	-

TABLE 3.

COUNTY APPROVED 1981-1982 OPERATING BUDGET
SWRC/ROMNEY STREET LANDFILL

DESCRIPTION		COST
Direct Labor:		
Administrative		$ 50,612
Operations		212,080
Overtime		25,000
	Subtotal	$262,692
Fringe (@ 20.2%)		53,064
Overhead (@ 18.1%)		47,547
	LABOR TOTAL	$363,303
Direct Non-Labor:		
Building Occupancy		$ 75,400
Consumables		6,250
Utilities		69,500
Equipment		263,100
	Subtotal	$414,250
Overhead (@ 18.1%)		74,980
	NON-LABOR TOTAL	$489,230

TABLE 4.

COUNTY APPROVED 1981-1982 OPERATING BUDGET
BEE'S FERRY LANDFILL

DESCRIPTION		COST
<u>Direct Labor:</u>		
Administrative		$ 13,990
Operations		122,344
Overtime		8,000
	Subtotal	$144,334
Fringe (@ 20.2%)		29,155
Overhead (@ 18.1%)		26,124
	LABOR TOTAL	$199,613
<u>Direct Non-Labor:</u>		
Building Occupancy		$ 10,750
Consumables		1,000
Utilities		4,200
Equipment		281,130
	Subtotal	$297,080
Overhead (@ 18.1%)		53,770
	NON-LABOR TOTAL	$350,850

TABLE 5.

COUNTY APPROVED 1981-1982 OPERATING BUDGET
SUMMARY TABLE

	SWRC/ROMNEY STREET LANDFILL (80,000 TPY)	BEE'S FERRY LANDFILL (82,500 TPY)
o Labor	$363,303	$199,613
o Non-Labor	489,230	350,850
o TOTAL	$852,533	$550,463
o $/Ton	$10.66	$6.67

TABLE 5A.
COUNTY APPROVED 1981-1982 OPERATING BUDGET
SUMMARY TABLE

	SWRC/ROMNEY STREET LANDFILL (80,000 TPY)	BEE'S FERRY LANDFILL (82,500 TPY)
o Labor	$363,303	$199,613
o Non-Labor	689,230 (1)	950,850 (2)
o TOTAL	$1,052,533	$1,150,463
o $/Ton	$13.16	$11.51

(1) Estimates landfill cover at $200,000 per year
(2) Estimates landfill cover at $600,000 per year

FUTURE CONSIDERATIONS

Charleston County is currently pursuing a long-term solution to their existing solid waste disposal problem with three (3) firms who have demonstrated experience in implementing full-scale resource recovery programs. It is anticipated that by the end of 1982, the County will have selected a system contractor and initiated plans to implement the preferred program. The three programs presently under consideration by the Charleston County Solid Waste Advisory Committee, are as follows:

- o Implement a multi-phase resource recovery program whereby the County's Solid Waste Reduction Center is modified to to accommodate increased quantities of solid waste and to produce a refuse derived fuel (RDF). The RDF is scheduled to be purchased by a local industry for use as an alternative source of energy within their existing facility process. The balance of material which will not be processed into RDF, will be utilized at "future" modular combustion units to be constructed within Charleston County. These modular combustion units will generate steam and/or electricity for sale depending upon energy markets secured prior to construction.

- o Construct a single waste-to-energy facility to accommodate the majority of solid waste generated within the County. This facility will consist of a dedicated boiler to convert the solid waste into steam and electricity (Co-generation). The steam is scheduled to be purchased by the Navy Shipyard, with the excess steam being converted into electricity, via turbine generators, for sale to South Carolina Gas & Electric.

- o Construct a series of modular combustion units throughout Charleston County and surrounding areas. The exact size and location of these units will be determined by the energy markets secured by the developer prior to construction. It is anticipated that the capacity of these units will be in the 100-200 ton per day (TPD) range and will be designed to produce steam for heating/air conditioning, or to co-generate steam and electricity.

Due to the limited impact of the County facilities on current disposal practice employed for fossil fuel contaminated materials, it is anticipated that regardless of the avenue pursued by the County with respect to solving their solid waste disposal problem, the disposal options available to the County (reference Section 4.0) will continue to be available for some time in the future. Additionally, the combustion facility which may be constructed in the Charleston area could provide an alternative diposal option for fossil fuel contaminated materials.