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POLLUTION RESPONSE SYSTEMS ANALYSIS

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INTERIM REPORT

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16. Abstract

This study was initiated as part of the U.S. Coast Guard effort to provide adequate response within six hours for a spill of up to 100,000 tons of oil in U.S. waters. The guidelines and assumptions for the study are described, and partial results are reported on. A data base of spills over 50,000 gallons in U.S. waters has been compiled from the Pollution Incident Reporting System and Nation Response Center files of the USCG. Spill rates are derived and applied for the U.S. as a whole and for four major sub-areas. A set of baseline pollution response equipment is adopted, and four equipment site configurations covering the U.S. are evaluated on the basis of six-hour coverage, historic spills encompassed and oil throughput. Relative levels of equipment capability for the sites are derived from a simple optimization model.

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PREFACE

This Report was prepared with the valuable assistance and guidance of Lt. R.V. Harding/GDSA and Lt. G.D. Marsh/GDOE, of the U.S. Coast Guard. Numerous others in the Coast Guard provided data and information contained herein. The manuscript was ably typed by Ms. E.B. Davis/DTS-50.

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1. INTRODUCTION

The Oil Pollution Response System study was undertaken by the U. S. Coast Guard in response to a White House policy statement communicated to the Congress on March 18, 1977. The President was moved to make this statement after a number of tanker accidents along the coasts of the United States, including the SANSINENA and the ARGO MERCHANT incidents in December of 1976.

In these and lesser pollution incidents, the Coast Guard may be required to assume responsibility for removing or arranging for the removal of any oil discharged into the navigable waters of the United States. The authority to exercise this responsibility is vested by Congress in the President[1] and delegated by him to the Coast Guard[2].

The Public Law which establishes the Executive authority in this area is the amended Federal Water Pollution Control Act of 1972. In Section 311 of the Act (86 STAT 863), Congress has declared that "it is the policy of the United States that there should be no discharge of oil or hazardous substances into or upon the navigable waters of the United States..." Whenever such discharges do, nevertheless, occur in the coastal regions, whether intentionally or accidentally, the responsible officer of the Coast Guard (the On-Scene Coordinator) has the authority to act if he determines that such action is necessary to limit and/or remove the discharge. In carrying out his responsibilities the OSC is assisted by the response mechanism set up by the National Contingency Plan, which includes the National Strike Force[3].

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[1] Public Law 92-500, The Federal Water Pollution Control Act Amendments of 1972.

[2] Executive Order No. 11735, August 3, 1973.

[3] Federal Register, Vol. 40, No. 28, Part II, Feb. 10, 1975.

This Interim Report covers work to date on the first task, which will be incorporated in a final report at the end of the third quarter of FY 78.

It has been pointed out in numerous places and on numerous occasions that more and larger oil spills are an inevitable consequence of the transport and transfer of ever increasing volumes of oil, and oil products. Preventive measures and prudent procedures can limit but not eliminate accidental spills, which are most often small and of minor consequence but occasionally massive, with major impact on the environment and on nearby communities.

It has also been pointed out that in many respects oil spills resemble fires. Both are potentially disastrous events that may happen anywhere and at any time, although it may be possible through careful study to identify the circumstances that increase the risk. Furthermore, the response organizations must maintain themselves in a continuous state of readiness and must always be prepared to act on an emergency basis. In the event, their first duty is to prevent the loss of life; following that, to limit the environmental impact.

When no lives are at stake, the principal concerns become to stop the leak and contain the damage (put out the fire and prevent its further spread). To perform this function efficiently and effectively requires specialized equipment and trained personnel. These are the resources that must be provided by the Coast Guard when large spills occur in open waters where private efforts may be of no avail. The amount and disposition of these resources is the subject of this study.

1.2 PROBLEM DESCRIPTION

Executive Order 11735 requires the Coast Guard to coordinate and direct pollution control efforts at the scene of an actual or potential oil spill on coastal waters of the United States. In most instances, especially in protected waters, this effort is limited to overseeing the actions of the party responsible for the spill or of his representatives. If the predesignated On-Scene Coordinator (OSC) determines, however, that containment and removal of the oil

1.3 ASSUMPTIONS AND GUIDELINES FOR THE OIL POLLUTION RESPONSE SYSTEMS STUDY

a. The regions of interest in the equipment siting study are the coasts, harbors, and adjacent waters of the contiguous United States, plus Puerto Rico, the Great Lakes, and oceanic waters out to 50 miles* from shore. In this context, the adjacent waters are defined to include rivers, bays and estuaries from the coast up to the agreed upon boundary that separates the area of responsibility of the Coast Guard from that of the Environmental Protection Agency.

b. The incidents to be studied are those involving actual and potential spills of 50,000 gallons or more of oil or oil products. Data will also be collected for spill magnitudes between 10,000 and 50,000 gallons.

c. For the purposes of this study, a response requirement for major spills, up to 100,000 tons (28×10^6 gallons) in magnitude, is to be able to make an adequate response within six hours.

d. An adequate six-hour response to a spill of 50,000 gallons or more is assumed to include the following features:

1. The On-Scene Coordinator has arrived at the response center.
2. The OSC has assessed the situation and has established an initial operating plan.
3. Lines of communication have been established.
4. The OSC has established control of the equipment he estimates will be needed.
5. Coast Guard response personnel have been briefed and dispatched in accordance with OSC orders.
6. Coast Guard response equipment requested by the OSC has arrived at the designated debarkation point.

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*Recent law extends some of the U. S. Coast Guard's responsibilities to 200 miles from shore.

2. Specialized Coast Guard equipment will be needed whenever the wave heights are between two and five feet (sea state 3).
3. An effective response is beyond the present state-of-the-art whenever wave heights exceed five feet (sea state 4, or greater).

1.4 SCOPE OF THIS INTERIM REPORT

This Interim Report presents work completed through January 1978 on the first task of the project: The Equipment Siting Study. The report is based on information and data acquired through January 1978 which are not yet complete in some respects. It is therefore preliminary in nature and its conclusions are subject to revision during the remainder of the study.

In order to focus on matters of greatest concern to the U. S. Coast Guard, attention has been restricted in this report to the problem of responding to spills in open, or unsheltered, waters. Consideration of sheltered bays, harbors, and river estuaries has been deferred to the Final Report, as have questions relating to communications, staffing, training and costs.

The Equipment Siting Study has been based primarily on historical data relating to oil spills and petroleum throughput. As one would expect, the number of spills increases in proportion to the product flow. A more detailed analysis of the statistics of spills greater than 50,000 gallons enables one to calculate expected spill distributions for each of several high-risk areas and to project spill probabilities cautiously into the future. The effects of future deepwater ports, of offshore drilling, and of shifts in the domestic/import oil trade will be discussed in the Final Report.

On the basis of the projected spill potential, it has been possible to produce and evaluate several equipment site configurations which satisfy the six-hour response requirement based on land transport. More comprehensive siting recommendations, including air transport, will be developed in the Final Report.

The second major task of the project, The Equipment Status Study, will be the subject of a later TSC working paper. For the

2. TECHNICAL APPROACH

The overall project objectives may be summarized in the answers to four questions:

a. What probable spills must the U. S. Coast Guard be prepared to combat in the next decade?

b. What types of equipment are needed?

c. How much of it is needed?

d. Where should it be located?

A fifth question may be added, the answer to which follows from the answers to the first four: What personnel, maintenance, communications and logistic support are required?

2.1 OUTLINE OF TASKS

The first question must be answered at least partly before the remaining ones can be attacked. An estimate of the number, location, size, and type of spills to be dealt with is fundamental to assessing what types or quantities of equipment are required, or where it should be placed. Hence, the Geographic Spill Potential Study, described in Section 3, is the starting point in the technical approach. The sequence of investigation, starting with the Geographic Spill Potential Study, is illustrated in Figure 2.1.

Geographic Spill Potential

The projection of spills to be dealt with in the next decade proceeds from a study of historic spills in the recent past. Data have been gathered for the 1974-1977 period on actual and potential spills in the contiguous United States. The national and regional spill rates can be related to oil throughput, historically, and projections made of the number of spills as a function of oil traffic. By adding considerations of future deep-water ports, offshore drilling, and import/domestic oil trade, these estimates can be improved to cover the 1980-1990 decade.

Environmental Data

Weather conditions at the scene of the spill can reduce the effectiveness of the recovery or offloading equipment, restrict the types of equipment that may be employed and, in fact, determine whether any effective action can be taken at all. Weather data on sea height, current, wind speed and water temperature in the various parts of the study area will be gathered for use in assessing the effectiveness of current equipment.

Equipment Capabilities Assessment

Given the environmental conditions and spill location and frequency statistics, it is necessary next to determine the effectiveness of currently available equipment in counteracting anticipated spills. It is necessary to estimate the rates and total quantities achievable for offloading and for recovery by different equipments, with given environmental conditions and petroleum types. This task has as its objective an assessment of the capabilities of available equipment. Having an estimate of recovery and offloading rates achievable by available equipment, plus the results of the environmental and spill potential studies, it is possible to make an estimate of the amount of equipment required to meet various spill threats.

Debarkation Point Estimates

A set of potential debarkation points, corresponding geographically to areas of high spill potential, is selected for application of the response criteria stated in Section 1.3, namely, delivery of significant amounts of equipment, as requested by the On-Scene Coordinator, to the debarkation point within six hours.

Logistic Assumptions

In order to determine the response range (i.e., the distance from a storage site that the equipment may be transported in the specified response time), an investigation will be carried out of and equipment types, keyed primarily to open water spills in difficult circumstances. These selections may be modified to assure adequate coverage of spills in sheltered waters, from the points of view of site location, equipment type, and equipment quantity.

Subsidiary Requirements

Given equipment quantities, types, and locations, the subsidiary requirements for communications, logistic equipment, and organization, maintenance, and staffing will be investigated.

Massive Spill Coverage

The upper extreme of the spill volume distribution is of particular concern because of the potential for serious ecological damage and public reaction. Therefore, the site locations, equipment types and equipment levels resulting from the above sequence of tasks will be analyzed further for effectiveness in responding to massive spills. This will be done by postulating a set of possible massive spills and examining the sequence of response actions likely to occur for each. The arrival sequence of equipment and personnel at the debarkation point will be examined as a function of time. Adjustments in location, type, and quantity of equipment will be made.

2.2 REMARKS

The sequence of tasks outlined above has intertwined in it the three general tasks mentioned in Section 1:

a. Equipment Status Study,

b. Equipment Siting Study, and

c. Massive Spill Response.

The three general tasks are, in fact, all interdependent. The subtasks outlined are intended to accomplish all three major tasks simultaneously, taking advantage of common information and subordinate studies.

3. GEOGRAPHIC SPILL POTENTIAL

This section will detail the development of geographic spill potential by first establishing the historical spill perspective, the volumes of petroleum throughput and the relationships between the two. Following this, threat spectra are developed on both a national and regional (geographic) basis.

The reader is cautioned that the developments to follow are preliminary in nature and contain information subject to change as data and methodologies are refined.

3.1 HISTORICAL OIL SPILL DATA BASE

The fundamental assumption in the derivation of probabilities of future oil spill occurrence is that meaningful estimates of spill frequency can be based on past experience. To this end, historical data on oil spills were obtained from reports of and personal contacts with the U. S. Coast Guard (USCG), Environmental Protection Agency (EPA), the U. S. Geological Survey (USGS) and the Bureau of Land Management (BLM) of the Department of the Interior (DOI), from non-governmental organizations, and from the open literature. Review of the available information revealed the fact that no one source of historical oil spill data was sufficiently extensive to satisfy the information needs of this effort. It thus became necessary to construct an appropriate data base to include all post-1973 spills of 50,000 gallons or more in and around the United States.* The spill size was selected so as to be consistent with earlier studies (References 3.1 and 3.2), and the time period

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*Data was also collected for spills between 10,000 and 50,000 gallons for future consideration.

FIGURE 3.1 ACTUAL SPILLS IN 48 UNITED STATES, 1974-1977

FIGURE 3.2 ACTUAL SPILLS IN STUDY AREA, 1974-1977

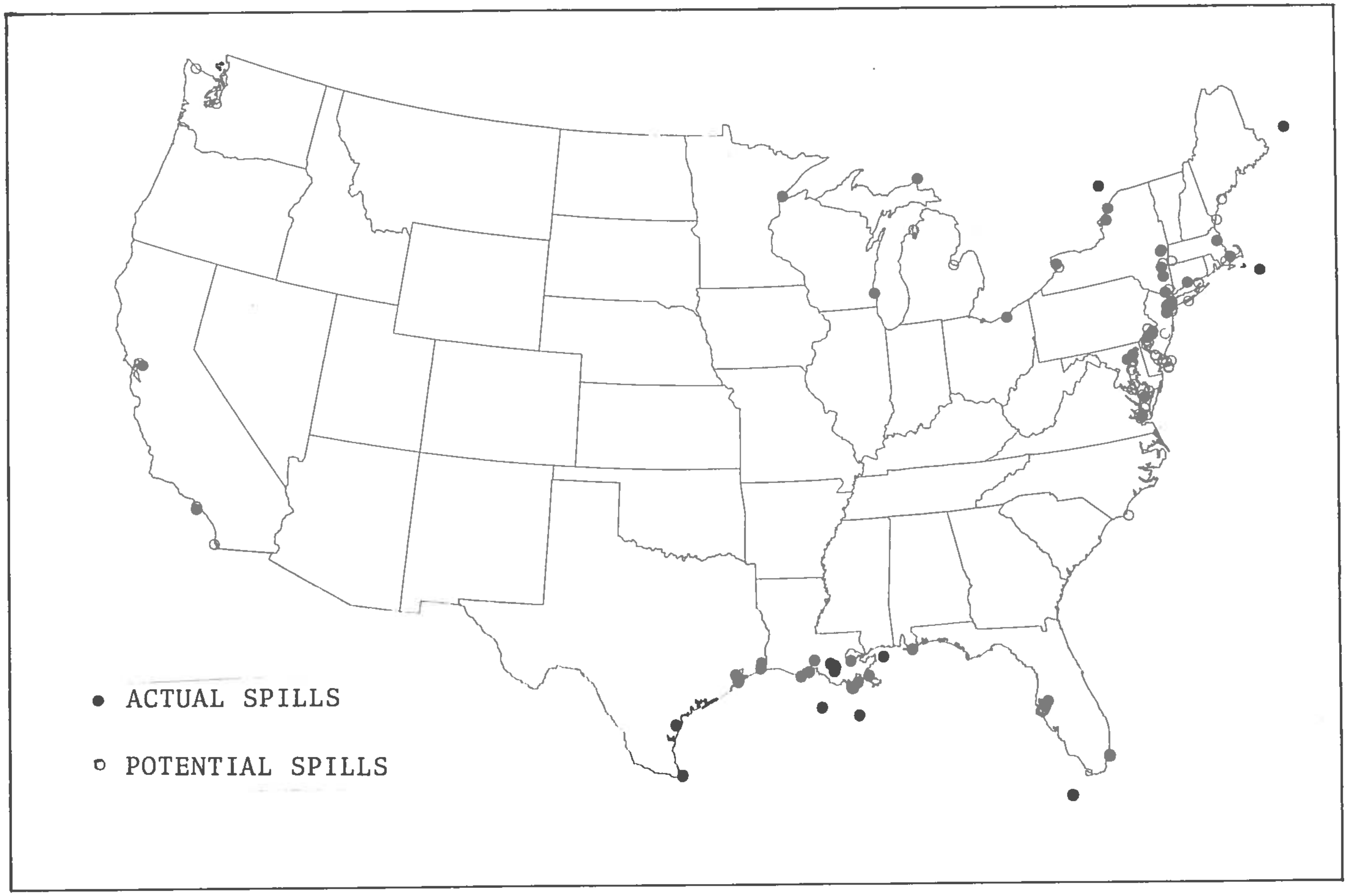

FIGURE 3.4 DISTRIBUTION OF ACTUAL AND POTENTIAL SPILLS IN THE STUDY AREA

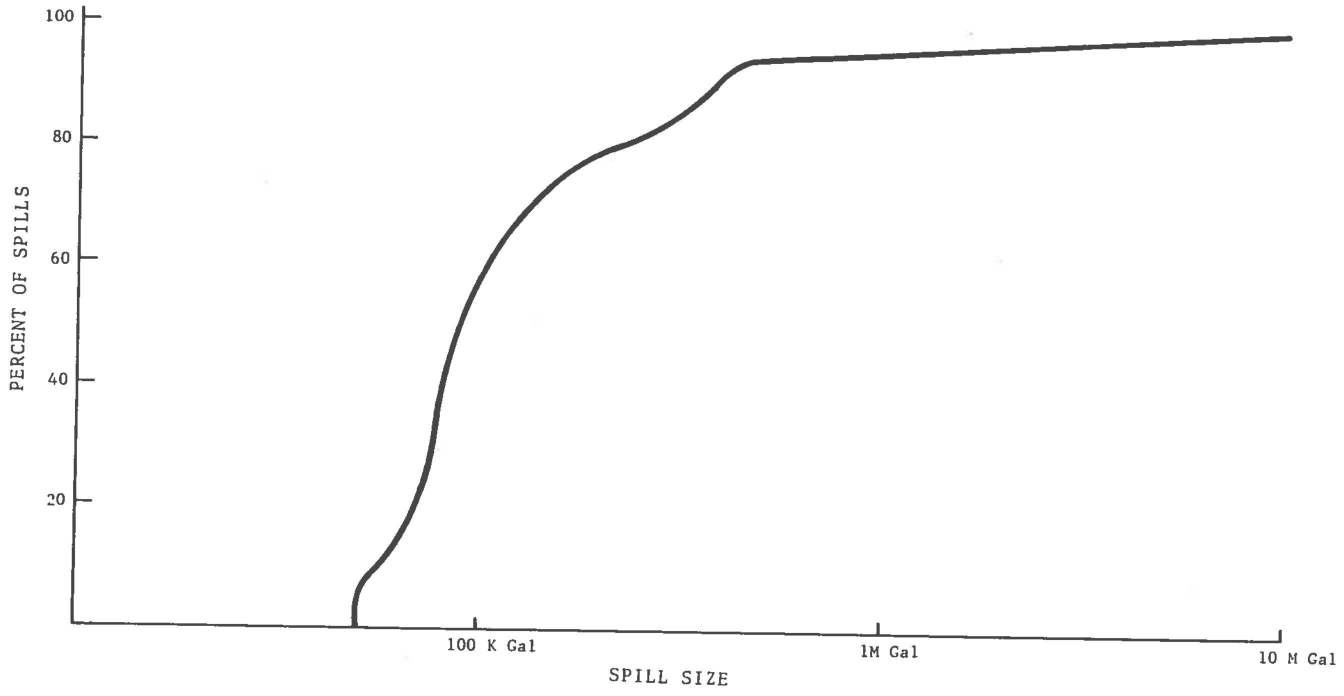

FIGURE 3.5 CUMULATIVE OF SPILL SIZE DENSITY FOR SPILLS $\geq$ 50,000 GAL

FIGURE 3.6(c) PETROLEUM THROUGHPUT BY TYPE FOR MAJOR PORTS

Year	Number of Spills	Throughput Volume(MTs)
1974	20	573.0
1975	20	572.2
1976	22	576.5
1977 (7 mos.)	9	345.0

where MTs represent millions of short tons. The least squares fit to the cumulative of these data is

$$n = 0.129 + 0.0349V$$

where n is the number of spills and V the throughput volume in MTs. Figure 3.7 shows this relationship graphically. This relationship has a correlation coefficient of 0.9993 and a standard error of estimate of 0.978, which reflects the near constancy of both the number of spills and throughput volume experienced on an annual basis over the time period of concern. It is assumed that such a trend can be expected to continue in the future.

3.3.2 Regional Level

Reference to the areal number density plot of Figure 3.4 indicates that there are few geographic regions that have historically experienced a large enough number of major spills to be examined as separate entities. In fact, only four such regions can be tentatively identified: Greater New York with 10 spills, Delaware Bay with 6, the Louisiana Coast with 16, and the Northern Coast of Texas with 6. No other region had more than 3 major spills in the 3-1/2 years of record.

From the considerations of Section 3.2, the regions noted above represent, nominally, 21.5, 4.7, 10.5 and 15.2 percent, respectively, of the total annual waterborne petroleum throughput volume. Least square fits to the regional spill and throughput data are as follows:

Greater New York: $n = -0.174 + 0.0219V$

Delaware Bay: $n = -0.385 + 0.0769V$

Louisiana Coast: $n = 0.641 + 0.0723V$

North Texas Coast: $n = 0.506 + 0.0229V$

where once again n is the number of spills and V is the throughput volume in millions of short tons. The associated correlation coefficients and standard errors of estimate are as follows:

	Correlation Coef.	Standard Error
Greater New York	0.985	0.623
Delaware Bay	0.985	0.414
Louisiana Coast	0.995	0.589
North Texas Coast	0.975	0.506

As with the overall study region, these regional relationships indicate a very high degree of correlation between spill rate and throughput volume. These relationships are shown graphically in Figure 3.8, along with that of the nationwide average for comparison. From these plots it is evident that there can be considerable variation in spill rate from region to region. However, for regions other than those identified here, there is little choice but to apply the nationwide average.

3.4 SPILL POTENTIAL

The methodology employed here to estimate probabilities of oil spill occurrence was taken from Devaney and Stewart (Reference 3.2). The application of this methodology requires the acceptance of three basic assumptions: the fundamental assumption that meaningful estimates of future spill incidents can be based on past experience, plus the two further specific assumptions (1) that spills occur independently of each other (i.e., as a Poisson process) and (2) that the number of spills is proportional to the volume of petroleum throughput. The data of the preceding sections are quite supportive of these assumptions.

The referenced methodology is developed from the assumption that spill experience is a Poisson process. If, within this process, the intensity, λ , is known, the probability density of the number of spills can be determined from the expression:

$$p(n|\lambda,t) = \frac{e^{-\lambda t}(\lambda t)^n}{n!}$$

where t is the amount of exposure contemplated and λ is the mean spill rate in spills per unit exposure.

Nominal spill rate as a function of throughput volume was examined in Section 3.3 where a high degree of correlation was noted. However, this correlation does not imply certainty. Thus, for example, past experience of ν spills in τ volume throughput does not necessarily imply that $\lambda = \nu/\tau$. In the limit, of course, the larger ν and τ the more likely it is that λ approaches ν/τ. However, with a limited data base, which is most certainly the case here, λ is most appropriately considered an uncertain quantity represented by a probability density about a known historic experience.

In the referenced development (Reference 3.2), it was assumed that, after having observed ν spills in τ volume throughput, the density on λ could be defined as a Gamma distribution of the form

$$f(\lambda|\nu,\tau) = \frac{e^{-\lambda\tau}(\lambda\tau)^{\nu-1}\tau}{(\nu-1)!}$$

This density is the vehicle through which the fundamental dependence on past spill experience enters the analysis as a prognosticator of future events.

Having defined this relationship, it is a simple matter to obtain the density of the number of future spills to be expected to occur on the basis of a particular throughput volume. Thus:

$$p(n|t,\nu,\tau) = \int_0^\infty p(n|\lambda,t)f(\lambda|\nu,\tau)d\lambda$$

This density function can be reduced algebraically to the form:

$$p(n|t,\nu,\tau) = \frac{(n+\nu-1)!\ \ t^n\tau^\nu}{n|\ (\nu-1)!\ \ (t+\tau)^{n+\nu}}$$

This function defines the probability density distribution of experiencing n spills for a given throughput, t, wherein past experience has noted a total of ν spills over an exposure of τ units. One of the more notable advantages of making predictions of oil spill frequency in the form of a probability distribution is that such data give not only an estimate for the most likely number of spills

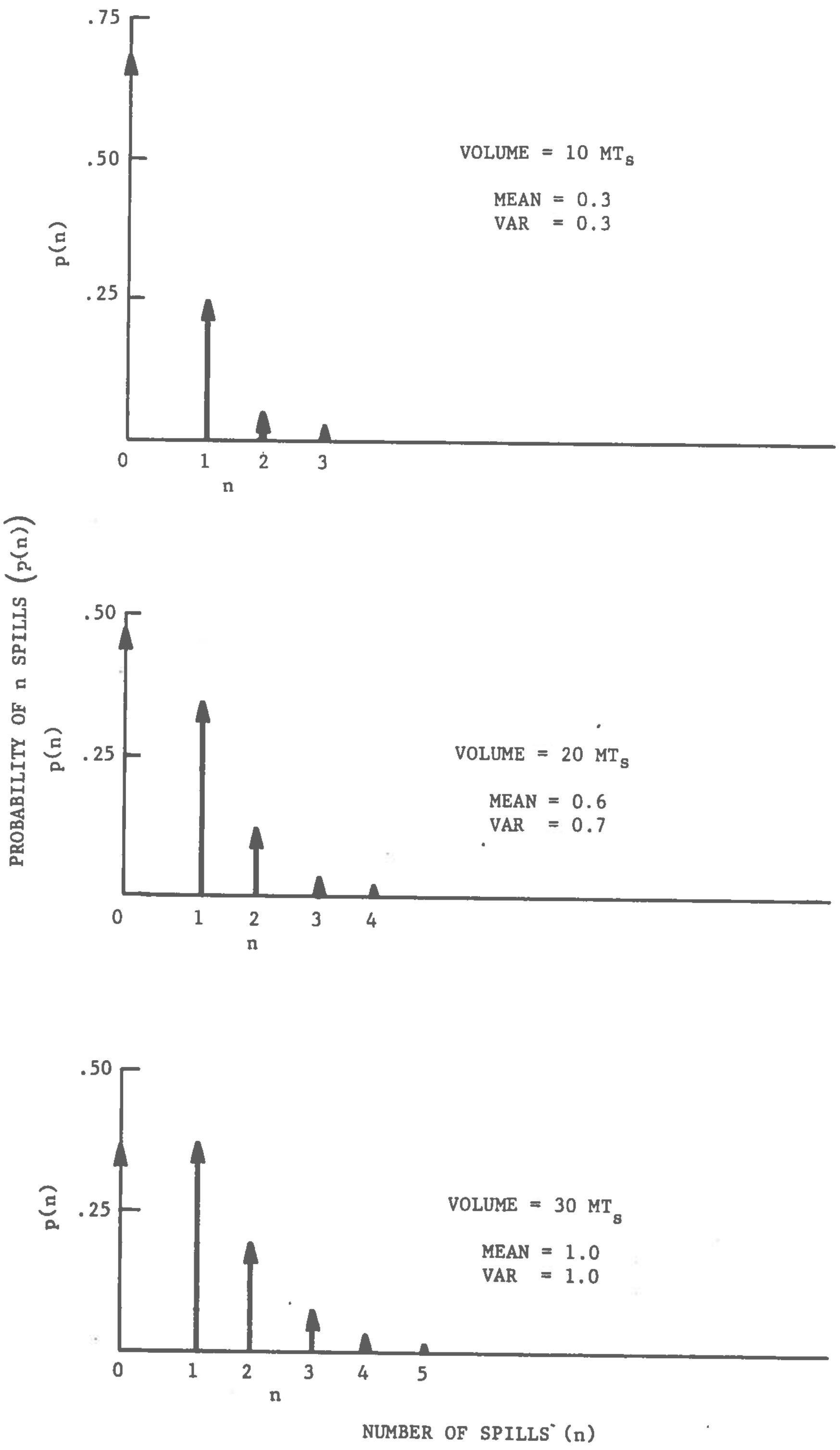

FIGURE 3.9(a) OVERALL SPILL THREAT SPECTRA AS A FUNCTION OF THROUGHPUT VOLUME IN MILLIONS OF SHORT TONS

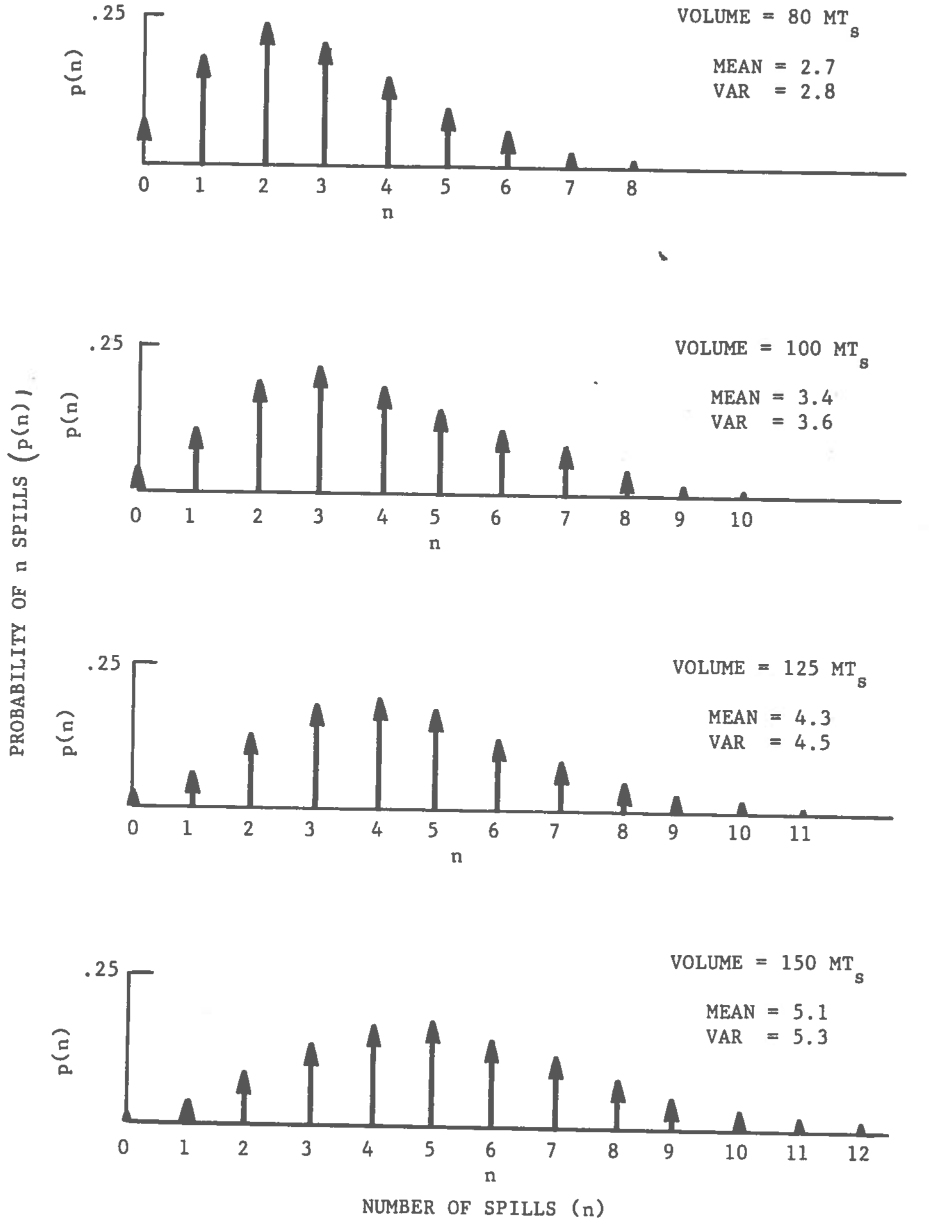

FIGURE 3.9(c) OVERALL SPILL THREAT SPECTRA AS A FUNCTION OF THROUGHPUT VOLUME IN MILLIONS OF SHORT TONS

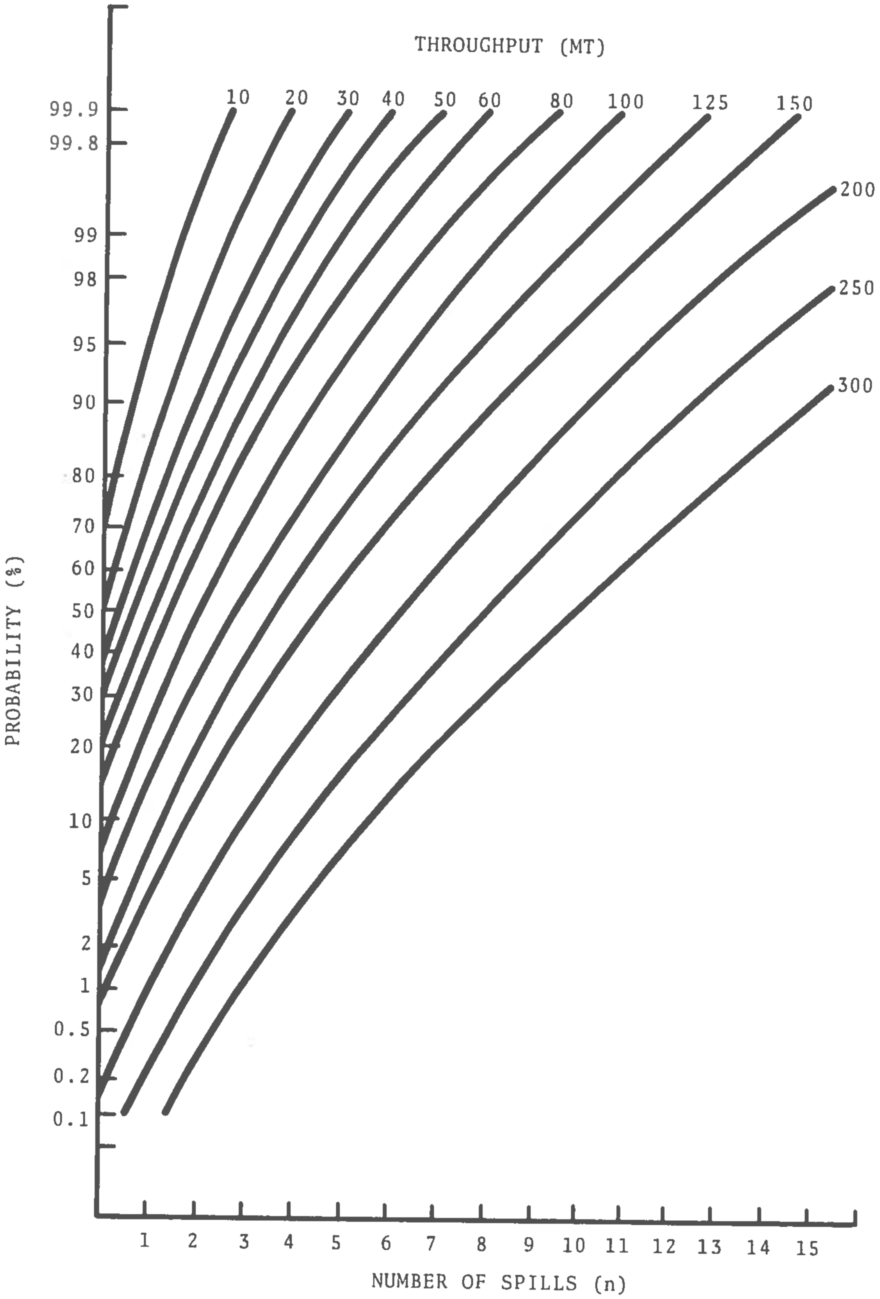

FIGURE 3.10 PROBABILITY OF n OR LESS (≤n) SPILLS AS A FUNCTION OF PETROLEUM THROUGHPUT IN MILLIONS OF SHORT TONS

time period since, by this treatment, prior spill experience becomes an endogenous parameter with throughput volume being the exogenous determining function. The range on parametric throughput has been made sufficiently wide to accommodate almost any regional throughput on an annual basis, at least over the next decade. It can also accommodate many regions over extended periods of time.

Thus, for example, during calendar year 1975, the area about Norfolk, Virginia experienced a petroleum throughput of some 11.5 million short tons. This amount is closely approximated by the parametric curves developed nationally for a nominal 10 MT throughput. The expected threat for the Norfolk area can thus be estimated directly from the plots representing this nominal throughput. For this particular case, the spectrum of Figure 3.9 for a throughput of 10 MT indicates a mean spill probability of 0.3 spills with a variance of 0.3. Figure 3.10 indicates a probability of about 99.5% of experiencing three or less spills in such a region. From Figure 3.11, it can be seen that the probability of experiencing at least one spill with this throughput is about 30%, of at least two spills, about 5%. From Figure 3.5, petroleum throughput in the Norfolk area has historically consisted of approximately 1% crude, 72.4% heavy and 26.6% light. Assuming this mix to remain fixed, the 30% expectation of at least one spill can be separated to threat by petroleum type thusly: crude - 0.3%, heavy - 21.7%, and light - 8.0%.

If one were to consider the same area over a five-year period with a nominal 2% annual increase in throughput volume, approximately 60MT of petroleum would have transited the area. Over this exposure experience, the 99.5% probability level of n or fewer spills is extended to 7 spills (Figure 3.10). The probability of at least one spill increases to some 88%, that of at least two spills becomes 62%, and that of three spills is about 35%. In this instance, the 88% expectation of at least one spill by petroleum type becomes: crude - 0.9%, heavy - 63.7%, and light - 35.4%, assuming the petroleum mix remains as previously noted.

Similar applications can be made for other areas, time periods, throughput volumes and type mixes where regionally specific spill-throughput data are not available.

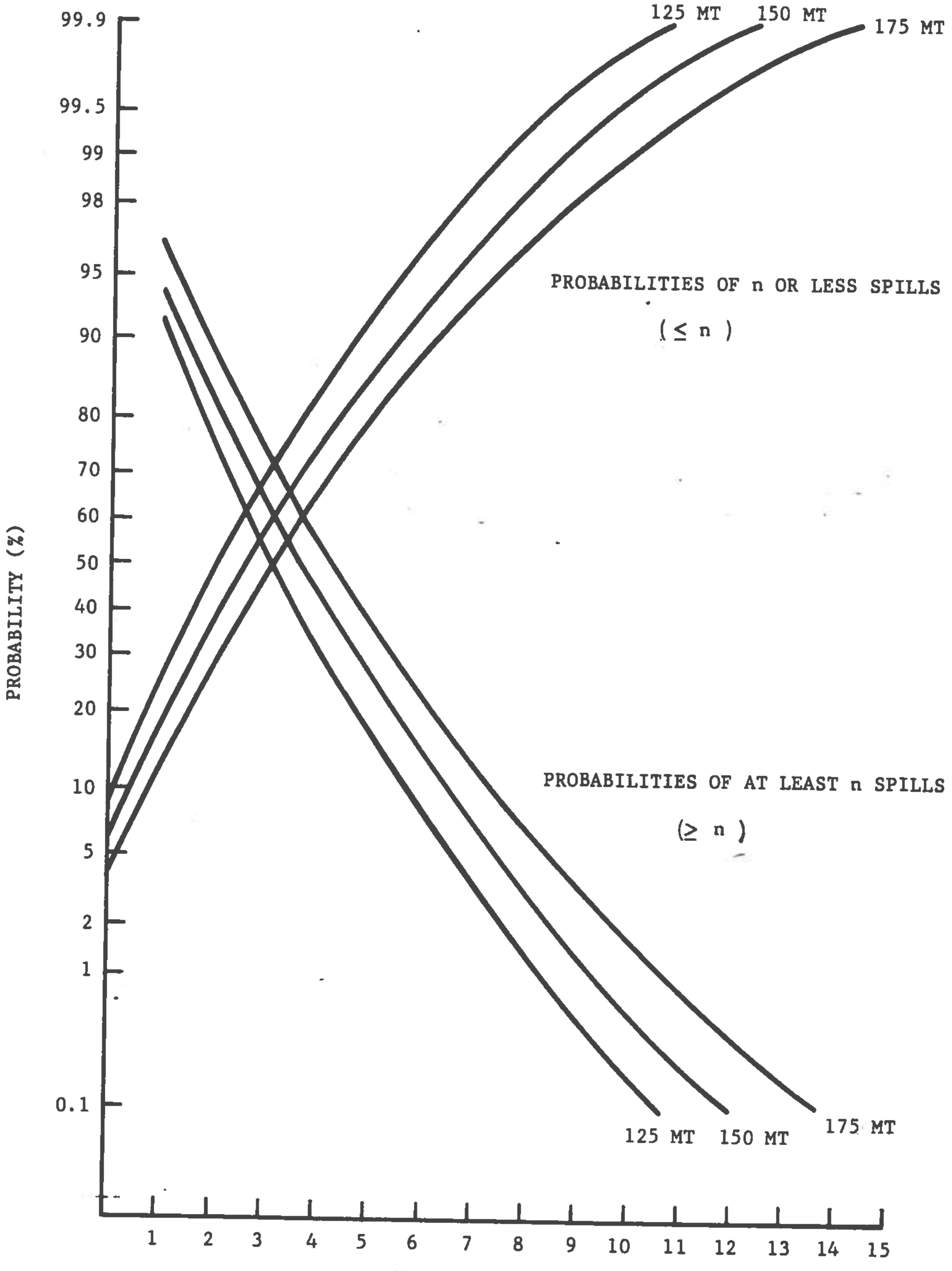

FIGURE 3.12 PROBABILITIES OF SPILLS > 50,000 GALLONS AS A FUNCTION OF PETROLEUM THROUGHPUT IN MILLIONS OF SHORT TONS-GREATER NEW YORK REGION

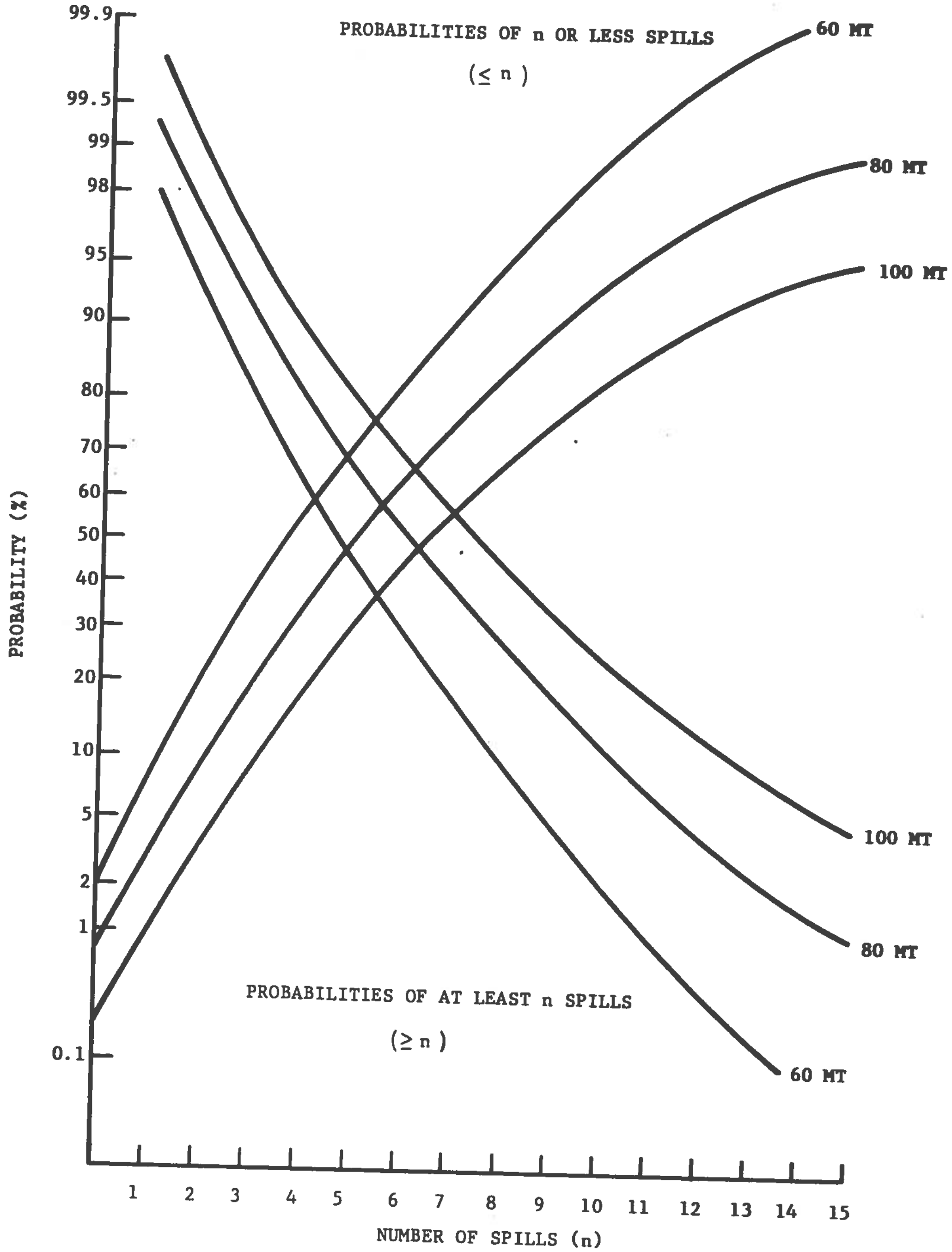

FIGURE 3.14 PROBABILITIES OF SPILLS > 50,000 GALLONS AS FUNCTION OF PETROLEUM THROUGHPUT IN MILLIONS OF SHORT TONS-LOUISIANA COASTAL REGION

Delaware Bay and the North Texas Coast may be questionable regional choices because of the limited number of spills experienced. These regions have been included, however, to provide some degree of diversity since no other region experienced more than three spills in the time period considered. Of these two "candidates", the Delaware Bay region appears to be the higher risk area, comparable in rate to the Louisiana Coast.

Once again, the caution - these are preliminary findings forced from limited data, and subject to revision as the data and/or analyses may be refined. They are reported here solely in the interest of information exchange to illustrate the processes developed for and applied to the problem at hand, the delineation of oil spill potential on a geographic basis.

3.5 FUTURE CONSIDERATIONS

The findings of the preceding sections were postulated on a limited spill experience and on a continuation of the status quo of future petroleum movement with but a nominal across-the-board annual increase in throughput. This may well be a gross oversimplification of future events. It is to be expected that well fields in the Outer Continental Shelf (OCS) regions may be developed, that Deepwater Ports (DWP) may be established, that imports may be increased selectively to meet a growing demand with reduced domestic resources, that additional refineries may be constructed, that at-sea lightering of VLCC's may become commonplace, that environmentally oriented protective legislation may be expanded, etc. The probable and/or possible impacts of these contingencies will be the subject of further investigation as this program continues.

In addition, the following specific extensions will be made to the limits of coverage available in this Interim Report:

a. The MOSIS file will be extended at least through CY 1977 and, if possible, through June of 1978.

b. Petroleum throughput estimates of Section 3.2 will be reevaluated and, where appropriate, revisions will be made to the preliminary results derived from such early estimates.

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3.3 Young, G. K. et al., Major Oil Spills From Tankers and Barges and Other Vessels, Analysis of Recent Trends and Patterns, GKY and Associates, Alexandria VA, May 1977.

3.4 U. S. Army Corps of Engineers, Waterborne Commerce of the United States, District Engineer, New Orleans LA, 1974, 1975.

3.5 Federal Energy Administration, National Energy Outlook, Washington DC, 1976.

3.6 Jimison, J.,Congressional Research Service, National Energy Transportation, Vol. I, Current Systems and Movements, U. S. Senate Report No. 95-15, Washington DC, May 1977.

4. EQUIPMENT BASELINE

The transport methods employed depend on the size, weight, and packaging of the equipment to be transported, as well as on the support equipment and operating personnel to be transported with it. Therefore, a total system must be considered for each of the two major operations, offloading and recovery from the water. Since the evaluation and selection of equipment for these two purposes are beyond the scope of this interim report, a nominal system will be assumed for each operation in order to derive logistic requirements and site locations.

4.1 OFFLOADING

A complete set of men and equipment required for offloading is assumed to comprise the following:

SYSTEM ELEMENT	SIZE	WEIGHT
ADAPTS Equipment, as given in Table 4.1	223 cu ft	5,526 lbs
Storage Barge, Dracone Type 0	709	13,104
Operating Personnel		
ADAPTS (4)	64	800
Barge (2)	32	400
	1028 cu ft	19,830 lbs

The ADAPTS equipment listed in Table 4.1 is not fully floatable. A fully floated and water tight package is approximately 5,700 lbs, and 549 cubic feet. (Reference (1) in Table 4.1).

The size and weight given for the storage barge is also for a transportable but not floatable package. It includes towing hose and recovery float, but does not include gripper bar, hook, and sling. The latter weigh 284 lbs unpackaged, and 410 lbs packaged.

This would bring the entire barge equipment to 13,514 lbs gross when packaged by the manufacturer for transportation. It is entirely possible that special packaging may be designed to bring the gross weight down closer to the 9804 lbs net weight of the components alone. The smaller barges have gross shipping weights of 8,064 lbs for Type F (50,000 gal size) and 3,052 lbs for Type D (12,000 gal size).

The number of operating personnel required for the ADAPTS has been estimated to be a minimum of four (Reference (1) of Table 4.1. No estimates are available for the storage barges; the two shown include one man for supervision of unloading and deployment, plus one backup. In addition the barge must be unloaded by crane or lift at the debarkation point. A five-ton crane is the smallest that can remove the Type O barge from its crate. The operation requires at least one crane operator, and perhaps one other dock hand. These personnel are not included in the above tabulation because they would be stationed at the debarkation point or nearby base and would not require transportation from the equipment site. The two personnel listed are USCG response team members.

The pump elements listed are capable of pumping approximately 1000 gal/min of water through a 45 ft head or 300 gal/min of No. 6 oil at 86°F (2600 CS),* according to recent tests by the USN. A more detailed study of the pumping characteristics of ADAPTS and other pumping systems is yet to be made. For present purposes, the ADAPTS capability will be taken to be 800 gal/min of light crude oil through 40 ft of head. This is a nominal figure, since substantial effects have yet to be accounted for. In particular, the Dracone Barge is fitted with a 4" bore towing hose, 15 ft in length. The coupling to this hose has an inside diameter of less than 4". The net result will be a reduction of pumping rate for a given head. Perhaps the greatest single limitation comes from higher viscosity oils. Hose bends will further reduce the flow rate. For these reasons the estimate of 800 gal/min is only a nominal rate for logistic studies.

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*CS = Centistokes

TABLE 4.2 STORAGE BARGES ORDERED BY USCG

Dracone Type =	OW	F	D10	
Weight	13,104	8,064	3,052	lbs
Shipping Size				
Length	19'2"	12'3"	9'2"	ft, in
Width	6'4"	5'4"	5'4"	ft, in
Height	5'10"	3'5"	3'5"	ft, in
Volume	709	223	167	cu. ft.
Capacity				
Nominal	290,400	50,400	12,000	gal
97% load	282,000	48,900	11,600	gal
at wave height	≤7	≤4	≤2.5	ft
85% load	246,840	42,800	10,200	gal
at wave height	>7	>4	>2.5	ft

NOTES TO TABLE 4.2

(1) "Fast Surface Delivery System for Pollution Response Equipment," R.M. Larrabee, R. Ward, 1977 Oil Spill Conference. These packages are floatable.

(2) Handling, Operating and Maintenance Manual for the Dracone Barge, The Dunlop Company Ltd., Carolyn House, Dingwall Road, Croydon, Surrey, England.

Type O carries 282,000 U.S. gallons in seas up to 7 ft.
or 246,840 U.S. gallons in seas over 7 ft.
Type F carries 48,900 U.S. gallons in seas up to 4 ft.
or 42,800 U.S. gallons in seas over 4 ft.
Type D10 carries 11,600 U.S. gallons in seas up to 2.5 ft.
or 10,200 U.S. gallons in seas over 2.5 ft.

TABLE 4.3 RESULTS OF PT. CONCEPTION TESTS OF USCG BARRIER, 1972

	SPEED (kts)	AM'T IN BOOM (gal)	LOSS RATE (gal/min)	LOSS MECHANISMS
Calm Water				
	0.71-.77	24,000	1.0	float agitation
	1.06	22,000	50-70	headwave
	1.6	9,400	680	headwave
Rough Water (2 ft. waves, 8 ft. swells with 10 sec period)				
	0.4	5,700	35	float agitation
	0.6	4,000	70	60% float agitation 40% headwave
	1.6	1,300	200 (1)	headwave

NOTES:

(1) This rate was independent of amount in boom.

(2) Tests performed with soybean oil (similar to No. 4., or to a typical crude).

(3) No substantial drainage losses occurred.

It can be seen from Tables 4.3 and 4.4 that the skimmer-barrier throughput efficiency is very high (above 98%) and its recovery efficiency relatively low (about 40%) in waves under 2 feet and speeds under 1.0 knot. The data give no information on performance in waves over 2 feet. Moreover, the effect of slick thickness on these figures is probably substantial, and there appears to be no data showing recovery efficiency as a function of thickness. Finally, no tests have yet been performed in open water of the combined barrier-skimmer under tow by USCG craft using a soybean oil such as was used at Pt. Conception.

Considering the above uncertainties, only very crude estimates can be made of the number of systems required for a given spill size. Since the nominal pumping rate of the skimmer is 600 gal/min, with about 40% recovery efficiency, it will be assumed that the recovery rate, under ideal conditions, is 240 gal/min for the skimmer-barrier combination. This corresponds to an average slick thickness of .015 inches (.38mm) at an encounter rate of 0.6 knots and an encounter gap of 420 ft.

At a rate of 600 gal/min, a single skimmer-barrier would fill a Type 0 barge in about 9 hours. The contents would be about 60% water unless a separator were employed. (At present no separator has been selected by the USCG for use with the barrier-skimmer).

A further allowance in the recovery rate must be made for maneuvering into and out of the slick. If the slick has been driven into windrows, or has broken up into patches, not all of the on-scene time of the barrier-skimmer-bag system is spent encountering oil. A substantial portion of time must be spent in locating the next patch of oil and maneuvering into it. Atlantic Strike Team personnel have suggested that in such circumstances a utilization factor of 20% would be appropriate for skimmers such as the Lockheed device. An important consideration is that night operation is generally not possible without illumination, which might be provided by tending vessels or from helicopters. The difficulties in making such estimates without data are readily apparent, but for rough estimation a utilization factor of 50% seems appropriate. This brings the net recovery rate to about 120 gal/min, from the 240 gal/min maximum rate estimated above.

5. LOGISTICS

The preceding sections of this report have investigated the statistics of oil spills and some of the equipment available to combat them. In this section the various logistic options available to bring the equipment to a suitable debarkation point will be examined. The purpose is to estimate the range of each transport option within the specified 6- or 12-hour response times. These ranges, and corresponding equipment payloads, will be employed in Sections 6 and 7 to select sites and equipment levels.

The procedure to be followed in this logistics study is as follows. First, the transport characteristics (weight, size, etc.) of the baseline equipment are assumed from Section 4. Next, the various vehicles that may be employed to carry the equipment are examined, in order to estimate their ranges, payloads, speeds and other characteristics. Finally, several logistic options (i.e., vehicles or combinations of vehicles) are selected and their payload-range characteristics developed. A review of these characteristics leads to the selection of two transport options (truck, air/truck) for primary consideration in the site selection study of Section 6.

5.1 BASELINE RESPONSE SYSTEMS

The baseline response systems described in Section 4 will be assumed for the logistics study. Some of the size and weight characteristics of that equipment should be noted. Most prominent is the open water barrier, 17,000 lbs, 9 feet wide, 18 feet long. The next largest single package is the Type 0 Dracone Barge, 13,000 lbs, 20 ft long, 7 ft wide, and 6 ft high. Finally, it should be noted that the only open water skimming equipment included is the integral barrier-skimmer.

TABLE 5.1 WATER VEHICLE CHARACTERISTICS

	Max Load					Cruise at Max Load		
Vehicle	Wt	L	W	H	Area	Speed	Range	Draft
	10^3lb	ft	ft	ft	ft^2	kts	n.mi.	ft
SLED/TOW								
FSD/HH3F(1)	17	27	9.0	-	243	46(2)	75(3)	1.5
FSD/RH53(1)	17	27	9.0	-	243	54(4)	-	1.5
FSD/82'WPB(1)	17	27	9.0	-	243	17(5)	419	6.0
FSD/210'WMEC(1)	17	27	9.0	-	243	17(5)	5800	10.0
FSD/41'UTB(1)	17	27	9.0	-	243	12	150	4.0
FSD/270'WMEC	17	27	9.0	-	243	19	4200	14.0
FSD/378'WHEC	17	27	9.0	-	243	28	2400	21.0
CUTTERS(6)								
52'MLB	10				100	11	430	6.0
63'ANB	16				375	15	210	4.5
82'WPB	6				200	24	470	6.0
95'WPB	8				400	20	440	6.0
210'WMEC	20				1500	16	6200	10.0
270'WMEC	60				2500	20	4130	14.0
378'WHEC	100				2500	16	10300	21.0

NOTES TO TABLE 5.1

(1) Reference 5.1. Although the FSD sled was designed to carry 20,000 lbs. (Ref. 5.2, p. 418) tests were performed with 17,000 lbs or less, as described in Reference 5.1. The lower figure is used here because the speed and range figures were obtained using 17,000 lbs.

(2) Significant wave height 1.5 ft. in tests.

(3) Estimate via USCG Aviation Branch, Search and Rescue Division. This estimate is based on 3,000 lbs of fuel employed in the Panama City tests, Ref. 5.1, and in the tests of Reference 5.3. Further investigation would be needed to determine if this range can be increased.

(5) Significant wave height 1.0 ft. in tests.

(6) Reference: Publication USCG-197, "Register of Cutters of U.S. Coast Guard."

(7) 9.0 knots applies to the 303 class; 11.3 knots applies to the 400 class.

TABLE 5.2 APPROXIMATE TOWING CAPABILITIES OF SOME USCG CUTTERS

CUTTER	MAX SPEED, V_m	MAX HP	DISPL, Δ	APPROXIMATE MAX TOW SPEED(1)	
				(a)	(b)
26'MRB	25 knots	300 HP	4 tons	kts	14.8 kts
32'PWB	25	390	9	15.3	18.0
41'UTB	26	640	15	18.0	20.6
44'MLB	14	400	19	10.2	11.5
52'MLB	11	400	35	8.9	9.8
55'ANB	22	1,090	34	17.8	19.4
63'ANB	15	800	42	12.5	13.5
82'WPB	24	1,600	67	21.2	22.4
95'WPB	20	2,324	100	18.3	19.0
210'WMEC	16	5,000	1,000	15.8	15.9
270'WMEC	20	7,000	1,730	19.9	19.9
378'WMEC	28	36,000	3,000	27.9	27.9

(1) Approximated as $V_m(\Delta/(\Delta_L+\Delta))^{1/3}$ where Δ_L, the load displacement, is (a) 30 tons, (b) 15 tons. Calm water is assumed.

TABLE 5.3 PAYLOAD AND RANGE RELATIONS FOR USCG AIRCRAFT

Vehicle	P_o 10^3 lbs	R_{max} n.mi.	P_{max} 10^3 lbs	Speed V kts	f lbs/hr	C_T lbs
HH52A	1.5	300	0.0	80	409	2,112
HH3F	6.3	660	0.0	126	1,200	7,200
HC130B	58.6	3,250	13.3	290	4,030	45,240
HC130H	87.9	3,850	25.0	300	4,900	62,920
HU16E	8.5	2,054	0.0	145	600	10,000
HC131A	34.9	1,580	25.6	170	990	9,180
HU25A	10.2	2,200	0.3	405	1,820	9,910

NOTES: (1) P_o = Payload at zero range = Maximum gross weight - empty weight - crew weight at 200 lbs per crewmember - reserve fuel for 45 minutes (if fixed wing), 20 minutes if helicopter

(2) R_{max}= Range when fuel is limited by either (a) payload, when used to carry fuel, or (b) capacity of fuel tank, = min $(VP_o/f, V\,C_T/f)$, where C_T is capacity of fuel tank (excluding auxiliary tanks)

(3) P_{max}= payload at R_{max} = max $(0, P_o - C_T)$

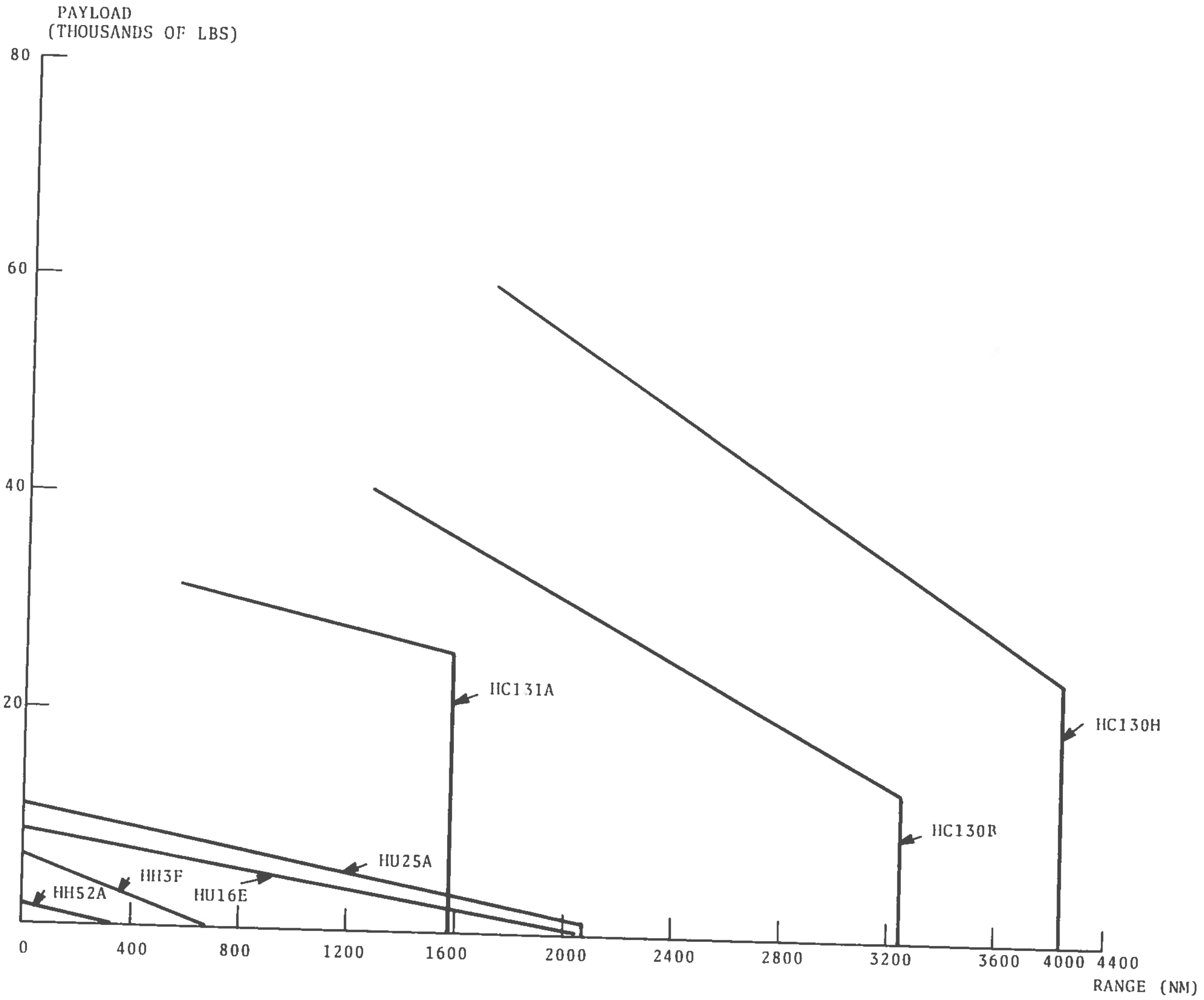

FIGURE 5.1(a) APPROXIMATE RANGE-PAYLOAD CHARACTERISTICS OF CURRENT USCG AIRCRAFT

The HC130H can carry two barriers over a 2000 n.mi. range, or one barrier over a 3400 n.mi. range, with approximately 5,000 lbs of additional cargo, assuming a gross weight of 90,000 lbs without fuel or payload. Additional cargo can be added when the required range is less than 3400 n.mi. Because the dimensions and weight of the skimmer, barges, and ADAPTS are less than those of the barrier, numerous combinations of equipment can be accommodated if the barrier is not loaded.

Aircraft not in the present USCG inventories are also relevant to air transport of pollution response equipment in the 1980-1990 time frame. These may either be borrowed from other services, or purchased by the USCG. In the latter category, it should be noted that the HH3F is expected to be replaced about 1980. The task of transporting pollution response equipment is likely to fall upon the replacement vehicle at least to the same extent that it has fallen upon the HH3F. In order to assess the impact of these future helicopters on the pollution response mission (and vice-versa) several heavy duty U.S. military helicopters currently in production or in late development, are listed in Table 5.4. This table shows the approximate range-payload characteristics of five such helicopters, (not including the HH3F and variants of it). While some of these offer payloads well in excess of the HH3F's, the one-way distances do not necessarily exceed that of the HH3F. This can be seen in Figure 5.1(b), showing payload-range points for the CH-47C Chinook, S-64 Skycrane, CH-53A/2-Turbine, and CH-53E/3-Turbine, as well as the payload-range line for the HH3F. Obviously, more information is needed for a complete comparison.

Since specific vehicles for the 1980-1990 period cannot be designated, it is necessary to consider several generic types, including one similar to the HH3F, for pollution response work. The three classes considered are:

TABLE 5.4 (Continued)

UTTAS - UTILITY TACTICAL TRANSPORT AIRCRAFT SYSTEM

The U.S. Army will replace the UH-1H Iroquois assault transport by this twin turbine combat assault squad transport in the late 1970's. The following data are for the Boeing YUH-61A version:

	YUH-61A
Weight empty, lbs	9,750
Max payload, lbs	5,924
Max useable fuel, lbs	2,288
Cruising speed, kts	145
Range at cruise speed, n. mi.(1)	321
Mission T-O weight, lbs	15,157
Max T-O weight, lbs	19,700
Cabin length, ft.in.	12'8"
max width, ft.in.	7'2"
max height, ft.in.	4'6"
Volume, cubic ft.	412

(1) 30 minute reserves

TABLE 5.4 (Continued)

CH-53A SEA STALLION (U.S. NAVY) 2-TURBINE

The first of these heavy assault transport helicopters was delivered in 1966. Versions are: CH-53A, RH-53A, HH-53B, HH-53C, HH-53 Pave Low III (USAF), CH-53D, RH-53D, plus non-military versions. Data for the CH-53D:

Weight empty, lbs	23,485
Mission T-O weight, lbs	36,400
Max T-O weight, lbs	42,000
Cruising speed, kts	150
Fuel, lbs, with 10% reserve	4,076
Range at 4,076 lb fuel, 150 kts	223 n. mi.
Payload @ 223 n. mi. range, lbs	8,839
Cabin, length	30'0"
max width	7'6"
max height	6'6"

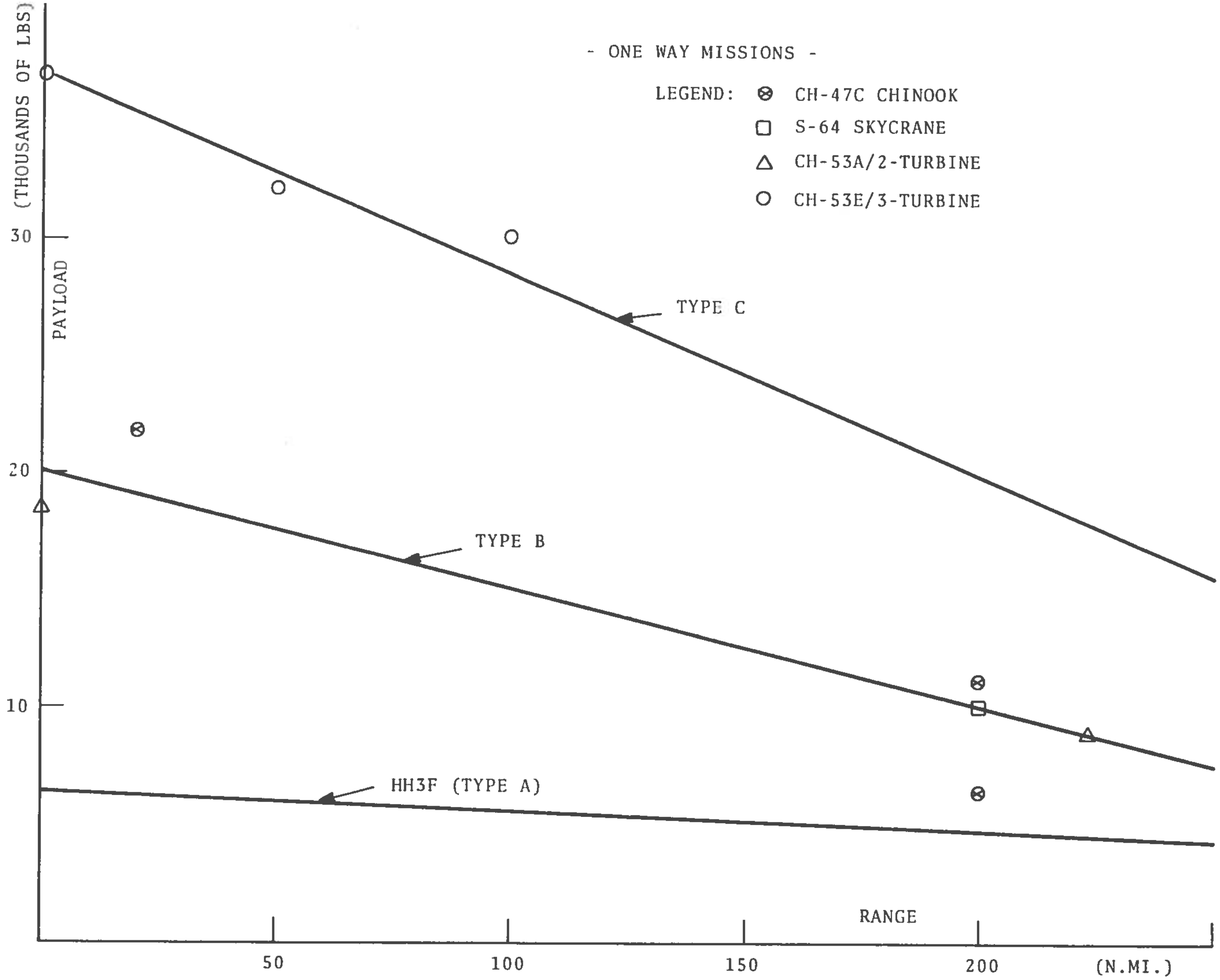

FIGURE 5.1(b) APPROXIMATE RANGE-PAYLOAD CHARACTERISTICS OF CURRENT U.S. MILITARY HELICOPTERS

TABLE 5.5 TYPICAL BASELINE EQUIPMENT - RANGE COMBINATIONS FOR THREE CLASSES OF HELICOPTERS

- 6-HOUR RESPONSE TIME -

HELI-COPTER CLASS	RANGE (n.mi.)	Barrier 17,000 lbs	OW Barge 13,000 lbs	F Barge 8,000 lbs	ADAPTS 5,500 lbs	1/2 ADAPTS* 3,000 lbs	D10 Barge 3,000 lbs	Skimmer 3,000 lbs	Team Member 200 lbs	TOTAL (lbs)
A	200					1			5	4,000
	200						1		5	4,000
	200							1	5	4,000
B	100		1						5	14,000
	100			1	1				2	13,900
	100			1		1	1			14,000
	100			1			2			14,000
	100				2		1			14,000
	200			1					5	9,000
	200				1		1		2	8,900
C	100	1					1	1	10	25,000
	100		1		2				5	25,000
	100		2							**26,000****
	100	1		1						25,000
	100		1		1		1	1	2	24,900
	100		1	1			1		5	25,000
	200	1							10	19,000
	200		1					2		19,000
	200				3				12	18,900
	200			1	2					19,000
	200		1				2			19,000
	200		1		1				2	18,900

*Any combination of equipment from Table 4.1 that totals less than 3000 lbs and less than 120 cu. ft.

**This combination is less than 1,000 lbs under the estimated max payload.

at about 50,000 lbs (allowing a 15,000 lb tractor, 12,000 lb trailer). Widths are limited to about 8 ft; semi-trailer lengths up to 40 feet are common, and longer lengths can be obtained readily. Platform semi-trailers can be as high as 54". In order to clear the usual 14' underpasses found on most highways, the cargo height is limited to approximately 9 ft, with 8 ft preferable. Non-conventional flat bed semitrailers are available to carry 10,000 lbs per foot of length. Drop frame flats are available with capacities of 80,000 lbs with evenly distributed loads. Special permits are required for excessively wide, long or heavy loads, according to state laws.

As a point of reference for costs, it is noted that an 80,000 lb gross combined weight tractor retails for about $50,000.

5.3 LOGISTIC OPTIONS

Having reviewed some of the relevant characteristics of the equipment to be transported and of the vehicles available to carry it, it is now possible to describe very generally several schemes for getting the equipment from its site(s) to the designated debarkation point. Only five general schemes are considered. In fact, it will be shown that only five are likely to be of any value. A brief discussion is in order of how these schemes were selected.

The debarkation point is necessarily dockside at a port, which dockside is accessible by sea, land, or (possibly) helicopter but not by fixed wing aircraft. (Except in unusual cases, airports that can accomodate C130 size aircraft are not adjacent to a dock; an intermediate land leg would be required). At the other end of the trip is the storage site, which is either on a vessel or on land.

If on a vessel, the equipment is either transported directly to the debarkation point by the vessel, or removed from the vessel and brought there through some intermediary vehicle(s) (truck, helicopter, fixed wing, another vessel). In the latter case, the vessel is used merely as a storage facility, which procedure has no advantage over land storage and can be eliminated. Hence, only direct transport by vessel to debarkation point will be considered

Option (2), Single-Mode Land: In this scheme the equipment is taken overland by truck to the debarkation point dockside, where it is unloaded (and re-loaded for transport to the spill, if the spill is not at the debarkation point dock).

Option (3), Single-Mode Air: The equipment is picked up by helicopter and brought to the debarkation point. The storage site in this case would most likely be at a USCG helicopter base, or near one. It is necessary that the debarkation point have facility to land a helicopter and refuel it.

Option (4), Dual-Mode Air/Land: As discussed above, this must be fixed-wing transport from the storage site to an intermediate field, and then by truck to the debarkation point.

Option (5), Dual-Mode Air/Air: This is fixed wing transport from the storage site to an intermediate field, and then by helicopter to the debarkation point.

Before discussing the above logistic options, some qualifications should be noted.

First, not all schemes apply to all pieces of equipment. For example, the current USCG helicopters cannot lift the barrier, even without the skimmer attached. Also, local facilities and geography may make some options more attractive at one location than at another.

Second, it should be emphasized that these options all refer to delivery of equipment to the debarkation point, rather than to the spill location. By debarkation point is meant the waterside location from which the equipment may be loaded or launched for delivery to the spill location. In Option 1 that delivery may be unnecessary if the spill occurs in the vicinity of the debarkation point. In Option 2, the equipment site may be a garage or storage area close to the pierside or launch ramp, but still far enough away to require a delivery device such as a loader, truck, or crane.

distance than the diameter of a military base.

The time intervals and speeds assumed below are based on USCG experience, discussions with Strike Team officers, and in some cases on subjective judgment. It will be assumed that all equipment has been pre-loaded on flat-bed trailers dedicated to pollution response. The tractors are assumed to be assigned to the base site, but not dedicated to pollution response. The major intervals are estimated as follows:

a. Alert time: Time elapsed during receipt and recording of OSC message, notification of response team commander, notification of other base officers and of destination personnel . . . . 15 min

b. Notification and assembly of strike team personnel . . . . 45 min

c. Personnel briefing. . . . . 15 min

d. Equipment check . . . . 30 min

e. Tractor availability and delivery . . . . 30 min

f. Response Range R/Mean Speed . . . . R n.mi./33.3 n.mi./hr

Intervals (d) and (e) are assumed to occur concurrently, and all others sequentially. If the equipment is not pre-loaded, approximately 1 to 3 hours will be required to do so. The appropriate loading devices (minimum capacity 10 tons) must be made available. A value of 120 minutes is assumed for acquiring the loader, and loading and securing the equipment on one semi-trailer. About 60 minutes will be added for each additional semi-trailer to be loaded and secured assuming one loading team and loader. This activity (g) is carried out simultaneously with (d) and (e). Figure 5.2 shows the parallel/sequential assumptions made for the time intervals (a) through (g). To estimate the mean road speed of (f), the driving time between 21 coastal city pairs was plotted against the straight line distance between them (Figure 5.3).*

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*Land distances and speeds have been expressed in nautical miles and knots, contrary to convention, so that the response range for land will be in units comparable to those conventionally used for air and sea i.e., nautical miles.

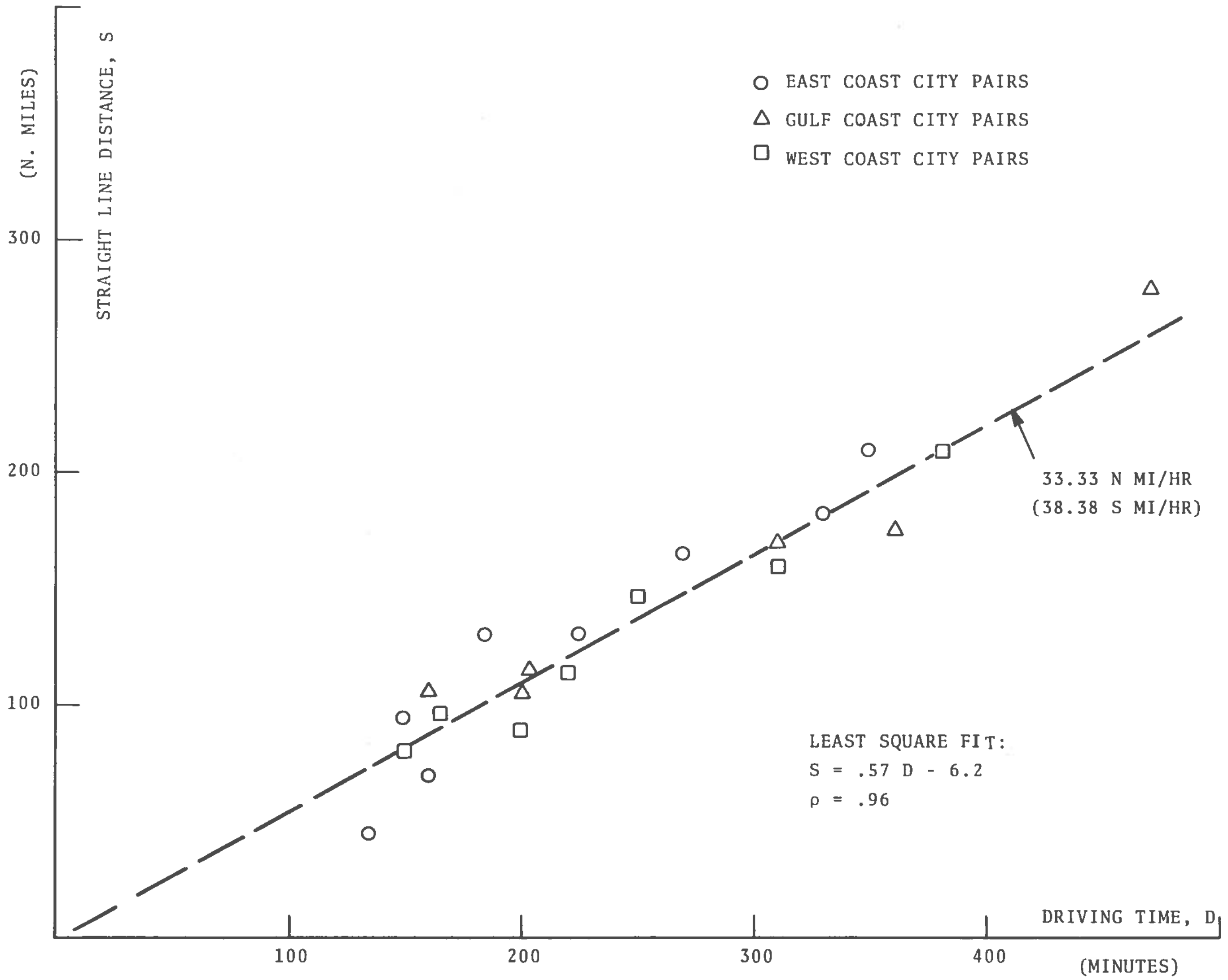


FIGURE 5.3 STRAIGHT LINE DISTANCE (S) VS DRIVING TIME (D) FOR 21 U.S. COASTAL CITY PAIRS

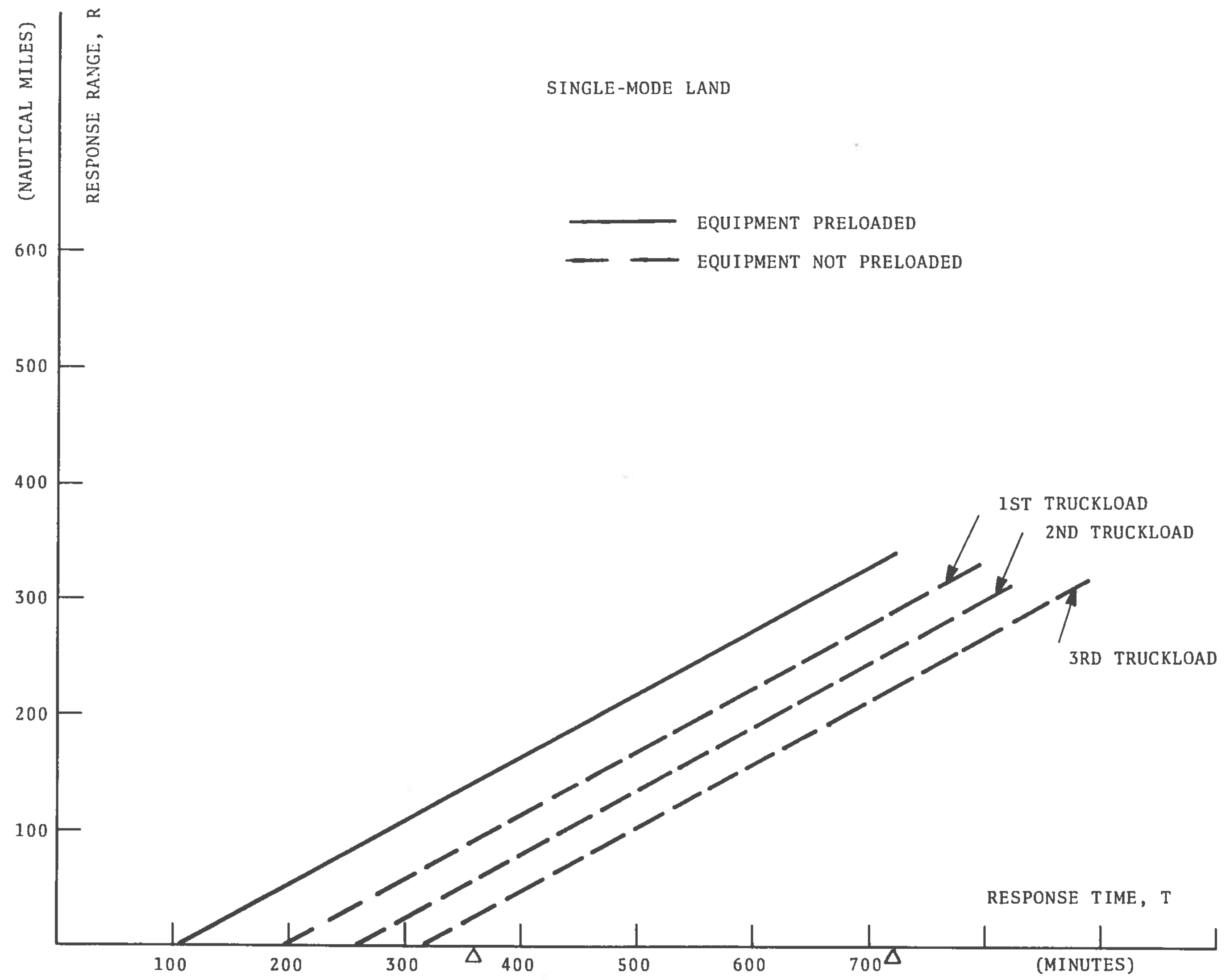
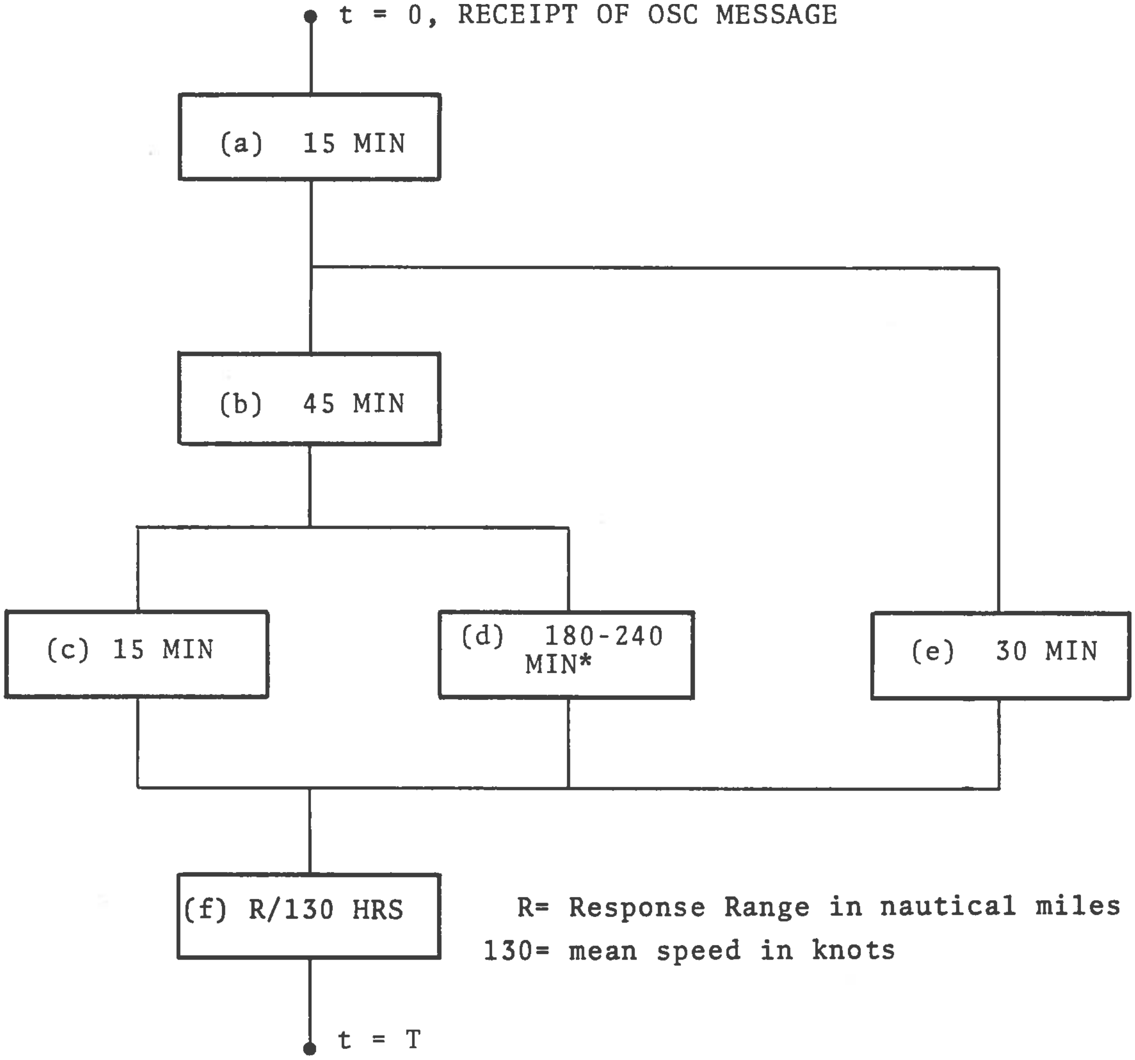


FIGURE 5.4 RESPONSE RANGE VS RESPONSE TIME, LAND



R= Response Range in nautical miles

130= mean speed in knots

*This may be about 30 minutes for special reconfiguration specification on new helicopters.

FIGURE 5.5 TIMING DIAGRAM FOR SINGLE-MODE AIR

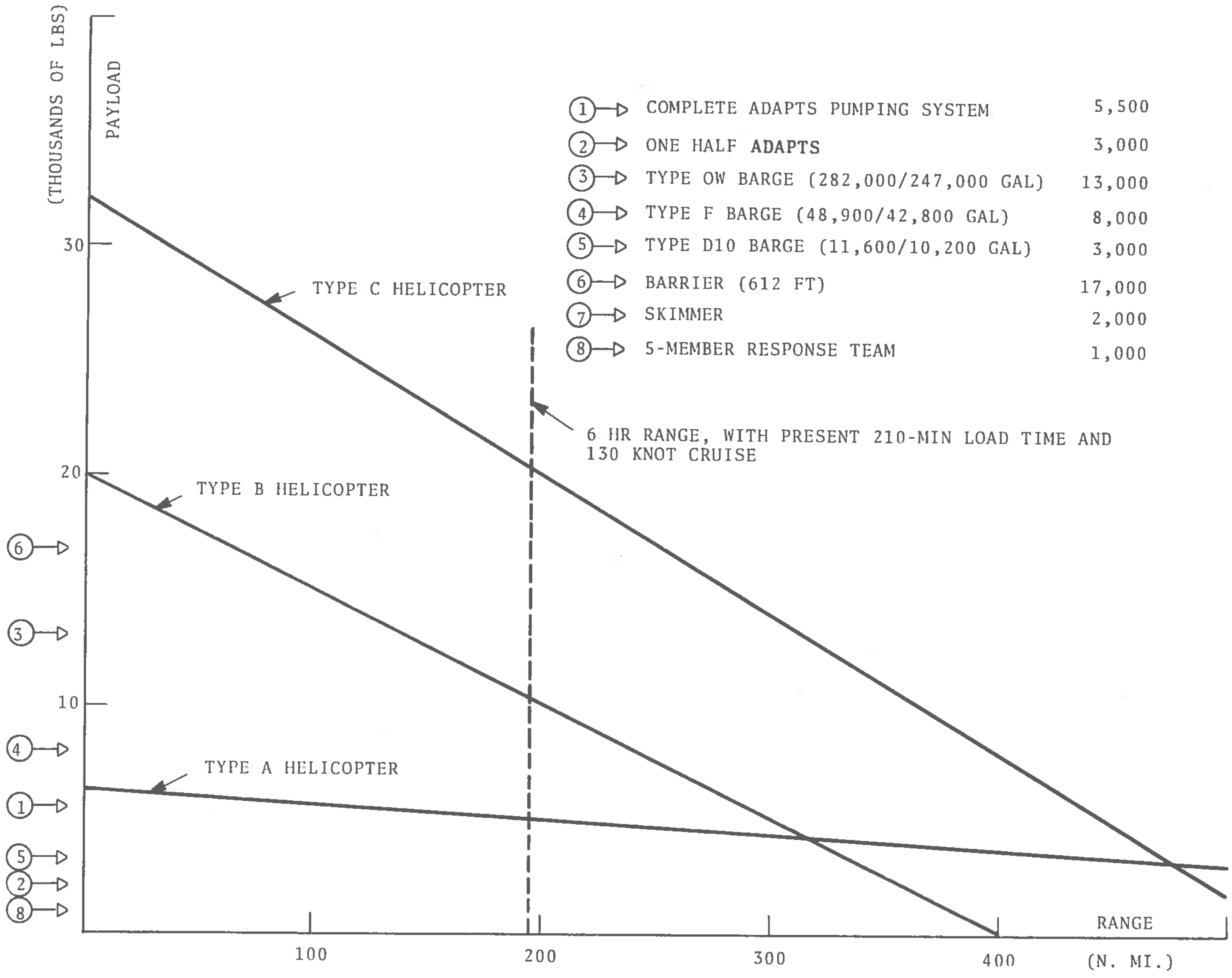


FIGURE 5.7 PAYLOAD-RANGE LINES FOR THREE CLASSES OF HELICOPTERS

e. Aircraft check, taxi, clearance, take-off, climb . . . . 15 min

f. Cruise (mean for C130-B, C130H) . . . . .295 knots

g. Approach, Landing, Rollout. . . . . 10 min

h. Unloading . . . . 10 min

j. Load truck. . . . . 30 min

k. Response Range R/Mean speed . . .R n.mi./33.3 n.mi./hr

The loading interval (d) shown here assumes availability of a loading truck appropriate to the C130 (or other aircraft employed). If this equipment is not available, an additional 15 to 30 minutes must be added to (d) for fork lift loading. If the aircraft must be hand loaded, the time is estimated at 4 to 8 hours.

The loading interval (j) assumes a crane or front loader capable of lifting 10 tons (if the barrier is transported), available at the transfer airport. The acquisition time for this loader is not critical since it may be acquired while the fixed-wing aircraft is enroute to the intermediate airport.

The relations among the intervals (a)-(k) are shown in Figure 5.8 and the corresponding range-time diagram of Figure 5.9. It can be seen from Figure 5.9 that the response time is highly sensitive to the distance between intermediate airports. In Figure 5.9 it is assumed, for illustrative purposes, that the intermediate airports are 200 n.mi. apart* and collinear with the equipment site. If the specified response time is 360 minutes, only those range-time combinations within the shaded areas can be realized. It can be seen that there are gaps in the four range intervals: 280-340 n.mi., 460-560 n.mi., 640-780 n.mi., and above 820 n.mi. These portions of coast line would be inaccessible by air/land modes within 6 hours if the equipment site and intermediate airports are at 200 n.mi. intervals along a straight line.

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*The average air distance between adjacent USCG air bases in the U.S. is 185 n.mi. ±69 n.mi., when Pacific and Great Lakes bases are grouped separately.

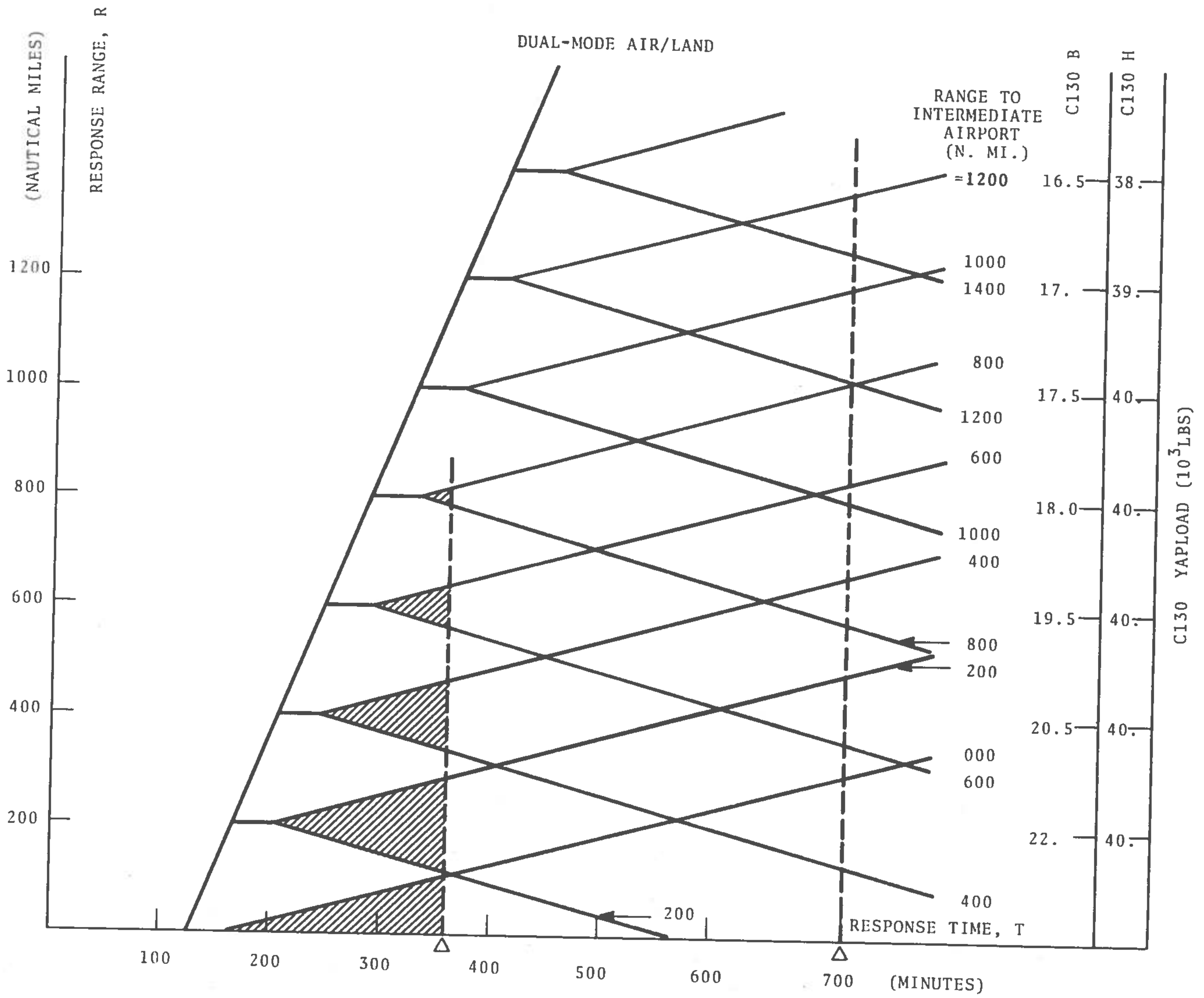

FIGURE 5.9 RESPONSE RANGE VS RESPONSE TIME, AIR/LAND

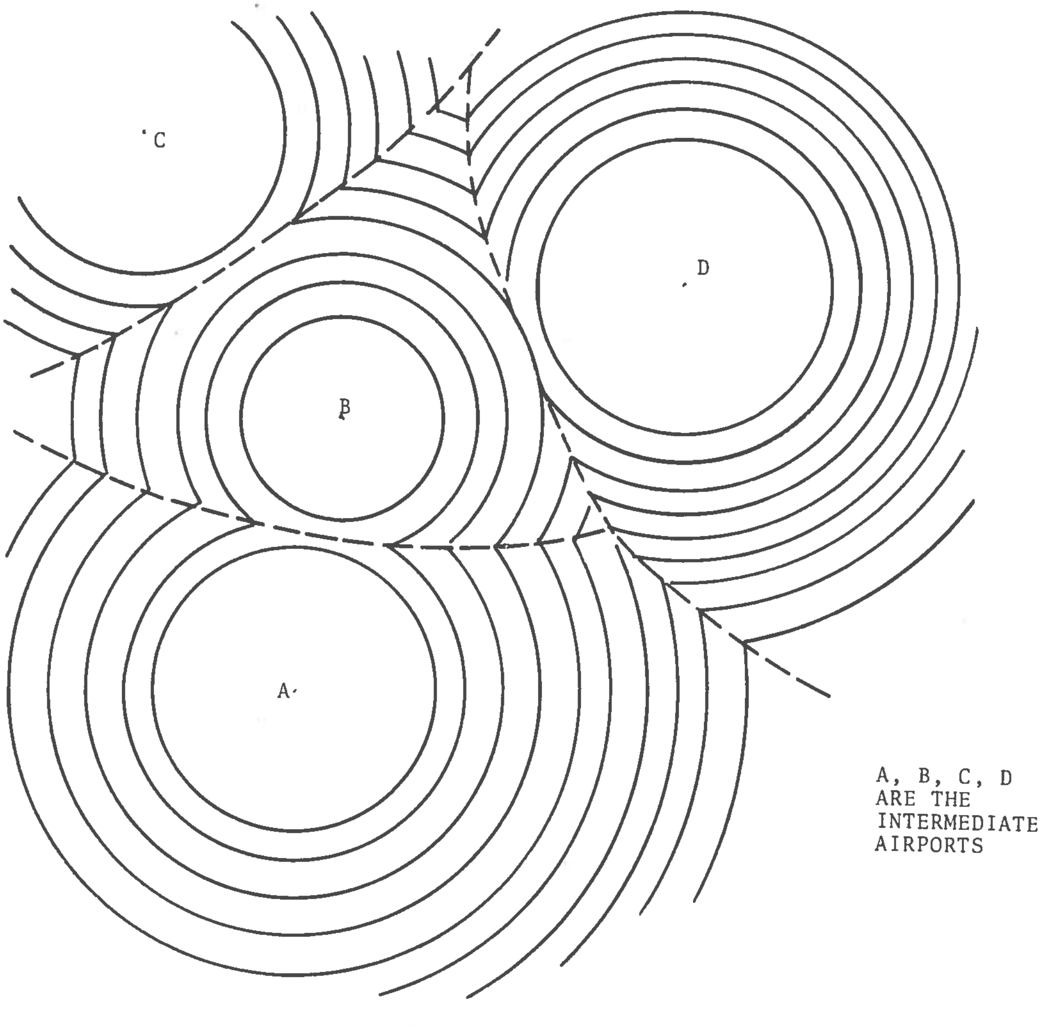

FIGURE 5.10 CONTOURS OF EQUAL TRANSPORT TIME DUAL-MODE AIR/LAND

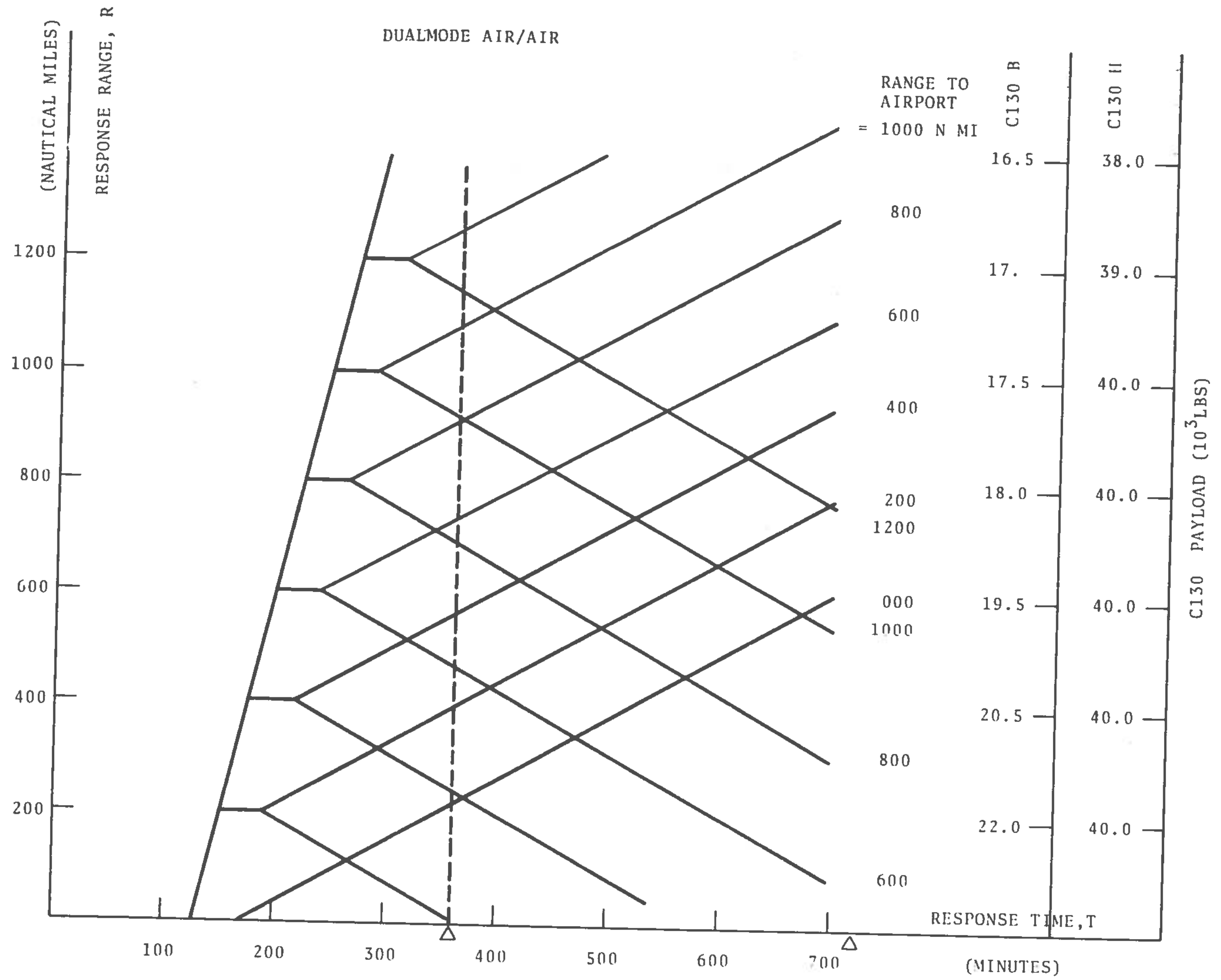

FIGURE 5.11 RESPONSE RANGE VS RESPONSE TIME, AIR/AIR

TABLE 5.7 SUMMARY OF EQUIPMENT, VEHICLES AND TRANSPORT OPTIONS (CONTINUED)

TRANSPORT OPTIONS		Systems/Vehicle-Trip				Response Range		
	Offloading			Recovery				
	(a)	(b)	(c)	(a)	(b)	6-hr (n.mi.)	12-hr (n.mi)	
Single-Mode								
Truck	2.5	3.3	5.0	1.4	1.6	140	340	
Helo A	-	-	0.5	-	-	100	100	(7)
B	0.75	1.0	1.5	-	-	100	100	(7)
C	1.3	1.7	2.6	(15)	(15)	100	100	(7)
Dual-Mode								
C130B/Truck	1.0	1.3	2.0	0.6	0.7	300-500	-	(8)
C130B/Truck	0.8	1.1	1.6	0.5	0.5	-	1639	(9)
C130H/Truck	2.0	2.7	4.0	1.1	1.3	300-500	-	(8)
C130H/Truck	1.9	2.5	3.7	1.0	1.2	-	1639	(9)
C130D/Helo A	-	-	0.5	-	-	1080	-	(10)
B	0.75	1.0	1.5	-	-	1080	-	(10)
C	1.0	1.3	2.0	(15)	(15)	600	-	(11)
C130B/Helo A	-	-	0.5	-	-	-	2300	(12)
B	0.75	1.0	1.5	-	-	-	1800	(12)
C	0.8	1.1	1.6	(16)	(16)	-	1600	(13)
C130H/Helo A	-	-	0.5	-	-	1080	-	(10)
B	0.75	1.0	1.5	-	-	1080	-	(10)
C	1.3	1.7	2.6	(17)	(17)	1080	-	(10)
C130H/Helo A	-	-	0.5	-	-	-	2545	(14)
B	0.75	1.0	1.5	-	-	-	2545	(14)
C	1.3	1.7	2.6	(15)	(15)	-	2545	(14)

TABLE 5.7 (CONTINUED)

(15) The Class C helicopters can transport the recovery barrier externally, but not internally. The 6-hr. range with external load is approximately 500 n.mi.

(16) The 12-hr. response range is about 1550 n.mi. if the recovery barrier is carried externally in Class C helicopters.

(17) The recovery barrier can be carried only externally, reducing the helicopter range to about 50 n.mi. and the 6-hr. response range to about 800 n.mi. (see Fig. 5-10).

(18) The recovery barrier can be carried only externally, reducing the helicopter range to about 50 n.mi., and the 12-hr. response range to about 2000-2500 n.mi., depending on separation of intermediate airports.

Second, from observations e. and f. it is seen that C130/Helo has no advantage over C130/truck except perhaps, range. Therefore, unless range is a primary consideration, the C130/truck option should be employed instead of the C130/Helo option. Considerations of cost, development and procurement time, and maintenance probably will reinforce this conclusion.

As a result of these two conclusions, primary attention will be directed in the remainder of this report to the single mode truck and dual-mode air/truck logistic options. Future investigation may show that single-mode sea transport is also of value.

6. SITE SELECTION

The criterion for site selection stated in Section 1 is the delivery of the equipment required by the OSC to the designated debarkation point within the specified 6- or 12-hour response time. This will be the primary, but not the only, measure applied to site selection in this Section.

Several methods of delivery were investigated in the preceding Section, two of which were selected as being of most value: single-mode truck and dual-mode air/truck. The assumptions and guidelines for this study (Section 1) state that "although aircraft may be used whenever it is advantageous to do so, the initial six-hour response shall not depend on the availability of aircraft." This effectively restricts consideration of the dual-mode air/truck method of delivery to 12-hour response times, where it provides much greater ranges than the truck mode. In order to simplify the site selection task in this Interim Report, only the single-mode truck option and the six-hour response will be treated. Both the truck and air/truck options will be considered in the Final Report.

The equipment types required by the OSC will be assumed to be those of the baseline systems described in Section 4. The quantities of equipment required will be investigated in Section 7, to follow. It will be assumed, for purposes of site selection, that whatever quantities of equipment are required can be delivered by truck. (The air/truck mode, however, may not be able to deliver adequate quantities of equipment for large or massive spills, and this point will be considered in a later report.)

Before discussing the method of site selection, it will be noted that there are (at present) three USCG strike teams, located at Elizabeth City, NC, Bay St. Louis, MS, and Hamilton AFB, CA. Siting schemes that place equipment at one or more of these locations are more easily implemented and, other things equal, will be given preference.

It should be clear from this description that the proposed procedure produces not a single site but a set of sites covering the entire U. S. coastline or, at least, a large section of coastline. Three U. S. geographic areas have been selected as being sufficiently isolated to apply the procedure: the West Coast, the Great Lakes area, the East and Gulf Coastal area. Separate site configurations will be investigated for each. (Puerto Rico, the Virgin Islands and Hawaii are very isolated cases and will be treated individually.)

6.2 METHOD OF EVALUATION

Even with a restricted number of sites, several site configurations can be found that satisfy the response criterion. Clearly, some measures are needed to evaluate competing configurations. The number of sites in the configuration is, of course, an approximate indicator of cost. What measures may be used to indicate the effectiveness or benefit? Several such indicators including the 6-hour criterion itself were devised and will now be discussed.

6.2.1 Debarkation Point Coverage

The extent to which the debarkation point requirement is met can be measured. First of all, the set of debarkation points needs to be defined. The discussion of Appendix D results in two sets: some 400 ports that have both channel and pier drafts greater than 10 feet, and a set of about 150 ports that have either a lift or crane, in addition to the 10-foot depths. For either of these sets, it is an easy matter to determine what fraction of the debarkation points in the set is covered by a given configuration of response regions. If there are gaps in the 6-hour coverage, this fraction may be less than unity. Similarly, using either set of debarkation points, it is possible to determine what fraction of them have multiple coverage, i.e., lie in overlapping regions.

reaching the spill in successive time intervals. Such measures will be considered in the remainder of the study and reported on in the Final Report.

6.2.5 Measures Selected for Use

Of the above measures, four were chosen for use in the present preliminary site selection:

a. Debarkation Point Gaps: The number of debarkation points (with lifts or cranes) that do not lie within the 6-hour response range of one or more sites, compared to the total number of such debarkation points, 149.

b. Debarkation Point Overlaps: The number of debarkation points (with lifts or cranes) that lie in the response area of two or more sites, compared to the total number of such debarkation points, 149.

c. Oil Throughput at Sites: The annual oil throughput at harbors with equipment sites, divided by the total annual oil throughput for the study area.

d. Historic Spills Encompassed: The fraction of actual and potential spills in the study area that have debarkation points within the coverage area.

6.3 CANDIDATE SITE CONFIGURATIONS

The measures just selected were applied to four candidate site configurations. The configurations represent different approaches to the site location problem and result in different numbers of sites. Each approach was applied to the three U. S. geographic areas mentioned above: East and Gulf, Great Lakes, and Western. The site configurations were determined and evaluated as follows:

Configuration A: 6-Hour Requirement

In this approach, the only criterion rigidly applied was the

TABLE 6.1 SITE CONFIGURATION A

LOCATION	USCG FACILITIES	USCG DISTRICT
<u>EAST AND GULF COASTS</u>		
Boothbay Harbor, ME	Station	1
New Haven, CT	Station, COTP, Group Office	3
Dahlgren, VA	Station	5
Charleston, SC	Base, MSO, Group Office	7
Clearwater, FL	Station, Air Station	7
Miami, FL	Base, COTP, Group Office	7
New Orleans, LA	Station, Base	8
Galveston, TX	Base, MSO	8
Corpus Christi, TX	MSO, Air Station	8
<u>GREAT LAKES</u>		
Sackets Harbor, NY*	Station	9
Erie, PA	Station, MSD	9
Bay City, MI	Station	9
Milwaukee, WI	Base, Station, COTP, Group Office	9
Duluth, MN	Station, MSO, Group Office	9
<u>WEST COAST</u>		
Seattle, WA	Base, Air Station, COTP, Support Center	13
San Francisco, CA	Station, MSO, Group Office	12
San Pedro/Long Beach, CA	Base, COTP	11

*This is a seasonal auxiliary station. The preferred alternate is Oswego, NY.

Towards the west of Lake Michigan, at least two sites are required: Milwaukee covers Chicago and Green Bay as well as itself, and Duluth covers Lake Superior.

The West Coast offers only one configuration that covers all debarkation points.

Configuration B: Minimum Overlap

The substantial number of debarkation points lying in two regions of Configuration A suggests that good coverage may be obtained with fewer sites. In addition, it is noted that several large oil ports, such as New York and Philadelphia, do not have direct coverage. Accordingly, Configuration B was devised as follows:

The Northeast was covered by sites at New York, NY, (a major oil port) and Portland, ME (which handles more crude and heavy oil than any other New England port). This allows dropping the Dahlgren, VA site to the Norfolk, VA area, also a prominent oil port.

The remainder of the East Coast is covered by two sites: one at Savannah, GA and one at Ft. Myers Beach, FL. While the latter site has no substantial oil movement or port facilities, it does cover both Tampa/St. Petersburg and Miami/Palm Beach. Unfortunately, Key West is not reachable in 6 hours at normal highway speeds, although it lies within the response circle from Ft. Myers.

By eliminating 6-hour coverage for Brownsville, TX it is possible to cover all Gulf debarkation points with two sites, New Orleans, LA and Freeport, TX. Similarly, two sites may be removed from the Great Lakes Configuration A if that at Duluth, MN is eliminated, and the two covering Lakes Erie and Ontario are combined into one at Buffalo, NY. The West Coast sites are unaltered from Configuration A.

The net result of the above adjustments is reduction of the number of sites from 17 to 13. The list of sites is given in Table 6.2 and shown in Figure 6.2.

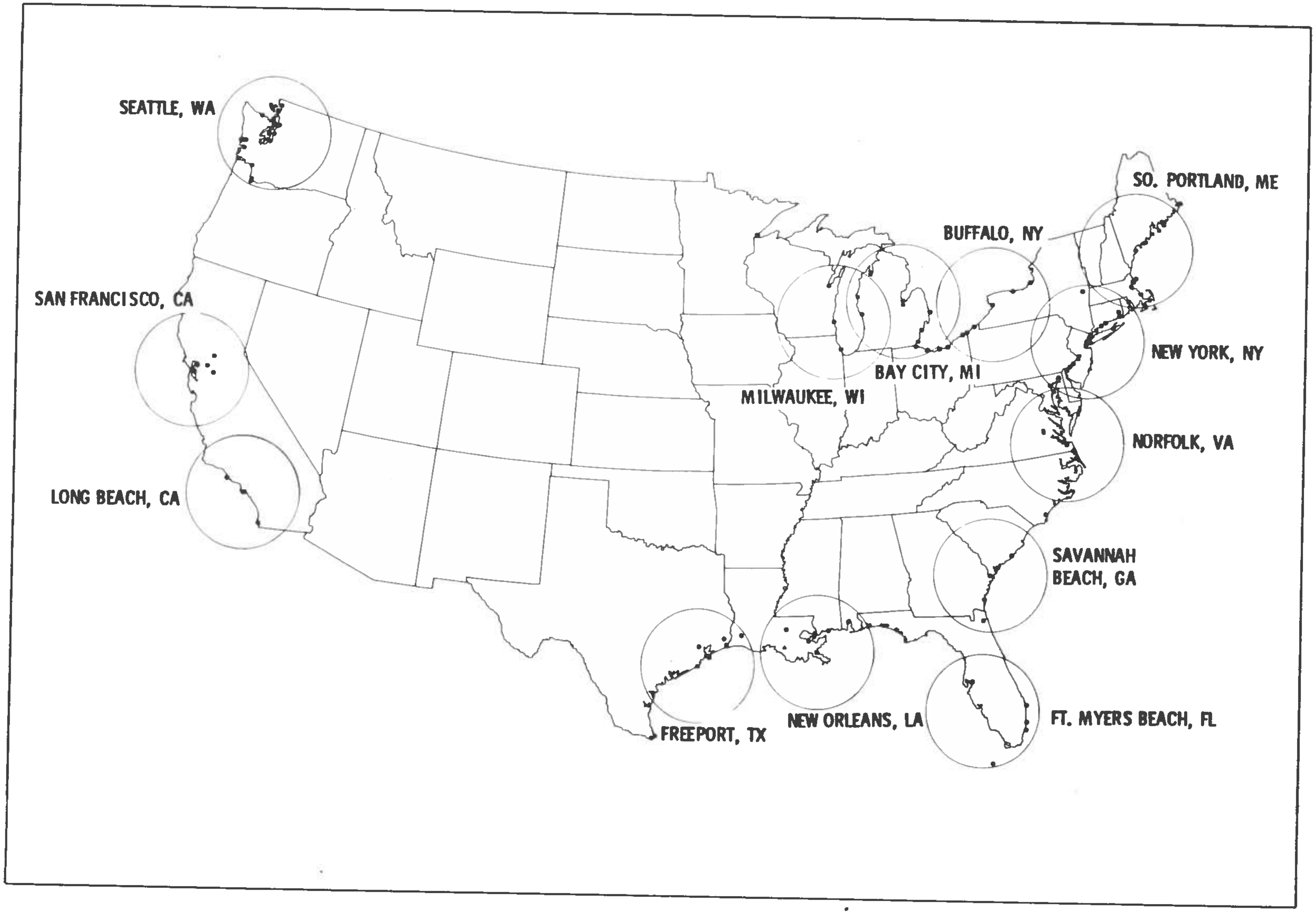

FIGURE 6.2 DEBARKATION POINTS WITHIN RESPONSE RANGE OF EQUIPMENT SITES - CONFIGURATION B

TABLE 6.3 SITE CONFIGURATION C

LOCATION	USCG FACILITIES	USCG DISTRICT
EAST AND GULF COASTS		
South Portland, ME	Base, Group Office	1
New York, NY	Station, COTP, Group Office	3
Baltimore, MD	Station, MSO, Yard, Group Office	5
Norfolk/Portsmouth, VA	Station, Base, MSO, Support Center, Group Office	5
Savannah Beach, GA	Station	7
Ft. Myers Beach, FL	Station	7
New Orleans, LA	Station, Base	8
Freeport, TX	Station	8
GREAT LAKES		
Sackets Harbor, NY*	Station	9
Erie, PA	Station, MSO	9
Bay City, MI	Station	9
Milwaukee, WI	Base, Station, COTP, Group Office	9
WEST COAST		
Seattle, WA	Base, Air Station, COTP, Support Center	13
San Francisco, CA	Station, MSO, Group Office	12
San Pedro/Long Beach, CA	Base, COTP	11

*See footnote (*) on Table 6.1.

TABLE 6.4 SITE CONFIGURATION D

LOCATION	USCG FACILITIES	USCG DISTRICT
EAST AND GULF COASTS		
Providence, RI	MSO	1
Baltimore, MD	Station, MSO, Yard, Group Office	5
Savannah Beach, GA	Station	7
Ft. Myers Beach, FL	Station	7
New Orleans, LA	Station, Base	8
Freeport, TX	Station	8
GREAT LAKES		
Chicago, IL	Station, COTP	9
Cleveland, OH	Station, MSO	9
WEST COAST		
Seattle, WA	Base, Air Station, COTP, Support Center	13
San Francisco, CA	Station, MSO, Group Office	12
San Pedro/Long Beach, CA	Base, COTP	11

This allotment is somewhat arbitrary, being based on relaxing the 6-hour response requirement for certain low oil traffic density coastal areas: Northern Maine, Lake Ontario, and Lake Superior. It also provides only marginal coverage for the Wilmington, NC area, northern Lake Michigan, and upper Lake Huron. Finally, it provides double coverage for the New York and Jersey City areas, but at the limit of the 6-hour criterion.

The configuration is shown in Figure 6.4 and the sites are listed in Table 6.4.

The Providence, RI location has logistic advantages over Newport, RI and Narragansett, RI, both of which are close to it. The advantage of Providence is proximity to I-95, which connects with Portland ME and New York, NY. The physical facilities at MSO Providence, however, may not be able to handle the required equipment, and one of the two alternates should then be employed.

The Savannah, GA location may be shifted to Charleston, SC, if necessary, affording better protection to Wilmington, NC rather than Jacksonville, FL.

The Great Lakes are covered, to an extent, by the Chicago site, which serves both sides of Lake Michigan, and the Cleveland site which must serve Lake Erie and Lake Ontario as well as the lower part of Lake Huron.

It can be seen from Figure 6.4 more clearly than from the preceding three figures that the East and Gulf Coasts include three separate debarkation point areas: the Northeast Atlantic, Southeast Atlantic, and Western Gulf Coasts. The Southeast sector is separated from the Northeast by the Cape Hatteras area and from the western Gulf by the Florida panhandle, both being characterized by a lack of significant oil ports.

6.4 EVALUATION

Table 6.5 shows the results of applying measures (1)-(4) of Section 6.2.5 to Configurations A,B,C,D. The measure, as a fraction of the total, is shown in parentheses. The configurations are ordered according to the number of sites, a rough

TABLE 6.5 EVALUATION OF FOUR SITE CONFIGURATIONS

	A	C	B	D
NUMBER OF SITES	17	15	13	11
(1) DEBARKATION POINTS OUT OF RESPONSE RANGE	0 (.00)	5 (.034)	8 (.054)	23 (.154)
(2) DEBARKATION POINTS COVERED BY TWO SITES	13 (.087)	18 (.121)	2 (.013)	0 (.00)
(3) OIL MOVEMENT AT SITES, IN 1975, MILLIONS OF TONS	267. (.411)	332. (.511)	318. (.489)	162. (.249)
(4) SPILLS WITH DEBARKATION POINTS OUT OF RESPONSE RANGE (1974-77 MOSIS)	1 (.007)	4 (.029)	6 (.043)	13 (.093)

Note: The numbers in parentheses are the fractional values of the numbers above them, based on 149 debarkation points, 650 million tons of oil, and 140 spills.

Second, it is certain that debarkation point and spill coverage cannot be improved by adding sites in excess of 17. Sites in excess of 17, however, can improve the coverage of major oil ports (measure 3) and increase multiple coverage of debarkation points (measure 2). Even though those two measures dropped as sites increased from 15 to 17, it is likely that a rearrangement of the 17 sites may be made so that both measures are better than in Configuration C, with measures (1) and (4) no worse. Therefore, if more than 15 sites are to be established, none of the four configurations should be employed directly; a new configuration should be evolved from Configuration A or C.

Configuration C differs from B in the extra site at Baltimore. This site adds little to the ability to respond to ocean spills which are handled in the midcoastal area by the sites at New York, NY and Norfolk, VA. It makes a partial contribution to handling Chesapeake and Delaware Bay spills, some of which may occur in open-water conditions. Its main value is in responding to spills in the Philadelphia-Trenton-Wilmington, DL area, as well as those in the Baltimore area, neither of which is an open-water area.

Some discussion is in order of the limitations of this analysis and how it may be improved. As in any such analysis, the results are strongly influenced by the measures applied. The list of potential debarkation points (Appendix D) is based on 10-ft. pier and channel depth and the presence of a lift or crane at the port. Modifying these requirements or employing other than the World Port Index as a source would modify the results.

Another factor to be considered is possible refinements in the data, particularly those on oil movement. The measure (3) has been applied using oil movement data for 1975 for the largest 29 oil ports. A slight adjustment is expected if all oil ports in the study area are considered. In addition, other measures of oil movement coverage are yet to be applied, such as described in Section 6.2.2.

Finally, it must be emphasized that the measures have been designed to determine effectiveness in getting equipment from storage site to debarkation point. Although measure (4) does

7. EQUIPMENT LEVELS

The site selection procedure in the preceding section gives only the locations of the sites, and does not indicate how much or what type of equipment is to be stored at each site. In this section the relative distribution of equipment among the sites of a given configuration will be explored. A method will be applied to yield relative equipment levels at the sites based on the expected number and volume distribution of spills within the area covered by each site. The spill rates and volume distributions obtained in Section 3 from the MOSIS data base will be employed.

Questions of types of equipment and absolute (rather than relative) quantities will be taken up in later reports.

7.1 METHOD

The initial approach taken to the question of equipment levels was to attempt to assign to each site adequate equipment to handle the largest spill expected (to be serviced by the debarkation points) in its region.* This approach was unsatisfactory because "the largest spill expected" was found to be too difficult to define at the present stage of the study. On one hand, account might be taken of possible VLCC (Very Large Crude Carrier) traffic to deepwater ports in the 1980-1990 period. The initial operating time of these ports is speculative at present, expect perhaps for LOOP. The probable location of spills from vessels using them must be estimated. Further, it is not clear that vessel size and spill size are related (Reference 7.1, Figures 2. and 3.). On the other hand, historic spill data from 1974-77 (Section 3) is found to be inadequate to yield volume

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*The term "region" is used in this Section to indicate the area within the response range of a given equipment site. It does not indicate USCG or DOT regions.

the regional spill rates of Section 3.3.2 to the oil throughput for the ports in the region. The oil throughput data available at the present stage of the study are limited to 29 major ports for 1970 and 1975. The 1975 data were employed. Unfortunately, the data do not yet include Great Lakes oil ports. The results of multiplying the spill rates of Table 7.1 by the available oil throughput data of Column 3 in Table 7.2 are shown in Column 4 of Table 7.2. The product is the average value of the number of spills per year associated with the oil movement into, out of, and through each port assuming a Poisson spill process relative to oil throughput, and the 1975 value for one year's throughput for each port.

It is next necessary to aggregate the spills occurring at ports within a region to obtain the average number of regional spills, $\bar{n}_i$ in the region. This is done in Table 7.3. In that table, each site of interest is listed in the first column and the oil ports within its region are listed (by number) in the second column. The last four columns give $\bar{n}_i$, the average spill rates for the regions, when employed in each of the four configurations established in Section 6. The rates were adjusted for any overlap of regions that occurs in the configuration. If two regions overlapped, the spill rate of a port in the common area would be evenly divided between the two regions, i.e., half added to each region. It will be noted that more than two overlapping regions do not occur in any configuration.

The last four columns of Table 7.3 and the distribution of Figure 3.5 were employed with the algorithm of Appendix E to obtain relative equipment levels.

7.3 RESULTS

The distribution of equipment among the sites of a configuration depends on the total response capability assumed. Since the total capability cannot yet be specified, equipment distributions were determined for several capability levels. They are shown in Tables 7.4 through 7.7 for site configurations

TABLE 7.2 OIL THROUGHPUT, 1975, AND AVERAGE NUMBER OF SPILLS PER YEAR

PORT NO.	PORT NAME	MILLIONS OF TONS/YR(1)	AVERAGE SPILLS/YR(2)
1	Portland, ME	27.5	0.96
2	Portsmouth, NH	22.6	0.79
3	Boston, MA	22.3	0.78
4	Providence, RI	11.4	0.40
5	New Haven, CT	16.5	0.57
6	New York Harbor, NY/NJ	142.4	3.12
7	Philadelphia, PA	30.5	2.35
8	Baltimore, MD	13.3	0.46
9	Norfolk, VA	11.4	0.40
10	Wilmington, NC	4.2	0.15
11	Charleston, SC	5.3	0.19
12	Savannah, GA	3.5	0.12
13	Jacksonville, FL	9.2	0.32
14	Port Everglades, FL	9.5	0.33
15	Tampa, FL	10.2	0.36
16	Mobile, AL	8.2	0.28
17	New Orleans, LA	31.6	2.28
18	Lake Charles, LA	19.7	1.43
19	Port Arthur, TX	46.3	1.06
20	Houston, TX	44.7	1.02
21	Texas City, TX	18.3	0.42
22	Corpus Christi, TX	24.5	0.85
23	Brownsville, TX	1.1	0.04
24	San Diego, CA	1.0	0.04
25	Los Angeles, CA	41.5	1.44
26	San Francisco, CA	5.7	1.97
27	Portland, OR	4.8	0.17
28	Seattle, WA	4.0	0.14
29	Anacortes, WA	4.5	0.16

(1) Short tons in 1975, extracted from Reference 3.4.

(2) Obtained by multiplying the spill rates of Table 7.1 by the oil throughput rates in millions of tons/year.

TABLE 7.4 EQUIPMENT LEVELS FOR CONFIGURATION A

	TOTAL CAPABILITY, MILLIONS OF GALLONS				
SITE	3.5	4.5	9.0	24.0	38.0
Boothbay Harbor, ME	6.3%	7.0%	5.1%	7.0%	9.6%
New Haven, CT	15.2	26.4	29.1	21.3	16.6
Dahlgren, VA	9.7	8.1	6.6	10.6	12.0
Charleston, SC	2.4	2.2	2.3	1.7	1.7
Clearwater, FL	2.0	1.8	1.7	1.6	1.2
Miami, FL	1.7	1.8	1.6	1.5	1.1
New Orleans, LA	11.4	8.8	9.7	10.6	12.0
Galveston, TX	12.9	11.9	19.5	21.3	15.3
Corpus Christi, TX	3.8	3.9	4.4	2.6	5.5
Long Beach, CA	6.4	7.0	5.1	7.5	9.8
San Francisco, CA	9.7	8.1	6.6	10.6	11.9
Seattle, WA	2.5	2.1	2.3	1.7	1.8
Duluth, MN	3.2	2.2	1.2	0.4	0.3
Milwaukee, WI	3.2	2.2	1.2	0.4	0.3
Bay City, MI	3.2	2.2	1.2	0.4	0.3
Erie, PA	3.2	2.2	1.2	0.4	0.3
Sackets Harbor, NY	3.2	2.2	1.2	0.4	0.3
	100.0	100.0	100.0	100.0	100.0

TABLE 7.6 EQUIPMENT LEVELS FOR CONFIGURATION C

	TOTAL CAPABILITY, MILLIONS OF GALLONS				
SITE	3.5	4.5	9.0	24.	38.0
South Portland, ME	8.1%	7.6%	5.6%	9.6%	12.0%
New York, NY	27.4	31.1	35.8	23.4	16.8
Baltimore, MD	6.6	7.1	4.6	8.2	10.7
Norfolk, VA	2.2	1.8	1.6	1.5	1.4
Savannah, GA	2.8	2.6	2.9	1.7	3.6
Ft. Myers, FL	2.1	1.7	1.5	1.4	1.4
New Orleans, LA	9.7	8.2	8.2	13.8	13.5
Freeport, TX	14.5	15.5	23.9	20.9	16.0
Long Beach, CA	5.4	6.6	4.3	6.8	9.8
San Francisco, CA	8.2	7.6	5.6	9.6	11.9
Seattle, WA	2.1	2.0	2.0	1.5	1.8
Milwaukee, WI	2.7	2.1	1.0	0.4	0.3
Bay City, MI	2.7	2.1	1.0	0.4	0.3
Erie, PA	2.7	2.1	1.0	0.4	0.3
Sackets Harbor, NY	2.7	2.1	1.0	0.4	0.3
	100.0	100.0	100.0	100.0	100.0

A through D. Because oil throughput data are not yet available for the Great Lakes, a minimum response capability of 100,000 gallons per region was assumed for Great Lakes sites, in accordance with Assumption 8, Section 1.3. The equipment levels shown for Great Lakes sites, as well as those for the other sites, will be revised when improved oil throughput data are available.

Some of the salient features of the Tables should be noted. The highest percentage of equipment, 37.9%, occurs in New York, NY, in configuration B. Other sites that are allotted relatively high concentrations of equipment are: New Haven, CT in configuration A which does not include New York, NY; Galveston, TX and Freeport, TX; Baltimore, MD and Providence, RI in configuration D which also does not include New York, NY. In general, the Tables show relatively high percentages of the equipment allotted to ports with high oil movement rates, as expected.

Another result of the analysis is shown in Figure 7.1. This is a plot of total response capability vs equipment utilization factor. The latter is defined as the ratio of the expected value of oil salvaged per year to total salvage capability of the equipment. It is seen that relatively low utilization is expected for higher total capability. For example, one notices that if a 17.5 million gallon capability is deployed, its utilization can be expected to be about .05; i.e. about 1/20 of the total equipment will see action in a year. Moreover, the curve in Figure 7.1 applies to all four configurations with an accuracy of about ±5%. This means that the efficiency of all four equipment configurations is about the same. In other words, all four configurations can be expected to recover about the same amount of oil for the same total amount of equipment deployed, assuming optimum deployment.

7.4 INTERPRETATION

The results above are stated in terms of response capability r_i of the i-th region. By the response capability of a set of equipment is meant the maximum amount of oil that the equipment can salvage in a single spill, given ideal conditions; spills less than that value will be completely salvaged and spills greater than that value will be recovered only to the response capability level. In actuality, the amount salvaged varies widely from spill to spill, and only a fraction rather than the entire amount of oil is usually saved in any operation. Unless region-to-region distinctions can be made, however, which may be possible on the basis of environmental data, the variation in amounts actually salvaged will affect all regions equally and on the average have no effect on the relative levels of equipment allotted to the regions. The response capability, then, is more accurately taken to be the limit of the average amount that the equipment can salvage.

In the case of off-loading, equipment capability in terms of gallons off-loaded is meaningful only if a specific time period is assumed during which the pumping occurs. Different periods may be taken for different incident types and a (weighted) average of the amount off-loaded by the equipment in the different incidents would then serve as the measure of capability. In addition, the total amount off-loaded may be limited by the tempory storage barges available in the equipment site. Since the intent here is to determine the distribution of USCG-owned equipment, private and contractor barges need not be included in estimating this limit in the first analysis. The net limit is set by either the amount that can be pumped off in the given period or by the capacity of the temporary storage barges, whichever is smaller.

In the case of recovery of oil from the water, a specific time period also must be assumed. This is determined from slick spreading rates, the rate of dispersion in the water column, and evaporation rate, as well as spill rate. The comments made above for off-loading apply here as well--several typical incidents involving different environmental conditions and spill rates may be investigated and a weighted average time period arrived at. Likewise, the temporary storage capacity available also provides a limit to the total recovery capability independently of the skimming rate.

REFERENCE FOR SECTION 7

7.1 Beyer, A. H. and L. J. Painter, "Estimating the Potential for Future Oil Spills from Tankers, Offshore Development, and Onshore Pipelines," in Proceedings of the 1977 Oil Spill Conference, March 8-10, 1977, New Orleans LA, American Petroleum Institute Publication No. 4284.

APPENDIX A
MAJOR OIL SPILL INFORMATION SYSTEM (MOSIS)

The data base assembled for this study has been designated the Major Oil Spill Information System (MOSIS). It contains information on all identifiable oil spills of 50,000 gallons or more affecting waters in and around the U. S. during the period from January 1974 through July 1977. The primary sources of information for the MOSIS file were Coast Guard maintained records, namely:

a. The Pollution Incident Reporting System (PIRS)
b. The National Response Center (NRC) case files
c. The On Scene Coordinator (OSC) Reports.

Supplementary information from other sources was included wherever possible and so identified.

The MOSIS file is reproduced in this Appendix followed by a sheet defining the coded entries. Further explanation of the first few entry columns is given here. The TSC file number is constructed as follows: The first digit (5) indicates that the data base is restricted to spills of 50,000 gallons or more; the second digit identifies the year (e.g., 4 = 1974); and the next three represent the sequential number of the spill, with a P as the third digit identifying a potential spill. The NRC file number consists of two parts: the first three digits are the case number and the last two the year. The PIRS file number also consists of two parts: the first two digits indicate the Coast Guard district involved and the remaining five digits represent the sequential oil spill count within that district. The "Other" column is to be used to identify incidents contained in filing systems other than NRC and PIRS. The entry CG in this column refers to the Coast Guard Vessel Casualty File. The entries PDS and SDS refer to primary and secondary data sources. The remaining headings are self-explanatory. Entries are in chronological order.

MAJOR OIL SPILL INFORMATION SYSTEM

TSC	NRC	PIRS	OTHER	P DS	S DS	L OC	T YP	LOCATION	DIST SHR	LATN	LONGW	POLL	OCC DATE	BODY OF WATER	AMT DISCH KGALS	AMOUNT IN WAT KGALS	SOURCE	CAT	CAUSE	PREOSC
54001		0300014		P		X		TRENTON NJ	0	4010	7444	DSTLL	0104	DELAWARE R	600	20	MOBILE OIL CO	2	PRSNERR	C PHIL
54002		0802185		P		X		LONGVIEW TX	0	3230	9443	CRUDE	0110	SABINE R	72		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54003		0804755		P		R		N ORLEANS LA	0	2959	9015	GAS	0110	MISS. RIVER	120		BULK STORAGE	2	HOSERUP	C N ORL
54004		0804824	CG	P	A	R	C	N IBERIA LA	0	3004	9145	CRUDE	0115	MISS. ML120	158	158	MV COLUMBIA	3	COLLSN	C N ORL
54005		0801920	CG	P	A	R		DNLDSNVLL LA	0	2955	9105	CRUDE	0118	MISS. ML119.5	1680	80	SHELL OIL CO	1	PPLNRUP	C N ORL
54006		0300075		P		R	G	YONKERS NY	0	4047	7356	#6	0119	HUDSON RIVER	84	84	TB1000-9999GT	5	GROUND	C ALBNY
54007		0300098		P		X		PATERSON NJ	0	4102	7402	#6	0123		60		NON TRANS FAC	2	CORRSN	EPA II
54008		0800662		P		X		POLK TX	0	3015	9444	CRUDE	0125	L. LIVINGSTON	98		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54009		0200044		P		X		SMYRNA TENN	0	3602	8635	DIESL	0126	PRCY PRIEST L	70		ONSHORE PLANT	2	STRCPLR	EPA IV
54010		0800121		P		X		POLK TX	0	3043	9456	CRUDE	0215	L. LIVINGSTON	168		ONSHORE PIPELN	1	PPLNRUP	EPA IV
54011		0300195	CG	P	A	R	C	PAULSBORO NJ	0	3951	7517	#6	0219	DELAWARE R	285	285	MV ATHOS	3	COLLSN	C PHIL
54012		0800438		P		X		DECATUR TX	0	3320	9750	CRUDE	0311	BRIDGEPORT L	126		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54013		0800499		P		X		PASADENA TX	0	2944	9523	GAS	0311		63		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54014		0802210		P		X		JACKSON MISS	0	3239	9018	CRUDE	0329	RSS BRNTT RES	121		ONSHORE PRODUC	2	PIPERUP	EPA VI
54015		0900162	CG	P	A	R	G	ALXNDR BAY NY	0	4430	7546	CRUDE	0415	ST LAWRNC RIV	147	147	TSIMPRL SARNIA	3	GROUND	C BUFFL
54016				U		O	B	EUG I BLCK LA	0	2800	9000	CRUDE	0417	GLF OF MEXICO	840	840	OFFSHORE PROD	8	PPLNRUP	USGS
54017		0801087		P		X		WOODVILLE TX	0	3047	9426	CRUDE	0429		176		ONSHORE PIPELN	1	CRASH	EPA VI
54018		1100442		P		X		WELTER ARIZ	0	3310	11410	DIESL	0507	GILA RIVER	60		BULK RAIL VEH	9	UNKNOWN	EPA IX
54019		1100448		P		X		BAKERSFLD CA	0	3520	11910	CRUDE	0508	KERN RIVER	714		ONSHORE PIPLN	1	PIPERUP	EPA IX
54020		0802214		P		X		TYLER TX	0	3228	9516	CRUDE	0520		50		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54021				O		X	C	CINCINNATI OH	0	3735	8415	KRSNE	0522	OHIO RIVER	73	73	BARGE EIDC #1	5	COLLSN	C CINC.
54022		0801837		P		X		MARSHALL TX	0	3237	9407	CRUDE	0621		63		ONSHORE PIPELN	1	CRASH	EPA VI
54023	00575			N		R	S	N ORLEANS LA	0	2950	9055	CRUDE	0625	MISS. ML106	84	84	TB ABC 2311	5	SINKING	C N ORL
54024		0801818		P		X		TYLER TX	0	3236	9513	CRUDE	0627		332		ONSHORE PIPELN	1	PPLNRUP	EPA VI
54025	00675	0803895		N	P	S	S	GALVESTON TX	0	2937	9500	#6	0708	BAYPORT CHNNL	378	378	TB TM 10	5	SINKING	P HSTN
54026		0900343		P		X		PARMA OHIO	0	4129	8141	GAS	0715		187		ONSHORE STORGE	2	FLNGPLR	EPA V
54027		0300921		P	A	S	G	RED HOOK NY	0	4202	7356	GAS	0719	HUDSON RIVER	130	130	TB HYGRADE2	5	GROUND	C N YRK
54028		0801834		P		S	C	PORT ARTHR TX	0	2950	9357	#6	0721	SABINE LAKE	84	84	TB 1-10K	5	COLLSN	M P ART
54029	00375	0300986		N	P	S		GLENMONT NY	0	4235	7346	#2	0731	HUDSON RIVER	940	100	BULK TRANSFER	2	TKOVRFL	C ALBNY
54030	00275			N		X	C	BANNER IL	0	4015	9010	#2	0804	ILL R ML139	92	92	TB IOT #162	5	COLLSN	M ST LO
54031	01175	0801956		N	P	S		BEAUMONT TX	0	3002	9355	GAS	0805	NECHES RIVER	84		COLONIAL PIPLN	1	PPLNRUP	C SABIN
54032	03075			N		X	G	GRAYS PT MO	0	0	0	TLUEN	0812	MISS. RIVER	66	66	TB CBC 241	5	GROUND	EPA VII
54033	04075	0802192		N	P	X		ABILENE TX	0	3228	9945	#4	0817	STOCK POND	54	54	6" LINE	1	LINERUP	EPA VI
54034		0802216		P		X		WCHTA FLLS TX	0	3353	9830	CRUDE	0822	WICHITA RIVER	63		BULK STORAGE	2	IMPHNDL	EPA VI
54035	06975			N	U	O	B	CHNDLUR IS LA	0	3003	8852	CRUDE	0909	GLF OF MEXICO	92	92	PIPELINE	8	PPLNBRK	C N ORL
54036	11475	0301289		N	P	S	G	NEW HAVEN CT	0	4118	7255	#6	1006	N HAVEN HRBR	105	105	MV MSSNK BRGN	3	GROUND	C N HVN
54037	11875	0802686		N	P	S		CORP CHRST TX	0	2749	9726	#6 CR	1009	CORP CHRST HR	307	307	TS 20-35K	3	UNDETRM	C CR CH
54038	13475			N		X	G	DNLDSNVLL LA	0	2955	9105	CRUDE	1021	MISS. ML176	92	92	MV ERCOLE(IT)	4	GROUND	C N ORL
54039	13675	0900513		P	N	R		TONOWANDA NY	0	4300	7854	GAS	1027	NIAGARA RIVER	73		BULK TRANSFER	2	PUMPFLR	C BUFFL
54040	18975	0900571		N	P	R	S	ALXNDR BAY NY	0	4520	7556	DIESL	1121	ST LWRNC RIVR	53		MV ROY A JODRY	3	SINKING	C BUFFL
54041	20375	0804145		N	P	S		CORP CHRST TX	0	2749	9725	CRUDE	1202	CORP CHRST HR	51	51	ONSHORE PIPELN	1	RUPTURE	C CR CH
54042				O		X	3	MARIETTA OH	0	3923	8126	OIL	1212	OHIO RIVER	100	100	UNDRGRND LEACH	2	SEEPAGE	M HUNT.
54043	23675			N		R		MISS. RIVER	0	2900	9014	CRUDE	1224	MISS. ML88	63	63	BARGE TRANS CO	5	TKOVRFL	C N ORL
54P01		0300024		P		S	C	WILMNGTON DL	0	3947	7435	CRUDE	0104	ATLANTIC	0	50P	TS 10-20K	3	COLLSN	C PHIL
54P02		0300160		P		S		FIRE I NY	0	4040	7308	MIXPTR	0207	ATLANTIC	0	330P	TS 500-999 GT	3	PRSNERR	C N YRK
54P03		1100174		P		O	G	PNT LOMA CA	0	3239	11714	#6	0215	PACIFIC	0	5880P	TS 10-20K	3	GROUND	M SAN D
54P04		1100175		P		O	B	S CLEMENTE CA	0	3348	11818	DIESL	0216	PACIFIC	0	50P	OFFSHR TR PPLN	8	PIPERUP	C LA

MAJOR OIL SPILL INFORMATION SYSTEM

TSC	NRC	PIRS OTHER	P D S	S D S	L O C	T Y P	LOCATION	DIST SHR	LATN	LONGW	POLL	OCC DATE	BODY OF WATER	AMT DISCH KGALS	AMOUNT IN WAT KGALS	SOURCE	CAT	CAUSE	PREOSC
55001	24575		N		R		TEXAS CITY TX	0	2923	9455	CRUDE	0104	INDSTRL CANAL	504	168	TXS CITY RFNRY	2	PPLNBRK	C GLVST
55002	25975		N	O	S	S	MIAMI FLA	0	2547	8011	DSLBK	0111	BISCAYNE BAY	90	>90	DRDGE CRBBEAN	6	SINKING	C MIAMI
55003	26175		N		X		PALESTINE TX	0	3140	9530	CRUDE	0107	LITTLE CREEK	210	210	8" PIPELINE	1	BRKPLNG	EPA VI
55004	27675	0700052	N	P	S	G	ST CROIX VI	0	1742	6445	CRUDE	0122	LIMETREE BAY	376	376	MV MCHL LEMOS	4	GROUND	C SAN J
55005	27775	0100828	N	P	X		W BOYLSTON MA	0	4215	7145	KRSNE	0121	WACHUSETT RES	122	UNKNWN	ONSHORE STORGE	2	PRSNERR	EPA I
55006	28175		N		R	C	N ORLEANS LA	0	2900	9013	CRUDE	0130	MISS. ML87	2814	>400	BARGES TS86/87	5	COLLSN	C N ORL
55007	29075		N		S		ABRDEEN PV GR	0	3920	7615	#2	0128	CHESAPK BAY	60	60	FUEL OIL TNK	2	LNFREEZ	C BALT
55008	28875	0300151	N	P	R	E	MRCS HOOK PA	0	3948	7525	CRUDE	0131	DELAWARE R	500	50	MV CORINTHOS	4	COLLSN	C PHIL
55009		1700138	P		X		ALASKA	0	6830	14915	DIESL	0201		65		ONSHORE PIPELN	1	PIPERUP	EPA X
55010	29875		N		X	L	PACIFIC	300	3500	13000	CRUDE	0212	PACIFIC	1680	1680	MV OSWGO PATRT	3	SLOWLK	C LA
55011	30875	0900053	O	N	S	G	MILWAUKEE WIS	1	4259	8752	#5	0224	LAKE MICHIGAN	74	74	HANNAH BRG2901	5	GROUND	C MILWA
55012	32075		N		X	C	VCKSBURG MISS	0	3215	9045	CRUDE	0305	MISS. ML437.3	1600	1600	MV JOHNNY DAN	3	COLLSN	EPA IV
55013	34875	0300390	N	P	X	B	ELZBTH CTY NJ	165	3702	6749	#6	0404	ATLANTIC	6000	6000	MV SPRTN LADY	3	BRKNTWO	CGD3
55014	35375	0100421	N	P	R		REVERE MA	0	4224	7101	#6	0407	CHELSEA RVR	60	35	BULK RAIL VEH	9	INTNTNL	P BOSTN
55015	37075	0801375	N	P	R	C	N ORLEANS LA	0	2947	9053	CRUDE	0425	MISS. ML102	209	>70	BARGE BUTANE	5	COLLSN	C N ORL
55016	42675	1100615	N	P	S		L ANGELES CA	0	3343	11816	#6	0716	L A HARBOR	84	84	MV LORENZO HAL	3	VALVFLR	C LA
55017	42975	0700949	N	P	O		KEY WEST FLA	0	2433	8149	BNKER	0720	STRTS OF FLA	60	>60	MV GARBIS	3	INTNTNL	C KEY W
55018	43775	1200286	N	P	S		MARTINEZ CA	0	3801	12204	GAS	0723	SAN PABLO BAY	130		S PACIFIC PPLN	1	TANKRUP	M SAN F
55019		0803908	P	A	X		LONGVIEW TX	0	3230	9450	CRUDE	0808	SABINE RIVER	63		ONSHORE PROD	2	CRASH	EPA VI
55020	44175	0500729	N	P	S		BALTIMORE MD	0	3913	7633	#6	0810	PATAPSCO RVR	126	126	TB SHAMROCK	5	TNKOVFL	M BALT
55021	44475	0802760	N	P	X	C	OFF GLVSTN TX	69	2825	9255	CRUDE	0815	GLF OF MEXICO	840	840	MV GLOBTIC SUN	3	COLLSN	GULFST
55022		0301162	P		R		PHILA PA	0	3954	7512	#6	0914	SCHUYLKILL R	60		ONSHORE RFNRY	2	FLNGFLR	C PHIL
55023	47575		N		X		PLYMOUTH MICH	0	0	0	GAS	0926	DRNGE DITCHES	50	50	PIPELINE	1	PPLNRUP	EPA V
55024	48575	0301274	N	P	R	G	BRONX NY	0	4048	7354	#6/#4	1007	EAST RIVER	102	102	BCHRD BARGE115	5	GROUND	C N YRK
55025	48675		N		X	G	EVANSVLLE IND	0	3750	8740	GASPL	1007	OHIO R ML309	84	84	TB CHTN 2181/5	5	GROUND	M EVANS
55026	48875	1700226	N	P	X		SKAGWAY AK	0	5927	13519	GAS	1009	LYNN CANAL	300	200	ONSHRE FUELING	2	TNKCLPS	C JNEAU
55027		0803699	P	A	S		MARSH IS LA	0	2939	9200	CRUDE	1016	VIRMILION BAY	2520		ONSHORE PROD	2	WLLBLWT	C N ORL
55028		0301387	P		R		CHESTER PA	0	3951	7520	MIXED	1104	DELAWARE R	73	73	TUGBOAT	6	STRCFLR	C PHIL
55029	50975		N		O	S	LAKE SUPERIOR	1	4652	8500	BNKER	1111	LAKE SUPERIOR	70	70	MV EDMND FITZ	3	SINKING	C SSMAR
55030	51775		N		X		BORDENTOWN NJ	0	4007	7444	#2	1122	CROSSWICKS CR	250	75	COLONIAL PPLNE	1	RUPTURE	EPA II
55031	52375		N		X		CONWAY PA	0	4040	8020	#2	1204	OHIO RIVER	60	60	PENN CNRTL RR	2	BRKPPLN	EPA III
55032	53175	0701101	N	P	O	G	SAN JUAN PR	0	1829	6608	BNKER	1209	ATLANTIC	500	500	TB Z102	5	GROUND	C SAN J
55033	54175	0804325	N	P	S		TEXAS CITY TX	0	2922	9453	CRUDE	1224	TXS CITY CHNL	76	76	MV AMCO YRKTWN	3	HOSERUP	C GLVST
55034	54575		N		X		WARREN OH	0	4120	8050	OIL	1231	MAHONING RIVR	100		STORAGE TANK	2	LKNGTNK	EPA V
55P01		0300066	P		O	C	DELAWARE BAY	0	3908	7515	MXPTR	0117	DELAWARE BAY	0	9200P	TS 20-35K	3	COLLSN	
55P02		0300070	P		O	C	SANDY HOOK NJ	0	4028	7401	WSOIL	0119		0	100P	TB 1000-9999GT	5	COLLSN	C N YRK
55P03		1200039	P		S		VALLEJO CA	0	3804	12214	CRUDE	0122	SAN PABLO BAY	0	252P	TS 20-35K	3	PRSNERR	C LA
55P04		0300096	P		O	G	DELAWARE BAY	0	3909	7516	DIESL	0124	DELAWARE BAY	0	3000P	TS 20-35K	3	COLLSN	
55P05	29675		N		O		PORTSMOUTH NH	0	4305	7045	DIESL	0208	ATLANTIC	15	5500P	TS ATHNIAN STR	4	STRNDNG	C PTLND
55P06	30775		N		S	G	OAK HRBR WASH	0	4810	12405	#6	0219	JUAN DE FUCA	0	945P	MV RELIEF	3	GROUND	C STTLE
55P07		0300234	P		S	C	NEW YORK NY	1	4039	7407	#6	0227	NY HARBOR	0	100P	TS 10-20K	3	COLLSN	C N YRK
55P08		0300243	P		S	C	NEW YORK NY	1	4038	7402	MIXED	0301	NY HARBOR	0	100P	TS 20-35K	3	COLLSN	C N YRK
55P09	32475		N		X	S	PITTSBURG PA	0	4015	7958	DIESL	0308	MNNGHLA ML0.5	0	50P	MV ONWARD	3	SINKING	C PITTS
55P10	32375	0700189	N	P	O	G	SAN JUAN PR	0	1828	6607	GAS	0309	RSVLT RDS PSS	0	1500P	BRG CHEMICAL#1	5	GROUND	C SAN J
55P11		0700203	P		S	G	TAMPA BAY FL	0	2738	8237	DIESL	0314	TAMPA BAY	0	5040P	TS 10-20K	3	GROUND	M TAMPA
55P12	34375		N	A	R		ALBANY NY	0	4238	7345	#2	0329	HUDSON RIVER	40	50P	MV COLORADO	3	TANKRUP	C ALBNY
55P13		0700239	P		S	G	ST PTRSBRG FL	3	2747	8234	MIXED	0331	GLF OF MEXICO	0	500P	TS 10-20K	3	GROUND	M ST P

MAJOR OIL SPILL INFORMATION SYSTEM

TSC	NRC	PIRS	OTHER	P D S	S D S	L O C	T Y P	LOCATION	DIST SHR	LATN	LONGW	POLL	OCC DATE	BODY OF WATER	AMT DISCH KGALS	AMOUNT IN WAT KGALS	SOURCE	CAT	CAUSE	PREOSC
56001	00176	0301587		N	P	R	C	TARRYTOWN NY	0	4110	7405	#2	0102	HUDSON RIVER	90	90	TB DELAWARE	5	COLLSN	C N YRK
56002	00376			N		S		BROOKLYN NY	0	4040	7400	#6	0105	GOWANUS CANAL	2000	2000	PTCHG OIL TERM	2	FIREXP	C N YRK
56003	00576			N		X		PRKRSBRG W VA	0	3920	8130	OIL	0107	LTHRWOOD CR	57	57	EUREKA PIPELN	1	HLNPPLN	EPA III
56004		0200646		P		X		SEMINOLE OK	0	3510	9630	CRUDE	0107		572		ONSHORE PIPLN	1	PIPERUP	EPA VI
56005		0200041		P		X		SHLBYVILLE IL	0	3920	8850	CRUDE	0108	ROBINSON CR	386		ONSHORE PIPELN	1	PIPERUP	EPA VI
56006	01876			N		X		SHLBYVILLE IL	0	3924	8850	CRUDE	0113	ROBINSON CR	210	210	CHICAP PIPELN	1	PPLNRUP	EPA V
56007	04576	0500064		N	P	O	S	CHESPKE BAY	0	3750	7609	#6	0202	CHESPKE BAY	250	250	BARGE STC101	5	SINKING	N HMP R
56008		0886423		P		X		STONEWALL TX	0	3315	10015	CRUDE	0209	WHITE RIVER	168		ONSHORE PIPELN	1	PIPERUP	EPA VI
56009	03676			N		X	C	LACON IL	0	4102	8922	JTFUL	0209	ILLINOIS RIVR	225	225	TB FLORIDA	5	COLLSN	EPA V
56010	04276	0802119		N	P	S	B	BURAS LA	2	2925	8932	CRUDE	0214	CALFORNIA BAY	56	56	OFFSHORE PROD	8	PIPERUP	C N ORL
56011	05676	0900085		P	N	S		SUPERIOR WIS	0	4644	9207	DIESL	0221	ST LOUIS BAY	90		ONSHORE STRGE	2	VALVFLR	C DULTH
56012	06376			N		R		CHALMETTE LA	0	0	0	CRUDE	0225	MISS. RIVER	84	84	BARGE SJT4	5	CRKNHLL	C N ORL
56013	07076	0803001		N	P	S	E	GIBSON LA	0	2938	9056	CRUDE	0301	BAYOU BLACK	59	59	TB 1-10K	5	EXPLOSN	C N ORL
56014	07276			N		X		BRADFORD PA	0	4155	7840	#2	0303	KENDALL CR	84	84	5" PIPELINE	1	LINERUP	EPA III
56015	09376	0200667		N	P	X		MARTNSVLLE IL	0	3920	8750	CRUDE	0401	EMBARRAS RVR	1764	966	ONSHORE PIPELN	1	HNFDFLR	EPA V
56016	10576			N		X		PITTSBURG PA	0	4016	7958	#2	0409	MNNGHLA RIVER	150	150	B&O RR	9	VLVLFTO	EPA III
56017		0200559		P		X		ANADARKO OK	0	3503	9822	OIL	0413	WASHITA RIVER	168		ONSHORE PROD	2	BOPFLR	EPA VI
56018	12076	0300474		N	P	R	C	WESTVILLE NJ	0	3953	7509	NPTHA	0429	DELAWARE RIVR	84	84	MV TEXACO ILL	3	COLLSN	C PHIL
56019		0300487		P		X		PLATTSBRGH NY	0	4442	7328	DIST	0502	LAKE CHMPLN	70		ONSHORE STRGE	2	PUMPFLR	EPA II
56020	12276	0830502		N	P	S		GALVESTON TX	0	2930	9453	#6	0504	GALVESTON BAY	210	210	TB MMS 3105	5	STRCFLR	C GLVST
56021	12776	0300561		N	P	X		SHELBURNE VT	0	4424	7313	GAS	0518	LAKE CHMPLN	65		ONSHORE STRGE	2	VALVFLR	EPA I
56022	12976	0900256		O	P	O	C	CLEVELAND OH	0	4129	8144	BNKER	0519	LAKE ERIE	123	123	TB E-17	5	COLLSN	C CLEVL
56023	13476	0300588		N	P	R		JERSEY CTY NJ	0	4044	7405	#6	0526	HACKENSAC RVR	5000	>70	ONSHORE STRGE	2	TANKRUP	C N YRK
56024		0886628		P		X		LONGVIEW TX	0	3245	9525	CRUDE	0603	SABINE RIVER	84		ONSHORE PIPELN	1	PPLNRUP	EPA VI
56025	14776			N		R	G	WELLSLEY I NY	0	4407	7600	#6	0623	ST LWRNCE RVR	307	307	TB NEPCO 140	5	GROUND	M BFFLO
56026	15676	0100025		N	P	O		ST JHN NB CAN	0	4518	6559	CRUDE	0629	BAY OF FUNDY	84	84	MV JL GREY(LI)	4	PARTHOS	M PRTLD
56027	15776			N		X		WHITEHSE FLA	0	0	0	WSOIL	0629	ORTEGA RIVER	120	>120	WASTE OIL PIT	2	FLOOD	EPA IV
56028	15976			N		R	C	N ORLEANS LA	0	2902	9017	#5	0708	MISS. ML92.5	84	84	B GLF STTS3002	3	COLLSN	C N ORL
56029		0820730		P		O		GLF OF MEXICO	0	2600	9710	MIXED	0716	GLF OF MEXICO	53		UNKNOWN VESSEL	0	UNKNOWN	C N ORL
56030	17076			N		X		EAST BRADY PA	0	4058	7942	CRUDE	0809	ALLEGHENY RVR	184	184	TANK CARS	9	DERLMNT	EPA III
56031	18576			N		X		HAVERFORD PA	0	0	0	WSOIL	0916	NAYLOR'S RUN	80	>80	WASTE OIL STRG	2	SEEPAGE	EPA III
56032	19676			N		X	G	NIKISHKA AK	0	0	0	JP-4	1005	COOK INLET	210	210	USNS SLFT PAC	6	GROUND	M ANCHR
56033		0301256		P		X		TROY NY	0	4250	7345	GAS	1010	HUDSON RIVER	150		ONSHORE TRANSP	9	TANKRUP	EPA II
56034	99999	0851006		P		X		MOBILE ALA	0	3045	8803	ASPHL	1012	MOBILE BAY	4956		ONSHORE STRGE	2	TANKRUP	EPA IV
56035	21276			N		S	G	PRTH AMBOY NJ	0	4028	7415	CRUDE	1029	ARTHUR KILL	75	75	MT RICHARD SVR	3	GROUND	C N YRK
56036	22876	0700966		N	P	X		BALBOA HTS CZ	0	0	0	BNKER	1116	PANAMA CANAL	70	70	ONSHORE PIPELN	1	CPLNFLR	PAN C C
56037		0831120		P		S		TEXAS CITY TX	0	2922	9454	GAS	1129	TEXAS CITY CH	168		ONSHORE PIPELN	1	PPLNRUP	C GLVST
56038	24076	0103073		N	P	O	G	NANTCKT SHLS	27	4101	6927	#6	1215	ATLANTIC	7600	7600	MV ARGO MRCHNT	4	GROUND	M BOSTN
56039	24376	1101114		N	P	S	E	L ANGELES CA	0	3343	11816	#6	1217	L A HARBOR	1000	>20	MV SANSINENA	3	EXPLOSN	C LA
56040		0812139		P		O	B	GLF OF MEXICO	0	2821	9130	DIESL	1218	GLF OF MEXICO	81	81	OFFSHORE PROD	8	PPLNRUP	C N ORL
56041	24776			N		R	G	MRCUS HOOK PA	0	3958	7507	CRUDE	1227	DELAWARE R	134	134	MV OLYMPC GAME	4	GROUND	C PHIL
56042	25576			N		O		PUERTO NVO PR	0	0	0	CRUDE	1230	ATLANTIC	349	349	TB PECK SLIP	5	OPNVALV	M SAN J
56P01		1300044		P		S		TACOMA WA	0	4716	12226	#6	0111	PUGET SOUND	0	546P	NON-TRANS FAC	2	TANKRUP	M SEATT
56P02	02576			N		O	G	SALVO NC	0	0	0	NAVYS	0118	ATLANTIC	0	84P	MV BTLGS(US)	3	GROUND	C HM RD
56P03	07776			N		O	G	SAN JUAN PR	0	1828	6607	#2	0305	ATLANTIC	33	80P	TUG GELDERLAND	6	GROUND	C SAN J
56P04		0900087		P		R		BUFFALO NY	0	4252	7850	DIST	0313	NIAGRA RIVER	0	84P	ONSHR BLK TRNS	2	TANKRUP	M BFFLO
56P05	12176	0500256		N	P	S	G	HOLLAND PT MD	0	3850	7630	DIESL	0503	CHSPKE BAY	0	370P	MV KNSHKA(IN)	4	GROUND	C BALT

MAJOR OIL SPILL INFORMATION SYSTEM

TSC	MRC	PIRS	OTHER	P D S	S D S	L O C	T Y P	LOCATION	DIST SHR	LATN	LONGW	POLL	OCC DATE	BODY OF WATER	AMT DISCH KGALS	AMOUNT IN WAT KGALS	SOURCE	CAT	CAUSE	PREOSC
57001	00977	0103073		N	P	S	C	TAMPA FLA	0	2756	8223	DIESL	0109	SPRKMAN CHANL	81	81	TB NEW YORK	5	COLLSN	M TAMPA
57002		1300225		P		X		TWIN FALLS ID	0	4236	11440	DIESL	0122	SNAKE R	55		ONSHORE PIPELN	1	PPLNRUP	EPA X
57003	02977			N		S	G	CLVLND LDG MA	0	4145	7037	#2	0128	BUZZARDS BAY	100	100	BARGE B-65	5	GROUND	CGG WDH
57004	03577			N		R	G	HGHLND FLS NY	0	4143	7359	#6	0204	HUDSON R	400	400	TB ETHEL H	5	GROUND	C N YRK
57005	04577			N		X		TUSCALOOSA AL	0	3310	8748	#6	0215	BLCK WRRIOR R	50	50	TB 33(US)	5	UNKNOWN	EPA IV
57006	05077			N		X	B	PACIFIC	300	3200	12800	CRUDE	0223	PACIFIC	4000	4000	MV HAWAIN PTRT	3	HULLRUP	CGD14
57007	06977			N		S		JRSEY CITY NJ	0	4042	7410	#2	0305	MORRIS CANAL	70	70	PRTSIDE TRMNL	2	UNKNOWN	C N YRK
57008	07777			N		X	G	LOUISVILLE KY	0	3728	8542	GAS	0405	OHIO R 604.2	75	75	BRGE HINES 360	5	GROUND	M LOUIS
57009	07977			N		S		YORKTOWN VA	0	3713	7626	GSOIL	0405	UNNAMED POND	240	240	STORAGE TANK	2	RUPHOSE	M HM RD
57010		1100305		P		X		MOJAVE CA	0	3500	11800	CRUDE	0407	L A AQUEDUCT	63		ONSHORE PIPELN	1	PIPERUP	EPA IX
57011		0804146		P		X		DELCAMBRE LA	0	2954	9202	CRUDE	0423		50		ONSHORE PIPELN	1	PIPERUP	EPA VI
57012	08777	1700146		N	P	X	G	PACIFIC	0	5418	16240	DIESL	0428	PACIFIC	72	72	FISHING VESSEL	6	GROUND	CGD17
57013	09577			N		X		BRISTOL PA	0	4004	7453	OIL	0509	DELAWARE R	97	97	SPRIOR ZINC CO	2	LEACHNG	C PHIL
57014		0850506		P		O		GULF SHORES	0	3014	8740	ASPHL	0509	GLF OF MEXICO	51		UNKNOWN	0	UNKNOWN	C N ORL
57015	11377			N		S		GRAND ISLE LA	0	2912	9000	CRUDE	0614	BAY MELVILLE	100	>100	PIPELINE	1	PPLNRUP	C N ORL
57016	11477			N		S	C	INTRC WTR WAY	0	2930	9220	#6	0626	INTCS WW M235	160	160	BARGE MM102	5	COLLSN	M PT AR
57017	11577	0500767		N	P	S	C	YORKTOWN VA	0	3713	7626	#6	0626	YORK RIVER	75	75	BRGE ATC586	5	COLLSN	M HM RD
57018	12077			N		X		JOHNSTOWN PA	0	4020	7900	OIL	0720	CONEMAUGH R	100	>100	FLOODING	2	FLOOD	EPA III
57019	12377			N		X		ANAHEIM CA	0	3350	11752	CRUDE	0727	SANTA ANA R	60	60	16" PIPELINE	1	RUPTURE	EPA IX
57P01	00577			N		R	G	NWCASTLE RNG	0	3938	7527	CRUDE	0104	DELAWARE R	0	21000P	MT UNVRSE LDR	3	GROUND	CGB GLC
57P02	01077			N		O	G	GRND T BAY MI	0	4505	8535	GAS	0111	LAKE MICHIGAN	0	2300P	MV AMCO IND	3	GROUND	C SS MR
57P03	01377			N		O	G	TNGR SOUND MD	0	3800	7555	#6	0112	TANGIER SOUND	0	608P	TB INTRSTATE17	5	GROUND	C BALT
57P04	01777			N		X		CAPE GRARD MO	0	3917	9106	#6	0116	UP MISS. ML56	0	168P	TB T250-SL(US)	5	BOTTHLD	M PDUCA
57P05	07377	0500354		N	P	S	G	CUCKHOLD CR	0	3820	7630	#2KER	0329	PATUXENT R	0	200P	TB ARGL175(US)	5	GROUND	M BALT
57P06		0500373		P		S		YORKTOWN VA	0	3717	7635	DIESL	0405	YORK R	0	265P	ONSHR FUELING	2	HOSERUP	M HM RD
57P07	08277	0500604		N	P	O	G	CRLN BCH INLT	0	3355	7755	BNKER	0411	CRLN BCH INLT	0	840P	TB ATC206/207	5	GROUND	M WLMNG
57P08		0500585		P		S		CHESAPK BAY	0	3728	7617	DIESL	0519	CHESAPK BAY	0	50P	TS 0-149GT	3	PRSNERR	

APPENDIX B

POTENTIAL DEBARKATION POINTS IN THE UNITED STATES AND PUERTO RICO WITH LIFTS OR CRANES

This appendix lists those U. S. and Puerto Rican ports in the World Port Index, 1976 edition, that have lifts or cranes. Pierside and channel depths are also given. Unfortunately, this reference does not give crane capacities, or a breakdown of lift capacities below 24 tons.

1st Column

ULO = United States Lake Ontario
ULE = United States Lake Erie
ULH = United States Lake Huron
ULM = United States Lake Michigan
ULS = United States Lake Superior
UEC = United States East Coast
UGC = United States Gulf Coast
PR = Puerto Rico
UWC = United States West Coast

2nd Column = Index Number of Reference

3rd Column = Name of Port

4th Column = Country of Port

5th Column = North Latitude, DDMM

6th Column = West Longitude DDDMM

7th Column: Port size

L = Large
M = Medium
S = Small
V = Very Small

11th Column: Anchorage Depth (Feet)

See codes for 8th column.

12th Column: Cargo Pier Depth (Feet)

See codes for 8th column.

13th Column: Cranes

y = one or more cranes
blank = no cranes

14th Column: Lifts

y = one or more lifts
blank = no lifts

Reference: Pub. 150 "World Port Index," Fifth Edition, 1976, Defense Mapping Agency Hydrographic Center, Code NVP3, Washington DC 20390

POTENTIAL DEBARKATION POIN

UEC	7640	MANHATTAN	US	4042	7401	L	RN	E	H	H	H	Y	Y
UEC	7650	YONKERS	US	4056	7354	S	RN	E	P	P	N		Y
UEC	7720	ALBANY	US	4239	7345	M	RN	G	K	J	L	Y	Y
UEC	7750	EDGEWATER	US	4049	7359	V	RN	G	K	K	M	Y	Y
UEC	7760	WEEHAWKEN	US	4046	7401	S	RN	G	H	H	K	Y	Y
UEC	7770	HOBOKEN	US	4045	7401	M	RN	G	H	H	K	Y	Y
UEC	7780	JERSEY CITY	US	4043	7402	M	RN	G	H	H	K	Y	Y
UEC	7790	BAYONNE	US	4041	7406	M	RN	G	K	H	H	Y	Y
UEC	7810	NEWARK	US	4042	7409	M	RB	G	L	J	J	Y	Y
UEC	7820	ELIZABETHPORT	US	4039	7411	S	CN	G	J	J	K	Y	Y
UEC	7830	STAPLETON SI	US	4038	7404		CN	G	H	H	J	Y	Y
UEC	7840	TOMPKINSVILLE SI	US	4038	7404	M	CN	G	H	H	J	Y	Y
UEC	7850	PORT RICHMOND SI	US	4039	7408	S	CN	G	J	J	L	Y	Y
UEC	7860	MARINERS HARBOR SI	US	4038	7410	S	CN	G	J	J	K	Y	Y
UEC	7870	GULFPORT SI	US	4038	7412	S	RN	G	J	J	K	Y	Y
UEC	7890	PORT SOCONY	US	4033	7415	S	RN	G	K	K	L	Y	Y
UEC	7895	BAYWAY	US	4038	7412	V	RN	G	K	K	L	Y	Y
UEC	8010	TUCKERTON	US	3936	7420	V	RN	G	P	P	P		Y
UEC	8050	WILMINGTON	US	3944	7533	M	RN	G	M	M	H	Y	Y
UEC	8080	CHESTER	US	3951	7521	L	RN	G	J	J	K	Y	Y
UEC	8110	PHILADELPHIA	US	3957	7508	L	RN	G	J	J	J	Y	Y
UEC	8130	CAMDEN	US	3957	7508	M	RN	G	J	J	J	Y	Y
UEC	8140	BURLINGTON	US	4005	7452	V	RN	G	O	M	N	Y	Y
UEC	8160	TRENTON	US	4012	7446	V	RN	G	N	N	M	Y	Y
UEC	8200	HAVRE DE GRACE	US	3932	7605	V	RN	G	O	N	O		Y
UEC	8210	BALTIMORE	US	3916	7635	L	RN	G	J	L	J	Y	Y
UEC	8225	ANNAPOLIS	US	3859	7629	V	RN	G	N	K	O	Y	
UEC	8280	NORFOLK	US	3651	7618	L	RN	E	H	M	J	Y	Y
UEC	8290	PORTSMOUTH	US	3649	7618	S	RN	E	H	M	J	Y	Y
UEC	8300	NEWPORT NEWS	US	3658	7626	M	CN	G	H	M	J	Y	Y
UEC	8318	WARWICK	US	3727	7725	S	RN	G	L	L	N	Y	Y
UEC	8320	RICHMOND	US	3732	7725	V	RN	G	N	N	N	Y	Y
UEC	8470	WILMINGTON	US	3414	7757	M	RN	G	K	K	K	Y	Y
UEC	8500	CHARLESTON	US	3247	7955	S	CN	G	K	K	K	Y	Y
UEC	8510	PORT ROYAL	US	3222	8041	V	RN	G	M	N	L	Y	Y
UEC	8530	SAVANNAH	US	3205	8105	M	RN	G	K	H	K	Y	Y
UEC	8550	BRUNSWICK	US	3109	8130	S	RN	G	L	L	L	Y	Y
UEC	8580	JACKSONVILLE	US	3019	8139	M	RN	E	K	M	K	Y	Y
UEC	8610	PALM BEACH	US	2646	8003	V	CN	G	L	P	L	Y	Y
UEC	8630	PORT EVERGLADES	US	2606	8007	M	CN	G	J	J	J	Y	Y
UEC	8640	MIAMI	US	2547	8011	S	CN	G	L	L	K	Y	Y
UGC	8660	KEY WEST	US	2433	8149	S	CN	G	L	N	K	Y	Y
UGC	8670	TAMPA	US	2755	8227	M	CN	G	K	M	K	Y	Y
UGC	8730	APALACHICOLA	US	2943	8459	V	RN	G	P	P	Q	Y	Y
UGC	8770	MOBILE	US	3041	8807	L	RN	G	J	K	J	Y	Y
UGC	8800	GULFPORT	US	3021	8905	S	CB	G	K	L	K	Y	Y
UGC	8810	SLIDELL	US	3016	8947	V	LC	G	P	P	P		Y
UGC	8830	PORT SULPHUR	US	2929	8941	V	RN	G	J	H	H	Y	
UGC	8860	NEW ORLEANS	US	2957	9003	L	RN	E	J	A	J	Y	Y
UGC	8970	BATON ROUGE	US	3027	9106	S	RN	G	K	H	K	Y	Y
UGC	8990	GRAND ISLE	US	2914	9000	V	CN	G	P	P	Q	Y	Y
UGC	9000	MORGAN CITY	US	2942	9113	V	RN	G	P	H	P	Y	Y

APPENDIX C
LOAD/RANGE TRADEOFF CURVES FOR THE HH3-F AND HC130 AIRCRAFT

This Appendix presents approximate curves for trading off payload and range for the HH3-F helicopter and the Lockheed Hercules Models HC130B and HC130H. The approximations are based on discussions with USCG search and rescue personnel (G-OSR-2) and the operating manuals of the aircraft involved. The curves and equations are not accurate enough for planning a specific mission, but will suffice for system analysis.

HH3-F HELICOPTER

Three limitations on range and payload are taken into account for the HH3-F. They are:

a. The gross weight of the HH3-F cannot exceed 22,050 lbs. at any time during the flight. The gross weight is a maximum at takeoff in the missions to be considered.

b. The gross weight cannot exceed a value, MGWHOGE, when the aircraft is hovering out of the ground effect. The value assumed here is 20,200 lb., corresponding to 22°C air temperature and sea level pressure.

c. The fuel carried cannot exceed the normal tank capacity of the HH3--about 4200 lb. for JP-4.

Additional fuel cannot be carried without modification and reduction in interior space for the payload.

These three limitations may be expressed as inequalities involving the payload, L, the mission range, R, and other mission and aircraft parameters:

$$(1)\quad L \leqslant MGW - W_{AC} - F_R - f_o \frac{R}{V_o} - f_H t_H - f_R \frac{R}{V_R}$$

TABLE C.1 PARAMETERS FOR THREE HH3-F MISSIONS

Parameter	Units	Mission 1	Mission 2	Mission 3
MGW	lbs	22,050	22,050	22,050
MGWHOGE	lbs	-	20,200	20,200
W_{AC}	lbs	15,300	15,300	15,300
F_R	lbs	400	400	400
f_O	lbs/hr	1,200	1,200	1,000
f_H	lbs/hr	-	1,200	1,200
f_R	lbs/hr	-	1,200	1,200
V_O	knots	130	130	60
V_R	knots	-	130	130
t_H	hrs	-	20	20
C_T	lbs	4,200	4,200	4,200

Mission 2: Two-Way, Internal Payload

In this mission, the helicopter proceeds from its base to the spill site, where it hovers for 20 minutes while the payload is lowered out of the cargo door, and then returns to its takeoff base.

As seen in Figure C.1, the hovering weight limit restricts the payload for almost all ranges up to the fuel tank capacity range. MGW is a limiting factor only for the ranges 200 n.mi. to 205 n.mi. It will be noted that at the maximum range of 205 n.mi., the maximum payload is just 1/2 of that for the one-way mission of equal range. This fraction is higher at shorter ranges, rising to 65% at zero range.

Mission 3: Two-Way, Belly Sling Payload

If the load is slung under the belly the speed on the outbound leg is reduced to 60 knots and fuel consumption to 1000 lbs/hr, according to USCG experience. The hovering weight limit and return leg are the same as in Mission 2, where the payload is internal. Because of the increased fuel consumption on the outbound leg (16.7 lbs/n.mi. compared to 9.2 lbs/n.mi.) the fuel tank capacity limits mission 3 to 130 n.mi., or 75 n.mi. less than if the cargo were carried internally. As in the case of the internal cargo mission, the belly sling method is limited in range primarily by the cruising speed rather than the MGW limit.

HC 130 FIXED WING

The USCG maintains two versions of the HC130 aircraft. The H-version has greater range and a higher maximum gross weight. Operational parameters for the two versions are shown in Table C.2. These parameters are based on common USCG practice.

In determining the maximum payload-range combinations for the C130, account must be taken of the fuel and gross weight limitations, of the fuel reserve requirements, and of the weight of the auxiliary tanks themselves.

TABLE C.2 PARAMETERS FOR TWO HC130 AIRCRAFT

	HC130-B	HC130-H
Cruise speed, kts	290	300
Fuel consumption, lbs/hr(1)	4,500	5,000
Minimum operating wt, lbs	70,000	70,000
Nominal operating wt, lbs(2)	85,000	90,000
Wing fuel capacity, lbs	45,000(3)	45,000
External tank capacity, lbs	-	18,000
Reserve fuel required, lbs	- 45% min or 10% of total -	
Weight of external tanks, lbs	-	2,000

(1) Based on JP4 weight fuel, 6.5 lbs/US gal.

(2) Approximate weight of equipped aircraft, exclusive of fuel and payload and external tanks.

(3) Including auxiliary tanks.

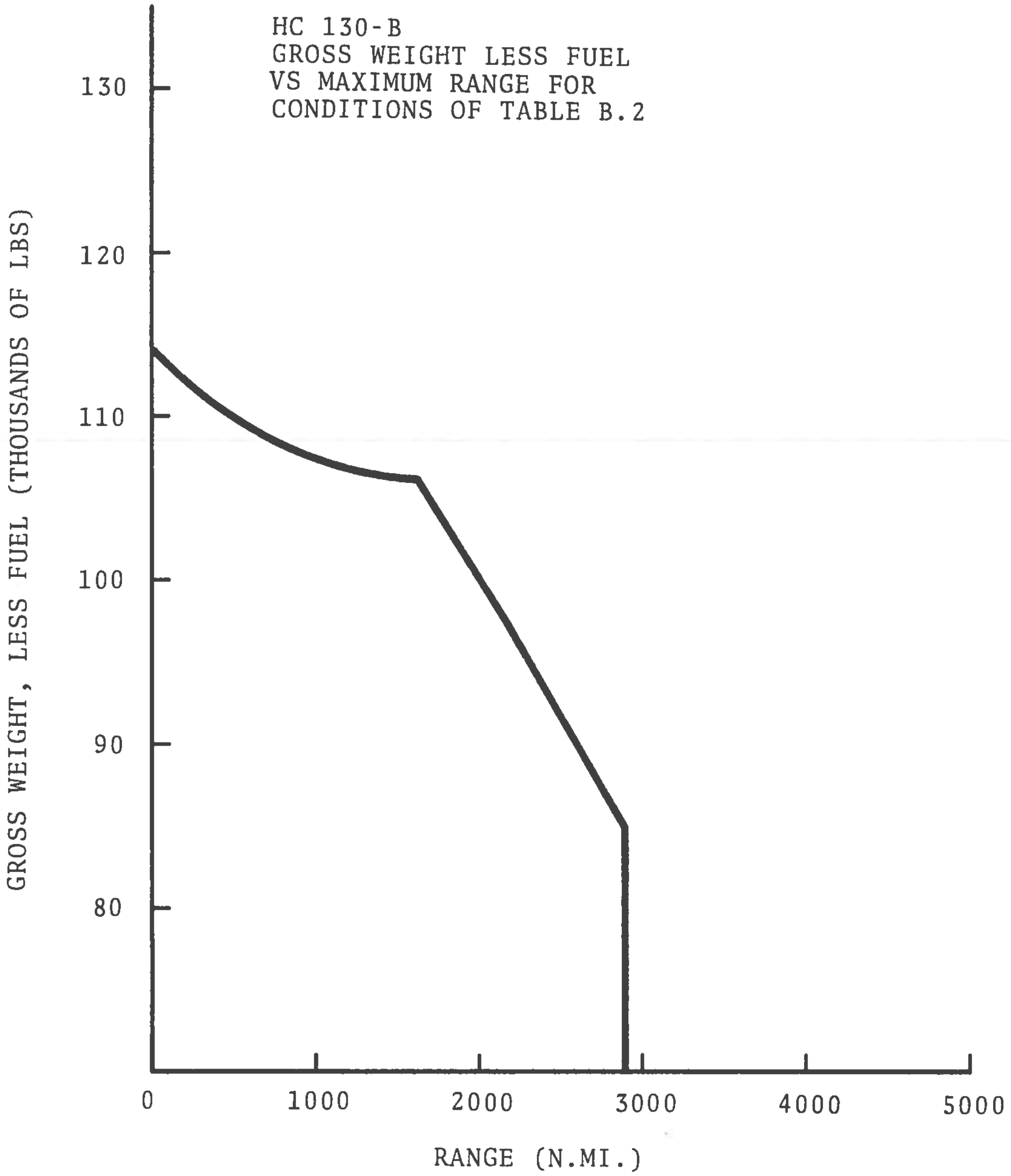

FIGURE C.3 GROSS WEIGHT-RANGE RELATIONS FOR HC130-B AIRCRAFT

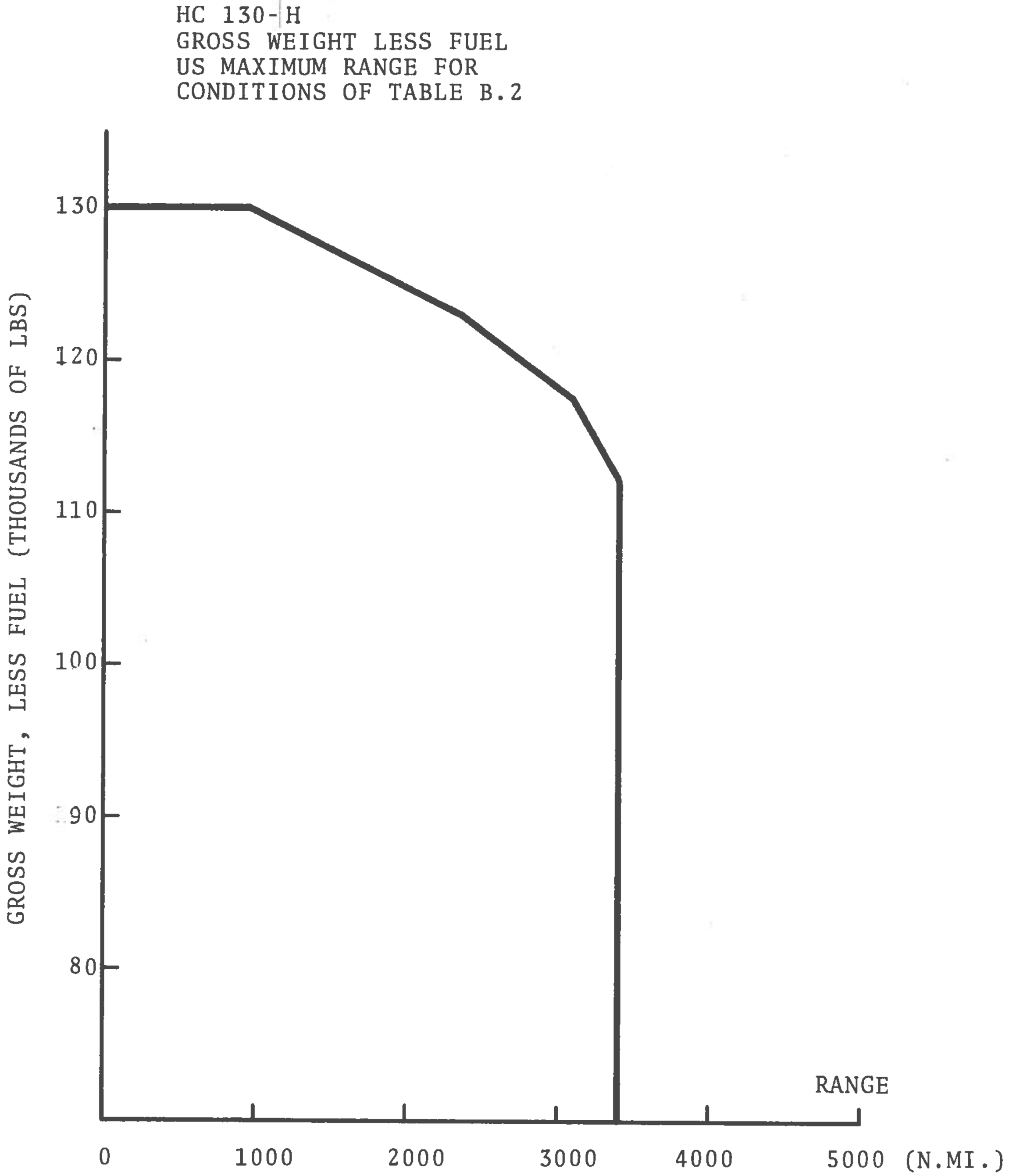

FIGURE C.5 GROSS WEIGHT-RANGE RELATION FOR HC130-H AIRCRAFT

APPENDIX D
DEBARKATION POINTS

The debarkation point is usually selected by the OSC soon after he determines that pollution control equipment must be brought to the scene. He usually selects the nearest port that can handle the required equipment. It may be more convenient to stage different equipment at different points, so there may be several debarkation points. It is not necessary that the debarkation point be a port. The equipment may be staged at a convenient dock or beach. For open water spills, however, the recovery equipment (barrier, barges) is so large that a port is much more likely to be selected. A review of OSC reports on file with the USCG shows a wide variety of selections (although the precise debarkation point is not always apparent in the report). Some samples:

M/V ORIENTAL WARRIOR (5/25/72): Port of Jacksonville, FL.
HANNAH BARGE 2901 (2/24/75): Breakwater at entrance to Milwaukee Harbor, accessible by road.
T/B TM-10 (7/8/74): Upper Galveston Bay.
ZOE COLOCOTRONI (3/18/73): Bahia Sucia, Cabo Rojo (southwest corner of Puerto Rico).
M/V CORINTHOS (1/31/75): Marcus Hook, PA, B.P. docks.
NO/TK TAMANO (7/22/72): Portland Harbor, Hussey Sound.
BARGE Z-102 (12/9/75): San Juan Harbor and Palo Seco area, Puerto Rico.
USNS JOSEPH MERRELL (12/29/74): Pt. San Luis, CA.
Dredge CARIBBEAN (1/11/75): Miami Harbor, FL.
T/B STC-101 (2/2/76): Reedville and Fleet Pt. MD.
(These were used by contractors as debarkation points.)
SS ARGO MERCHANT (12/15/76): Woods Hole, MA.

Not all cases cited here are open water spills. (The CORINTHOS and CARIBBEAN incidents occurred in harbors.) In none of these cases was the USCG open water boom deployed, and in only

APPENDIX E

A SIMPLIFIED MODEL FOR OPTIMUM DISTRIBUTION OF RESPONSE CAPABILITIES

This Appendix derives the optimum levels of oil recovery capability in each of N regions, when the total available recovery capability is limited. A region is defined here as the geographic area serviced by a single equipment site, and does not indicate a U.S. Coast Guard or DOT Region or District. The major assumptions are:

1. The regions do not overlap.
2. The distributions of the number and volume of spills are independent and are known for each region.
3. The amount of oil recovered at a spill is no greater than the recovery capability r_i for the region i in which it occurs.
4. The total recovery capability $\sum_{i=1}^{N} r_i$ is limited.
5. The probability of simultaneous spills in a region is negligible.
6. The optimum deployment is that which maximizes the expected value of the total amount of oil recovered in all regions.

With the above assumptions, the problem is to assign the capabilities r_i to each region so as to maximize the expected amount of oil recovered, subject to the limit in 4.

If the amount of oil spilled in an incident is x, the amount recovered, ρ, is assumed to be

$$\rho = \begin{cases} x \text{ if } x \leqslant r_i \\ r_i \text{ if } x > r_i \end{cases} \quad . \tag{1}$$

Finally, this may be averaged over all possible n, to obtain the expected amount $\overline{R}_i$ recovered in region i:

$$\overline{R}_i = \sum_{n=0}^{\infty} p_i(n)\overline{R}_i(n)$$

$$= \sum_{n=0}^{\infty} n\, p_i(n) \int_0^{\infty} \rho_i(x) f_i(x)\,dx$$

$$= \overline{n}_i \int_0^{\infty} \rho_i(x) f_i(x)\,dx, \tag{4}$$

where $p_i(n)$ is the probability of exactly n spills in the region. Substituting (1) for $\rho_i(x)$ gives

$$\overline{R}_i = \overline{n}_i \left[\int_0^{r_i} x\, f_i(x)\,dx + \int_{r_i}^{\infty} r_i f_i(x)\,dx \right]$$

$$= \overline{n}_i \left(r_i - \int_0^{r_i} F_i(x)\,dx \right) \tag{5}$$

where $F_i(x)$ is the cumulative distribution of spill volume (corresponding to $f_i(x)$). The last expression is obtained by integration by parts. The total amount recovered has an expected value $\overline{R}$ given by

$$\overline{R} = \sum_{i=1}^{N} \overline{R}_i$$

$$= \sum_{i=1}^{N} \overline{n}_i \left[r_i - \int_0^{r_i} F_i(x)\,dx \right]. \tag{6}$$

This is to be maximized by selection of the r_i values, subject to

$$\sum_{i=1}^{N} r_i \leqslant K, \tag{7}$$

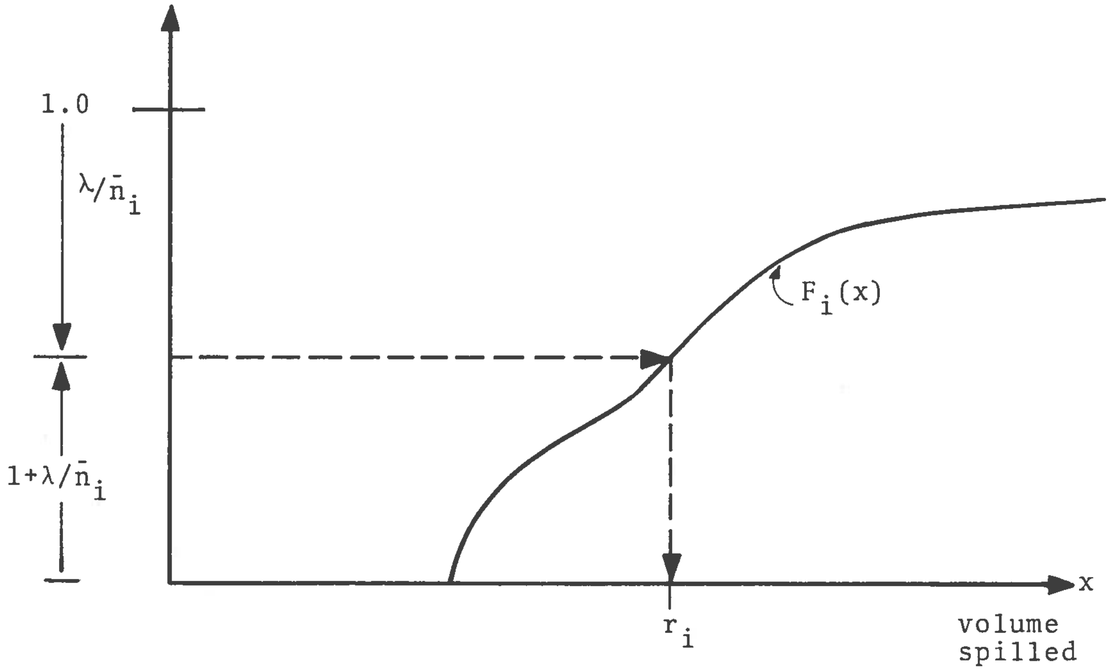

FIGURE E.1 GRAPHICAL SOLUTION OF (14)