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DEPLOYMENT REQUIREMENTS FOR U.S. COAST GUARD POLLUTION RESPONSE EQUIPMENT

Volume II: Appendixes

U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142

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FINAL REPORT

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U.S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
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This is the second of two volumes. Volume I contains the major analysis and conclusions.

16. Abstract

The volume contains 13 technical appendixes dealing with:

1. The Major Oil Spill Information System (data base)
2. Outflow rates from seven massive tanker oil spills
3. Distribution of US Coastal Tanker traffic in 1958
4. Narratives of 17 selected oil spills, 1967-1978
5. A list of debarkation ports, with Figures, in the U.S.
6. Load/Range Tradeoff curves for the USCG HH3-F and C130 aircraft
7. An analysis of availability of USCG towing vessels
8. Maps of USCG installations and DOD air bases.
9. The spill potential data base employed in Volume I
10. A model for distribution of equipment
11. An analysis of the probabilities of large and simultaneous spills
12. A list of non-USCG pollution response capabilities
13. A brief review of the behavior of surface oil slicks.

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PREFACE

This report is one of a series of studies conducted by the United States Coast Guard in support of the Presidential initiative of March 1977, concerning the ability of the United States to respond to the threat of larger oil spills in U.S. waters. The study was directed by the U.S. Coast Guard Office of Research and Development and Office of Marine Environment and Systems. The authors wish to acknowledge with thanks the expert and indispensible assistance rendered by these Offices throughout the project, and in particular that of Cdr. J.T. Leigh/GDOE, Cdr. J.L. Valenti/GWEP, Lt. R.V. Harding/GDSA and Lt. G.D. Marsh/GDOE. They are also indebted to numerous Coast Guard personnel, both at headquarters and in the field organizations, who were enthusiastic in the provision of data, advice and information.

This, the second of two volumes, contains the technical Appendixes.

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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 following 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	NAC	PIRS	OTHER	P D S	S D S	L O C	T Y P	LOCATION	DIST SHE	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	DSELL	0104	DELAWARE R	600	20	MOBILE OIL CO	2	PRSNERR	C PHIL
54002		0802185		P		X		LONGVIEW TX	C	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		DNLDSNVIL 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	COFRSN	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	SIRCFLR	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	C	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	FLNGFIR	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		GLENMOUNT 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 IOI #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	65	65	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	4420	7556	DIESL	1121	ST LWRNC RIVR	53		MV ROY A JODEY	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. ML89	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	MXPTR	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	DEDGE CHDBEMN	6	SINKING	C MIAMI
55003	26175			N		X		PALESTINE TX	0	3140	9530	CRUDE	0107	LITTLE CREEK	210	210	6" PIPELINE	1	BRKFLNG	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	PRSNEPR	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	INFREEZ	C BALT
55008	28875	0300151		N	P	P	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	3530	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	F	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	GASFL	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	C	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	STRMDMG	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	RICHG 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	M HMP F
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	E	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		E		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		MARTNSVILE IL	0	3920	8750	CRUDE	0401	EMBARRAS RVR	1764	966	ONSHORE PIPELN	1	MNFDFLR	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	EQPFLR	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 NMS 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 L-17	5	COLLSN	C CLEVL
56023	13476	0300588		N	P	E		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		E	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. M192.5	84	84	B GLF STS3002	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 SLPT PAC	6	GROUND	M ANCHR
56033		0301256		P		X		TROY NY	0	4250	7345	GAS	1010	HUDSON RIVER	150		ONSHORE TRANSF	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	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
57001	00977	0700062		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	0103020		N	P	S	G	CLVLND LDG MA	0	4140	7039	DIESL	0128	BUZZARDS BAY	100	100	BARGE B-65	5	GROUND	CGG WDH
57004	03577	0300115		N	P	R	G	HGHLND FLS NY	0	4121	7357	#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		0200787		P		X		BRISTOW OK	0	3550	9610	DIESL	0216		84		ONSHR PIPELN	1	PIPERUP	
57007	05077			N		X	B	PACIFIC	300	3200	12800	CRUDE	0223	PACIFIC	4000	4000	MV HAWAIN PTRT	3	HULLRUP	CGD14
57008		0300200		P		X		HEMPSTEAD NY	0	4036	7340	DIESL	0227		90		ONSHR BLKSTRG	2	MATFLT	
57009	06977			N		S		JRSEY CITY NJ	0	4042	7410	#2	0305	MORRIS CANAL	70	70	PPTSIDE TRMNL	2	UNKNOWN	C N YRK
57010	07777	0200259		N	P	X	G	LOUISVILLE KY	0	3728	8542	GAS	0405	OHIO R 604.2	75	75	BRGE HINES 360	5	GROUND	M LOUIS
57011	07977			N		S		YORKTOWN VA	0	3713	7626	GSOIL	0405	UNNAMED POND	240	240	STORAGE TANK	2	RUPHOSE	M HM RD
57012		1100305		P		X		MOJAVE CA	0	3500	11800	CRUDE	0407	L A AQUEDUCT	63		ONSHORE PIPELN	1	PIPERUP	EPA IX
57013		0804146		P		X		DELCAMBRE LA	0	2954	9202	CRUDE	0423		50		ONSHORE PIPELN	1	PIPERUP	EPA VI
57014	08777	1700146		N	P	X	G	PACIFIC	0	5418	16240	DIESL	0428	PACIFIC	72	72	FISHING VESSEL	6	GROUND	CGD17
57015	09577			N		X		BRISTOL PA	0	4004	7453	OIL	0509	DELAWARE R	97	97	SPRIOR ZINC CO	2	LEACHNG	C PHIL
57016		0850506		P		O		GULF SHORES	0	3014	8740	ASPHL	0509	GLF OF MEXICO	51		UNKNOWN	0	UNKNOWN	C N ORL
57017		0887527		P		X		TRINITY TX	0	3115	9530	CRUDE	0528		395		ONSHR PIPELN	1	PIPERUP	
57018		0102084		P		O		PORTLAND ME	0	4342	7012	DIESL	0606	ATLANTIC	128		ONSHR BLKSTRG	2	TANKRUP	
57019		0820631		P		O		CORP CHRST TX	0	2749	9726	GAS	0607		218		ONSHR PIPELN	1	PIPERUP	
57020	11377			N		S		GRAND ISLE LA	0	2912	9000	CRUDE	0614	BAY MELVILLE	100	>100	PIPELINE	1	PPLNRUP	C N ORL
57021	11477	0860633		N	P	S	C	INTRC WTR WAY	0	2930	9220	#6	0626	INTCS WW M235	160	160	BARGE MM102	5	COLLSN	M PT AR
57022	11577	0500767		N	P	S	C	YORKTOWN VA	0	3713	7626	#6	0626	YORK RIVER	75	75	BRGE ATC586	5	COLLSN	M HM RD
57023		0887607		P		X		GUTHRIE TX	0	3335	10015	CRUDE	0712		147		ONSHR PIPELN	1	PIPERUP	
57024	13577	0300866		N	P	S		WEST HAVEN CT	0	4114	7256	DIESL	0717	NEW HAVEN HBR	55	55	STORAGE TANK	2	PIPERUP	C N HVN
57025	12077			N		X		JOHNSTOWN PA	0	4020	7900	OIL	0720	CONEMAUGH R	100	>100	FLOODING	2	FLOOD	EPA III
57026	12377			N		X		ANAHEIM CA	0	3350	11752	CRUDE	0727	SANTA ANA R	60	60	16" PIPELINE	1	RUPTURE	EPA IX
57027		0701667		P		S		BRUNSWICK GA	0	3105	8130	WSOIL	0727		300		ONSHR IND PLNT	2	EQUPFLR	
57028		0200783		P		X	U	MT CARMEL IL	0	3830	8750	CRUDE	0801		55		ONSHR PIPELN	1	UNKNOWN	
57029		0808022		P		S	C	INTRC WTR WAY	0	2930	9240	DIESL	0805	INTCS WW M55	63		TB 1-10K	5	COLLSN	
57030	14177			N		R	U	BAYONNE NJ	0	4035	7408	OIL	0813	PLATTY KILL C	2000	2000	BAYONNE IND	2	UNKNOWN	C N YRK
57031	13477			N		O	U	OCEAN CITY MD	0	3820	7505	BUNKC	0821	ATLANTIC	100	100	UNKNOWN	0	UNKNOWN	M BALT
57032	13977	0900729		N	P	X		OREGON OH	0	4141	8328	GAS	0910	DUCK CREEK	69	69	BUCKEYE PIPELN	1	PIPERUP	M TOLDO
57033	14077			N		R		RESERVE LA	0	2950	9100	CRUDE	0913	MISS. R M115	74	74	ATL MARQUESS	4	STKBUOY	C N ORL
57034		0201526		P		X		SPRINGFLD MO	0	3720	9325	ASPHL	0926		86		ONSHR NON-TR	2	NATPHEN	
57035		0201275		P		X		JASPER TN	0	3505	8530	DIESL	1015		90		ONSHR OIL FAC	2	INT DIS	
57036	15377			N		S		HOUSTON TX	0	2940	9458	OILCH	1026	GALVESTON BAY	300		REDWOOD CHEM	2	FIRE	EPA VI
57037	16677	0201487		N	P	X		FRANKLIN MS	0	3117	9100	CRUDE	1201	HOMOCHITTO R	294	84	8" PIPELINE	1	PIPERUP	EPA IV
57P01	00577			N		R	G	NWCASTLE ENG	0	3938	7527	CRUDE	0104	DELAWARE R	0	21030P	MT UNVRSL 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. M156	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	
57P09	15777			N		O	G	AVON NC	0	3515	7540	ASPHL	1104	ATLANTIC	0	2100P	TB MORANIA 200	5	GROUND	M HM RD
57P10	17077			N		O	C	EUGENE I LA	0	2800	9000	CRUDE	1212	GLF OF MEXICO	0	100P	HUNT OIL PLTFM	2	COLLSN	C N ORL

APPENDIX B:

OUTFLOW RATES FROM SEVEN MASSIVE TANKER SPILLS

In this Appendix seven massive tanker oil spill incidents selected from Table 4-4 of Section 4 are analyzed in order to estimate the rates at which oil entered the water during the incident. Only rough estimates are possible, in most cases, because no direct observations are usually made of oil outflow at the time of the incident. As a result, outflow rates must be deduced indirectly from several sources.

1. POLYCOMMANDER (Source: Reference 4-4)

May 5, 0330 :	49,414 tons onboard.
May 5, 0420 :	Went aground, immediately began to spill oil. Spark from assisting vessel started fire. "Now appears there are three big fires."
May 6, 1530*:	Fire quenched 36 hours after start.
May 7 :	Fire considered terminated as of PM May 6.
May 8, 1200*:	"Engineers battled to stem flow of crude oil leaking from Norwegian Motor tanker." 200 tons out of 35,000 onboard have been pumped off, slowly.
May 9 :	Navy officials estimate "500 tons of oil had leaked from the tanker." Offloading stopped.
May 12, 1200*:	Oil leakage stopped, apparently. "Officials estimate small vessels transferred 15,000 of the 35,000 tons of crude oil left inside the vessel."
May 16 :	Estimated 20,000 tons pumped out, 15,000 tons remaining.

From May 5, 0430 to May 8, 1200*, a total of about 80 hrs, the vessel lost about 49,414-35,000 = 14,414 tons of oil to the fire and to Vigo Bay. If the Navy estimate of 500 tons leaked is correct,

*Indicates estimated time.

Jan. 7, 1200* : Master says 3,300 tons (1 million gallons) has leaked so far.

Jan. 7, PM : "The SHOWA MARU has stopped leaking:

Jan. 13, : At least 4,000 tons are believed to have leaked out.

Jan. 25, : "Previous estimates of cargo spillage may have to be revised downward."

The estimated leakage in the first 4-5 hours comes to a rate of 633 to 792 tons per hour. If the vessel stopped leaking at say 1200 hrs on Jan. 7, then the leakage rate from 1000 Jan. 6 to 1200 Jan. 7, was about 32 tons per hour assuming that a total of 4000 tons was lost, as stated on Jan. 13. But if the total lost was the 3300 tons stated by the vessel master on Jan. 7, then the rate would be only 5 tons per hour. (See Figure B-1). From Figure B-1, it is seen that in either case there would have had to have been a dramatic drop in outflow rate from Jan. 6, to Jan. 7 if the vessel master's estimates on Jan. 6 are correct. These estimates are consistent with (a) his later statements and (b) the ultimate estimates of total loss made on Jan. 13. If correct, the initial loss rate was very high.

4. <u>URQUIOLA (References 4-4, 4-6, and 4-8)</u>

May 12, 1200 : URQUIOLA grounds, 100,000 tons of crude on board. Tugs tried for an hour to free her.

1247 : Port closed due to explosion and fire. Series of blasts reported. Still burning late in day.

May 13, : Oil turns water of port black. Huge oil slicks moved towards shore. 80,000 tons believed still on board.

May 14 : Undersecretary of State for Spanish Merchant Navy said last night that "as little as 5,000 tons" of oil cargo could have seeped into the sea, with the balance going up in flames.

May 14 : An estimated 5000 tons going toward shore. New explosion and fire; fire brought under control same day.

May 25 : Still 9,000 tons in the vessel, salvage experts estimate. "More than 6,000 tonnes have been discharged."

If the Undersecretary's statement is correct, and if it was made at, say, 2000 May 13, then at least 5,000 tons leaked out in 32 hours, which gives an average outflow rate of 156 tons per hour.

Subsequent reports, however, report that the vessel contained 107,000 tons of crude and 3,000 tons of Bunker C, and that an estimated 100,000 tons were lost in the fire and leakage to the water (Reference B-2). Reference 4-6 notes that an estimated 25,000 - 30,000 tons of oil were washed ashore, and "most of the oil burned in the fire," which burned for a day (May 12-13) and restarted on the 14th. It is noted that the POLYCOMMANDER (50,000 DWT) supposedly burned off 14,000 tons in 36 hours, or about 10,000 tons per day. If the URQUIOLA burned at a rate of 10-20,000 tons per day for two days, then some 20-40,000 tons went up in smoke. Taking the upper figure leaves 67,000 tons to account for of the original 107,000 tons. Since there were about 9,000 tons still on board on May 25, and allowing 30,000 tons washed ashore, one obtains 28,000 tons of oil lost to the harbor directly, about the same amount as came ashore. This entire chain of conjecture yields about 58,000 tons outflow between May 12 and May 25. The corresponding outflow rate, which is also highly conjectural, is 185 tons per hour on the average.

The surprising aspect of this number, however, is that it is only 18% more than that obtained above from the statements of the Undersecretary of State for the Spanish Merchant Navy, for the first day's outflow rate. The average of the two estimates is 170 tons per hour.

5. <u>METULA (Reference B-3)</u>

Aug. 9, 2220 : METULA with 194,000 tons of light Arabian crude grounds at 14.5 knots, opening up 5 of her forward compartments. "About 6,000 tons of oil was initially released."

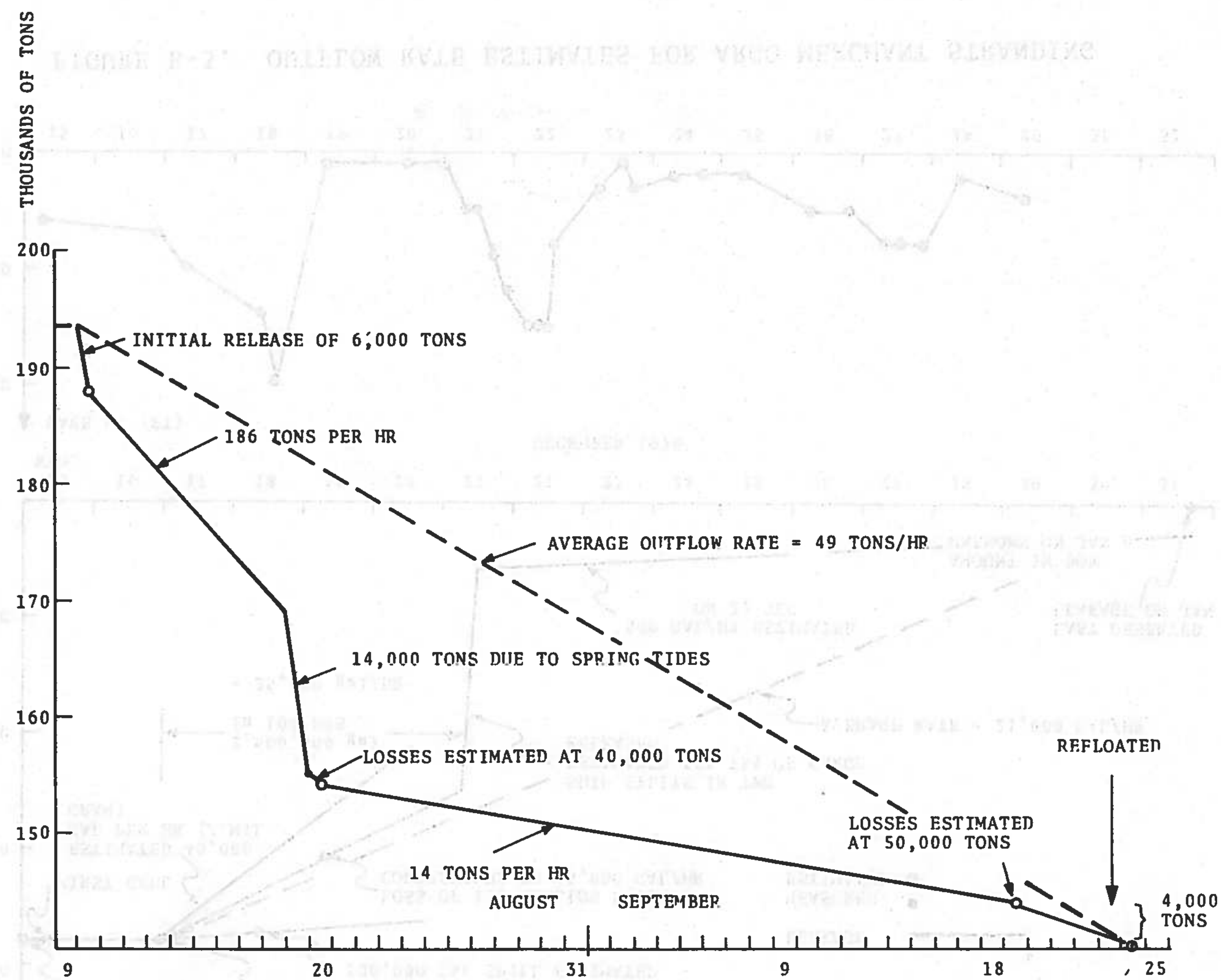

FIGURE B-2. OUTFLOW RATE ESTIMATES FOR METULA STRANDING

March 20 : "About 60,000 tons of oil leaking into the sea."

March 21 : "Heavy seas have apparently opened another leak in a tank."

March 21 : "Senior official of owners of AMOCO CADIZ said tonight the vessel had leaked some 170,000 tonnes of crude." Estimates that only 50,000 tons were still onboard. "more than 3 tanks have blown."

March 24 : Aft part completely free of fore part, which is issuing more and more oil.

March 24 : Estimates are that 30,000-35,000 tons are still inside.

March 26, 1300: French Navy opens hatches to release oil.

March 27 : About 25,000 tons still on board.

March 29 : Breaks into 3 parts; almost all oil released.

March 30 : About 10,000 tons left.

March 30 : Depth charges release remaining oil.

March 31 : Divers report no oil remaining, only Bunker fuel left.

The time history of outflow for the AMOCO CADIZ is shown in Figure B-4. The initial rate of 4200 tons per hour is relatively uncertain because of the time at which the first estimate was made is uncertain. Because the vessel broke up early (1000 on March 17), it seems that the pattern seen in Figure B-4 is realistic., i.e., rapid discharge at first, followed by slower discharges. The average outflow rate of 600 tons per hour, shown by the dotted line in Figure B-4, is probably accurate to within 5%, the main uncertainty being the initial amount onboard.

REFERENCES FOR APPENDIX B

B-1 Canelas, L.D., and J.D. Monteiro, "Some Studies of an Oil Spillage Due to the Jacob Maersk Accident," Proceedings of the 1977 Oil Spill Conference, New Orleans LA, published by the American Petroleum Institute, 2101 L Street N.W., Washington, DC 22037

B-2 Gundlack, E.R., and M.O. Hayes, "The Urquiola Oil Spill: Case History and Discussion of Clean-Up and Control Methods," Marine Poll. Bull. 8(6): 132-136, 1977.

B-3 U.S. Coast Guard, "Report of the VLCC Metula Grounding, Pollution and Refloating in the Strait of Magellan in 1974," Submitted by R.I. Price, Rear Admiral, U.S. Coast Guard, Chief, Office of Marine and Environment and Systems, February 1975.

B-4 "Chronology of Events Concerning Groundings of SS ARGO MERCHANT," (Revised Feb. 2, 1977) U.S. Coast Guard internal notes.

APPENDIX C:
DISTRIBUTION OF U.S. COASTAL TANKER TRAFFIC IN 1985

Reference 4-16, Volume 3, gives U.S. petroleum imports and exports by trade route for the years 1973-2000. The U.S. exports in 1985 are small and will be ignored, and only the major import routes will be employed. The flows of crude/product in thousands of long tons for 1985, as extracted from Reference 4-16, are shown in Table C-1 along with the origins and destinations. The routes of Reference 4-16 are grouped by one of seven foreign origins and one of three domestic destinations. The major U.S. coastal passage area for each route is shown above the crude/product figure.

It should be noted that the petroleum movement projections of Reference 4-16 were made by assuming a 9.8% increase per year from 1975 through 1980, and a 1.1% increase from 1980-2000, in accordance with administrative goals for reduction of energy imports.

Next, one must add to Table C-1 the Canadian, Alaskan and U.S. Gulf-East Coast traffic, as is done in Table C-2.

Canadian Traffic. This has three components. The Caribbean-Canadian component was obtained by taking the 14,000,000 tons of Venezuelan-Canadian oil shown in Reference 4-1 for 1977 and dividing it evenly between crude and products, and then allowing an expansion of 3% per year from 1977 to 1985. The East Coast-Canada and the Gulf Coast-Canada figures for 1985 were taken directly from Reference 4-16, and include exports as well as imports.

Alaskan Traffic: The Trans-Alaska Pipeline is projected to put out 2.0 million BBL per calendar day at its peak in 1983-86. It was assumed that 80% of this amount is transported by vessel from Valdez to the West Coast and 10% to the East and Gulf Coasts each. Transshipment of refined and residual oil from the West Coast is allowed for by assigning 35% of the incoming crude as outbound product movement, 25% to the East Coast and 10% to the Gulf Coast. This is arrived at by allowing for 25% consumption on the West Coast and 40% shipment by pipeline to the Texas/Lousiana

TABLE C-2. CRUDE AND PRODUCT COASTAL FLOWS IN 1985 (THOUSANDS OF LONG TONS)

From \ To	East Coast	Gulf Coast	West Coast	Canada (Atlantic)
Ecuador	216/110	315/14	5,398/109	
Caribbean	25,580*/83,760	33,965*/6,687	2,766/2,452	9,000/9,000
N. Europe	554/4,859	539/185	16/15	
Mediterranean	25,700/10,732	11,234/548	273/160	
S.W. Pacific			26,148/855	
Persian Gulf	14,660/325	34,207/760	28,426/464	
W. Africa	45,759/867	23,233/65		
Canada	472/3,250			
Alaska	10,000/00	10,000/00	80,000/00	
Gulf Coast	9,000/60,000			13/166
West Coast	0/20,000	0/8,000		
Total	121,948/163,830	103,489/8,256	163,027/39,055	9,013/9166

*Approximately 10,000 should be shifted to Persian Gulf origination if deepwater ports on U.S. East and Gulf Coasts are employed in 1985 to receive crude from the Persian Gulf that would otherwise be transshipped at P.R. and V.I. See text.

APPENDIX D:

Reports on Marine Oil Spills
1967 – 1978

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
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Submitted by:

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AMOCO CADIZ OIL SPILL
16 March 1978
off Portsall, France
(48°36'02"N, 04°45'09"W)

Event:

At 2226 LT on 16 March 1978, the 224,914-DWT tanker Amoco Cadiz ran aground in heavy seas off Portsall, France, on Men Goulven Rocks at 48°36'02"N, 04°45'09"W, after experiencing a flange failure in her steering hydraulic system. She incurred a 30-meter gash below the water line, just forward of the house. The rupture widened in the severe weather, and the aft storage tank began spilling its cargo of Arabian crude oil into the English Channel.

At 1045 LT on 16 March, while navigating in a storm through the Channel, the ship lost its rudder. At 1110 LT, the captain summoned the assistance of a German tug from Brest. By 1330 LT, the tug had the tanker in tow but made little progress toward port. At 1615 LT, the weather worsened and the towline broke. A second tow, established after nightfall, was only able to slow the tanker's drift, and the Amoco Cadiz grounded while still under tow.

By 2305 LT, French Navy helicopters arrived on-scene to airlift the 41 crew members to safety. The captain and first officer remained on board until dawn. At 0500 LT on 17 March, after hours of pounding by 6-meter seas in winds up to 80 km per hour, the tanker ruptured 3 tanks on its starboard, forward of the aft tank, and began to spill oil. By 18 March, the Amoco Cadiz had spilled 80,000 tons of oil. On 24 March, the stern section split off and swung around 180 degrees.

The Amoco Cadiz was built in 1974 in Cadiz, Spain, and had no history of previous spill incidents. Under Liberian registry, she was on lease to Royal Dutch Shell from a subsidiary of the Standard Oil Company (Indiana). She was carrying 216,000 tons of crude oil from Saudi Arabia and Iran to Le Havre, and then to Lyme, England, for transshipments to Rotterdam.

(AMOCO CADIZ OIL SPILL)

Spill:

By 19 March, 10 cm of oil covered the harbor of Portsall, while oil fumes spread over coastal regions. After a week of heavy seas, the tanker had spilled over 200,000 tons. The slick was then 6.5 km wide and 201 km long. It stretched from Portsall to the Ile du Brehat and the port of Paimpol along the Britanny coast. The French military bombed the tanker from 29 to 31 March to release the remaining cargo.

According to local authorities, the spill has caused severe damage to the fishing grounds and commercial seaweed beds. The authorities expect that the seaweed beds, which provide 90% of the French commercial harvest, will take several years to recover and that the fishing industry will take at least a year. A 50% decrease in tourist business is already evident in Britanny.

(TORREY CANYON OIL SPILL)

The Navy's threat to seize and impound the Torrey Canyon's sister ship, the Lake Palourde, enforced demands that the tanker's owner, in turn, reimburse the British government.

Spill:

By dusk of 18 March, northerly winds had carried a narrow slick over 13 km long to the south. By the next day, an estimated 20,000 tons had leaked from the tanker, with another 10,000 tons leaking out on 20 March. The slick was then more than 30 km long. The winds shifted to the west, driving oil into the English Channel. The westerly winds continued until 24 March, and on 25 March the morning tide brought the first oil onshore in thick layers. On 26 March, when the tanker broke in two, more than 40,000 tons of oil escaped, threatening the British coast and then the Britanny coast, before moving into the Bay of Biscay. After the bombing, oil seeped out in small amounts. In late April, the Torrey Canyon slipped off Pollard Rock and sank. Officials estimated that the sunken tanker contained no significant amounts of oil.

The spilled oil contaminated about 140 km of British coast from Trevose Head to Lizard Point, 150 km of French coast from Roscoff to Paimpol, 40 km of Britanny's west coast, and 25 km along the Channel Island of Guernsey. The oil caused extensive mortalities among seabird populations. The oil and especially the detergents were extremely toxic to marine life, especially planktonic organisms.

(TRANSHURON OIL SPILL)

dead fish, lobsters, crabs, and other species. Some of them washed onto the beach a few days later. The spill adversely impacted the hermatypic corals, which build and protect the atoll.

NAPIER OIL SPILL
8 June 1973
Island of Guamblin, Chile
(44°50'S, 75°00'W)

Event:

On 8 June 1973, the 35,000-DWT tanker *Napier* ran aground on the Island of Guamblin, 35 km off the Chonos Archipelago in Chile. The ship's radar was not functioning when the ship struck the island, which is 330 km south of Puerto Montt, the nearest port. After a severe storm on 14 June, the tanker reportedly sank. The *Napier* was carrying an unspecified quantity of light Bolivian crude.

Cleanup:

Because of the remoteness of the Island of Guamblin, the Chilean government decided that the most effective way to deal with the spilled oil was to burn it. On 12 June, the Chilean Air Force dropped incendiary bombs on the slick, igniting the tanker's stern. The next day, airplane pilots observed that the ship was burning.

Spill:

It was not known how much oil spilled, burned, or remained in the *Napier*. There was no reported fouling of any shorelines or coastal waters. The spill raised concern about the fate of a mussel farm located in the interior of the Chonos Archipelago. There was, however, no reported damage to the farm.

(ESSO ESSEN OIL SPILL)

Spill:

The slick, first seen extending from Scarborough to Clifton, was carried southeastward by northwesterly winds. It followed the coast until, by 1 May, the northern end had cleared Duiker Point. The first landfall was on the night of 30 April from Scarborough to a point 25 km south. On 2 May, Chapman's Bay, just north of Scarborough, was contaminated. On 3 May, oil reached Cape Point and began moving across the mouth of False Bay. On 4 and 5 May, the slick impacted Cape Hangklip and Pringle Bay, on the other side of False Bay. The oil had a frothy appearance, indicating emulsification. Thick oil was deposited above the kelp, which had been washed up by heavy seas. Beach cores showed little penetration into the sand.

The oil killed millions of sand hoppers, but that seemed to be the only massive mortality. Periwinkles, limpets, and anemones suffered appreciable mortalities. Many pelagic birds were seen oiled, but only a few gannets and cormorants were found dead. Scientists sampled the water and found no probable adverse effects to phytoplankton but moderate to high mortalities among zooplankton. By 6 May, the pollution along the Atlantic coast had diminished, except for some oil-covered rocks in Chapman's Bay.

(BRAZILIAN MARINA OIL SPILL)

The USCG/EPA team found no serious long-term danger to marine life. Local officials estimated that short-term mortalities of sardines, shrimp, and mussels will ruin the season's harvest. Few dead fish or oiled birds were found, although it was estimated that thousands had been contaminated.

enough heat for combustion. By 9 February, the cleanup crews had still not decided on the best way to ignite the oil, and a large amount of the oil had emulsified, reducing the probability that it would burn. Where the oil had not already emulsified beyond flammability, it was difficult to sustain combustion temperature. The Canadian Ministry of Transport, responsible for cleanup operations, reported that no dispersants or sinking agents had been used on the slick, although Imperial Oil Co. had reportedly chartered 2 planes to spray dispersants. Due to low temperatures and poor penetration into the slick, the dispersants were largely ineffective. The Ministry of Transport planned to hold both Sunstone Maritime and Imperial Oil liable for cleanup costs, estimated at $3 million.

Spill:

During the first day after the grounding, the slick was carried north and east by 50-knot winds blowing from the south. In the first several hours, a falling tide helped initiate the seaward movement of the slick. On the second day, the wind changed and blew largely from the north for 3 to 4 days. The slick extended for 6.5 km on the open ocean, with smaller slicks remaining inside Cape Auget. After water cushions had developed in many tanks, precluding further major spillage, oil leaked only sporadically from the bow. Although no divers inspected the sunken stern, officials do not believe it leaked any oil.

In total, the spilled oil impacted 320 km of Chedabucto Bay coastline, with the larger portion on the southern shore. A rock dam constructed from Ile Madame to Cape Breton Island to combat the spill prevented contamination of the sound between the islands. On 27 February, oil washed ashore on the northern coast of Sable Island, some 200 km southeast of the Arrow. Chemical analysis traced the oil to the spilled Bunker C.

BORAG OIL SPILL
7 February 1977
Keelung, Taiwan
(25°12'10"N, 121°44'30"E)

Event:

At 1145 LT on 7 February 1977, the Kuwaiti-registered tanker Borag hit a reef and ran aground in the East China Sea, 3 km north of Keelung, Taiwan. The grounding ruptured 2 of the vessel's 30 tanks; other tanks leaked later. An estimated 4000 tons of the 33,068-ton cargo of crude oil spilled into the sea. A Keelung pilot was on the Borag at the time of the grounding. Of the 37 people on board, 19 were taken ashore immediately, and the others were rescued by 10 February.

On the first day, no attempt was made to refloat the tanker since the pilot feared a break-up. The next day, 3 tugs and 2 patrol vessels failed to free the Borag from the reef. The bow sank during the first 4 days, and the buoyant stern finally sank on 15 February. Strong winds and high waves hampered efforts to remove oil prior to the sinking. On 8 March, a dredge struck the submerged tanker and sank. The 35,351-DWT Borag was en route from Kuwait to a Shenao, Taiwan refinery when the grounding occurred. The cargo was owned by the Chinese Petroleum Corporation and the vessel by Hamoor Tanker Corporation.

Cleanup:

The Taiwanese Navy supervised the efforts to contain and cleanup the spilled oil, and received assistance from the Keelung Harbor Bureau, other government agencies, and industry experts. Industrial and utility plants using seawater coolant systems shut down their operations. On 8 February, the Harbor Bureau prepared a sea boom to fend the spill away from the coast. Aside from attempts to offload the cargo from the sunken ship, there were no reported efforts to recover the oil. Large amounts of dispersants were used to keep the slick out of Keelung harbor. No attempt was made to disperse the entire slick.

PACIFIC GLORY OIL SPILL
23 October 1970
off Isle of Wight, England
(01°05'W, 50°40'N)

Event:

On 23 October 1970, the tankers Pacific Glory and Allegro collided in the English Channel while headed towards Rotterdam and Fawley, England, respectively, and the Pacific Glory immediately caught on fire. Thirteen of the Pacific Glory's crew were killed in the collision and fire. The Allegro sustained minor damage and proceeded to Fawley to unload its cargo. After the collision, the Pacific Glory was grounded in 5 meters of water 5 km off the Isle of Wight. Two weeks and several storms later, 20,000 tons of the Pacific Glory cargo were offloaded to another tanker. Then the grounded tanker was refloated and repaired, and 14,000 tons were loaded back onto the tanker. On 17 November, the Pacific Glory arrived in Rotterdam with 64,000 tons of her original 77,000-ton cargo. The 6000 tons that had been offloaded were also shipped to Rotterdam. In total, almost 7000 tons of oil spilled from the Pacific Glory.

Cleanup:

The British Admiralty coordinated the initial efforts to cleanup the oil. The Navy employed two Dutch government-owned ships: one specially equipped to apply dispersants and the other a dredger converted to spray chemically treated sand for sinking oil slicks. Shell Marine International, the Pacific Glory's charterer, volunteered its service during the cleanup. Since the collision was outside British territorial waters, C.Y. Tung of Hong Kong, the owner, contracted with a Dutch salvage firm on 27 October to refloat the tanker and relieve the Admiralty of the cleanup operation.

Channel tugs moving at full speed sprayed dispersants on the slicks. Wooden frames towed behind the tugs agitated the water, mixing together the oil and dispersant and thereby increasing the dispersant's effectiveness. Officials described

OCEAN EAGLE OIL SPILL
3 March 1968
San Juan, Puerto Rico
(18°30'N, 66°10'W)

Event:

At 0937 LT on 3 March 1968, the 18,524-DWT, Liberian-registered tanker Ocean Eagle ran aground in heavy seas while heading into San Juan Harbor, Puerto Rico. The captain attempted to head the tanker seaward by pivoting her on the grounded mid-section. During this procedure, the 15-year-old Ocean Eagle split in half. The tanker was carrying 5.7 million gallons of crude oil from Venezuela to San Juan. The stern half, which remained intact, retained its oil, which was eventually pumped out. The spillage from the bow was estimated at 2 million gallons: 1 million by 7 March, and 1 million by 19 March.

Cleanup:

The USCG and Navy undertook a lead role in the cleanup, with the tanker owners paying for the cleanup costs. On 1 April, the bow and stern sections reportedly contained no oil, and the Army towed them to deep water to sink them.

Where oil threatened shores and beaches, cleanup crews initially used detergents. Marine scientists objected to the potentially adverse ecological effects of the detergents, and the cleanup crews switched to Ektopearl, a non-toxic, porous substance that absorbs oil and floats. The damage to the marine environment appeared slight.

Spill:

Oil spread east and west, covering a 16-km stretch and impacting public, private, and military beaches. Currents carried the oil onshore, where patches washed within 100 meters of resort hotels. By 19 March, favorable currents had carried most of the oil out to sea, and public beaches were reopened. Some oil remained in San Juan Harbor, with accumulations at La Perla and slum areas.

VENOIL/VENPET COLLISION AND OIL SPILL
16 December 1977
near Port Elizabeth, South Africa
(34°25'S, 24°05'E)

Event:

At 0938 LT on 16 December 1977, the Liberian-registered sister tankers Venoil and Venpet collided and caught fire less than 40 km off the South African coastline near Port Elizabeth. The motor vessel Clan Menzies successfully evacuated the entire 44-man crew of the Venpet. When the crew members from the Venoil abandoned ship, many lept into the shark-infested waters around the tanker; 38 men were rescued, and 2 were reported missing. After the collision, the ships separated from each other and both drifted in a southeasterly direction until they were taken under tow on 17 December.

The Venoil and Venpet are both owned by the Venoil Company. The Venoil, laden with 307,045 tons of Iranian heavy oil, was en route from Kharg Island in the Persian Gulf to Point Tupper, Nova Scotia; the Venpet was making a return voyage in ballast along the same route, with only cargo residues and bunker fuel on board.

Cleanup:

On 16 December, 5 coastal anti-pollution vessels arrived on-scene, along with rescue boats and fire-fighting salvage tugs. The fire hampered efforts to approach the damaged tankers and offload the cargo, but the heat increased the rate of emulsification and evaporation.

As soon as the fire was extinguished on 17 December, the anti-pollution vessels started to apply dispersants to the slick. Conservation organizations were reportedly pouring dispersants on the slick with little effect. From 5 to 7 January 1978, the Venoil's cargo was safely offloaded to another tanker, the Litiopa. When the wind and swells increased, the offloading hoses were disconnected, and the vessels were kept headed into the wind by tugs.

TSESIS OIL SPILL
26 October 1977
Sodetalje, Sweden
(58°49'42"N, 17°43'48"E)

Event:

At 1000 LT on 26 October 1977, the 177-meter Soviet tanker Tsesis struck an uncharted, submerged rock while navigating through a narrow 480-meter-wide channel into Sodetalje, near Stockholm, Sweden. A Swedish pilot was on board when the vessel hit the rock at the edge of the channel. Navigational charts indicated a channel depth of 9.75 meters, although subsequent soundings showed a rock 8.23 meters below the water surface.

The grounding ruptured 8 cargo tanks, and the Tsesis began to spill oil immediately. An estimated 1600 tons of oil were lost. Initially, the Soviet captain of the Tsesis wanted to off-load his cargo into another Soviet tanker. When that tanker arrived, its tanks proved unfit to receive the oil. The cargo was offloaded into Swedish ships. The Tsesis was pulled free on 31 October and anchored near the grounding site. On 4 November, the Tsesis proceeded slowly to a Stockholm shipyard under her own power for repairs.

Cleanup:

Swedish authorities responded quickly to the spill. The Swedish Coast Guard assumed responsibility for the cleanup operations, and the Air Force undertook helicopter overflights. Booms were deployed around the tanker, and "slick-licker" belts and suction equipment were used to recover the oil. While the weather was calm, recovery proceeded with fair success.

On 29 October and again on 1 November, strong winds and rough seas rendered the booms, skimmers, and suction equipment ineffective. Local fire brigades helped cleanup the shore. On 31 October, the Soviet captain said that Sweden should pay the cleanup costs since a Swedish pilot was aboard. Swedish law, however, requires the shipowner to pay, even when a Swedish pilot is on duty.

JULIANA OIL SPILL
30 November 1971
Niigata, Honshu, Japan
(38°00'N, 138°40'E)

Event:

On 30 November 1971 at 1650 LT, the Liberian-registered tanker Juliana dragged her anchor in rough weather, while waiting for a pilot to guide her into Niigata harbor on the west coast of Honshu, Japan. Drifting aground just outside the harbor, the Juliana split in two, the bow coming to rest 300 meters and the stern 100 meters from shore, with a distance of 3000 meters separating the sections. All 47 crew members were rescued. The Juliana was carrying 18,000 tons of crude oil from the Persian Gulf to Niigata. In total, an estimated 4000 tons of oil spilled, and the remainder was offloaded to other boats.

Cleanup:

In Japan, at the time of the grounding, there was only enough dispersant to treat 5000 tons of oil. By 2 December, nearly 600,000 liters of dispersant had arrived in Niigata, and 60,000 liters had already been applied to the slick. By 3 December, 2 helicopters and 6 fire engines joined the 12 patrol boats applying dispersants.

Oil companies, on the recommendation of the Japanese government, placed a floating plastic boom around the slick. Initially high winds rendered the boom ineffective. On 2 December, winds subsided, and the boom was able to contain the slick. Straw mats were used to absorb the oil.

On 5 December, the tanker's sections were secured with anchors at sea and ropes onshore. A plan to place a siphon pump inside the stern section was abandoned, because rough weather made it impossible for salvage tugs and a small tanker to approach the wreck. As an alternative, a 10-cm water hose with PVC flotation collars was laid from the ship along the shore to the harbor, but bad weather also hampered this plan.

M/V SAINT PETER OIL SPILL
4 February 1976
off coast of Colombia
(01°30'N, 79°34'W)

Event:

On 4 February 1976, a fire broke out in the engine room of the 34,175-DWT Liberian-registered M/V Saint Peter while the vessel was sailing 45 km west of the Ecuadorian coast. Due to the danger of explosions, the 34-man crew abandoned ship. At the time, the tanker was bound for Peru with a cargo of 243,442 barrels of crude oil, and 6000 to 7000 barrels of bunker fuel oil. On 6 February, at 01°35'N, 79°13'W, oil was observed bubbling to the surface and spreading out into a large slick. It was assumed that the ship had drifted and then sunk near this location in more than 700 meters of water.

Cleanup:

The USCG undertook overflight surveys and predicted that sea currents and wind would disperse much of the light oil before it reached the shore. As of 19 February, no cleanup operations had been initiated. Officers from the USCG and the Canadian Coast Guard developed a cleanup plan for Colombia in case of pollution. The Ecuadorian government also asked the USCG for advice.

Spill:

On 13 February, 3 separate oil ribbons, covering a total area of approximately 124 sq km, were observed drifting toward shore. The longest ribbon was 24 km long and 15 meters wide and was still being fed by oil bubbling to the surface. As of 13 February, the slicks were about 24 km from shore. The slick characteristics indicated that the discharge had been cargo rather than fuel oil.

On 17 February, oil slicks of medium to heavy thickness, covering approximately 52 sq km, were observed 5 km from the Colombian coast. The slicks, which had spread southward into Ecuadorian waters and had streaks extending into Tumaco Harbor, reached beaches and mangrove swamps in Tumaco. There was apprehension that local tuna and shrimp industries would be adversely impacted by continuing seepage.

HAWAIIAN PATRIOT OIL SPILL
24 February 1977
North Pacific Ocean
(21°10'N, 164°00'W)

Event:

At 1040 Honolulu time on 24 February 1977, the Liberian-registered tanker Hawaiian Patriot caught fire and exploded in the North Pacific Ocean more than 600 km west of Honolulu. A pilot in a reconnaissance plane reported seeing smoke amidships, as the crew began to leap into the sea. The merchant ship Philippine Bataan rescued 38 of the 39 crewmen. One was found dead.

The Hawaiian Patriot burned fiercely for several hours and eventually sank. The 258-meter, 51,576-GWT tanker was owned by Indo-Pacific Carriers and was under lease to Groton Pacific Carriers. She was carrying 28.2 million gallons of light Indonesian crude oil to Honolulu.

Cleanup:

Although the USCG monitored the spill, no cleanup operations were undertaken. Some of the spilled oil burned with the ship.

Spill:

The oil started leaking from the No. 2 port and stern cargo holds. It is unclear whether there was a crack or an entire missing hull plate. The spill was reported at 1639 Honolulu time on 23 February. By the time of the explosion, an estimated 5.25 million gallons of the cargo had leaked into the sea, forming a slick almost 85 km long. The rest of the cargo sank with the ship.

On 28 February, the slick was about 750 km west of Honolulu and reportedly 23 km wide and 70 km long, with the heaviest concentration of oil at the western end. On 7 March, the slick, located more than 780 km west of Honolulu, had evaporated and emulsified until it was only 32 km long and 3 km wide.

APPENDIX E:
DEBARKATION PORTS

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

7, 9, 5, and 4 feet depths, respectively. Therefore, these last four may use the 400 ports that have 11 feet minimum depth. The WLB/180 and WLM/157, however, would be restricted to ports that have 15 feet minimum depth. There are approximately 342 such ports.

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. The codes employed are as follows:

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

In order to aid visualization of the distribution of debarkation facilities of interest to the pollution response problem, two plots were prepared.

Figure E-1: Debarkation ports with more than 10 feet draft in channel and pier areas and a lift or crane.

Figure E-2: Debarkation ports with more than 15 feet draft in channel and pier areas.

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

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

POTENTIAL DEBARKATION PORTS

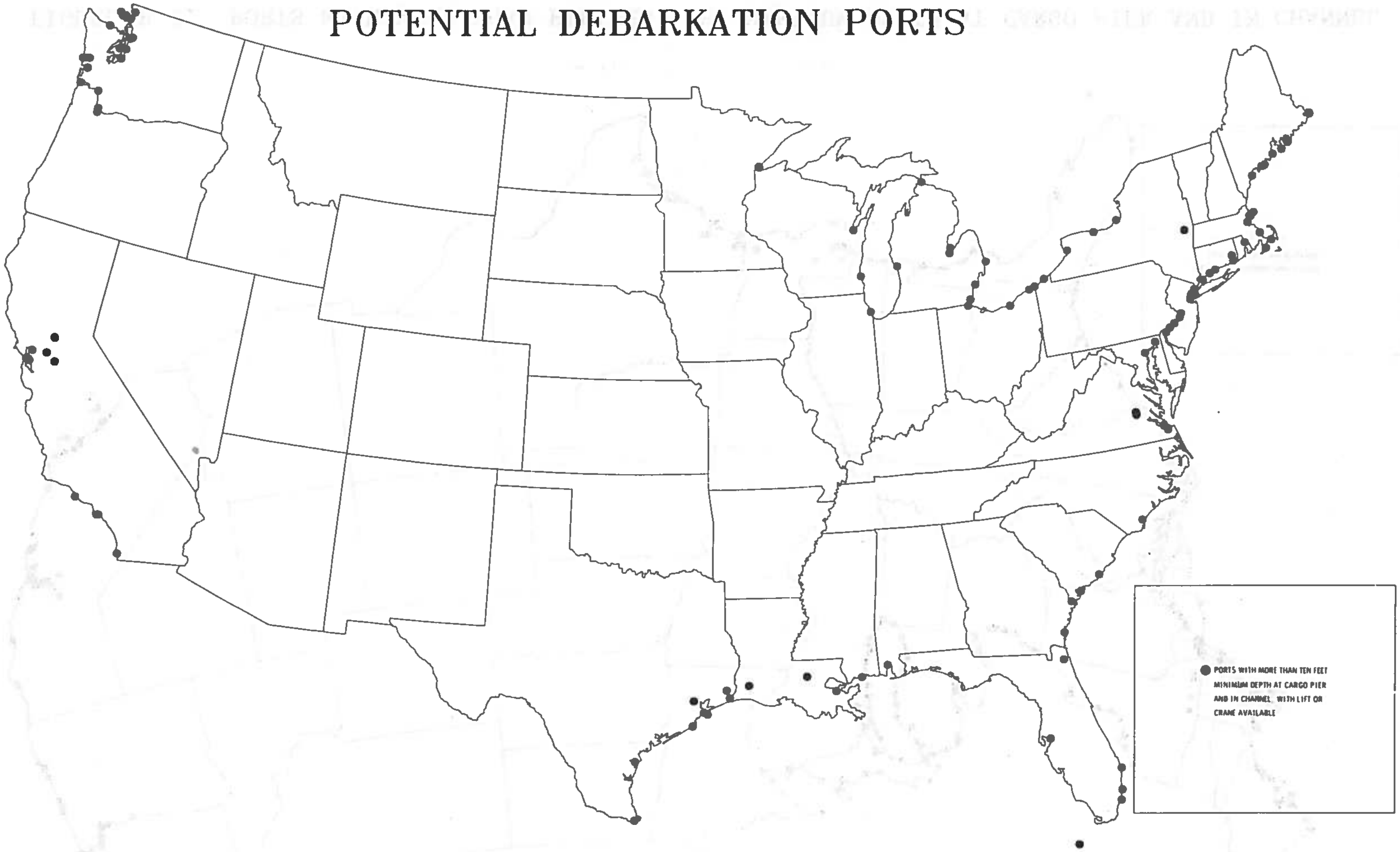

FIGURE E-1. PORTS WITH MORE THAN TEN FEET MINIMUM DEPTH AT CARGO PIER AND IN CHANNEL, AND HAVING A LIFT OR CRANE AVAILABLE

APPENDIX F:
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:

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

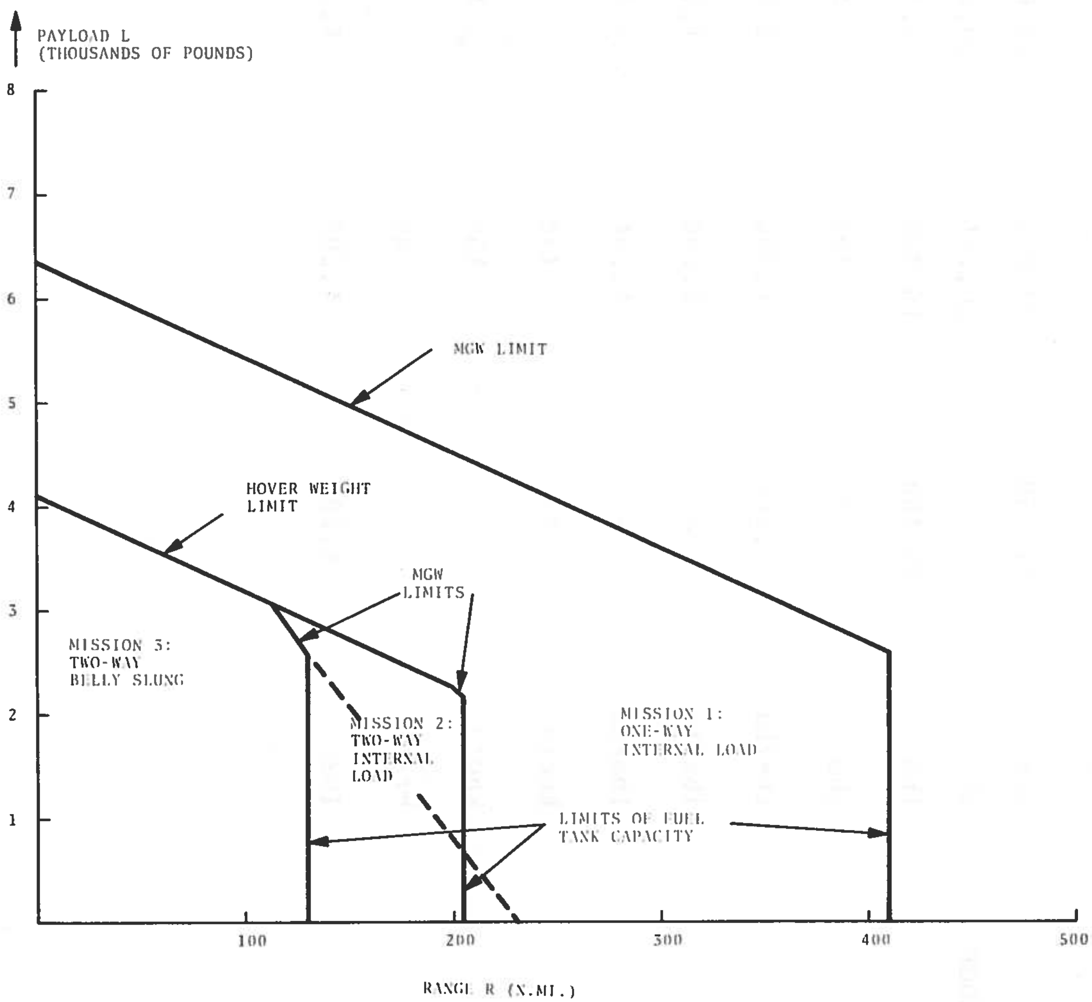

FIGURE F-1 PAYLOAD-RANGE RELATIONS FOR HH3F HELICOPTER

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 F-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 F-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.

HC130-B

Figure F-2 shows the maximum gross aircraft weight, less fuel, as a function of the total fuel weight. (The gross aircraft weight, less fuel, is the nominal operating weight plus payload.) It may not exceed the values shown in Figure F-2 at any point in the flight in order to stay within the recommended 2.5G maneuver factor. Since the gross weight, less fuel, is constant during a flight, while the fuel weight decreases with time, (not necessarily to zero) the operating point moves on the chart from right to left on a horizontal line segment of length equal to the fuel expended, at a distance above the x-axis equal to the gross weight less fuel.

Using the chart of Figure F-2, it is possible to determine the maximum achieveable gross weight, less fuel, as a function of the mission range. The latter is defined as the one-way distance from takeoff to landing. The result is shown in Figure F-3. The reserve and nominal fuel consumption and speed shown in Table F-2 were employed in constructing Figure F-3.

Finally, the payload is determined by subtracting aircraft operating weight (nominally 90,000 lbs. for the HC130-B) from the Vertical axis of Figure F-3 for the selected range.

HC130-H

The payload-range relation for the H-version is obtained in the same way as for the B-version. The combinations of gross weight, less fuel, and total fuel that lie under the lines of Figure F-4 are permissible at load factors up to 2.25G in the H-version. The corresponding ranges, allowing for the fuel reserves, speed, and fuel consumption rates shown in Table F-2 are plotted in Figure F-5. As is the case of the B-version, the nominal operating weight of about 90,000 lbs. must be subtracted from the gross weight less fuel. Finally, 2000 lbs. must be subtracted from the payload if the aircraft is fitted with external tanks.

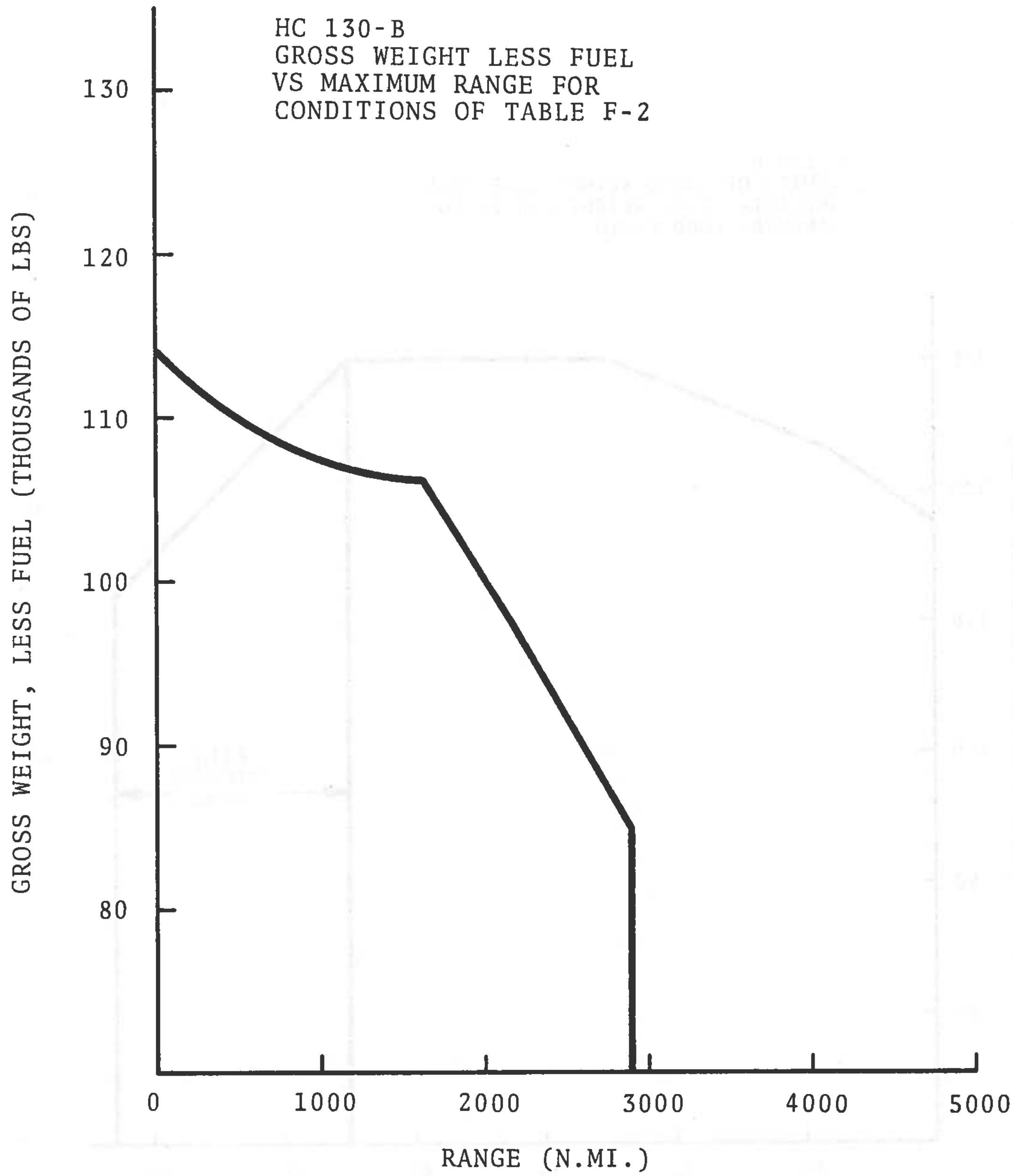

FIGURE F-3 GROSS WEIGHT-RANGE RELATIONS FOR HC130-B AIRCRAFT

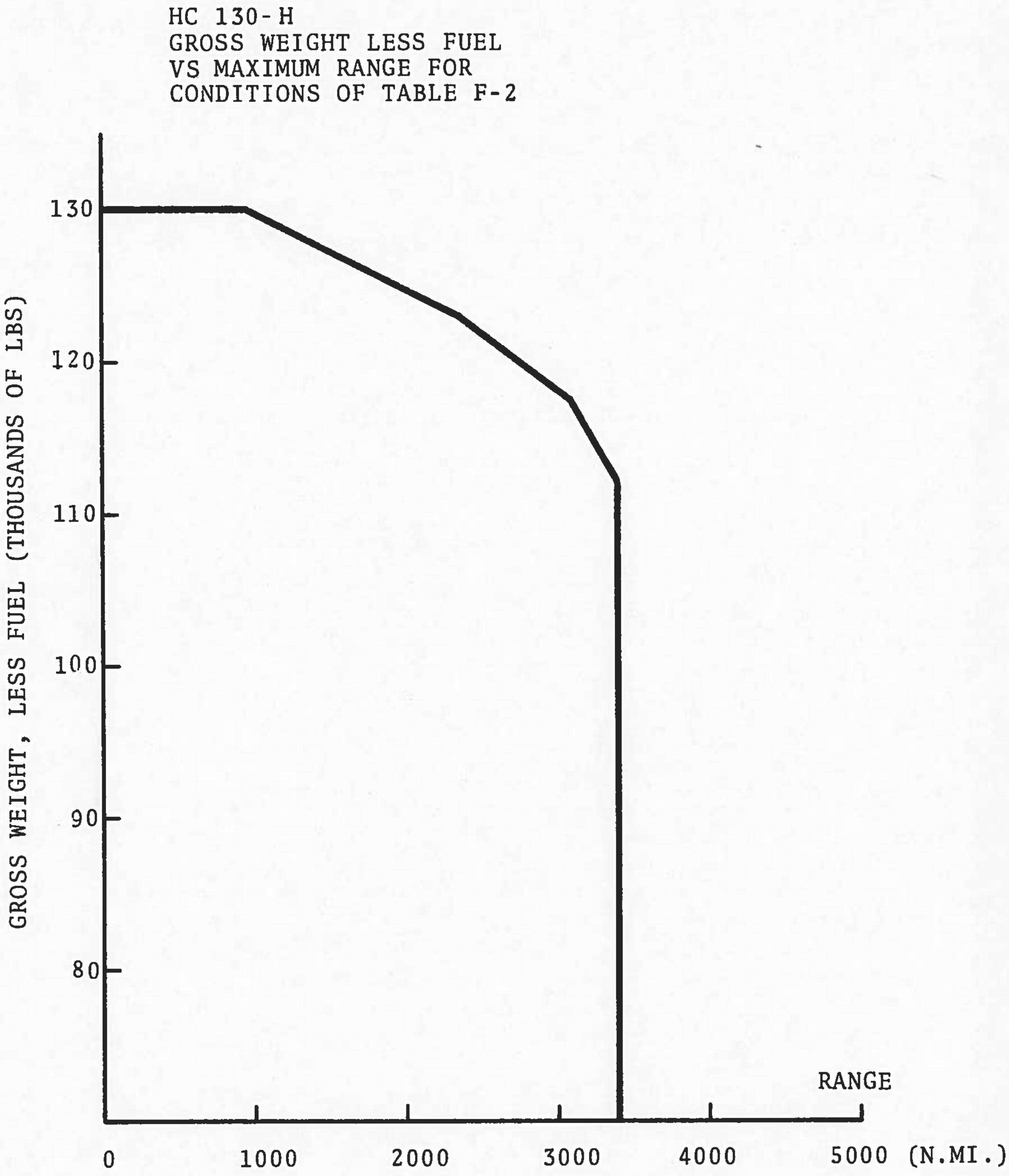

FIGURE F-5 GROSS WEIGHT-RANGE RELATION FOR HC130-H AIRCRAFT

APPENDIX G:
CURRENT U.S. MILITARY HEAVY HELICOPTER CHARACTERISTICS

BOEING VERTOL MODELS 114 AND 234 (CHINOOK SERIES)

The Chinook CH-47 is a U.S. Army, all-weather, medium transport helicopter. The latest U.S. version is the CH-47C, for which the following data apply under 4 conditions of operation, A, B, C, and F (ferry)

	A	B	C	F
Weight empty, lbs	21,464	21,464	21,633	21,162
Payload, lbs, internal)	11,650	6,400	21,700	00
T-O weight, lbs	38,500	33,000	45,400	46,000
Cruise speed, kts	139	137	114	133
Mission radius	100 (1)	100 (1)	20 (1)	1,156 (2)

Appx. fuel consumption, lbs/hr 2500

Cabin length, ft/in......................30/2
width (mean, ft/in.................. 7/6
width, at floor, ft/in.............. 8/3
height, ft/in....................... 6/6
floor area, sq. ft.................. 226
Usable volume, cu. ft...............1474

A: T-O gross weight = design gross weight

B: T-O gross weight = gross weight to hover out of ground effect at 6,000 ft and 95°F

C: T-O gross weight = gross weight to hover out of ground effect at sea level, International Standard Atmosphere

(1) Maximum distance from base before return, with 10% reserve
(2) One-way distance, 10% reserve,

Source: Jane's All the World's Aircraft, 1976-1977

SIKORSKY-64 SKYCRANE

This heavy lift twin turbine helicopter was intended as a troop transport, minesweeper, cargo and missile transporter, anti-submarine aircraft, and field hospital. It has designations CH-54A, (U.S. Army, 1963), CH-54B (U.S. Army, 1968), plus commercial versions.

Weight empty, lbs	19,234
Max T-O weight, lbs	42,000
Max payload, lbs	20,000
Max fuel, lbs (@ 6.5 lb/gal)	8,580
Typical Mission (One-Way)	
T-O weight, lbs	38,000
Cruise speed, kts	91
Fuel, lbs	8,580
payload, lbs	10,000
Range, with 10% reserve, n.mi.	200
Payload Dimensions (Internal dimensions of external pod)	
Length	27'5"
Width	8'10"
Height	6'6"

CH-53E (U.S. NAVY) 3-TURBINE

This is a three-engine version of the S-65A. The U.S. Navy plans to use the CH-53E for vertical on-board delivery operations, to support mobile construction battalions, and to remove damaged aircraft from decks.

Weight empty, lbs	32,048
Typical mission	
T-O weight, lbs	56,000
Cruising speed, kts	150
Range, n.mi.	266
Internal payload at 100 n.mi. range, lbs.	30,000
Cabin	
Length	30'0"
Width at Maximum	7'6"
Height at Maximum	6'6"

NOTE: The following aircraft evolved from the U.S. Navy SH-3A Sea King, first ordered in 1957 and flown in 1959; their performance characteristics are not dissimilar enough from the USCG HH3F to warrant separate tabulation. Sikorsky designations S-61A, S-61B, S-61F, S-61R; Military Designations RH-3A, SH-3A, CH-124, HH-3A, VH-3A, SH-3G, SH-3H, S-61R, CH-3C, CH-3E.

APPENDIX H: AVAILABILITY OF USCG TOWING VESSELS

It is necessary to develop the statistics of the time required to make available at a USCG coastal equipment storage site one of the USCG cutters or boats that is suitable for towing the FSD or similar hull, loaded with pollution control equipment, to a debarkation point, or directly to a spill.

SELECTION OF VESSELS

In selecting USCG vessels suitable for towing duty on short notice, vessels less than 40 feet long were excluded. Although it is possible that some vessels less than 40 feet long can perform this duty, the only test information available (Reference 7.1, PE-24) is for the UTB/41. This reference merely states that the 41 foot UTB successfully towed the loaded FSD at 12 knots on several occasions.

Not all USCG vessels of 40 foot length or greater were included in the calculations. Icebreakers (WAGB), Reserve Training Cutters (WTR), Construction Tenders (WLIC), River Buoy Tenders (WLR), Lightships (604, 612, 613), Training Cutters (WIX) and Oceanographic Cutters (WAGO) were judged not suitable or not generally available for pollution response duty. Of those that are included some are not usually underway along the full length of District coasts, and have been treated with a nominal coastline distance D, as explained below.

The use of the 378 WHEC for pollution response is slightly compromised by its draft (21 feet) which makes it unsuitable for some ports. Nevertheless, the FSD and similar towed vessels are more likely to be stationed with pollution control equipment at the larger ports where draft is not a serious limitation on use of the 378 WHEC. Hence, the 378 has been included in the list.

is shown in Figure H-1(c), where it is seen that the probability the vessel will return in t hours is just $P = 2Vt/D - (Vt/D)^2$. If there are N similar vessels distributed along the coast, then the probability that one or more will be available in t hours is $1 - (1 - P)^N$ or $1 - (1 - Vt/D)^{2N}$.

Further assumptions are now made regarding the availability of cutters on Bravo-6 status, on Bravo-X status (where $x \geq 6$) and boats on standby status. The distribution of availability time for three cases is assumed to be shown in Figure H-3. These diagrams essentially, quantify the uncertainties expressed in assumptions (b), (c) and (d).

From the preceding it can be seen that the probability that one or more cutters will be available in t hours or less is $P_c(t)$:

$$P_c(t) = 1 - (1 - P_{uc})^{N_{uc}} (1 - P_6)^{N_6} (1 - P_X)^{N_x} \qquad (1)$$

where P_{uc}, P_6, and P_x are the probability functions of t shown in Figures H-1(c), H-2(a) and H-2(b) for cutters underway, on Bravo-6 status, and on standby other than Bravo-6. Similarly, the probability that one or more boats will be available in t hours or less is

$$P_B(t) = 1 - (1 - P_{uB})^{N_{uB}} (1 - P_S)^{N_S} \qquad (2)$$

where P_{uB} and P_S are the probability functions of t shown in Figures H-1(c) and H-3(c) for boats underway and in standby status.

In (1) and (2), the numbers N_{uC}, N_{uB}, N_6, etc., have the following meanings:

N_{uC} = Average number of cutters of the given type, speed V, underway at any time in the District

N_6 = Average number of cutters of given type, on Bravo-6 status, at any one port of the district

N_X = Same as N_6, but for Bravo-X status

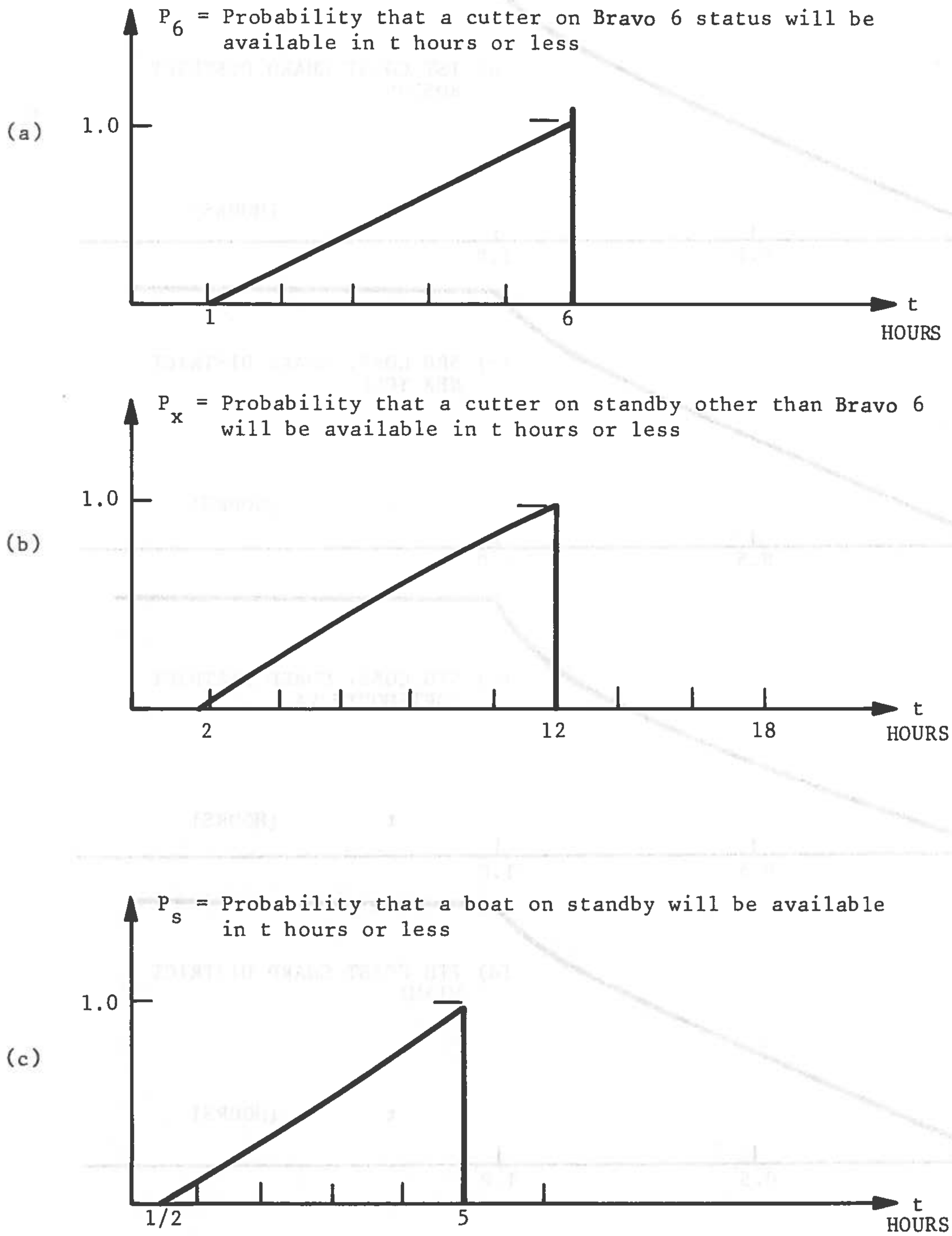

FIGURE H-2. ASSUMED DISTRIBUTION OF AVAILABILITY TIMES FOR BOATS AND CUTTERS ON READY STATUS

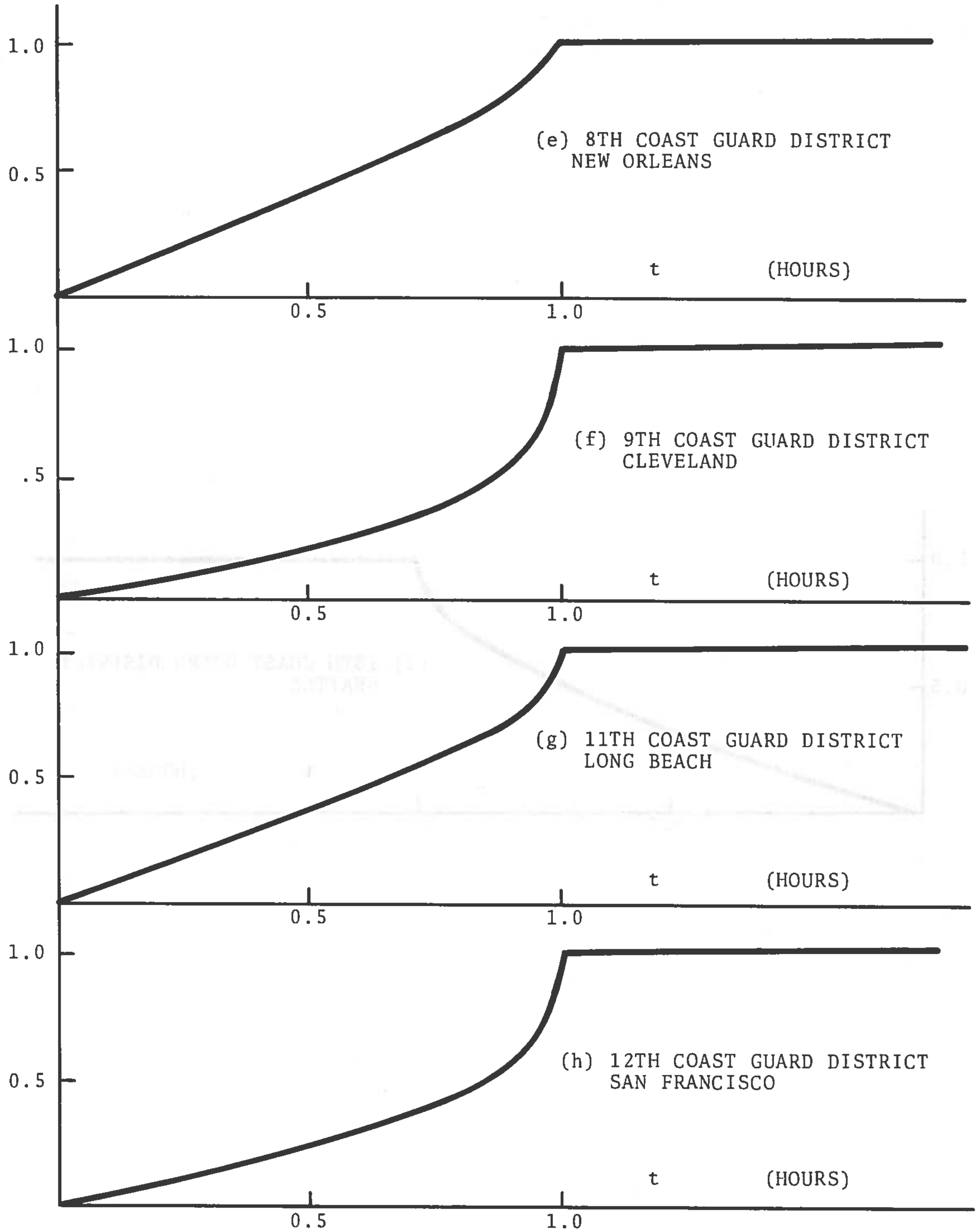

FIGURE H-3. PROBABILITY OF CUTTER AVAILABILITY IN t HOURS OR LESS (e-h).

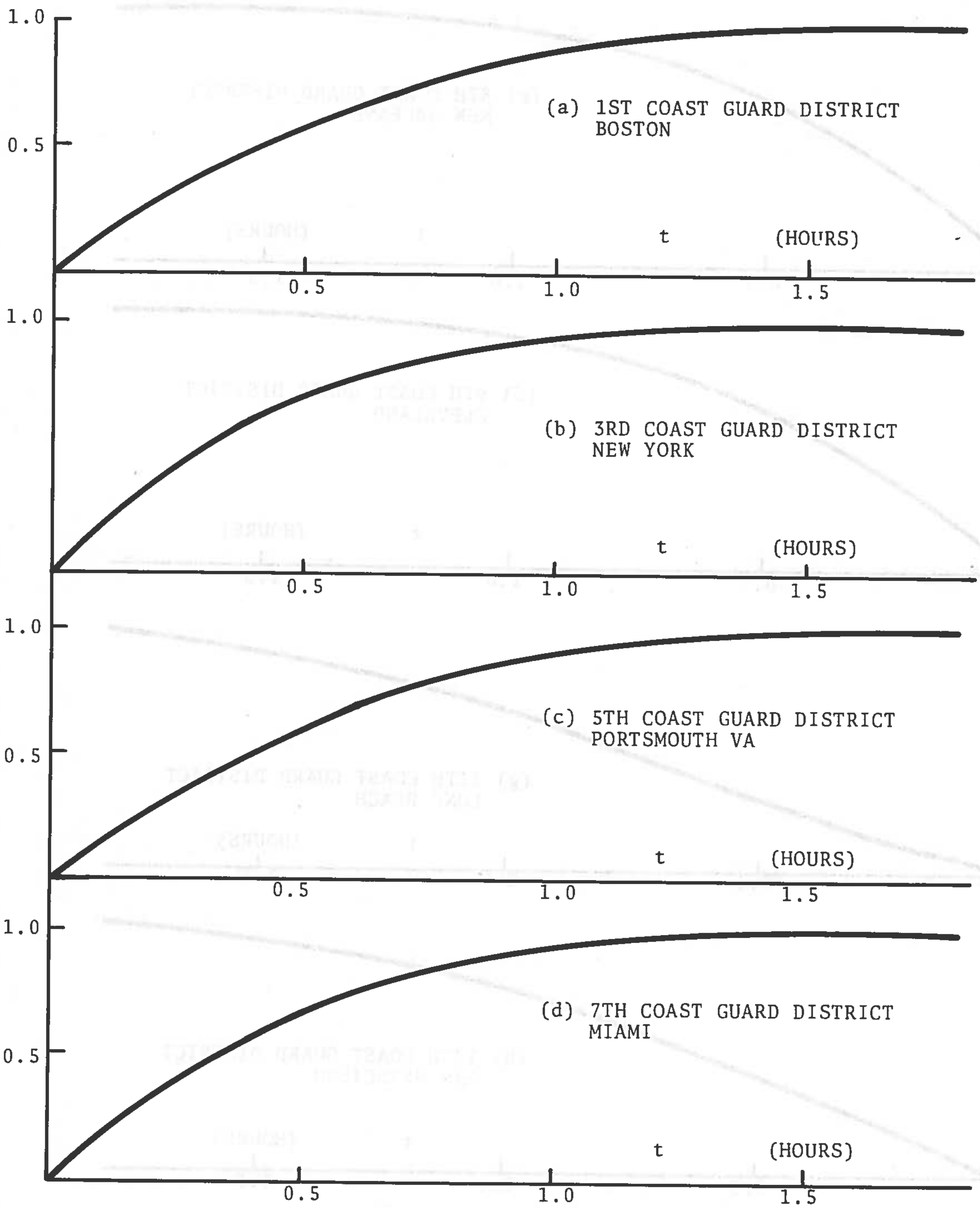

FIGURE H-4. PROBABILITY OF BOAT AVAILABILITY IN t HOURS OR LESS (a-d).

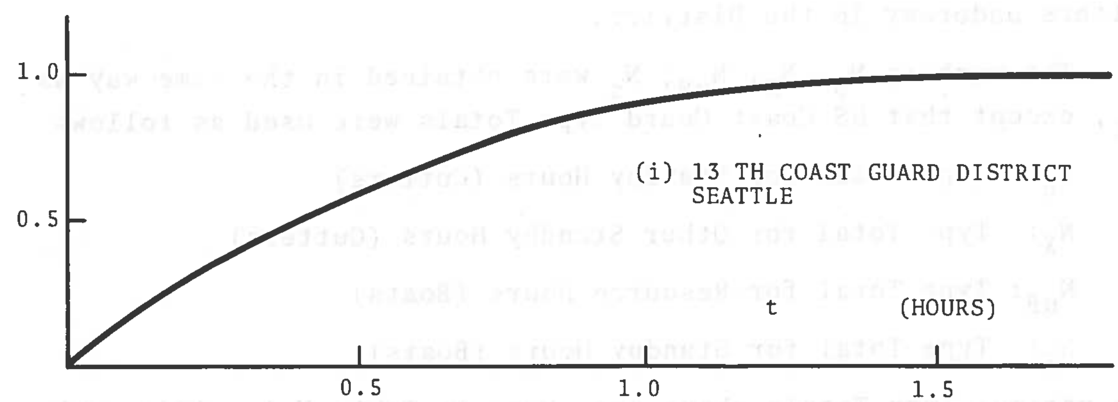

FIGURE H-4. PROBABILTY OF BOAT AVAILABILTY IN t HOURS OR LESS (i)

TABLE H-1 USCG VESSEL UTILIZATION FOR FY1975[1] BY TYPE

CUTTERS

Cutter Type	Underway Hours	Bravo-6 Hours	Bravo-X Hours	Maintain Hours
WHEC/327	14,517	1,231	3,015	25,037
WHEC/378	37,023	1,881	12,395	53,823
WMEC/210	37,522	36,230	26,635	39,852
WMEC/213	1,581	4,803	280	2,095
WMEC/205	3,919	10,433	671	11,256
WMEC/143	3,900	9,070	0	4,550
WMEC/-	2,912	2,102	1,049	2,697
WPB/95	15,047	116,558	16,577	46,713
WPB/82	41,333	276,283	44,735	101,923
WLB/180	47,819	75,414	78,068	72,695
WLM/177	5,313	4,139	15,648	9,940
WLM/157	5,104	15,151	13,426	10,119
WLM/133	6,948	15,480	24,124	14,768
WLI/100	7,015	12,094	21,912	13,747
WLI/100[2]	1,425	41	13,527	2,527
WLI/74	3,219	4,356	6,694	3,251
WLI/65	4,983	16,647	20,802	10,128
WYTM/110	9,130	57,835	13,896	33,019
WYTL/65	13,633	40,292	49,866	27,609
WYTM/UNK	219	0	8,507	34

BOATS

Boat Type	Underway Hours	Standby Hours	Maintain. Hours	Storage Hours
BU/40	727	9,740	637	6,008
BU/45	9,758	115,414	17,065	19,883
MLB/41	42,909	702,834	125,180	46,216
MLB/52	1,333	30,434	5,481	0
UTB/40	69,099	864,567	214,174	251,605
OTH/>40[4]	48,199	385,408	79,887	38,435

(1) Source: Reference H-1.
(2) The Reference has two entries for WLI/100.
(3) Total Accounting hours for the type is the sum of the four entries on the line.
(4) Type not specified. Apparently includes such types as ANB/65, BUSL/46, UTB/41, Bu/52.

TABLE H-3 USCG CUTTER AND BOAT SPEEDS USCG DISTRICT COASTAL LENGTHS

Vessel Type	Max Speed, V	District	Distance, D[1]
CUTTERS			
WHEC/327	28 knots	1	925 n.mi.
WHEC/378	28	3	525
WMEC/210	16	5	600
WMEC/213	16	7	1100
WMEC/205	16	8	1100
WMEC/143	16	9	2500
WMEC/-	16	11	250
WPB/95	20	12	650
WPB/82	24	13	700
WLB/180	13		
WLM/177	12		
WML/157	13		
WLM/133	10		
WLI/100	10		
WLI/100	10		
WLI/74	10		
WLI/65	10		
WYTM/110	10		
WYTL/65	10		
WYTM/UNK	10		
BOATS			
BU/40	10		
BU/45	10		
MLB/44	14		
MLB/52	11		
UTB/40	26		
OTH/>40	15		

(1) Approximate length of coast when traversed, at about 25 miles from shore.

It can be concluded from this analysis that while there is a high probability of a boat being available within one hour, the corresponding probability for cutters is more difficult to estimate using the present method. An accurate estimate of cutter availability can be obtained only by a port-by-port analysis using actual vessel assignments for data and models tailored to each control area.

APPENDIX I:

COAST GUARD AND DOD AIR BASES

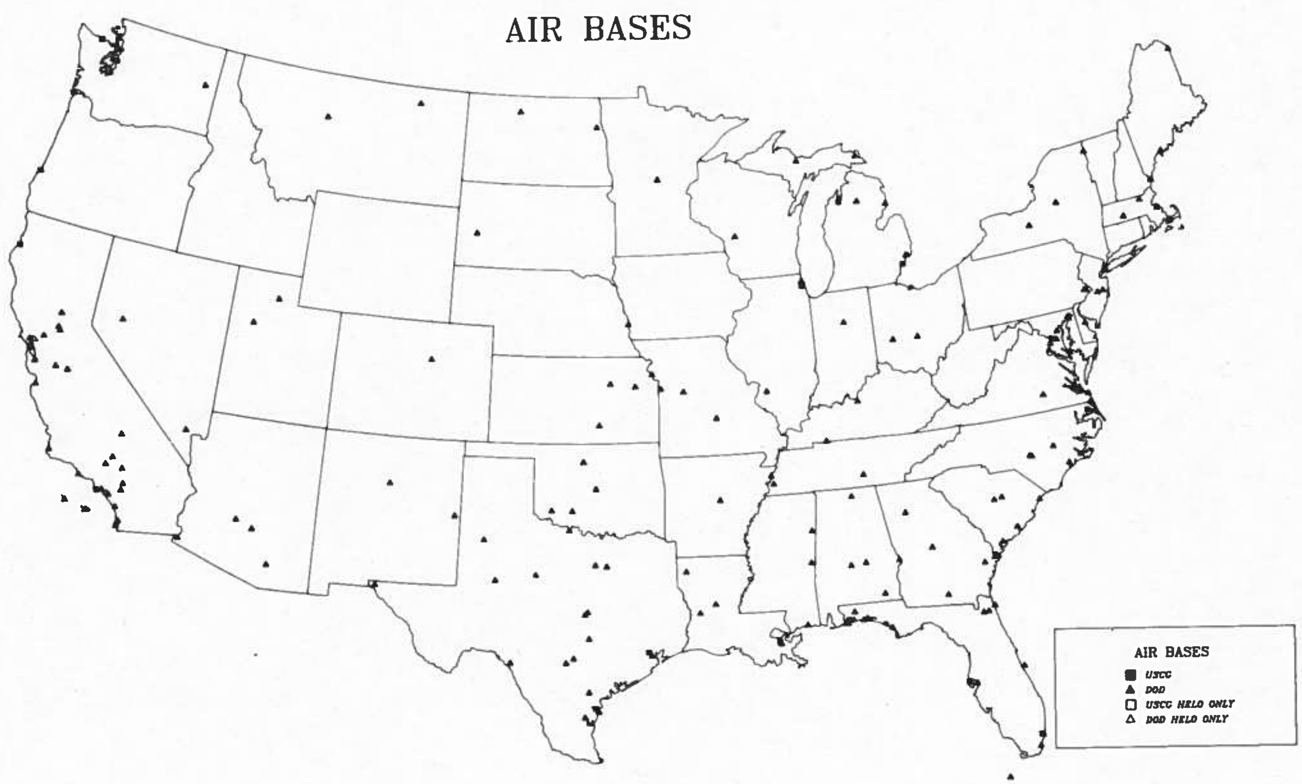

FIGURE I-2 USCG AND DOD AIR BASES IN THE 48 STATES

APPENDIX J:

SPILL POTENTIAL DATA BASE

The spill potential data base was assembled from (1) the U.S. Army Corp. of Engineer's "Waterborne Commerce of the United States", 1976, (2) USGS estimates of future OCS leases and data on current (1977) OCS production, and (3) spill rates obtained in Section 3 of this report.

1. ACOE PORT OIL MOVEMENT

Reference J-1 contains ACOE CY 1976 data on domestic waterborne petroleum movements, plus Bureau of the Census data on oil imports and exports. The data are classified by

(1) Waterway, channel, or port

(2) Type of petroleum or product

(3) Type of traffic.

Selection of data was made, based on these three classifications, so as to most nearly represent the oil movement of concern to the study. The selection was based on the following criteria.

(1) Waterway, channel or port: The ACOE data represents oil movements, rather than oil landed or shipped. This is not inappropriate to the estimation of spill potential, since many spills occur in passage through channels due to groundings, collisions and rammings. However the study area does not encompass movements on the Mississippi River System above Baton Rouge, the Intracoastal waterways, and inland lakes and rivers, except the Great Lakes. In addition, many coastal rivers and creeks carry almost insignificant amounts of petroleum, mainly light oils, and can be ignored. A complete list of exclusions from Parts 1 through 4 of Reference J-1 is given at the end of this Appendix. All other movements of the 1976 ACOE data were included in the spill potential data base. Exclusions of over 1,000,000 tons of petroleum/year are noted in the list, as well as exclusions of

n. Inbound

o. Outbound

p. Through.

These categories were extracted separately (for the waterways and petroleum types of (1) and (2)) and then grouped as follows:

Group 1, Coastal and Foreign, comprising types a,b,c,d,g,h, j, k, n, o

Group 2, Internal and Local, comprising types e,f,i,l,m,p.

Traffic at some of the smaller ports is broken down by petroleum type (2) but not by traffic type (3). They are listed simply as total tonnage. Such totals were classified as Group 2.

2. ESTIMATES OF OCS PRODUCTION

The expected total reserves and production life of East Coast, Gulf Coast and West Coast OCS areas were extracted from References 3-8, 3-9, 3-10, 3-11, 3-13, and J-2, and estimates for 1985 made as follows (Table J-1).

For future well fields the annual production shown was assumed to be distributed evenly over

13 well fields in Georges Bank
4 well fields in Baltimore Canyon
8 well fields in South East Georgia Embayment
14 well fields in Eastern & Western Gulf
6 well fields in Southern California.

based on the number of lease sites planned. Their geographic distribution was as shown in Section 3, Figures 3-19, 3-20, 3-21, 3-22, 3-23, and 3-24. The present well fields were assumed to continue to produce, although both a shift in location and production level is likely. Nevertheless the existing sites, and production shown in the Table were taken as an approximation to the situation in 1985 with regard to present wellfields. Their locations were extracted from Reference J-2 and inserted into the spill potential data base. The estimated total reserves of the present fields were also extracted from reference J-2 and

TABLE J-2: EXISTING OCS WELL FIELDS[1]

FIELD		LAT/LON[2]	1976 PRODUCTION 10^6 BBL/YR	RESERVES AS OF 1/77 10^6 BBL
Louisiana				
Bay Marchand	Blk 2	2905/9010	22	176
Eugene I.	Blk 330	2840/9142	31	132
Eugene I.	Blk 276	2849/9133	3	111
Grand I.	Blk 16	2903/8955	8	119
Grand I.	Blk 43	2900/8950	15	174
Main Pass	Blk 41	2924/8900	1	120
Main Pass	Blk 69	2915/8905	5	58
Ship Shore	Blk 207	2832/9105	6	119
South Pass	Blk 24	2900/8920	11	95
South Pass	Blk 27	2855/8925	6	111
South Pass	Blk 62	2900/8900	4	132
South Pass	Blk 65	2900/8900	7	128
Timbalier Bay	Blk 30	2401/9016	2	92
West Delta	Blk 30	2910/8936	17	103
West Delta	Blk 73	2855/8945	10	143
West Delta	Blk 58	2900/8950	8	130
Southern California				
Dos Cuadros		3420/11935	12	93
Santa Ynez		3418/12022	0	-
Huntington Beach		3340/11805	15	120
Wilmington		3346/11811	60	610

(1) Source: Reference J-2

(2) Approximate only.

PART 1 (Cont'd)

* 4. Burlington Harbor, VT

* 5. Plattsburgh, NY

** 6. Inland Waterway from Delaware R. to Chesapeake Bay-Chesapeake and Delaware Canal

* 7. Mantua Creek, N.J.

* 8. Big Timber Creek, N.J.

9. Cohansey River, N.J.

10. Oldman's Creek, N.J.

11. Cooper River, N.J.

12. Chaptank River, N.J.

13. Warwick River, MD

* 14. Atlantic Intracoastal Waterway Between Norfolk, Va and the St. John's River, Fla. (Norfolk District) via Great Bridge Loch Route.

* 15. Roanoke River, N.C. (Albermarly Sound, Plymouth, NC)

16. Pamlico and Tar Rivers, N.C.

17. Neuse River, NC

18. Atlantic Intracoastal Waterway between Norfolk VA and the St. John's River, Fla. (Wilmington District)

19. Cape Fear River, (except Wilmington Harbor), NC

* 20. Cape Fear River above Wilmington

* 21. Northeast Cape Fear River

22. Smith's Greek (Pamlico County) NC

* 23. Atlantic Intracoastal Waterway between Norfolk VA and the St. John's River (Charleston District)

24. Atlantic Intracoastal Waterway between Norfolk Va and the St. John's River, Fla (Savannah District)

25. Satilla River, Ga.

* 26. Savannah River below Augusta, Ga.

* 27. Atlantic Intra coastal Waterway between Norfolk, Va and the St. John's River, Fla. (Jacksonville District)

** 28. St Johns River Fla, Jacksonville to Lake Harney

** 29. Intra coastal Waterway, Jacksonville to Miami, Fla.

30. Intra coastal Waterway, Miami to Key West, Fla.

*30.5 Rice Creek Fla.

PART 2 (Cont'd)

** 28. Lake Charles Deep Water Channel Intracoastal Waterway, La.
29. Bayou Teche, La.
30. Mermentau River, La.
31. Bayou Teche and Vermillion River, La.
* 32. Mermentau River, Bayous Nezpique and Des Cannes, La.
33. Bayous: Dupre, Segnette Waterway, La. Loutre, St. Malo, vs Closkey, Big Pigeon, Little Pigeon.
34. Chefuncta and Bogue Falia Rivers, Franklin Canal, Fresh water Bayou, Vinton Waterway,
35. Lake Pontchartrain
* 36. Johnson's Bayou
** 37. Chocolate Bayou, Tex.
* 38. San Bernard River, Tex.
39. Colorado River and Flood Discharge Channels, Tex.
* 40. Tributary Arroyo Colorado, Tex.
41. Port Mansfield, Tex.
42. Chicago, Ill. District. (Port of Chicago is tabulated)
43. Blackwater River, Fla.
44. Gulf County Canal, Fla.
45. La Grange Bayou, Fla.

PART 3

** 1. Illinois River, Illinois Waterway
2. St. Marys River, Mich
3. St. Clair River, Mich,
* 4. Channels in Lake St. Claire
** 5. Detroit River, Mich. (includes port of Detroit, which is tabulated)
* 6. Gray's Reef Passage, Mich (all through)
7. Sturgeon Bay and Lake Michigan Ship Canal (through)

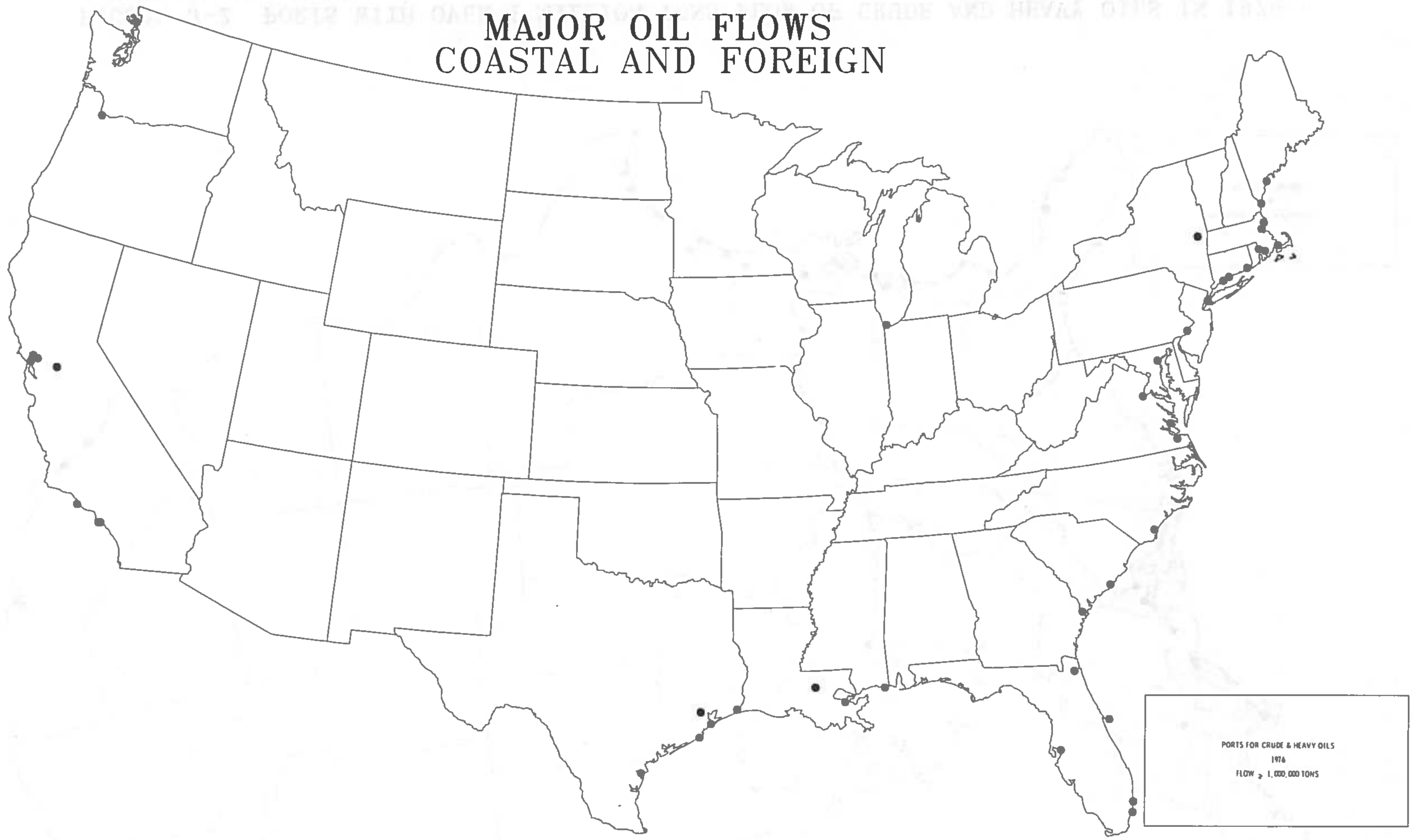

FIGURE J-1 PORTS WITH OVER 1 MILLION TONS FLOW OF CRUDE AND HEAVY OILS IN 1976 (COASTAL AND FOREIGN)

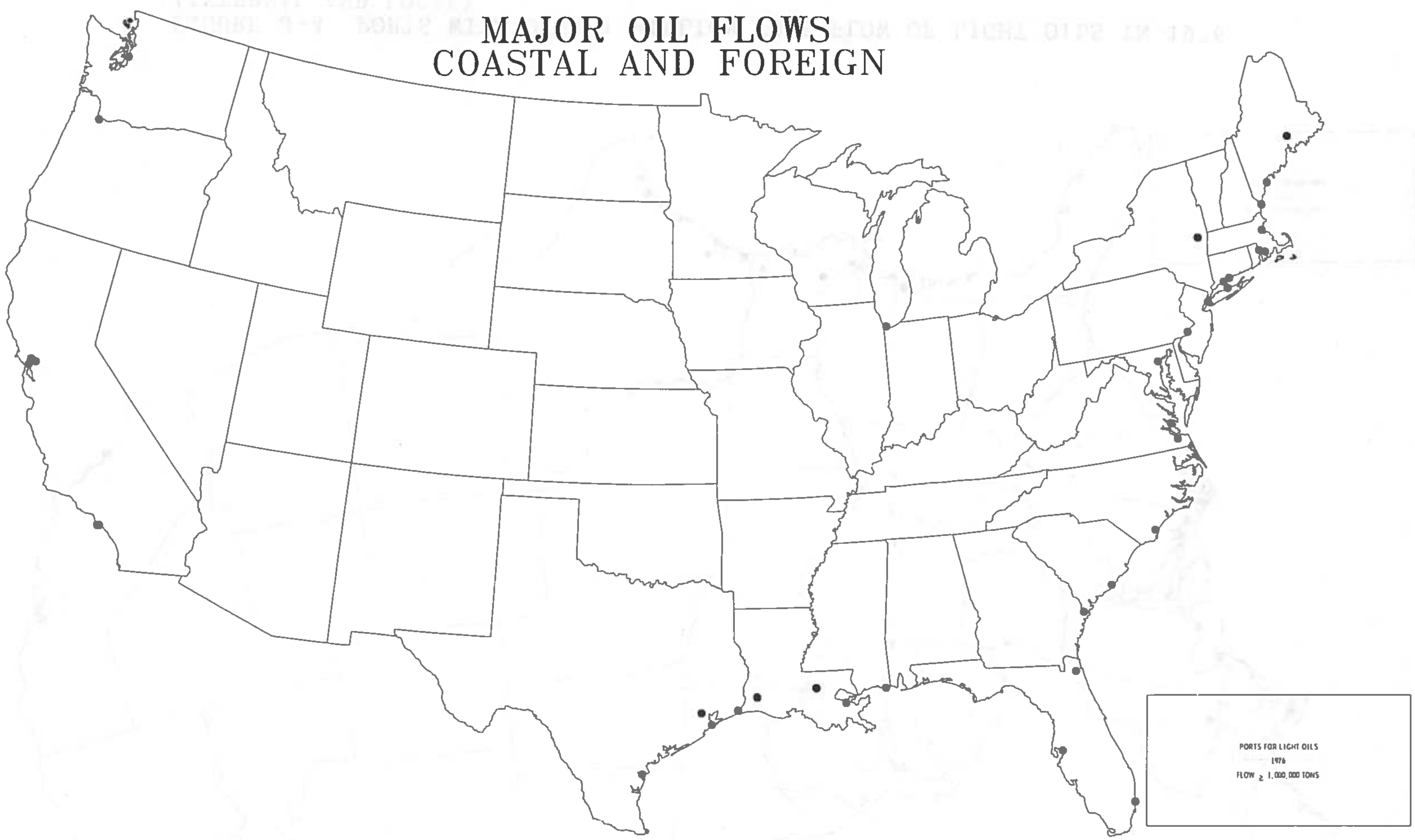

FIGURE J-3 PORTS WITH OVER 1 MILLION TONS FLOW OF LIGHT OILS IN 1976
(COASTAL AND FOREIGN)

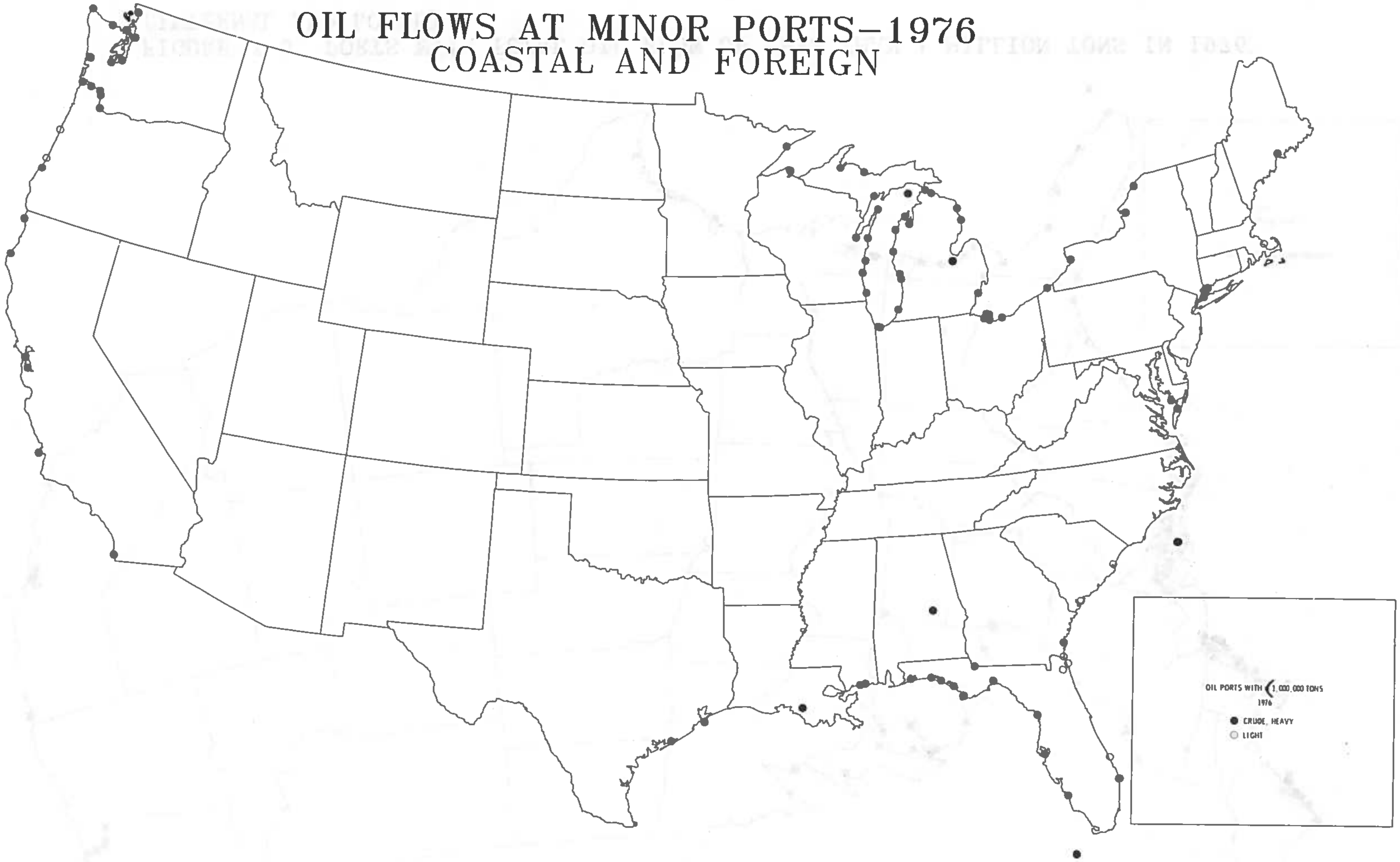

FIGURE J-5 PORTS WITH TOTAL OIL FLOW OF LESS THAN 1 MILLION TONS IN 1976 (COASTAL AND FOREIGN)

REFERENCES FOR APPENDIX J.

J-1. Department of the Army, Corps of Engineers, "Waterborne Commerce of the United States", Calendar Year 1976, Parts 1 through 4.

J-2. International Petroleum Encyclopedia, 1977, Vol. 10, The Petroleum Publishing Co., Tulsa, OK. 74101.

APPENDIX K

POLLUTION RESPONSE ALLOCATION MODEL

This Appendix derives the optimum levels of oil pollution recovery capability to be allocated to each of N equipment storage sites when the total capability is limited. The i^{th} site, $i = 1,2,3,\ldots,N$, is to be assigned an amount of equipment with oil recovery capability s_i, measured in gallons, which will be brought to bear upon any spill that occurs in the geographic region served by that equipment site. The major assumptions are:

1. The regions do not overlap.

2. Spills occur one at a time.

3. The distributions of the number and volume of spills in a year are independent and are known for each region.

4. The amount of oil recovered at a spill is no greater than the recovery capability s_i of the region in which it occurs, plus a fraction a_{ij} of the capability of each other site j. Symbolically,

$$r_i = \sum_{j=1}^{N} a_{ij}\, s_j$$

   where r_i is the maximum amount of oil recovered at a spill in region i. (Note that $a_{ii}=1$.)

5. The total capability $\sum_{i=1}^{N} s_i$ is limited.

6. The optimum deployment is that which maximizes the expected value of the total amount of oil recovered from all spills.

With the above assumptions, the problem is to assign the site capabilities s_i so as to maximize the amount of oil recovered in a year, subject to the equipment limit 5. and the assistance from

$$f_i(x_1, x_2, \ldots, x_n) = f_i(x_1)\, f_i(x_2) \ldots f_i(x_n),$$

where $f_i(x)$ is the volume distribution of a single spill in region i. When this is substituted into (3), one has

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

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

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

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

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

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

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

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

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

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

or

$$r_i = F_i^{-1}\left(1 + \frac{\lambda}{\bar{n}}\right) \tag{14}$$

Thus, by choosing λ, the r_i may be obtained from (14), or graphically as shown in Fig. K-1. The sum $\sum_{i=1}^{N} r_i$ is then compared to K to determine if (12) is satisfied. If not, increasing (or decreasing) λ will increase (or decrease) that sum until it equals K. The success of this process derives from the monotony of the cumulative distribution functions $F_i(x)$. In detail, the process is as follows:

1. Select a small, negative value for λ
2. Calculate $1 + \lambda/\bar{n}_i$ for $i = 1, 2, 3, \ldots, N$
3. Find r_i, $i = 1, 2, 3, \ldots, N$ from (14) or graphically
4. Calculate $\text{TEST} = \sum_{i=1}^{N} r_i$
5. If TEST > K, decrease λ by a small amount δ, and go to 2. Otherwise, STOP.

Note that $\lambda < 0$ and $\delta > 0$. Decreasing λ by an amount δ, in step 5., amounts to replacing λ by $\lambda - \delta$.

When the process terminates the resulting set of response capabilities s_i, $i = 1, 2, 3, \ldots, N$ will be the optimum allocation of the total available capability to the N regions, under the given assumptions, with no assistance among sites.

CASE 2, ASSISTANCE AMONG SITES

If a fraction a_{ij} of the capability of site j is brought to the assistance of site i, where $i \neq j$, then the matrix a_{ij} is no longer the identity matrix. The above procedure may be employed to obtain the net regional capabilities r_i and then the unassisted site capabilities s_i obtained from (7) by inverting the matrix a_{ij}. But the resulting site capabilities, s_i, are often negative. To avoid such an unrealistic answer it is desirable to select the s_i directly, subject to the constraint $s_i \geq 0$, so that $\overline{R}$ of (6) will be a maximum. The constraint (7) must be satisfied as well. The (assisted) regional capabilities r_i must also be calculated, but only as intermediate quantities because they relate the independent variables s_i to the objective function (6). A slight generalization of this problem replaces the constraints $s_i \geq 0$ by $s_i \geq m_i$, where m_i are given minimum site capabilities.

The problem just described is a common one in mathematical programming. The solution is obtained by a process not unlike that in the previous case. The constraint (7) is multiplied by a constant λ and the constraints $s_i \geq m_i$ are multiplied by constants μ_i. Both products are added to $\overline{R}$ to form the Hamiltonian H:

$$H = \overline{R} + \lambda\left(\sum_{i=1}^{N} s_i - K\right) + \sum_{i=1}^{N} \mu_i \ (s_i - m_i) \qquad (15)$$

The necessary conditions for a maximum* are:

$$\frac{\partial H}{\partial \lambda} = \sum_{i=1}^{N} s_i - K = 0 \qquad (16)$$

$$\frac{\partial H}{\partial s_i} = \frac{\partial \overline{R}}{\partial s_i} + \lambda + \mu_i = 0 \qquad (17)$$

$$\mu_i = 0 \text{ for } s_i > m_i \qquad (18)$$

$$\mu_i \geq 0 \text{ for } s_i = m_i \qquad (19)$$

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[1]A.E. Bryson and Y-C. Ho, "Applied Optimal Control," Blaisdell Publishing Co., 1969, p. 27.

where $\lambda = \alpha_{max}$; for sites with $s_i = m_i$, (condition (19)), one has μ_i such that

$$\frac{\partial H}{\partial s_i} = \alpha_i + \lambda + \mu_i = 0 \qquad (22)$$

It will be observed that λ here is negative, just as in the previous case. In fact, when no site is at its minimum $\mu_i = 0$ for all i and the present case reduces to the previous. As in the previous case, the procedure terminates because as s_i increases α_i generally decreases and $\overline{R}$ increases.

The major difficulty in carrying out the procedure is selecting the step size δ. It was found that a second-order gradient (Newton-Raphson) technique worked satisfactorily for about 20 sites, provided the step was limited to about 0.1 K/N. Specifically, δ was calculated as

$$\delta = \underset{\text{of}}{\text{min}} \begin{cases} K/10N \\ (\overline{\alpha} - \alpha_{min})/\beta_{min} \\ (\alpha_{max} - \overline{\alpha})/\beta_{max} \\ s_i - m_i \end{cases} \qquad (23)$$

where

$$\overline{\alpha} = \sum_{i=1}^{N} \alpha_i/N \qquad (24)$$

$$\beta_i = - \partial\alpha_i/\partial s_i$$

$$= \sum_{i=1}^{N} \overline{n}_j \, \alpha_{ji}^2 \, f_j(r_j) \qquad (25)$$

The subscripts max or min indicate the values of i for which $s_i > m_i$ and α_i is maximum or minimum.

APPENDIX L:
SPILL PROBABILITY MODELS

1. PROBABILITY OF LARGE SPILLS - GENERAL DISTRIBUTION

In this section we derive the probability that in any one year one or more oil spills in U.S. waters will be larger than x gallons in magnitude. The result, P(x), will turn out to be

$$P(x) = \bar{n}(1 - F(x)), \qquad (1)$$

where $\bar{n}$ is the average number of spills per year in U.S. waters, and F(x) is the probability of a spill being x gallons or less. The approximation is good if x represents a large spill, i.e., one large enough so that F(x) is close to 1. More precisely, the error E in the approximation is about

$$f^2 \left(\sigma^2 + (\bar{n})^2 - \bar{n}\right)/2, \qquad (2)$$

where $f = 1-F(x)$ and σ^2 is the variance of n.

Two observations may be made regarding this result.

<u>Observation 1</u>. The estimate depends on the distribution F(x) of spill size, but on only the mean $\bar{n}$ of the distribution of the number of spills. As will be seen in its derivation, the estimate is valid whether or not the spill number is distributed according to Poisson, Negative Binomial, or other law, as long as the mean and variance of the number of spills are known.

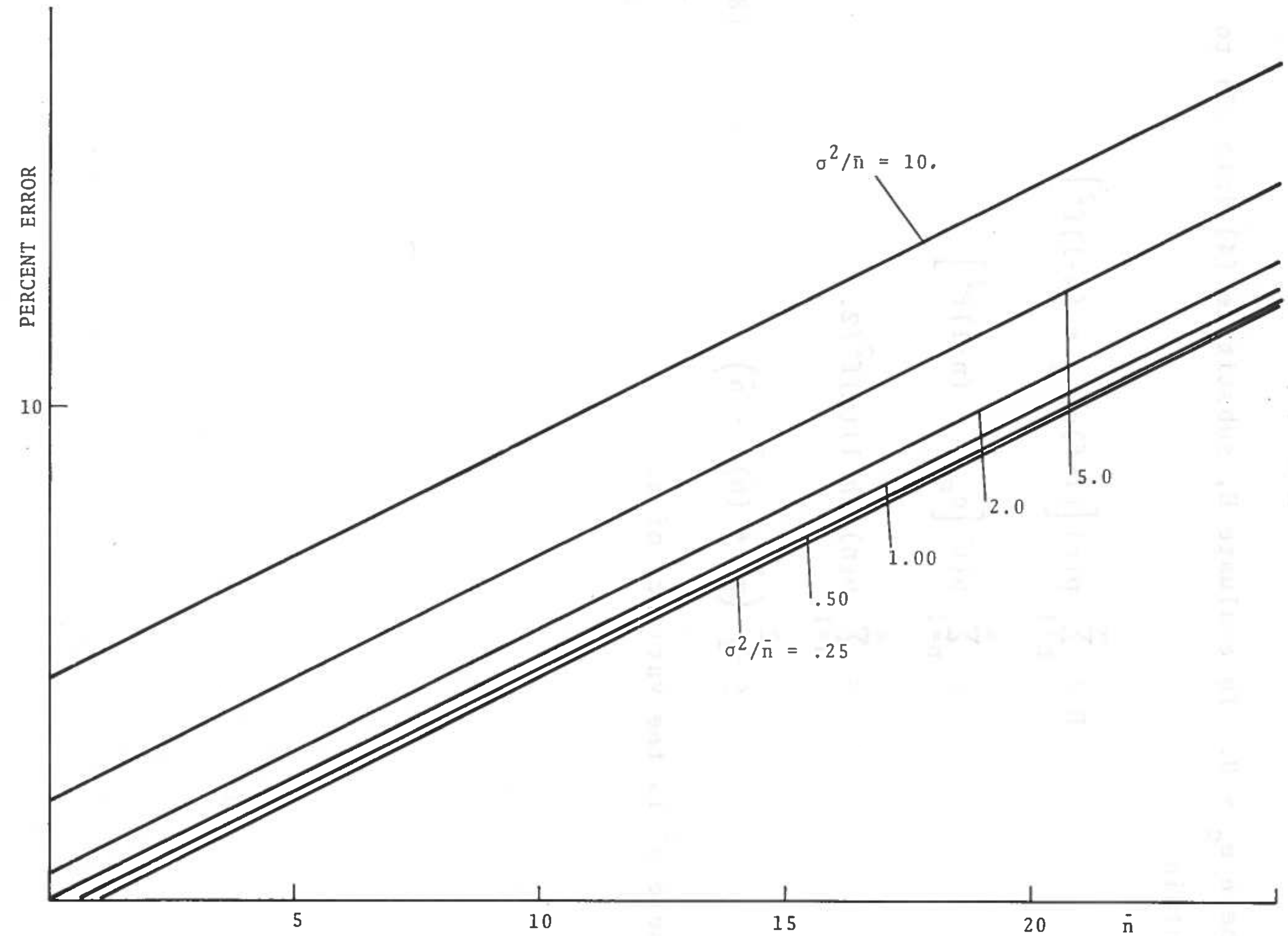

FIGURE L-1 PERCENT ERROR IN ESTIMATE OF P(x) AS A FUNCTION OF EXPECTED NUMBER $\bar{n}$ OF SPILLS

2. PROBABILITY OF LARGE SPILLS - POISSON DISTRIBUTION

If one is willing to assume that the spill number is Poisson distributed, and independent of spill size, then an exact answer to the large spill question is easily obtained. If n spills occur in an interval T then they constitute n Bernoulli trials, each with probability f(x) that it will exceed the level x. The probability that exactly k of these n spills will exceed x gallons is therefore Binomially distributed:

$$B(k/n) = \binom{n}{k}\left[f(x)\right]^k\left[1 - f(x)\right]^{n-k} . \qquad (9)$$

When all possible values of n are considered, one has the probability $P_k(x)$ that exactly k spills will exceed the value x:

$$P_k(x) = \sum_{n=k}^{\infty} B(k/n)\ p(n), \qquad (10)$$

where p(n) is the probability of n spills in the interval T. If, now, one assumes that p(n) is a Poisson distribution, i.e.,

$$p(n) = (\lambda T)^n\ e^{-\lambda T}/n! \qquad (11)$$

he obtains the following from (10) and (9) for $n \geq k$:

$$P_k(x) = \frac{\left[f(x)\right]^k\ e^{-\lambda T}(\lambda T)^k}{k!} \sum_{n=k}^{\infty} \frac{\left[\lambda T\left(1-f(x)\right)\right]^{n-k}}{(n-k)!}$$

$$= \left[\lambda T f(x)\right]^k\ e^{-\lambda T f(x)}/k! \qquad (12)$$

3. PROBABILITY OF SIMULTANEOUS LARGE SPILLS

In this section we derive the probability that one or more spills greater than y gallons will occur while recovery efforts are still in progress for a spill of size x gallons. This result has implications for the selection of storage levels for pollution response equipment.

First it is necessary to estimate the probability of a spill of size between x gallons and $x + \Delta x$ gallons. This is $h(x)$

$$h(x) = F(x+\Delta x) - F(x). \tag{16}$$

If n spills occur the probability that exactly k of them will be between x and $x + \Delta x$ is

$$B(k/n) = \binom{n}{k}\Big[h(x)\Big]^k\Big[1 - h(x)\Big]^{n-k}, \tag{17}$$

just as in (9) above. By an argument similar to that employed for (9) - (12) above, one may determine the probability that exactly k spills are in the range x to $x + \Delta x$, with a result analogous to (12):

$$P_k(x) = \Big[\lambda T\, h(x)\Big]^k e^{-\lambda T h(x)}/k!. \tag{18}$$

As in (11) it has been assumed that spill number is Poisson distributed. In the present case, however, it is more convenient to interpret T and λ as time and spills per unit time, rather than as throughput and spills per unit throughput.

Substituting (18) and (20) into (21) gives, after a calculation similar to that of (12),

$$S(j,y,x) = \left[\lambda T\omega(x,y)\right]^j e^{-\lambda T\omega(x,y)}/j! \qquad (22)$$

where

$$\omega(x,y) = h(x)\left(1 - e^{-\lambda\delta(x)f(y)}\right) \qquad (23)$$

If the probability is small of a second spill of size y or greater occurring in the interval $\delta(x)$, then the approximation in (19) may be used, giving

$$\omega(x,y) \cong \lambda\, h(x)\, \delta(x)\, f(y) \qquad (24)$$

1. It should be noted that j here is not the number of spills occurring simultaneously, but the number of times that simultaneous spills occur, i.e., the number of times in the period T that one or more spills of size greater than y occur during a spill of size x.

2. It should also be noted that the calculation is not restricted to large spills if the exact form (23) is used instead of the approximation (24). Moreover, (24) is a good approximation as long as $\lambda\ \delta(x)f(y)$ is small, which can occur if (a) the spill rate λ is small, or (b) the duration $\delta(x)$ of the first spill is small, or (c) the second spill size, y, is so large that the probability f(y) of its occurrence is small, or if (d) some combination of (a), (b) and (c) occurs.

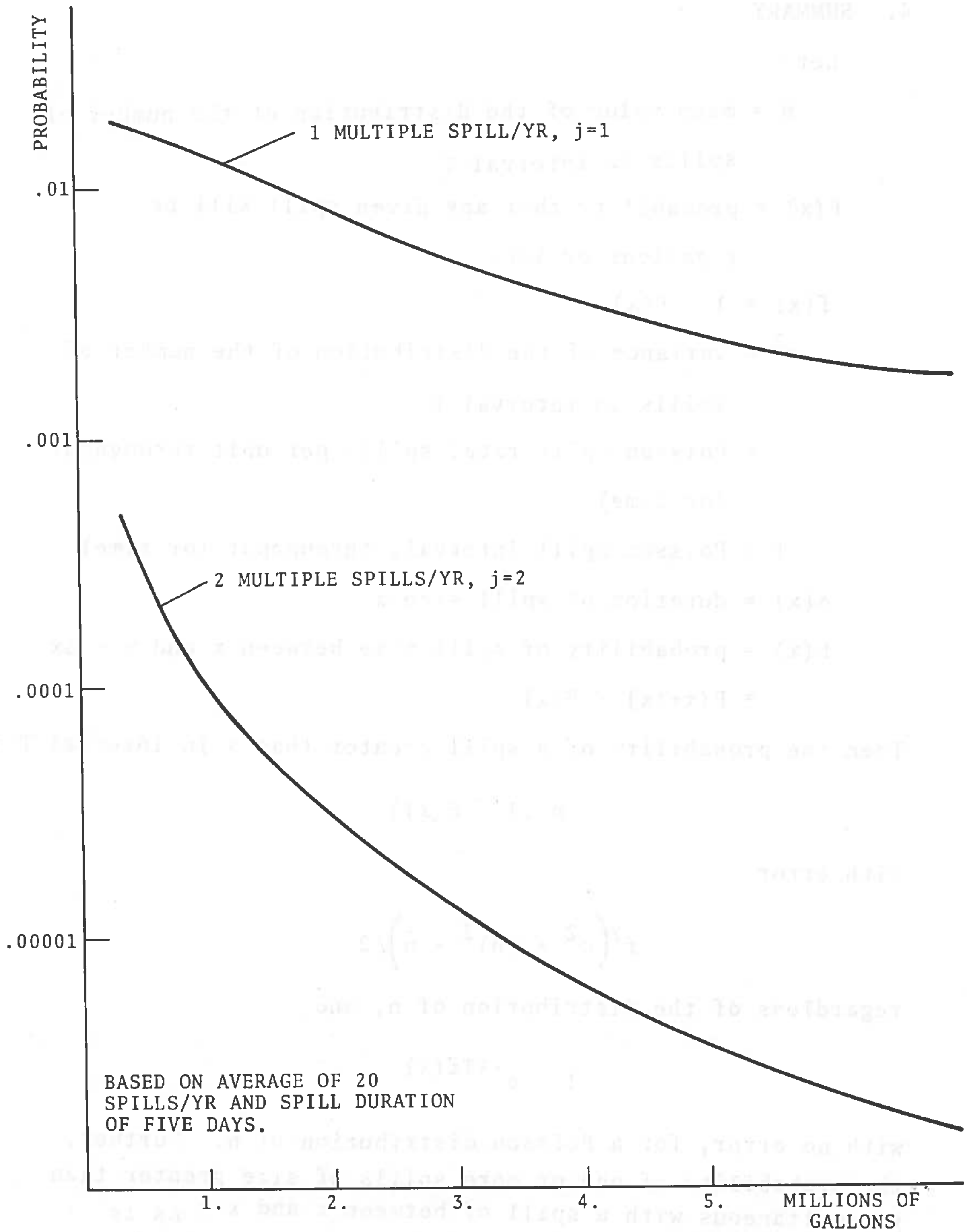

FIGURE L-2 PROBABILITY OF MULTIPLE SPILLS

$$\left[\lambda T\omega(x,y)\right]^{j} e^{-\lambda T\omega(x,y)}/j!$$

where

$$\omega(x,y) = h(x)\left(1 - e^{-\lambda\delta(x)f(y)}\right)$$

and where j is the number of times in T that simultaneous spills occur.

APPENDIX M:

NON-COAST GUARD EQUIPMENT CAPABILITIES

Appendix M contains a discussion and presentation of geographical locations and performance capabilities of the following selective pieces of pollution response equipment:

1. Booms
2. Skimmers
3. Pumps
4. Storage Containers

The capabilities presented herein are predicated upon a knowledge of the extent of existing equipment inventories and some reasonable assumption s concerning the availability and performance degradation that reflect pseudo-real-world situations. Emphasis is placed upon Non-Coast Guard equipment inventories such as those owned and operated by:

1. U.S. Navy
2. Private Companies
3. Cooperatives
4. States, Cities, and Towns

Emphasis was also placed upon equipment stored at locations close to the shoreline of the states including the Great Lakes. Close means within approximately 100 miles. All other inland locations were deleted from the established inventories.

The bulk of the equipment information was derived from a data base entitled, Spill-Cleanup Inventory, developed by the Coast Guard at headquarters. It, in turn, was compiled from data supplied by the existing strike teams, MSO's and CTOP's. TSC then collapsed this data base further by aggregating all non-federal government owned equipment at or near previously specified port cities. In short, this then becomes the total amount of capability that can be called up and deployed subsequent to a notification at a spill, grounding, etc. The resulting collapsed data base is given on Table M-1.

TABLE M-1 NON-FEDERAL GOVERNMENT POLLUTION RESPONSE EQUIPMENT (CONTINUED)

PUMPS WITH CAPACITY $\geq$ 200 GPM

CITY	STATE	LAT	LONG	TOTAL NUMBER OF UNITS	TOTAL PUMP CAPACITY GPM
STOUGHTON	MA	4215	7107	13	5,500
BOSTON	MA	4221	7102	23	11,390
GLOUCESTER	MA	4238	7035	3	1,500
BRIDGEWATER	MA	4139	7014	8	3,150
FALMOUTH	MA	4131	7037	8	2,240
BANGOR	ME	4448	5846	2	400
PORTLAND	ME	4338	7017	8	10,160
GRAY	ME	4342	7012	1	260
SOMERSET	MA	4230	7111	4	960
JOHNSTON	RI	4149	7128	3	1,500
DUBUQUE	IL	4230	9030	6	360
ROCK ISLAND	IL	4130	9030	2	200
SPRING PARK	MN	4500	9310	1	380
EAU CLAIRE	WI	4450	9212	3	1,485
SPOONER	WI	4555	9155	1	385
SPRING PARK	MN	4450	9337	2	380
WOOD RIVER	IL	3854	9006	1	340
HARTFORD	IL	3845	9008	1	300
GRANITE CITY	IL	3842	9010	3	700
RENSSELAER	NY	4239	7344	2	575
WEST HAVEN	CT	4117	7256	1	350
BAYONNE	NJ	4040	7406	12	8,380
NEWARK	NJ	4044	7405	1	300
LONG ISLAND CY	NY	4045	7358	2	400
NEWARK	NJ	4042	7047	1	600
VERPLANK	NY	4115	7458	1	350
EDISON	NJ	4420	7430	10	2,600
CLAYTON	NJ	3940	7509	2	500
BALTIMORE	MD	3914	7636	42	21,555

TABLE M-1 NON FEDERAL GOVERNMENT POLLUTION RESPONSE EQUIPMENT

PUMPS WITH CAPACITY ≥ 200 GPM (CONTINUED)

CITY	STATE	LAT	LONG	TOTAL NUMBER OF UNITS	TOTAL PUMP CAPACITY GPM
LEMONT	IL	4140	8800	3	880
FINLAY	IL	4125	8850	1	900
BLUE ISLAND	IL	4140	8741	1	300
LEMONT	IL	4140	8801	3	900
BRIDGEVIEW	IL	4145	8748	1	1,200
FINLAY	IL	4125	8850	1	700
TRENTON	MI	4208	83135	31	25,055
BAY CITY	MI	4337	83505	1	1,500
ECORSE	MI	4215	8309	2	1,280
MOUNT CLEMENS	MI	4235	82472	8	2,860
DETROIT	MI	4217	83070	4	12,800
KAWKAWLIN	MI	4340	8353	1	1,500
ROSEVILLE	MI	4230	82576	1	360
INKSTER	MI	4218	8320	7	2,940
WAYNE	MI	4217	8324	2	1,000
FERNDALE	MI	4228	8306	3	1,020
BAYFIELD	WI	4750	9105	1	250
HOUGHTON	MI	4707	8835	3	2,400
SUPERIOR	WI	4642	9202	10	3,400
HOLLAND	MI	4243	8607	1	1,000
FRUITPORT	MI	4307	8610	3	965
PENTWATER	MI	4345	8625	6	2,615
MUSKEGON	MI	4313	8620	40	17,395
FRUITPORT	MI	4307	8610	3	600
RAPID RIVER	MI	4445	8557	9	3,400
PLAINWELL	MI	4227	8538	3	3,600
FRANKFORT	MI	4440	8615	3	900
ELBERTA	MI	4438	8615	1	200
ST JOSEPH	MI	4206	8628	5	1,500
OXNARD	CA	3410	11911	4	950

TABLE M-1 NON-FEDERAL GOVERNMENT POLLUTION RESPONSE EQUIPMENT
OPEN-WATER SKIMMERS (CONTINUED)

CITY	STATE	EQUIPMENT LOC LAT	EQUIPMENT LOC LONG	TOTAL NUMBER OF UNITS	TOTAL RECOVERY CAPACITY IN GPM
ANACORTES	WA	4831	12236	3	290
FERNDALE	WA	4852	12245	1	265
BELLINGHAM	WA	4846	12230	1	
HONOLULU	HI	1944	15503	1	30
PEABODY	MA	4229	7058	1	750
PORLAND	ME	4342	7012	1	25
DAVISVILLE	RI	4136	7125	4	2,000
FINDLAY	OH	4102	8340	4	
NEW HAVEN	CT	4119	7254	1	200
BROOKLYN	NY	4040	7401	1	
ELIZABETH	NH	4039	7411	2	
MIAMI	FL	2548	8013	5	208
FT LAUDERDALE	FL	2605	8007	2	205
BRUNSWICK	GA	3109	8129	1	40
SAVANNAH	GA	3205	8106	1	600
YABACOA	PR	1803	6550	1	20
SAN JUAN	PR	1828	6607	5	60
SAN JUAN	PR	1826	6606	1	40
FLOUR BLUFF	TX	2736	9717	1	500
BAYTOWN	TX	2943	9501	2	70
VENICE	LA	2916	8929	1	
INTERCOASTAL	LA	2947	9209	1	
NEW ORLEANS	LA	2936	9043	5	
BELLE CHASE	LA	3000	9002	2	588
SULPHUR	LA	3014	9323	2	400
WADDINGTON	NY	4452	7512	2	1,000
WAYNE	MI	4217	8324	1	300
MOUNT CLEMENS	MI	4235	82472	5	2,100
BAY CITY	MI	4337	83505	1	100
VENTURA	CA	3424	11954	6	650
LOS ANGELES	CA	3423	12003	1	15
SANTA BARBARA	CA	3424	11930	16	5,643

TABLE M-1 NON-FEDERAL GOVERNMENT POLLUTION RESPONSE EQUIPMENT

BARGES (CONTINUED)

CITY	STATE	LAT	LONG	TOTAL NUMBER OF UNITS	TOTAL CAPACITY IN GALS
BELLE CHASE	LA	3000	9002	6	
NEW ORLEANS	LA	2916	8957	2	4,200
INTERCOASTAL	LA	2947	9209	2	4,200
MORGAN CITY	LA	2941	9113	3	
HOUMA	LA	2936	9043	7	
BERWICK	LA	2941	9113	12	
VENICE	LA	2916	8929	2	192,570
PORT ARTHUR	TX	2952	9356	4	22,000
CHICAGO	IL	4143	8733	3	
CICERO	IL	4150	8746	1	
LEMONT	IL	4140	8801	1	1,000
CLEVELAND	OH	4131	81415	3	6,000,000
DETROIT	MI	4217	83070	2	6,400
MOUNT CLEMENS	MI	4235	82472	1	4,000
SUPERIOR	WI	4649	9202	5	
DULUTH	MN	4647	9205	2	1,400
SUPERIOR	WI	4649	9202	5	78,000
MUSKEGON	MI	4312	8620	29	15,000
FRANKFORT	MI	4440	8615	2	
RAPID RIVER	MI	4445	8537	3	
FERRYSBURG	MI	4305	8620	8	
ST JOSEPH	MI	4205	8630	4	
FRUITPORT	MI	4307	8610	1	15,000
FERRYSBURG	MI	4305	8610	3	
OREGON	OH	4140	8328		
SANTA BARBARA	CA	3408	11912	1	329,280
NATIONAL CITY	CA	3240	11706	3	680,400
MOSS LANDING	CA	3648	12147	1	748
ALAMEDA	CA	3747	12217	2	1,320
SAN FRANCISCO	CA	3747	12223	2	175,968

TABLE M-1 NON-FEDERAL GOVERNMENT POLLUTION RESPONSE EQUIPMENT

OFFSHORE BOOMS (WAVE HEIGHTS > 3 FT.) (CONTINUED)

CITY	STATE	LAT	LONG	TOTAL LENGTH FEET	TOTAL NUMBER OF UNITS
LONGISLAND	ME	4342	7004	750	1
DAVISVILLE	RI	4136	7125	1,000	10
TIVERTON	RI	4138	7114	2,000	20
BAYONNE	NJ	4039	7407	5,000	100
PERTH AMBOY	NJ	4031	7415	1,000	40
ELIZABETH	NJ	4039	7411	2,500	50
JACKSONVILLE	FL			1,730	1
FT LAUDERDALE	FL	2605	8007	10,500	3
SAVANNAH	GA	3204	8105	1,500	30
BRUNSWICK	GA	3112	8132	750	18
ST PERTERSBURG	FL	2751	8236	800	8
BOCA GRAND	FL	2738	8233	1,410	44
CORPUS CHRISTI	TX	2749	9724	540	1
HOUSTON	TX	2940	9515	6,000	190
MOBILE	AL	3045	8803	2,000	40
PANAMA CITY	LA	3009	8536	1,640	82
BATON ROUGE	LA	3030	9110	102	48
NEW ORLEANS	LA	3000	9002	1,500	30
CHICAGO	IL	4141	8733	930	9
RIVER ROUGE	MI	4216	83080	350	7
MILWAUKEE	WI	4300	8755	200	4
TOLEDO	OH	4139	8332	400	4
SANTA BARBARA	CA	3424	11941	3,600	12
VENTURA	CA	3420	11938	2,800	11
LOS ANGELES	CA	3423	12003	1,400	2
MORRO BAY	CA	3522	12052	30,000	1
SAN LUIS OBISBO	CA	3510	12044	1,300	26
PITTSBURG	CA	3802	12253	1,800	2
HERCULES	CA	3801	12216	2,200	1
SEATTLE	WA	4735	12221	9,750	71
BELLINGHAM	WA	4845	12230	7,000	60

The capabilities of U.S. Navy equipment - predominantly barges, skimmers, and booms were derived from information supplied by:

1. Navfac
2. Navsea

The locations and equipment levels shown on Table 9C-2 are, however, tentative at the present time. Since there is an abundance of harbor booms, the number of feet of Navy booms was not included. The barges and skimmers are attractive candidates for recovery operations.

The following three pieces of equipment were added to the total available capability from the Navy inventory:

1. JBF 3001 Skimmer
2. Mark Class V Skimmer
3. Ship's Waste Offload Barge (SWOB)

These are essentially harbor and coastal equipment, however, under reasonably good environmental conditions they can be employed in open waters. A small skimmer, if it can survive, has better wave-following characteristics than a large heavier one with correspondingly higher moments of inertia, etc., but its ability to survive is doubtful unless accompanied or protected by a larger vessel.

The Dip 3001 skimmer is a self-contained skimming system. It is designed to harvest oil in the open harbor with waves up to two feet in height. It can also operate effectively in between piers or in a stationary mode at the apex of a boom catenary configuration. This unit is approximately 25 feet long and 10 feet wide. Articulating sweeps extend the skimming width to 15 feet. It is diesel powered with two screws for propulsion. All pumping, propulsion, and belt functions are hydraulically operated. One thousand gallons of storage capacity is provided on board for collected oil.

TABLE M-2 (CONT'D)

U.S. NAVY EQUIPMENT

NUMBER	DESCRIPTION	LOCATION
1	Skimmer	Manchester, WA
5	SWOB	Bremerton, WA
1	Skimmer	" "
4	Skimmer (Mod)*	Yorktown, VA
4	Skimmer	Yorktown, VA
4	Skimmer	Stockton, CA
4	Skimmer (Mod)	Stockton, CA

*JBF-3001 Skimmer, up to 100 gal./min.

**Ship's Waste Offload Barge (SWOB), 75,000 gal.

***Marco Class V Skimmer 300 gpm

(Mod) Modified Class V Skimmer

1. Total feet of available offshore booms for:
   A. Sea state (0-3 ft.)
   B. Sea state (over 3 ft.)
2. Total gallons capacity of available:
   A. Barges
   B. Tankships
   C. Bladders
3. Maximum recovery rate (gpm) of skimmers*
4. Storage (gal.) and pumping rates (gpm) of:
   A. Pumps*
   B. Transfer/lightering systems

All hand-held skimmers and vacuum types were deleted.

The amount of pollutant or oil to be recovered or offloaded respectively, the location, and some primitive form of scenario (time intervals over which specified recovery operations are performed) must be established to facilitate the estimate of required equipment capability levels. This together with the estimate of the actual levels indicated in the inventories will point out areas where there are excessive amounts of capability or deficiencies. The equipment capability levels contained herein are based upon a subjective judgement of the availability of equipment and some factor for degrading performance to account for the influence of average environmental conditions and product types.

Availability is the fraction of the response equipment that is operational and/or not diverted to the performance of other services from which revenue is derived.

Since the maximum performance of skimmers and pumps is usually specified, it is assumed that the above-mentioned inventories contain maximum values. Tables M-3 and 4 are tabulations of the factors that were employed to yield more realistic values. The following is a description of the primitive scenarios employed.

*limited to units that exceed or are equal to 200 gpm.

TABLE M-4

NON-COAST GUARD

OPEN-WATER EQUIPMENT CAPABILITY

PERFORMANCE CHARACTERISTICS

EQUIPMENT TYPE	AVAILABILITY	% OPERATING HOURS/DAY	AVERAGE CAPABILITY % OF MAX	% OF OIL RECOVERED	% * ENCOUNTERED	PERIOD OF OPERATION HRS
Booms	-	-	-	-	-	-
Skimmers	1.0	42	100	60	35	62
Pumps	.95	75	60	-	-	110
Storage for Skimming	0.8	-	-	-	-	42
Storage for Offloading	0.8	-	-	-	-	90

In order to calculate the spill response capabilities of equipment available to each site of Configuration 5 from organizations other than the Coast Guard, we define the following quantities at each of n locations close to the site in question:

S_n = maximum skimming capability (gals/hr.)

P_n = maximum pumping capability (gals/hr.)

Q_n = floating storage capacity (gals.)

C_n = boom containment capacity (gals.)

$\sim (2/3\ L_n) \times 10^3$, where

L_n = boom length (ft.)

The relation between containment capacity and boom length was arrived at by selecting a nominal harbor spill size and boom effectiveness. Thus, on the assumption that 3,000 feet of boom can contain 2,000,000 gallons of oil, L_n feet of boom have been assigned a nominal capacity equal to the integral part of $L_n/3{,}000$ times 2,000,000 gallons.* The total response capability available to each site is proportional to the sum for the n locations nearest to each site. Complete formulas for harbor and open-water equipment are given in Tables M-5 and M-6. Numerical results for each site of Configuration 5 are given in Tables M-7 and M-8.

*Two million gallons of oil is approximately half the cargo of a tanker of 10,000 gross tons.

TABLE M-6

NON-COAST GUARD OPEN WATER EQUIPMENT

FORMULAS FOR TOTAL CAPABILITY AT EACH SITE

EQUIPMENT TYPE	TOTAL CAPABILITY[1] (SCENARIO PP. M-20)
Skimmers	$S = 5.47 \sum_n S_n$ (gallons)
Pumps	$P = 47.0 \sum_n P_n$ (gallons)
Floating Storage	$Q = 0.80 \sum_n Q_n$ (gallons)
Boom Containment	None

1. Numerical factors are obtained by multiplying the factors on the corresponding lines of Table M-4.

TABLE M-8
NON-COAST GUARD
OPEN-WATER EQUIPMENT CAPABILITY*
(KILOGALLONS)

SITE	BOOMS	PUMPS	SKIMMERS	STORAGE
Philadelphia, PA		69,048	32.5	27,296
New Orleans, LA		754,702	191	6.7
New York, NY		39,635	32.5	92
San Francisco, CA		106,596	877	382
Galveston, TX		7,332	0	0.044
Los Angeles, CA		13,846	260	1,407
Pascagoula, MS		6,048	97.5	154
Sabine, TX		81,892	130	17.6
Port Aransas, TX		0	162.5	0.88
Boston, MA		104,650	959	1,587
Portsmouth, VA		16,356	975	621
Seattle, WA		52,113	325	305
Clearwater, FL		14,785	227	1,529
Chicago, IL		359,380	0	6,201

*Adjusted

APPENDIX N:

A BRIEF REVIEW OF THE BEHAVIOR OF SURFACE OIL SLICKS

When petroleum or petroleum products are spilled on the surface of the sea a complex set of physical changes takes place that are determined by the composition of the oil, the state of the sea, and the prevailing atmospheric conditions. All these factors combine to influence two major processes:

1) Oil movement
2) Oil weathering

The movement of the oil may be either on the surface of the water by spreading and by transport through the action of wind and current, or it may be down into the water column by mixing and subvection due to waves. Weathering is used here to designate the complex of physical, chemical and biological processes that affect the composition of a surface oil slick exposed to a marine environment. Of these the most prominent is the evaporation of the lighter fractions of the oil leaving a residue which interacts with the sea water to form heavy viscous "pancakes" and "tar balls" some of which sink beneath the surface and some of which float. All of these processes are strongly influenced by the amount of oil spilled and its physical and chemical properties.

A variety of empirical and analytical studies have been made of the movement and transformation of oil on the surface of the sea. Many of these have been reviewed and evaluated in Ref. N-1, which is the basic source of material for this discussion.

1.1 OIL MOVEMENT

1.1.1 Wind Induced

The wind at the ocean's surface affects the movement of oil through the generation of surface waves and through the shear stress induced on the slick surface. Neither of these mechanisms is well

1.1.4 Spreading

Oil slick spreading is defined as the movement of oil on the surface of the water relative to the center of mass of the slick. This movement is governed by gravitational, viscous and surface tension forces and by the processes that change the mass of oil in the slick. All of these forces are different for different components of the oil so that some spread much faster than others, with the result that the oil tends to fractionate into viscous clumps (pancakes) within thinner patches of more rapidly spreading components. These pancakes may cover only 10 percent or less of the area encompassed by the oil (Reference N-1, pp. 4-32).

An additional complication is that analytical spreading models assume radial spreading whereas actual slicks are distorted by wind, currents, and the pressure of new oil leaking from the source. The result is that predictions from spreading models and observations of actual slicks usually do not agree very well. For example, Blokker's spreading model (Reference N-2) predicts that in 24 hrs. the area of a crude oil slick will increase by a factor of 4, while some observations (Reference N-3) indicate that the increase is by a factor of 100.

Reference N-4 points out that most pure hydrocarbons do not spread spontaneously by surface forces. "Only aromatic and aliphatic hydrocarbons more volatile than n-nonane have positive spreading coefficients while none of the cyclic hydrocarbons will spread by surface forces." This may provide partial explanation of observations by Jeffrey (Reference N-5) and Hollinger and Manella (1973) which "have shown that with time one or more patches of thick oil (several millimeters thick) were surrounded by a much larger area of thin film, (less than 4 micrometers). Approximately 90 percent of the oil volume was located in these thicker layers that occupied only 10 percent of the visible slicked area of the sea." Reference N-1 also notes this phenomenon, as observed in the 1975 San Francisco Bay spill, where observations show that the area actually covered with oil may be only about 10 percent of the area spanned by the oil around its center of mass.

An "average" crude was determined by Koons (Reference N-6) to consist of

Gasoline (C_5 - C_{10}) - 30%
Kerosene (C_{10}-C_{12}) - 10%
Light Distillate (C_{12} - C_{20}) - 15%
Heavy Distillate (C_{20} - C_{40}) - 25%
Residium (C_{40+}) - 20%

The evaporation of the lighter molecules, up to C_{14}, is approximately uninfluenced by the heavier ones, and they experience an exponential decay in concentration. As given in References N-1 and N-6, the times required for 90% evaporation are:

$<C_{11}$: 8.7 hours
C_{12} : 16.4 hours
C_{13} : 2 to 2.5 days
C_{14} : 5 days

A composite curve is given in Figure 10-5 of the report.

1.2.2 Emulsification

One of the most important and least understood of the processes affecting an oil slick at sea is the formation of water-in-oil emulsion. These emulsions may contain up to 80% water and may be 2 orders of magnitude more viscous than the oil alone. They spread more slowly and are less susceptible to weathering. When the water content is high they become semi-solid and grease-like (chocolate mousse). Emulsification is a weathering process that occurs 1-3 days after a spill. Its formation and subsequent fate are matters of conjecture. Whether chocolate mousse can be skimmed from the sea surface and pumped into storage containers is problematic. In any case, the recovered product may be mostly water.

The data of Reference N-6 are valuable as an approximation of the water-in-oil emulsion characteristics. They show that changes in viscosity and density are closely related to the changes in the amount of water in the oil, and are greater for oil undergoing natural weathering than for oil in sealed containers. For Kuwait crude and Iranian heavy crude, viscosity increased from 16 cs to about 316 in one day and to about 800 in

REFERENCES FOR APPENDIX N

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