ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-12 WATER SAMPLE # MB-12 DATE 30 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	45.7		8.4	
AMMONIA NITROGEN (ppm)	0.07		0.38	
T.K.N. (ppm)	0.11		0.67	
PHOSPHORUS	0.162		0.318	
CONDUCTIVITY (umhos)	17900		26100	
SALINITY (ppt)	13.0		17.5	
pH	7.88		8.02	
MERCURY (ppb)	<0.2		0.2	
ARSENIC (ppb)	24.0		21.0	
COPPER (ppb)	1.0		0.8	
ZINC (ppb)	23.4		6.0	
CADMIUM (ppb)	0.2		0.2	
LEAD (ppb)	1.2		<0.5	
NICKEL (ppb)	1.1		1.4	
CHROMIUM (ppb)	0.5		<0.5	
IRON (ppb)	<10.0		24.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-12 WATER SAMPLE # Mobile Offshore DATE N.R.

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	21.9		17.4	
AMMONIA NITROGEN (ppm)	0.07		0.21	
T.K.N. (ppm)	0.17		2.41	
PHOSPHORUS (ppm)	0.072		0.370	
CONDUCTIVITY (umhos)	35500		38600	
SALINITY (ppt)	25.3		25.2	
pH	8.03		7.80	
MERCURY (ppb)	0.2		0.2	
ARSENIC (ppb)	31.0		14.0	
COPPER (ppb)	3.6		0.8	
ZINC (ppb)	18.4		14.0	
CADMIUM (ppb)	1.0		0.2	
LEAD (ppb)	5.9		1.4	
NICKEL (ppb)	4.3		1.4	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	<10.0		<10.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-16 WATER SAMPLE # MB-16 DATE 30 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	51.7		14.6	
AMMONIA NITROGEN (ppm)	1.05		4.66	
T.K.N. (ppm)	1.21		9.80	
PHOSPHORUS (ppm)	0.560		0.277	
CONDUCTIVITY (umhos)	21900		25200	
SALINITY (ppt)	14.7		17.5	
pH	7.79		7.99	
MERCURY (ppb)	<0.2		<0.2	
ARSENIC (ppb)			<10.0	
COPPER (ppb)	3.1		1.0	
ZINC (ppb)	20.9		13.6	
CADMIUM (ppb)	0.7		<0.2	
LEAD (ppb)	4.5		1.2	
NICKEL (ppb)	3.9		6.6	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	<10.0		37.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-16 WATER SAMPLE # Mobile Offshore DATE N.R.

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	21.9		40.8	
AMMONIA NITROGEN (ppm)	0.07		3.32	
T.K.N. (ppm)	0.17		8.06	
PHOSPHORUS (ppm)	0.072		0.643	
CONDUCTIVITY (umhos)	35500		34500	
SALINITY (ppt)	25.3		25.0	
pH	8.03		7.79	
MERCURY (ppb)	0.2		< 0.2	
ARSENIC (ppb)	31.0		21.0	
COPPER (ppb)	3.6		3.6	
ZINC (ppb)	18.4		13.8	
CADMIUM (ppb)	1.0		0.7	
LEAD (ppb)	3.9		6.3	
NICKEL (ppb)	4.3		5.0	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	<10.0		28.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-18 WATER SAMPLE # MB-18 DATE 29 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	5.9		51.7	
AMMONIA NITROGEN (ppm)	1.04		2.42	
T.K.N. (ppm)	2.03		5.66	
PHOSPHORUS (ppm)	0.117		0.115	
CONDUCTIVITY (umhos)	16100		19700	
SALINITY (ppt)	10.5		12.1	
pH	7.73		8.48	
MERCURY (ppb)	0.2		~~0.9~~ <0.2	
ARSENIC (ppb)	<10.0		<10.0	
COPPER (ppb)	1.0		0.9	
ZINC (ppb)	28.9		15.4	
CADMIUM (ppb)	0.3		0.3	
LEAD (ppb)	3.1		1.6	
NICKEL (ppb)	2.8		1.6	
CHROMIUM (ppb)	0.8		<0.5	
IRON (ppb)	26.0		<10.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-19 WATER SAMPLE # MB-19 DATE 30 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	5.9		15.7	
AMMONIA NITROGEN (ppm)	0.14		0.88	
T.K.N. (ppm)	2.44		2.18	
PHOSPHORUS (ppm)	0.027		0.312	
CONDUCTIVITY (umhos)	8300		14000	
SALINITY (ppt)	5.2		9.0	
pH	8.00		8.01	
MERCURY (ppb)	<0.2		<0.2	
ARSENIC (ppb)	17.0		14.0	
COPPER (ppb)	1.3		1.3	
ZINC (ppb)	29.9		8.2	
CADMIUM (ppb)	<0.2		0.4	
LEAD (ppb)	2.0		0.9	
NICKEL (ppb)	1.8		1.8	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	33.0		63.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-20 WATER SAMPLE # MB-20 DATE 30 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	6.5		19.1	
AMMONIA NITROGEN (ppm)	0.21		1.50	
T.K.N. (ppm)	1.43		4.14	
PHOSPHORUS (ppm)	0.037		0.642	
CONDUCTIVITY (umhos)	8600		18400	
SALINITY (ppt)	5.5		14.0	
pH	8.00		7.87	
MERCURY (ppb)	0.5		<0.2	
ARSENIC (ppb)	17.0		<10.0	
COPPER (ppb)	1.2		1.2	
ZINC (ppb)	29.5		26.1	
CADMIUM (ppb)	1.0		<0.2	
LEAD (ppb)	5.0		2.3	
NICKEL (ppb)	1.8		2.1	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	30.0		30.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-20 WATER SAMPLE # Mobile Offshore DATE N.R.

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	21.9		11.0	
AMMONIA NITROGEN (ppm)	0.07		0.38	
T.K.N. (ppm)	0.17		5.71	
PHOSPHORUS	0.072		0.325	
CONDUCTIVITY (umhos)	35500		31500	
SALINITY (ppt)	25.3		20.6	
pH	8.03		7.81	
MERCURY (ppb)	0.2		<0.2	
ARSENIC (ppb)	31.0		<10.0	
COPPER (ppb)	3.6		0.8	
ZINC (ppb)	18.4		21.3	
CADMIUM (ppb)	1.0		0.3	
LEAD (ppb)	3.9		2.7	
NICKEL (ppb)	4.3		3.1	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	<10.0		48.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-22 WATER SAMPLE # MB-22 DATE 31 July 74

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	15.2		33.5	
AMMONIA NITROGEN (ppm)	1.30		1.46	
T.K.N. (ppm)	5.91		8.49	
PHOSPHORUS (ppm)	0.223		0.560	
CONDUCTIVITY (umhos)	11900		13000	
SALINITY (ppt)	7.5		9.0	
pH	7.[illegible]1		8.08	
MERCURY (ppb)	0.2		<0.02	
ARSENIC (ppb)	<10.0		<10.0	
COPPER (ppb)	5.5		8.7	
ZINC (ppb)	7.8		11.3	
CADMIUM (ppb)	9.2		3.5	
LEAD (ppb)	4.8		2.9	
NICKEL (ppb)	2.4		3.7	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	18.0		<10.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLES FOR CHEMICAL AND HEAVY METALS CONSTITUENTS, MOBILE HARBOR, ALABAMA

SEDIMENT SAMPLE # MB-22 WATER SAMPLE # Mobile Offshore DATE N.R.

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	21.9		16.3	
AMMONIA NITROGEN (ppm)	0.07		4.02	
T.K.N. (ppm)	0.17		9.97	
PHOSPHORUS	0.072		0.642	
CONDUCTIVITY (umhos)	35500		27000	
SALINITY (ppt)	25.3		20.0	
pH	8.03		7.82	
MERCURY (ppb)	0.2		<0.2	
ARSENIC (ppb)	31.0		14.0	
COPPER (ppb)	3.6		3.7	
ZINC (ppb)	18.4		12.3	
CADMIUM (ppb)	1.0		1.4	
LEAD (ppb)	3.9		3.9	
NICKEL (ppb)	4.3		6.1	
CHROMIUM (ppb)	<0.5		<0.5	
IRON (ppb)	<10.0		10.0	

SEDIMENT CORE SAMPLES, 1974

Mobile Harbor

ELUTRIATE TEST

SEDIMENT SAMPLE # 13-8

DATE

WATER SAMPLE # ~~P. Island~~ Bay

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/l	0.98				11.45	
TOTAL KJELDAHL NITROGEN mg/l	1.18				11.37	
TOTAL PHOSPHATE mg/l	0.010				0.095	
SALINITY ppt	1				4	
CONDUCTIVITY umhos	1,280				6,000	
pH	6.60				7.55	
TOTAL ORGANIC CARBON mg/l	67.0				23.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

SEDIMENT SAMPLE # MB-8

DATE

WATER SAMPLE # ~~B Inland~~ Bay

PARAMETER	ψ_1				ψ_3	
Hg (ppb)						
As (ppb)	1.08				1.25	
Cu (ppb)	1.75				1.75	
Zn (ppb)	43.5				50.0	
Cd (ppb)	0.00				3.90	
Pb (ppb)	7.0				0.0	
Ni (ppb)	20.0				50.5	
Cr (ppb)	0.10				0.00	
Fe++ (ppb)	29.2				25.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # NB-16 DATE ____________

WATER SAMPLE # ~~W Island~~ Bay

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/1	0.98				1.68	
TOTAL KJELDAHL NITROGEN mg/1	1.18				6.55	
TOTAL PHOSPHATE mg/1	0.01				0.010	
SALINITY ppt	1				1	
CONDUCTIVITY umhos	1,280				1650	
pH	6.60				6.65	
TOTAL ORGANIC CARBON mg/1	67.0				38.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

DATA SHEET

SEDIMENT SAMPLE # MB-36 DATE

WATER SAMPLE # ~~R Island~~ Bay

PARAMETER	ψ_1				ψ_3	
Hg(ppb)						
As(ppb)	1.08				1.20	
Cu(ppb)	1.75				1.25	
Zn(ppb)	43.5				77.5	
Cd(ppb)	0.00				0.00	
Pb(ppb)	7.0				0.0	
Ni(ppb)	20.0				90.0	
Cr(ppb)	0.10				0.00	
Fe++(ppb)	29.2				66.7	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # HB-20

DATE

WATER SAMPLE # ~~B Inland~~ Bay

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/l	0.98				9.91	
TOTAL KJELDAHL NITROGEN mg/l	1.18				5.60	
TOTAL PHOSPHATE mg/l	0.010				0.040	
SALINITY ppt	1				4	
CONDUCTIVITY umhos	1,280				5,500	
pH	6.60				7.55	
TOTAL ORGANIC CARBON mg/l	67.0				61.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

DATA SHEET

SEDIMENT SAMPLE # MB-20

DATE

WATER SAMPLE # ~~Island~~ Bay

PARAMETER	ψ_1				ψ_3	
Hg (ppb)						
As (ppb)	1.08				1.20	
Cu(ppb)	1.75				1.60	
Zn(ppb)	43.5				45.7	
Cd (ppb)	0.00				21.2	
Pb (ppb)	7.0				0.0	
Ni (ppb)	20.0				41.7	
Cr (ppb)	0.10				0.10	
Fe++(ppb)	[illegible]2				16.7	

ϕ_1 Dilution Water

ϕ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # MB-24

DATE __________

WATER SAMPLE # ~~B Island~~ Bay

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/l	0.98				6.23	
TOTAL KJELDAHL NITROGEN mg/l	1.18				6.10	
TOTAL PHOSPHATE mg/l	0.010				0.018	
SALINITY ppt CONDUCTIVITY umhos	1 1,280				3 4,220	
pH	6.60				7.50	
TOTAL ORGANIC CARBON mg/l	67.0				33.0	

ψ_1 **Dilution Water**

ψ_3 **Elutriate Water Centrifuged and filtered through a 0.45 μ filter**

DATA SHEET

SEDIMENT SAMPLE # MB-24 DATE

WATER SAMPLE # ~~D Island~~ Bay

PARAMETER	ψ_1				ψ_3	
Hg(ppb)						
As(ppb)	1.080				0.121	
Cu(ppb)	1.75				1.25	
Zn(ppb)	43.5				57.5	
Cd(ppb)	0.00				0.00	
Pb(ppb)	7.0				0.00	
Ni(ppb)	20.0				54.5	
Cr(ppb)	0.10				0.00	
Fe++(ppb)	29.2				20.8	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # MB-8

DATE

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/1	1.96				13.09	
TOTAL KJELDAHL NITROGEN mg/1	4.03				14.00	
TOTAL PHOSPHATE mg/1	0.018				0.061	
SALINITY ppt	25				22	
CONDUCTIVITY umhos	32,800				7.25	
pH	6.90				7.25	
TOTAL ORGANIC CARBON mg/1	48.0				62.0	

ψ_1 **Dilution Water**

ψ_3 **Elutriate Water Centrifuged and filtered through a 0.45 µ filter**

DATA SHEET

SEDIMENT SAMPLE # MB 8 DATE

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
Hg(ppb)						
As(ppb)	1.51				1.33	
Cu(ppb)	0.50				0.90	
Zn(ppb)	74.5				52.0	
Cd(ppb)	2.20				0.00	
Pb(ppb)	0.00				0.00	
Ni(ppb)	80.2				60.5	
Cr(ppb)	0.00				0.70	
Fe++(ppb)	4.2				20.8	

ϕ_1 Dilution Water

ϕ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # MB-16 DATE ____________

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/1	1.95				21.91	
TOTAL KJELDAHL NITROGEN mg/1	4.03				24.47	
TOTAL PHOSPHATE mg/1	0.018				0.108	
SALINITY ppt	25				22	
CONDUCTIVITY umhos	32,800				30,100	
pH	6.90				7.75	
TOTAL ORGANIC CARBON mg/1	48.0				30.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

DATA SHEET

SEDIMENT SAMPLE # MB-15 DATE

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ϕ_1				ϕ_3	
Hg(ppb)						
As(ppb)	1.510				0.484	
Cu(ppb)	0.50				4.10	
Zn(ppb)	74.5				95.0	
Cd(ppb)	2.20				21.90	
Pb(ppb)	0.00				86.4	
Ni(ppb)	80.2				51.0	
Cr(ppb)	0.00				0.00	
Fe++(ppb)	4.2				33.3	

ϕ_1 Dilution Water

ϕ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # MB-20

DATE ______________

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/l	1.96				14.56	
TOTAL KJELDAHL NITROGEN mg/l	4.03				16.30	
TOTAL PHOSPHATE mg/l	0.018				0.095	
SALINITY ppt	25				23	
CONDUCTIVITY umhos	32,800				31,000	
pH	6.90				7.30	
TOTAL ORGANIC CARBON mg/l	48.0				61.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

DATA SHEET

SEDIMENT SAMPLE # MB-20 DATE __________

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ϕ_1				ϕ_3	
Hg(ppb)						
As(ppb)	1.51				1.88	
Cu(ppb)	0.50				0.50	
Zn(ppb)	74.5				110.0	
Cd(ppb)	2.20				5.00	
Pb(ppb)	0.00				4.50	
Ni(ppb)	80.2				59.2	
Cr(ppb)	0.00				0.90	
Fe++(ppb)	4.2				29.2	

ϕ_1 Dilution Water

ϕ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE TEST

SEDIMENT SAMPLE # MR-24 DATE ____________

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
AMMONIA NITROGEN mg/l	1.96				6.62	
TOTAL KJELDAHL NITROGEN mg/l	4.03				7.90	
TOTAL PHOSPHATE mg/l	0.018				0.045	
SALINITY ppt	25				21	
CONDUCTIVITY umhos	32,800				30,200	
pH	6.90				7.15	
TOTAL ORGANIC CARBON mg/l	48.0				44.0	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

DATA SHEET

SEDIMENT SAMPLE # M3-24 DATE

WATER SAMPLE # Hopper Dredge (Gulf)

PARAMETER	ψ_1				ψ_3	
Hg(ppb)						
As(ppb)	1.510				0.571	
Cu(ppb)	0.50				0.75	
Zn(ppb)	74.5				67.5	
Cd(ppb)	2.20				0.00	
Pb(ppb)	0.00				10.00	
Ni(ppb)	80.2				54.5	
Cr(ppb)	0.00				0.10	
Fe++(ppb)	4.2				20.8	

ψ_1 Dilution Water

ψ_3 Elutriate Water Centrifuged and filtered through a 0.45 μ filter

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLE FOR CHEMICAL AND HEAVY METALS CONSITUTENTS, THEODORE SHIP CHANNEL

SEDIMENT SAMPLE # T-1 WATER SAMPLE # * Bay

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
**T.O.C. (ppm)	68.0		65.5	
AMMONIA NITROGEN (ppm)	1.09		2.91	
T.K.N. (ppm)	0.84		4.59	
PHOSPHORUS (ppm)	0.128		0.126	
CONDUCTIVITY (µmhos)	1,650		4,080	
SALINITY (ppt)	1		3	
pH	6.65		7.35	
ARSENIC (ppb)	1.08		3.3	
COPPER (ppb)	2.25		2.3	
ZINC (ppb)	66.7		0.0	
CADMIUM (ppb)	0.0		0.0	
LEAD (ppb)	91.5		2.6	
NICKEL (ppb)	64.5		0.0	
CHROMIUM (ppb)	0.0		5.9	
IRON (ppb)	37.5		0.0	

ELUTRIATE ANALYSES OF SEDIMENT AND WATER SAMPLE FOR CHEMICAL AND HEAVY METALS CONSITUTENTS, THEODORE SHIP CHANNEL

SEDIMENT SAMPLE # T-3 WATER SAMPLE # E Bay

PARAMETER	DILUTION WATER		STANDARD ELUTRIATE	
T.O.C. (ppm)	68.0		64.0	
AMMONIA NITROGEN (ppm)	1.09		2.87	
T.K.N. (ppm)	0.84		1.29	
PHOSPHORUS (ppm)	0.128		0.155	
CONDUCTIVITY (umhos)	1,650		2,100	
SALINITY (ppt)	1		2	
pH	6.65		7.55	
ARSENIC (ppb)	1.08		0.0	
COPPER (ppb)	2.25		2.6	
ZINC (ppb)	66.7		30.0	
CADMIUM (ppb)	0.0		0.0	
LEAD (ppb)	91.5		0.0	
NICKEL (ppb)	64.5		8.5	
CHROMIUM (ppb)	0.0		0.0	
IRON (ppb)	37.5		0.0	

Appendix 5

ATTACHMENT D-2

Toxicity Test Report

In accordance with the requirements of Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, Public Law 92-532, the proposed disposal of dredged material from the Mobile (AL) ship channel into Gulf of Mexico waters was evaluated to determine the potential environmental impact. Specifically, laboratory toxicity tests (bioassays) were conducted with the liquid phase, suspended particulate phase, and solid phase of samples of the material to be dredged with appropriate, sensitive marine organisms.

All methods for (a) sample collection and preparation, (b) toxicity and bioaccumulation testing, and (c) data analysis followed the methods outlined by the Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material (1977), hereafter referred to as the EPA/COE Manual.

MATERIALS AND METHODS

Test material

The material to be dredged (hereafter referred to as dredged material) was collected from Mobile Ship Channel, AL, by Bionomics Marine Research Laboratory (BMRL) personnel on 10 February 1978. The collection site was in the middle of the ship channel, at buoy #56, west of Point Clear, AL. A Peterson dredge was used to collect the sample. The dredged material, a mixture of silt and clay, was placed in 8-liter (ℓ) polyethylene containers with lids. (See Appendix A for collecting location.)

Water from the proposed disposal site (hereafter referred to as disposal site water) was also collected on 10 February 1978 by BMRL personnel. The collection site was 13 nautical miles southwest (250°) of buoy #1 which marks the entrance to the Mobile Bay ship channel. A 12-ℓ polyvinylchloride (PVC) sampling bottle (General Oceanics Model 1010-12) was used to collect the sample. Disposal site water was poured into 19-ℓ polyethylene bottles. Each bottle received approximately equal amounts of water taken from near bottom, mid-depth in the water column, and near the water surface. The depth at the disposal site was approximately 25 meters (m). Salinity was 34 parts per thousand (°/oo) and temperature was 12 degrees Celsius (°C) for all water collection depths.

Sediment from the proposed disposal site (hereafter referred to as reference sediment) was collected by BMRL personnel on 16 February 1978 (see Appendix A). The site was the same as that described above for disposal site water collection. A Peterson dredge was used to collect the sample. The reference sediment, a fine hard-packed sand, was placed in 8-ℓ polyethylene containers with lids.

All samples (dredged material, disposal site water, and reference sediment) were transported to the lab in coolers containing ice and upon arrival at BMRL were stored in a water bath maintained at 4±1 °C until used for test sample preparation.

Sample preparation

Liquid phase — Samples were prepared on 13 February 1978, three days after the dredged material and disposal site water samples were collected. Procedures outlined in the EPA/COE Manual, Appendix B.9-17 were followed, except that the dredged material/disposal site water slurry was not centrifuged after settling but was filtered through a 1.2-micrometer (μm) pore size polypropylene core filter before final filtration through 0.45-μm pore size filters.

Suspended particulate phase -- Samples were also prepared on 13 February 1978, according to procedures outlined in the EPA/COE Manual, Appendix B.19.

Solid phase -- Reference sediment was prepared for testing on 17 and 20 February 1978 and the dredged material was prepared on 23 February 1978. Reference sediment and the dredged material were wet-sieved through a 1.0 millimeter (mm) mesh size sieve following the procedures outlined in the EPA/COE Manual, Appendix F.15.

Test organisms

Animals for the liquid phase and suspended particulate phase toxicity tests were either collected from Big Lagoon, an estuary adjacent to BMRL, or cultured in the laboratory. Copepods, Acartia tonsa, were collected by plankton net and acclimated for 48 hours in natural seawater at 20±1 °/oo and 15±1°C. Mortality was <4% during acclimation. Mysid shrimp, Mysidopsis bahia, and sheepshead minnows, Cyprinodon variegatus, were cultured in natural seawater in BMRL. Mysid shrimp were 8-12 days old, 4-6 mm total length. The sheepshead minnows were 21-28 days old, 10-12 mm standard length.

Animals for the solid phase test were either purchased and acclimated or cultured in the laboratory. Quahogs, Mercenaria mercenaria, were purchased from a commercial supplier on the Atlantic coast and acclimated in the laboratory in flowing, natural seawater for 42 days. The clams were 32-60 mm total length. Polychaetes, Neanthes arenaceodentata, were purchased from a university in Texas and acclimated in the laboratory in static, aerated seawater for 49 days. The worms were 10-22 mm total length when contracted. Mysid shrimp, 7-12 mm total length, were cultured in the laboratory.

Test conditions

Liquid and suspended particulate phases -- Copepods were tested in 50 x 90-mm glass crystallizing dishes, each of which contained 200 milliliters (mℓ) of test solution and 10 animals. A culture water control, a site water control, and three concentrations (10%, 50%, and 100%) of the liquid and suspended particulate phases were maintained in a temperature-controlled water bath at 12±1°C. All test containers were covered and all treatments were triplicated. Animals were not fed during the test, nor were test solutions aerated.

Mysid shrimp and sheepshead minnows were tested under the conditions described above, except that the test containers were 1-ℓ glass jars, each of which contained 900 mℓ of test solution for mysids, and 4-ℓ glass jars, each of which contained 3 ℓ of test solution for sheepshead minnows. Diluent water for the liquid phase and suspended particulate phase tests was disposal site water.

Solid phase -- Quahogs, polychaetes, and mysid shrimp were tested in 38-ℓ glass aquaria 26-centimeters (cm) wide x 51-cm deep x 31-cm deep. The reference sediment, dredged material, seawater, and animals were added to control or exposure aquaria as outlined in the EPA/COE Manual, Appendix F.14-21, except as noted. Seawater used was natural, filtered (1.2-μm), seawater pumped from Big Lagoon, an estuary adjacent to BMRL. In order to reflect the physical conditions at the disposal site, artificial sea salts (Rila Marine Mix®, Rila Products, Teaneck, NJ) were added to the seawater prior to filtering to raise the salinity to 30±1 °/oo. Ambient temperature was maintained by placing the test aquaria in a constant flowing seawater bath. Gentle aeration was supplied to all aquaria during the test. The only exception to the test procedures outlined in the EPA/COE Manual were that (a) msyid shrimp were not removed from the aquaria prior to the addition of 2.5 ℓ of reference sediment or dredged material, and (b) 75% of the seawater in the aquaria was not replaced one hour after the start of the test. These changes were discussed with Dr. Henry Tatem, COE, WES, Vicksburg, MS, and were considered reasonable by him. At the termination of the test, polychaetes were removed by sieving the sediment through a 1-mm mesh sieve instead of the 0.5-mm mesh recommended because the reference sediment would not pass through the latter. Mysid shrimp were removed by using a small dip net to count and transfer them to clean seawater. Quahogs were removed by hand.

Bioaccumulation potential -- At the end of the solid phase bioassay test, live clams were transferred to clean tanks which received flowing, natural BMRL seawater. The animals were maintained in the tanks for two days to allow them to void their digestive tracts of sediment and were then shucked, frozen, and shipped to Bionomics Analytical Chemistry Laboratory, Wareham, MA, for chemical analyses.

Data analyses

Data from the liquid phase and suspended particulate phase tests were analyzed according to methods outlined in the EPA/COE Manual, Appendix D.17-28; data from the solid phase test were also analyzed according to Appendix D.17-28. Differences were considered statistically significant at the 95% confidence level ($P<0.05$). The statistical treatment of the data differs from the methods suggested in the EPA/COE Manual; the solid phase test results were compared with a t test. The reason for the change was that only one dredged material sample was used in the study instead of the suggested three samples.

Information for the dilution curve was calculated from equations in Appendix H. Initial mixing zone from H.10-14, liquid phase concentration from H.21-23, and suspended particulate phase concentration from H.24-28. Graphic comparison of mortality data versus dilution followed the discussion in Appendix D.39-41.

RESULTS

Liquid phase

Copepods -- After 96 hours of exposure to the liquid phase, significant mortality occurred in the 50% and 100% test concentrations. There was 23% mortality in 100% liquid phase and 13% mortality in 50% liquid phase. No mortality occurred in the site water control and only 3% mortality occurred in the culture water control and 10% liquid phase (Table 1).

The total number of survivors of *Acartia tonsa* and the results of t tests where statistically significant mortality occurred are given in Table 2. The calculated t values for the 50% and 100% liquid phase were 4.03 and 3.48, respectively. These values were higher than the tabular t value of 2.13, indicating significant toxicity ($P \leq 0.05$) in both treatments. However, mortality was less than 50% at each time and LC50 values could not be calculated.

Dissolved oxygen remained ≥80% of saturation in all test concentrations and controls throughout the test. The pH was from 7.7 in the culture water control to 8.2 in the site water control after 96 hours (Table 3).

Mysid shrimp -- There was no mortality in any of the test concentrations or controls after 96 hours of exposure (Table 4).

Dissolved oxygen remained $\geq 57\%$ of saturation in all treatments throughout the test; pH was from 7.9-8.1 after 96 hours (Table 5).

Sheepshead minnows -- No fish died in any test concentration or control (Table 6).

Dissolved oxygen remained $\geq 72\%$ of saturation in all treatments throughout the test; pH was from 8.0-8.2 after 96 hours (Table 7).

Suspended particulate phase

Copepods -- After 96 hours of exposure to the suspended particulate phase, significant mortality occurred in the 50% and 100% test concentrations. There was 30% mortality in 100% suspended particulate phase and 20% mortality in 50% suspended particulate phase. There was 10% mortality in 10% suspended particulate phase. No mortality occurred in the site water control and 3% mortality occurred in the culture water control (Table 8).

The total number of survivors of *Acartia tonsa* and the results of t tests where statistically significant mortality occurred are given in Table 9. The calculated t values for the 50% and 100% suspended particulate phase were 3.51 and 3.00, respectively. These values were higher than the tabular t value of 2.13 indicating significant ($P \leq 0.05$) toxicity in both treatments. However, mortality was less than 50% at each time and LC50 values could not be calculated.

Dissolved oxygen remained $\geq 80\%$ of saturation in all test concentrations and controls throughout the test. The pH was from 7.7 in the culture water control to 8.2 in the site water control after 96 hours (Table 10).

Mysid shrimp -- No significant mortality occurred after 96 hours of exposure to the suspended particulate phase. Mortality was 0% in concentrations $\leq$50% and both controls to 7% in 100% suspended particulate phase (Table 11).

Dissolved oxygen remained $\geq$53% of saturation in all test concentrations and controls throughout the test. The pH was from 7.9-8.1 after 96 hours (Table 12).

Sheepshead minnows -- No fish died in any test concentration or control (Table 13).

Dissolved oxygen remained $\geq$71% of saturation throughout the test. The pH was from 8.0-8.2 after 96 hours (Table 14).

Solid phase

After 10 days of exposure to the solid phase there was no significant difference ($P \leq 0.05$) between mortality in the reference sediment and in the dredged material. Mortality in the reference sediment was 0% for Mercenaria mercenaria, 23% for Neanthes arenaceodentata, and 24% for Mysidopsis bahia; mortality in the dredged material was 0%, 14%, and 25% for Mercenaria, Neanthes, and Mysidopsis, respectively (Table 15). Total number of survivors and the results of t test statistical analysis are given in Table 16. Analysis of variance was not used to compare mortality in the reference sediment and dredged material because only two treatments was tested. The calculated t value for the dredged material mortality was 0.90, less than the tabular t value of 1.81. Therefore, there was no statistical difference between the mortality in the two treatments.

Ten days comprises a major portion of the life cycle of mysid shrimp as evidenced by the presence of newly hatched nauplii in reference sediment replicate 1 and in dredged material replicate 2 at the termination of the test. That fact, and the harsh treatment of pouring the reference sediment and dredged material directly on the fragile mysids, undoubtedly contributed to the mortality that occurred among the shrimp.

Salinity was 30±1 ‰ and temperature was 16±1°C; the range was 15-18°C. Dissolved oxygen concentrations remained ≥5.6 milligrams (mg)/ℓ (72% of saturation) during the 10-day test in both treatments. The pH ranged from 7.4-8.1 in the reference sediment and from 7.5-8.2 in the dredged material (Table 17).

Bioaccumulation potential

There was no statistically significant bioaccumulation of any of the chemical constituents by Mercenaria mercenaria (Table 18). Cadmium and mercury concentrations were slightly higher in the dredged material exposed animals compared to the reference sediment, but the differences were not significant based on the results of a t test. The pesticides aldrin, BHC (lindane), heptachlor, p,p' DDT, p,p' DDD, o,p' DDE, chlordane, dieldrin, endrin, mirex, methoxychlor, and the PCB, Aroclor® 1254 were below the detection limit of 70 parts per billion (ppb) (nanograms per gram) in all tissue samples. The pesticide toxaphene was not detected in any of the tissue samples and was assumed to be below the detection limit of 100 ppb. Petroleum hydrocarbons were below 1.0 part per million (ppm) (micrograms per gram) for all tissue samples.

Methods for chemical analyses of all constituents and quality control procedures are presented in Appendix B.

DISCUSSION

Statistically significant copepod mortality occurred in both the liquid phase and suspended particulate phase. In each case mortality was less than 50%, even in the 100% concentration of the test solutions, and LC50 values could not be calculated. For the purpose of determining if the limiting permissible concentration (LPC) would be exceeded, it was assumed that the LC50 for both phases is greater than 100% of the test concentration.

The initial mixing zone was determined by using equation (H1) of Appendix H in the EPA/COE Manual and the following information:

Disposal site depth = 20 meters (m)
Width of the disposal vessel = 14.6 m
Length of the disposal vessel = 65 m
Speed of the disposal vessel = 2.7 m/second
Disposal discharge time = 1,200 seconds

The initial mixing zone volume was 14,312,870 cubic meters (m^3).

Equation H4 was used to calculate the volume of liquid phase in the initial discharge. The total volume of the discharge vessel was 2,295 m^3 and the calculated volume of liquid phase was 1,584 m^3. Equation H6 was then used to determine the percent of the original liquid phase concentration after initial mixing (4 hr), and was found to be 0.01% of the original concentration.

Figure 1 is a time-concentration mortality curve and estimates dilution curve for the liquid phase of dredged material from Mobile Ship Channel. The mortality curve is plotted at 100% liquid phase, although the LC50 for all times during the exposure period could not be calculated. It can be seen that the two curves constantly diverge and even using the conservative approach of 50% mortality at 100% liquid phase the LPC requirement would not be exceeded at 4 hr or at any time after that period. The concentration of liquid phase after initial mixing is 0.01% of the original (equation H6) and when the application factor of 0.01 is applied to the toxic concentration (here greater than 100% liquid phase), it can be seen that the LPC would not be exceeded.

Figure 2 is a time-concentration mortality curve and estimated dilution curve for the suspended particulate phase of dredged material from Mobile Ship Channel. Using equation H7 and the assumption that the dredged material is 45% clay and 45% silt, the volume of suspended particulates in the initial discharge was 640 m^3. The concentration remaining after initial mixing, calculated from equation H8, is 0.005% of the original. Since the two curves in Figure 2 constantly diverge, the LPC for the suspended particulate phase is not exceeded at 4 hr or any time after initial mixing. The 50% mortality curve is plotted at 100% suspended particulate phase because the LC50 values could not be calculated for any of the time intervals during the test. Applying the application factor of 0.01 to the toxic concentration of 100% it can be seen that the LPC would not be exceeded.

The mysid shrimp and sheepshead minnows were unaffected by any concentration of liquid or suspended particulate phase of the dredged material.

Mortality occurred among the polychaetes and mysids in the solid phase toxicity test. Polychaete mortality was slightly higher in the reference sediment (23%) compared to mortality in the dredged material (14%). Mysid mortality was approximately equal in the two sediments (24% and 25%). However, when total survival of the three species was compared in the two treatments, no statistically significant difference was found.

The results of chemical analyses on whole tissue samples of the clams showed no bioaccumulation potential under the test conditions employed for cadmium, mercury, petroleum hydrocarbons, aldrin, BHC (lindane), heptachlor, p,p' DDT, p,p' DDD, o,p' DDE, chlordane, dieldrin, endrin, toxaphene, mirex, methoxychlor, and Aroclor® 1254.

The copepod mortality was statistically significant, but the LPC was not exceeded for the liquid phase or the suspended particulate phase. Mysids and sheepshead minnows were unaffected by the liquid and suspended particulate phases. Mortality occurred in the solid phase test, but was not statistically significant and clams showed no potential to bioaccumulate selected chemical constituents during the 10-day test. It is therefore recommended that sediments from Mobile Ship Channel be dredged and that ocean disposal is an acceptable means of dumping. It is further recommended, however, that in future dredging bioassays more than one dredged material sample station be selected and tested. A minimum of three stations are recommended for toxicity testing.

SUMMARY

1. Exposure to 50% and 100% of the liquid phase of the dredged material from Mobile Ship Channel, AL, caused significant mortality of copepods. The LPC was not exceeded. Mysid shrimp and sheepshead minnows were not significantly affected.
2. Exposure to 50% and 100% of the suspended particulate phase of the dredged material from Mobile Ship Channel, AL, also caused significant mortality of copepods. The LPC was not exceeded. Mysid shrimp and sheepshead minnows were not significantly affected.

3. Exposure to the solid phase of the dredged material from Mobile Ship Channel, AL, caused no significantly greater mortality of quahogs, polychaetes, or mysid shrimp than occurred in the reference sediment.
4. Quahogs exposed to the solid phase of dredged material from Mobile Ship Channel, AL, did not demonstrate any potential for bioaccumulation of selected chemical constituents.
5. Based on the results of the tests, dredging and ocean disposal of sediment from Mobile Ship Channel, AL, should not produce an adverse environmental impact.

REFERENCES

Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material, "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters; Implementation Manual for Section 103 of Public Law 92-532 (Marine Protection, Research, and Sanctuaries Act of 1972)," July 1977 (Second Printing April 1978), Environmental Effects Laboratory, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

TABLE 1. Survival of copepods, *Acartia tonsa*, during a 96-hour exposure to the liquid phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number[a] of Survivors: 0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	9	9	9	9
	3	10	10	10	10	10	10	10
		30	30	30	29	29	29	29
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	10	10	10	9
	2	10	10	10	10	10	9	7
	3	10	10	10	10	9	8	7
		30	30	30	30	29	27	23[b]
50% test medium	1	10	10	10	10	9	9	9
	2	10	10	10	10	10	10	8
	3	10	10	10	10	10	10	9
		30	30	30	30	29	29	26[b]
10% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	9
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30

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[a] Initial number in each replicate was 10.

[b] Significantly different ($P<0.05$) from the control.

TABLE 2. Total number of survivors of copepods, *Acartia tonsa*, after 96 hours of exposure to the liquid phase of dredged material from Mobile Ship Channel, AL.

Replicate	Number of survivors		
	Disposal site water	50% liquid phase	100% liquid phase
1	10	9	9
2	10	8	7
3	10	9	7
Total	30	26	23
Mean	10	8.67	7.67
Variance	0	0.34	1.34
Calculated t value	---	4.03	3.48
Tabular $t_{.05(4)}$	2.13		

TABLE 3. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with copepods, Acartia tonsa, and the liquid phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% liquid phase)	Salinity ($^{o}/oo$)	pH		Dissolved oxygen (mg/ℓ and % saturation)
		0 hr	96 hr	96 hr
Site water control	28	8.3	8.2	7.3 (82)
Culture water control	22	8.1	7.7	7.3 (80)
10	28	8.3	8.1	7.3 (83)
50	26	8.3	8.1	7.2 (81)
100	25	8.3	8.1	7.2 (80)

TABLE 4. Survival of mysid shrimp, *Mysidopsis bahia*, during a 96-hour exposure to the liquid phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number of Survivors						
		0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
50% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
10% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30

TABLE 5. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with mysid shrimp, *Mysidopsis bahia*, and the liquid phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% liquid phase)	Salinity (°/oo)	pH		Dissolved oxygen (mg/ℓ and % saturation) 96 hr
		0 hr	96 hr	
Site water control	28	8.3	8.1	5.5 (62)
Culture water control	22	8.1	7.9	5.3 (58)
10	28	8.3	8.1	5.3 (60)
50	26	8.2	8.0	5.3 (60)
100	25	8.1	8.0	5.2 (58)

TABLE 6. Survival of sheepshead minnows, Cyprinodon variegatus, during a 96-hour exposure to the liquid phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number of Survivors						
		0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
50% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
10% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30

TABLE 7. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with sheepshead minnows, *Cyprinodon variegatus*, and the liquid phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% liquid phase)	Salinity (°/oo)	pH		Dissolved oxygen (mg/ℓ and % saturation)	
		0 hr	96 hr	0 hr	96 hr
Site water control	28	8.3	8.0	8.3 (94)	6.3 (72)
Culture water control	25	8.3	8.2	9.9 (110)	7.2 (80)
10	28	8.3	8.1	8.2 (93)	7.1 (81)
50	26	8.3	8.0	7.7 (87)	6.9 (78)
100	26	8.3	8.0	6.7 (75)	6.6 (74)

TABLE 8. Survival of copepods, *Acartia tonsa*, during a 96-hour exposure to the suspended particulate phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number of Survivors						
		0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	9	9	9	9
	3	10	10	10	10	10	10	10
		30	30	30	29	29	[illegible]	29
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	8	8	8	7
	2	10	10	10	9	9	7	7
	3	10	10	10	9	9	7	7
		30	30	30	25	25	22	21[a]
50% test medium	1	10	10	10	10	10	9	9
	2	10	10	10	10	10	9	8
	3	10	10	10	10	10	8	7
		30	30	30	30	30	26	24[a]
10% test medium	1	10	10	10	10	9	9	9
	2	10	10	10	10	10	10	10
	3	10	10	10	10	9	8	8
		30	30	30	30	28	27	27

[a] Significantly different ($P<0.05$) from the control.

TABLE 9. Total number of survivors of copepods, Acartia tonsa, after 96 hours of exposure to the suspended particulate phase of dredged material from Mobile Ship Channel, AL.

Replicate	Number of survivors		
	Disposal site water	50% suspended particulate phase	100% suspended particulate phase
1	10	9	7
2	10	8	7
3	10	7	7
Total	30	24	21
Mean	10	8	7
Variance	0.00	1.00	0.00
Calculated t value	—	3.51	3.00
Tabular $t_{.05(4)}$	2.13		

TABLE 10. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with copepods, *Acartia tonsa*, and the suspended particulate phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% suspended particulate phase)	Salinity (‰)	pH		Dissolved oxygen (mg/ℓ and % saturation)
		0 hr	96 hr	96 hr
Site water control	28	8.3	8.2	7.3 (82)
Culture water control	22	8.1	7.7	7.3 (80)
10	28	8.3	8.1	7.2 (82)
50	26	8.3	8.1	7.2 (81)
100	25	8.3	8.1	7.3 (81)

TABLE 11. Survival of mysid shrimp, *Mysidopsis bahia*, during a 96-hour exposure to the suspended particulate phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number of Survivors						
		0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	10	10	10	9
	2	10	10	10	10	10	10	10
	3	10	10	10	9	9	9	9
		30	30	30	29	29	29	28
50% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
10% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30

TABLE 12. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with mysid shrimp, Mysidopsis bahia, and the suspended particulate phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% suspended particulate phase)	Salinity (°/oo)	pH		Dissolved oxygen (mg/ℓ and % saturation)
		0 hr	96 hr	96 hr
Site water control	28	8.3	8.1	5.5 (62)
Culture water control	22	8.1	7.9	5.3 (58)
10	28	8.3	8.1	5.2 (59)
50	26	8.2	7.9	5.1 (57)
100	25	8.1	7.8	4.8 (53)

TABLE 13. Survival of sheepshead minnows, *Cyprinodon variegatus*, during a 96-hour exposure to the suspended particulate phase of dredged material from Mobile Ship Channel, AL.

Exposure condition	Replicate	Time of Observation - Number of Survivors						
		0 hr	4 hr	8 hr	24 hr	48 hr	72 hr	96 hr
Culture water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
Site water control	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
100% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
50% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30
10% test medium	1	10	10	10	10	10	10	10
	2	10	10	10	10	10	10	10
	3	10	10	10	10	10	10	10
		30	30	30	30	30	30	30

TABLE 14. Measured salinity, pH, and dissolved oxygen during a 96-hour toxicity test with sheepshead minnows, Cyprinodon variegatus, and the suspended particulate phase of dredged material from Mobile Ship Channel, AL. The dissolved oxygen values are the means of measurements in three replicates from each treatment; salinity and pH measurements were in Replicate A of each treatment.

Nominal concentration (% suspended particulate phase)	Salinity (^{o}/oo)	pH		Dissolved oxygen (mg/ℓ and % saturation)	
		0 hr	96 hr	0 hr	96 hr
Site water control	28	8.3	8.0	8.3 (94)	6.3 (72)
Culture water control	25	8.3	8.2	9.9 (110)	7.2 (80)
10	26	8.3	8.2	8.4 (94)	6.8 (76)
50	24	8.2	8.2	7.6 (84)	6.4 (71)
100	24	8.1	8.1	7.7 (86)	6.6 (73)

TABLE 15. Survival of quahogs (Mercenaria mercenaria), polychaetes (Neanthes arenaceodentata), and mysid shrimp (Mysidopsis bahia) exposed for 10 days to the solid phase of dredged material from Mobile Ship Channel, AL.

Species and sample replicate		Number of survivors on day 10	
		Reference sediment	Dredged material
Quahogs	1	20	20
	2	20	20
	3	20	20
	4	20	20
	5	20	20
		100	100
Polychaetes	1	14	20
	2	12	15
	3	18	16
	4	17	18
	5	16	17
		77	86
Mysids	1	16	15
	2	15	13
	3	17	18
	4	13	13
	5	15	16
		76	75

TABLE 16. Total number of survivors after 10 days of exposure to the solid phase of dredged material from Mobile Ship Channel, AL.

Replicate	Total Number of Survivors	
	Reference sediment	Dredged material
1	50	55
2	47	48
3	55	54
4	50	51
5	51	53
Total	253	261
Mean	50.60	52.20
Variance	8.30	7.70
Calculated t value	---	0.90
Tabular $t_{.05(8)}$	1.81	

TABLE 17. Measured salinity, temperature, pH, and dissolved oxygen (DO) during a 10-day toxicity test with quahogs (*Mercenaria mercenaria*), polychaetes (*Neanthes arenaceodentata*), and mysid shrimp (*Mysidopsis bahia*), and the solid phase of dredged material from Mobile Ship Channel, AL. The DO values are the means of measurements in five replicates from each treatment; salinity, temperature, and pH measurements were from replicate 1 of each treatment.

Exposure condition and measurement	Time (days)										
	0	1	2	3	4	5	6	7	8	9	10
Reference sediment											
Salinity (°/oo)	30	31	30	31	30	30	30	31	30	30	30
Temperature (°C)	15	15	16	17	18	17	17	17	15	15	15
DO (mg/ℓ; % of sat.)	6.5 (80)	6.4 (79)	6.5 (81)	6.7 (86)	6.5 (84)	5.6 (72)	6.4 (82)	5.8 (74)	7.4 (91)	7.8 (96)	5.9 (73)
pH	7.4	7.6	7.6	7.7	8.1	7.5	7.4	7.5	7.4	7.6	7.7
Dredged material											
Salinity (°/oo)	30	31	30	31	30	30	30	31	30	30	30
Temperature (°C)	15	15	16	17	18	17	17	17	15	15	15
DO (mg/ℓ; % of sat.)	6.6 (81)	6.5 (80)	6.3 (79)	6.7 (86)	6.5 (84)	6.1 (78)	6.7 (86)	6.0 (77)	7.6 (94)	7.8 (96)	6.7 (83)
pH	7.7	7.7	7.7	7.7	8.2	7.5	7.5	7.5	7.5	7.6	7.6

TABLE 18. Concentrations in clams, Mercenaria mercenaria, from the test population (background) and in those exposed to the solid phase of reference sediment and dredged material from Mobile Ship Channel, AL. Concentrations are reported as whole-body tissue (less shell) based on wet weight, and are parts per million (micrograms per gram) for cadmium and petroleum hydrocarbons and parts per billion (nanograms per gram) for pesticides and PCB.

Constituent	Replicate	Tissue concentration					
		Background		Reference sediment		Dredged material	
Cadmium	1	0.18		0.22		0.24	
	2	---		0.24		0.24	
	3	---		0.19		0.24	
	4	---		0.20		0.24	
	5	---		0.20		0.19	
	Mean	---		0.21		0.23	
Mercury	1	31		36		25	
	2	---		12		35	
	3	---		<11		31	
	4	---		24		33	
	5	---		40		46	
	Mean	---		25		34	
		F1	F2+F3	F1	F2+F3	F1	F2+F3
Petroleum hydrocarbons	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
	2	---		<1.0	<1.0	<4.0*	<1.0
	3	---		<1.0	<1.0	<1.0	<1.0
	4	---		<1.0	<1.0	<1.0	<1.0
	5	---		<1.0	<1.0	<1.0	<1.0
Aldrin	1	<70		<70		<70	
	2	---		<70		<70	
	3	---		<70		<70	
	4	---		<70		<70	
	5	---		<70		<70	

*Lower limit is higher than other replicates because of a low recovery of the internal standard.

(continued)

TABLE 18, continued.

Constituent	Replicate	Tissue concentration Background	 Reference sediment	 Dredged material
BHC (lindane)	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
Heptachlor	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
p,p' DDT	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
p,p' DDD	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
o,p' DDE	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
Chlordane	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
Dieldrin	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70

(continued)

TABLE 18, continued.

Constituent	Replicate	Tissue concentration Background	Reference sediment	Dredged material
Endrin	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
Toxaphene	1	<100	<100	<100
	2	---	<100	<100
	3	---	<100	<100
	4	---	<100	<100
	5	---	<100	<100
Mirex	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
Methoxyclor	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70
PCB (Aroclor® 1254)	1	<70	<70	<70
	2	---	<70	<70
	3	---	<70	<70
	4	---	<70	<70
	5	---	<70	<70

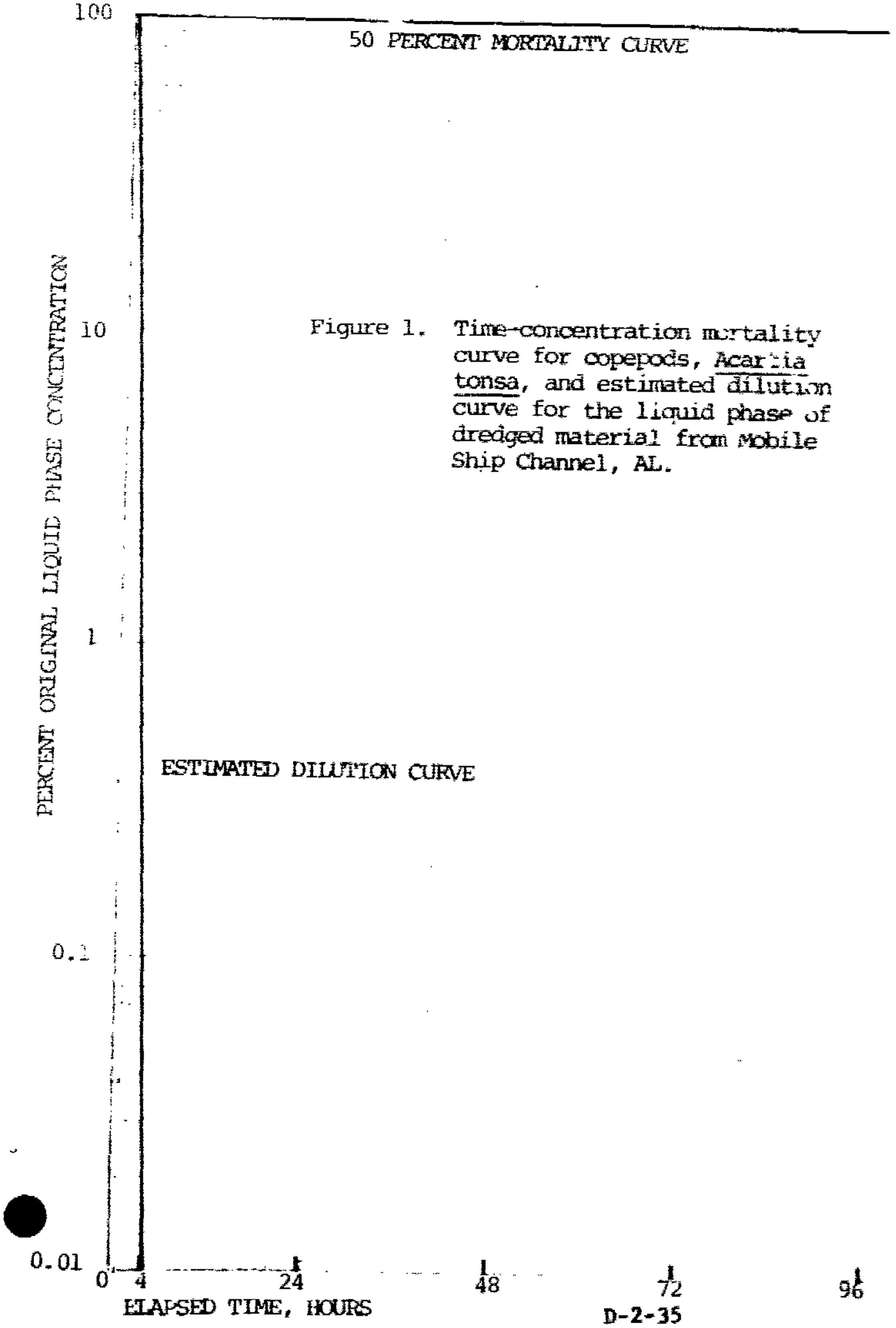


Figure 1. Time-concentration mortality curve for copepods, *Acartia tonsa*, and estimated dilution curve for the liquid phase of dredged material from Mobile Ship Channel, AL.

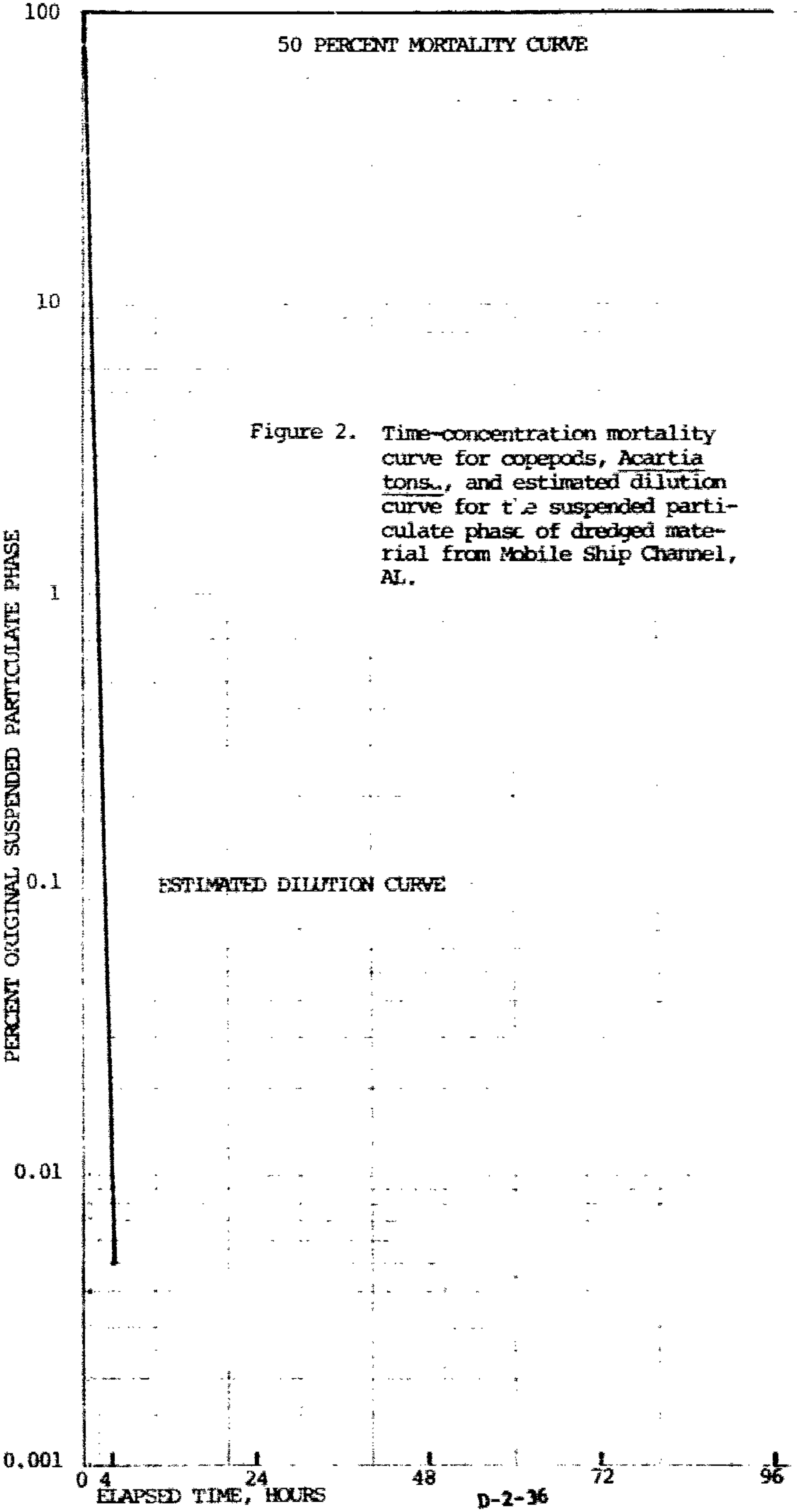
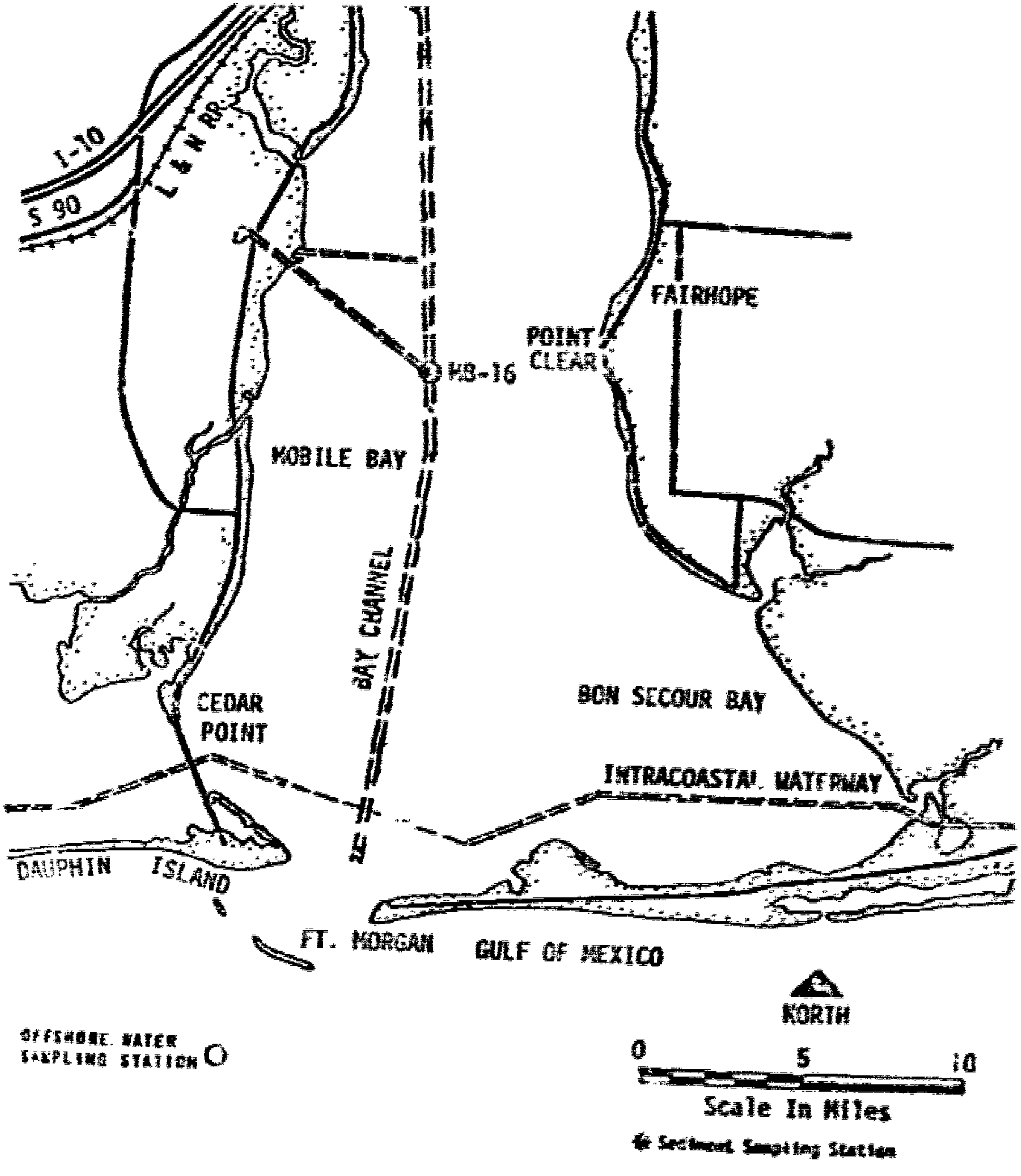


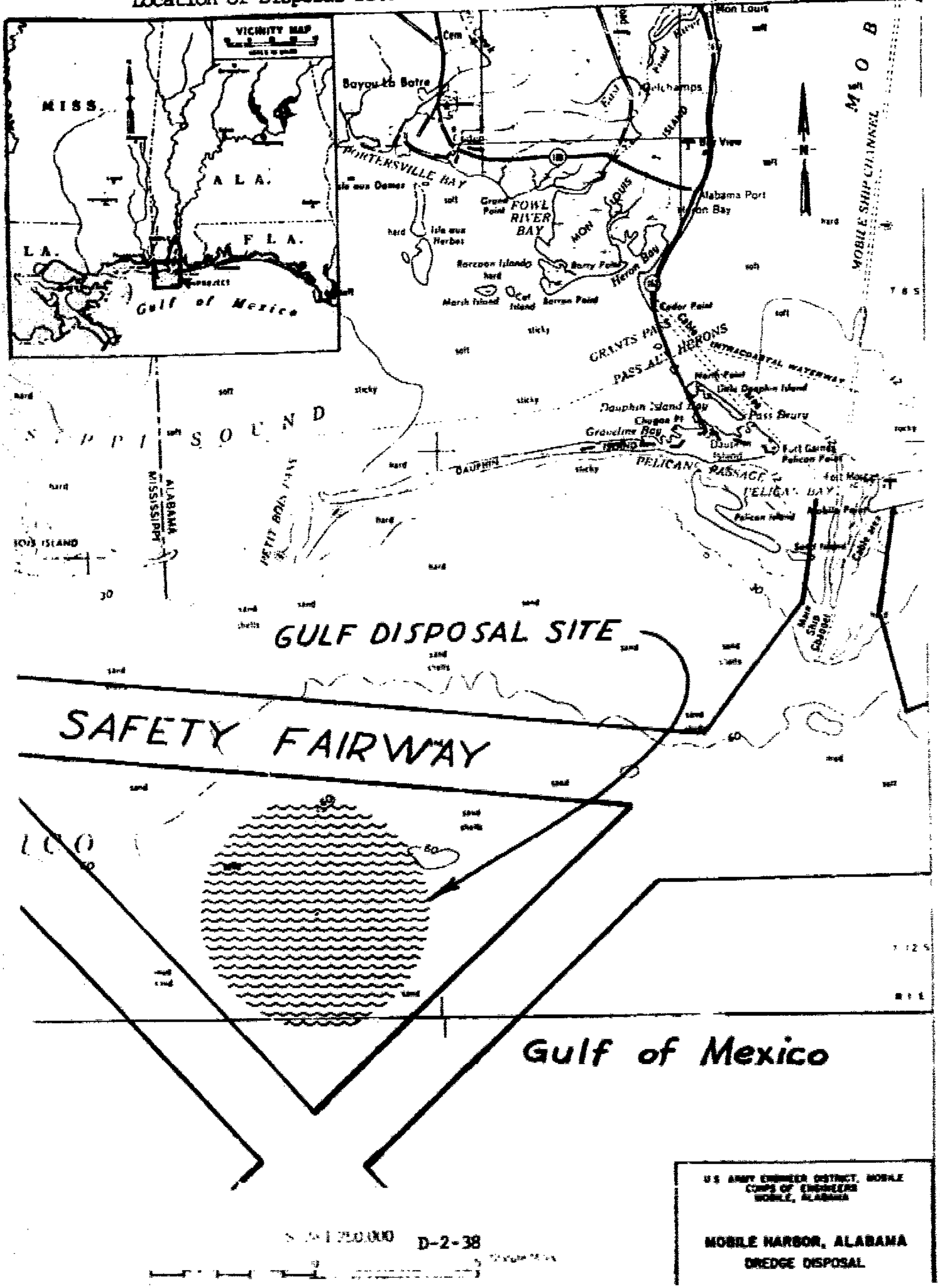
Figure 2. Time-concentration mortality curve for copepods, *Acartia tonsa*, and estimated dilution curve for the suspended particulate phase of dredged material from Mobile Ship Channel, AL.

APPENDIX A

Location of Dredged Material Sampling Station, Mobile Harbor, Alabama



Location of Disposal Site Sediment and Water Collecting Station



U S ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALABAMA

MOBILE HARBOR, ALABAMA
DREDGE DISPOSAL

D-2-38

APPENDIX B

Analytical Methodology for the Determination of Selected Chemicals in Clam Tissue (*Mercenaria mercenaria*)

Cadmium (Cd)

Samples were thawed and homogenized using a Willems PT20 Polytron® homogenizer. A rinse of 1:1 nitric acid (HNO_3) followed by 1:3 hydrochloric acid (HCl) and a final rinse with deionized water was used between samples. A weighed aliquot (4-5 grams [g]) of homogenized tissue was placed into a Technicon digestion tube containing 15 milliliters (mℓ) of acid-digest mix (2:1 volume:volume [v:v] solution of 30% hydrogen peroxide and concentrated reagent grade HNO_3) and heated at approximately 70 degrees Celsius (°C) until foaming ceased (about 2 hours). To insure that all the tissue was digested, the sample was mixed with a vortex mixer and an additional 5 mℓ of acid-digest mix was added. The sample was then boiled vigorously at 130°C for one hour, and then at 200°C for one hour.

The concentrated extract was quantitatively transferred to a 25-mℓ volumetric flask and diluted with distilled/deionized water. The diluted extract was transferred to an acid-washed scintillation vial (1:1 HNO_3 and 1:3 HCl rinse) equipped with a Teflon®-lined screw cap, for storage prior to analysis by atomic absorption spectroscopy.

The Cd concentration was determined by flame atomization using the following instrumental conditions:

Instrument:	Perkin-Elmer Model 305A, equipped with a deuterium arc background correction accessory
Source lamp:	Cd, electrodeless discharge lamp

Lamp: 5.5 watts

Wavelength: 228.8 nanometers (nm)

Signal band width: 0.7 nm

Range: 1 mV

Scale expansion: 90°

Damping: 1

Flame conditions: Fuel - acetylene Rotometer - 8.5
Oxident - air Rotometer - 11.0

Chart speed: 5 millimeters (mm)/minute (min)

Response: Half-scale chart deflection for 0.15 parts per million (ppm) Cd

Calibration curves were obtained by plotting response (mm peak height) versus concentration (micrograms [μg]/mℓ) of Cd standards in distilled/deionized water containing 1% Ultrex HNO_3. One standard and reagent blank were analyzed after every 5 samples. Quality control samples were prepared by fortifying approximately 1 g clam tissue with 1, 5, and 10 μg of Cd to yield concentrations of 1, 5, and 10 μg/g Cd, respectively. Samples were analyzed by the above method with the results shown in Table B-1.

The analysis of blank tissue (Table B-1) shows varying concentrations of Cd. The effect of biological variability on analytical determinations of environmental organisms, is well known. In order to statistically determine a background tissue concentration, and use it as a correction in analytical results of samples, multiple analyses (greater than 20) of unexposed organisms as well as samples, would be required (Montgomery et al., 1976).

TABLE 1. Recovery of Cd from clam tissue

Cd added, μg	Cd recovered, μg	% recovery
Blank	0.098	---
Blank	0.20	---
Blank	0.098	---
1.0	1.1	110
	1.1	110
	1.1	110
5.0	4.8	96
5.0	4.7	94
5.0	4.6	92
10.0	9.5	95
10.0	9.6	96
10.0	9.7	97

Average recovery 100 (±7.6) %

The minimum detectable concentration of Cd in tissue was 0.18 μg. The method demonstrates a quantitative recovery of Cd from tissue, therefore no correction factor was used in the calculation of analytical results of samples.

Mercury (Hg)

Samples were thawed and homogenized, using a Willems PT20 Polytron homogenizer. A rinse with 1:1 HNO_3 and 1:3 HCl, and a final rinse of deionized water was used between samples. Weighed aliquots (1-4 g) of the homogenized tissue were placed into Technicon digestion tubes. A low-temperature sulfuric acid (H_2SO_4) digestion procedure (Perkin-Elmer, 1972, #303-3119) was used with the following modifications. A 10-mℓ volume of concentrated reagent grade H_2SO_4 was added to each sample, mixed using a vortex mixer and an additional 10 mℓ of acid added. Samples were digested, in the Technicon tubes, for 2 hours at 60°C, using a Technicon block digester. If particulate matter was still present, an additional 2 mℓ of concentrated H_2SO_4 was added. Once digested, approximately 0.2 g of potassium permanaganate ($KMnO_4$) crystals was added to each sample and mixed, using a vortex mixer, until the solution turned purple. If no purple color was obtained, the sample was mixed for a longer time, or if still unsuccessful, more $KMnO_4$ crystals were added and the sample further mixed. Samples were transferred volumetrically, with three 5 mℓ aliquots of deionized water, to 50 mℓ volumetric flasks. The volumetric flasks were cooled in an ice bath and swirled to assure complete mixing, prior to dilution to 50 mℓ with deionized water.

The diluted extract was transferred to acid-washed bottles equipped with Teflon-lined screw caps, for storage prior to analysis by atomic absorption spectroscopy.

The mercury concentration was determined by an automated cold vapor technique (Koirtyolann and Khalil, 1976) and atomic absorption spectroscopy. The sample rate was 20 per hour, with distilled/deionized water used between samples to improve the baseline. The samples were mixed internally with 3% sodium chloride-3% hydroxylamine sulfate in water (weight/volume [w/v]), to react readily reducible components. The mixture was further reduced using a 10% stannous sulfate solution, in 2N H_2SO_4 (w/v), thus liberating elemental Hg vapor, which was transferred to the closed cell.

Because of problems with bubbling, modification of the gas phase separation apparatus were made. A hot air dryer was used to heat the gas separator and a bubble was blown in the tubing between the gas separator and absorption cell. Both modifications inhibited bubbles from being carrier into the light beam.

The following instrumental conditions were used to determine the Hg concentrations:

Automated sampler: Technicon Autoanalyzer V and Cam 27-B162
20/hour 1:1

Instrument: Perkin-Elmer Model 305A

Recorder: Perkin-Elmer Model 56, 0-5 mV full-scale

Purge gas: air 12.5 [illegible]/min

Source lamp: Hg, electrodeless discharge lamp

Lamp: 5 watts

Wavelength: 253.7 nm

Signal band width: 0.7 nm

Range: 5 mV

Scale expansion: 90°

Damping: 1

Chart speed: 5 mm/min

Response: Half-scale chart deflection for 7 nanograms (ng)/mℓ Hg

Calibration curves were obtained by plotting response (mm peak height) versus concentration (ng/mℓ) of Hg standards in deionized/distilled water containing 40% H_2SO_4 and 1 drop (or to excess) of 5% $KMnO_4$ Two standards and a blank were analyzed after every 5 samples . Quality control samples were prepared by fortifying approximately 2 g of blank clam tissue with 0.25, 0.50, and 1.0 μg of Hg to yield concentrations of 0.13, 0.25, and 0.50 μg/g, respectively. Samples were analyzed by the above method with the results shown in Table B-2.

The analysis of blank tissue (Table B-2) shows varying concentrations of Hg. The effect of biological variability on analytical determinations of environmental organisms, is well known. In order to statistically determine a background concentration and use it as a correction in analytical results of samples, multiple analysis (greater than 20) of unexposed organisms (blanks) would be required (Montgomery, op. cit.). Therefore no correction for background concentration was used.

The minimum detectable concentration of Hg in tissue was 0.23 ng. Since results of the recovery study indicated a quantitative recovery

TABLE B-2. Recovery of Hg from Clam Tissue

Hg added, ng	Hg recovered, ng	% recovery
Blank	97	---
Blank	41	---
250	360	140
250	290	120
500	520	100
500	540	110
500	590	110
1,000	1,100	110
1,000	1,120	110
1,000	1,110	110
Average recovery 110 (±11.9) %		

of Hg, using the method, no correction factor was used in the calculation of analytical results of samples.

Pesticides and PCB

Tissue samples (approximately 10 g) were prepared for gas chromatographic analysis by extracting the sample twice with 30-mℓ portions of 1:1 diethyl ether:hexane for 1 minute by using a Polytron® PT20 homogenizer. The sample was centrifuged between extractions and the extracts filtered through anhydrous sodium sulfate into a Kuderna-Danish evaporative concentrator equipped with a 10-mℓ graduated evaporator tube. The extract was concentrated over a steam bath and the volume adjusted to exactly 5.0 mℓ.

A 3.0-mℓ portion of the concentrate was transferred to a 0.9 x 25-centimeter (cm) Pyrex® chromatographic column containing 2.3 g of activated (130°C) Florisil 60/100 mesh with a 1 cm layer of anhydrous sodium sulfate above it. The column was prerinsed with 50 mℓ of hexane before sample application.

The column was eluted with a 50-mℓ volume of 6% diethyl ether-in-hexane to remove PCB and pesticides, except endrin, which was stripped from the column with a 50-mℓ portion of 1% methanol-in-benzene. The 6% diethyl ether-in-hexane fraction was concentrated to approximately 2 mℓ for silica gel chromatography. The 1% methanol-in-hexane fraction was concentrated to 5.0 mℓ for gas chromatographic analysis. Both concentrations were carried out over a steam bath by using a gentle stream of clean dry air.

The concentrated 6% diethyl ether-in-hexane fraction was transferred to a 0.9 x 25-cm Pyrex chromatographic column containing 3.0 g of activated (150°C) grade 922 Silica Gel. The column was prerinsed with a

50-mℓ volume of pentane before sample application.

The column was eluted with a 50-mℓ volume of pentane followed by a 50-mℓ volume of 1% methanol-in-hexane by using 2-3 pounds per square inch (psi) nitrogen gas pressure. The fractions were collected separately, concentrated to 5.0 mℓ by using a gentle stream of clean dry air, and analyzed by gas-liquid chromatography with the fraction pattern listed in Table B-3 and retention time and response listed in Table B-4.

Gas chromatographic analyses were performed by using the following instrumental conditions:

Instrument: Perkin-Elmer Model 3920 gas chromatograph equipped with 15 microcuries Ni^{-63} electron capture detector

Recorder: Perkin-Elmer Model 023; 0-1 mV full scale

Column: 6' x 2-mm (ID) Pyrex packed with 3% OV-10, 80/100 mesh Supelcoport

Temperatures (°C): Column - 200
Inlet - 250
Interface - 250
Detector - 350

Gas flows: Carrier:50 cc/min 5% methane:95% argon

Chart speed: 40 cm/hour

Attenuation: 32X

Calibration curves were produced by plotting peak height (mm) versus weight (ng) of standard injected. Analytical standards were prepared by [illegible] of analytical pesticide and PCB standards with hexane to yield working standards of the required concentrations. A mixed standard was used for all the pesticides quantitated except chlordane. Separate analytical standards were used for chlordane and Aroclor® 1254. Aroclor 1254 and chlordane were each quantitated based on a single isomer peak.

TABLE B-3. Silica Gel Fraction Pattern

Compound	Pentane	1% methanol-in-benzene
Aldrin	x	
Heptachlor	Approximately 5%	Approximately 95%
Chlordane	Approximately 5%	Approximately 95%
Aroclor 1254	x	
Mirex	x	
Lindane		x
o,p'DDE		x
Dieldrin		x
p,p'DDD		x
p,p'DDT		x
Methoxychlor		x

TABLE B-4. Retention Times and Response

Compound	Retention time (minutes)	Half-scale chart-response (picograms)
Lindane	1.0	160
Heptachlor	1.6	240
Aldrin	2.2	220
o,p'DDE	3.3	500
Dieldrin	4.2	500
p,p'DDD	5.4	500
Endrin	8.2	1,500
Methoxychlor	10.9	3,500
p,p'DDT	7.2	1,500
Mirex	13.4	1,600
Aroclor® 1254	6.1*	250
Chlordane	1.5*	200

*Isomer used for quantitation.

Blank tissue (approximately 10 g) was fortified with pesticides/PCB standards-in-acetone and analyzed by the above method. The analytical results of all samples were corrected for the average percentage recoveries shown in Table B-5. The minimum detectable concentration of pesticide for PCB in tissue was 50 ng/g.

Petroleum hydrocarbons

A 10-g sample of frozen tissue was homogenized in a 50-mℓ centrifuge tube equipped with a Teflon-lined screw cap by using a Willems PT10 homogenizer. The probe was rinsed with 5 mℓ of 4N NaOH and the rinse added to the centrifuge tube. The centrifuge tube was capped and placed in an oven at 90°C for 2 hours. The sample was shaken vigorously at the end of the first hour.

Once the sample had cooled, 15 mℓ of ethyl ether was added and the tube shaken vigorously for 1 minute. The sample was then centrifuged at 2,000 revolutions per minute for 10 minutes and the ethyl ether layer transferred to a 1-ounce narrow-mouth glass bottle equipped with a Teflon-lined screw cap, using a 50-mℓ syringe equipped with a long, large-gauge needle.

An additional 10-mℓ volume of ethyl ether was added to the aqueous layer in the centrifuge tube, and the extraction repeated as before. The two ethyl ether extracts were combined and dried by the addition of 1 g of anhydrous magnesium sulfate.

The combined extract was decanted into a 25-mℓ evaporator tube containing a few small porcelain chips and fitted with a modified Snyder column; the extract was concentrated to approximately 1 mℓ by using a

TABLE B-5. Concentrations and Percentage Recoveries of Pesticides and PCB added to Tissue Samples

Compound	ppm added	Percent recovery 1	2	3	Mean	Mean average (standard deviation)
BHC (lindane)	0.48	88.9	104 9	90.0	94.9	
	0.96	78.3	85.7	91.4	85.1	
						90.0 (8.7)
Heptachlor	0.48	71.7	93.9	79.8	81.8	
	0.96	62.1	62.0	87.9	70.7	
						76.3 (13.3)
Aldrin	0.46	100.0	94.8	96.2	97.0	
	0.92	96.6	94.2	1-9.0	113.3	
						105.2 (21.6)
o,p'DDE	0.48	125.0	91.2	84.5	100 2	
	0.96	97.6	97.6	130.9	108.7	
						104.5 (18.9)
Dieldrin	0.48	97.4	76.4	65.5	79.8	
	0.96	83.3	92.6	111.1	95.6	
						87.7 (16.2)
p,p'DDD	0.96	87.2	103.6	96.4	95.7	
	1.92	74.7	85.3	90.7	83.6	
						89.7 (9.9)
p,p'DDT	0.96	89.7	110.3	100.0	100.0	
	1.90	71.7	88.7	98.1	86.2	
						93.1 (13.1)
Endrin	0.96	86.8	85.3	86.3	86.1	
	1.90	81.4	100.0	95.3	92.2	
						89.2 (7.0)
Methoxychlor	2.40	96.8	93.8	93.7	94.7	
	4.80	72.7	90.2	92.1	85.0	
						89.9 (8.7)
Mirex	0.96	90.5	95.2	95.2	93.6	
	1.90	92.3	92.3	84.6	89.7	
						91.7 (3.9)
Aroclor® 1254	15.4	81.3	89.6	81.3	84.1	
	30.8	90.2	96.1	96.1	94.1	
						89.1 (6.7)
Chlordane	0.4	84.9	84.9	78.6	82.9	
	1.0	104.0	94.0	106.0	101.3	
						92.1 (11.2)

Kontes® Tube Heater set at 75°C. A 2.0-mℓ volume of hexane was added, and the sample again concentrated to approximately 1 mℓ at 110°C. The sample was removed from the tube heater and the tip heated at approximately 120°C until the solvent had been allowed to reflux and rinse the walls of the tube.

A silica gel separation column was prepared using a 9 x 250-mm column equipped with a sintered glass disc, Teflon stopcock, and 100-mℓ reservoir. The column was packed by first filling it with petroleum ether and then adding 10 g of silica gel (MCB No. SX 144-7), activated at 150°C overnight, with gentle vibrating to eliminate air bubbles. A needle valve was attached to the top of the reservoir and the system pressurized at 2-3 psi with nitrogen gas.

The column was prewashed with 25 mℓ of methylene chloride, followed by two 2-mℓ petroleum ether rinses, and a final 40-mℓ petroleum ether rinse. All of the prewash eluates were discarded. An elution rate of 1-2 mℓ/minute was maintained.

The concentrated tissue extract was transferred onto the column, followed by three 1-mℓ petroleum ether rinses, eluted under pressure, and the eluate collected in a 25-mℓ concentrator tube. An additional 22-mℓ volume of petroleum ether was added to the column, eluted under pressure and collected in the same concentrator tube. This total eluate was Fraction I and contained the saturated hydrocarbons.

A 50-mℓ volume of 20% methylene chloride-in-petroleum ether (volume:volume) was added to the column and two 25-mℓ eluates collected, under pressure, in separate 25-mℓ concentrator tubes. These were Fractions 2 and 3 and contained the mono- and diaromatic-hydrocarbons, and the triaromatic hydrocarbons, respectively.

A 100-microliter (μℓ) volume of 1 milligram (mg)/mℓ n-dotriacontane-in-heptane standard was added to each fraction and the fractions concentrated to approximately 0.2 mℓ by using the tube heater. The concentrated eluates were adjusted to a 0.5-mℓ volume with heptane, and an aliquot of each fraction removed for gas chromatographic analysis. The aliquots for Fractions 2 and 3 were combined and the volume concentrated to exactly half. Fraction 1 and the combined Fractions 2 and 3 were analyzed by using the following instrumental conditions:

Instrument: Hewlett-Packard Model 5840A gas chromatograph equipped with dual flame ionization detectors, and a Model 7671A automatic sampler

Columns: 2 each 10' x 2-mm (ID) stainless steel, packed with 3% OV-17 on 100/120 mesh Chromosorb Q

Temperatures (°C): Column - 60-300 at 8°C/minute
Inlet - 250
Detector - 325

Time 5: 20.00 minutes

Gas flows: Carrier - 25 mℓ/min nitrogen
Reactant - 40 mℓ/min hydrogen
Support - 240 mℓ/min air

Chart speed: 0.5 cm/min

Area rejection: 0 counts

Attenuation: 128

Slope sensitivity: 0.50

Retention time: 28.1 min for internal standard

FID signal: -A+B

Response: Half-scale chart response with 200 ng n-dotriacontane

In order to verify the recovery of the internal standard, n-dotriacontane, quality control standards were produced by extracting blank tissue (approximately 10 g) by the above procedure and analyzing the resultant sample extracts. A calibration curve was produced by plotting peak height (mm) versus weight (ng) of n-dotriacontane injected. The recovery of the internal standard is shown in Table B-6.

Two chemicals were chosen to verify the recovery of petroleum hydrocarbons with the method. Analytical standards of nonadecane and 2,3-dimethylnaphthalene were prepared by dilution of stock material with heptane to yield 1,000 mg/ℓ nonadecane and 2,3-dimethylnaphthalene standards, respectively. Control tissue (approximately 10 g) was fortified by the addition of 1 mℓ of the 1,000 ppm nonadecane and 2,3-dimethylnaphthalene mix and analyzed by the above method with the results as shown in Table B-7. Unfortified tissue was also analyzed to act as blanks. A calibration curve was produced by plotting peak height (mm) versus weight (ng) of injected nonadecane and 2,3-dimethylnaphthalene, respectively.

The analytical results of samples were calculated by comparison of the total peak areas found, from 4.0 minutes retention time through the end of the program, with the area of the n-dotriacontane internal standard. No correction for method recovery was used in the calculation of sample concentrations. All analytical results of samples are reported in μg/g as n-dotriacontane. The minimum detectable concentration of petroleum hydrocarbon in tissue was 0.5 μg/g as dotriacontane.

TABLE B-6. Recovery of n-dotriacontane

Sample	Sample weight (g)	n-dotriacontane added (μg)	n-dotriacontane recovered (μg)	% recovery
Fraction 1-A	10.04	100	102	102
Fraction (2 + 3)A		100	83	83
Fraction 1-B	10.03	100	80	80
Fraction (2 + 3)B		100	107	107
Fraction 1-C	10.16	100	113	113
Fraction (2 + 3)C		100	100	100
		Mean and standard deviation		97.5 ± 13.2

TABLE B-7. Recovery of nonadecane and 2,3-dimethylnaphthalene

Sample	Sample weight (g)	nonadecane, 2,3-dimethylnaphthalene added (μg)	nonadecane recovered (μg)	% recovery	2,3-dimethylnaphthalene recovered (μg)	% recovery
Spike - A	10.18	1,000				
Fraction 1			1,150	115		
Fraction 2&3					1,220	122
Spike - B	10.17	1,000				
Fraction 1			1,130	113		
Fraction 2&3					1,180	118
Blank A	10.04	—				
Fraction 1			<5	—		
Fraction 2&3					<5	—
Blank B	10.03	—				
Fraction 1			<5	—		
Fraction 2&3					<5	—
			Average	114	Average	120

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Montgomery, J.R., S.E. Kolehmainen, M.D. Banus, B.J. Bendien, J.L. Donaldson, and J.A. Ramirez. 1976. Individual variation of trace metal content in fish. National Bureau of Standard Special Publication. 422 pp.

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SECTION E

THE SELECTED PLAN

THE SELECTED PLAN
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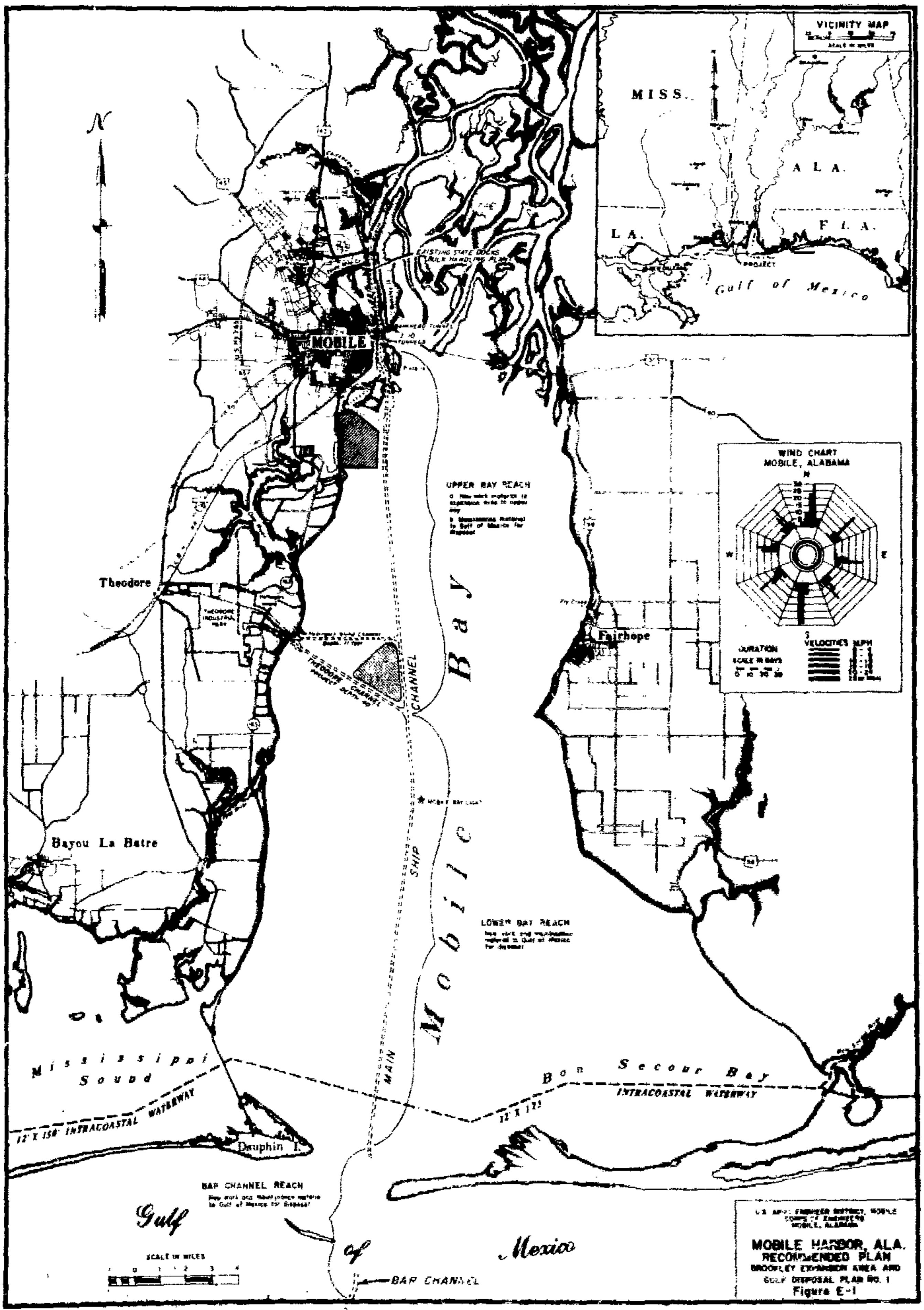
SECTION E
THE SELECTED PLAN

1. This section describes the plan selected as a result of the formulation process presented in Section D, Appendix 5 of this report. The plan elements are defined and information is presented on design, construction, and operation and maintenance for a general understanding of the technical aspects, along with the plan's accomplishments and effects. Section F of Appendix 5 presents an economic analysis of the selected plan. A general map showing the recommended plan is shown in figure E-1.

PLAN DESCRIPTION

2. The plan selected for improvement of Mobile Harbor consists of enlarging the existing ship channel to provide a depth of 57 feet and a width of 700 feet from the 57-foot depth contour in the Gulf of Mexico for a distance of about 7.4 miles to a point in Mobile Bay near the eastern end of Dauphin Island; enlarging the channel through Mobile Bay to a depth of 55 feet and a width of 550 feet for a distance of about 27 miles between the inner end of the gulf entrance channel and a point about 3.6 miles south of the mouth of Mobile River; enlarging the channel into the harbor to provide a depth of 55 feet and a width of 650 feet for a distance of about 4.2 miles to a point 1 mile south of the Interstate Highway 10 tunnels and providing an anchorage area 500 feet wide, in addition to the channel width, 55 feet deep and 4000 feet long on the east side of the main channel and immediately south of a turning basin to be constructed to a 55-foot depth, a 1500-foot width (including the channel) and 1500 feet long just south of Little Sand Island. Total length of the improved harbor channels is 38.6 miles. The channels have side slopes of one vertical on five horizontal. The plan provides two feet of allowable overdepth to compensate for inaccuracies in dredging.

3. New work channel excavation between the gulf and the lower 8000



APPENDIX 5
E-2

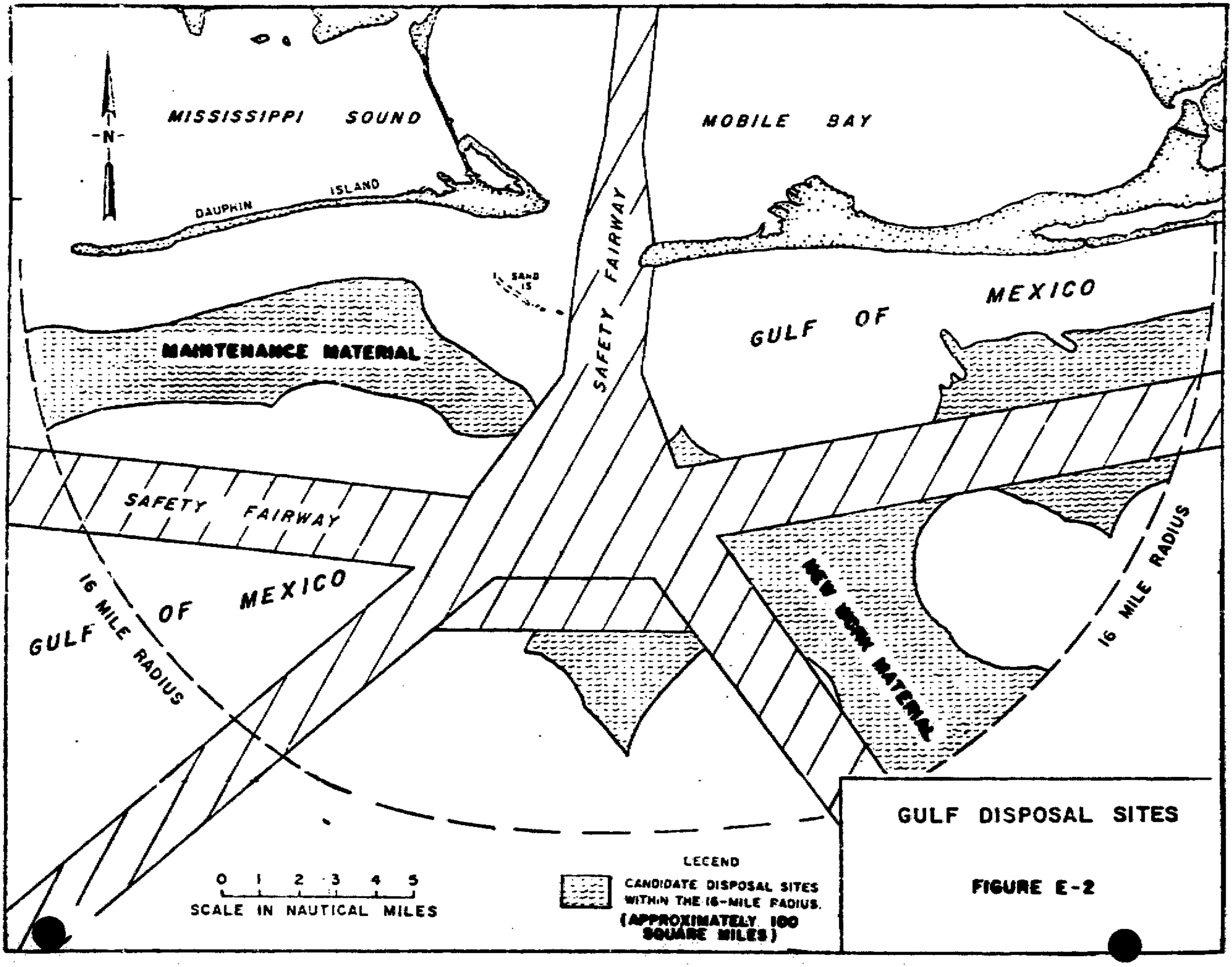
feet of the main bay channel would be by hopper dredge with materials deposited in a deep-water disposal area in the gulf tentatively located within a 16 mile radius of the mouth of Mobile Bay. Initial excavation of the lower bay channel to a point near Theodore ship channel would be by a 27 inch or comparable hydraulic dredge utilizing dump scows and tow boats to transport the dredged material to deep-water in the gulf for disposal in the same location as the material from the entrance channel. Costs developed for this plan are based on the dredged new work from the lower bay channels and the total harbor maintenance material disposal sites being located as shown on figure E-2. Final selection of a site is pending Phase 1 studies and preparation of an EIS by the Environmental Protection Agency. The remainder of the new work material in the upper bay would be excavated with a 30 inch or comparable hydraulic pipeline dredge with the material being place in a fill area to be constructed in the vicinity of the Brookley waterfront.

EVALUATED ACCOMPLISHMENTS

4. Evaluated accomplishments that would result from implementation of the selected plan are direct transportation savings to deep-draft commerce and land enhancement benefits. The transportation savings would be realized principally in the movement of iron ore and coal through Mobile. Total savings constitutes an average annual equivalent benefit of $33,130,000.

IMPACTS OF PLAN

5. Unavoidable adverse impacts associated with the plan would arise from the dredging and disposal operations which would destroy some benthic populations, increase turbidity, cause permanent physical loss of a shallow water bottoms to be filled in the upper bay, commit additional bay and gulf bottom to navigation channels, and result in long-term intermittent disruption of habitat at the gulf disposal areas. Other adverse impacts, that can be avoided only through remedial measures, are associated with modifications to overall circulation patterns in the bay caused by channel construction, and sites of historical significance,



GULF DISPOSAL SITES

FIGURE E-2

if any, located within the channel alignment and disposal areas. Secondary impacts would result from stimulated economic development of the area that would probably occur upon construction of the selected plan.

6. Benthic populations would be destroyed by channel construction and layers of sediment deposited on the bottom by mud flows during disposal. The amount of bay bottom that would be affected by the considered plan would be about 5.8 square miles including; 1.1 square miles due to widening the bay channel, 2.7 square miles for the Brookley expansion area, and 2.0 square miles attributed to mud flows during construction of the disposal area dikes. The 2.7 square miles committed to the disposal area would result in permanent loss of esturaine nursery habitat and recreation/fisheries use of that portion of the upper bay. The 2.0 square miles affected by mud flows adjacent to the dikes would result in temporary loss of benthic habitat. In addition, the offshore area affected by the dredging and disposal operations would include 0.8 square miles for modifications to the bar channel and an unquantified area within the 100 square miles designated for gulf disposal.

Under the present maintenance practices for Mobile Harbor 31.3 square miles of bay bottom adjacent to the channel and 4.0 square miles of near shore gulf bottom are committed to disposal of dredged material. The impacts associated with the considered disposal plan as compared to the existing maintenance practices will be investigated further during Phase 1 studies. This will include an overall study of the usage of the various portions of Mobile Bay, and additional studies of the gulf disposal area. These studies are discussed in more detail in paragraph 31.

7. A minor release, to the water column, of nutrient related constituents and some heavy metals would occur during the open water disposal operations. The release of pollutional constituents would be expected to be transitory and limited to the immediate vicinity of the discharge point. Reduced dissolved oxygen levels would be associated with the

initial high levels of turbidity and suspended solids near the discharge point. Increased turbidity would temporarily reduce photosynthesis and, hence phytoplankton, the base of many food chains, would be reduced during the construction period. However, turbidity and mud flows can be minimized by modifying the pipeline configuration at the discharge point. There will also be short-term effects from air pollution and increased noise levels during the dredging operations.

8. According to limited physical model studies, modifications to the bay ship channel would cause a change in the overall salinity distribution within Mobile Bay. This is the apparent result of the deepened channel which increases the salt wedge intrusion up the Mobile River. Additional model tests would be conducted for the considered plan during Phase 1 studies to determine the order of magnitude and effects of the 55-foot deep channel and any mechanisms for offsetting the effects of the enlarged channel if the impacts are deemed to be undesirable. The model studies indicated a general freshening of the water within Bon Secour Bay. Oyster production within this area could increase with the possibility of improved spatfall.

9. A complete cultural resources survey of the areas to be affected would have to be completed prior to any construction. Magnetometer surveys of the under water areas would identify any anomalies. Measures would be taken to protect and preserve any objects or sites of historical significance within the channel alignment and disposal areas.

10. The selected plan would provide a long term solution for dredged material disposal. The life of the bay should be extended as a result of taking all the future maintenance dredged material to the gulf.

11. Secondary impacts of the considered plan could include higher levels of noise, water, and air pollution related to increased economic development of the area. The channel improvement would enhance the Port of Mobile's importance and competitive position in world shipping. There would be an increase in population, employment, housing, industrial and commercial development, water borne commerce, and port expansion. However, similar patterns of growth are expected to occur with or without the considered plan of development.

12. The selected plan would enhance the possibility of economic development in the area as a result of lowered shipping costs and the creation of an additional parcel of prime area for deepwater oriented industrial or harbor terminal uses. The considered plan would make major contributions to both National and regional economic development and toward easing the present United States import-export imbalance. Various effects of the plan on both economic and environmental parameteres have been discussed in Section D, Appendix 5 of this report.

SUBSURFACE INVESTIGATIONS

13. The boring logs, density, grain size, and samples inspected all indicate the material in Mobile Bay to be predominately clay and silt with no hard material and relatively little sand and organic matter. The clay is shown to be "fat" and appears to be plastic in nature.

14. A series of borings were made in 1964 prior to the deepening of the main channel to 40 feet. These samples indicated sand can be found in the upper section of the bay and to a point about 6.5 miles south of the mouth of Mobile River. Progressing down the bay, the material becomes very soft. Below a point near the upper third of the bay, the soft material is not considered satisfactory for constructing fast land. Logs of borings along the main bay channel and the Theodore channel are reproduced in Attachment E-1.

15. No borings were made along the dike profiles of the proposed Brookley expansion area to establish the depth of soft material of the location of firm sand. For the purpose of this study it is assumed that a satisfactory foundation exists and that consolidation and displacement of existing material will not occur below -12.0 feet m.l.w. This assumption is supported by islands presently existing in the vicinity that were constructed with dredged material.

DESIGN

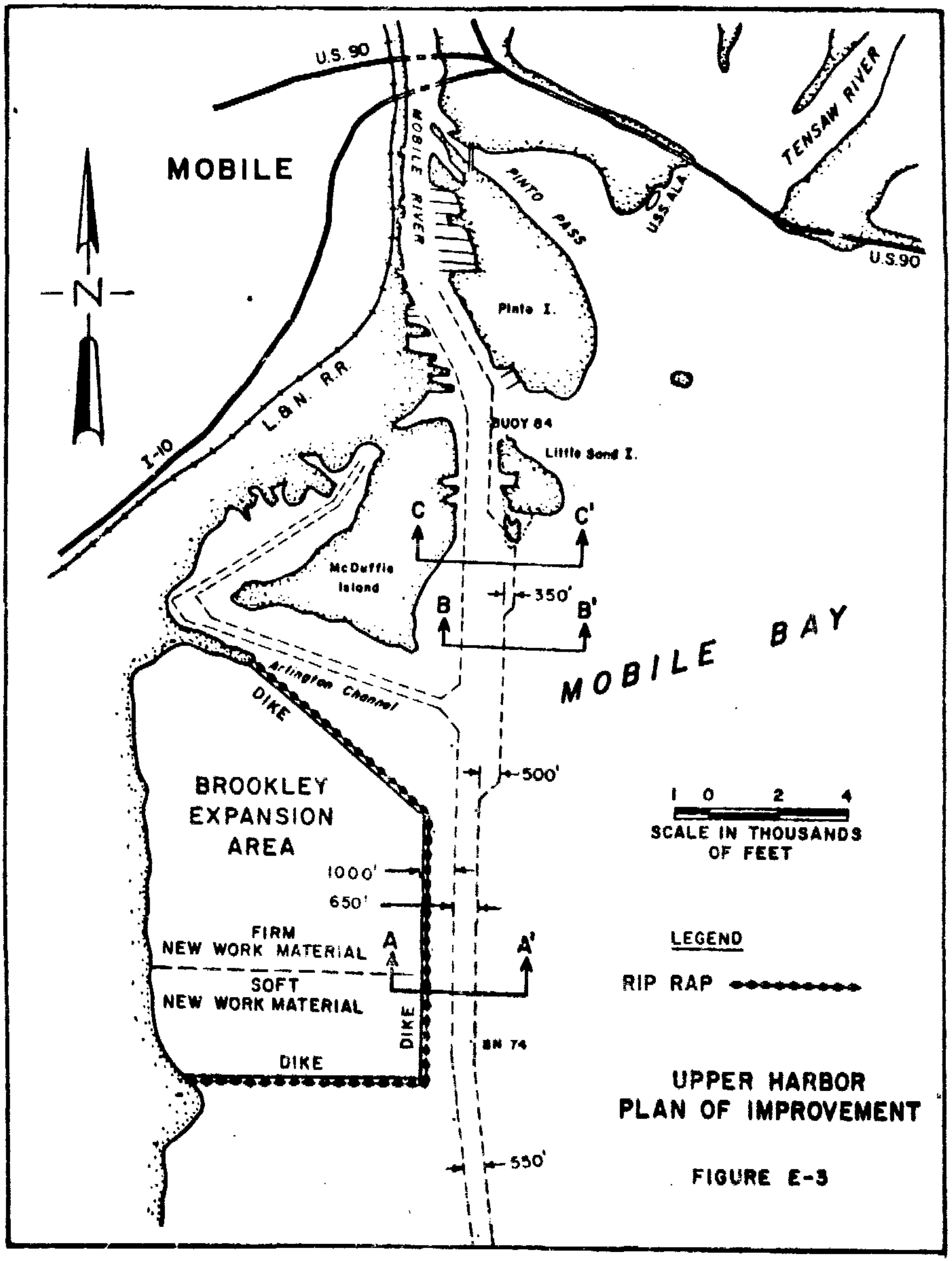
CHANNELS

16. Design of the various channel features in the selected plan for improvement of Mobile Harbor was determined through an evaluation of existing conditions and the application of available criteria and professional judgement. Applicable criteria exist only in the form of guides established through case observations. The guides are in fact variables selected on the basis of bottom and sea conditions known to occur at the existing area, present operating conditions, projected traffic densities, and the varied characteristics of the anticipated fleet. The application of these guides and analysis to determine the optimum channel widths, depths and alinements is essential to plan formulation and as such was discussed in Section D, of this appendix.

17. Figures E-3 through E-9 illustrates designed features of the selected plan including the alinement, channel depths, channel widths, anchorage area and turning basin. The channel widths, developed in Section D, are based on one-way traffic for the largest vessel expected to navigate the 55-foot channel. Unconstrained two-way traffic will exist for a majority of vessels utilizing the channels.

TURNING AND ANCHORAGE AREAS

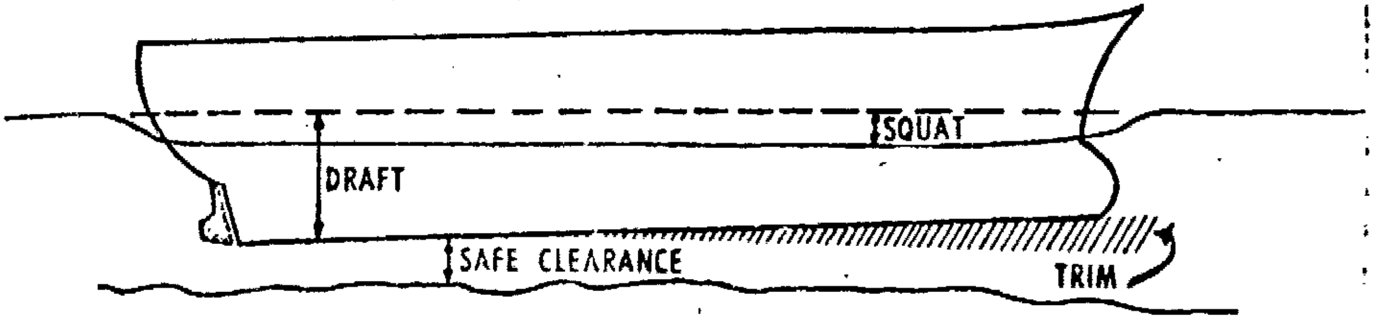
18. Turning and mooring areas considered herein were designed to accommodate the larger bulk carriers which will constitute a continually increasing percentage of the fleet of vessels expected to utilize the proposed improvements over the life of the selected plan. The lengths of the larger bulk carriers range between 900 and 1,000 feet. Therefore, in accordance with established criteria, the proposed turning basin has been designed to provide a minimum circular turning area with a diameter of 1,500 feet (1.5 X 1,000). In view of the limited area of the turning basin, and the density of anticipated deep-draft and barge traffic, the selected plan provides for an anchorage area 500 feet wide and 4,000 feet long adjacent to the east side of the channel and just south of the turning basin. The width of the anchorage area is considered necessary to minimize effects of passing vessels on these moored. Anchorage facilities to accomodate four bulk carriers would include mooring dolphins in shallow water along side the basin to prevent drifting of the vessels into the traffic channel. Due to the soft nature of the bottom material of Mobile Bay, local navigation interests consider provision of structures to prevent drift of the vessels agains the east bank of the anchorage area unnecessary. Figure E-10 shows a typical layout of the considered mooring facilities and details of the mooring dolphins.



UPPER HARBOR PLAN OF IMPROVEMENT

FIGURE E-3

FACTORS AFFECTING CHANNEL DEPTH



NAVIGATION FACTOR	ALLOWABLE DEPTH IN FEET	
	Entrance Channel	Bay Channel
FRESH WATER SINKAGE	0.5	0.5
SQUAT	0.5	0.5
TRIM	1.0	1.0
PITCHING & ROLLING	2.0	0.0
SAFE CLEARANCE	2.0	2.0
TOTAL	6.0	4.0

Figure E-4

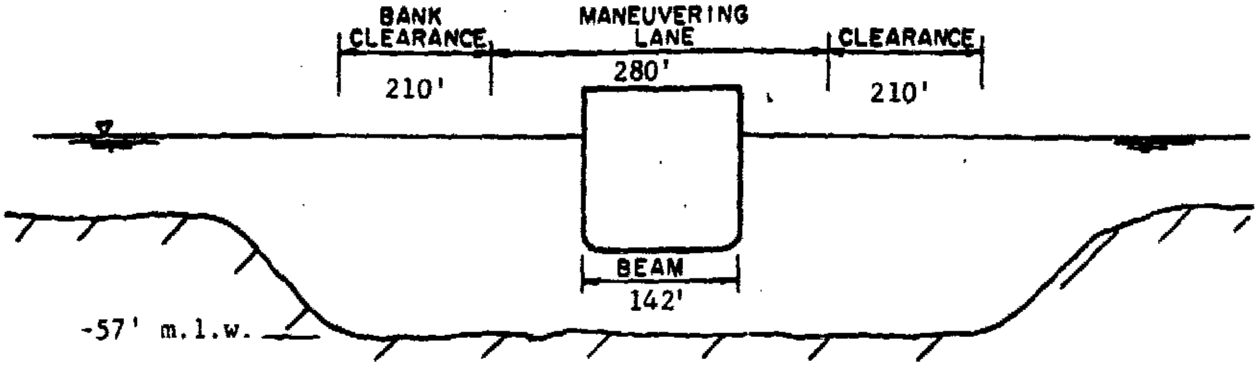


FIGURE E-5 GULF ENTRANCE CHANNEL

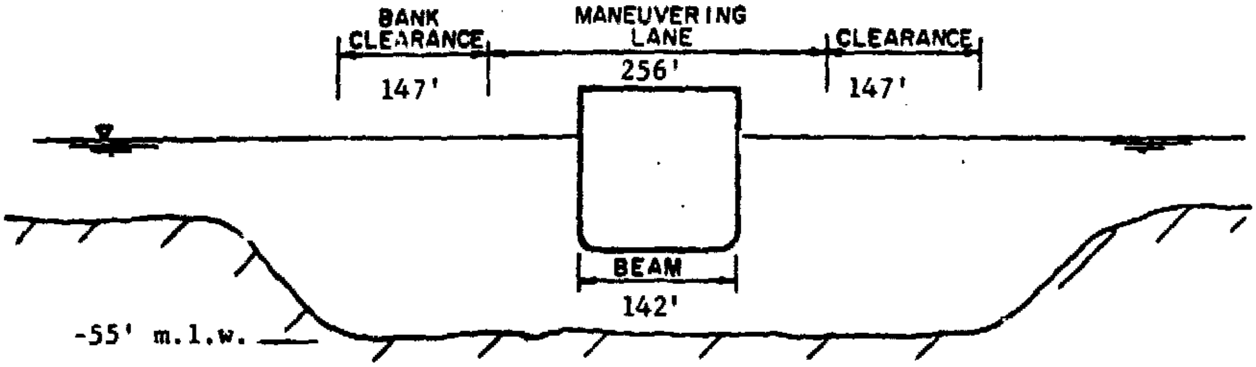


FIGURE E-6 MAIN BAY CHANNEL

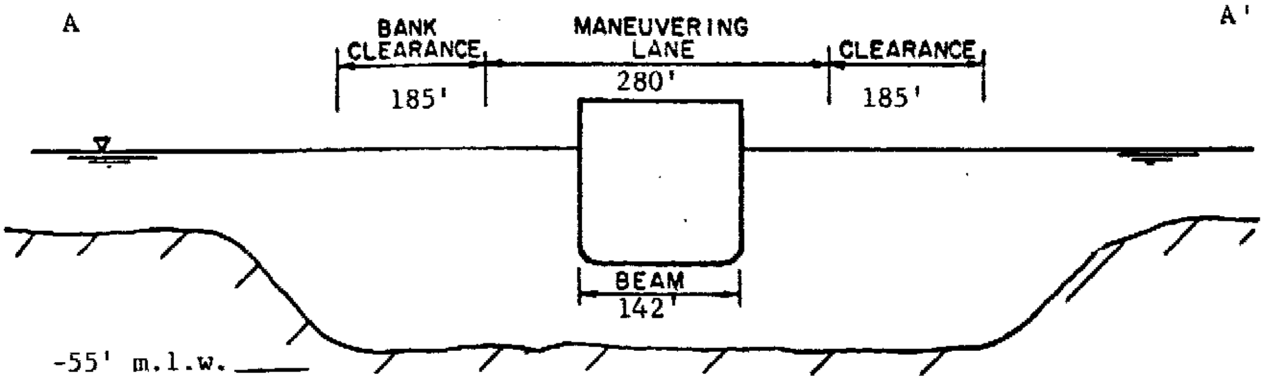


FIGURE E-7 UPPER MAIN BAY CHANNEL
(RE: FIGURE E-3, SECTION AA')

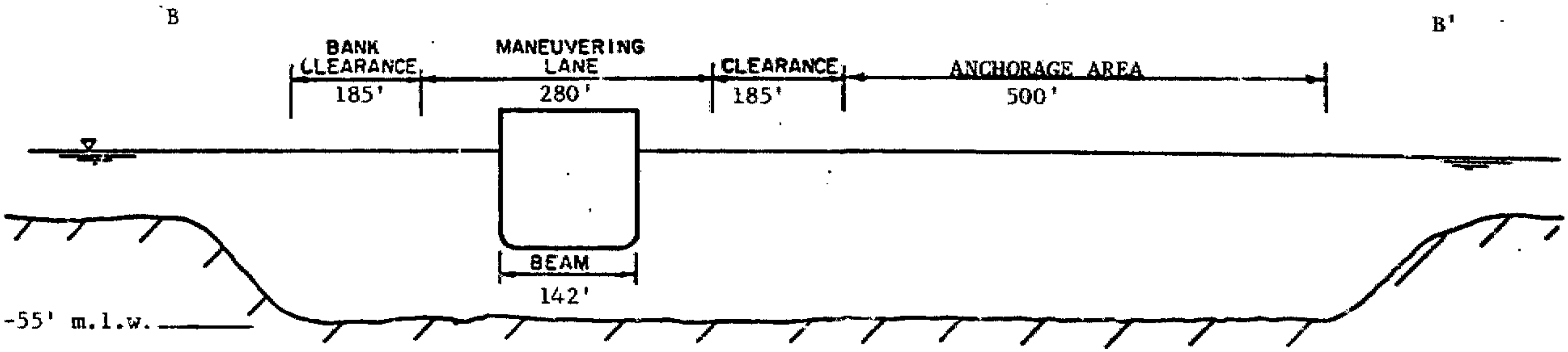


FIGURE E-8 UPPER MAIN BAY CHANNEL AND ANCHORAGE AREA
(RE: FIGURE E-3, SECTION BB')

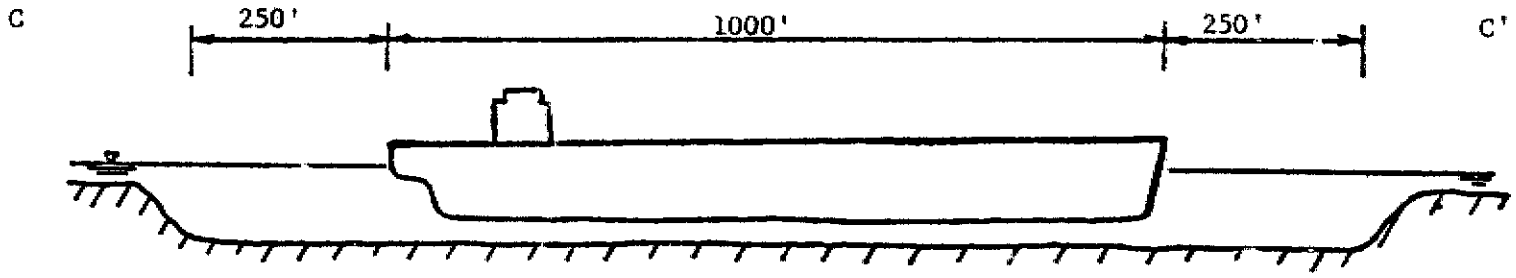
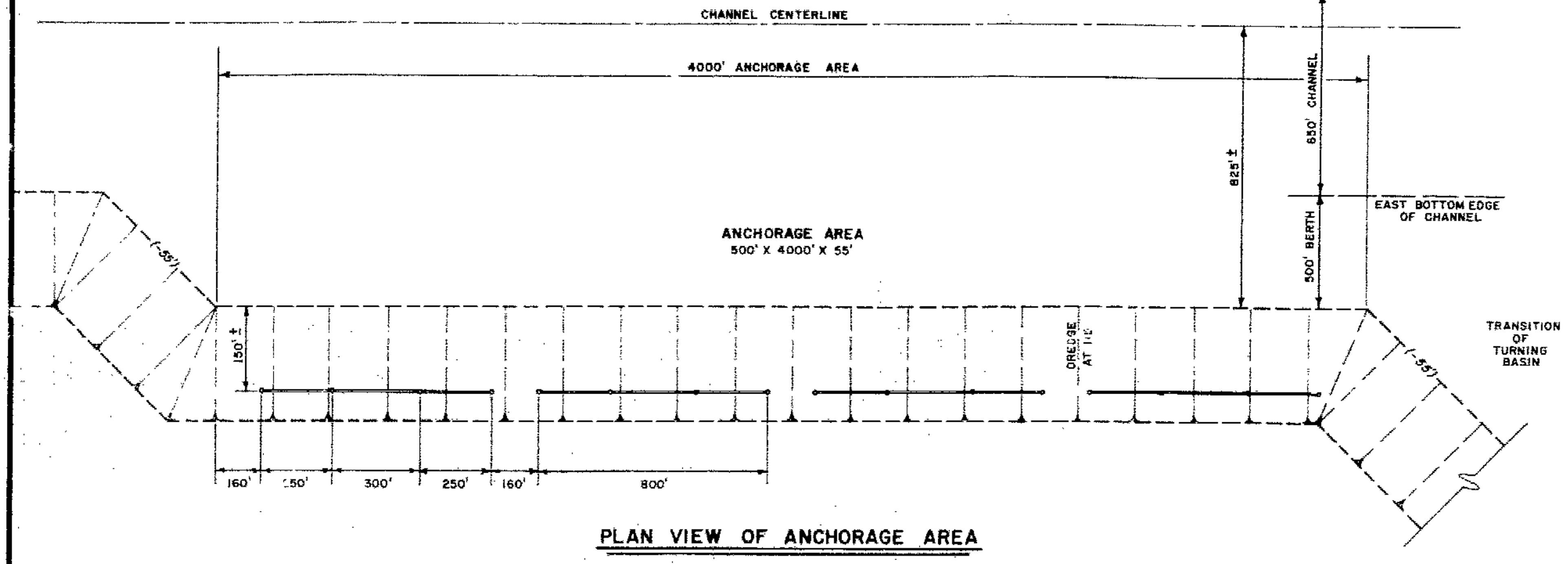
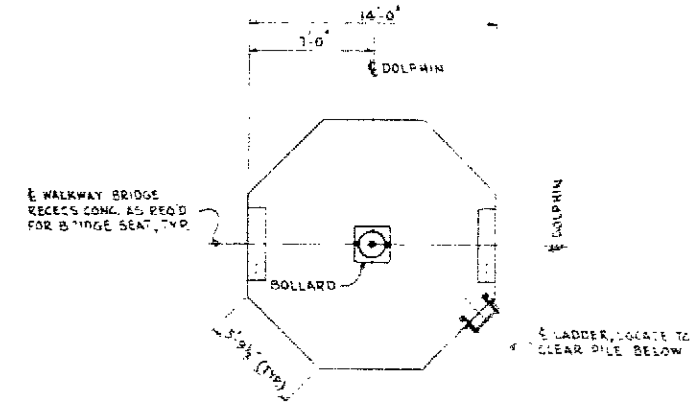


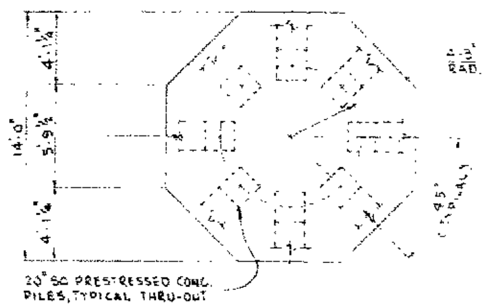
FIGURE E-9 TURNING BASIN
(RE: FIGURE E-3, SECTION CC')



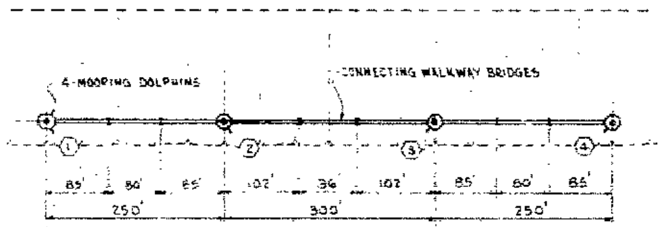
PLAN VIEW OF ANCHORAGE AREA
NOT TO SCALE



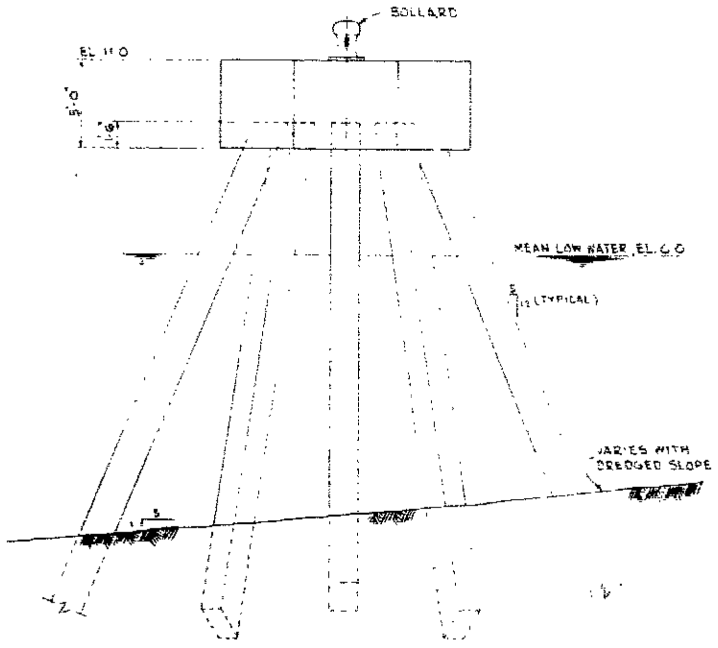
PLAN AT TOP OF CAP



PLAN OF CAP AT TOP OF PILES

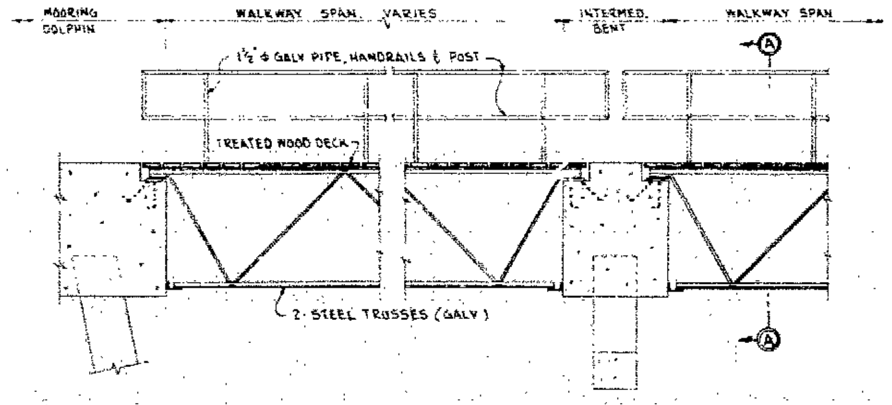


DETAIL OF TYPICAL MOORING FACILITY
NOT TO SCALE

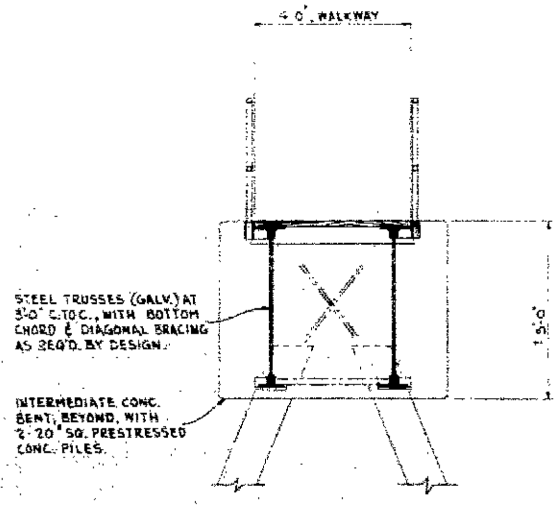


ELEVATION

TYPICAL MOORING DOLPHINS
SCALE: ¼" = 1'-0"



TYPICAL WALKWAY BRIDGE SPAN
SCALE: 3/16" = 1'-0"



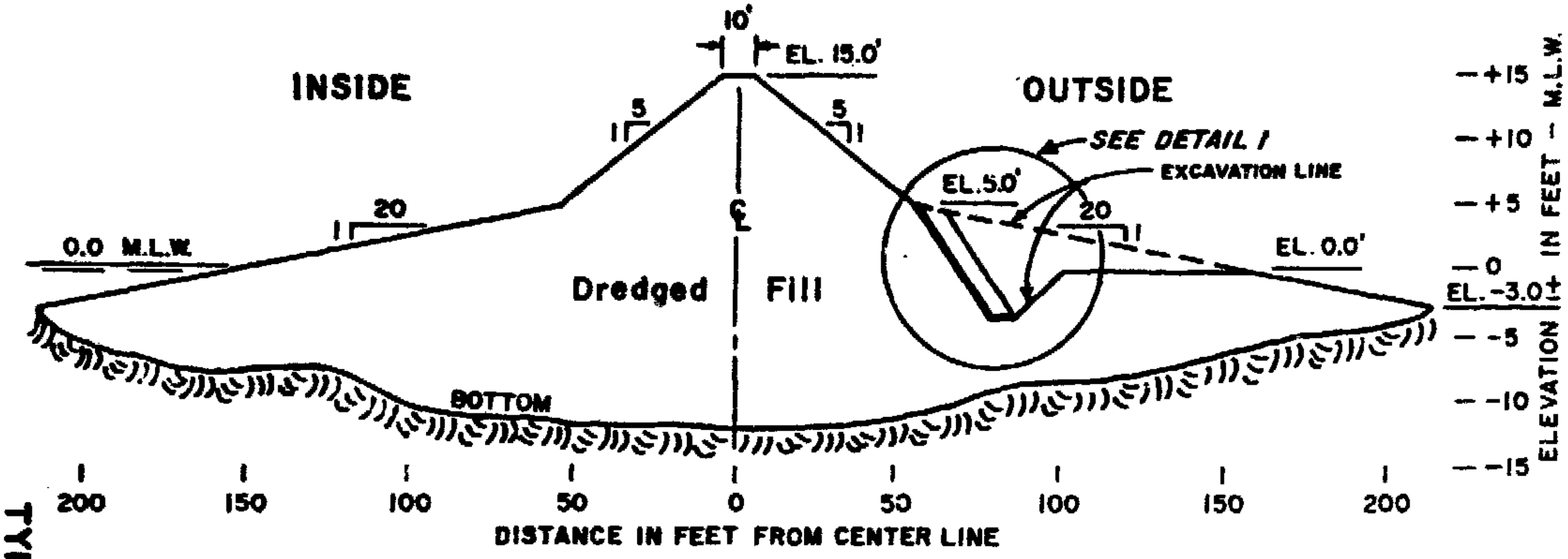
SECTION "A-A"
SCALE: ½" = 1'-0"

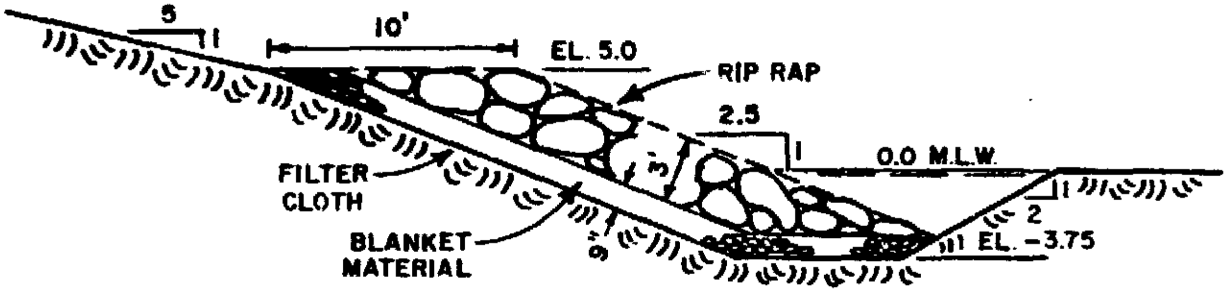
MOBILE HARBOR, ALABAMA
ANCHORAGE DETAILS
FIGURE E-10

BAY DISPOSAL AREA

19. The dikes to contain the "new work" dredged material from the upper bay channel will be constructed of high content sand material pumped to an approximate fill elevation of +5 feet, m.l.w., with slopes of 1 vertical to 20 horizontal. The next stage would be to construct from the hydraulic fill a dike section from +5 to +17.5 feet, m.l.w., with a crown width of 10 feet and side slopes of 1 vertical to 5 horizontal. The southern portion of the disposal area will have similar dikes constructed to an elevation of +15 feet, m.l.w. This lower portion of the disposal area will contain the soft new work material that is not suitable for development. Above mean high water and the wave wash area the dike slopes will be stabilized with grass. Those areas exposed to high energy waves will be armored with riprap. The new work material from the upper 7.4 miles of channel (39.6 million cubic yeards) would be used to construct the dikes for the disposal area and fill approximately the northern 61 percent of the Brookley expansion area. This would provide 1,047 acres of fast land to an elevation approximately + 17.5 feet, m.l.w. The remainder of the fill area will accommodate approximately 24 million cubic yards of soft new work material from the next 6 miles of channel down to the intersection of the Theodore channel. Figure E-3 illustrates the considered disposal area and other upper harbor features. Figure E-11 shows a typical dike cross-section.

20. The design assumptions for sizing the disposal area are based on minimal drying techniques for management of surface water. It is assumed that two unit volumes of space in the disposal area will contain three unit volumes of institu dredged soft new work material. The new work sand will occupy one unit of storage for one unit of dredged material and the consolidated clays from the upper channel are assumed to swell approximately 25 percent. The consolidation of underlying sediment was assumed to equal the swell of the firm new





DETAIL 1

NOT TO SCALE

TYPICAL DIKE SECTION

Figure E-11

work material; therefore, one unit volume of consolidated clay dredged material is assumed to occupy one unit volume of storage.

CONSTRUCTION

21. Construction would be by hydraulic cutterhead dredge in Mobile Bay and by hopper dredge in the gulf entrance channel. In the upper bay, north of the authorized Theodore channel, all the dredged new work material will be excavated by a cutterhead dredge and transported by pipeline to the diked Brookley disposal area. The dredged new work material from the lower bay will be excavated by a modified cutterhead dredge and transported by dump scows to the gulf. The dredged new work material from the lower 8,000 feet of the main bay channel and the entrance channel will be dredged by hopper dredge and placed in the gulf. Application of the various techniques to the different channel sections was determined on the basis of equivalent costs and natural channel divides.

22. The total dredging should take about seven years, utilizing one 30 inch hydraulic pipeline type dredge in the upper bay, one modified 27 inch hydraulic dredge with dump scows and towboats for the area between the Theodore channel and the lower bay, and one hopper dredge for the entrance channel and the lower 8,000 feet of bay channel. The dredging should be staged so benefits of the incrementally deepened project would be realized during the construction period. These benefits, however, have not been addressed in the survey study analysis. No dredging would be performed within 100 feet of any established or proposed harbor line, pier, wharf, or other structure. Design, location and construction of the disposal site have considered guidelines established for implementation of Section 404b of PL 92-500 and Section 103 of PL-532. However, complete evaluations in terms of these requirements cannot be accomplished prior to preconstruction planning.

23 The 27 inch cutterhead dredge will be modified by lowering the pump on the dredge ladder near the cutterhead to obtain greater densities in the dredged effluent and better economics from the barging operation. Also, the dredge will be modified to discharge into dump scows at a production rate of 2500 cubic yards per hour insitu. It is estimated a fleet of 8 tow boats (750 hp) and 16 (3,000 cubic yard) dump scows would be required to transport the new work dredged material from the lower main bay channel to the gulf disposal site without delaying dredging operations. Through utilization of the above techniques, the effluent was assumed to have a 35 percent insitu solids consistency thereby creating an effective barge capacity of 1,050 cubic yards each.

24. Data on insitu densities that provided the basis for the foregoing assumptions and resulting cost estimates are summarized in table E-1.

TABLE E-1
DENSITY OF MATERIAL TO BE DREDGED

New Work	Grams/Liter
Upper Bay	1,770
Lower Bay	1,440
Entrance Channel (Sand)	2,000
Maintenance	
Upper Bay Lower Bay	1,280
Entrance Channel (Sand)	2,000

OPERATION AND MAINTENANCE

25. Maintenance of the existing project consists of redredging the channel to authorized depths as often as needed, which is approximately once every two years.

26. Estimates for increased maintenance with the selected plan were based upon records of maintenance required for the existing and prior channels. Data was extracted from annual reports on the Mobile Bay channel and Mobile entrance channel for maintenance dredging from 1939 to 1975. Maintenance was lower during the period of 1955 to 1965 due to new work construction, therefore, this period of record was deleted from the analysis. The periods 1939 to 1955 and 1965 to 1975 were chosen as representative years of typical maintenance operations. Table E-2 shows the recorded historical annual dredging rates.

TABLE E-2
ANNUAL DREDGING RATES (cubic yards)

Year	Entrance Channel	Bay Channel
1939-1955	211,332	3,654,888
1956-1965	53,387	2,503,280
1966-1975	264,216	3,824,071

27. A comparison of shoaling rates with the increases in channel cross-sectional perimeters was made from the historical data. It was found that the increases in maintenance did not directly correlate with the increased cross-sectional perimeters. For an increase in the bay channel perimeter of 35 percent (enlargement of 32- x 300-foot to 40- x 400-foot channel) the annual maintenance increased 5 percent, and for an increase in the entrance channel perimeter of 35 percent the annual maintenance increased 25 percent. However, the increase in the entrance channel was considered to be attributed more to the increase in channel length than the increase in channel perimeter. On the basis of these historical observations, a curve was constructed to proportionally predict future maintenance of the channels as provided by the selected plan. These additional annual maintenance quantities that would be expected after construction of the selected plan are shown in table E-3.

TABLE E-3

ADDITIONAL ANNUAL MAINTENANCE DREDGING
(cubic yards)

Channel Reach	Present Quantities	Additional Quantities	Total
Main Bay	3,824,071	229,444	4,053,515
Entrance	264,216	474,516	738,732
Totals	4,088,287	703,960	4,792,247

28. The disposal method presently used in maintenance of the existing Mobile Harbor channel consists of discharging the material dredged by pipeline dredge in open water along both sides of the main channel in the bay and placing the material from the Mobile River channel in diked upland areas and transporting the material dredged by hopper dredge to an EPA interim approved disposal area in the Gulf of Mexico just south of Dauphin Island. With the selected plan this practice will be modified in that all of the upper bay channel and the lower bay channel dredged maintenance material will be placed in a gulf disposal site. The increased costs for maintenance of the existing project has not been charged against the benefits of the selected plan since with or without implementing the selected plan,the disposal method may change and the existing project can easily provide the economic justification of modifying the present maintenance disposal method. Based on available data discussed in detail in Section D, the gulf disposal alternative would create less adverse environmental impacts than continued open water disposal in the bay.

29. During the seven year construction period shoaling would continue in the channel. Routine maintenance operations would be scheduled to insure authorized depths by the end of new construction. In the upper bay the additional maintenance cost during construction due to the larger channel (average 40,000 cubic yards/year) is amortized over

the 50-year period of analysis for the selected plan and charged as a Federal annual charge. In the lower bay the additional maintenance cost during construction for the main channel (average 75,000 cubic yards/year) and entrance channel (average 237,0[illegible] cubic yards/year) were likewise charged as a Federal annual charge of the considered plan.

PRECONSTRUCTION PLANNING

30. Due to existing hydraulic model data veing based on a plan with a 50-foot channel, additional model tests would be conducted for the selected plan to determine the effects of the 55-foot deep channel and required mechanisms for offsetting any significant adverse affects of the enlarged channel. The model study could also include tests for other structural modifications, such as removing the existing dredged material ridges from along the upper main channel, to determine if they would improve water quality conditions in the bay and/or offset changes caused by the enlarged channel.

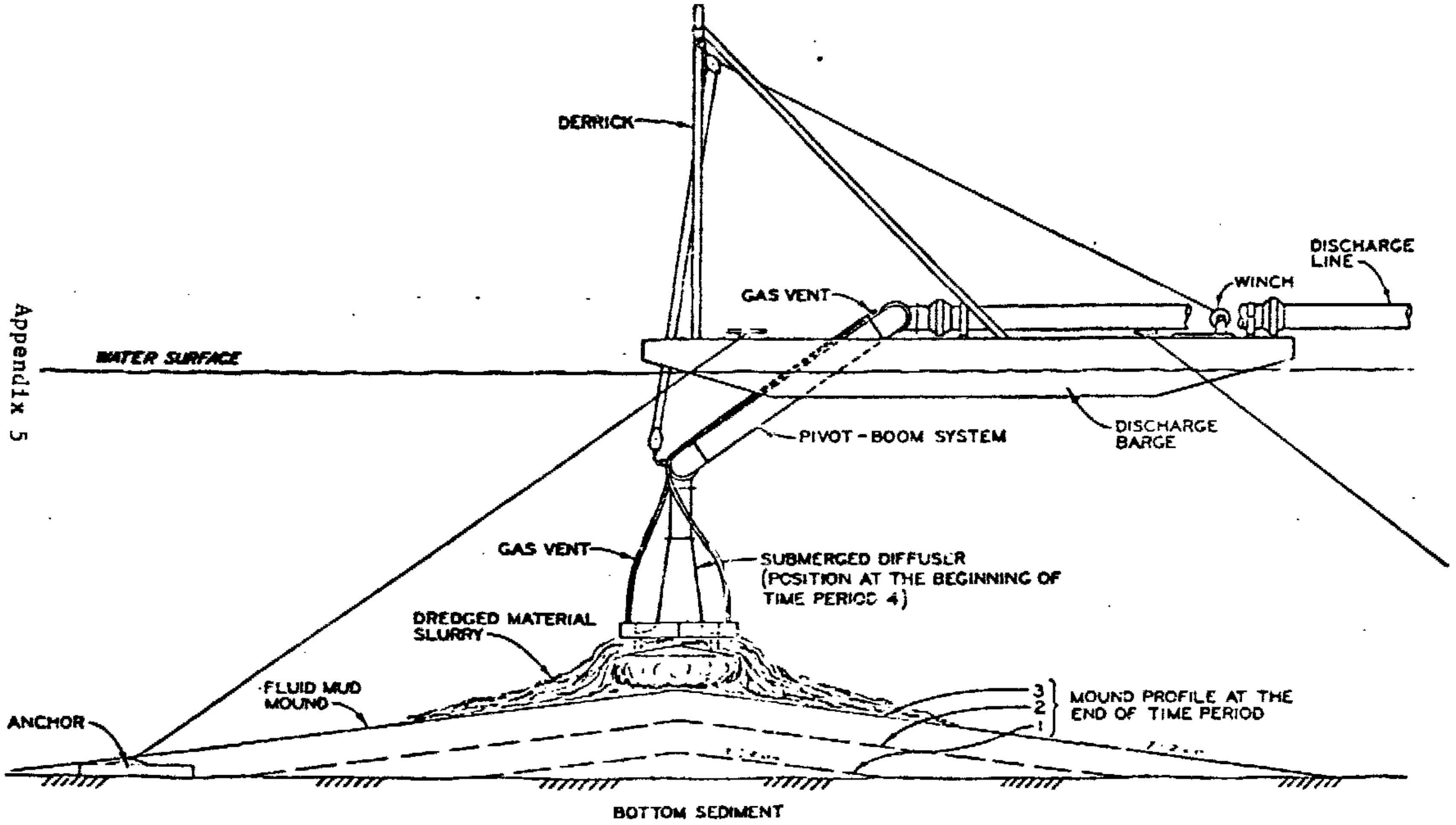
31. A usage study will be conducted for Mobile Bay to define the biological productivity of the bay bottom, gather water quality data, and predict recreational potential for the variouw sections of the bay. The results of the study will be used to further assess the impact of constructing the Brookley fill area. Other environmental studies will be conducted in the considered gulf disposal sites to include additional biological sampling, analysis of the bottom sediments, and water-quality data collection.

32. A cultural resources survey will be conducted on land areas adjacent to Brookley that would be altered by the selected plan. The survey, performed prior to any construction, would result in recommendations for the preservation or mitigation of cultural resources found to be threatened. A magnetometer survey of underwater areas would be included as part of the survey or cultural resources.

33. Justified mitigation measures would be considered for any permanent losses which might be identified in the selected plan and adopted disposal method. Also, the feasibility of establishing wetland areas as provided under Section 150 of PL 94-587, will be evaluated.

34. In response to long standing concern over the potential impact of suspended solids and turbidity associated with dredged material disposal one task within the Corps of Engineers Dredged Material Research Program, conducted at the Waterways Experiment Station, was to evaluate methods for controlling the dispersion of dredged material. Results of the studies indicate that the most promising method for controlling water column turbidity and mud flows involves modifying the pipeline configuration at the discharge point. It was found that the amount of water column turbidity generated by a submerged discharge decrease as the angle of the pipeline discharge increase from 0 to 90 degrees. By adding a 15 degree conical section at the end of the 90 degree elbow, the effective velocity of the discharged slurry can be reduced by a factor of 2 or 3 (without affecting the dredge's production rate). This decreases the levels of water-column turbidity and increases the mounding tendency of the fluid mud. Laboratory test involving the control of dredged material dispersion have resulted in the development of a submerged diffuser system (figure E-12). Although the diffuser has not been field tested, it has a great deal of potential for most effectively eliminating turbidity in the water column and maximizing the mounding tendency of the discharged dredged material, thereby minimizing the aerial coverage of the fluid mud flow. The slurry remains in the pipeline/diffuser until it is discharged at a low velocity near the bottom, thus, preventing any interaction of the

slurry with the water column above the diffuser. This eliminates water column turbidity as well as any depression of the dissolved oxygen levels in the water column. A system for control of dredged material dispersions would be environmentally beneficially for the open water dike construction in the upper bay, and will be considered further during Place I studies.



SUBMERGED DIFFUSER
DISPOSAL SYSTEM

Figure E-12

PLAN IMPLEMENTATION

35. Review of the selected overall plan indicates several separable features that can be incrementally justified economically, and are not dependent upon further model studies for adequate impact assessment. These features can be implemented at an early stage without suboptimizing or binding future action to the framework plan. These features are identified and discussed in the following paragraphs.

36. The selected plan presents a comprehensive guide for development of Mobile Harbor over the next 15 years. In order to maintain efficiency and safety, separable early implementation features that should be considered include channel widening in the upper bay, a turning and anchorage area at the head of the bay, a passing lane in the central area of the bay and several mitigating features to improve water circulation in the bay.

CHANNEL WIDENING

37. The upper portion of the main bay channel as identified in figure E-3 is subjected to adverse conditions that create steerage difficulties for vessels navigating this reach of channel. The projected commodity movements will also add to the problems encountered in this area by generating more barge and deep-draft traffic, resulting in more navigation delays.

38. Widening the existing 40-by 400-foot channel from beacon 74 to buoy 84 to 650 feet would releave these problems. This action would require dredging of approximately 6.7 million cubic yards of new work material. The relatively good structural material to be dredged from the channel widening would be used to dike and fill a part of the area adjacent to the Brookley mainland.

TURNING AND ANCHORAGE AREAS

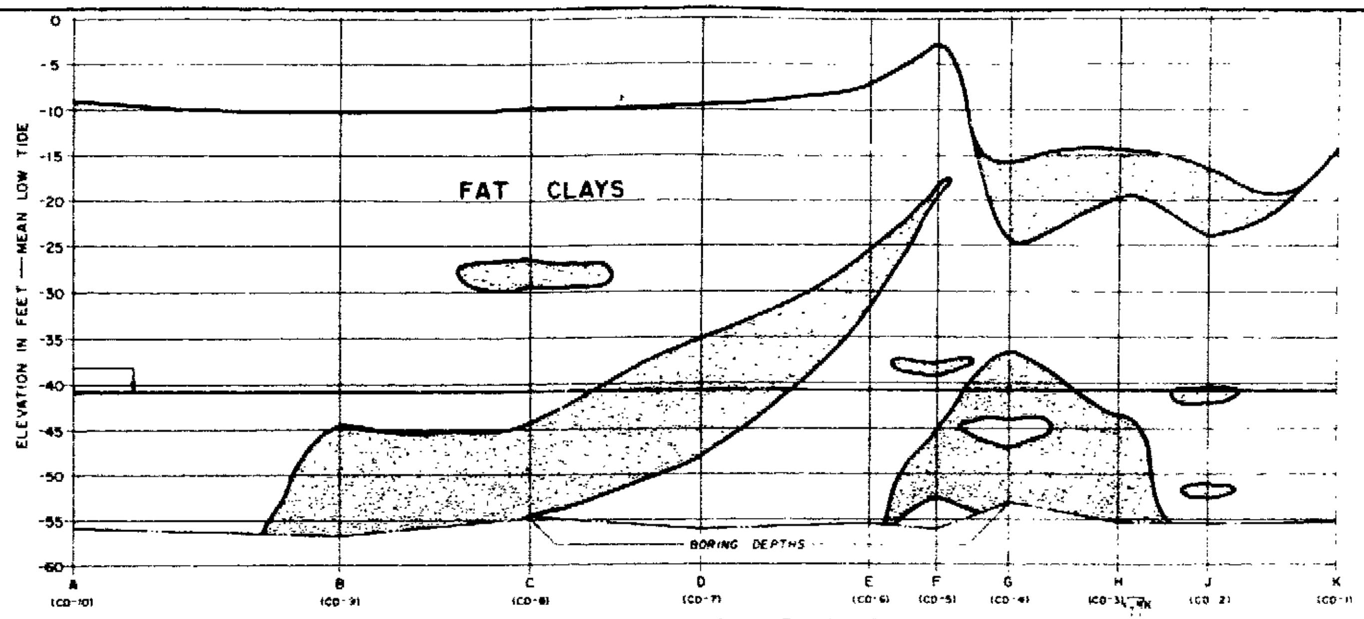
39. The efficient operation of the Port of Mobile, as pointed out in the Section C, Appendix 5, on problems and needs, also depends on providing adequate turning and anchorage basins near the mouth of Mobile River. The turning basin would require dredging of approximately 2.4 million cubic yards of new work material. The anchorage basin would require dredging of approximately 2.9 million cubic yards of new work material. This material would be deposited in the Brookley fill area to create a portion of the new development area.

PASSING LANE

40. Constructing a passing lane about mid-way along the main bay channel will significantly reduce the delays of larger vessels entering and leaving Mobile Harbor and the Theodore Industrial area. The passing lane can be constructed adjacent to the east side of the existing channel to a bottom width compatible to the selected plan for a distance of about two miles without sacrificing any economics of future development. The increment of development would require dredging of about 2 million cubic yards of new work material. The material would be pumped by hydraulic dredge into the island presently constructed to contain material excavated from the Theodore Ship Channel.

DREDGED MATERIAL DISPOSAL

41. Approximately 12 million cubic yards of new work dredged material will be excavated from the upper harbor early implementation features. This material will be suitable to construct the dikes of the Brookley Expansion Area (5 million cubic yards) and provide 7 million cubic yards of suitable fill in the northern end for port development. This stage of development will provide about 341 acres of fast land to elevation +17.5 m.l.w.



THEODORE CHANNEL MATERIAL PROFILE

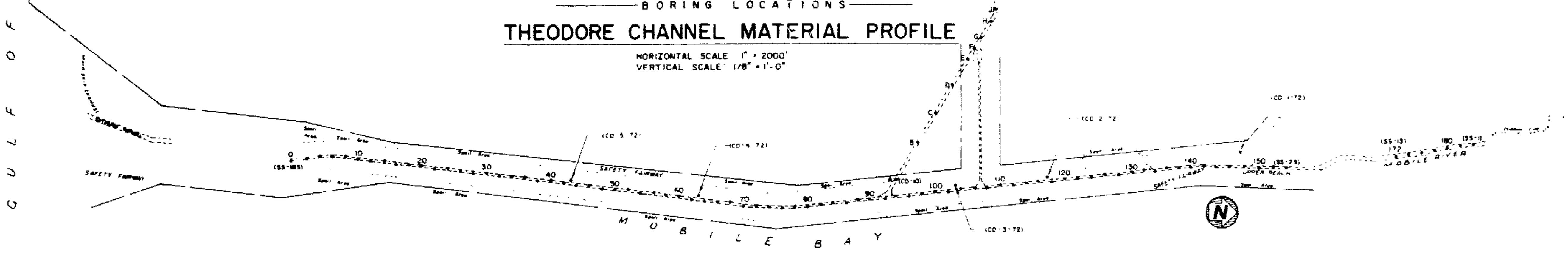
HORIZONTAL SCALE 1" = 2000'
VERTICAL SCALE 1/8" = 1'-0"

GENERAL NOTES

1 DATA SOURCE CORPS OF ENGINEERS LAYOUT AND LOG OF BORINGS
MOBILE BAY - FILE NO D-13-2-153 THRU 161
MOBILE RIVER FILE NO D-13 2-127
THEODORE - FILE NO D 13 2 225

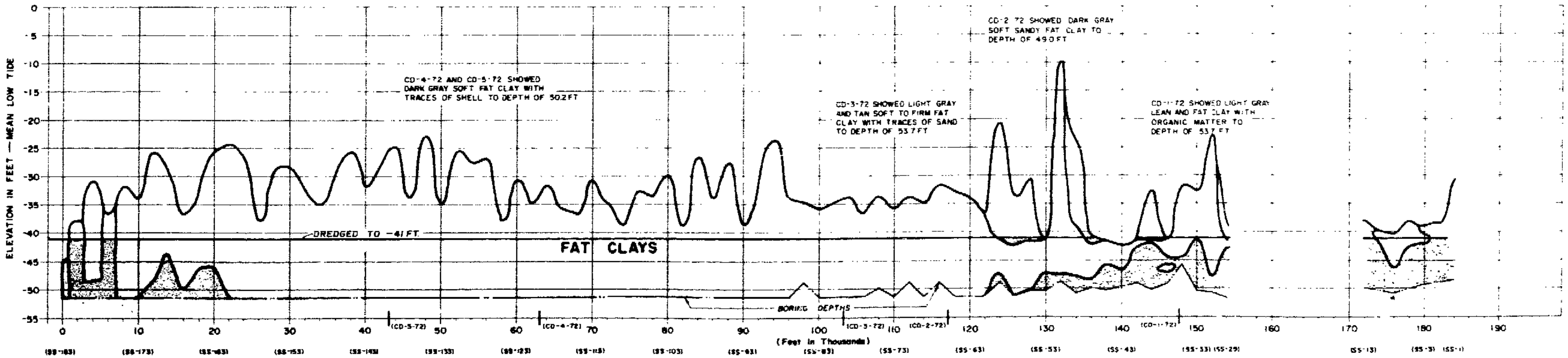
2 ALL NUMBERS IN PARENTHESIS, (SS 183) REFER TO DATA SOURCE DWGS

3 1972 BORING DATA SHOWN BY PREFIX "CD"



PLAN SHOWING BORING LOCATIONS

SCALE 0.9" = 6000'



CD-4-72 AND CD-5-72 SHOWED DARK GRAY SOFT FAT CLAY WITH TRACES OF SHELL TO DEPTH OF 50.2 FT

CD-3-72 SHOWED LIGHT GRAY AND TAN SOFT TO FIRM FAT CLAY WITH TRACES OF SAND TO DEPTH OF 53.7 FT

CD-2-72 SHOWED DARK GRAY SOFT SANDY FAT CLAY TO DEPTH OF 49.0 FT

CD-1-72 SHOWED LIGHT GRAY LEAN AND FAT CLAY WITH ORGANIC MATTER TO DEPTH OF 53.7 FT

LEGEND

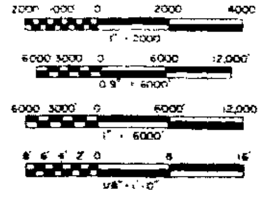
☐ INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS

▨ LIGHT MATERIAL CONTAINING SILT, FINE SAND, LEAN CLAY, AND SOME ORGANIC MATTER

MOBILE BAY CHANNEL MATERIAL PROFILE

HORIZONTAL SCALE 1" = 6000'
VERTICAL SCALE 1/8" = 1'-0"

GRAPHIC SCALES



MOBILE HARBOR, ALABAMA

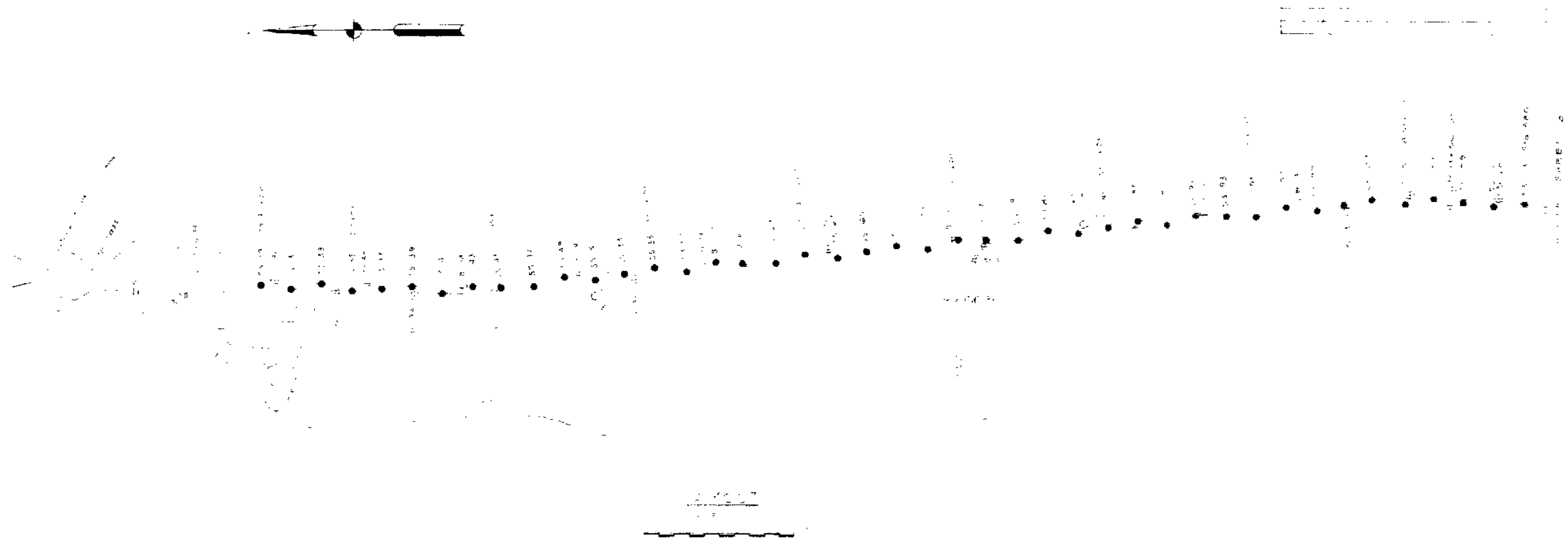
DREDGE MATERIAL
SOIL CLASSIFICATION PROFILE
AND BORING LOCATIONS

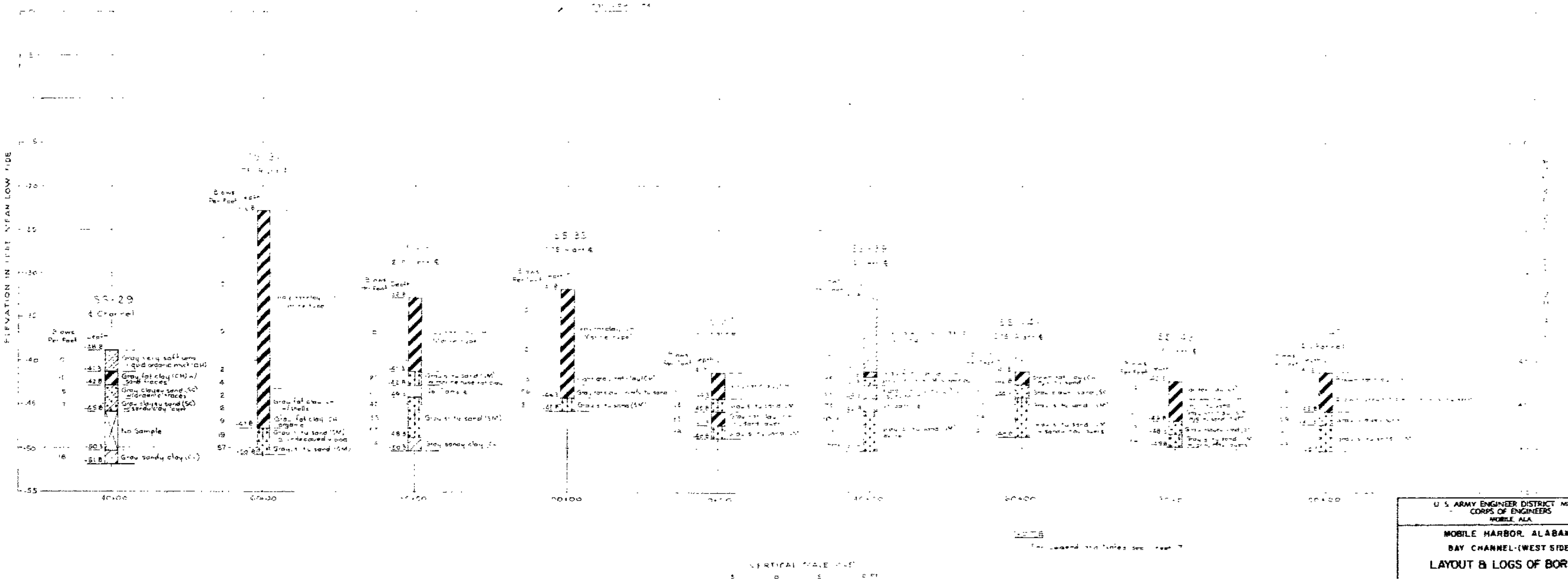
Plate E-1

ATTACHMENT E-1

LAYOUT & LOGS OF BORINGS

REVISIONS





U. S. ARMY ENGINEER DISTRICT MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)
LAYOUT & LOGS OF BORINGS

SM REF NO
SPEC NO CIVENG-01-076-64-98
SIZE
FILE NO D-13-2-153
DRAWING NO
SCALE AS SHOWN DATE MAY 1964 SHEET 3 of 13

E-1-1

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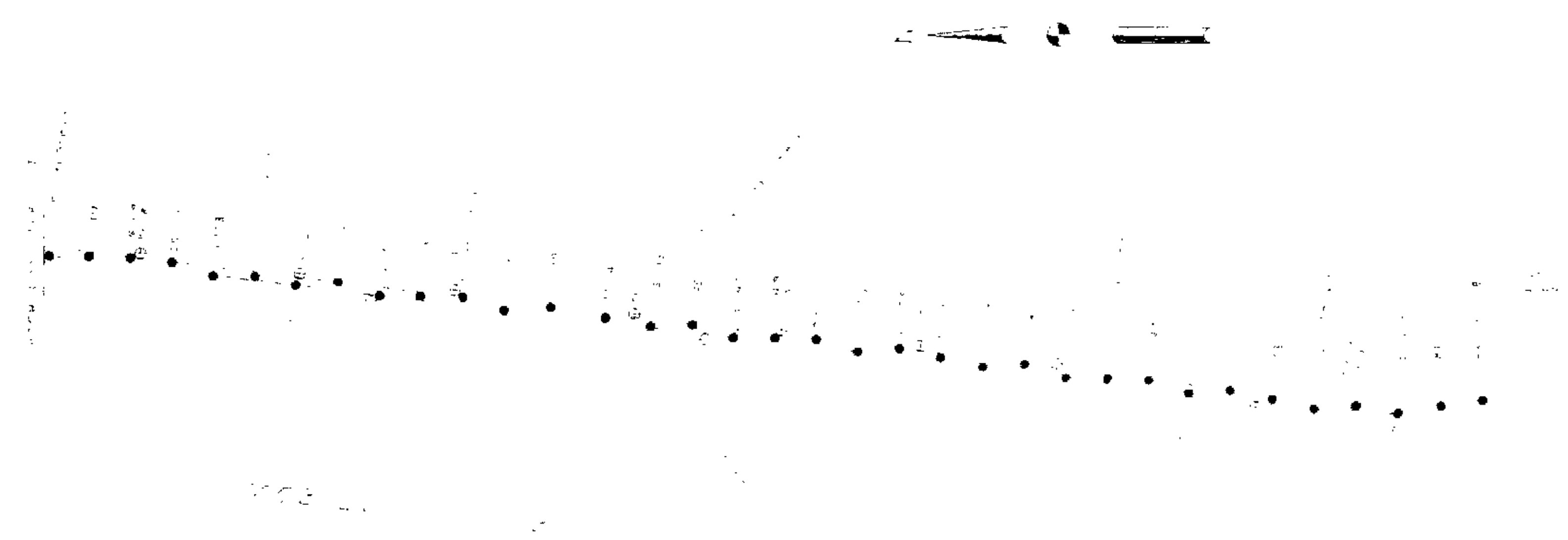

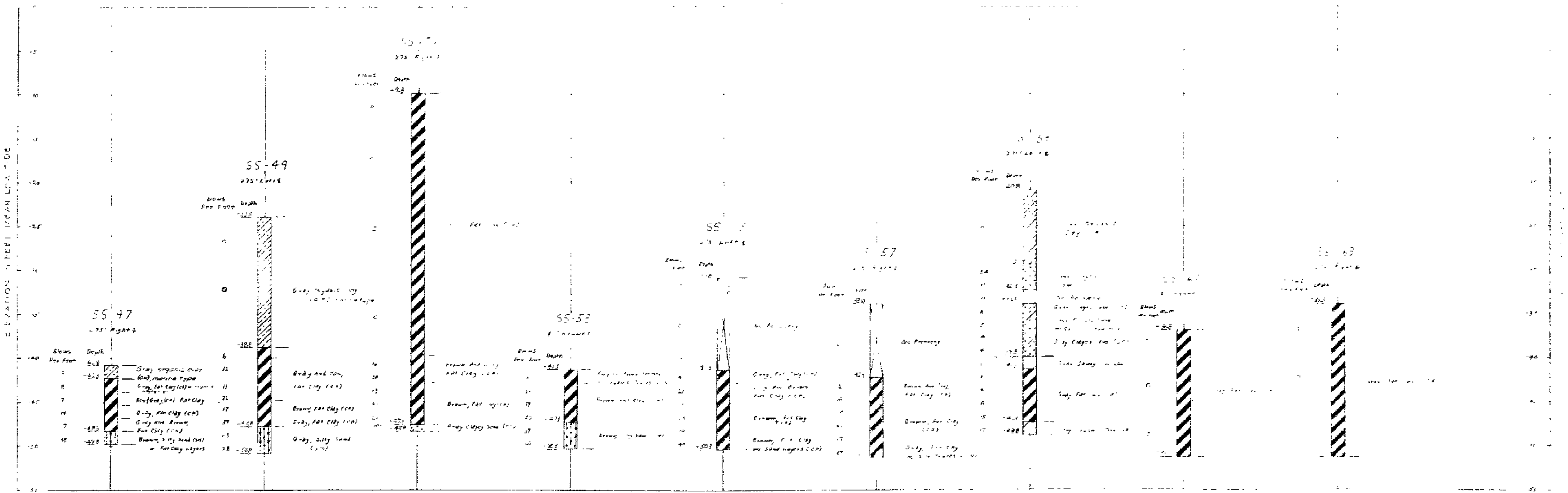

VERTICAL SCALE

NOTES
For location of Borings see Sheet 3
For Legend and Notes see Sheet

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE
LAYOUT & LOGS OF BORINGS

SH. REF. NO. SPEC. NO. FILE NO. D-13-2-154
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OF-07-64-98 DRAWING NO.
SCALE AS SHOWN DATE MAY 1964 SHEET 6 of 13

CORPS OF ENGINEERS

U. S. ARMY

REVISIONS

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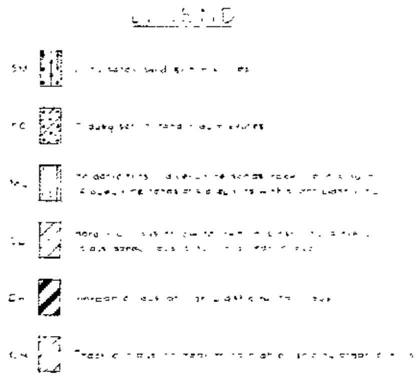

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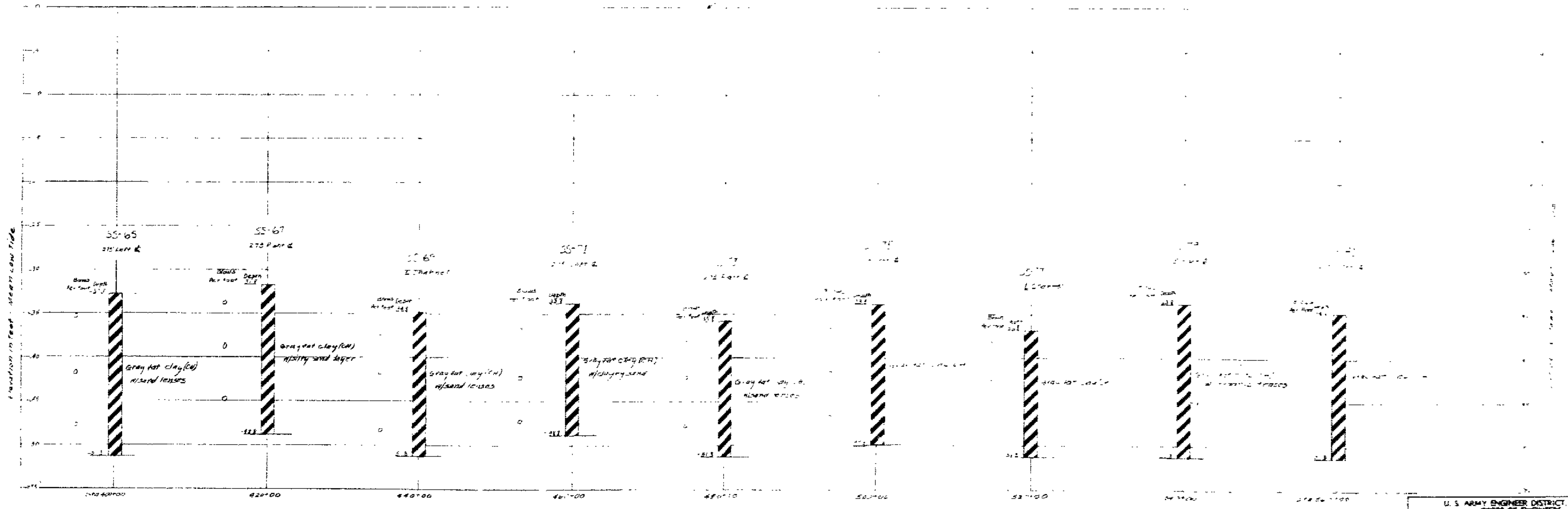


NOTE
For location of Borings see Sheet 5

VERTICAL SCALE 1"=5'

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

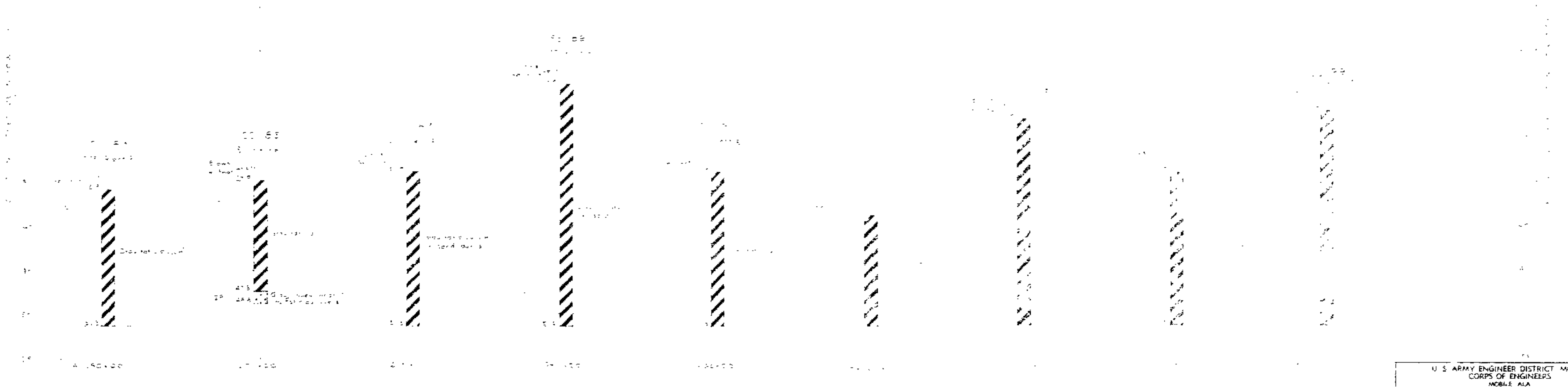
MOBILE HARBOR, ALABAMA
BAY CHANNEL, WEST SIDE
LOGS OF BORINGS

SH. REF. NO. | SPEC. NO. | SIZE | FILE NO. D-13-2-135
CIVENG - CI 078-64-98 | DRAWING NO.
SCALE | DATE MAY 1964 | SHEET 7 of 13

CORPS OF ENGINEERS

U. S. ARMY

REVISIONS



U. S. ARMY ENGINEER DISTRICT MOBILE
CORPS OF ENGINEERS
MOBILE ALA

MOBILE HARBOR, ALABAMA

BAY CHANNEL (WEST SIDE)

LOGS OF BORINGS

FILE NO D-13 2 156
CIVENG -
OI 075 64 98
AS SHOWN
MAY 1964
8 of 13

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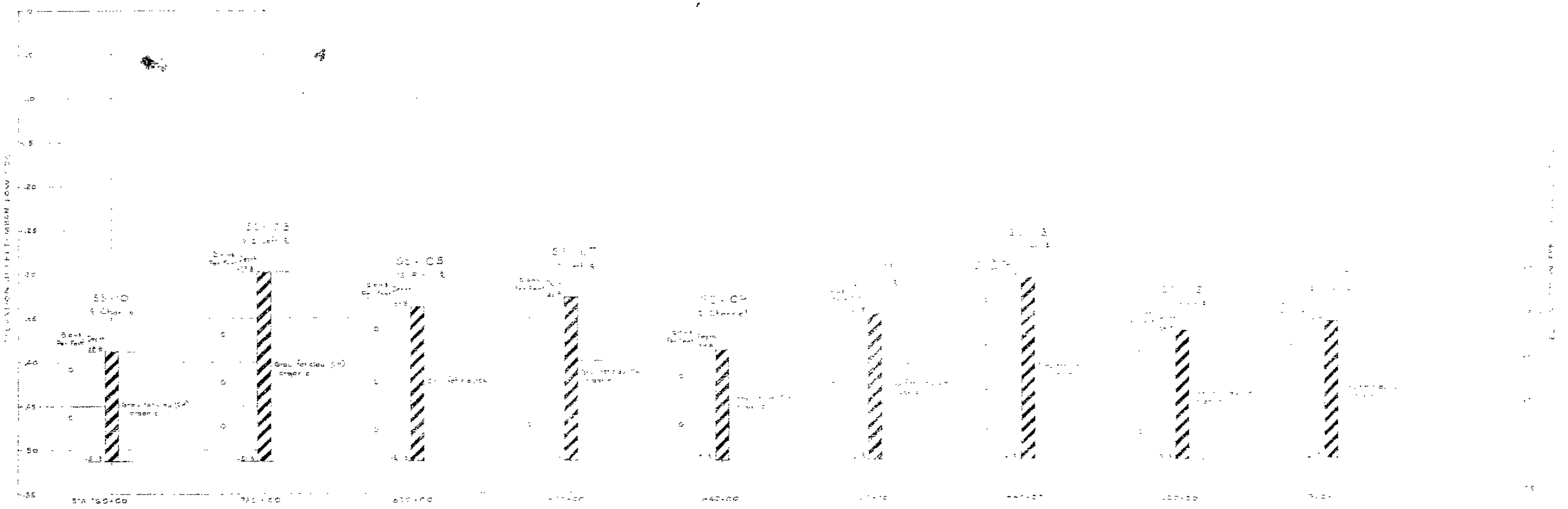

VERTICAL SCALE

NOTES:

[illegible]

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)
LOGS OF BORINGS

SH REF NO	SPEC. NO INV SER NO CIVENG - 01-078-64-98	SIZE	FILE NO D-43-2-157 DRAWING NO
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E-1-5

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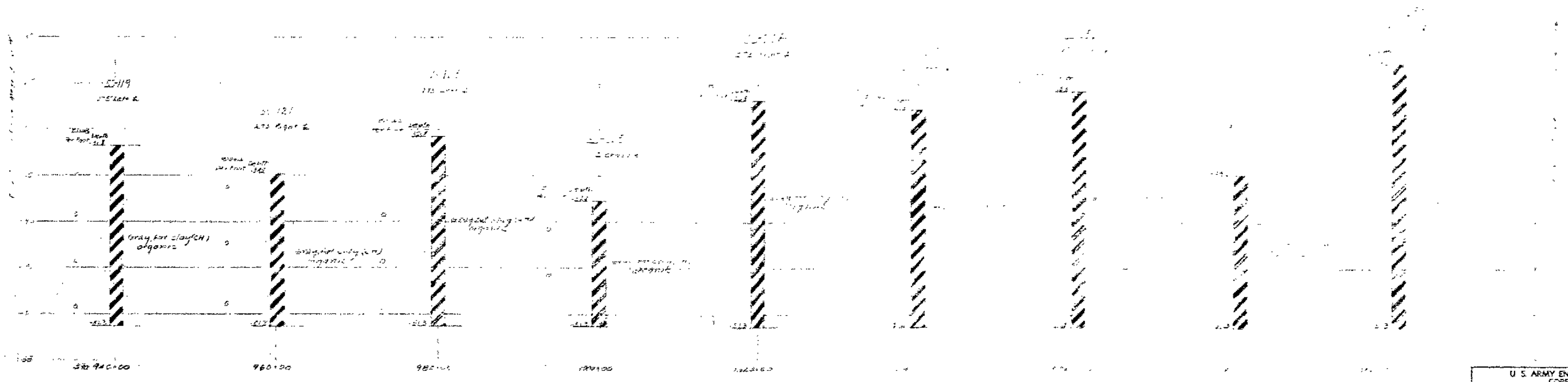

NOTES

For Location of Borings see Sheet 2
For Legend and Notes see Sheet 7

VERTICAL SCALE: 1"=5'

5 0 5 10 FT

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)
LOGS OF BORINGS

SH. REF. NO.
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INV. SER. NO.
CIVENG-
01-078-64-98
SIZE
FILE NO. D-13-2-158
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SCALE AS SHOWN
DATE MAY 1964
SHEET 10 of 13

E-1-6

REVISIONS

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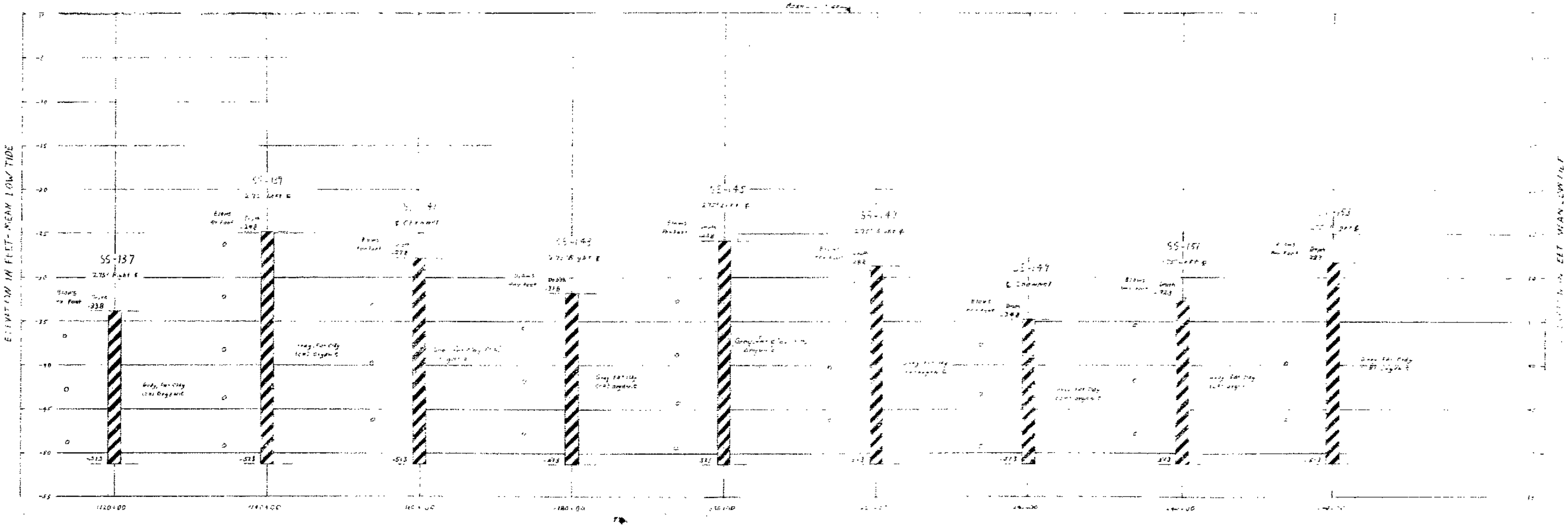

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)
LOGS OF BORINGS

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REVISIONS

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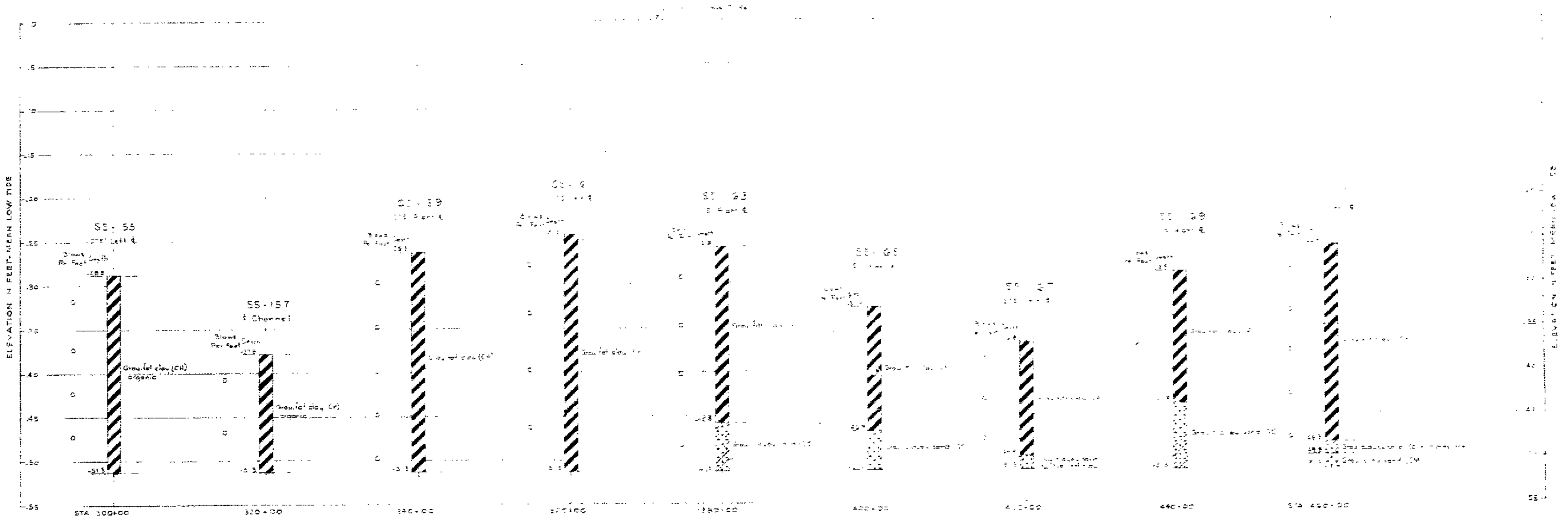

VERTICAL SCALE 1"=5'
5 0 5 10 Feet

NOTES
For Location of Borings see Sheet 6
For Legend and Notes see Sheet 7

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)
LOGS OF BORINGS

SH. REF. NO.	SPEC. NO. INV. SER. NO. CIVENG-DA-01-078-64-98	SIZE	FILE NO. D-13-2-160 DRAWING NO.
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E-1-8

REVISIONS

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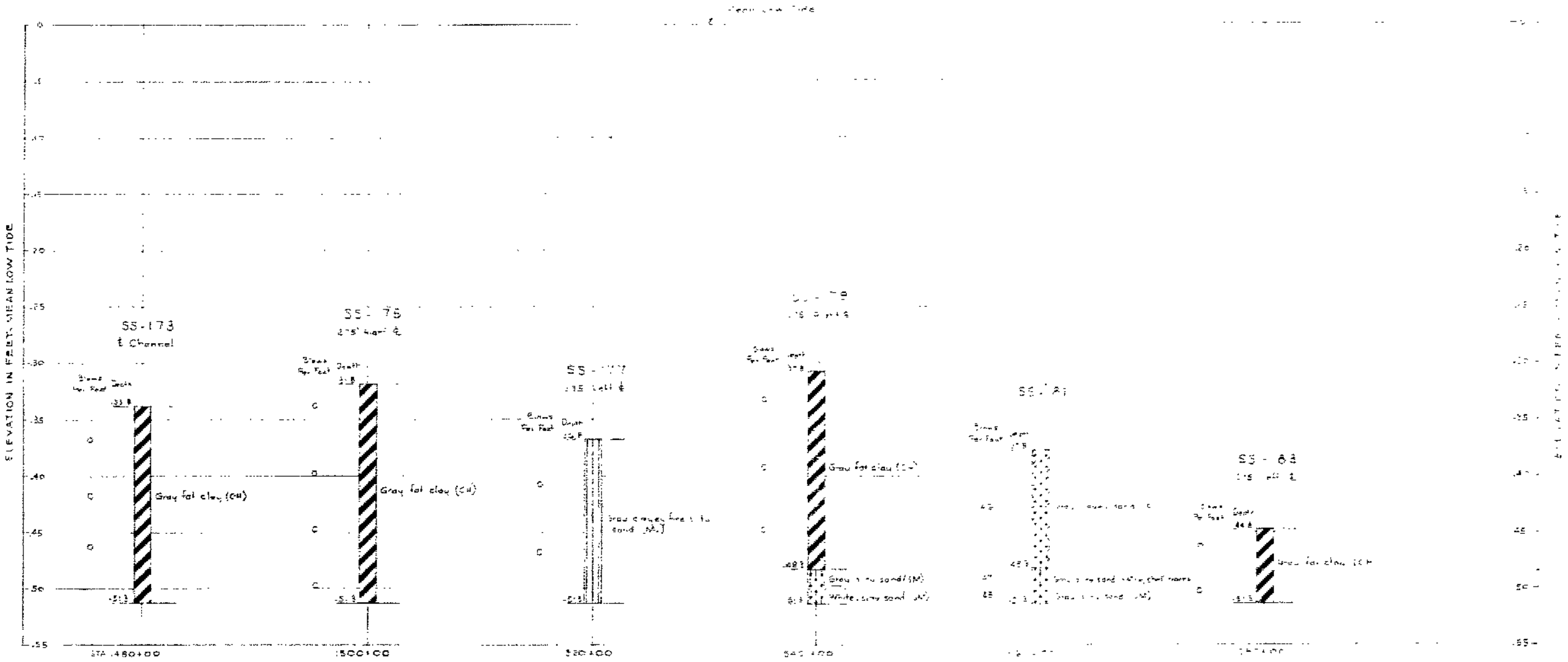

VERTICAL SCALE 1"=5'
5 0 5 10 FT

NOTES

For Layout of Borings see Sheet 6
For Legend and Notes see Sheet 7

U. S. ARMY ENGINEER DISTRICT, MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR, ALABAMA
BAY CHANNEL-(WEST SIDE)

LOGS OF BORINGS

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SPEC. NO.
INV. SER. NO.
CIVENG-
01-076-64-98
SIZE
FILE NO. D-13-2-161
DRAWING NO.
SCALE AS SHOWN
DATE MAY 1964
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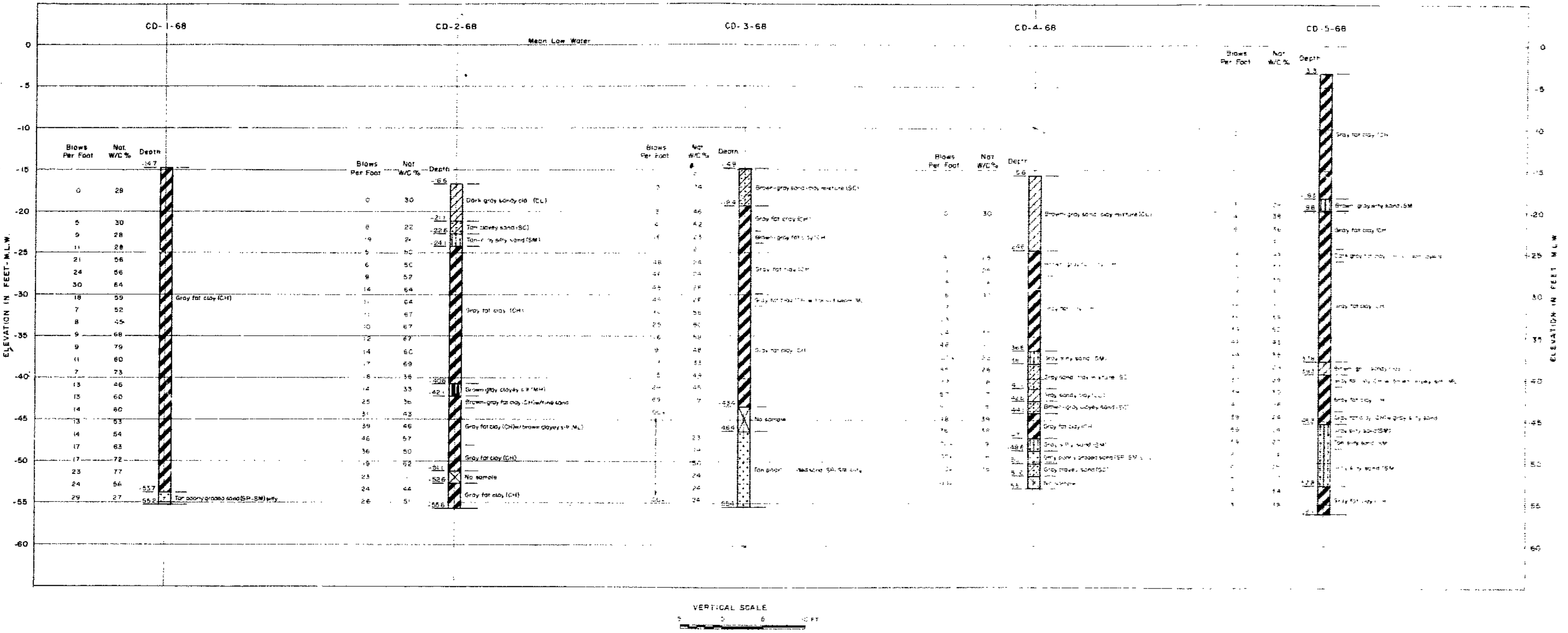
E-1-9

CORPS OF ENGINEERS **U. S. ARMY**



LEGEND

SP ⁙	Poorly graded sands or gravelly sands, little or no fines
SM ▥	Silty sands, sand-silt mixtures
SC ▨	Clayey sands, sand-clay mixtures
CL ▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
CH ▨	Inorganic clays of high plasticity, fat clays
OH ▨	Organic clays of medium to high plasticity, organic silts
Nat. W/C%	Natural water content percent

NOTES

Boring logs shown on these sheets shall not be copied or altered.

The natural water content shown is expressed as a percentage of the dry weight of the soil.

While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local minor variations in characteristics of the subsurface materials of the region are anticipated and, if encountered, such variations will not be considered as differing materially from the description shown with the logs.

Soils are classified in accordance with the Unified Soil Classification System, Technical Memorandum No. 3-357, dated 20 March 1953.

Driving resistances are expressed as blows per foot. These are determined with a standard split spoon sampler ($1\frac{3}{8}$" I.D., 2" O.D.) and a 140 lb driving hammer with a 30" drop.

NOTE

For location of borings see Plate No. E-1

U. S. ARMY ENGINEER DISTRICT MOBILE
CORPS OF ENGINEERS
MOBILE, ALA.

MOBILE HARBOR
THEODORE INDUSTRIAL PARK SHIP CHANNEL
PLAN OF IMPROVEMENT
LOGS OF BORINGS

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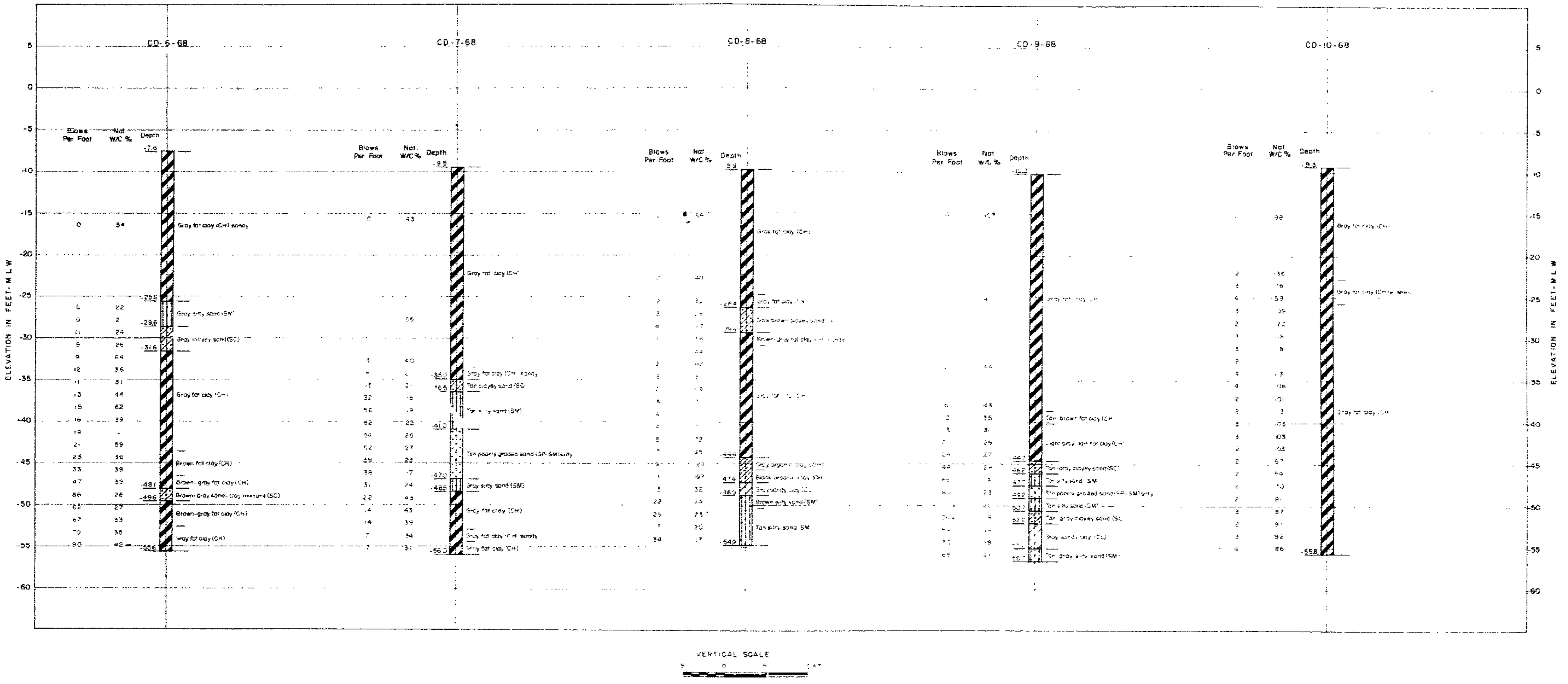
DRAWING NO.
SCALE DATE DEC. 1975 SHEET 13 of 18

1E-1-1C



NOTES

For location of borings see Plate No *E-1*

For legend and notes see *E-1-10*

U S ARMY ENGINEER DISTRICT MOBILE
CORPS OF ENGINEERS
MOBILE ALA

MOBILE HARBOR
THEODORE INDUSTRIAL PARK SHIP CHANNEL
PLAN OF IMPROVEMENT

LOGS OF BORINGS

SH REF NO SPEC NO SIZE FILE NO D-13-2-224
DRAWING NO
SCALE DATE DEC. 1975 SHEET 14 OF 16

SECTION F

ECONOMICS OF SELECTED PLAN

SECTION F

ECONOMICS OF SELECTED PLAN

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TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

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LIST OF TABLES (CONT'D)

LIST OF TABLES (CONT'D)

LIST OF TABLES (CONT'D)

LIST OF FIGURES

LIST OF PLATES

LIST OF ATTACHMENTS

SECTION F

ECONOMICS OF SELECTED PLAN

INTRODUCTION

1. This section of the report contains estimates of first costs, annual charges, benefits and other supporting data pertaining to the economics of the selected plan for enlargement of the Mobile Harbor ship channel. First cost and annual charges presented herein are based upon the selected plan as evaluated and defined previously in Sections D and E of this Appendix, respectively. The selected plan consists essentially of deepening the project from the presently authorized 40-foot depth in the main bay channel to 55 feet, widening it from the authorized 400-foot width to 550 feet, deepening the gulf entrance channel from the presently authorized 42-foot depth to 57 feet, and widening it from the authorized 600-foot width to 700 feet. A range of channel widths and depths was investigated for the selected plan as well as for all alternatives that were given detailed consideration in order that the optimum level of development could be identified.

2. A 40-foot ship channel into the Theodore Industrial Park has been authorized and is under construction. The economic feasibility for the expansion of the authorized channel, in conjunction with the overall Mobile Harbor improvement study, was investigated to determine the navigation benefits that could be realized by modifying the authorized project to a depth greater than 40 feet.

3. An investigation to determine the prospective beneficiaries of any modification of the authorized Theodore project revealed that two companies could be potential users. One of the companies indicated a probable use for a deeper channel; however, they could not give any firm commitments as to their need of a deeper channel into Theodore at this time. Based on this uncertainty as to their use of any deeper channel, they were not considered as a prospective user that would realize benefits from the expansion of the authorized Theodore segment of the existing project.

4. Another potential beneficiary of any modification of the authorized Theodore project plans to import crude oil through Theodore with further delivery to their proposed refinery by pipeline. This company has given assurances they would use a deeper channel than that presently authorized for Theodore; however, they have not completed construction of their refinery or pipeline. In view of the contingency of future benefits to this company on both the completion of their facilities and the authorized Federal improvements for Theodore, such benefits were regarded only as a potentiality at this time rather than a firm estimate.

5. Without firm prospective beneficiaries for depths in the Theodore Channel greater than those presently authorized and under construction, consideration of greater depths at this time is not warranted. Accordingly, all modifications to the existing Federal navigation project for Mobile Harbor considered herein are directed toward the main Mobile Bay ship channel and other ancillary components.

METHODOLOGY

6. The primary purpose of this section is to identify and measure the direct economic and monetary impacts the considered channel improvements would have on the transportation of products shipped through the port of Mobile by deep-draft vessels and to review the need for expanding the port facilities to handle the anticipated future tonnage. The study principally involves examining present and future commerce and vessel traffic that would move on the Mobile ship channel, review the industrial developement that will support the traffice over the projected 50-year period of economic analysis (1995-2044) and determine the monetary benefits and costs associated with channel improvements.

7. Navigation benefits and costs herein were developed for each of the channel depths investigated ranging from 45 to 60 feet at 5-foot increments. The navigation benefits, while valid for the selected plan, are applicable to all the main bay channel deepening plans of improvement

considered and are not sensitive to construction alternatives being considered, such as, dredged material disposal methods and channel widening. Land enhancement benefits presented herein are applicable to the selected plan and were computed based on the 5-foot levels of considered development.

8. A field canvass was made to interview industries presently shipping through the port, prospective shippers, steamship lines or their agents, and other shipping interests. The survey was conducted to determine what impact the enlargements of the ship channel would have on present and future commodity shipments through the port of Mobile. Information collected includes: (1) present and future volume of commerce that will be shipped through the port, (2) type of transportation service required for shipping their products, (3) origin/destination matrix or shipping patterns required for the delivery of each commodity, (4) the terminals and/or docks generally used at Mobile, (5) adequacy of terminals at the port, (6) volume of shipments per consignment normally required, and (7) other pertinent data concerning their transportation needs.

9. An economic analysis was also made to determine the historical growth in port tonnage, present and prospective commerce, and associated transportation costs and benefits. Benefits were calculated to determine the savings in transportation costs creditable to the various channel depths considered.

10. This Section documents the current commerce moving through the port and current vessel activity; identifies and evaluates the commerce that would benefit by the considered improvements; provides estimates of volume of commerce that can be expected throughout the project life (1995-2044); documents procedures in determining vessel operating costs and the resulting benefits and costs that can be expected from the plans of improvement.

11. Benefits and costs for the selected plan were derived in terms of equivalent average annual benefits and equivalent average annual charges (interest, amortization and maintenance costs). These were computed for a 50-year period of analysis and converted to an average annual basis using the current interest rate of 6 7/8 percent, applicable to all water resource projects under investigation at the time of this report. Benefits and costs reflect October 1978 prices.

12. Benefits are based on transportation savings which would result principally from the future use of larger, more economical vessels. Supplemental benefits from improvements of the project reflect savings in delay time to ships navigating the main bay channel. Land enhancement benefits also result from the creation of lands adequate for industrial or port terminal development. The total benefits derived from various considered channel depths were compared with costs for the various depths to identify the optimum depth.

13. Costs consist principally of dredging. These costs are based on current prices for maintenance dredging, updated prices for new work on prior construction for Mobile Harbor and similar projects and detailed analysis of new dredging techniques.

FIRST COST

14. First costs given herein are estimated for the selected plan as described in Section E of this Appendix and illustrated on figure E-1. Dredging costs are based on the quantities of new work for the selected plan shown in table F-1. Estimated first costs, shown in table F-2, are based upon October 1978 dollar values. This table includes advance engineering and design costs, which are scheduled on plate F-1. The contribution required by local interest is based on all of the cost allocated for land enhancement of the Brookley expansion area. A detailed development of this cost is presented in "Implementation Responsibilities" in the main body of this report.

TABLE F-1

DREDGING QUANTITIES FOR CONSTRUCTION
(cubic yards)

Reach	Quantity	
Mobile Ship Channel		
Turning Basin	3,611,852	
Anchorage Area	4,416,677	
Upper Channel	55,371,500	
Lower Channel	58,653,704	
Berthing Areas	1,890,000	
Total Pipeline Dredging		123,943,723
Gulf Entrance Channel *		
Total Hopper Dredging		19,018,594
Total Dredging Quantity for Construction		142,962,317

* The lower 8,000 feet of the main channel is included in the quantities for hopper dredging.

TABLE F-2

ESTIMATE OF FIRST COST

FEDERAL FIRST COST	
Dredging	
Upper bay reach (above Theodore) 63,400 cu.yds. @ $1.04/cu.yd.	$ 65,936,000
Lower bay reach 58,654,000 cu.yds. @ $1.28 cu.yd.	75,077,000
Entrance channel 19,019,000 cu.yds. @ $1.75 cu.yd.	33,283,000
Mooring Dolphins (16 @ $54,142 ea.)	866,000
SUB-TOTAL	$175,162,000
Contingencies @ 20%	35,032,000
Engineering & Design @ 3%	6,306,000
Supervision & Administration @ 3%	6,495,000
Interest during Construction (7 yrs. @ 6-7/8%)	53,658,000
SUB-TOTAL	$276,653,000
Less Required Contribution by Local Interest	-36,641,000
Navigation Aids (U.S. Coast Guard)	93,000
TOTAL FEDERAL FIRST COST	$240,105,000
NON-FEDERAL FIRST COST	
Dredging	
Berthing Areas (1,890,000 cu.yds. @ $1.04/cu.yd.)	1,966,000
Dike Construction (over & above C.E. Cost) 13,800,000 cu.yds. @ $0.05/cu.yd.	690,000
Initial Dike Construction	
Dressing & Shaping	35,000
Waste Weirs	34,000
Revetment	4,289,000
SUB-TOTAL	$ 6,574,000
Contingencies @ 20%	1,315,000
Cash Contribution (8.1% of 276,653,000)	22,409,000
Cash Contribution (5% of 284,635,000)	14,232,000
TOTAL NON-FEDERAL FIRST COST	$ 44,530,000
TOTAL ESTIMATED FIRST COST	$284,635,000

ANNUAL CHARGES

15. Total annual charges are summarized in table F-3. These include interest, amortization and future maintenance for the considered plan of improvement. Charges are given for both Federal and Non-Federal interests. Estimates are based upon October, 1978 dollars, an interest rate of 6 7/8% and an economic period of an analysis of 50 years (1995-2044).

BENEFIT ANALYSIS

16. Benefits derived herein accrue principally through use of larger, more economical vessels, and land enhancement from the fast land created adjacent to the Brookley Industrial Complex. Other supplemental benefits creditable to improving the harbor channel would result from elimination of lost vessel time due to constrained traffic in the channel. Documentation of such supplemental savings apart from benefits of a deeper channel are not clearly distinguishable and as such have not been evaluated in monetary terms as justification of the selected plan.

17. The benefit analysis presents an evaluation of trends that would affect the type and quantity of future commerce moving through the port and navigation benefits associated with this trade. In this analysis, consideration is given to the trend toward use of larger, more efficient vessels that has been prevelant over the past few years, and the fact that some vessels presently calling at the port are being light-loaded due to channel depth restrictions.

18. Supporting data used in the economic analysis and computations were obtained from a survey of users of the port and from related statistics. These include information furnished by local interests, records and statistics furnished by maritime and industry representatives, and specialized information such as ship operating cost data and commercial waterborne statistics compiled annually by the Corps of Engineers.

TABLE F-3

ESTIMATE OF ANNUAL CHARGES

FEDERAL ANNUAL CHARGES	
Interest	
$240,105,000 @ 6.875%	$16,508,000
Amortization	
$240,105,000 @ 0.2567%	616,000
Maintenance Dredging	
Increase due to larger channel	
Upper Bay (79.322 cu. yd. @ $1.34/cu. yd.)	106,000
Lower Bay (150,122 cu. yd. @ $0.88/cu. yd.)	132,000
Entrance (474,516 cu. yd. @ $1.75/cu. yd.)	830,000
Maintenance During Construction	
$4,514,000 X 0.071317	322.000
Maintenance of Mooring Dolphins	30,000
Maintenance of Navigation Aids (U.S.C.G.)	4,000
TOTAL FEDERAL ANNUAL CHARGES	$18,548,000
NON-FEDERAL ANNUAL CHARGES	
Interest	
$44,530,000 @ 6.875%	$ 3,062,000
Amortization	
$44,530,000 @ 0.2567%	114,000
Maintenance of Dikes	
20,900 lin. feet @ $2.42/ft.	51,000
Maintenance of Berthing Areas	
189,000 cu. yds. $1.34/cu. ft.	253,000
TOTAL NON-FEDERAL ANNUAL CHARGES	$ 3,480,000
TOTAL ESTIMATED ANNUAL CHARGES	$22,028,000

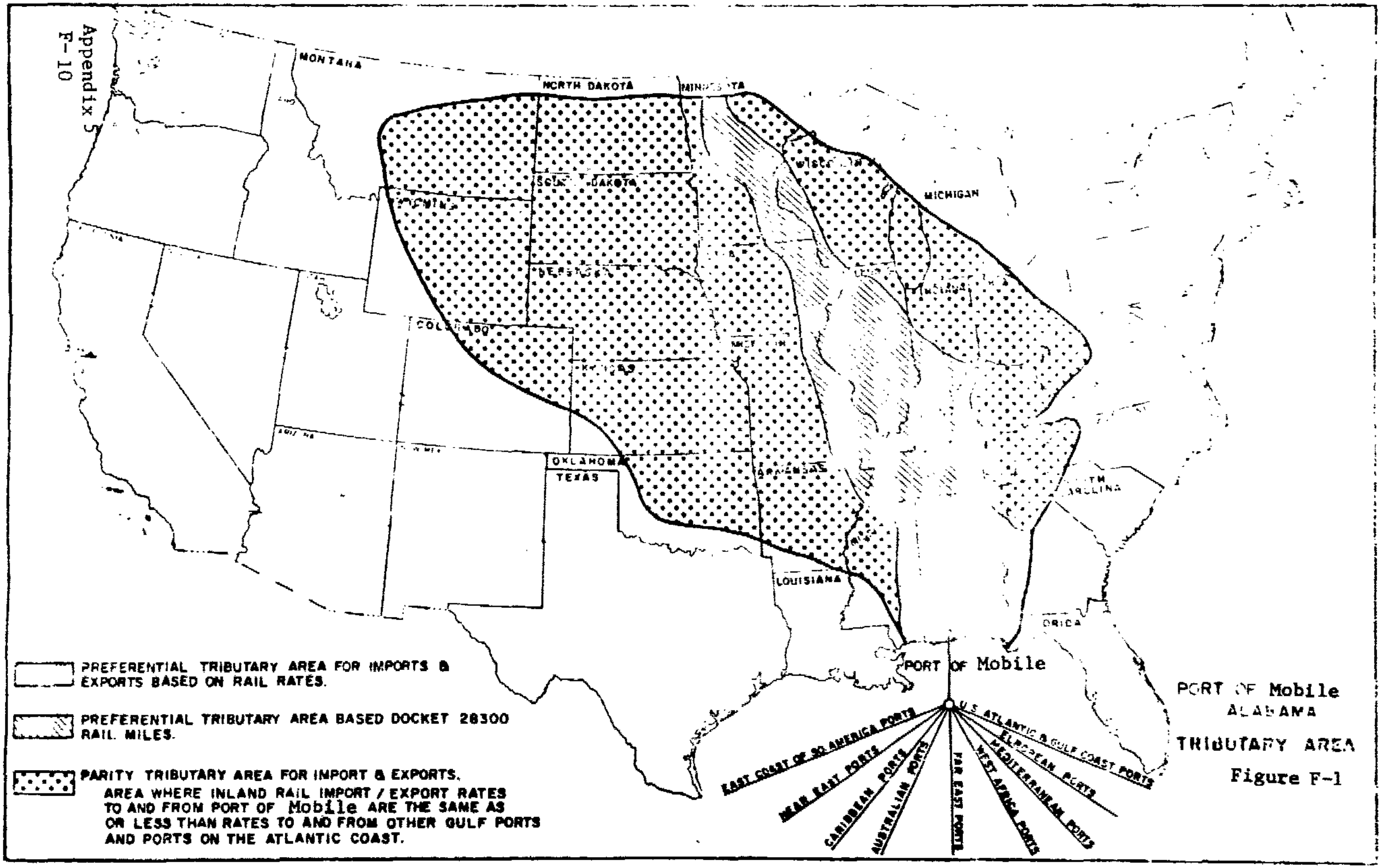
19. The selected plan for improving the existing Mobile Harbor channel considered depths of 45, 50, 55 and 60 feet in the bay with 2 feet additional depth in the gulf entrance channel to compensate for wave action. Estimates of navigation benefits that could be expected to accrue to the depths investigated are presented in subsequent paragraphs.

TRIBUTARY AREA

20. The geographical area considered commercially tributary to the port of Mobile is very broad in scope. The area considered directly tributary to this port would be an area contiguous to the origin/destination of the domestic patterns of present and future commerce that would move through the port. The preferential area where the port has a freight rate advantage over other Gulf Coast ports encompasses an area of Alabama and parts of Mississippi and Georgia. Another preferential area that is served by the port, where the rail miles to Mobile are less or equal to competing ports, is delineated by hatched lines on figure F-1. A secondary area, designated as the parity area within which freight rates to Mobile would be generally equalized with other Gulf Coast ports, includes all or part of the states in the Southeast and Mid-America. A fourth, more generalized, tributary area would include traffic patterns on a worldwide basis. For more exact delineation, refer to figure F-1.

EXISTING AND PLANNED PORT FACILITIES

21. Existing Facilities. The port of Mobile is located at the mouth of the Mobile, Tensaw, Tombigbee, Black Warrior, and Alabama-Coosa River System. With the completion of the Tennessee-Tombigbee Waterway, the basin will directly connect the Tennessee River with navigation access to all rivers to the north. In addition to the river system other



☐	PREFERENTIAL TRIBUTARY AREA FOR IMPORTS & EXPORTS BASED ON RAIL RATES.
▨	PREFERENTIAL TRIBUTARY AREA BASED DOCKET 28300 RAIL MILES.
⁙	PARITY TRIBUTARY AREA FOR IMPORT & EXPORTS. AREA WHERE INLAND RAIL IMPORT / EXPORT RATES TO AND FROM PORT OF Mobile ARE THE SAME AS OR LESS THAN RATES TO AND FROM OTHER GULF PORTS AND PORTS ON THE ATLANTIC COAST.

PORT OF Mobile
ALABAMA
TRIBUTARY AREA

Figure F-1

waterways serving the navigation needs of Mobile consists of Mobile Bay, the Gulf Intracoastal Waterway and inland waterways tributary to Mobile Bay. The existing ship channel in Mobile Bay is 40' x 400' and extends from the Cochrane Bridge for about 33 miles to the Gulf of Mexico. The extensive system of inland waterways presently permits barge navigation as far north as Port Birmingham and Montgomery, AL. The Gulf Intracoastal Waterway, which extends 1100 miles between Brownsville, TX to the Apalachee Bay in Florida, makes connection with the port via the Mobile ship channel.

22. Interstate Highways I-10 and I-65, which are essentially complete, provide an efficient highway system connecting Mobile to other southeastern cities and serves important waterfront areas in Mobile County. An adequate network of local highways afford convenient access to waterfront facilities. The Mobile area is also served by four national trunk-line railroads. The Alabama State Docks Terminal Railway connects these railroads to dock-sides and marine terminals and serves industries near these facilities. Commercial air transportation is available at the municipally owned Bates Field, located about 15 miles west of the port. More than 40 truck freight lines have terminals located in Mobile and the harbor is being served by nearly all the major barge lines. To serve the foreign and coastwise trade at Mobile, there are over 15 steamship agencies that represent over 130 steamship lines that operate at the port. Other port supporting services include stevedoring companies, freight forwarders, bunkering service, ship chandlers, shipbuilding and repair service, tug service and marine surveyors. All of these facilitate the movement of goods and perform the needed services associated with the loading, unloading and handling of waterborne cargo.

23. Principal public terminals located at the Port of Mobile include 26 general cargo berths and a grain elevator above the I-10 and Bankhead tunnels on the west side of the Mobile River, a dry bulk ore handling terminal on Three Mile Creek, also above the tunnels, and a coal export terminal on McDuffie Island near the mouth of the river. The general cargo berths vary from relatively modern to 50 years old facilities but are considered adequate for foreseeable general cargo handling needs of the port. A two stage expansion and modernization program is nearing completion on the grain elevator that will increase its annual throughput capacity to about 3.5 million tons. The dry-bulk terminal on Three Mile Creek was originally constructed in 1927 and has gone through several renovations to maintain modern efficiency and to increase its storage and handling capacities. The facility presently operates near its maximum capacity of about 5 to 6 million tons annually. The McDuffie Coal Terminal is a modern facility that began operation in 1975. The facility is presently being expanded to provide a capacity for handling about 10.2 million tons annually. Space and plans have been provided to expand this facility as needed. All existing public facilities in the Port of Mobile are owned and operated by the Alabama Department of State Docks.

24. Principal private terminals in the main port area of Mobile include: The liquid petroleum storage and loading facilities of Amerada-Hess, Citmoco, Chevron Asphalt Refinery, Texaco and Argon; the molasses importing docks of Pro Rico Industries; Pinto Island Metal's scrap metal dock; "Port of Chickasaw" general cargo docks; and the Tennessee Coal and Iron bulk ore handling terminal. Another major facility in the immediate harbor area is the numerous berths of the Alabama Dry Dock and Shipbuilding Corporation. There are numerous other lesser facilities in the main harbor area primarily used for barge unloading and vessel repairs. Other private terminals either existing or under construction on the Theodore Ship Channel located about 10 miles south of Mobile include the docks of Ideal Basic Industries, Airco Alloys, Kerr-McGee, Degussa Alabama, Inc. and Marion Corporation.

25. All existing public and private terminals are discussed in detail in Section C of this Appendix and many are illustrated by photographs therein.

26. Planned Facilities. The Alabama State Docks Department assumes the role of both operating and planning for public port facilities in the State of Alabama. As a required measure of local participation in connection with the Federal improvements under construction for the Theodore Industrial area, the Docks Department has planned the construction of a public liquid bulk terminal. In addition to this and other public terminals on the Theodore Channel, the State has developed a comprehensive long range plan for modernizing and expanding its facilities in the main Mobile Harbor vicinity. While this plan provided for improving access and operations of its facilities above the Mobile River tunnels, essentially all new facilities are planned to be located below the tunnels near the mouth of the river. Major new terminals planned, in addition to expansion of the McDuffie Island Coal terminal, are a dry bulk ore terminal to be located on the north end of McDuffie Island and grain elevators in the vicinity of the "Mobile Aerospace Industrial Complex". The department has and is continuing to purchase necessary properties to implement this plan. Details of the State's plans are discussed and illustrated in Section D of this Appendix under "Local Plans". State plans are considered compatible with the selected plan considered herein for Federal implementation. No long term plans of private interests are generally known until immediately prior to their intent to initiate construction.

27. Desired Port Improvements. Overall water resources problems and needs of the Port of Mobile are discussed in detail in Section C of this Appendix. However, the basic navigation problems facing the port are the inadequate existing terminals and the ability of the harbor to accommodate the larger and more economical bulk carrier vessels now engaged in World deep-draft shipping. The Alabama State Docks Department has identified and is actively pursuing a plan to construct new

and expand existing bulk terminals in unconstrained locations within the harbor. However, fulfillment of harbor needs cannot be realized without commensurate channel improvements that will facilitate the optimum utilization of new ships and terminals. It is these improvements in the existing Federal Project that are desired by local interests and for which, along with other water related needs, the "Selected Plan" herein has been formulated. Navigation benefits for the considered improvements can only be determined through detailed analysis of commerce movements, origins and destinations, vessel characteristics and operating costs and available alternative modes. These analysis are presented in the following paragraphs.

28. Coal and a portion of the iron ore imports plus bauxite and other miscellaneous ores are presently being handled through the Alabama State Dock's bulk handling facility (Tipple) at Three Mile Creek. It is expected by 1995 the coal and a portion of the iron ore will move through a newly constructed facility at McDuffie Island. The present facility is currently being operated at near capacity of 6.0 million tons. According to Alabama State Dock's records over 5.5 million tons were handled at this facility in 1978. By 1995 it is estimated that 7.2 million tons will be available to unload from ocean-going vessels plus another 1.0 millions tons that could be reloaded into barges for further transport on inland waterways.

29. With a new facility available at McDuffie by 1995, it is expected that 1.6 million tons would be shifted to this facility. This would include 896,000 tons of coal imports, 249,000 tons or 43 percent of iron ore from Australia, and 482,000 tons of iron ore from Canada and Brazil. This would leave 5.6 million tons (7.2 - 1.6) that would continue to be unloaded from ocean-going vessels at the Tipple, about the same tonnage that was handled at the facility in 1978.

PORT COMMERCE

30. <u>Traffic Studies</u>. All known industries and shipping interests presently using the Port of Mobile and companies that have expressed a desire to use the port in the future, were contacted to determine the potential use of the port relative to savings that could be realized from harbor improvements to commerce and ship traffic in the coastwise and import-export trade. Interviews with companies associated with the shipments of coal, grain, iron ore, bauxite, petroleum and other bulk commodities, steamship lines, bar pilots, railroads, Alabama State Docks and other Government agencies were conducted at various intervals during the course of this study to determine the need for greater dimensions in Mobile ship channel and to assess the volume of traffic that can be expected in the future. Special emphasis was placed on interviews with firms associated with large bulk commodity movements that bear the largest potential for savings from harbor improvements. A list of major industries that were interviewed is presented below.

a. The Drummond Company (Coal)
b. Jim Walters Corp. (Coal)
c. Sumitomo Shoji America, Inc. (Coal)
d. Smith Coal Sales (Coal)
e. Mannesman Pipe and Steel (Coal)
f. Ataka America, Inc. (Coal)
g. Hawley Fuel Corp. (Coal)
h. Alabama By-Products Corp. (Coal)
i. Wallace and Wallace Chemical & Oil Corp. (Crude Oil)
j. Peabody Coal Co. (Coal)
k. Mitsui & Co. (USA) Inc. (Coal)
l. United States Steel Corp. (Iron Ore)
m. Consolidated Aluminum Corp. (Alumina)

n. Revere Copper & Brass, Inc. (Alumina)
o. Marion Corp. Refinery Div. (Crude Oil)
p. Republic Steel Corp. (Iron Ore)
q. Alcoa (Bauxite-Alumina)
r. Amerada-Hess Corp. (Crude Oil)
s. Kerr-McGee Corp. (Manganese Ore)
t. Phillip Bros. (Various Commodities)
u. Lapeyrouse Export, Inc. (Grain)
v. Pillsbury, Inc. (Grain)

31. Other firms or agencies that were contacted include major steamship agents at Mobile, Mobile Bar Pilots Association, Alabama State Docks. U.S. Department of the Interior, Bureau of Mines, Louisiana Offshore Oil Port (LOOP), Standard Oil Company of California, and Geological Survey of Alabama.

32. Historical Trends in Port Commerce. Annual commerce shipped through the port of Mobile, by deep-draft vessels, increased from 14.4 million tons in 1966 to 16.7 million tons in 1975. Barge traffic increased from 7.9 million tons to 15.9 million tons during the same period. Total traffic increased from 22.3 million tons to 32.5 million tons during the 10-year period. A sharp increase in port traffic has occurred subsequent to 1975, according to the Alabama State Docks' records and preliminary data as published in the Waterborne Commerce of the United States, Part 2, for Calendar Year 1975. The overall increase in tonnage moving through the port can be attributed to the growth in all areas except bauxite, marine shells, fertilizers, lumber, paper, food products and commerce termed as miscellaneous traffic. For more detailed statistics on the past trends in port commerce, refer to table F-4.

33. The most significant changes in volume of deep-draft vessel traffic is the increase in coal, both inbound and outbound, and grain exports. The impressive increase in coal tonnage is due to the heavy demand for

TABLE F-4

Tabulation of tonnages by commodity and type of movement for
Period 1966 - 1975

Source: Waterborne Commerce of The United States - Part 2 for years 1966 - 1975, inclusive

COMMODITY GROUP	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Grain & Grain Products										
Deep-draft vessel traffic	1,715,000	1,613,000	1,907,800	1,463,700	1,234,500	873,700	1,548,100	2,161,600	1,716,200	2.327,500
Barge traffic	651 800	550,300	722,800	793,900	365,200	343,300	436,900	518,300	533,300	1,102,100
Ores & Concentrates										
Deep-draft vessel traffic	5,178,200	5,106,130	4,853,300	4,879,100	5,571,300	5,511,000	4,039,200	4,812,800	6,561,700	4.908,900
Barge traffic	1,689,500	2,165,822	1,989,400	1,974,200	2,029,700	2,569,500	3.031,000	3,269,300	4,368,900	2,472,100
Bauxite (Aluminum Ore)										
Deep-draft vessel traffic	2,557,800	2,875,775	2,748,000	2,313,800	2,436,900	2.197,200	1,776,700	1,9[illegible]	2,023,100	1,871,600
Barge traffic	----	----	1,900	----	----	----	----	1,500	[illegible]100	----
Coal										
Deep-draft vessel traffic	500	402	1,700	700	343,600	749,000	1,141,400	1,122,800	1,889,900	3,116,000
Barge traffic	460,800	448,844	427,000	285,200	911,700	1,859,100	3,039,000	1,630,800	2.080,800	2,824,500
Crude Petroleum										
Deep-draft vessel traffic	2,131,700	1,457,979	1,076,700	1,653,700	1,343,900	1,316,300	2,460,200	4,296,100	3,446,000	2,597,800
Barge traffic	864,000	803,770	1,295,800	1,147,100	741,900	1,054,300	1,380,000	977,700	1,041,800	2,361,000
Marine Shells, Unmanuf.										
Deep-draft vessel traffic	13,100	85	100	----	----	----	----	----	200	----
Barge traffic	1,469,000	1,409,895	1,354,000	1,427,300	1,526,000	1,797,000	1,510,600	1,597,000	1,579,700	1,491,200
Sand, Gravel, Crushed Rock										
Deep-draft vessel traffic	99,900	53,457	153,800	213,200	252,500	149,900	226,600	250,000	149,400	81,800
Barge traffic	729,800	650,549	854,100	973,100	1,350,000	1,432,400	1,401,800	1,612,400	1,635,000	2,014,700
Fertilizer & Fertilizer Materials										
Deep-draft vessel traffic	137,100	93,581	47,500	106,100	59,500	19,000	17,200	3,000	4,200	105,100
Barge traffic	118,000	65,069	27,900	58,900	21,200	----	6,500	5,000	13,500	3,100

TABLE F-4 (Continued)

Tabulation of tonnages by commodity and type of movement for Period 1966 - 1975

COMMODITY GROUP	YEARS 1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Lumber & Other Forest Products										
Deep-draft vessel traffic	447,800	157,758	165,200	132,400	169,800	151,600	215,900	239,500	252,200	206,300
Barge Traffic	312,900	296,797	321,300	383,500	396,000	262,000	204,500	300,000	321,400	137,300
Paper & Paper Products										
Deep-draft vessel traffic	97,900	118,024	207,200	176,500	196,000	191,700	175,400	266,300	275,600	181,700
Barge traffic	----	----	----	----	2,000	----	1,000	96,500	108,600	48,400
Chemical & Chemical Products										
Deep-draft vessel traffic	93,200	81,322	179,100	140,200	137,100	83,000	107,800	87,700	63,600	69,700
Barge traffic	156,900	142,878	143,600	236,000	500,400	454,800	441,900	373,200	611,300	475,800
Refined Petroleum Products										
Deep-draft vessel traffic	893,000	577,200	684,400	760,500	767,200	522,200	361,200	828,000	508,800	612,900
Barge traffic	1,203,500	1,684,700	2,156,800	2,448,900	2,038,000	2,284,300	2,641,900	2,850,300	2,882,200	2,652,600
Iron & Steel Products										
Deep-draft vessel traffic	415,200	514,611	532,300	798,500	780,300	460,100	506,800	674,300	388,800	379,700
Barge traffic	45,900	65,516	113,800	383,400	317,500	200,600	217,500	244,600	323,900	116,200
Food & Kindred Products										
Deep-draft vessel traffic	141,000	159,645	109,600	173,400	176,800	276,500	194,600	196,500	115,000	38,700
Barge traffic	36,300	31,344	22,400	11,700	25,600	17,600	20,400	19,500	12,100	8,500
Farm Products										
Deep-draft vessel traffic	10,000	15,431	11,200	7,900	4,900	3,900	5,100	8,500	37,700	84,800
Barge traffic	----	----	----	----	----	----	----	----	----	200

TABLE F-4 (Continued)

Tabulation of tonnages by commodity and type of movement for Period 1966 - 1975

COMMODITY GROUP	YEARS 1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Non-Metallic Min. Nec.										
Deep-draft vessel traffic	2,400	5,832	7,700	8,100	14,400	4,500	4,400	20,400	4,200	9,700
Barge traffic	23,000	32,000	12,000	44,000	8,000	----	----	6,600	700	51,600
Transportation Equipment										
Deep-draft vessel traffic	4,500	2,617	3,600	3,600	1,200	1,300	1,100	----	4,100	8,000
Barge traffic	----	----	----	----	300	----	600	----	2,100	10,600
Department of Defense										
Deep-draft vessel traffic	15,200	12,539	7,200	7,200	5,600	5,800	10,800	15,300	15,300	39,200
Barge traffic	----	----	----	----	----	----	----	----	----	----
Sub-Total										
Deep-draft vessel traffic	14,353,500	12,839,218	12,776,400	12,838,600	13,495,500	12,516,700	12,792,500	16,926,400	17,456,100	16,639,400
Barge traffic	7,761,400	8,347,484	9,442,800	10,209,600	10,233,500	12,274.900	14,333,000	13,502,700	15,520,400	15,769,900
Total	22,114,900	21,186,702	22,219,200	23,048,200	23,729,000	24,791,600	27,125,500	30,429,100	32,976,500	32,409,300
Miscellaneous										
Deep-draft vessel traffic	66,265	21,599	104,011	112,876	92,754	124,751	132,185	64,413	140,544	38,388
Barge traffic	126,748	75,485	3,107	1,265	7,831	2,877	33,378	24,909	36,910	5,224
Total	193,013	97,084	107,118	114,141	100,585	127,628	165,563	89,322	177,454	43,612
Grand Total										
Deep-draft vessel traffic Total--------------------	14,419,765	12,860,817	12,880,411	12,951,476	13,588,254	12,641,451	12,924,685	16,990,813	17,596,644	16,677,788
Barge traffic Total--------------------	7,888,148	8,422,969	9,445,907	10,210,865	10,241,331	12,277,777	14,366,378	13,527,609	15,557,310	15,775,124
Grand Total--------------	22,307,913	21,283,786	22,326,318	23,162,341	23,829,585	24,919,228	27,291,063	30,518,422	33,153,954	32,452,912

coking coal to Japan and their interests in coal mining operation in Alabama. The Japanese interests have deemed the construction of the McDuffie Island Coal Handling Terminal, a public facility, a breakthrough in facilitating their assured supply of coal. Public coal terminals are not available at the ports of Newport News and Norfolk, VA, and Baltimore, MD as they are operated and controlled by the railroads who own the docks and terminal facilities.

34. Grain exports have also shown a marked increase in the past several years, particularly in 1975 and 1976. This is primarily accredited to the significant increase in production of corn and soybeans in the southeast and the demand for grain in foreign countries. The Alabama State Docks is completing a series of major expansions of their fully public grain elevator at Mobile. While potential for further expansion remains, grain shipments have in recent years been essentially increasing to approximate the facility's expanding capacity.

35. Published statistics on total commerce for years 1966-1976, allocated by foreign imports and exports, coastwise receipts and shipments, and internal receipts, shipments, and local traffic, are presented in table F-5. Internal traffic designates waterborne commerce moving in vessels other than deep-draft ships. Imports since 1966 remained fairly stable at about 8.0 million tons with no significant increase. Exports increased from 2.0 million tons in 1966 to 5.7 million tons in 1976. For years 1975 and 1976, the significant increase in exports is due to the increase in coal and grain shipments. Coastwise receipts reflect a small percentage of the overall traffic for the port. Coastwise shipments had a high fluctuation during this 10-year period, ranging from a low 1.6 million tons in 1968 to a high of 4.7 million tons in 1973, giving an average figure of 2.6 million tons for the 10-year period. Internal traffic, which represents mostly barge traffic, has increased considerably since 1966. Receipts increased from 3.3 million tons in 1966 to 6.8 million tons in

TABLE F-5

MOBILE HARBOR, ALABAMA ANNUAL COMMERCE, 1966 - 1975

(thousand short tons)

				Domestic				
		Foreign		Coastwise		Internal		
Year	Total	Imports	Exports	Receipts	Shipments	Receipts	Shipments	Local
1966	22,307.9	9,359.3	2,020.1	423.3	2,617.1	3,250.8	3,430.3	1,207.0
1967	21,283.8	8,873.4	1,873.6	236.5	1,877.3	3,510.2	3,584.8	1,327.9
1968	22,326.3	8,884.7	2,236.1	158.6	1,600.9	4,109.1	3,950.8	1,386.0
1969	23,162.3	8,206.2	2,503.9	69.2	2,172.2	4,774.7	4,113.6	1,322.6
1970	23,829.6	8,777.0	2,940.3	33.2	1,837.7	5,009.7	3,983.7	1,247.9
1971	24,919.2	8,527.3	2,325.1	15.5	1,773.6	6,086.3	4,964.0	1,227.5
1972	27,291.1	6,674.4	3,053.7	170.8	3,025.7	7,975.7	5,220.9	1,169.8
1973	30,518.4	7,909.6	3,856.4	554.4	4,670.4	6,351.8	6,001.3	1,174.6
1974	33,154.0	9,415.5	3,962.6	447.6	3,770.9	7,148.7	7,016.6	1,391.9
1975	32,452.9	7,895.8	5,404.7	363.7	3,013.6	7,559.1	6,832.3	1,383.7
Ten Year Average	26,124.6	8,452.3	3,017.7	247.3	2,635.9	5,577.6	4,909.8	1,283.9
1976[1]	35,379.3	8,215.6	5,744.8	384.1	1,817.4	7,625.0	9,519.1	2,073.1

Source: Waterborne Commerce of the United States 1966-75, Part 2

1975 with a drastic increase to 9.5 million tons in 1976. The commodities that contributed to the increase in internal traffic are grain, ores, coal, crude oil, sand and gravel, and refined petroleum products. The average annual volume of traffic during this 10-year period was 14.4 million tons of deep-draft vessel traffic with 11.8 million tons of shallow-draft traffic.

36. Present Commerce. A record of freight traffic for CY 1975, giving the volume of commerce, by commodity, is presented in tab e F-6. The volume of commerce under the heading of "Foreign" and "Coastwise" represents that which moved in deep-draft vessels, including fishing vessels. Commerce moving by barge is shown under the caption of "Internal" and "Local."

37. The major commodities that comprise the port commerce are: iron ore, coal, crude oil, grain, bauxite, refined petroleum products, marine shells, sand and gravel, and munerous commodities that are shipped as break-bulk cargo. An overview of the principal commodity movements in 1975 is presented below.

38. Iron ore tonnage represents the largest volume of traffic for a single commodity. Iron ore imports amounted to 4.8 million tons. Shipments of iron ore moving from the port by barge amounted to 2.4 million tons. The total volume of iron ore shipped by barge was imported by deep-draft vessels. Total volume of iron ore shipped through the port was 7.2 million tons. Coal tonnage was the second largest volume of traffic shipped through the port with 2.7 million tons exported and 371,000 tons imported. Barge receipts and shipments of coal amounted to 2.8 million tons which was subsequently exported by deep-draft vessels. Crude oil shipments by tanker amounted to 2.4 million tons in 1975. About 2.4 million tons, or 50 percent of the total crude oil shipments, were by barge. Imports of crude oil amounted to 189,000 tons. Total volume of crude oil shipped through the port was 5.0 million tons. Bauxite imported accounted for 1.9 million tons of traffic.

TABLE F-6

FREIGHT TRAFFIC THAT MOVED THROUGH MOBILE IN 1975

COMMODITY	TOTAL	FOREIGN		DOMESTIC				
				COASTWISE		INTERNAL		LOCAL
		IMPORTS	EXPORTS	RECEIPTS	SHIPMENTS	RECEIPTS	SHIPMENTS	
TOTAL	32,452,912	7,895,820	5,404,733	363,652	3,013,583	7,559,129	6,832,326	1,383,669
0101 COTTON, RAW	295	-	295	-	-	-	-	-
0103 CORN	1,036,704	-	645,576	-	141,219	187,705	-	30,204
0104 OATS	261	-	-	-	-	-	261	-
0105 RICE	211,325	-	194,951	-	9,244	1,393	5,737	-
0106 SORGHUM GRAINS	5,807	-	730	-	-	4,984	93	-
0107 WHEAT	662,676	-	241,275	6,273	100,117	307,454	4,469	3,091
0111 SOYBEANS	1,086,112	-	632,124	-	-	311,605	3,167	139,215
0119 OILSEEDS, NEC	9,871	-	7,768	-	-	300	1,803	-
0122 HAY AND FODDER	12	-	12	-	-	-	-	-
0129 FIELD CROPS, NEC	4,300	-	-	-	4,300	-	-	-
0131 FRESH FRUITS AND TREE NUTS	2,030	1,996	34	-	-	-	-	-
0132 BANANAS AND PLANTAINS	76,689	76,689	-	-	-	-	-	-
0133 COFFEE	198	-	-	-	-	-	198	-
0141 FRESH AND FROZEN VEGETABLES	42	32	10	-	-	-	-	-
0161 ANIMALS AND PRODUCTS, NEC	1,469	14	1,455	-	-	-	-	-
0191 MISCELLANEOUS FARM PRODUCTS	308	308	-	-	-	-	-	-
0841 CRUDE RUBBER AND ALLIED GUMS	1	-	1	-	-	-	-	-
0861 FOREST PRODUCTS, NEC	110	104	6	-	-	-	-	-
0911 FRESH FISH, EXCEPT SHELLFISH	480	145	-	-	-	335	-	-
0931 MARINE SHELLS, UNMANUFACTURED	1,491,175	-	-	-	-	196,228	262,980	1,031,967
1011 IRON ORE AND CONCENTRATES	7,179,651	4,780,624	-	-	-	-	2,399,027	-
1051 ALUMINUM ORES, CONCENTRATES	1,871,562	1,871,562	-	-	-	-	-	-
1061 MANGANESE ORES, CONCENTRATES	105,621	17,209	28,027	-	-	52,578	7,797	-
1091 NONFERROUS ORES, CONCENT, NEC	64,299	57,141	6,249	-	-	909	-	-
1121 COAL AND LIGNITE	5,940,544	370,581	2,745,452	-	-	2,489,256	335,255	-
1311 CRUDE PETROLEUM	4,958,815	188,535	-	-	2,409,294	22,164	2,301,441	37,391
1411 LIMESTONE	1,310	-	-	-	-	1,310	-	-
1412 BUILDING STONE, UNWORKED	176	176	-	-	-	-	-	-
1442 SAND, GRAVEL, CRUSHED ROCK	1,809,616	8	59,721	-	-	1,304,556	359,521	85,810
1451 CLAY	124,045	992	14,575	-	-	106,622	1,856	-
1471 PHOSPHATE ROCK	3,658	-	-	2,200	-	-	1,458	-
1479 NATURAL FERTILIZER MATS, NEC	226	226	-	-	-	-	-	-
1499 NONMETALLIC MINERALS, NEC	14,235	1,930	481	-	-	10,239	1,585	-
1911 ORDNANCE AND ACCESSORIES	6	-	6	-	-	-	-	-
2012 MEAT AND PRODUCTS, NEC	4,314	493	307	-	-	3,208	306	-
2015 ANIMAL BY-PRODUCTS, NEC	491	9	482	-	-	-	-	-
2022 DRIED MILK AND CREAM	5,719	104	5,615	-	-	-	-	-
2031 FISH AND SHELLFISH, PREPARED	1,611	988	27	-	596	-	-	-
2034 VEGETABLES AND PREP, NEC	410	150	159	-	-	101	-	-
2039 PREP FRUIT AND VEG JUICE, NEC	938	908	24	6	-	-	-	-
2041 WHEAT FLOUR AND SEMOLINA	100,607	-	80,781	-	-	10,651	9,175	-
2042 PREPARED ANIMAL FEEDS	50,269	27,525	15,192	-	-	-	7,552	-
2049 GRAIN MILL PRODUCTS, NEC	266,032	43	134,399	2,809	87,499	33,024	8,256	-
2062 MOLASSES	9,397	5,205	-	-	-	1,292	2,900	-
2081 ALCOHOLIC BEVERAGES	5,325	4,565	209	35	-	516	-	-
2091 VEGETABLE OILS, MARG, SHORT	867	-	111	-	756	-	-	-
2099 MISCELLANEOUS FOOD PRODUCTS	18,048	6,537	11,364	-	-	147	-	-
2111 TOBACCO MANUFACTURES	13	1	12	-	-	-	-	-
2211 BASIC TEXTILE PRODUCTS	2,850	2,528	175	-	-	-	147	-
2311 APPAREL	225	73	152	-	-	-	-	-
2411 LOGS	20,425	56	232	-	137	19,750	250	-
2413 FUEL WOOD, CHARCOAL, WASTES	205	205	-	-	-	-	-	-
2414 TIMBER, POSTS, POLES, PILING	32,326	-	24,523	-	4,023	2,257	1,523	-
2415 PULPWOOD, LOG	98,778	-	-	-	-	98,778	-	-
2416 WOOD CHIPS, STAVES, MOLDINGS	4,771	4,715	56	-	-	-	-	-
2421 LUMBER	138,743	54,201	35,319	-	39,579	3,650	5,995	-
2431 VENEER, PLYWOOD, WORKED WOOD	9,890	2,384	-	-	7,412	94	-	-
2491 WOOD MANUFACTURES, NEC	40,630	8,856	22,875	-	6,113	2,337	449	-
2511 FURNITURE AND FIXTURES	2,533	220	99	-	-	2,214	-	-
2611 PULP	170,547	49,776	77,640	-	-	36,053	7,078	-
2631 PAPER AND PAPERBOARD	53,752	5,148	39,700	-	3,642	3,578	1,684	-
2691 PULP AND PAPER PRODUCTS, NEC	387	30	356	-	1	-	-	-
2711 PRINTED MATTER	2	1	1	-	-	-	-	-
2810 SODIUM HYDROXIDE	144,294	-	-	-	-	143,849	445	-
2811 CRUDE TAR, OIL, GAS PRODUCTS	1,401	-	-	-	-	1,401	-	-
2813 ALCOHOLS	3,622	-	-	-	901	1,380	1,341	-
2817 BENZENE AND TOLUENE	28,895	-	-	-	-	28,201	-	694
2819 BASIC CHEMICALS AND PROD, NEC	334,629	16,861	43,659	-	-	17,386	256,723	-
2821 PLASTIC MATERIALS	1,370	31	937	-	-	-	402	-
2822 SYNTHETIC RUBBER	27,449	328	2,933	-	-	9,109	15,079	-
2823 SYNTHETIC (MAN-MADE) FIBERS	4,561	-	4,333	-	-	-	228	-
2831 DRUGS	14	-	14	-	-	-	-	-
2841 SOAP	133	1	132	-	-	-	-	-
2851 PAINTS	31	1	30	-	-	-	-	-
2861 GUM AND WOOD CHEMICALS	2,445	1,136	1,141	-	1	-	167	-
2871 NITROGENOUS CHEM FERTILIZERS	1,811	-	141	-	-	-	1,670	-
2873 PHOSPHATIC CHEM FERTILIZERS	55	-	55	-	-	-	-	-
2872 INSECTICIDES, DISINFECTANTS	387	-	387	-	-	-	-	-
2879 FERTILIZER AND MATERIALS, NEC	102,491	102,387	104	-	-	-	-	-
2891 MISCELLANEOUS CHEMICAL PROD	2,106	472	1,633	-	1	-	-	-
2911 GASOLINE	1,050,164	-	-	144,237	6,008	848,916	48,356	2,647
2912 JET FUEL	350,556	-	-	13,671	-	-	336,885	-
2913 KEROSENE	2,262	-	-	-	-	2,262	-	-
2914 DISTILLATE FUEL OIL	429,285	9,713	-	41,964	32,449	179,769	152,508	12,882
2915 RESIDUAL FUEL OIL	704,249	23,224	-	155,174	-	442,574	86,481	4,727
2916 LUBRICATING OILS AND GREASES	1,350	-	6	-	1,344	-	-	-
2917 NAPHTHA, PETROLEUM SOLVENTS	14,549	-	-	-	-	3,198	11,351	-
2918 ASPHALT, TAR, AND PITCHES	645,598	-	-	-	139,678	444,404	61,516	-
2920 COKE, PETROLEUM COKE	14,172	-	-	-	38	13,014	1,120	-
2951 ASPHALT BUILDING MATERIALS	28	28	-	-	-	-	-	-
3011 RUBBER AND MISC PLASTICS PROD	945	-	907	-	-	38	-	-
3111 LEATHER AND LEATHER PRODUCTS	285	285	-	-	-	-	-	-

TABLE F-6 (Continued)

FREIGHT TRAFFIC THAT MOVED THROUGH MOBILE IN 1975 (CONTD)

COMMODITY	TOTAL	FOREIGN		DOMESTIC				LOCAL
				COASTWISE		INTERNAL		
		IMPORTS	EXPORTS	RECEIPTS	SHIPMENTS	RECEIPTS	SHIPMENTS	
3211 GLASS AND GLASS PRODUCTS	246	156	90	----------	----------	----------	----------	----------
3241 BUILDING CEMENT	123,712	----------	----------	----------	3,747	50,649	69,325	----------
3251 STRUCTURAL CLAY PRODUCTS	37,564	119	4,145	----------	----------	33,300	----------	----------
3271 LIME	25	----------	25	----------	----------	----------	----------	----------
3281 CUT STONE AND STONE PRODUCTS	599	599	----------	----------	----------	----------	----------	----------
3291 MISC NONMETALLIC MINERAL PROD	52,438	331	445	----------	21	51,641	----------	----------
3311 PIG IRON	43,950	32,166	134	----------	----------	----------	11,650	----------
3312 SLAG	1,344	----------	----------	----------	----------	1,344	----------	----------
3313 COKE, PET ASPHALTS, SOLVENTS	53,317	----------	53,317	----------	----------	----------	----------	----------
3314 IRON AND STEEL PRIMARY FORMS	714	401	----------	----------	----------	313	----------	----------
3315 IRON, STEEL SHAPES, EXC SHEET	50,543	29,902	879	----------	----------	14,986	4,776	----------
3316 IRON AND STEEL PLATES, SHEETS	50,637	24,791	441	----------	819	13,500	11,086	----------
3317 IRON AND STEEL PIPE AND TUBE	77,141	8,736	50,959	----------	10,994	4,615	1,837	----------
3318 FERROALLOYS	20,881	9,271	5	----------	----------	8,408	3,194	----------
3319 IRON AND STEEL PRODUCTS, NEC	26,785	7,209	11,519	----------	----------	8,057	----------	----------
3321 NONFERROUS METALS, NEC	30,872	30,397	39	----------	436	----------	----------	----------
3322 COPPER ALLOYS, UNWORKED	3,311	3,311	----------	----------	----------	----------	----------	----------
3323 LEAD AND ZINC, UNWORKED	2,482	2,482	----------	----------	----------	----------	----------	----------
3324 ALUMINUM AND ALLOYS, UNWORKED	12,714	12,685	28	----------	1	----------	----------	----------
3411 FABRICATED METAL PRODUCTS	36,079	20,462	3,415	2,000	565	7,897	1,734	----------
3511 MACHINERY, EXCEPT ELECTRICAL	12,122	4,106	4,485	228	1,530	1,618	155	----------
3611 ELECTRICAL MACH AND EQUIP	3,292	2,900	392	----------	----------	----------	----------	----------
3711 MOTOR VEHICLES, PARTS, EQUIP	18,591	181	7,753	22	55	589	9,994	----------
3721 AIRCRAFT AND PARTS	894	----------	882	----------	----------	12	----------	----------
3731 SHIPS AND BOATS	401	91	228	----------	----------	----------	82	----------
3791 MISC TRANSPORTATION EQUIPMENT	1,536	1,258	197	----------	5	----------	76	----------
3811 INSTR, TIME, PHOTO, OPT GOODS	92	23	69	----------	----------	----------	----------	----------
3911 MISC MANUFACTURED PRODUCTS	2,413	1,139	26	36	----------	1,412	----------	----------
4011 IRON AND STEEL SCRAP	157,358	----------	133,177	----------	1,000	11,383	11,798	----------
4012 NONFERROUS METAL SCRAP	8,866	8,642	224	----------	----------	----------	----------	----------
4022 TEXTILE WASTE, SCRAP, SHEEP	34	----------	34	----------	----------	----------	----------	----------
4024 PAPER WASTE AND SCRAP	5,376	----------	5,376	----------	----------	----------	----------	----------
4111 WATER	208	----------	----------	----------	----------	----------	208	----------
4112 COMMODITIES, NEC	3,948	----------	50	----------	----------	3,622	276	----------
9999 DEPARTMENT OF DEFENSE AND SCI	39,194	----------	39,194	----------	----------	----------	----------	----------
TOTAL TON-MILES. 908,970,401.								

SOURCE:

Waterborne Commerce of the United States, 1975 - published by the Waterborne Statistics Center in New Orlenas, LA

39. Refined petroleum products shipped through the port amounted to 3.2 million tons. About 84 percent of the traffic moved by barge, with 1.9 million tons inbound and .7 million tons outbound and a small amount of local traffic. Nearly all of this traffic originated or terminated at docks above the I-10 tunnels. Total grain tonnage for the port that was handled through the public elevator amounted to 2.9 million tons. Of this total, about 2.0 million tons were shipped by deep-draft vessels. The other .9 million tons was shipped by barge. About .8 million tons of the grain receipts by barge were the same tonnage shipped out by deep-draft vessels. Other major products shipped through the port include 1.5 million tons of marine shells and 1.8 million tons of sand and gravel, all shipped by barge. The above commodities accounted for about 29.4 million tons or 90 percent of the total tonnage of 32.5 million tons shipped through the port in 1975.

40. Deep-draft traffic amounted to 16.7 million tons or 51 percent of the total tonnage shipped. Of this amount, 15.1 million tons were shipped in dry-bulk carriers and tankers with 1.4 million shipped in general cargo vessels.

COMMODITIES SCREENED FROM BENEFIT ANALYSIS

41. All commerce moving through the port of Mobile and the potential commerce that would move via the Tennessee-Tombigbee Waterway for export was analyzed to determine what traffic would realize benefits from a deeper ship channel into Mobile with dimensions greater than the 40 x 400 foot channel now available. Those commodities that for various reasons would not benefit from considered harbor improvements are discussed below.

42. Excluded Commodities. Commodities that were eliminated from the benefit analysis are shown in table F-7. The reasons for eliminating these commodities are given below.

a. Traffic moving through terminals north of the highway tunnels where the shippers did not indicate they would relocate to terminals below the tunnels. Channel depths above the tunnels are restricted to -40 feet because of top-of-tunnel elevations.

TABLE F-7

COMMODITIES THAT WERE ELIMINATED FROM BENEFIT ANALYSIS

COMMODITY	ANNUAL VOLUME (000 tons) MOBILE[1]	TENN-TOM[2]
Bauxite	1,872	-
Manganese Ore	45	-
Coke	55	-
Alumina	-	684
Ferro-Phosphorus	44	-
Ferro-Silicon	-	22
Grain	1,989	77
Copper Ore	-	13
Scrap Iron	133	216
Crude Oil	2,409	-
Dist. Fuel Oil	38	-
Residual Fuel Oil	122	-
Gasoline	132	-
General Break-Bulk Cargo	1,407	-
TOTAL	8,246	1,012

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[1] Current (1975) traffic

[2] New traffic to begin in 1986

b. Traffic to or from foreign ports where the channel depths would restrict vessel sizes to those that would not need greater channel depths at Mobile.

c. Cargo consignment per vessel is too small to warrant the use of large vessels.

d. Break-bulk general cargo normally hauled in general cargo vessels which require a channel depth of 40 feet or less.

43. The commodities currently moving through the port, plus certain new commerce generated by the Tennessee-Tombigbee Waterway, which were excluded from the benefit analysis, are described in subsequent paragraphs.

44. Bauxite. Bauxite is being shipped into Mobile for processing into alumina at Alcoa's reduction plant located adjacent to the Alabama State Docks Bulk Handling Terminal. It is presently being hauled in general cargo and dry-bulk ships. Vessels currently used in this service range in size from 14,000 to 52,000 d.w.t. with loaded drafts ranging from 23 to 39 feet. Company officials state that a 40-foot channel is adequate since bauxite is shipped from countries in South America and those located in the Caribbean Sea area which have ports with relatively shallow channel depths. Also, Alcoa's plant is located above the highway tunnels and the company does not have any plans for relocating the plant; therefore, bauxite must be received at the ASD bulk handling plant near Three Mile Creek. Consequently, bauxite has been eliminated as a commodity that would benefit by a deeper ship channel into Mobile.

45. Alumina. Alumina was eliminated from the benefit analysis in this study because the Alabama State Docks stated they would provide facilities for handling alumina at their bulk handling plant at Three Mile Creek, which would restrict the use of large ships. Also, ports where alumina will be shipped have restrictive channel depths which would prohibit the use of large ships. Therefore, a 40-foot ship channel at Mobile will be adequate for future ships hauling alumina.

46, Manganese Ore. This product is being imported into Mobile in relatively small-lot consignments. It is shipped in vessels ranging in size from 15,000 to 48,000 d.w.t. Some of the larger vessels are not fully loaded when arriving at Mobile due to methods of making split-delivery service, i.e., small deliveries at several ports. Ferro-manganese plants dictate small consignments of manganese ore because of the nature of manufacturing and their ability to store large quantities. Therefore, movements of imported manganese ore would not benefit from channel improvements at Mobile.

47. Grain. Although sites for new grain elevators have been identified below the Mobile River tunnels, the present elevator capability and possible expansion will assure continued movement of grain through the existing elevator without any undue vessel delays or grain backlogs for the foreseeable future. The continued use of this elevator precludes the use of deeper draft vessels. Consequently, grain was eliminated as prospective traffic that would benefit by the project modification.

48. Miscellaneous Cargo. The annual volume of miscellaneous dry-bulk commodities, such as, coke, ferrosilicon, copper ore, and scrap iron, are presently moving through the port in small quantities and in relatively small ships. These products are received or shipped from or to numerous origins or destinations in small-lot shipments. No benefits would be realized on these movements of commerce by providing a deeper ship channel into Mobile.

49. Crude Oil. The outbound crude oil through the port of Mobile is being shipped by Amerada-Hess Oil and Citmoco. Their storage and dock facilities are located on the west bank of Mobile River just below Cochrane Bridge. This crude oil is being delivered into the Mobile terminal by a series of pipelines. It originates at oil fields in north-west Florida, northern Mobile County from the newly discovered Creola fields, the Citronelle fields in west Mobile County and oil fields in the area of Laurel, Mississippi. Some of the production in these fields is serving Marion Refinery at Theodore and a portion is shipped by Hess

pipeline through connections at Liberty, MS thence, via the Capline, a major trunk line serving refineries in the Midwest. In 1975, these two companies at Mobile shipped 2.4 million tons by tanker on a coastwise move with 1.8 million tons going to the Houston/Port Arthur, TX area, .3 million tons to the New York/Philadelphia area, and .3 million tons to the New Orleans area.

50. Interviews with these shippers revealed they have no intention of moving their storage facilities and docks to a new location below the highway tunnels. Therefore, no benefits could be assessed on this traffic due to the tunnel restrictions.

51. Refined Petroleum Products. These products, which consist of distillate and residual fuel oil, gasoline, and asphalt, are presently being received in Mobile by small tankers and will continue to move in these relatively small ships. Due to the methods of marketing these products and limited waterside storage, the demand for large consignments is prohibitive. These petroleum products are shipped in convenient size tankers ranging in size from 20,000 to 45,000 d.w.t. The present 40-foot ship channel is adequate for this type of shipping. Based on these conditions, no benefits from channel deepening would be expected for refined petroleum products.

52. General Break-Bulk Cargo. Products in this class of traffic are comprised of commodities shipped in packages, bundles, bags or other type packaging that require the loading or unloading to be accomplished by use of the ship's tackle. This type of commerce is usually hauled in general cargo ships equipped with booms and other tackle that give them the capability of loading or unloading packaged cargo with the use of slings or pallets.

53. During CY 1975, the Alabama State Docks reported 1.4 million tons of general cargo that moved over their general cargo piers. This commerce consists of commodities such as, bananas, prepared food products, wood products, chemicals, paper and paper products rubber, iron and steel products, rice, packaged grain mill products, cotton, and numerous other miscellaneous goods.

54. Vessels used in this trade are general cargo ships ranging in size from small mini-ships to vessels in the 24,000 d.w.t. class. The fully loaded draft of these ships is less than 36 feet; consequently, the existing 40-foot ship channel at Mobile is adequate for ships operating in this trade.

55. Very little containerized cargo moves through the port on a regular basis which requires the use of container, SEEBEE or LASH type vessels. Therefore, no consideration is given to this type service in the benefit analysis.

COMMERCE ACCEPTED FOR BENEFIT ANALYSIS

56. Each commodity presently being shipped through the port in deep-draft vessels was examined to determine if it would move in quantities and in traffic patterns that would warrant the use of ships that could not safely navigate the existing channel at Mobile. This entailed interviews with shippers, steamship lines or their agents, terminal operators, and, in some cases, making resource studies to determine if adequate supplies are available. After examining the total commerce for the port and screening out that traffic which obviously could not benefit from the project improvement, the two commodities that remain to be further analyzed were: Iron ore and coal.

57. Iron Ore. There are three (3) companies that import iron ore through Mobile. Republic Steel Corp. and Jim Walter Resource Corp. (formerly

U.S. Pipe and Foundry) import iron ore through the Alabama State Docks dry-bulk terminal (Tipple) located at Three Mile Creek. The other company, U.S. Steel, imports iron ore through a private terminal owned and operated by T.C.I., a subsidiary of U.S. Steel. All the iron ore imports for Republic Steel and Jim Walters are shipped by rail to their steel mills at Gadsden and Birmingham, AL, respectively. Iron ore for U.S. Steel is shipped to their Birmingham steel mill by barge to Port Birmingham, thence, rail beyond. From time to time, they do rail a portion of the ore to Birmingham, but, for the last few years, they have been shipping by barge exclusively.

58. Coal Imports. Steam coal is being imported through Mobile and then barged to Pensacola and Panama City, Florida for use in Gulf Power Company's steam electric generating plants. This coal has been imported from various countries in the past few years but the Southern Services, Inc., a service company for the Southern Company, and a parent company of Gulf Power, has signed a contract with Mannesman Pipe and Steel Company for the delivery of 7.7 million tons of imported coal. All this coal will originate at Richards Bay, South Africa. The contract was signed on 1 April 1977. This is a 10-year contract that will expire in 1986.

59. This coal is being handled through the Alabama State Dock bulk-handling plant at Three Mile Creek, which is located above the I-10 tunnels. This terminal is presently operating at near capacity. Officials of the Alabama State Docks state their long-range plans call for a new dry-bulk handling facility to be located below the I-10 tunnels. With bauxite and miscellaneous ores being dedicated to the old terminal, coal imports would be one of the two commodities that would be shifted to a new terminal below I-10. With the completion of the Tennessee-Tombigbee Waterway, which would generate new commerce for the old terminal, and the anticipated increase in the annual volume of commodities now moving through the facility, the terminal and storage

area will be fully utilized even with the planned expansion programs to modernize the facility. It is expected that coal imports will be handled through a facility below the tunnels by the time the considered channel improvements could be completed.

60. Steam coal is being imported as a supplement to the domestic supply because it is a better grade with a low sulphur content and the delivered price is lower than the coal brought from domestic mines. The Southern Services, Inc. have negotiated a very attractive ocean freight rate. Officials of this company state rail and barge rates for long-haul of domestic coal are rapidly increasing to a point where they are not competitive with imports. Other deterrents that are affecting the purchase of domestic steam coal are poor delivery and scheduling of rail cars and barges, delays caused by car shortages, miners strikes, and other mining problems, according to information received from the companies involved.

61. Based on the above constraints, which seem to be persistent in supplying coal to steam electric generating plants along the northwest Florida coast, company officials believe coal imports through Mobile will continue as far into the future as they can predict without any major rate of increase from that which is being received under the initial contract.

62. Coal Exports. Coal is one of the principal commodities exported through the port. The major source of supply for this coal is the Coosa, Cahaba Plateau and Warrior fields in north Alabama, western Kentucky, Tracy City fields in Tennessee with small shipments from eastern Kentucky, Illinois and Indiana. At the present time, most of the coal is being mined in the north Alabama fields and shipped by barge to McDuffie Island Coal Terminal for export. In 1975, about 75 percent of the total coal exports through Mobile was being received by barge. A small amount was being railed into Mobile from the Kentucky area.

63. The four coal fields in Alabama cover all or parts of 22 counties. The Warrior field is the most productive of the four fields in Alabama. It is about 70 miles long and 65 miles wide and covers Tuscaloosa, Jefferson, Lamar, Marion, Winston, Fayette, Cullman, Blount and Walker Counties. These fields embrace about 3,500 square miles. The Cahaba field is approximately 66 miles long and has an average width of 5 to 6 miles. The field covers parts of Bibb, Shelby, St. Clair, and Jefferson Counties for a total area of about 350 square miles. The Coosa field is an elongated coal-bearing structure along the southeast margin of the Appalachian Mountains. It is a narrow, north-east-trending field covering approximately 280 square miles in Shelby, St. Clair and Calhoun Counties. The Coosa field averages 60 miles in length and 5 miles in width. The Plateau coal field is located in Blount, Cherokee, Cullman, DeKalb, Etowah, Franklin, Jackson, Jefferson, Lawrence, Madison, Marion, Marshall, Morgan, St. Clair and Winston Counties. This field has a greater area than all the other fields combined, with a maximum width of 110 miles and a maximum length of 120 miles. It covers an area of more than 4,500 square miles. A map designating the location of the four coal fields in Alabama is shown in figure F-2. Also, figure F-3 shows the active coal mining areas in Alabama.

64. Many estimates of Alabama's coal reserves have been made in the past. Most of these estimates have varied tremendously because of the different criteria used in their formulation. The latest reserve figures, as estimated by the Geological Survey of Alabama, is 35 billion tons. The National Coal Association has estimated the total U.S. coal reserves to be 671 billion tons. Based on these figures, Alabama has approximately five (5) percent of the total U.S. reserve. Alabama has a recoverable reserve of 18.4 billion tons with 15 percent or 2.76 billion tons which meet the most stringent sulphur requirements and an additional 78 percent or 14.3 billion tons which contain from 1 to 2 percent sulphur. A map showing the coal fields in the United States is presented as figure F-4.

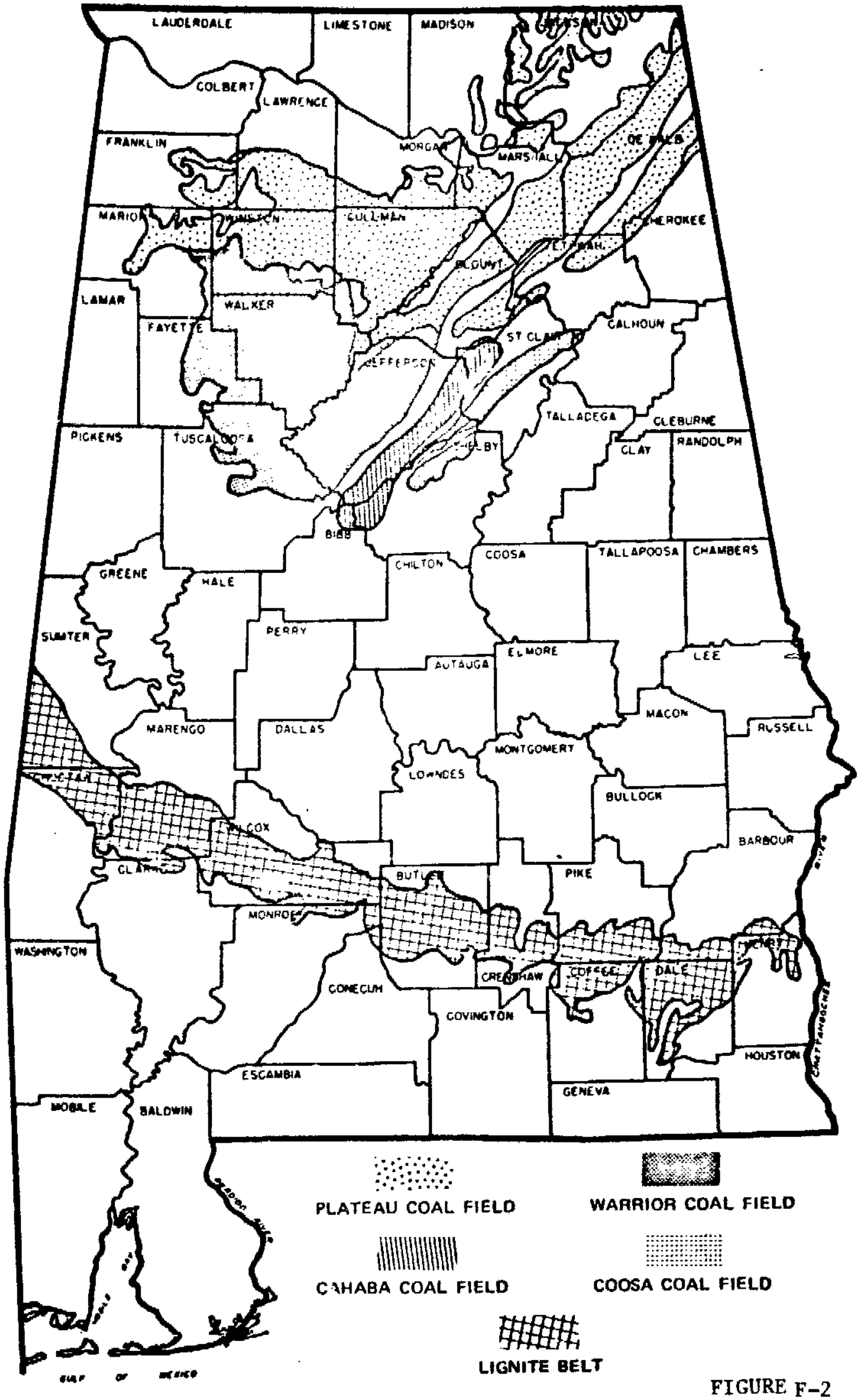

FIGURE F-2

COAL FIELDS IN ALABAMA

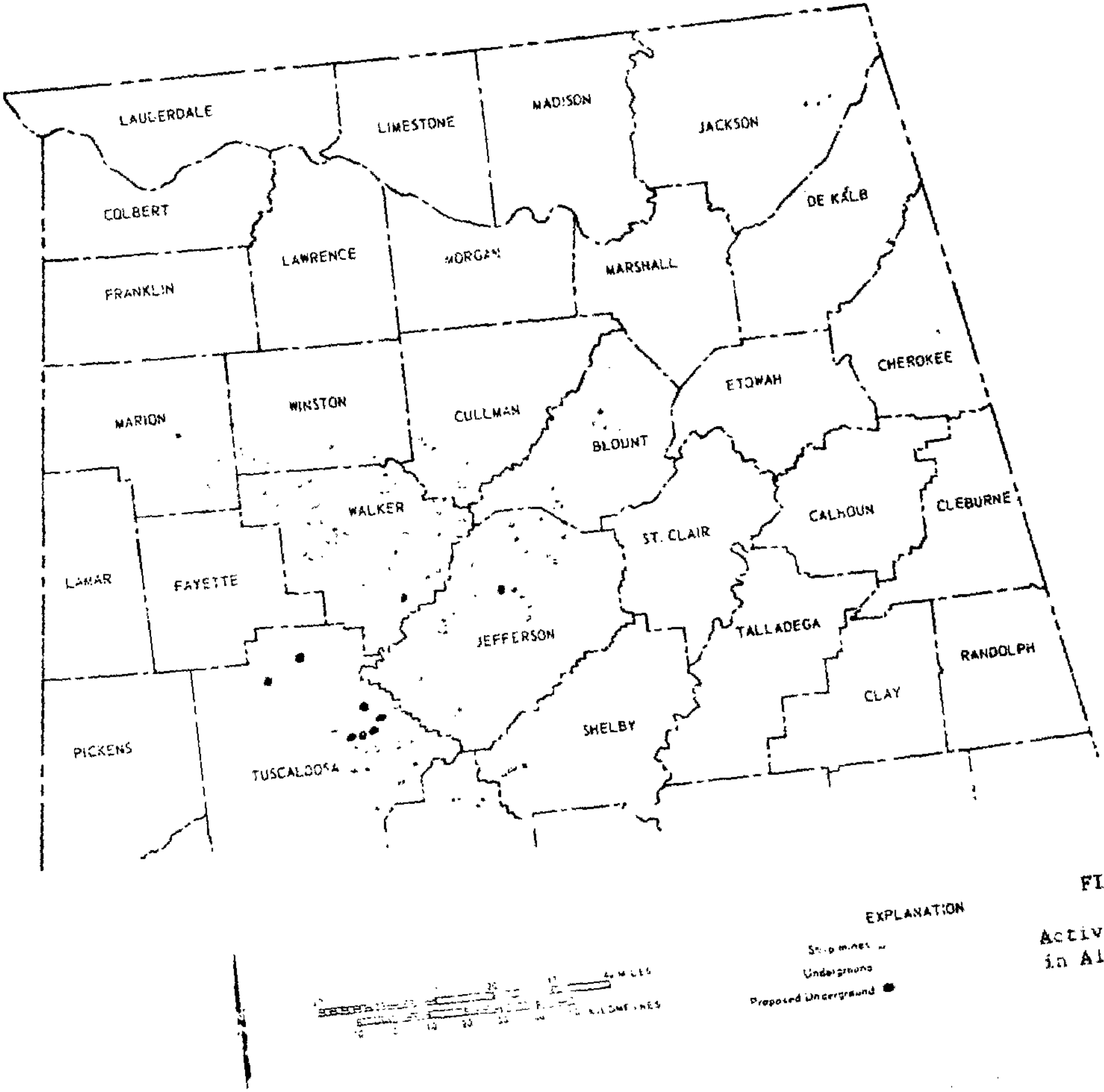

FIGURE F-3

Active mining areas in Alabama

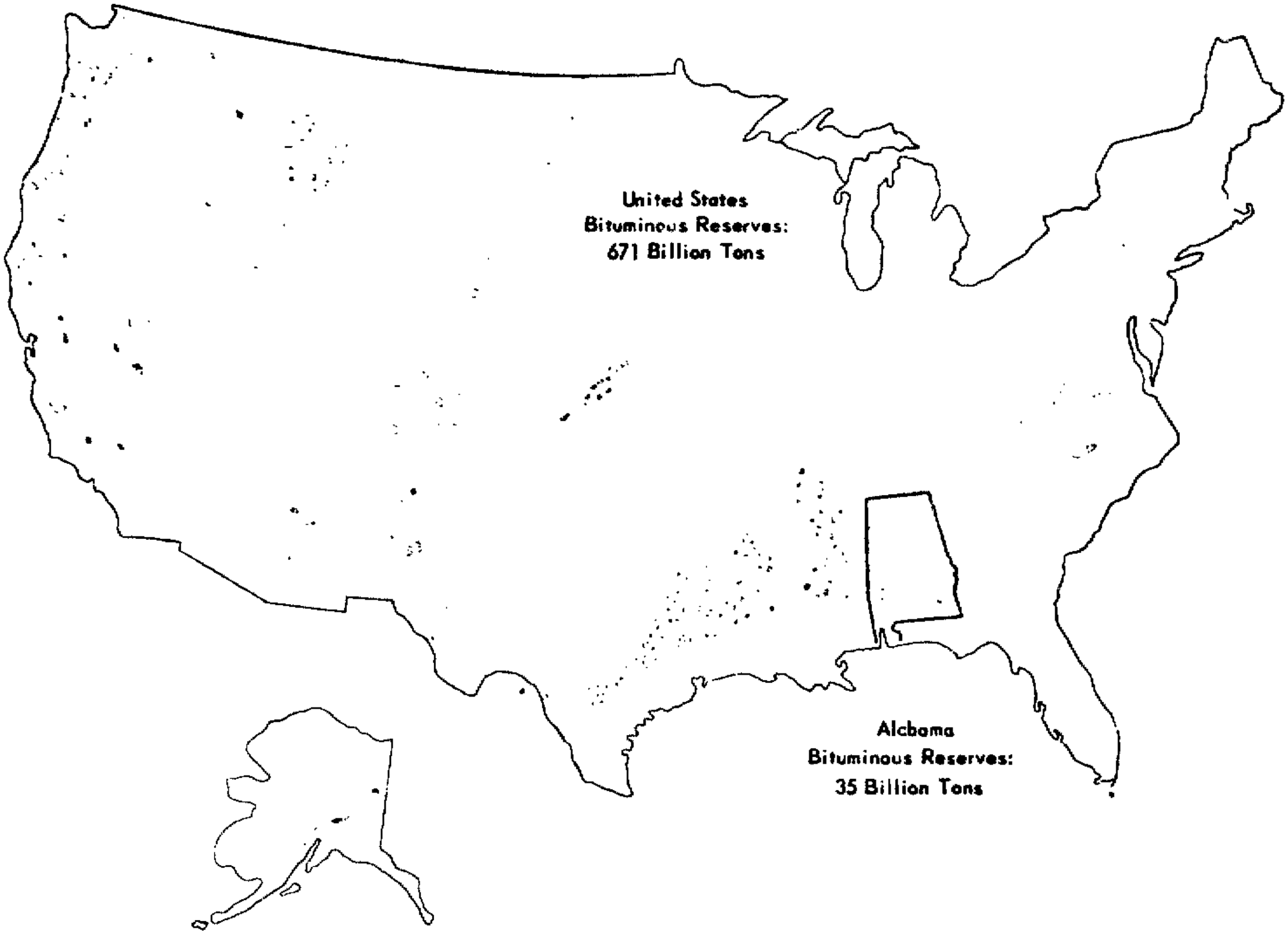

FIGURE F-4

Coal fields in the United States (modified from National Coal Association, 1973).

65. The most prevalent demands for Alabama coal are in the electric generating industry, domestic coking for steel mills, and coking coal for export. Of the 21.1 million tons of coal mined in Alabama during FY 1975-76, approximately 3.0 million tons or 14 percent were shipped through Mobile for export. If the export demand for Alabama coal were held constant at 14 percent, it would deplete approximately 2.6 billion tons of the 18.4 billion tons of recoverable reserve. At this rate of depletion of the reserves, the 2.6 billion tons could support an annual export rate of 26.0 million tons for 100 years. The annual growth in coal exports through Mobile, as projected in this report, clearly indicates that reserves of coal in Alabama will be adequate to support the export demand. Also, with the new development and use of nuclear and solar energy for providing electric power and heat, the use of coal as fuel for power plants will diminish to some degree. Therefore, the tonnage of coal reserves in Alabama allocated for export is a conservative extimate.

66. By 1986, the Tennessee-Tombigbee Waterway will generate additional coal for export through Mobile. The source of this coal will be from mines in Tennessee, north Alabama, and western Kentucky. This will be coal now moving through New Orleans or new coal shipments from mines that will be opened in the future.

67. The Drummond Coal Company, Jim Walters Corp., and Ataka America, Inc. have entered into a joint venture to furnish Alabama coal to the Japanese steel mills. Other major shippers to Japan include Smith Coal Sales and Sumitome Shoji America. The above companies accounted for about 85 percent of the coal exported through Mobile in 1976.

68. Coal exports generated by the Tennessee-Tombigbee Waterway will amount to approximately 39 percent of the total coal exports through Mobile, beginning in 1986, the scheduled completion date of the waterway.

69. Currently, coal exports through Mobile are shipped to about 16 countries. The predominant shipments are going to Japan, with 75 percent of the total exports in 1975 being shipped there. Other areas that receive coal from Mobile are: England, Europe, Scandinavian countries, countries bordering the Mediterranean Sea, and the East Coast of South America. Some of the leading ports are: Tobata, Kashima, Kobe, Chiba, Ohita, Jimitsa and Kukuyama, Japan; Taranto, Genoa, Savonia, and Venice, Italy; Alexandria, Egypt; Tubarao, Brazil: Iskenderun, Turkey; Newport, England; Cardiff and Port Talbot, Wales; and Rio de Janeiro, Brazil.

DETERMINATION OF BASE YEAR TONNAGE

70. 1975 Tonnage. After examining all the commerce moving through the port in deep-draft vessels, commerce which would not benefit from a greater ship channel dimension was screened and eliminated. This includes tonnage that would continue to move through the Panama Canal, move in relatively small vessels, and that tonnage restricted by channel depths in foreign ports. The volume of commerce accepted as initial-year traffic is the remaining 1975 net tonnage that will be used in the transportation benefit analysis to derive the annual savings from the recommended project improvements.

71. Alternative Routing Via the Panama Canal. Two routes are available for traffic moving between Mobile and Far Eastern Countries, including Australia. One route would be through the Panama Canal. Vessels using the Panama Canal are limited to a draft of 41 feet. If this route is used under "without" project conditions, vessel drafts would be restricted to the present 40-foot channel at Mobile. Vessel sizes used in the benefit analysis that would be subjected to this route are dry-bulk carriers ranging in size from 20,000 to 56,000 d.w.t. The other route available is the longer distance around the Cape of Good Hope, with size of vessels being unrestricted.

72. Under the existing channel condition at Mobile, traffic moving between Mobile and the Far East is routed through the Panama Canal. With a greater channel dimension available, it is expected a portion of this traffic will continue to move through the Panama Canal.

73. To determine the volume of Far East traffic that will continue to move through the Panama Canal in dry-bulk carriers, it is expected the total volume will be in direct proportion to the carrying capability of vessels in the world fleet. The carrying capability of vessels in the world fleet between 15-56,000 d.w.t is 57 percent. Consequently, the remainder or 43 percent of the tonnage will be shipped in vessels ranging in size between 61,000 and 182,000 d.w.t. via the Cape of Good Hope, which would benefit by channel improvements. Table F-8 gives the number of dry-bulk carriers in the world fleet and their carrying capability.

74. <u>Iron Ore</u>. One of the terminals handling iron ore is the Bulk Marine Terminal owned and operated by T.C.I., a subsidiary of U.S. Steel. In 1975, this terminal received 3,060,000 tons of imported iron ore, with 77 percent or 2,356,000 tons of iron ore fines originating at Puerto Ordaz, Venezuela. The company prefers to import pelletized iron ore which is not available at Puerto Ordaz. With a greater channel depth available at Mobile, the company has stated it will change its source of supply to other ports in South America which have deeper depths and at which pelletized ore is available. The remainder of the initial-year tons originated at Port Cartier, Quebec; Vitoria (Tubarao) Brazil; and San Nicolas, Peru, representing 5, 10 and 8 percent of the total imports, respectively. The 245,000 tons originating at San Nicolas, Peru were eliminated as prospective traffic due to the restrictions at the Panama Canal with no economic alternative routing being available. The total initial-year volume of iron ore for this terminal, accepted as prospective commerce, was 2,815,000 tons.

TABLE F-8

CARRYING CAPABILITY OF DRY BULK CARRIERS IN THE WORLD FLEET
(U.S. AND FOREIGN FLAG REGISTRY)

Vessel Size (d.w.t.)	Average Draft (ft)	Number of Vessels	Payload per Vessel	Payload Capability of Total Vessels
15,000	29	216	16,128	3,483,648
17,000	30	236	18,278	4,313,702
20,000	31	315	21,504	6,773,760
23,000	32	335	24,730	8,284,416
26,000	33	339	27,955	9,476,813
29,000	34	323	31,181	10,071,398
32,000	35	324	34,406	11,147,673
36,000	36	233	38,707	9,018,777
39,000	37	145	41,933	6,080,256
43,000	38	104	46,234	4,808,294
47,000	39	92	50,534	4,649,165
52,000	40	84	55,910	4,696,474
56,000	41	85	60,211	5,117,952*
61,000	42	84	65,587	5,509,325
65,000	43	78	69,888	5.451,264
70,000	44	72	75,264	5,419,008
75,000	45	57	80,640	4,596,480
81,000	46	39	87,091	3,396,557
86,000	47	29	92,467	2,681,549
92,000	48	29	98,918	2,868,634
98,000	49	29	105,370	3,055,718
104,000	50	28	111,821	3,130,982
110,000	51	30	118,272	3,548,160
117,000	52	28	125,798	3,522,355
123,000	53	25	132,250	3,306,240
130,000	54	22	139,776	3,075,072
137,000	55	19	147,302	2,798,746
144,000	56	19	154,829	2,941,747
151,000	57	21	162,355	3,409,459
159,000	58	20	170,957	3,419,136
166,000	59	16	178,483	2,855,731
174,000	60	10	187,085	1,870,848
182,000	61	1	195,686	195,686
TOTAL		3487	2.967,552	154,975,000

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* Total payload capability for vessels ranging from 15,000 through 56,000 d.w.t. is 87.9 million tons or 57 percent.

75. Iron ore imports that were shipped through the Alabama State Docks Terminal, commonly known as the "Tipple", amounted to 1,721,000 tons in 1975. Of this total, 472,000 tons originated in Australia. Since traffic from Australia can use the Panama Canal, only 43 percent or 203,000 tons of this commerce were accepted for benefit analysis. Shipments from Chile and Peru moving through this terminal in 1975 amounted to 817,000 tons. All of this traffic was eliminated from the benefit analysis due to ship size restrictions at the Panama Canal and there being no economical alternative routing from these two countries. Also, 39,000 tons originating at Pointe Noive, Congo, South Africa, were eliminated due to the restrictive channel depths at this port. The remaining 393,000 tons from Canada and Brazil were included in the tonnage base giving a total of 596,000 tons accepted as initial-year tonnage of iron ore moving through the "Tipple."

76. In 1975, total iron ore imports through Mobile amounted to 4,781,000 tons. Of this total, 269,000 tons would continue to be shipped through the Panama Canal in vessels sizes 56,000 d.w.t. and under which would not benefit from a deeper channel at Mobile, 1,062,000 tons originating in Chile and Peru would continue to move through the Panama Canal in vessels that would not benefit from the project, and 39,000 tons originating at Pointe Noive, South Africa was eliminated due to the channel depth at this port, giving a total tonnage of iron ore eliminated of 1,370,000 tons. The total initial-year tonnage for iron ore accepted for benefit analysis is 3,411,000 tons.

77. <u>Coal (Import)</u>. Coal imports for 1975 amounted to 371,000 tons. The consignee that uses this coal states they have recently signed a 10-year contract for the delivery of coal imports with an average annual volume of 896,000 tons per year beginning in 1978. The 371,000 tons that were shipped in 1975 were accepted as initial-year tonnage.

78. Coal (Export). The percentage of U.S. coal exports to foreign markets has varied from year to year as indicated in table F-21. This is also true for exports from Mobile to Japan as shown in table F-9. Table F-9 also shows exports to other countries to have continually increased from 1975 through 1978. For purposes of this draft report, average tonnages for the 4-year period has been used to determine preliminary allocation of percentages of coal exports to all countries (four groups) to which movements of this commodity result in benefits to the Mobile Harbor study. This distribution pattern is very conservative especially since it is assumed to be representative for all present and future shipments of export coal. Based on these 4-year averages, the distribution would be: 60% to Japan, 27% to Italy, 9% to England/Europe, and 4% to the East Coast of South America. However, some individual shippers will ship 100 percent of their coal to Japan in the future because it will be dedicated coal for steel mills in that country. Based on existing information concerning future dedicated tonnage to Japan, the adjusted distribution pattern changes to 67, 22, 8 and 3 percent for the respective areas shown above.

79. Until 1970, coal exports through Mobile were negligible. Beginning in 1970, these exports were 343.6 thousand tons and subsequently had increased to 2,745.0 thousand tons in 1975, as reported in Waterborne Statistics. With new contracts for coal exports and with the Tennessee-Tombigbee Waterway being available, it is expected coal exports will increase rapidly until 1986. However, to be consistent with other commodities, the unadjusted initial-year tonnage is 2,865,000 tons in 1976, as recorded by McDuffie Coal Terminal. This tonnage has been adjusted downward by eliminating that coal destined to Japan which could continue to move through the Panama Canal in ships suitable for passage through that waterway.

80. The initial year volume of coal exports was distributed to foreign market areas based on the 4-year average as developed from Waterborne Statistics. The distributed tonnages were: 1,595,000 tons to Japan; 521,000 to the Italy area; 174,000 tons to England/Europe; and 77,000 tons to the East Coast of South America. Of the 1,595,000 tons to Japan, 57 percent or

TABLE F-9

DISTRIBUTION OF COAL EXPORTS FROM MOBILE BY FOREIGN MARKET AREAS

MARKET AREA	VOLUME (Short Tons) (thousand tons)	PERCENT
Japan:		
1975	2,026.9	
1976	1,554.3	
1977	1,785.3	
1978	1,633.4	
4-Year Average	1,750.0	60%
Italy (Mediterranean Sea):		
1975	494.8	
1976	750.5	
1977	1,090.2	
1978	806.3	
4-Year Average	785.4	27%
England/Europe:		
1975	167.0	
1976	255.0	
1977	435.1	
1978	158.2	
4-Year Average	253.8	9%
East Coast of South America (Caribbean Sea):		
1975	48.7	
1976	144.8	
1977	214.5	
1978	116.3	
4-Year Average	131.1	4%
All Other (Canada and West Coast of Mexico):		
1975	8.1	
1976	51.3	
1977	86.6	
1978	91.4	
4-Year Average	59.4	
TOTAL (Excluding "All Other" Tonnage)		
1975	2,737.5	
1976	2,704.6	
1977	3,525.1	
1978	2,714.2	
4-Year Average	2,920.3	

SOURCE: Point-to-Point Foreign Waterborne Statistics compiled by the Bureau of Census in 1975, 1976, 1977 and 1978 as reported by the Alabama State Docks.

909,000 tons would continue to go through the Panama Canal in relatively small ships. The remainder, or 686,000 tons, would move in larger ships around the Cape of Good Hope, South Africa and was accepted as initial tonnage for benefit analysis. This adjusted tonnage to Japan, combined with the remaining tonnage to other market areas as shown above, gives a total tonnage accepted for rate analysis of 1,458,000 tons.

81. Table F-10 presents the tonnage distribution of coal by company and the adjusted tonnage by destination for selected years from 1975 through 1986. The adjusted tonnage for 1975 reflects the above percentages of total tonnage. This percentage distribution does not remain constant over the 11-year period of analysis due to the variance in annual volumes of export, growth rates and trade patterns between the companies expected to utilize the project. Growth rates used in tonnage projections were based on the beginning year of export for each company and the annual volume of coal exports as stipulated by contract. In the absence of a contract or upon expiration of an existing contract, the Bureau of Mines growth estimate of 1.2 percent per annum was used to project future company exports.

82. As a result of projecting each company individually, there is a slight change in percentages of total annual exports claimed by the four categories of destination. In 1986, 67 percent of coal exports is expected to move to Japan, 22 percent to Italy, 8 percent to England/Europe, and 3.0 percent to the East Coast of South America.

83. A summary of commerce and tonnage accepted as initial-year traffic that will be subjected to a rate analysis is shown in table F-11.

TABLE F-10

BASE-YEAR TONNAGES ON COAL EXPORTS EXTENDED TO 1986 FORMING A COMPOSITE BASE FOR PROJECTIONS

(thousand tons)

SHIPPER [1]	1975	1976	1978 [3]	1986
COMPANY A	-	-	-	399.0
COMPANY B	-	-	-	2,122.0
COMPANY C	-	-	-	1,592.0
COMPANY D	-	-	-	2,705.0
COMPANY E	1,443.0	1,719.0	1,867.0	6,366.0
COMPANY F	373.0	325.0	247.0	366.0
COMPANY G	437.0	404.0	557.0	455.0
COMPANY H	114.0	417.0	128.0	466.0
TOTAL	2,367.0 [2]	2,865.0 [2]	2,799.0 [2]	14,471.0 [4]
ADJUSTED TONNAGES ACCEPTED FOR BENEFIT ANALYSIS				
To Japan [5]	686.0	809.0	817.0	4,177.0
To Italy	521.0	664.0	605.0	3,211.0
To England/Europe	174.0	221.0	202.0	1,070.0
To E. Coast South America	77.0	98.0	90.0	476.0
TOTAL	1,458.0	1,792.0	1,714.0	8,934.0

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[1] Names of companies withheld to avoid possible disclosure of confidential information.

[2] Actual exports obtained from Port records.

[3] Decrease in exports for 1978 is due to U.S. coal miners' strike in early 1978.

[4] Substantial increases brought about by information on file from shippers which show new contracts beginning in 1979 and 1981. Totals include 5.23 million tons that will be diverted from New Orleans because of lower transportation cost via Tennessee-Tombigbee Waterway. All tonnages projected at 1.2 percent average annual growth rate from last historic year of movement or from first year of new contract to 1986.

[5] Tonnage reflects 43 percent of the total to Japan which is expected to move in large dry bulk carriers around the Cape of Good Hope. The remainder (57%) will continue to move through the Panama Canal.

TABLE F-11

SUMMARY OF INITIAL-YEAR (1975) TONNAGE ACCEPTED FOR BENEFIT ANALYSIS

Commodity	Annual Volume (Short Tons)
Iron Ore (Import)	3,411,000
Coal (Import)	371,000
Coal (Export)	1,458,000
TOTAL	5,240,000

84. <u>1986 Tonnage</u>. With the initial-year of survey being 1975 and the completion of the Tennessee-Tombigbee Waterway in 1986, it is appropriate to consider tonnage expected to use the Mobile Channel at these periods of time. The following paragraphs will discuss each commodity movement in detail as related to abnormal growth. Those movements that grow under the normal projection process will be mentioned but details concerning these projected values will be explained later in this appendix.

85. Iron Ore is expected to grow from 3,411,000 tons in 1975 to 3,755,000 tons in 1986, based on the normal economic projection processes.

86. Based on information received from the consignee for import coal, a recent 10-year contract has been signed which will increase the tonnage of this commodity to 896,000 tons beginning in 1978. This tonnage is accepted as 1986 commerce and is held constant throughout the 50 year period of economic analysis.

87. The volume of coal exports through Mobile in 1975, according to records at McDuffie Coal Terminal, was 2,367,000 tons, increasing to 2,865,000 tons for 1976 with a decrease to 2,799,000 in 1978 due to U. S. coal miners strike in early 1978. Based on information received from major coal exporters that ship coal through Mobile, and firm contracts with foreign principals indicate a rapid increase in coal exports for the next 10 to 15 years. First-year tonnage on this traffic will vary depending on the beginning data of new contracts. In developing expected growth rates on coal exports to 1986, the base for projection purposes would be that tonnage shipped during the first year of contract as given by company officials or where the companies did not indicate a firm contract is forthcoming, the 1976 tonnage was used as the base-year. Tonnage movements for all of the smaller shippers that reported coal shipments through Mobile for 1976 was used in the development of a total tonnage base. The base-year tonnage on coal exports for traffic expected to move over the Tennessee-Tombigbee Waterway for export through Mobile was taken from the A.T. Kearney Report. The base tonnage, as reported by Kearney, ranged from 1975 to 1986 depending on individual company's ability to begin operation. Shipments that would move through other ports or via rail to Mobile were used to develop a base, although it is not expected to move over the Tennessee-Tombigbee Waterway until 1986. All tonnage was projected from the varying base tonnages using an annual growth rate of 1.2 percent to 1986. This was considered to be a common year that would include base tonnage on all coal movements.

88. Coal shipments are separated into four categories for benefit analysis purposes. This includes coal being shipped to Japan, England/Europe, Italy and East Coast of South America.

89. Exports of coal through the port are expected to be 14,471,000 tons in 1986. Of this total, 9,714,000 tons will be shipped to Japan. It is expected that about 60 percent of the total coal exports will be shipped to Japan except that being shipped by Sumitomo Shoji America where 100

percent of the tonnage will go to Japan. On this basis, about 67 percent of the tonnage is shipped to Japan. Only 43 percent or 4,177,000 is anticipated to move via the Cape of Good Hope if a greater channel depth is provided at Mobile. It is expected that 3,211,000 tons or 22 percent of the total will be shipped to Italy. The 1,020,000 tons going to the England/Europe area represent about 8 percent of the total. About 3 percent or 476,000 tons is expected to be shipped to the East Coast of South America.

90. The distribution of coal exports in 1975 by destination, moving through Mobile differs from that of total exports from U.S. ports, in that Japanese customers of coal have more financial interest in coal mining and shipping in this area than other areas of the country on a proportionate scale of tonnage shipped. The Japanese have long-term contracts with coal producers in Alabama while shipments to other countries are based on short-term contracts or one-time "spot" sales. Also, coal shipped through Baltimore, Norfolk and Newport News to England and Europe have a rate advantage over Mobile due to their geographic location. Consequently, the largest market for coal shipped from Mobile will be Japan. A comparison of coal distribution for the United States and the port of Mobile in 1975 is shown in table F-12. It should be noted that the distribution, as shown in this table, is for comparison purposes only and that the actual distribution of coal for this study is shown in table F-9 and discussed in Paragraph 78 in this appendix.

91. The base tonnage on coal exports will begin at different time periods until the year 1986. In 1986, all base tonnage will have been accounted for and used as a common base for all coal shipments. Table F-10 shows the historical annual volumes of coal shipped from the Port of Mobile and the expected shipments to occur in 1986.

TABLE [illegible]- 2

PERCENTAGE DISTRIBUTION OF COAL EXPORTS IN 1975

Country or Region	Percent Distribution U.S. Ports[1]	 Mobile[2]
Japan	54	75
England/Europe	30	6
Italy	9	17
East Coast of South America	7	2
TOTAL	100%	100%

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[1] SOURCE: Bureau of Mines as published in "International Coal Trade" January 1977 issue.

[2] SOURCE: Point-to-Point Waterborne Statistics as reported by the Bureau of Census as compiled in their computer file SA 705.

92. Summary of 1986 Tonnages. A summary of the 1986 tonnage accepted for benefit analysis is shown below in table F-13

TABLE F-13

SUMMARY OF 1986 TONNAGE ACCEPTED FOR BENEFIT ANALYSIS

Commodity	Annual Volume (Short Tons)
Iron Ore (Imports)	3,756,000
Coal (Imports)	896,000
Coal (Exports)	8,934,000
TOTAL	13,586,000

PROJECTIONS OF COMMERCE

93. Commodity Forecasts. After the 1986 volume of commerce was determined, further economic investigations and analysis were conducted to establish the future volume of the deep-draft vessel commerce accepted as prospective traffic for the port to the beginning of and during the economic project life (1995-2044). Appropriate economic indicators were selected to reflect the growth rate for each individual commodity movement accepted as prospective traffic. For iron ore imports, a statistical analysis was conducted to develop a functional relationship between the OBERS earning data and various measures of production. For other commodities in the initial-year traffic pattern, growth indicators were developed by various other procedures due to the nature of commodity and restrictions in their growth patterns. Each of the indices selected was converted to an index of growth or projection factor. The projection factors were then applied to the initial-year commerce to estimate the future volume of commodity movements. Commodity tonnage assessments and supporting rationale used to forecast future growth in port commerce are discussed in subsequent paragraphs.

94. Iron Ore Imports. Iron ore imported through the port of Mobile is reshipped by rail and barge to inland points, such as, Birmingham and Gadsden, Alabama. This product is used in the primary metals industry and its growth is highly dependent on the demands in this industry. Imported iron ore in the United States, used in iron and steel production, has been steadily increasing as a source of supply. As shown in table F-14, the United States steel industry presently acquires about one-third of iron ore supplies from foreign sources as compared with 5 percent in 1947. Domestic iron ore, on the other hand, has remained relatively stable during the 1947-1974 period. The average annual growth in total iron ore shipments during this 27-year period was 1.1 percent.

95. Production of the U.S. steelmaking industry as measured by the Federal Reserve Board (FRB) Index of quantity output (iron and steel) exhibited an average annual growth rate of about 2.6 percent from 1947 through 1974. Earnings in primary metals for the U.S. experienced a similar rate of growth as shown in table F-15. During the same 21-year period, primary metals earnings in Alabama, and BEA 45 increased at a 3.1 percent rate and at a 2.4 percent rate, respectively. Increase in imports of iron ore at the port of Mobile from 1953 to 1974, shown on table F-14, has been about 10 percent annually. This growth rate reflects the relative increase of imported iron ore over domestic supplies as well as an increase in ore imports greater than the national rate of increase.

96. Statistical regression analyses summarized in table F-16 were conducted using various combinations of national values for earnings in primary metals, the FRB Iron and Steel Production Index, ore imports, and total ore shipments as variables. The significance of these regressions was based on the premise that a relationship between earnings in primary metals and iron ore shipments could be verified as shown by regression 2 on table F-16.

97. With regard to prospective iron ore shipments through Mobile, these imports are anticipated to comprise a constant proportion of the total raw material consumed in steel production at Birmingham and Gadsden, Alabama. Accordingly, the anticipated growth of iron ore shipments was estimated using OBERS (Series E) projections of earnings in primary metals for the BEA 45 area. During the 1980-2020 time frame, projected earnings in primary metals exhibit an average annual growth rate of 1.3 percent and 1.4 percent for BEA 45 and the nation, respectively. This modest growth rate is also consistent with the annual increase in total U.S. iron ore shipments during the period 1947-1974. Forecast indicators for raw materials of the primary metals industry were developed using regression equation 4 (table F-16). Projected earnings in primary metals for the U.S. (OBERS, Series E) were were substituted into equation 4 to estimate the future production index of

TABLE F-14

IRON ORE OPERATIONS IN THE U.S.

1947-1974

Year	Shipments from Mines	Imports	Total Shipments	Ratio of Imports To Total	Federal Reserve Board Index Iron and Steel Production[1]	Iron Ore Imports at Mobile Harbor (Thousands of Tons) Total	Three Mile Creek[3]
	(Thousands of Tons)						
1947	93,315	4,896	98,211	.05	N/A	N/A	N/A
1948	100,822	6,109	106,931	.06	N/A	N/A	N/A
1949	84,687	7,399	92,086	.08	N/A	N/A	N/A
1950	97,764	8,297	106,061	.08	N/A	N/A	N/A
1951	116,230	10,148	126,378	.08	N/A	N/A	N/A
1952	97,973	9,772	107,745	.09	N/A	N/A	N/A
1953	117,822	11,086	128,908	.09	N/A	895.6	624.6
1954	76,954	15,793	92,747	.17	71.4	2,150.3	652.8
1955	106,258	23,476	129,734	.18	94.9	2,038.2	150.4
1956	97,924	30,424	128,348	.24	93.2	2,407.7	379.5
1957	104,970	33,654	138,624	.24	89.8	3,269.6	[illegible]
1958	66,959	27,623	94,582	.29	67.7	3,198.2	145.0
1959	59,855	35,627	95,482	.37	77.9	3,723.1	224.3
1960	83,784	34,584	118,368	.29	79.1	2,673.5	268.0
1961	72,949	25,808	98,757	.26	75.6	1,674.2	136.0
1962	70,410	33,435	103,845	.32	78.7	1,641.8	185.7
1963	74,387	33,488	107,876	.31	85.8	2,994.5	230.7
1964	85,184	42,417	127,601	.33	98.7	3,419.7	381.8
1965	84,930	45,105	130,035	.35	106.2	4,378.5	1,136.4
1966	90,824	46,259	137,083	.34	107.5	4,797.7	1,194.7
1967	83,016	44,627	127,643	.35	100.0	4,545.7	650.3
1968	82,530	43,941	126,471	.35	103.6	4,413.1	1,515.0
1969	90,583	40,758	131,341	.31	113.0	4,576.0	707.4
1970	87,891	44,876	132,767	.34	105.3	5,360.3	2,210.5
1971	77,692	40,124	117,816	.34	96.6	5,333.8	1,276.8
1972	78,825	35,761	114,586	.31	107.1	3,846.7	1,100.5
1973	90,863	43,331	134,194	.32	121.7	4,611.0	1,296.9
1974	85,256	48,029	123,285	.36	119.9	6,393.1	1,492.6
Average Annual Growth Rate (1947-74)	-.33%	8.82%	1.14%		2.63%[2]		

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[1] N/A - Not available.

[2] Growth rate based on 1954-1974.

[3] Imported iron ore into Three Mile Creek is discharged at the Alabama State Docks Bulk Handling Plant and is subsequently shipped to Birmingham and Gadsden. The remainder of the tonnage is imported at a private dock and is reshipped to Birmingham.

SOURCE: Survey of Current Business, various issues. Waterborne Commerce of the United States, 1953-1974.

TABLE F-16

SUMMARY OF REGRESSION ANALYSES - PRIMARY METALS

Variables and Regression Equation	Coefficient of Multiple/Partial Correlation ($R/r_{12.3}$)	F Values Computed	F Values Critical at .01 level	Standard Error of the Estimate
1. Y = U.S. Iron Ore Imports X_1= FRB Production Index Iron and Steel X_2= Time $Y = 27,447.1 + 199.7X_1 + 704.9X_2$	.830/.373	19.96 (DF = 2,18)	6.01	5,031.7
2. Y = U.S. Total Iron ore shipments X_1= Earnings in Primary Metals X_2= Time $Y = 17.9 + .0011X_1 - .44X_2$	.978/.889	32.42 (DF = 2,3)	30.82	4.4
3. Y = U. S. Total Iron Ore Shipments X_1= FRB Production Index - Iron & Steel X_2= Time $Y = 93,245.5 + 1,229.6X - 1,405.0X_2$	.888/.861	33.50 (DF = 2,18)	6.01	7,370.7
4. Y = FRB Production Index - Iron & Steel X_1= Earnings in Primary Metals X_2= Time $Y = 34.4 + .0124X_1 - 1.20X_2$	.996/.983	171.9 (DF = 2,3)	30.82	1.7
5. Y = U. S. Iron Ore Imports X_1= Earnings in Primary Metals X_2= Time $Y = 12.5 + .00256X_1 - .0256X_2$	.870/.561	4.7 (DF = 2,3)	30.82	2.9

the primary metals industry of the U.S. Adjustment of the production index from a national indicator to a regional indicator was based on the following proportion:

$$\frac{\text{Earnings Growth Factor (Regional)}}{\text{Earnings Growth Factor (National)}} = \frac{\text{Production Growth Factor (Regional)}}{\text{Production Growth Factor (National)}}$$

98. The various factors were based on regional and national earnings for 1974, interpolated from OBERS projections and the 1974 production index developed from the regression equation, and the regional production ratio was an unknown. Solving this production for each projected decade results in estimates of the growth factor of regional production which was applied to 1974 volumes of commodity movements associated with the primary metals industry. Resulting projection indicators are shown in table F-17, designated as Index A. These growth indicators are applicable on all the imported iron ore destined to Birmingham and Gadsden, Alabama areas which are encompassed in BEA 45.

99. Sensitivity Analysis of Iron Ore Projection. Two statistical regression analyses were performed in order to test the significance of the projection factors developed and utilized in this study to forecast iron ore movements. The analyses, one at the national level and the other for the project's tributary area, BEA 45, both employed the $y = mx + b$ equation for simple linear regression. Sources for the historic data used in the regressions were OBERS Series E projections of economic activity and Waterborne Commerce Statistics. OBERS Series E also provided the basis for projected earnings data.

100. At the national level x represented the annual earnings for primary metals and y represented the annual volume of iron ore imports for the United States from 1950 through 1971. The regression resulted in a factor of growth from 1986 to 2044 of 2.76 with an R value of .87. Tests for significance and standard error of estimate also produced acceptable results. In the regression analysis of the study area x represented the annual

TABLE F-17

A composite of Earnings in Primary Metals for U. S. and BEA 045 and an index of U. S. Production of Iron & Steel to be used in the projection of Iron Ore Imports

Index A

	Earnings		FRB Prod.	Earnings Ratio		Regional Production	Growth
Year	U. S.	BEA 45	Index[1]	U. S.	BEA 045	Index[4]	Indicator
1970	12,284.3	332.2	103.5	-	-	-	-
1975	13,293.0[2]	352.0[2]	110.1	1.00000	1.00000	110.1	1.000
1978	13,898.0[2]	364.0[2]	114.0	1.04551	1.03409	112.8	1.025
1980	14,302.0	372.0	116.7	1.07590	1.05681	114.6	1.041
1986	15,563.0[2]	399.0[2]	125.2	1.17077	1.13352	121.2	1.101
1990	16.404.0	417.0	130.9	1,23403	1.18465	125.7	1.142
1995	17,746.0[2]	447.8[2]	141.6	1.33498	1.27201	135.0	1.225
2000	19.088.0	478.5	152.3	1.43594	1.35937	144.2	1.310
2010	22,074.0[2]	552.8[2]	177.5	1.66057	1.57045	167.9	1.525
2020	25,528.0	627.0	208.6	1.92040	1.78125	193.5	1.757
2030	29,522.0[3]	701.3[3]	246.3	2,22086	1.99232	221.0	2.007
2035	33,516.0[3]	738.0[3]	290.1	2.52133	2.09659	241.2	2.191
2044	33,516.0	738.0	290.1	2.52133	2.09659	241.2	2.191

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[1] Based on regression equation: $Y=34.4+[.01245\,(X_1)]-[1.1972\,(X_2)]$, where $Y=$ FRB Production Index, $X_1=$ U. S. Earnings in Primary Metals and $X_2=$ Time (i.e. 70=1970, 90= 1990 and 135 = 2035, etc.)

[2] Interpolated based on compound growth between previous and subsequent decades.

[3] Extrapolated based on compound growth rate for 2000 - 2020 timeframe.

[4] Based on the earnings ratio for BEA 045 ÷ ratio for U. S. X FRB Production index.

[5] First year of project life.

earnings in primary metals for BEA 45 and 6 represented the annual tonnage of iron ore imports for Mobile Harbor for the 1950-1971 period. The resulting 1986-2044 factor of growth was 3.35 with an R value of .88. The tests for significance and standard error were also acceptable for this regression. As can be seen, the 1986-2044 growth rate of 1.99 derived through the analysis described in this report is a very conservative projection of iron ore imports expected to utilize Mobile Harbor during the project life.

101. Coal Imports. Imports of coal at Mobile began in 1974 with 143,000 tons being imported that year. By 1975, these imports increased to 371,000 tons. In April of 1977, the Southern Company, a parent company to four electric power generating companies located along the Gulf Coast in Alabama, Florida and Mississippi, signed a 10-year contract for importing coal through Mobile, The contract calls for 500,000 tons to be imported in 1977 and 896,000 tons for each of the next 9 years.

102. Due to the uncertain conditions in domestic coal supply, no assurance could be given that this imported coal will continue to substitute domestic supply of coal to the aforementioned steam generating plants after the contract expires. It is expected the annual volume of coal imports will remain at about the same level as that between 1978 and 1987 or 896,000 tons during the remaining years of the project life. The growth rate for coal imports is projected to be 142 percent over the 1975 volume, beginning in 1978 and remaining constant thereafter. Table F-18 gives the factors that were used in projecting coal imports. Growth factors shown in this table are designated as Index B.

TABLE F-18

PROJECTION FACTORS FOR COAL (IMPORT)

INDEX B

Year	Tonnage estimated by shipper (Thousands short tons)	Ratio to 1975
1975	371	1.000
1977	500	1.348
1978	896	2.415
1986	896	2.415
1995[1]	896	2.415
2000	896	2.415
2010	896	2.415
2020	896	2.415
2030	896	2.415
2035	896	2.415
2044	896	2.415

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[1] First year of project life.

103. Coal Exports. The movements of coal for export through Mobile is relatively new to the port. Prior to 1973, very little coal moved through the port for export. With the increase in demand of metallurgical coal in Japan, their interests in the coal supply from the southeast U.S. region, particularly in north Alabama, and the construction of a new coal handling facility at Mobile, the volume of coal exports through the port has shown a marked increase since 1973. The major coal suppliers that were interviewed during the course of this study have stated that long-term contracts have been signed or firm commitments have been negotiated which would increase the volume of coal over the next several years. Also, additional coal for export, generated by the Tennessee-Tombigbee Waterway, would begin in 1986. Based on new coal movements beginning at staggering time intervals, the annual volume that moved through the port for the latest year where records are available (1978) cannot be used as a traffic base for projecting future tonnages. However, the year 1976 was used to establish an initial-year tonnage for coal that was exported by smaller companies that were not shipping under long-term contracts.

104. It is difficult to predict future U.S. coal exports, and particularly that which would move through a given port, due to (1) uncertainties in demand from foreign countries, (2) new discoveries of sources of supply in the world that would compete with U.S. exports, (3) new energy policies being developed in the United States which might increase the domestic demand for coal, thereby decreasing the coal available for export, and (4) the demand for iron and steel on a worldwide market.

105. A report entitled "United States Energy Through the Year 2000 (Revised)", written by Messrs. Walter G. Dupree, Jr. and John S. Corsentine and published by the U.S. Department of the Interior, Bureau of Mines in December 1975, reveals some estimates concerning the domestic consumption and net export demand projected to the year 2000. It is shown in this report that domestic consumption of coal is expected to increase from 556.5 million tons in 1974 to 736 million tons in 1980 and to 1,560 million tons in 2000. Also, it shows that coal exports would increase from 59.1 million tons in 1974 to 100 million tons in 2000. This indicates an annual growth rate for coal exports of 2.04 percent. These data are further documented in more detail as exhibited in table F-19.

106. Another report, written by Mr. Leonard W. Westerstrom, Industry Economist, Division of Coal for the Bureau of Mines, and published in the Bureau of Mines' annual publication of Mineral Facts and Problems - 1975 issue, gives some forecasts on domestic production and consumption, expected exports by year 2000, and world production. This report states that: "The energy policy being developed by the United States is committed to increasing the Nation's energy supply from coal. Early in 1975, President Ford established a goal of doubling production to 1.2 billion tons by 1985. In 1974, the Interagency Coal Task Force of Project Independence determined that production of that magnitude could be achieved by relaxing or removing constraints on limiting the expansion and use of coal production.

107. Although bituminous coal and lignite production reached an all time high of approximately 640 million tons in 1975, U.S. consumption increased only marginally over the amount consumed in 1974. Essentially, all of the increase in production went into replenishing stockpiles that had been heavily drawn upon during the coal miners strike in the fourth quarter of 1974 and into meeting increased demands for export coal.

TABLE F-19

Consumption of United States Coal Resources by Major Consuming Sectors, 1974 Preliminary and Projected to the Year 2000 1/

	1974	1980	1985	2000
Domestic Consumption				
Household & Commercial				
Million short tons	10.9	4	3	--
Trillion Btu	292	100	100	--
Percent of total 2/	2.0	0.5	0.4	0
Industrial				
Million short tons	155	185	190	228
Trillion Btu	4,210	4,800	4,930	5,910
Percent of total 2/	28.5	25.2	21.1	15.7
Electrical Generation				
Million short tons	390.6	547	704	941
Trillion Btu	8,668	12,250	15,700	20,700
Percent of total 2/	58.7	64.3	67.3	55.1
Synthetic Gas				
Million short tons	--	--	26	300
Trillion Btu	--	--	520	6,000
Percent of total 2/	0	0	2.2	16.0
Synthetic Liquids				
Million short tons	--	--	--	91
Trillion Btu	--	--	--	2,140
Percent of total 2/	0	0	0	5.7
Total Domestic Demand				
Million short tons	556.5	736	923	1,560
Trillion Btu	13,170	17,150	21,250	34,750
Percent of total 2/	89.2	90.0	91.0	92.5
Export Demand 3/				
Million short tons	59.1	70	75	100
Trillion Btu	1,584	1,900	2,100	2,800
Percent of total 2/	10.8	10.0	9.0	7.5
Total Demand				
Million short tons	615.6	806	998	1,660
Trillion Btu	14,774	19,050	23,350	37,550

1/ Includes anthracite, bituminous, and lignite.
2/ Based on Btu content.
3/ Net exports.

Source: U. S. Department of Interior - Bureau of Mines

108. New mine construction lagged in 1975, as it had in 1974, because of several constraints that continued to limit the expansion of coal production and use. These constraints include stringent air pollution regulations, the lack of a viable Federal coal-leasing program, productivity declines (particularly in underground mining), and delays in decisions to convert oil- and gas-burning facilities to coal. Although steps were taken in 1975 toward reducing some of these constraints, there was insufficient assurance to coal producers, consumers, or investors to encourage the long-term investments needed to meet the national goal for coal.

109. The Bureau of Mines forecast range of coal demand in the United States for 2000 is 1.2 billion to 3.5 billion tons. The probable domestic demand level is 1.56 billion tons. To attain this demand level, the average annual growth rate between 1973 and 2000 must average 3.9 percent. Reaching the goal established earlier of doubling the 1973-74 production level of approximately 600 million tons by the end of 1985 no longer appears likely. The supply and demand limitations affecting coal (including anthracite) are reflected in the revised Bureau of Mines projection of 923 million tons of domestic demand, 75 million tons of exports, and a production level of 998 million tons by 1985.

110. As shown in table F-20, the United States produced 487.0 million tons in 1964, representing about 17 percent of world production of 2,821.4 million tons. United States production as a percentage of world production remained fairly constant over a time period between 1964 and 1974 with United States producing 603.4 million tons in 1974 representing about 19 percent of the world production of 3,243.6 million tons. United States coal exports between this same time frame increased from 48.0 million tons in 1964 to 59.9 million tons in 1974, representing 10 percent of United States production.

TABLE F-20

Bituminous coal and lignite supply-demand relationships, 1964-74

(Million short tons)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974*
World mine production											
United States	487.0	512.1	533.9	552.9	545.2	560.5	602.9	552.2	595.4	591.7	603.4
Rest of world	2,334.4	2,355.0	2,305.8	2,244.3	2,344.4	2,410.4	2,464.4	2,558.2	2,564.6	3,258.5	2,604.2
Total	2,821.4	2,867.1	2,693.7	2,796.9	[illegible]	2,970.9	3,065.3	3,110.4	3,160.0	[illegible]	3,243.6
Components of U.S. supply											
Domestic mines	487.0	512.1	533.9	552.6	545.2	560.5	603.0	552.2	595.4	591.7	603.4
Imports	.3	.2	.2	.2	.2	.1	...	.1	...	.1	2.1
Industry stocks, Jan. 1	73.0	77.9	79.7	76.8	95.4	87.5	82.0	93.7	91.3	117.5	103.0
Total U.S. supply	560.3	590.2	613.8	629.6	640.8	648.1	685.0	646.0	686.7	709.3	706.5
Distribution of U.S. supply											
Industry stocks, Dec. 31	78.0	79.7	76.8	95.4	87.5	82.0	93.7	91.2	117.4	103.0	96.6
Exports	45.0	50.2	49.3	49.5	50.5	56.2	71.0	56.6	56.0	52.9	59.9
Demand	431.1	459.2	486.3	480.4	498.8	507.3	517.0	494.9	516.8	556.0	552.7
Losses and unaccounted for	3.3	1.1	1.4	4.3	3.9	2.6	3.3	3.3	-3.5	-2.6	-.7
U.S. demand pattern											
Household and commercial	19.6	19.0	20.0	17.1	15.2	17.7	12.1	11.4	8.7	8.2	8.8
Electric utilities	223.0	242.7	264.2	271.8	294.7	308.5	320.5	326.3	348.6	385.9	390.1
Food products	9.0	9.3	9.7	9.0	8.5	7.8	7.0	6.2	7.5	5.4	5.1
Paper products	15.6	16.0	16.7	15.6	14.9	13.0	13.2	10.8	10.2	9.5	9.4
Primary metal industries	101.6	108.0	108.0	104.2	93.3	104.1	106.9	97.8	90.7	105.4	95.9
Nonmetallic products	12.6	12.9	13.2	12.9	13.0	11.9	11.5	9.5	9.6	8.3	8.1
Transportation	.7	.7	.6	.5	.4	.3	.3	.2	.2	.2	.1
Chemicals	23.2	23.9	24.8	23.2	21.5	19.7	19.1	15.6	14.8	13.7	13.1
Other	25.9	26.7	28.3	26.1	31.3	28.7	25.6	21.1	18.5	18.5	22.1
Total U.S. demand	431.1	459.2	486.3	480.4	498.8	507.3	517.0	494.9	516.8	556.0	552.7

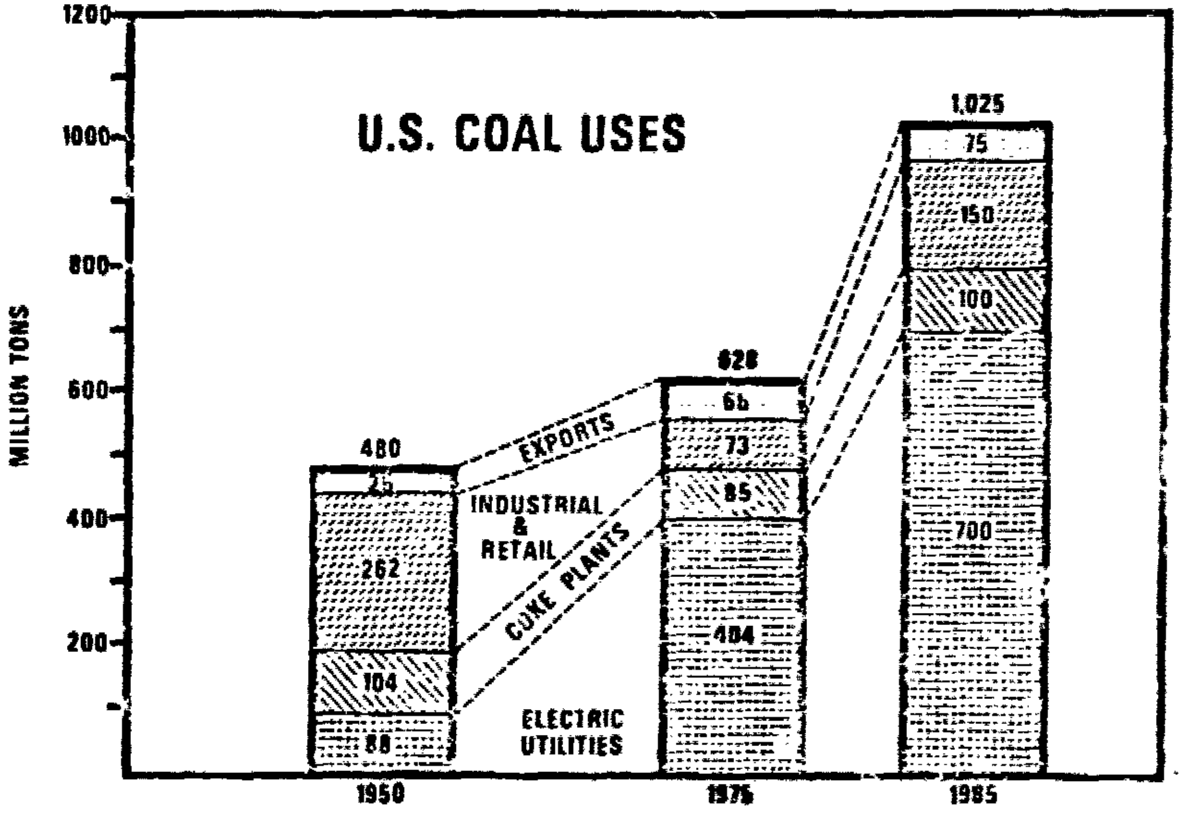
* Preliminary

Source: Bureau of Mines - U. S. Department of Interior

111. The major countries that import coal from the United States, excluding Canada, are: Brazil, Belgium-Luxembourg, France, Italy, Netherlands, United Kingdom, Spain, Sweden and Japan. Japan was the largest importer of U.S. coal in 1976 with 18.8 million tons or 44 percent of the total U.S. exports excluding that which was shipped to Canada. Table F-21 shows a complete distribution of U.S. coal exports for a 10-year period between 1967 and 1976.

112. The diagram below, **Figure F-5, gives a distribution** of the uses of U.S. coal production for year 1950 and 1975 projected to 1985. Exports accounted for 25 million tons or 5 percent of the total U.S. production in 1950. By 1975, exports accounted for 66 million tons or 10 percent. It is expected that exports will be 75 million tons or 7 percent of production by 1985. The 1985 percentage of annual production is expected to remain approximately the same through 2000.

Figure F-5



SOURCE: Bureau of Mines - U.S. Department of Interior

TABLE F-21

UNITED STATES EXPORTS OF BITUMINOUS COAL BY CONTINENTAL GROUPS AND COUNTRIES OF DESTINATION, 1967-76*

(Short tons)

Country of destination	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976 1/
North and Central America:										
Canada	15,307,986	16,748,201	16,787,801	18,673,375	[illegible],631	18,161,384	16,231,170	13,705,791	16,735,231	16,497,271
Costa Rica	-	299	-	-	143	77	139	21	8	52
Dominican Republic	-	114	-	189	67	99	37	165	18	10
El Salvador	-	-	114	-	-	-	420	40	-	139
French West Indies	643	-	-	-	-	-	-	-	-	-
Guatemala	75	43	89	100	42	-	-	-	-	51
Honduras	354	366	117	305	209	97	125	-	-	8
Jamaica	-	-	-	-	-	137	76	35	45	45
Mexico	61,648	74,016	115,790	172,668	284,608	466,340	305,399	410,564	527,142	250,536
Miquelon and St. Pierre	6,354	2,728	3,207	2,276	1,674	-	1,466	-	-	-
Panama	442	157	123	-	69	52	-	-	-	410
Trinidad and Tobago	252	-	-	-	37	630	-	-	-	-
Other	412	196	450	161	44	-	-	-	-	-
	15,378,166	16,826,140	16,907,751	18,849,074	17,851,524	18,628,916	16,538,832	14,116,616	17,282,429	16,748,522
South America:										
Argentina	590,348	441,319	476,850	595,590	539,592	393,472	771,705	630,056	430,279	526,187
Brazil	1,734,361	1,786,823	1,842,844	2,020,461	1,868,696	1,916,624	1,644,696	1,292,296	2,096,536	2,741,376
Chile	193,141	306,242	518,725	275,419	206,996	239,729	194,410	312,334	253,726	145,274
Ecuador	-	-	20,237	-	-	-	-	-	-	-
Peru	-	319	167	3,123	25,718	67,627	22,401	84,780	47,721	22
Uruguay	43,306	23,893	9,823	25,579	32,266	32,098	21,081	31,293	-	-
Venezuela	473	403	374	257	126	691	106	100	204	34
Other	298	101	-	-	-	306	35	34	-	-
	2,562,077	2,569,095	2,869,020	2,920,429	2,672,394	2,650,547	2,654,634	2,350,873	3,271,566	3,412,893
Europe:										
European Economic Community:										
Belgium-Luxembourg 2/	1,422,246	1,052,536	943,113	1,881,476	765,722	1,143,990	1,204,569	1,108,814	627,420	2,201,630
Denmark	-	-	-	-	-	-	-	-	-	34,405
France	2,130,969	1,459,544	2,252,035	3,345,568	3,125,814	1,575,379	1,865,899	2,510,001	3,583,153	3,426,631
Fed. Rep. of Germany 2/	4,693,792	3,794,602	3,451,445	5,022,481	2,931,468	2,396,803	1,632,474	1,486,602	1,449,385	993,597
Ireland (Rep. of)	267,236	165,201	83,493	69,166	26,788	21,665	-	-	-	-
Italy	5,814,516	4,253,674	3,676,242	4,205,213	2,687,321	3,677,517	3,294,040	3,903,067	4,492,967	4,210,931
Netherlands 2/	2,227,488	1,490,630	1,622,670	2,111,963	1,524,795	2,298,149	1,789,406	2,545,003	2,597,246	3,490,284
United Kingdom	-	-	-	1,701	1,659,181	2,381,031	949,782	1,404,990	1,838,462	842,968
Total EEC	16,556,237	12,209,187	12,032,473	16,637,439	12,773,589	13,487,163	10,738,170	12,955,877	14,574,573	15,200,446
Austria	-	-	-	65,253	-	-	-	-	-	-
German Democratic Rep.	77,345	101,425	86,766	395,630	76,680	19,779	-	-	-	-
Greece	-	-	-	-	62,547	-	32,499	40,767	119,259	464,798
Norway	245,874	304,514	248,342	192,380	83,274	157,656	174,288	145,273	80,500	173,331
Portugal	85,897	-	15,569	-	11,709	164,443	345,194	333,619	245,664	257,903
Romania	-	82,245	7,894	70,210	-	-	291,809	167,402	342,562	211,750
Spain	1,011,978	1,479,816	1,824,769	3,153,064	2,556,409	2,179,033	2,333,780	2,016,561	2,891,615	2,313,320
Sweden	913,261	760,662	667,641	763,534	617,932	424,828	342,284	199,427	763,634	815,917
Switzerland	38,669	28,244	-	-	31,803	-	-	-	32,707	14,330
Yugoslavia	532,094	435,894	140,706	224,915	185,558	141,538	110,024	-	21,052	183,931
Other	-	-	-	-	-	-	-	-	476	-
	19,361,305	15,402,441	15,088,151	21,502,424	16,402,593	16,678,340	14,251,848	15,355,076	18,971,492	19,735,826
Asia:										
Hong Kong	-	-	-	10,165	-	-	-	-	-	-
Israel	-	16,819	291	-	-	-	-	11,421	20	-
Japan	12,215,388	15,822,460	21,366,795	27,636,495	19,705,354	18,037,659	19,190,305	27,345,39[illegible]	25,422,798	18,802,987
Korea (Rep. of)	4,878	-	-	-	-	-	190,570	245,564	119,313	467,909
Philippines	-	139	-	109	163	1,223	261	-	123	20
Turkey	-	-	-	1,795	-	-	-	-	101,658	239,284
Other	-	66	1,070	26	824	59	-	211	40	
	12,220,266	15,839,484	21,368,156	27,648,590	19,706,341	18,038,941	19,381,136	27,603,469	25,943,302	19,510,[illegible]
Oceania:										
Australia	-	-	-	22,752	44	-	41,709	19	-	-
New Zealand	-	-	802	192	-	-	-	-	-	-
Other	-	-	-	-	-	37	-	-	-	-
	-	-	802	22,944	44	37	41,709	19	-	-
Africa:										
Egypt	-	-	-	-	-	-	-	-	217,840	321,796
Nigeria	6,064	-	-	-	-	-	-	-	-	-
Zaire	-	-	-	-	-	-	-	-	-	-
Other	-	100	-	97	-	-	243	5	-	126,172
	6,064	100	-	97	-	-	243	5	217,840	447,968
Total exports	49,527,828	51,637,263	56,233,860	70,943,[illegible]	56,632,966	55,996,721	52,870,402	59,926,089	65,669,629	59,405,569

*Does not include shipments to U.S. military forces.

1/ Preliminary figures.

2/ Shipments as indicated in vessel manifests upon departure from U.S. ports; includes tonnage for transshipment to undesignated European destinations.

Compiled by the International Coal Staff, Bureau of Mines.

113. One of the difficulties Drs. Rimberger and Wettig point out in their study of the world coking coal market until 1985 is the lack of a definition of coking coal. Good quality coke is produced in different countries from coals with a wide range of coking characteristics and mineral impurities. This means that, for the most part, there are coals which are used for coking that would, by themselves, yield a coke with low ash and mineral impurities but it would only be a lower quality coke. The other extreme is that certain coals could yield an outstanding coke which would be useless because of the high content of impurities. In the Federal Republic of Germany (FRG), coking coal is usually considered to be low in ash and sulphur with 21-27 percent volatile matter. In some countries, low-sulphur coking coal is being burned in power generating stations to minimize the cost of cleaning emissions. The coals which today are termed coking coals in a narrow sense, that is, coals from which a usable coke may be produced, account for less than 50 percent of total coking coal demand. The blending of low-volatile coal with good coking properties and high-volatile coal with poor coking properties to produce a usable coke is not uncommon, but the proper ratios must be used not only to produce a usable coke but also to prevent damage to the coke oven walls.

114. Other difficulties in the analysis of the world coking coal market are the limited economically minable worldwide reserves of coking coal, the possibilities of short-term production disruptions, and transportation tie-ups and disruptions between the producing and consuming areas. The dependence of the steel industry on coking coal, or rather good quality coke, has caused the industry to take steps to prevent the possible shortfall in supply. These measures include regulated, long-term supply contracts and participation in domestic and foreign coal mining.

115. Coking coal production in 1975 was about 27 percent of the total world output of 2,350 million metric tons or between 620-630 million metric tons. Three countries, the U.S.S.R., the United States, and the FRG, accounted for almost two-thirds of total coking coal production.

Together with Poland, Australia, and the People's Republic of China (PRC), 80 percent of world coking coal production is accounted for with the remaining 20 percent coming from a number of nations. Between 1960 and 1975, world coal (anthracite and bituminous) production increased by 29 percent while coking coal production increased only by 22-23 percent.

116. Future production of coking coal will not be determined by demand but rather by the investments of the mining enterprises in existing and new production capacity. The authors estimate that, in 1985, the additional world coking coal demand over that of today will be 260 million tons while known, planned additional productive capacity will be 160 million tons. This indicates a shortfall of 100 million tons. The pattern of the world coking coal trade is not expected to change in the future. Australia, the United States, and Poland should be the principal exporters and Western Europe, including Scandanavia, Japan, and South America should remain the principal importers. Excluding US-Canada trade and the European Economic Community (EEC) and Council for Economic Assistance (CEMA) internal trades, world coking coal trade is expected to increase from the current 85 million tons to 160 million tons in 1985, with 100 million tons being high quality coal.

117. The international trade in coke is rather insignificant, compared with coking coal trade. In general, the rule is that coke is produced where it is used. The reasons for this are economic and technical and are to assure a given plant a supply of coke of the quality and quantity required. In addition, the handling of coke during loading, transport, and unloading causes degradation, reducing the size and increasing the amount of coke breeze. In 1974, world coke trade amounted to about 30 million tons. Of this total, internal trade in the EEC accounted for about one-third and total EEC trade about one-half. An additional 25 percent was internal CEMA trade. Actual international (external) coke trade in 1974 was 11 million tons or about 40 percent of the total. Total coke trade in 1985 is expected to be about 32 million tons with 12.5-13 million tons being involved in international trade.

118. Between 1963 and 1974, the use of coking coal rose on the average 2.5 percent per year from 473 million tons to about 620 million tons. Of the totals, a constant 80 percent has been used for the production of blast furnace coke and the remaining 20 percent is used by gas works, electricity generating stations, and other consumers. The amount of coal charged into coke ovens increased between 1963 and 1974 by 90 million tons from 380 million tons to 470 million tons, an average yearly increase of 2.0 percent. The use of coking coal by other consumers increased by a yearly average of 4.3 percent or from 94 million tons in 1963 to 150 million tons in 1974. In the nine member countries of the EEC, the use of coking coal for the production of coke dropped from 150 million tons in 1963 to 91 million tons in 1974, a decrease of about 40 percent. In comparison, the production of coking coal in the EEC dropped from 218 million tons in 1963 to 96 million tons in 1974, a decrease of 57 percent. Total world coke production in 1975 was 362 million tons, an increase of 28 percent or a yearly average increase of 2.1 percent over the 282 million tons produced in 1963.

119. In the period to 1985, the iron and steel industry, energy generation, households, and other small consumers will still be the principal consumers of coals which could be used for coking. It is unlikely that gas works, the chemical industry, or the non-ferrous metal industry will be using appreciable amount of coking coal for coke. Households and other traditional small consumers of coke in Europe are expected to account for a demand for 25 million tons of coke (or 35 million tons of coking coal) by 1985. The demand by electric power plants for coking coal (coal which could be used in coking) will be of importance only in the FRG, the U.S., and the United Kingdom. The authors estimate these needs in 1985 to be 30 million tons in the FRG, 260 million tons in the U.S., and 290 million tons in the United Kingdom.

120. World crude steel production is expected to reach 1,023 million metric tons by 1985, an increase over 1974 of 315 million tons or a yearly average of 2.4 percent (average yearly increase between 1963-1974

was 5.6 percent). The production of one metric ton of pig iron in 1985 will require, on a worldwide average, 530-535 kg of coke, which includes the coke needed for sintering. Considering a 70 percent coke yield, this total will require about 570 million tons of coking coal in 1985, or 150 million tons more than in 1974.

121. Taking all factors into consideration, the authors predict a worldwide demand for coking coal in 1985 of 880 million metric tons, two-thirds of which will be used for coke production with the rest used to fuel electric power plants. Imports to cover domestic shortfalls will be provided by three or four countries, principally the United States, provided increases in productive capacity can prevent the possibility of a 100-million ton shortage.

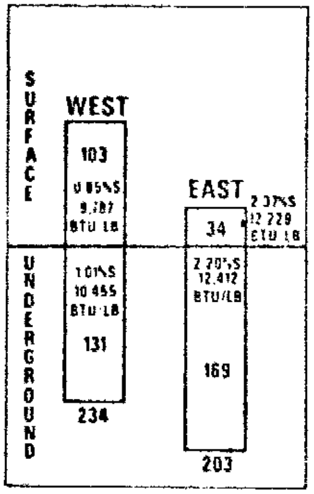
122. In 1974, the World Energy Conference and the U.S. Geological Survey estimated world resources of hard coal at nearly 80 percent of all in-place resources. Hard coal includes all coals of higher rank than lignite or "brown" coal. These resources, including anthracite (amounts of which are not available separately), are estimated at 9,933 million short tons, and brown coal and lignite are estimated at 2,666 billion short tons. As shown in table F-22, the total in-place resources of all ranks of coal were estimated at 12,599 billion short tons. The United States has approximately 31 percent of world coal resources. However, it should be noted that the several nations that report coal resources do not do so using the same criteria; therefore, these values are not directly comparable.

123. Coal exports through the Port of Mobile during 1974 and 1975 represented 4 and 5 percent of total U.S. exports, respectively. With the expected increase generated by the Tennessee-Tombigbee Waterway and new contracts from present shippers, the annual volume of coal exports through Mobile should increase to about 14.3 million tons by 1985. This represents about 19 percent of the total expected U.S. exports of 75.0 million tons as shown ir Figure F-5 and Table F-19.

TABLE F-22

COAL RESERVES IN THE UNITED STATES

COAL RESERVES IN THE UNITED STATES BY GEOGRAPHIC AREA AND TYPE OF MINING



(FIGURES IN BILLIONS OF TONS)

BUREAU OF MINES
U.S. DEPARTMENT OF INTERIOR

Figure 1.—U.S. coal reserves, classified according to geographic area and type of mining.

Table 2.—Summary of demonstrated coal reserve base of the United States

(Billion short tons)

Rank of coal	Underground mining reserve base	Surface mining reserve base	Total	Estimated total heat value, (quadrillion Btu)
Bituminous	192	41	233	6,100
Subbituminous	101	68	169	2,800
Lignite	0	28	28	400
Anthracite	7	[1]	7	200
Total	300	137	437	9,500

[1] Less than ½ unit.

Total world bituminous coal and lignite resources [1]

(Million short tons)

	Reserves	Other	Total
North America			
United States	[2] 436,700	3,531,600	3,968,300
Canada	600	119,400	120,000
Total	437,300	3,651,000	4,088,300
South America			
Brazil	200	3,400	3,600
Chile	300	4,000	4,300
Colombia	350	5,550	5,900
Other	900	21,600	22,500
Total	1,750	34,550	36,300
Europe			
Germany, East	900	32,200	33,100
Germany, West	8,000	308,400	316,400
France	50	1,550	1,600
Netherlands	160	3,940	4,100
Spain	80	3,820	3,900
United Kingdom	6,000	173,500	179,500
Poland	5,000	61,800	66,800
U.S.S.R.	350,000	5,948,200	6,298,200
Other	10,000	58,225	68,225
Total	380,190	6,591,635	6,971,825
Africa			
South Africa	3,500	45,400	48,900
Other	30	15,959	15,989
Total	3,530	61,359	64,889
Asia			
China, People's Republic of	60,000	1,042,300	1,102,300
India	2,000	89,500	91,500
Other	600	22,886	23,466
Total	62,600	1,154,686	1,217,286
Oceania			
Australia	3,000	215,900	218,900
New Zealand	40	1,160	1,200
Total	3,040	217,060	220,100
World total	886,410	11,710,290	12,598,700

[1] Includes anthracite.

[2] Demonstrated reserve base (Jan. 1, 1974).

SOURCE: Bureau of Mines - U.S. Department of Interior

124. The Bureau of Mines forecasts the world-wide demand for coal, excluding the U.S., will range from 3.5 to 4.5 billion tons by the year 2000. This represents an average annual growth rate of 0.9 to 1.9 percent, respectively. The annual growth rate at the probable demand rate is 1.2 percent during this period.

125. World-wide demand for coal should equal world-wide production in most instances based on historical tonnages associated with production, demand, and export of coal in the United States, one of the world's largest producers. From 1954 through 1975 the U.S. produced a surplus of coal above the demand of U.S. industry each year. Accumulated exports from the U.S. during the period 1964 through 1975 exceeded surplus production by about 10 percent which tends to show that production is about equal to total demand at least in the United States.

126. It has been assumed that world-wide demand for coal will be equal to world-wide production in the future. During the 11-year period from 1964 through 1974, U.S. exports have consistently ranged from 1.7 to 1.9 percent of world production. Therefore, it has been assumed that if world-wide demand of coal increases at an average annual rate of 1.2 percent to the year 2000, then, U.S. exports of coal will grow, accordingly. Coal exports from Mobile have been assumed to remain constant from 2000 through 2044 since no support can be located for growth during these later years.

127. Increase factors developed from the 1.2 percent annual growth rate applicable to varying base years (1975-1986) are shown in table F-23.

128. Projection of Coal Exports to Japan. Records for 1975-78 indicate that an average of 60 percent of coal exports through Mobile were shipped to Japan. An adjustment to reflect some shippers sending 100% to Japan gives an adjusted figure of 67 percent. The allocation of coal exports by market areas was done on a shipper-by-shipper basis. Using this criteria for allocating coal exports, a total tonnage base on coal shipped to Japan

TABLE F-23

Project indices applicable to coal exports through Mobile based on an average annual growth rate of 1.2 percent[1].

Year	Growth Factors						
1975	1.000	-	-	-	-	-	-
1976	1.012	1.000	-	-	-	-	-
1977	1.024	1.012	1.000	-	-	-	-
1978	1.036	1.024	1.012	1.000	-	-	-
1979	1.049	1.036	1.024	1.012	1.000	-	-
1981	1.074	1.061	1.049	1.036	1.024	1.000	-
1986	1.140	1.127	1.113	1.100	1.087	1.061	1.000
1995	1.269	1.254	1.240	1.225	1.210	1.182	1.113
2000[2]	1.347	1.331	1.316	1.300	1.285	1.254	1.182
2010	1.347	1.331	1.316	1.300	1.285	1.254	1.182
2020	1.347	1.331	1.316	1.300	1.285	1.254	1.182
2030	1.347	1.331	1.316	1.300	1.285	1.254	1.182
2035	1.347	1.331	1.316	1.300	1.285	1.254	1.182
2044	1.347	1.331	1.316	1.300	1.285	1.254	1.182

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[1] Factors to be used in making a composite tonnage for each of the four destination groups.

[2] Latest year of growth.

for 1976 was 1,881,000 tons. Where the shipper did not indicate future growth, the 1976 volume for each shipper was used as a base for projecting to 1986. Where a shipper is currently exporting coal and gave a growth due to firm contracts, tonnage for the first year of contract was used as a base for projecting to 1986. When a new shipper, including those that would ship via the Tennessee-Tombigbee Waterway, indicate the first year they will begin shipping, tonnage for this year was used as a base for projecting to 1986. A growth factor based on an annual growth rate of 1.2 percent was used to project the varying base tonnages to 1986. By using the above procedure for projection, the 1986 tonnage destined to Japan would be 9,714,000 tons. The unadjusted tonnage was used in establishing the growth factors. With the 1986 volume of 9,714,000 tons being a new base, the 1.2 percent annual growth rate or a factor of 1.182 was applied to this tonnage giving an annual volume of 11,478,000 tons, beginning in the year 2000 and remaining constant during the project life until the year 2044. The resulting increase factors are shown in table F-24. These indices of growth on coal exports to Japan are designated as Index E.

129. Projections of Coal Exports to Italy. Records for 1975-1978 indicate that an average of 22 percent of the coal exports through Mobile were shipped to the area designated as Italy. By applying the 22 percent to the annual volume of individual shippers, other than those who ship exclusively to Japan, the annual volume shipped to Italy in 1976 was 664,000 tons. The 1976 volume for each shipper was used as a base for projection to 1986, where shippers are currently using the port and did not indicate their future growth. Where shippers gave a growth due to firm contracts, the first year of contract was used as a base. When new shippers indicate the year they will begin shipping through Mobile, this year was used as a base. All base volumes were increased at an annual rate of 1.2 percent to develop a new base in 1986. The year 1986 was selected as a new base because, by this time, all known contracts will be in force and new shippers will have begun shipping, including those that will ship via the Tennessee-Tombigbee Waterway. The annual volume of coal exports to Italy for the year 1986 will

be 3,211,000 tons. By using an annual growth rate of 1.2 percent applied to the 1986 volume, with the growth rate leveling off by the year 2000, the annual volume in 2000 will be 3,795,000 tons and will remain constant thereafter until 2044, the last year of the project life.

130. Increase factors developed from the above projection procedure are shown in table F-25 and designated as Index F.

TABLE F-24

PROJECTION FACTORS FOR COAL EXPORTS DESTINED TO JAPAN

INDEX E

Year	Composite of annual tonnage destined to Japan [1] (thousand short tons)	Ratio to 1986
1986	9,714,000	1.000
1995 [2]	10,819,000	1.114
2000	11,478,000	1.182
2010	11,478,000	1.182
2020	11,478,000	1.182
2030	11,478,000	1.182
2044	11,478,000	1.182

[1] Unadjusted tonnage, which includes tonnage that will continue to move through the Panama Canal with project improvements at Mobile.

[2] First year of project life.

TABLE F-25

PROJECTION FACTORS FOR COAL EXPORTS DESTINED TO ITALY

INDEX F

Year	Composite of annual tonnage destined to Italy (Thousand short tons)	Ratio to 1986
1986	3,211	1.000
1995 [1]	3,576	1.114
2000	3,795	1.182
2010	3,795	1.182
2020	3,795	1.182
2030	3,795	1.182
2035	3,795	1.182
2044	3,795	1.182

[1] First year of project life.

131. Projection of Coal Exports to England/Europe. Initial-year (1976) tonnage of coal allocated to this area was 221,000 tons. By use of the same criteria used for projecting coal exports to Italy, as previously discussed, the volume of coal exports to this area by 1986 will be 8 percent of total or 1,070,000 tons. With a 1.2 annual growth rate, this volume will increase to 1,265,000 tons by the year 2000. No increase in tonnage is expected beyond this time, therefore, the 1,265,000 tons will remain constant over the remaining project life. The resulting increase factors developed from this composite of tonnage are shown in table F-26. This index of growth factors is designated as Index G.

TABLE F-26

PROJECTION FACTORS FOR COAL EXPORTS DESTINED TO ENGLAND/EUROPE

INDEX G

Year	Composite of annual tonnage destined to England/Europe (Thousand short tons)	Ratio to 1986
1986	1,070	1.000
1995 [1]	1,192	1.114
2000	1,265	1.182
2010	1,265	1.182
2020	1,265	1.182
2030	1,265	1.182
2035	1,265	1.182
2044	1,265	1.182

[1] First year of project life.

132. Projection of Coal Exports to East Coast of South America. Only 3 percent of the total coal exports from Mobile will be shipped to this area. The initial-year (1976) tonnage, allocated to this area, was 99,000 tons. By applying the same method of projecting coal exports to Italy, as previously discussed, the 99,000 tons will increase to 476,000 tons by 1986. With a 1.2 annual growth rate, this volume will increase to 562,000 tons by the year 2000. No increase in tonnage is expected beyond this time, therefore, the 562,000 tons will remain constant over the remaining project life. The resulting increase factors developed from this composite of tonnage are shown in table F-27. This index of growth factors is designated as Index [illegible]

TABLE F-27

PROJECTION FACTORS FOR COAL EXPORTS DESTINED TO THE EAST COAST OF SOUTH AMERICA

INDEX H

Year	Composite of annual tonnage destined to the East Coast of South America (Thousand short tons)	Ratio to 1986
1986	476	1.000
1995 [1]	530	1.114
2000	562	1.182
2010	562	1.182
2020	562	1.182
2030	562	1.182
2035	562	1.182
2044	562	1.182

[1] First year of project life.

SUMMARY OF PROSPECTIVE AND ACCEPTED COMMERCE

133. <u>Prospective Commerce</u>. The annual volume of commodities that was accepted as prospective commerce for this project in 1975 was 7.5 million tons. This tonnage was projected to 1995, the first year of economic life of the selected plan, and then extended over the next 50 years ending in 2044. The annual volume of prospective commerce for selected years is presented in table F-28.

134. <u>Accepted Commerce</u>. This traffic was further screened to determine the tonnage that would obviously be eliminated due to the continued use of small ships, that which would continue to be shipped through the Panama Canal in relatively small ships, that eliminated because of limited depths at foreign ports where traffic originates or terminates, and other restrictions as previously discussed in this appendix. The annual volume of traffic

TABLE F-28

PROSPECTIVE COMMERCE FOR SELECTED YEARS THROUGHOUT THE PROJECT LIFE (1995-2044)

Commodity	1975	1986	1995[1]	2000	2010	2020	2030	2035	2044
Iron ore	4,781,000	5,264,000	5,857,000	6,263,000	7,291,000	8,400,000	9,596,000	10,475,000	10,475,000
Coal (Import)	371,000	896,000	896,000	896,000	896,000	896,000	896,000	896,000	896,000
Coal (Export)	2,367,000	14,471,000	16,117,000	17,100,000	17,100,000	17,100,000	17,100,000	17,100,000	17,100,000
TOTAL	7,519,000	20,631,000	22,870,000	24,259,000	25,287,000	26,396,000	27,592,000	28,471,000	28,471,000

[1] First year of project life.

accepted for benefit analysis is 5.2 million tons in 1975 which will increase to 15.0 million tons by 1995 and, by the year 2044, the volume will be 18.9 million tons. Detailed volume for each commodity accepted as commerce, which would benefit from project modification, is shown in table F-29. The differences in prospective and accepted traffic are explained in previous paragraphs of this appendix.

VESSEL TRAFFIC

135. Vessel Trips. The total vessel trips on all types of vessels, including deep-draft cargo ships, fishing vessels, tows, and miscellaneous boats, that called at Mobile during 1975, is presented in table F-30. Deep-draft vessels with drafts of 19 feet and above accounted for 1866 of the total trips of 29,805.

136. Trend in Vessel Traffic. The total number of vessels with drafts 19 feet and over that called at the port decreased from 2488 vessels in 1966 to 1866 vessels in 1975 while the volume of commerce that moved through the port in deep-draft vessels increased from 14.4 million tons in 1966 to 16.7 million tons in 1975. This indicates that an increase in the use of larger vessels is being experienced. During this time period, the number of vessels with drafts 36 feet and over increased from 359 in 1966 to 704 in 1975, further showing a trend in the increase in size of vessels calling at the port. The number of vessels tabulated by draft when entering and/or leaving the port during the latest 10-year period of record is given in table F-31.

137. Vessels carrying some of the major bulk commodities range in size from 14,000 to 88,000 d.w.t. Records indicate these particular ships have registered loaded drafts ranging from 23 feet for the 14,000 d.w.t. ship to 43 feet for the 88,000 d.w.t. ship. These drafts do not reflect an average draft for these size vessels in the world fleet. This indicates a need for a deeper channel as the larger vessels are being light-loaded because of limitation from channel depths at Mobile. The figures do not reveal the

TABLE F-29

PROJECTED COMMERCE ACCEPTED FOR BENEFIT ANALYSIS FOR SELECTED YEARS THROUGHOUT THE PROJECT LIFE (1995-2044)

Commodity	1975	1986	1995[1]	2000	2010	2020	2030	2035	2044
Iron ore	3,411,000	3,756,000	4,178,000	4,468,000	5,202,000	5,993,000	6,846,000	7,474,000	7,474,000
Coal (Import)	371,000	896,000	896,000	896,000	896,000	896,000	896,000	896,000	896,000
Coal (Export)	1,458,000	8,934,000	9,950,000	10,558,000	10,558,000	10,558,000	10,558,000	10,558,000	10,558,000
TOTAL	5,240,000	13,586,000	15,024,000	15,922,000	16,656,000	17,447,000	18,300,000	18,928,000	18,928,000

[1] First year of project life.

TABLE F-30

TOTAL INBOUND AND OUTBOUND TRIPS AND DRAFTS OF VESSELS CALLING AT MOBILE DURING YEAR 1975

HARBOR OR WATERWAY	DIRECTION						DIRECTION					
	Self Propelled Vessels			Non-Self Propelled Vessels			Self Propelled Vessels			Non-Self Propelled Vessels		
DRAFT (FEET)	Passenger and Dry Cargo	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	TOTAL	Passenger and Dry Cargo	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	TOTAL
MOBILE HARBOR, AL				INBOUND						OUTBOUND		
41 - - - - - - -	2					2						
40 - - - - - - -	25	1				26	20	4				24
39 - - - - - - -	9	2				11	17	13				30
38 - - - - - - -	14	6				20	18	18				36
37 - - - - - - -	16	4				20	13	3				16
36 - - - - - - -	17					17	17	4				21
35 - - - - - - -	32	3				35	11	12				23
34 - - - - - - -	16	2				18	22	6				28
33 - - - - - - -	30	2				32	24	5		1		30
32 - - - - - - -	20	8				28	29	4				33
31 - - - - - - -	23	10				33	32	2				34
30 - - - - - - -	16	2				18	20	5				25
29 - - - - - - -	22					22	17	5				22
28 - - - - - - -	21	2				23	42	4				46
27 - - - - - - -	34	1				35	38	3				41
26 - - - - - - -	38	1				39	52	6				58
25 - - - - - - -	60	6	9	1		76	61	3	8	12		84
24 - - - - - - -	47	16				63	55	8				63
23 - - - - - - -	75	12				87	57	2				59
22 - - - - - - -	56	16				72	70	7		2		79
21 - - - - - - -	76	11				87	69	4		4		77
20 - - - - - - -	65	15				81	65	8		1		74
19 - - - - - - -	46	10				56	49	5		1	7	62
18 and less- -	337	32	3,579	7,858	2,195	14,001	336	11	3.557	7,857	2,177	13,938
TOTAL	1,098	162	3,588	7,859	2,195	14,902	1,134	142	3,565	7,878	2,184	14,903

SOURCE: Waterborne Commerce of the United States - Part 2 for Calendar Year 1975.

TABLE F-31

TOTAL INBOUND AND OUTBOUND TRIPS AND DRAFTS OF VESSELS WITH DRAFTS 19 FEET AND OVER ON VESSELS THAT CALLED AT MOBILE FOR SELECTED YEARS - 1966-1975 [1]

Draft	Number of Vessel Trips									
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
41 feet and over	0	0	0	0	0	0	0	0	0	2
40 feet and over	20	9	8	19	15	19	30	48	83	52
39 feet and over	48	35	25	51	30	39	45	93	121	93
38 feet and over	64	54	48	68	45	58	67	150	183	149
37 feet and over	83	77	64	99	86	108	122	222	250	185
36 feet and over	144	123	100	128	122	146	171	282	331	223
35 feet and over	174	150	120	157	156	196	212	337	414	281
34 feet and over	213	182	150	193	215	242	241	408	470	327
33 feet and over	256	217	199	229	247	269	270	452	522	388
32 feet and over	311	282	252	293	286	314	306	511	570	449
31 feet and over	392	342	310	329	349	349	340	539	619	516
30 feet and over	471	415	389	376	410	406	407	599	676	559
29 feet and over	563	497	464	426	481	452	459	649	729	603
28 feet and over	658	584	568	524	565	523	526	715	791	672
27 feet and over	757	674	689	630	674	601	614	812	860	748
26 feet and over	880	800	850	727	775	692	737	931	964	845
25 feet and over	1037	917	989	837	891	799	872	1102	1091	975
24 feet and over	1224	1099	1151	987	1063	922	1024	1255	1249	1101
23 feet and over	1427	1308	1342	1157	1251	1086	1197	1446	1386	1247
22 feet and over	1700	1592	1636	1431	1513	1310	1405	1662	1575	1396
21 feet and over	1898	1865	1864	1659	1717	1502	1604	1845	1707	1556
20 feet and over	2180	2203	2145	1962	2009	1755	1802	2068	1866	1710
19 feet and over	2488	2477	2392	2207	2219	1918	1997	2218	1967	1820

Source: Annual Publications of Waterborne Commerce of the United States - Part 2 for years 1966-1975 potential of larger vessels that are not used in the service on traffic to Mobile due to the 40-foot channel restriction. The characteristics of vessels used in the transportation of major bulk commodities shipped through Mobile in 1975 are shown in table F-32

138. Vessel Sizes. A range in vessel sizes was used to determine benefits for each channel depth being analyzed. The minimum size dry-bulk carriers and tankers is based on the minimum size of vessels presently being used at the port of Mobile. The maximum size is based on the largest vessel that can use a particular channel depth, light-loaded by 5 feet with a bottom clearance of 4 feet. The exception to this is on commodities originating or destined to countries where the routing via the Panama Canal is shorter. These commodities are coal to Japan and iron ore from Australia. For these commodities, benefits were based on the difference in transportation cost of a fleet of vessels (15-56,000 d.w.t. dry-bulk carriers) that can use the 40-foot channel at Mobile routed via the Panama Canal, and the costs of a fleet of vessels that would go around the Cape of Good Hope, using a minimum size vessel of 61,000 d.w.t. A range in vessel sizes for dry-bulk carriers, based on drafts at one-foot intervals, for each channel depth considered is shown in table F-33.

139. Routing. Commodities of iron ore from Australia and coal to Japan are presently being routed via the Panama Canal. However, with a channel depth at Mobile of 45 feet or greater, a portion of the volume of these commodities will be routed via the Cape of Good Hope, South Africa. Table F-34 gives the relative difference in miles when routed through the Canal versus routing via the Cape of Good Hope. The distances shown in this table are those used in the report for determining transportation costs "with" and "without" channel improvements at Mobile. Distances on commodities not subjected to routing through the canals will be the same for all channel depths at Mobile.

TABLE F-32

CHARACTERISTICS OF VESSELS PRESENTLY CALLING AT MOBILE (1975)

Crude Oil - Tankers

D.W.T. - 16,000 to 54,000
Registered loaded draft - 30.0 to 43.0 feet
Length - 512 to 751 feet
Width - 66 to 102 feet
Actual loaded draft - 32 to 40 feet

Iron Ore (ASD Tipple) (Dry Bulk Carriers)

D.W.T. - 18,000 to 74,000
Registered loaded draft - 30.0 to 43.0 feet
Length - 541 to 601 feet
Width - 72 to 105 feet
Actual loaded draft - 26 to 40 feet

Bauxite (ASD Tipple) (Dry Bulk Carriers)

D.W.T. - 14,000 to 52,000
Registered loaded draft - 23 to 39 feet
Length - 509 to 978 feet
Width - 62 to 98 feet
Actual loaded draft - 25 to 38 feet

Coal (Import) (ASD Tipple) (Dry Bulk Carriers)

D.W.T. - 31,000 to 74,000
Registered loaded draft - 36 to 43 feet
Length - 643 to 719 feet
Width - 75 to 105 feet
Actual loaded draft - 34 to 40 feet

Iron Ore (TCI Term.) (Dry Bulk Carriers)

D.W.T. - 25,000 to 88,000
Registered loaded draft - 33 to 43 feet
Length - 577 to 850 feet
Width - 72 to 128 feet
Actual loaded draft - 31 to 40 feet

TABLE F-32 (Continued)

Grain (Dry Bulk Carriers)

D.W.T. - 11,000 to 66,000
Registered loaded draft - 23 to 43 feet
Length - 440 to 768 feet
Width - 62 to 105 feet
Actual loaded draft - 25 to 40 feet

Coal exports (McDuffie) (Dry Bulk Carriers)

D.W.T. - 19,000 to 80,000
Registered loaded draft - 30 to 46 feet
Length - 528 to 837 feet
Width - 69 to 105 feet
Actual loaded draft - 29 to 40 feet

TABLE F-33

Vessel sizes, by channel depths, used in determining benefits on Coal and Iron Ore, with certain exceptions.[1] Dry Bulk Carriers (Foreign Flag)

40-foot channel		45 foot channel		50-foot channel		55-foot channel		60-foot channel	
Vessel		Vessel		Vessel		Vessel		Vessel	
DWT	Draft	DWT	Draft	DWT	Draft	DWT	Draft	DWT	Draft
15,000	29	15,000	29	15,000	29	15,000	29	15,000	29
17,000	30	17,000	30	17,000	30	17,000	30	17,000	30
20,000	31	20,000	31	20,000	31	20,000	31	20,000	31
23,000	32	23,000	32	23,000	32	23,000	32	23,000	32
26,000	33	26,000	33	26,000	33	26,000	33	26,000	33
29,000	34	29,000	34	29,000	34	29,000	34	29,000	34
32,000	35	32,000	35	32,000	35	32,000	35	32,000	35
36,000	36	36,000	36	36,000	36	36,000	36	36,000	36
39,000	37	39,000	37	39,000	37	39,000	37	39,000	37
43,000	38	43,000	38	43,000	38	43,000	38	43,000	38
47,000	39	47,000	39	47,000	39	47,000	39	47,000	39
52,000	40	52,000	40	52,000	40	52,000	40	52,000	40
56,000	41	56,000	41	56,000	41	56,000	41	56,000	41
		61,000	42	61,000	42	61,000	42	61,000	42
		65,000	43	65,000	43	65,000	43	65,000	43
		70,000	44	70,000	44	70,000	44	70,000	44
		75,000	45	75,000	45	75,000	45	75,000	45
		81,000	46	81,000	46	81,000	46	81,000	46
				86,000	47	86,000	47	86,000	47
				92,000	48	92,000	48	92,000	48
				98,000	49	98,000	49	98,000	49
				104,000	50	104,000	50	104,000	50
				110,000	51	110,000	51	110,000	51
						117,000	52	117,000	52
						123,000	53	123,000	53
						130,000	54	130,000	54
						137,000	55	137,000	55
						144,000	56	144,000	56
								151,000	57
								159,000	58
								166,000	59
								174,000	60
								182,000	61

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[1] On coal to Japan and Iron Ore from Australia, benefits are based on costs for a vessel fleet from 15-56,000 dwt which could go thru the Panama Canal versus the costs of a vessel-fleet ranging from 51,000 dwt to maximum size for a particular depth. Only benefits applicable to that tonnage which would be shipped around the cape of Good Hope was accepted on traffic from or to Japan and Australia.

NOTE: The designated incremental increase in vessel sizes for each depth of channel improvement is shown below the lines of demarcation in this table.

TABLE F-34

DISTANCE OF OCEAN MILES (NAUTICAL) BETWEEN PORTS OF ORIGIN AND DESTINATION ON ACCEPTED COMMERCE

			Nautical Miles (One Way)			
Commodity	Origin	Destination	Via the Panama Canal	Via the Suez Canal	Via Cape of Good Hope	Direct Routing
Iron Ore unloaded at "Tipple"	Dampier, Australia	Mobile, AL	10,861	12,830	12,012	N/A
	Port Cartier, Quebec	Mobile, AL	N/A	N/A	N/A	2,600
	Point Ubu, Brazil	Mobile, AL	N/A	N/A	N/A	4,734
Iron Ore unloaded at TCI Terminal	Puerto Ordaz, Venz.	Mobile, AL	N/A	N/A	N/A	2,160
	Port Cartier, Quebec	Mobile, AL	N/A	N/A	N/A	2,600
	Victoria (Tubarao) Brazil	Mobile, AL	N/A	N/A	N/A	4,784
Coal (Import)	Richards Bay, So. Africa	Mobile, AL	N/A	N/A	N/A	5,600
Coal (Export)	Mobile, AL	Japan 1/	9,300	14,192	15,556	N/A
	Mobile, AL	Italy 2/	N/A	N/A	N/A	5,684
	Mobile, AL	England/Europe 3/	N/A	N/A	N/A	4,720
	Mobile, AL	E. Coast of So. Amer. 4/	N/A	N/A	N/A	3,084

N/A - NOT APPLICABLE

1/Typical ports in Japan that receive coal from Mobile are: Kobe, Ohita, Kimitsu, Tobata, Fukuyama, Kashima, and Yokohama with Tobata being the principal port.

2/Typical ports in Italy are: Genoa, Taranto, Venice, Salerno with Taranto being the principal port.

3/Typical ports for England/Europe are: Oxelosund, Sweden; Rotterdam, Neth.; Cardiff and Port Talbert, Wales; with Port Talbert, Wales being the principal port.

4/Typical port for East Coast of So. American is Rio de Janeiro, Brazil.

SOURCE: Distance Between Ports - 1965, published by U. S. Naval Oceanographic Office, U. S. Navy in document H.O. Publication No. 151.

CHANNEL DEPTHS AT FOREIGN PORTS

140. General. The maximum depths at foreign ports vary widely and in some cases are not well-defined in publications that are readily available. These depths were obtained from several sources which include shippers/receivers, steamship agents and a widely used publication entitled, "Port Dues Charges and Accommodation - 1977-78 Issue," published by George Philip and Son Limited - London, England.

141. Iron Ore. Iron ore for U.S. Steel, being imported through their marine bulk handling plant at Mobile, originates at foreign ports where they have invested interest, and the pattern of shipments are fairly stable. Sources of supply are: Puerto Ordaz, Venz., Port Cartier, Quebec; and Tubarao, Brazil. The size of vessels used in the benefit analysis was restricted to drafts comparable to the maximum depths at the above ports of 45, 54, and 74 feet, respectively. Although the depths at Puerto Ordaz, Venz. located on the dredged channel of Boca Grande at the mouth of the Orinoco River, fluctuates from a minimum depth of 32 feet to a maximum of 45 feet, benefits for this commerce are based on a channel depth of 45 feet. These benefits are considered to be conservate since company officials state that tonnage now being loaded at Puerto Ordaz is iron ore fines. This type of ore is gradually being replaced with iron ore pellets, available at ports which are a greater distance from Mobile. They state, that, with a deeper channel available at Mobile larger vessels would be used in hauling iron ore pellets from alternative sources of supply, such as, Tubarao, Brazil with a sailing depth of 66 feet plus rise of tide, which can accommodate vessels up to 270,000 deadweight tons. The distance from Puerto Ordaz to Mobile is 2160 nautical miles. The distance from Tubarao is 4784 nautical miles. By use of Tubarao as alternative source of supply the unit savings would be increased from $0.80 N.T. to $2.21 N.T. giving an increase in average annual benefits of $4.9 million. Consequently, benefits accepted in this report on iron ore from Puerto Ordaz are considered to be conservative. Sources of supply for iron ore imports for Jim Walters

Resources at Birmingham, AL and Republic Steel at Gadsden, AL, being shipped through the Alabama State Docks' bulk handling terminal, seem to fluctuate from year to year. However, the primary source of supply is Dampier, Australia; Port Cartier, Quebec; and Point Ubu, Brazil, with maximum depths at these ports of 51, 54, and 60 feet, respectively. Vessel drafts were restricted to these depths for the benefit analysis in this report.

142. Coal Imports. Coal imported through Mobile has originated from several foreign ports in the past. However, the principals that are involved in the movements of this coal state that all future coal will be imported from Richards Bay, South Africa. The harbor depth of this port is 62 feet and the depths are being increased to 75 feet. No restrictions are placed on the maximum size vessel that can be used in this service, based on port depths at the foreign origin.

143. Coal Exports. The market areas for coal exports through Mobile can be any of the twenty-eight countries listed among the world's importers of significant tonnages of coal, with Japan being the major importer. Countries that receive coal exports from Mobile are divided into four regions defined as Japan, Italy, England/Europe and East Coast of South America. According to letters received from Ataka America, Inc., a principal coal broker that coordinates coal supply with steel mills in Japan, the major ports in Japan that received coal from Mobile are: Ohita, Kimitsu, Tabata, Fukuyama, and [illegible]ma with depths at piers of 89, 62, 57, 56, and 52 feet, respectively. Data from the U.S. Bureau of Census, published in their annual report, "U.S. Waterborne General Exports and Imports - 1975", indicate additional Japanese ports that receive coal from Mobile are: Kawasaki, Kobe, Yokohama, Chiba, and Tokyo. Channel depths at these ports are: 39, 43, 60, 67, and 30 feet, respectively. Because of the depths at major Japanese ports, it is assumed that vessels hauling coal from Mobile to Japanese ports would not be restricted. Ports in the region designated as "Italy" have harbor depths that range from

30 feet at Venice to 66 feet at Genoa. Other minor ports in this region are: Iskenderun, Turkey and Alexandria, Egypt. The major Italian port receiving coal from Mobile is Taranto with a harbor depth of 50 feet. Vessels delivering coal to this area will be restricted to a 50-foot draft. Principal ports that comprise the England/Europe region are: Rotterdam, Neth.; Newport, England; Oxelosund, Sweden; Cardiff and Port Talbot, Wales. The major port is Port Talbot, Wales with a maximum harbor depth of 80 feet. Consequently, no restrictions are placed on the maximum size vessels that will deliver coal from Mobile to the England/Europe region. The fourth region designated as "East Coast of South America" is comprised of the following principal ports: Buenos Aires, Argentina; Paranam, Surinam; Vitoria, Brazil; and Rio de Janeiro, Brazil. The major port in this region is Rio de Janeiro, Brazil with a maximum depth in the anchorage basin of 70 feet. No restrictions are assessed on benefits due to the size and draft of vessels hauling coal to this region.

144. For more detailed information on depths at foreign ports, refer to table F-35.

ALTERNATIVE MODES, VESSEL UTILIZATION RATES, AND UNIT COSTS

145. Evaluation of benefits for the selected plan is based on transportation savings that would accrue primarily from increased loading of vessels presently using the project and from future utilization of larger, more economical vessels. Net transportation savings are herein defined as the difference between the transportation costs of the fleet of vessels which would use the existing 40-foot channel and the fleets of vessels that could utilize the various considered depths, i.e., 45, 50, 55 and 60 feet. The vessels used in the cost analysis were world fleet vessels expected to use Mobile Harbor.

TABLE F-35

CHANNEL DEPTH AVAILABLE AT FOREIGN PORTS

PORT	DEPTH (Ft)	REMARKS
Iron Ore Imports for TCI Terminal		
Puerto Ordaz, Venz.	45	Fluctuates with depth in river
Port Cartier, Quebec	54	Depths in channel
Tubarao, Brazil	74	Depths at Piers [1/]
Iron Ore Imports for ASD Tipple		
Dampier, Australia	51	Minimum depth at berth
Port Cartier, Quebec	54	At mean low tide
Point Ubu, Brazil	60	Depths quoted by shipper
Coal Exports Through McDuffie Coal Terminal		
Ohita, Japan	89	Depths at berth
Kimitsu, Japan	62	Depths at berth
Tobata, Japan	57	Depths at berth
Kukuyama, Japan	56	-
Kashima, Japan	52	-
Kawasaki, Japan	39	-
Kobe, Japan	43	Channel depths not well-defined
Yokohama, Japan	60	-
Chiba, Japan	67	Depths at Private berths
Tokyo, Japan	30	-
Taranto, Italy	50	-
Genoa, Italy	66	-
Savonia, Italy	-	Port can accommodate a 45,000 d.w.t. vessel
Venice, Italy	30	-
Alexandria, Egypt	30	Tonnage to this port was eliminated
Iskenderun, Turkey	30	-
Rotterdam, Neth.	77	-
Newport, England	35	Max depth depends on berth used
Oxelosund, Sweden	42	-
Cardiff, Wales	42	Max depth depends on berth used
Port Talbot, Wales	80	-
Rio de Janeiro, Brazil	70	Depths at anchorage - unloading by lighterage
Buenos Aires, Argentina	28	-
Vitoria, Brazil	36	Depth at coal berth
Coal Imports		
Richards Bay, So. Africa	62	Being dredged to 75 feet

SOURCE: Port Dues, Charges and Accommodation - 1977-78, published by George Philip and Son, Limited, London, England

[1/] Can accommodate vessels up to 270,000 d.w.t.

146. Factors considered in the transportation cost computations were: the d.w.t. range of vessels which would utilize the various channel depths; the composition of these vessel fleets based on the number of vessels in each size (d.w.t.) class and the total carrying capability in each class; "at sea" and "in port" hourly operating costs; distance of haul; vessel port time; vessel speed; registered vessel draft; type vessel used per commodity and the utilization factor per vessel type. All costs were adjusted to reflect the cost-per-ton.

147. The major components of the transportation cost computations are described in the following paragraphs. Because of their size, general cargo vessels would not benefit from the proposed project improvements and, therefore, were not included in the cost analysis.

148. Vessel Operating Costs. All costs for dry-bulk carriers reflect only costs for vessels operating under foreign flag registry. Vessel operating costs are in terms of costs-per-hour for the operation of the vessel while at sea and while in port. Hourly vessel operating costs were obtained from the Office, Chief of Engineers (OCE). A regression analysis was used to determine the costs for those vessel sizes not supplied by OCE. Costs-per-hour for dry-bulk carriers are based on the 1 January 1977 shipbuilding costs; however, OCE has authorized these price levels to remain in effect through 1 October 1978. Consequently, vessel costs in this report reflect an effective date of 1 October 1978.

149. Table F-36 contains the estimated average hourly operating costs and vessel characteristics for the size range of dry-bulk carriers expected to move iron ore and coal through Mobile Harbor.

TABLE F-36

GENERAL CHARACTERISTICS AND HOURLY OPERATING COST DATA FOR OCEAN-GOING DRY BULK CARRIERS EXPECTED TO TRANSPORT IRON ORE AND COAL THROUGH MOBILE HARBOR FOR ALL DEPTHS CONSIDERED

(Foreign Flag)

Vessel Size (d.w.t) (long tons)	Length[1] (feet)	Breadth[2] (feet)	Maximum Registered Draft (feet)	Immersion Factor (short tons per foot)	Payload Capacity[3] (short tons)	Average Speed (knots)	Port Time (hours)	Hourly Operating Costs 1978 Price Levels[4] At Sea	In Port
15,000	521	69	29	811	16,128	15	101	$ 364	$ 282
17,000	535	71	30	914	18,278	15	101	378	292
20,000	554	74	31	1,017	21,504	15	102	401	309
23,000	571	77	32	1,120	24,730	15	103	427	327
26,000	587	80	33	1,224	27,955	15	104	455	345
29,000	602	82	34	1,327	31,181	15	105	483	363
32,000	617	85	35	1,430	34,406	15	106	509	379
36,000	635	88	36	1,533	38,707	15	107	540	399
39,000	648	90	37	1,636	41,933	15	108	558	411
43,000	665	93	38	1,739	46,234	15	109	577	424
47,000	681	96	39	1,842	50,534	15	110	594	436
52,000	700	99	40	1,945	55,910	15	112	619	451
56,000	715	101	41	2,048	60,211	15	113	645	465
61,000	732	104	42	2,151	65,587	15	114	667	483
65,000	746	107	43	2,254	69,988	15	116	700	495
70,000	762	109	44	2,357	75,264	15	117	721	507
75,000	778	112	45	2,460	80,640	15	118	738	518
81,000	796	115	46	2,563	87,091	15	120	760	523
86,000	811	118	47	2,666	92,467	15	122	783	549
92,000	828	120	48	2,769	95,918	15	124	814	572
98,000	844	123	49	2,872	105,370	15	125	845	594
104,000	860	126	50	2,975	111,821	15	127	873	614
110,000	876	129	51	3,078	118,272	15	129	898	631
117,000	893	132	52	3,181	125,798	15	131	923	648
123,000	908	134	53	3,284	132,250	15	133	942	661
130,000	925	137	54	3,387	139,776	15	135	962	673
137,000	941	140	55	3,490	147,302	15	137	980	685
144,000	957	142	56	3,593	154,829	15	139	998	696
151,000	972	145	57	3,696		15	141	1,015	706
159,000	989	148	58	3,800		15	143	1,109	753
166,000	1,004	150	59	3,902		15	145	1,142	758
174,000	1,021	153	60	4,006		15	148	1,181	765
182,000	1,037	156	61	4,109		15	150	1,219	783

SOURCE: Data drawn from vessel operating statistics provided annually by OCE and ical analysis on data extracted from The Dry B lk Carrier Register - 1975, compiled and published by H. Clarksc v, Ltd., London, England.

[1] Computed based on regression equation: LNG = 313.9 + 1.694 (square root of d.w.t.).

[2] Computed based on regression equation: BRD = 33.43 + .287 (square root of d.w.t.).

[3] Computed based on the following equation: d.w.t. (.96 X 1.12).

[4] The 1 January 1977 prices effective to 1 October 1978, as authorized by OCE.

150. Due to the absence of an obligated vessel fleet in Mobile Harbor, a range in vessel sizes was utilized in the determination of benefits for each considered channel depth. The minimum size for dry-bulk carriers used in the cost computation is based on the minimum size of vessels presently servicing the harbor. The maximum size is based on the largest vessel that can use a particular channel depth light-loaded by 5 feet with a bottom clearance of 4 feet. The resulting range for each channel depth was weighted according to the availability of each vessel size in the world fleet. Weighting of the fleet for costing purposes consists of determining the total carrying capability in each vessel size (number of vessels in d.w.t. size X payload capacity of the vessel). Since the exact size of vessel to be utilized in the different movements is based totally on the availability at time of need, the weighting process was considered necessary for determination of unit transportation costs and savings.

151. Vessel Utilization. Vessel utilization is the measurement of time or distance a vessel is operating at sea with cargo aboard. In order to assign the operating conditions to a factor for application in adjusting unit costs and savings, the time or distance a vessel operates at sea loaded and empty is converted to a percentage of time a vessel is operating with cargo aboard.

152. A canvass was made to interview local steamship agents and charter brokers at Mobile and other locations for the purpose of obtaining information on vessels' activity as it pertains to their ability in obtaining cargo for the various shipping trades. It was revealed that utilization rates for vessels have a wide variation depending on numerous conditions that affect the shipowner's ability to secure cargo for their vessels. They vary by type of charter, number of competing vessels available in the world fleet, availability of cargo at ports-of-call, shipowners' method

of operation, type of cargo being handled, and trade routes the shipowners select for their operation. Because of the variations in the world shipping and trade business that affect shipowners' ability to secure cargo for their vessels, it is difficult to establish a pattern of vessel utilization for a particular commodity movement in a given time frame.

153. Shipping interests furnished judgment estimates on the utilization of vessels that would call at Mobile applicable to those hauling bulk cargo, such as, grain, coal, iron ore and crude oil. The following information in table F-37 was given.

TABLE F-37

VESSEL UTILIZATION RATES

(Percent)

Source	Iron Ore (Tipple)	Iron Ore (TCI)	Coal (To Japan)	Coal All other (Countries)	Coal (Import)	Grain (Export)
Strachan Shipping Co.-Mobile	50	50	80	50	-	80
Norton Lilly & Co. Inc. -Mobile	-	50	-	-	-	-
Fillette Grain & Co. - Mobile	-	-	80	80	80	80
Bulk Shipping Inc. - Mobile	-	-	83	63	67	63
Hansen & Tideman, Inc. -Mobile	90	-	-	-	-	90
Stiegler Shipping Co.- Mobile	85	-	-	-	-	85
Page and Jones, Inc. - Mobile	75	-	-	-	-	75
Rodriquez & Sons -New York	65	-	74	-	-	50
J. H. Winchester & Co.,-New York	N/A	N/A	N/A	N/A	N/A	N/A
Typical Vessel Utilization Factor	75	50	80	65	75	75

N/A Data not available or could not be released.

154. A more realistic method for obtaining data relative to determining an average utilization rate for vessels calling at Mobile would be to randomly board vessels docked at terminals in Mobile Harbor and examine their log records. A total of 15 vessels were boarded at Mobile during March and April of 1977. Of the 15 ships boarded, 8 made their logs available for examination. Data obtained from these logs include: name of vessel, type of charter, date of departure and arrival at next port-of-call for each voyage during a one- or two-year time frame, name of cargo or empty between each port-of-call, origin/destination of each trip, and vessel travel time or distance between each port.

155. The dry-bulk carriers that were examined ranged in size from 22,000 to 114,000 d.w.t. One vessel operated under a voyage charter, two operated under a combined time and voyage charter, and five operated under a time charter. These vessels hauled a variety of cargo during the course of a year or more. The major commodities hauled were: grain, coal, iron ore, bauxite, and alumina. It was found that utilization of vessels ranged from 50 to 71 percent, with an average utilization rate of 60 percent. There was no definite basis for the difference in utilization rates.

156. A utilization rate of 60 percent was applied to all traffic except iron ore delivered to the TCI terminal at Mobile. A 50 percent utilization rate was applied to the latter commodity. Dry-bulk carriers hauling iron ore to the TCI terminal at Mobile usually operate on a time charter due to the relatively short haul and the need for an accurate schedule of delivery required by U.S. Steel.

157. Sensitivity of Vessels' Utilization Rate. A comparative benefit analysis was made on the movements of iron ore shipped from Puerto Ordaz, Venezuela; Port Cartier, Quebec; and Tubarao, Brazil to the TCI terminal at Mobile. The results of this analysis reveal the rate of reduction in benefits by the use of a vessel

utilization rate over 50 percent. Benefits were computed to reflect a 50, 60, 70, 80 and 100 percent vessel utilization rate. A comparison of the benefits, using the vessel utilization rates shown above, indicates that a reduction in benefits of 8, 16, 25, and 41 percent would be realized by the use of a 60, 70, 80, and 100 percent utilization rate, respectively, when compared to the benefits for a 50 percent utilization rate. Benefits for varying channel depths adjusted by use of the various vessel utilization rates are shown in table F-38.

158. Unit Transportation Costs. The cost-per-ton was determined for each size bulk carrier presented in table F-39. This involved the costing of the vessels fully-loaded and light-loaded up to 5 feet in 1-foot increments, dependent on the draft restrictions of the various considered channel depths. The 5-foot limit of light-loading is based on the fact that deep-draft vessels cannot economically operate when light-loaded beyond 5 feet. In a recent sampling of foreign flag dry-bulk carrier records, it was determined that these vessels are utilized, i.e., carrying cargo, 60 percent of the time. To reflect this in the unit cost computation for bulk carriers, a utilization factor of .60 was applied to the one-way distance, with the single exception of iron ore movements into the TCI terminal. The bulk carriers moving these iron ore shipments will return empty to point of origin thus yielding a utilization factor of .50.

159. The following sample shows the computation used to determine the cost-per-ton of cargo transported in a 56,000 d.w.t. dry-bulk carrier of foreign registry. Since it is assumed that dry-bulk carriers will have a 60 percent utilization rate, the distance of haul is increased by 40 percent for costing purposes. The cost-per ton or unit transportation costs were derived by dividing the total operating costs by the maximum volume of cargo which can be moved by that size vessel with varying channel depths.

TABLE F-38

A COMPARATIVE ANALYSIS OF BENEFITS FOR IRON ORE (TCI) BY USE OF VESSELS' UTILIZATION RATES WITH A RANGE BETWEEN 50 TO 100 PRECENT[1]

Vessel Utilization Rate	Percentage Reduction in Benefits	Channel Depths 45'	50'	55'	60'
		Average Annual Benefits ($000) (1 October 1978 prices)			
50%	-	$2,282[2]	$3,369[2]	$3,641[2]	$3,811[2]
60%	8%	2,095	3,092	3,340	3,495
70%	16%	1,908	2,817	3,040	3,180
80%	25%	1,721	2,540	2,740	2,864
100%	41%	1,348[2]	1,988[2]	2,139[2]	2,233[2]

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[1] These are not the benefits as shown in the report, but were computed for comparative purposes only.

[2] Benefits actually computed, other benefits were interpolated by use of a formula:

$$Y = \frac{X}{50} \times (\text{Benefit}_{50\%} - \text{Benefit}_{100\%}) + \text{Benefit}_{100\%},$$

where X = (100% utilization - desired % of utilization).

Example: X = 70, $\text{benefit}_{50\%}$ = $2,282, $\text{benefit}_{100\%}$ = $1,348.

Solution: 100% - 70% ÷ 50% x (2,282 - 1,348) + 1,348 = $1,908.

TABLE F-39

CARRYING CAPABILITY OF EACH SIZE CLASS OF WORLD FLEET DRY-BULK CARRIERS EXPECTED TO USE MOBILE HARBOR FOR MOVEMENTS OF IRON ORE AND COAL

(Foreign Flag Registry)

Vessel Size (d.w.t.)	Payload Capacity[1]	Number of Vessels in Size Class	Carrying Capability[2]	% Capability
15,000	16,128	194	3,128,832	2.05
17,000	18,278	177	3,235,277	2.12
20,000	21,504	222	4,773,888	3.13
23,000	24,730	245	6,058,752	3.98
26,000	27,955	282	7,883,366	5.17
29,000	31,181	306	9,541,325	6.26
32,000	34,406	334	11,491,737	7.55
36,000	38,707	247	9,560,678	6.28
39,000	41,933	151	6,331,853	4.16
43,000	46,234	105	4,854,528	3.19
47,000	50,534	90	4,548,096	2.99
52,000	55,910	83	4,640,563	3.05
56,000	60,211	89	5,358,797	3.52
61,000	65,587	92	6,034,022	3.96
65,000	69,888	86	6,010,368	3.95
70,000	75,264	80	6,021,120	3.95
75,000	80,640	62	4,999,680	3.28
81,000	87,091	40	3,483,648	2.29
86,000	92,467	29	2,681,549	1.76
92,000	98,918	30	2,967,552	1.95
98,000	105,370	31	3,266,458	2.14
104,000	111,821	31	3,466,445	2.28
110,000	118,272	31	3,666,432	2.41
117,000	125,798	28	3,522,355	2.31
123,000	132,250	25	3,306,240	2.17
130,000	139,776	24	3,354,624	2.21
137,000	147,302	22	3,240,653	2.13
144,000	154,829	20	3,096,576	2.03
151,000	162,355	21	3,409,459	2.24
159,000	170,957	19	3,248,179	2.13
166,000	178,483	15	2,667,248	1.75
174,000	187,085	10	1,870,848	1.23
182,000	195,686	3	587,059	0.39
		TOTALS	152,308,207	100.00

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[1] Developed by the equation: d.w.t. x (.96 x 1.12).

[2] Carrying capability = (Payload capacity of a vessel) x (number of vessels in the size class).

*The number of vessels represent those 15 years old and under, plus those under construction or on order as of 1 January 1977.

SOURCE: Source for number of world fleet vessels in each class size was: Lloyd's Register of Shipping, Statistical Tables, 1975

SAMPLE COMPUTATION

Deadweight Tons: 56,000 Payload Capacity: 60,211 tons

Maximum Draft: 41 feet Immersion Factor: 2,048 tons per foot

Costs-per-hour: $645 at sea, $465 in port

One-way distance: 5684 nautical miles

Adjusted distance: 5684 divided by .60 = 9,473 nautical miles

Time at sea: 9,473 nautical miles divided by 15 knots = 632 hours

Time in port (origin and destination): 113 hours

Cost per adjusted distance: $645 X 632 hours + $465 X 113 hours = $460,185

Cost-per-ton light-loaded to 36 feet for a 40-foot channel: $460,185 divided by (60,211 - 2,048 X 5) = $9.21

Cost-per-ton fully-loaded to 41 feet for a 45-foot channel: $460,185 divided by 60,211 = $7.64.

160. In order to derive the weighted unit costs, the carrying capability was determined for each d.w.t. size vessel expected to use Mobile Harbor, ranging in size from 15,000 to 182,000 d.w.t. for dry-bulk carriers. The carrying capability represents the total amount of tonnage that can be hauled in each vessel for vessels in the selected fleet. Table 9-39 records the carrying capability of world fleet dry-bulk carriers which were considered in the analyses of the studied depths. Weighted unit costs were derived for each depth; i.e., 40, 45, 50, 55 and 60 feet, by multiplying the percentage of each vessel's carrying capability times the unit transportation costs of each size vessel and summing the products.

161. To expedite the computation of weighted average unit costs, a computer model was devised. An example computer printout of the subroutines and the resulting answers are shown in attachment 9-1. This exhibit covers iron ore to TCI terminal at Mobile from the following origins: Puerto Ordaz, Venz., Port Cartier, Quebec; and Vitoria (Tubarao) Brazil.

162. The computer model also produces the annual tonnage and benefits for each year during the project life. From the annual benefits, an average annual equivalent benefit is produced for each movement of commerce.

163. On merchant ships routed through the Panama Canal, a charge of $1.29 per Panama Canal ton for loaded vessels and $1.03 per Panama Canal ton for those vessels moving through in ballast (empty). These figures were adjusted to reflect a cost per deadweight ton (d.w.t.) giving a cost of $0.64 per d.w.t. loaded and $0.51 per d.w.t. empty. These costs were further adjusted to reflect a round-trip vessel cost for transiting the Panama Canal, with a vessel utilization (loaded vs empty) factor of 60 percent. The following formula was used to arrive at the weighted cost per round-trip of $1.18 per d.w.t.

Cost for the vessel transit-loaded $0.64 d.w.t.
Cost for the vessel transit-empty $0.51 d.w.t.

<u>Round-trip costs</u>:

100% vessel utilization (loaded 100% of trips)

$0.64 + $0.64 = $1.28 per d.w.t.

50% vessel utilization (loaded 50% of trips)

$0.64(loaded) + $0.51 (empty) = $1.15 per d.w.t.

<u>Costs interpolated for a 60% utilization factor by use of a formula:</u>

$$y = \frac{x}{50} \times (\text{R/T cost}_{50\%} - \text{R/T costs}_{100\%}) + \text{R/T costs}_{50\%}$$

where x = (50% utilization - desired % utilization)

$x = 60$, $\text{R/T cost}_{50\%} = \$1.15$, $\text{R/T cost}_{100\%} = \$1.28$

60% - 50% ÷ 50% x ($1.28 - $1.15) + $1.15 = $1.18 per d.w.t.

164. Records on ship characteristics and toll charges for each vessel that transited the Panama Canal during a period from 1 May 1978 to 31 May 1979 was obtained from the Panama Canal Company. These records revealed that the toll charge is $1.29 per P.C. ton (loaded) and $1.03 per P.C. ton (empty). The weighted average charge per d.w.t. for dry bulk carriers was determined by dividing the total toll charges for these vessels that transited the

Panama Canal during this time period by the total d.w.t. of these vessels. The weighted average for the Panama Canal toll charges of $1.18 per d.w.t. were included in the total operating costs of dry bulk carriers in determining the unit (per ton) costs for a fleet of ships hauling iron ore from Australia and coal to Japan under the present channel condition at Mobile.

UNIT SAVINGS

165. General. Unit savings are measured by the difference in per-ton costs for a fleet of vessels that can operate on the existing 40-foot ship channel and the costs for a fleet of vessels that can operate with increased channel depths ranging from 41 to 60 feet. Savings are reported for channel depths of 45, 50, 55, and 60 feet only, as these are the only depths that are being considered in the benefit/cost analysis. These savings reflect vessel operating costs effective as of 1 October 1978.

166. Factors that affect the unit savings and, in some cases, restrict the savings, are: channel depths at foreign ports, vessel utilization rate, traffic that can be routed by more than one route, such as, through the Panama Canal or via the Cape of Good Hope, South Africa, distance of haul, and size of vessel fleet.

167. There is a greater variation in vessel operating costs on iron ore moving from Australia via the Panama Canal versus routing around the Cape of Good Hope than for those costs associated with coal exports by the same routings to Japan and other Far East countries. This is mainly due to the difference in miles of haul by the two routes from different origins/destinations. A comparison of costs by the alternative routings is shown in table F-40.

TABLE F-40

COMPARISON OF PER-TON TRANSPORTATION COSTS ON IRON ORE AND COAL ROUTED THROUGH THE PANAMA CANAL VERSUS COSTS FOR VESSELS ROUTED AROUND THE CAPE OF GOOD HOPE

55-foot channel

Item	Via Panama Canal[1] Miles[3]	Via Panama Canal[1] Costs[4]	Via Cape of Good Hope[2] Miles[3]	Via Cape of Good Hope[2] Costs
Iron Ore				
Australia to Mobile	17,934	$20.75	20,020	$12.18
Cost Differential		$ 8.57		
Difference in distance - 2,086 nautical miles				
Coal				
Mobile to Japan	15,499	$17.67	25,926	$15.55
Cost Differential		$ 2.12		
Difference in distance - 10,427 nautical miles				

[1] Vessel fleet size 15-56,000 d.w.t. for iron ore and 20-56,000 d.w.t. for coal.

[2] Vessel fleet size 61-110,000 d.w.t.

[3] Adjusted to reflect a 60 percent vessel utilization rate.

[4] Costs include Panama Canal toll charges.

168. Iron Ore. Unit savings on imported iron ore vary with each movement only to the extent that: miles of haul are different; different utilization rates for vessels; and alternative routing available when shipped from Far East countries. On iron ore for the TCI terminal at Mobile, the origins are: Puerto Ordaz, Venz.; Port Cartier, Quebec; and Tubarao, Brazil. The unit savings for these movements are shown in table F-41.

169. Iron ore moving through the Alabama State Docks bulk handling plant (Tipple) originates at Port Cartier, Quebec: Point Ubu, Brazil; and Dampier, Australia. Unit savings on iron ore from Port Cartier and Point Ubu are shown in table F-42. Unit savings on iron ore from Dampier, Australia are given in table F-43.

170. Coal Imports. Unit savings on coal imports range from $1.03 per ton for a 45-foot channel to $2.43 per ton for a 60-foot channel. This coal originating at Richards Bay, South Africa, as no restrictions assessed against the unit savings other than the 60 percent vessel utilization rate. Because of its geographical location and 62-foot channel depth, there is no alternative routing and the channel depth is greater than those under study for Mobile Harbor. The unit savings that can be realized by greater channel dimensions at Mobile given at 5-foot increments are shown in table F-44.

TABLE F-41

UNIT SAVING ON IRON ORE DESTINED TO TCI TERMINAL AT MOBILE[1]

	From					
Channel	Puerto Ordaz, Venezuela		Port Cartier, Quebec		Tubarao, Brazil	
Depths	Cost (per ton)[2]	Savings	Cost (per ton)[2]	Savings	Cost (per ton)[2]	Savings
40	$5.66	-	$6.56	-	$11.04	-
45	5.11	$0.55	5.92	$0.64	9.96	$1.08
50	4.86	0.80[3]	5.56	1.00	9.35	1.69
55	4.86	0.80[3]	5.26	1.30	8.83	2.21
60	4.86	0.80[3]	5.10	1.46[4]	8.49	2.55

[1] Unit savings reflect a 50 percent vessel utilization rate.

[2] Costs calculated by use of a computer model.

[3] Savings restricted to a 49-foot channel depth due to the 45-foot channel depth available at Puerto Ordaz, Venezuela.

[4] Savings restricted to a 58-foot channel depth due to the 54-foot channel depth available at Port Cartier, Quebec.

TABLE F-42

Unit savings on iron ore destined to the Alabama State Docks "Tripple" at Mobile, except from Dampier, Austrailia.[1]

Channel Depths	From Port Cartier, Quebec Cost (per ton)[2]	Unit savings	Point Ubu, Brazil Cost (per ton)[2]	Unit savings
40	$5.67	-	$9.40	-
45	5.12	$0.55	8.48	$0.92
50	4.81	0.86	7.97	1.44
55	4.55	1.12	7.52	1.88
60	4.41	1.26[3]	7.23	2.17

[1] Unit savings reflect a 60 percent vessel utilization rate.

[2] Costs calculated by use of a computer model.

[3] Savings restricted to a 58-foot channel depth due to the 54-foot channel depth available at Port Cartier, Quebec.

TABLE F-43

UNIT SAVINGS ON IRON ORE IMPORTED FROM DAMPIER AUSTRALIA

Channel Depths	Vessel Costs per ton: Via Panama Canal with a vessel fleet range: 15,000-56,000 d.w.t.[1]	Vessel Costs per ton: Via Cape of Good Hope with a vessel fleet range: 61,000-182,000 d.w.t.[2]	Unit Savings (per ton)
40	$20.75	$ -	$ -
41	20.75	17.24	3.51
42	20.75	16.74	4.01
43	20.75	16.13	4.62
44	20.75	15.50	5.25
45	20.75	14.91	5.84
46	20.75	14.38	6.37
47	20.75	13.98	6.77
48	20.75	13.66	7.09
49	20.75	13.40	7.35
50	20.75	13.18	7.57
55	20.75	12.18	8.57
60	20.75	11.58	8.57[3]

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[1] Vessel fleet size restricted by the 41-foot depth of the Panama Canal. Costs include Panama Canal toll charges.

[2] Costs based on unrestricted vessel operation except channel depths at Mobile.

[3] Savings are restricted to a 55' channel depth at Mobile due to the 51' channel depth available at Dampier, Australia.

TABLE F-44

UNIT SAVINGS ON COAL IMPORTS FROM RICHARDS BAY, SOUTH AFRICA[1]

Channel Depths	Costs (per ton)[2]	Unit Savings
40	$10.43	-
45	9.40	$1.03
50	8.82	1.61
55	8.33	2.10
60	8.00	2.43

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[1] Costs were calculated by computer model.

[2] Costs based on a fleet of dry-bulk carriers ranging in size from 15,000 to 182,000 d.w.t. with limitations for each channel depth.

171. Coal Exports. Two methods for calculating unit savings on coal exports from Mobile were used in this analysis. On coal destined to Japan, the lowest cost alternative routing, with a 40-foot channel available at Mobile, would be via the Panama Canal. The vessel operating cost by this route, using a fleet of dry-bulk carriers ranging from 20,000 to 56,000 d.w.t., is $17.67 per short ton, which includes the Panama Canal toll charges. On a vessel fleet moving via Cape of Good Hope, the operating costs with greater channel depths available at Mobile range from $22.03 per ton with a 41-foot channel available to $14.78 per ton with a 60-foot channel available. No benefits can be realized by deepening for depths between 40 and 47 feet. The unit savings range from $0.22 per ton for 48-foot channel to $2.89 per ton for a 60-foot channel. More detailed figures on unit costs and savings for coal exports to Japan are shown in table F-45.

TABLE F-45

UNIT SAVINGS ON COAL EXPORTS TO JAPAN[1]

Vessel Operating Cost (per ton)[2]

Channel Depths (ft)	Via Panama Canal[3]	Via Cape of Good Hope[4]	Unit Savings
40	$17.67	$ -	$ -
41	17.67	22.03	-
42	17.67	21.42	-
43	17.67	20.61	-
44	17.67	19.81	-
45	17.67	19.06	-
46	17.67	18.37	-
47	17.67	17.86	-
48	17.67	17.45	0.22
49	17.67	17.12	0.55
50	17.67	16.84	0.83
55	17.67	15.55	2.12
60	17.67	14.78	2.89

[1] The principal ports are: Tabuta, Tokyo, Ohita, Kimitsu and Fukuyama.

[2] Costs were calculated by computer model.

[3] Costs for a fleet of dry-bulk carriers 20-56,000 d.w.t. restricted by the depth of the Panama Canal and 40-foot channel at Mobile. Costs include the Panama Canal toll charges.

[4] Costs for a fleet of dry-bulk carriers 61-182,000 d.w.t. with channel depth at Mobile the only restrictions in vessel operation.

172. The other method of determining unit savings on coal exports to countries other than to Japan is by use of the computer model that gives the costs per-ton for a designated fleet of vessels for each channel depth under study Unit savings on coal exports to the three regions other than Japan are given in table F-46.

TABLE F-46

UNIT SAVINGS ON COAL EXPORTS DESTINED TO COUNTRIES OTHER THAN JAPAN

Channel Depth (ft)	To Italy[1] Costs[4] (Per ton)	 Unit Savings	 England/Europe[2] Costs[4] (Per ton)	 Unit Savings	 E. Coast of So. America[3] Costs[4] (Per ton)	 Unit Savings
40	$10.57	$ -	$8.98	$ -	$6.28	$ -
45	9.53	1.04	8.10	0.88	5.66	0.62
50	8.94	1.63	7.60	1.38	5.32	0.96
55	8.53[5]	2.04[5]	7.17	1.81	5.03	1.25
60	8.53[5]	2.04[5]	6.90	2.08	4.83	1.45

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[1] The principal ports in this area are: Taranto, Genoa and Venice, Italy; and Iskenderun, Turkey. Tonnage to Alexandria, Egypt was eliminated.

[2] The principal ports in this area are: Newport England; Cardiff and Port Talbot, Wales; Glasgow, Scotland; and Antwerp, Belgium; Bunkerque, France; Goteborg, Sweden; and Kristiansand, Norway.

[3] The principal ports in this area are: Vitoria and Rio de Janeiro, Brazil.

[4] Costs were calculated by use of a computer model.

[5] Costs and benefits are restricted to a 54-foot channel at Mobile due to the limited depths at ports in the Italy region.

173. Summary of 1975 Benefits. A summary of total initial-year (1975) transportation benefits that would have been realized from the considered improvements at Mobile Harbor is presented in table F-47.

TABLE F-47

INITIAL-YEAR (1975) BENEFITS (THOUSAND DOLLARS)

Commodity	Channel Depths (feet) 45	50	55	60
Iron Ore Imports (ASD Tipple)	$1,480	$1,998	$2,340	$2,427
Iron Ore Imports (TCI Terminal)	1,724	2,555	2,760	2,888
Coal Imports (ASD Tipple)	382	597	780	900
Coal Exports (McDuffie Island)	745	1,732	2,928	3,519
Total Initial-Year Benefits	$4,331	$6,882	$8,809	$9,734

174. Unit Savings and Benefits for 1986. As previously stated, the 1975 base traffic was extended to 1986 as a new base because additional commerce is expected to be developed due to new coal contracts. Consequently, the unit savings and benefits for 1986 are established to show the savings that would be developed by this date. Unit savings and benefits on each commodity movement for 1986 are presented in tables F-48, F-49, and F-50.

TABLE F-48

ANNUAL SAVINGS ON IRON ORE IMPORTS AT MOBILE FOR YEAR 1986

ITEM	Channel Depth (feet)			
	45	50	55	60
FROM PUERTO ORDAZ, VENEZUELA [1]				
Tons (Thousands)	2,594	2,594	2,594	2,594
Unit Savings	$0.55	$0.80[4]	$0.80[4]	$0.80[4]
Total Savings (Thousands)	$1,429	$2,070	$2,070	$2,070
FROM PORT CARTIER, QUEBEC[2]				
Tons (Thousands)	369	369	369	369
Unit Savings	$0.59	$0.92	$1.20	$1.34[5]
Total Savings (Thousands)	$ 219	$ 340	$ 444	$ 497
FROM VITORIA (TUBARAO), BRAZIL[1]				
Tons (Thousands)	337	337	337	337
Unit Savings	$1.08	$1.69	$2.21	$2.55
Total Savings (Thousands)	$ 365	$ 569	$ 745	$ 860
FROM DAMPIER, AUSTRALIA [3] [7]				
Tons (Thousands)	224	224	224	224
Unit Savings	$5.84	$7.57	$8.57[6]	$8.57[6]
Total Savings (Thousands)	$1,305	$1,692	$1,915	$1,915
FROM POINT UBU, BRAZIL [3]				
Tons (Thousands)	232	232	232	232
Unit Savings	$0.92	$1.44	$1.88	$2.17
Total Savings (Thousands)	$ 214	$ 334	$ 437	$ 504
TOTAL SAVINGS FOR IRON ORE	$3,532	$5,005	$5,611	$5,846

Totals may not balance due to rounding

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[1] For iron ore unloaded at Marine Bulk Terminal (TCI) below I-10 tunnels destined to U.S. Steel at Birmingham.

[2] For iron ore currently being unloaded at Marine Bulk Terminal (TCI) and ASD "Tipple" destined to Jim Walters Resource Corp. and U.S. Steel at Birmingham, AL and Republic Steel at Gadsden, AL.

[3] For iron ore currently being unloaded at ASD "Tipple" destined to Jim Walters Resource Corp. at Birmingham, AL and Republic Steel at Gasdaen, AL.

[4] Savings restricted to a 49' channel.

[5] Savings restricted to a 48' channel

[6] Savings restricted to a 55' channel.

[7] Savings reflect the Panama Canal toll charge assessed for the vessel fleet operating under present channel conditions at Mobile.

TABLE F-49

ANNUAL SAVINGS ON COAL IMPORTS AT MOBILE FOR YEAR 1986

	Channel Depth (feet)			
	45	50	55	60
<u>FROM: RICHARDS BAY, SOUTH AFRICA</u>				
Tons (Thousands)	896	896	896	896
Unit Savings	$1.03	$1.61	$2.10	$2.43
Total Savings (Thousands)	$ 923	$1,441	$1,883	$2,175

TABLE F-50

ANNUAL SAVINGS ON COAL EXPORTS AT MOBILE FOR YEAR 1986

ITEM	Channel Depths (feet) 45	 50	 55	 60
TO JAPAN				
Tons (Thousands)	4,177	4,177	4,177	4,177
Unit Savings	None	$0.83	$2.12	$2.89
Total Savings (Thousands)	None	$3,467	$8,855	$12,072
TO ITALY[1]				
Tons (Thousands)	3,211	3,211	3,211	3,211
Unit Savings	$1.04	$1.63	$2.04	$2.04
Total Savings	$3,352	$5,234	$6,544	$6,544
TO ENGLAND/EUROPE				
Tons (Thousands)	1,070	1,070	1,070	1,070
Unit Savings	$0.88	$1.38	$1.81	$2.08
Total Savings (Thousands)	$ 947	$1,479	$1,932	$2,230
TO EAST COAST OF SOUTH AMERICA				
Tons (Thousands)	476	476	476	476
Unit Savings	$0.62	$0.96	$1.25	$1.45
Total Savings (Thousands)	$ 293	$ 457	$ 597	$ 688
TOTAL SAVINGS FOR COAL EXPORT	$4,592	$10,637	$17,928	$21,534

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[1] Benefits restricted to those for a 54' channel because of channel depths at foreign ports.

175. Summary of Unit Savings for 1986 Traffic. Estimates of the transportation benefits which would result from the considered improvement were developed by comparing the transportation costs by use of a 40-foot channel on that commerce which would benefit from the deeper channels with the transportation costs that are expected to occur with the improvements. The savings would result principally from economics of scale associated with the use of larger, more efficient ships and increased loadings of ships. A summary of average unit savings that would be realized in 1986, based on total benefits divided by the total tonnage for each commodity, is presented in table F-51.

176. Summary of Total Navigation Benefits for 1986. A summary of benefits developed by application of unit savings applied to the 1986 tonnage on each commodity movement giving a composite of benefits is shown in table F-52.

FUTURE AND AVERAGE ANNUAL EQUIVALENT BENEFITS

177. Transportation Benefits. Projected tonnage, unit savings, and benefits for each 5-foot increment of depth are shown in tables F-53 through F-55. Average annual equivalent benefits are also shown on these tables and are based on the use of a 6 7/8 percent interest rate.

178. Iron Ore Imports. Detailed information on unit savings and benefits for iron ore imports with average annual benefits for each movement is presented in table F-53. Uniform increase in iron ore imports is expected between 1995 and 2035 with no growth between 2035 and 2044. The only constraints that affect benefits are the channel depth at foreign ports.

179. Coal Imports. All coal imports will originate at Richards Bay, South Africa. No increase in tonnage is expected over the 50-year project life (1995-2044). Detailed information on benefits for coal imports is presented in table F-54.

TABLE F-51

SUMMARY OF 1986 COMMERCE* AND AVERAGE UNIT SAVINGS FOR ALTERNATIVE CHANNEL DEPTHS INVESTIGATED

	1986 Commerce (Thousands of Tons)	Savings/Ton			
		45	50	55	60
Commerce through Bulk Terminals above I-10 Tunnels					
Iron Ore (import)	656	$2.48	$3.35	$3.93	$4.07
Coal (import)	896	1.03	1.61	2.10	2.43
Commerce through Bulk Terminals in Mobile below I-10 Tunnels					
Iron Ore (import)	3,099	$0.61	$0.91	$0.98	$1.02
Coal (export)	8,934	0.96[1]	1.19	2.01	2.41

*Includes only commerce that would benefit from deeper channel.

[1] Based on tonnage and savings for traffic to all destinations except Japan. No savings on traffic to Japan with a 45-foot channel at Mobile. Tonnage excluding Japan is 4,757,000.

TABLE F-52

SUMMARY OF NAVIGATION BENEFITS FOR ALTERNATIVE CHANNEL DEPTHS INVESTIGATED FOR YEAR 1986

Type of Commodity	Channel (Depth in Feet)			
	45	50	55	60
Commerce through bulk terminals in Mobile above I-10 Tunnels[1]				
Iron Ore (import)	$1,630,000	$2,198,000	$2,577,000	$2,671,000
Coal (import)	923,000	1,441,000	1,883,000	2,175,000
Sub-Total	2,553,000	3,639,000	4,460,000	4,846,000
Commerce through bulk terminals in Mobile below I-10 Tunnels				
Iron Ore (import)	$1,902,000	$2,807,000	$3,034,000	$3,175,000
Coal (export)	4,592,000	10,637,000	17,928,000	21,534,000
Sub-Total	6,494,000	13,444,000	20,962,000	24,709,000
Total Benefits for Mobile Channel Improvement	$9,047,000	$17,083,000	$25,422,000[2]	$29,555,000

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[1] This traffic will be diverted to terminals below I-10 Tunnels.

[2] Average annual costs for the recommended 55-foot channel are $22,028,000. The B/C ratio in 1986 is 1.15.

TABLE F-53

ANNUAL TONNAGE AND BENEFITS ON IRON ORE IMPORTS

		Channel Depths (feet)							
	Annual Tonnage	45		50		55		60	
		Savings		Savings		Savings		Savings	
YEAR	(000)	Unit	Total(000)	Unit	Total(000)	Unit	Total(000)	Unit	Total(000)
				FROM: PUERTO ORDAZ, VENZ.[2]					
1995[1]	2,887	$.55	$1,591	$.80	$2,304	$.80	$2,304	$.80	$2,304
2000	3,087	.55	1,701	.80	2,463	.80	2,463	.80	2,463
2010	3,593	.55	1,980	.80	2,867	.80	2,867	.80	2,867
2020	4,140	.55	2,281	.80	3,304	.80	3,304	.80	3,304
2030	4,729	.55	2,606	.80	3,774	.80	3,774	.80	3,774
2035	5,162	.55	2,844	.80	4,119	.80	4,119	.80	4,119
2044	5,162	.55	2,844	.80	4,119	.80	4,119	.80	4,119
Avg. Annual Benefits			1,931		1,796		2,796		2,796
				FROM: PORT CARTIER, QUEBEC[3]					
1995[1]	410	.59	243	.92	378	1.20	494	1.34	553
2000	438	.59	260	.92	405	1.20	529	1.34	591
2010	511	.59	302	.92	472	1.20	615	1.34	688
2020	589	.59	349	.92	543	1.20	709	1.34	793
2030	672	.59	398	.92	620	1.20	810	1.34	905
2035	734	.59	436	.92	677	1.20	883	1.34	988
2044	734	.59	436	.92	677	1.20	883	1.34	988
Avg. Annual Benefits			296		460		600		672
				FROM: VITORIA (TUBARAO), BRAZIL					
1995[1]	375	1.08	406	1.69	633	2.21	829	2.55	957
2000	401	1.08	434	1.69	677	2.21	886	2.55	1,024
2010	467	1.08	505	1.69	788	2.21	1,032	2.55	1,191
2020	538	1.08	582	1.69	908	2.21	1,189	2.55	1,372
2030	614	1.08	665	1.69	1,037	2.21	1,358	2.55	1,568
2035	670	1.08	726	1.69	1,132	2.21	1,482	2.55	1,711
2044	670	1.08	726	1.69	1,132	2.21	1,482	2.55	1,711
Avg. Annual Benefits			493		769		1,006		1,162
				FROM: POINT UBU, BRAZIL					
1995[1]	259	.92	238	1.44	372	1.88	486	2.17	561
2000	276	.92	255	1.44	397	1.88	519	2.17	600
2010	322	.92	297	1.44	462	1.88	605	2.17	698
2020	371	.92	342	1.44	533	1.88	697	2.17	805
2030	424	.92	390	1.44	609	1.88	796	2.17	919
2035	462	.92	426	1.44	664	1.88	869	2.17	1,003
2044	462	.92	426	1.44	664	1.88	869	2.17	1,003
Avg. Annual Benefits			289		451		590		681
				FROM: DAMPIER, AUSTRALIA[4]					
1995[1]	249	5.84	1,454	7.57	1,885	8.57	2,134	8.57	2,134
2000	266	5.84	1,553	7.57	2,014	8.57	2,280	8.57	2,280
2010	310	5.84	1,810	7.57	2,347	8.57	2,657	8.57	2,657
2020	357	5.84	2,085	7.57	2,702	8.57	3,059	8.57	3,059
2030	407	5.84	2,377	7.57	3,081	8.57	3,488	8.57	3,488
2035	445	5.84	2,599	7.57	3,369	8.57	3,814	8.57	3,814
2044	445	5.84	2,599	7.57	3,369	8.57	3,814	8.57	3,814
Avg. Annual Benefits			1,764		2,287		2,590		2,590

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[1] First year of project life.

[2] Benefits are restricted to a 49' channel depth because of the 45' channel depth available at origin.

[3] Benefits are restricted to a 58' channel depth because of the 54' channel depth available at origin.

[4] Benefits are restricted to a 55' channel depth because of the 51' channel depth available at origin.

NOTE: Total savings may vary due to rounding.

TABLE F-54

ANNUAL TONNAGE AND BENEFITS ON COAL IMPORTS

		Channel Depths (feet)							
	Annual	45		50		55		60	
	Tonnage	Savings		Savings		Savings		Savings	
YEAR	(000)	Unit	Total (000)	Unit	Total (000)	Unit	Total (000)	Unit	Total (000)
				FROM: RICHARDS BAY, SOUTH AFRICA					
1995[1]	896	$1.03	$923	$1.61	$1,441	$2.10	$1,883	$2.43	$2,175
2000	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
2010	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
2020	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
2030	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
2035	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
2044	896	1.03	923	1.61	1,441	2.10	1,883	2.43	2,175
Avg. Annual Benefits			923		1,441		1,883		2,175

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[1] First year of project life.

TABLE F-55

ANNUAL TONNAGE AND BENEFITS ON COAL EXPORTS

		Channel Depth (feet)							
	Annual Tonnage	45		50		55		60	
		Savings		Savings		Savings		Savings	
YEAR	(000)	Unit	Total (000)[3]	Unit	Total (000)[3]	Unit	Total (000)[3]	Unit	Total (000)[3]
				TO: JAPAN					
1995[1]	4,653	None	None	$0.83	$3,862	$2.12	$ 9,865	$2.89	$13,448
2000	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
2010	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
2020	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
2030	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
2035	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
2044	4,937	None	None	0.83	4,098	2.12	10,467	2.89	14,269
Avg. Annual Benefits			None		4,055		10,356		14,118
				TO: ITALY[2]					
1995[1]	3,577	$1.04	$3,734	1.63	5,831	2.04	7,290	2.04	7,290
2000	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
2010	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
2020	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
2030	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
2035	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
2044	3,795	1.04	3,962	1.63	6,187	2.04	7,735	2.04	7,735
Avg. Annual Benefits			3,920		6,121		7,653		7,653
				TO: ENGLAND/EUROPE					
1995[1]	1,192	0.89	1,055	1.38	1,647	1.81	2,153	2.08	2,484
2000	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
2010	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
2020	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
2030	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
2035	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
2044	1,265	0.89	1,119	1.38	1,748	1.81	2,284	2.08	2,636
Avg. Annual Benefits			1,108		1,729		2,260		2,608
				TO: EAST COAST OF SOUTH AMERICA					
1995[1]	530	0.62	327	0.96	510	1.25	665	1.45	767
2000	563	0.62	347	0.96	541	1.25	705	1.45	814
2010	563	0.62	347	0.96	541	1.25	705	1.45	814
2020	563	0.62	347	0.96	541	1.25	705	1.45	814
2030	563	0.62	347	0.96	541	1.25	705	1.45	814
2035	563	0.62	347	0.96	541	1.25	705	1.45	814
2044	563	0.62	347	0.96	541	1.25	705	1.45	814
Avg. Annual Benefits			343		535		698		805

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[1] First year of project life.

[2] Benefits are restricted to a 54' channel depth because of limited depths at ports in the Italy region

[3] Total savings may not exactly equal the product of unit savings times tonnage due to rounding.

180. Coal Exports. No benefits can be realized by providing a 45-foot channel at Mobile on coal exports to Japan. It is more economical to route the commerce through the Panama Canal in vessels suitable for this waterway. Benefits on coal exports to Italy are restricted to a 54-foot channel project at Mobile due to limited depths at these foreign ports. Detailed information on benefits for coal exports are presented in table F-55.

181. Summary of Transportation Benefits. Estimates of the future annual commerce and transportation savings for selected years throughout the economic life for the considered improvements are presented in table F-56. These estimated future annual savings were converted to average annual equivalent benefits using an interest rate of 6-7/8 percent over the 50-year project life. A summary of the average annual equivalent benefits attributable to the various considered channel depths is presented in table F-57.

182. An analysis of navigation benefits is presented herein to test the benefit/cost ratio for the first year (1995) after the project has been completed. The total navigation benefits that would occur, with the recommended 55-foot project in place, is estimated to be $28,106,000. The annual charges are $22,028,000. This would give a BCR of 1.3. If the land enhancement benefits of $2,697,000 are added to the navigation benefits, a total benefit of $30,803,000 is realized. The BCR will change to 1.4. This demonstrates that the recommended project is justified at beginning of the project life.

183. Land Enhancement Benefits. For a 55-foot level of development, it is proposed that 34,630,000 cubic yards of the new work material dredged from the upper bay channel be deposited inside the diked disposal area adjacent to Brookley. It is estimated that the 1047 acres of new fast land would be usable for industrial or commercial purposes and would be enhanced in value by an amount equal to the cost of providing the same improvement by the least costly method.

TABLE F-56

SUMMARY OF ANNUAL VOLUME OF TRAFFIC AND SAVINGS

(Thousands)

	1975		1986		1995[1]		2000		2010		2020		2030		2035		2044	
Commodity	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savings	Tons	Savi
									45-Foot Channel Depth									
Iron Ore	3,411	$3,204	3,755	$3,532	4,180	$3,931	4,468	$4,204	5,203	$4,892	5,994	$5,637	6,846	$6,440	7,473	$7,030	7,473	$7,0
Coal (imports)	371	382	896	923	896	923	896	923	896	923	896	923	896	923	896	923	896	9
Coal (exports)	772[2]	745	4,757[2]	4,592	5,299[2]	5,116	5,623[2]	5,428	5,623[2]	5,428	5,623[2]	5,428	5,623[2]	5,428	5,623[2]	5,428	5,623[2]	5,4
TOTAL	4,554	$4,331	9,408	$9,047	10,375	$9,970	10,987	$10,555	11,722	$11,243	12,513	$11,988	13,365	$12,791	13,992	$13,381	13,992	$13,3
									50-Foot Channel Depth									
Iron Ore	3,411	$4,553	3,755	$5,005	4,180	$5,571	4,468	$5,955	5,203	$6,932	5,995	$7,988	6,846	$9,124	7,473	$9,959	7,473	$9,9
Coal (imports)	371	597	896	1,441	896	1,441	896	1,441	896	1,441	896	1,441	896	1,441	896	1,441	896	1,4
Coal (exports)	1,458	1,732	8,934	10,637	9,952	11,850	10,560	12,574	10,560	12,574	10,560	12,574	10,560	12,574	10,560	12,574	10,560	12,5
TOTAL	5,240	$6,882	13,585	$17,083	15,028	$18,862	15,924	$19,970	16,659	$20,947	17,451	$22,003	18,302	$23,139	18,929	$23,974	18,929	$23,9
									55-Foot Channel Depth									
Iron Ore	3,411	$5,100	3,755	$5,611	4,180	$6,245	4,468	$6,677	5,203	$7,772	5,995	$8,956	6,846	$10,230	7,473	$10,845	7,473	$10,8
Coal (imports)	371	780	896	1,883	896	1,883	896	1,883	896	1,883	896	1,883	896	1,883	896	1,883	896	1,8
Coal (exports)	1,458	2,928	8,934	17,923	9,952	19,973	10,560	21,192	10,560	21,192	10,560	21,192	10,560	21,192	10,560	21,192	10,560	21,1
TOTAL	5,240	$9,808	13,585	$25,422	15,028	$28,101	15,924	$29,752	16,659	$30,847	17,451	$32,031	18,302	$33,305	18,929	$33,920	18,929	$33,9
									60-Foot Channel Depth									
Iron Ore	3,411	$5,315	3,755	$5,846	4,180	$6,507	4,468	$6,957	5,203	$8,097	5,995	$9,332	6,846	$10,658	7,473	$11,634	7,473	$11,6
Coal (imports)	371	900	896	2,175	896	2,175	896	2,175	896	2,175	896	2,175	896	2,175	896	2,175	896	2,1
Coal (exports)	1,458	3,519	8,934	21,534	9,952	23,989	10,560	25,454	10,560	25,454	10,560	25,454	10,560	25,454	10,560	25,454	10,560	25,4
TOTAL	5,240	$9,734	13,585	$29,555	15,028	$32,671	15,924	$34,586	16,659	$35,726	17,451	$36,961	18,302	$38,287	18,929	$39,263	18,929	$39,2

[1] First year of project life.

[2] Does not include tonnage to Japan because there are no benefits for a 45-foot channel depth on this traffic.

TABLE F-57

SUMMARY OF AVERAGE ANNUAL NAVIGATION BENEFITS FOR ALTERNATIVE CHANNEL DEPTHS INVESTIGATED[1]

Type of Commodity	Benefits for varying channels (Depth in feet)			
Commerce through bulk terminals above I-10 tunnels	45	50	55	60
Iron Ore (import)	$2,203,000	$2,971,000	$3,484,000	$3,611,000
Coal (import)	923,000	1,441,000	1,883,000	2,175,000
Sub-Total	$3,126,000	$4,412,000	$5,367,000	$5,786,000
Commerce through bulk terminals in Mobile, below I-10 tunnels				
Iron Ore (import)	$2,570,000	$3,792,000	$4,098,000	$4,290,000
Coal (export)	5,371,000	12,440,000	20,968,000	25,184,000
Sub-Total	$7,941,000	$16,232,000	$25,066,000	$29,474,000
Total Benefits for Mobile	$11,067,000	$20,644,000	$30,433,000	$35,260,000

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[1] Project life 1995-2044 with interest rate of 6-7/8 percent.

184. The accomplishment by local interests of the work described above would involve the cost of dredging material from the nearest available source. These costs are estimated and shown in table F-58.

TABLE F-58

LEAST COSTLY ESTIMATE OF LANDFILL AREA

Dredging	
Dikes (4,000,000 c.y. @ $0.79/c.y.)	$ 3,160,000
Fill (30,630,000 c.y. @ $0.75/c.y.)	22,973,000
Dike Shaping & Dressing	28,000
Waste Weirs	17,000
Revetment	3,734,000
SUB-TOTAL	$29,912,000
Contingencies @ 15%	4,487,000
Engineering & Design @ 3%	1,032,000
Supervision & Administration @ 5%	1,772,000
TOTAL FIRST COST	$37,203,000

The estimated capital value of enhancement, as shown above, would be $37,203,000. This converts to a value of approximately $36,000 per acre which is substantially less than the existing market value of land ($65,000 to $100,000 per acre) in the area. Average annual equivalent benefits over the life of project (50-year @ rate of return of 6-7/8 percent per annum) which includes annual maintenance of $44,000 would be $2,697,000.

185. <u>Supplemental Navigation Benefits</u>. The present channel dimensions would soon create traffic delays due to the indicated traffic not being able to pass unconstrained in the bay channel. Supplemental savings to shippers calling at Mobile would result from widening and deepening the main bay channel. Annual costs for delays were computed and used in Section D to optimize the channel width designs; however, these are not necessary to establish feasibility of the selected plan.

186. Summary of Total Benefits. Average annual equivalent benefits for navigation and land enhancement for each level of development of the Mobile ship channel are summarized in table F-59.

TABLE F-59

SUMMARY OF AVERAGE ANNUAL EQUIVALENT BENEFITS[1]

Project Depth (feet)	Transportation Benefits ($)	Land Enhancement Benefits ($)	Average annual benefits ($) Total	Average annual benefits ($) Incremental
45	11,067,000	1,530,000	12,597,000	-
50	20,644,000	2,002,000	22,646,000	10,049,000
55	30,433,000	2,697,000	33,130,000	10,557,000
60	35,260,000	3,696,000	38,956,000	5,826,000

[1] Benefits based on 6-7/8 percent interest rate and 50-year project life (1995-2044).

SENSITIVITY OF BENEFIT ANALYSIS

187. General. The approach to the benefit analysis in this report is thought to be conservative based on information which became available too recently to incorporate into the report. Also, the conservative assumptions relating to future growth trends result in lower benefits to the project than if more liberal trends were adopted. Information is not available to allow changes at this time in the report. The impact of the assumptions on project benefits, as well as other changes which will be incorporated into later reports, are discussed in the paragraphs that follow.

188. Alternative Source of Japanese Coal. It is expected that approximately 9.7 million tons of coal will be exported through Mobile for the Japanese steel mills in 1986. This will increase to 11.5 million tons by the year 2000 and remain constant thereafter, during the 44 remaining years of the project life. The average annual benefits on this coal that could be

realized by providing a 55-foot channel depth at Mobile would be $10,356,000. If the source of supply was diverted from Mobile where it would be supplied from Australia, Poland, South Africa, etc. the average annual benefits for the 55-foot project would decrease to $20,077,000, giving a BCR of .91.

189. Coal Imports. The base year tonnage for this commodity was accepted as 896,000 tons based on a 10-year contract initiated for the importation of South African coal in 1977. At the time the information was obtained, there was no indication that imports would increase. Therefore, the annual tonnage of 896,000 tons was held constant throughout the period of analysis. Imports of this commodity amounted to about 1,600,000 tons in 1978. Contacts with company officials directly responsible for these imports revealed that the increase in volume was due to spot purchases of coal from Port Kembla, Australia which is located about 50 miles south of Sidney. The officials indicated that, because of the price and quality of the coal, the company's long-term plans are to further increase this import tonnage beginning in 1979. The officials further stated that the most probable method of projecting these imports would be to increase the movements at a decreasing rate of growth throughout project life. The spot purchases of this coal, as well as the availability of only one year's data, was not believed to be sufficient justification for increasing benefits to this commodity. However, if imports continue to increase as stated by the company officials, the report should consider additional benefits based on the increases in these imports. The procedures used to project these movements will be determined if and when the future increases can be supported. The increase from 896,000 tons to 1,600,000 tons without projections would increase the benefits by about $2,500,000 ($3.50 x 704,000) for a 55-foot channel at Mobile. This benefit considers the use of a 36,000 d.w.t. vessel for the existing 40-foot channel and a 110,000 d.w.t. vessel for a modified 55-foot channel. Additional computer runs will be necessary to determine actual benefits.

190. Coal Export Projections. Coal exports were projected to increase at a compound annual growth rate of 1.2 percent from 1975 through 2000 and remain constant thereafter. In order to test the sensitivity of this assumption,

the annual export tonnage was also projected to increase at a compound annual growth rate of 1.2 percent throughout the period of analysis, and alternatively, to increase at 1.2 percent through the year 2000 with a declining rate of growth thereafter, such that, by the end of the period of analysis, the rate of annual growth would be zero. These alternative projections would both increase project benefits, resulting in additional average annual benefits of $2.3 and $1.5 million, respectively, for a 55-foot channel depth. Benefits to other channel depths would show greater increases for deeper channels and smaller increases for the more shallow channel depths under study.

191. Vessel Costs. Vessel operating costs "at sea" and "in port" for foreign vessels are based on January 1977 costs furnished by OCE. With the inflationary increases in fuel, labor, and construction costs, it is unrealistic to assume these costs are representative of costs being incurred at this time. However, there is no acceptable procedure at this time which will allow updating of these costs. Any increase in these costs would result in increases in benefits to most commodity movements.

192. Traffic Delays. Under existing conditions, vessels will soon encounter delays because of traffic congestion. Modification of the width and depth of the channel will reduce or eliminate these delays. Annual costs (benefits) for these delays have been computed and are shown in Section D; however, benefits have not been included in the recommended plan since they are not necessary to establish feasibility.

SUMMARY OF ECONOMIC ANALYSIS

193. The estimated annual charges, the estimated annual benefits, and the ratios of benefits to charges summarized in table F-60 indicate that the proposed plan of imporvement to provide a 55-foot main bay channel and entrance channel to Mobile Harbor is economically justified.

TABLE F-60

SUMMARY OF ECONOMIC ANALYSIS

Project Depth (feet)	Annual Charges ($)	Annual Benefits ($)	Net Benefits ($)	BCR
45	9,195,000	12,597,000	3,402,000	1.4
50	15,252,000	22,646,000	7,394,000	1.5
55	22,028,000	33,130,000	11,102,000	1.5
60	34,435,000	38,956,000	4,521,000	1.1

AVERAGE ANNUAL BENEFITS AND CHARGES AT 7-1/8 PERCENT INTEREST RATE

194. The average annual equivalent benefits based on an interest rate of 7-1/8 percent for each commodity that would benefit by the project for the various channel depths considered is presented in table F-61.

195. Average annual equivalent benefits for navigation and land enhancement for each level of development of Mobile ship channel based on an interest rate of 7-1/8 percent are summarized in table F-62.

196. The estimated annual charges, benefits and ratios of benefits to charges, based on an interest rate of 7-1/8 percent is summarized in table F-63.

197. The change in interest rate from 6-7/8 to 7-1/8 percent did not significantly affect the BCR. For the recommended 55-foot channel, the annual charges increased from $22,028,000 to $22,833,000 and the benefits increased from $33,130,000 to $33,159,000. The BCR remained at 1.5.

TABLE F-61

SUMMARY OF AVERAGE ANNUAL NAVIGATION BENEFITS FOR ALTERNATIVE CHANNEL DEPTHS INVESTIGATED[1]

Type of Commodity	Benefits for varying channels (Depth in feet)			
Commerce through bulk terminals above I-10 tunnels	45	50	55	60
Iron Ore (import)	$2,193,000	$2,956,000	$3,452,000	$3,592,000
Coal (import)	923,000	1,441,000	1,883,000	2,175,000
Sub-Total	$3,116,000	$4,397,000	$5,335,000	$5,767,000
Commerce through bulk terminals in Mobile, below I-10 tunnels				
Iron Ore (import)	$2,558,000	$3,775,000	$4,081,000	$4,271,000
Coal (export)	5,369,000	12,436,000	20,961,000	25,177,000
Sub-Total	$7,927,000	$16,211,000	$25,042,000	$29,448,000
Total Benefits for Mobile	$11,043,000	$20,608,000	$30,377,000	$35,215,000

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[1] Project life 1995-2044 with interest rate of 7-1/8 percent.

TABLE F-62

SUMMARY OF AVERAGE ANNUAL EQUIVALENT BENEFITS[1]

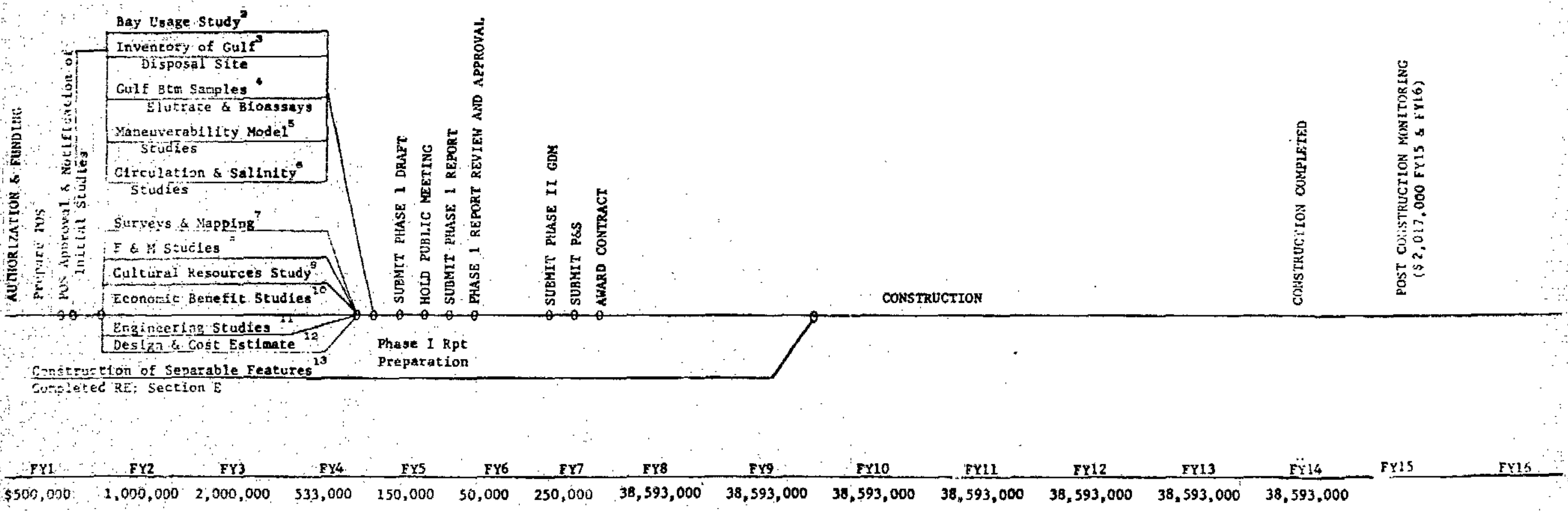
Project Depth (feet)	Transportation Benefits ($)	Land Enhancement Benefits ($)	Average Annual Benefits ($)	
			Total	Incremental
45	11,043,000	1,578,000	12,621,000	-
50	20,608,000	2,065,000	22,673,000	10,052,000
55	30,377,000	2,782,000	33,159,000	10,486,000
60	35,215,000	3,813,000	39,028,000	5,869,000

[1] Benefits based on 7-1/8 percent interest rate and 50-year project life (1995-2044).

TABLE F-63

SUMMARY OF ECONOMIC ANALYSIS

Project Depth (feet)	Annual Charges ($)	Annual Benefits ($)	Net Benefits ($)	BCR
45	9,419,000	12,621,000	3,202,000	1.3
50	15,873,000	22,673,000	6,800,000	1.4
55	22,833,000	33,159,000	10,326,000	1.5
60	35,524,000	39,028,000	3,504,000	1.1



1. Construction
E&D (Monitoring)
S&A

2. $ 200,000
3. $ 500,000
4. $1,450,000
5. $ 200,000
6. $ 500,000
7. $ 300,000

8. $500,000
9. $ 50,000
10. $100,000
11. $100,000
12. $100,000
13. Upper Harbor Channel Widening
Passing Lane
Brookley Expansion Area
Mitigation Measures
Turning and Anchorage Basins

SURVEY REPORT
ON
MOBILE HARBOR ALABAMA
CPM FOR
AE&D AND CONSTRUCTION

Appendix 5

PLATE F-1

ATTACHMENT F-1

COMPUTER PROGRAM

DEEP-DRAFT BENEFITS

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MOBILE HARBOR.AL SHIP CHANNEL   WITH EXISTING CHANNEL DEPTH OF 40 FEET
CHANNEL 40 TO 60 FT DRY BULK SHIP-FOR.FLAG- 50% UTILIZED 1 JAN. 1977  331986 R
 1986 1995       20442915.0
  364  292  811  101  15000  194
  378  292  914  101  17000  177
  401  309 1017  102  20000  222
  427  327 1120  103  23000  245
  455  345 1224  104  26000  282
  483  363 1327  105  29000  306
  509  379 1430  106  32000  334
  540  399 1533  107  36000  247
  558  411 1630  108  39000  151
  577  424 1739  109  43000  105
  596  436 1842  110  47000   96
  619  451 1945  112  52000   83
  645  465 2048  113  56000   89
  667  483 2151  114  61000   92
  700  495 2254  116  65000   86
  721  507 2357  117  70000   80
  738  518 2460  118  75000   62
  760  533 2563  120  81000   40
  783  549 2666  122  86000   29
  814  572 2769  124  92000   30
  845  594 2872  125  98000   31
  873  614 2975  127 104000   31
  898  631 3078  129 110000   31
  923  648 3181  131 117000   28
  942  661 3284  133 123000   25
  962  673 3387  135 130000   24
  980  685 3490  137 137000   22
  998  696 3593  139 144000   20
 1015  706 3696  141 151000   21
 1109  753 3800  143 159000   19
 1142  758 3902  145 166000   15
 1151  745 4005  146 174000   10
 1219  793 4109  150 182000    3
 IRON ORE(IMP)  W15000
 4320   2562956AQUE-TO ORE27.VENZ SA TCI TERM MOBILE AL  50% UTILIZATION
[illegible]99999999999999999999999999999999999999
 IRON ORE(IMP) AL15000
 5200    1464PORT CARTIER QUE.CAN  50% UTILIZATION
[illegible]999999999999999999999999999999999
 IRON ORE (IMP) [illegible]
 [illegible]  [illegible] VIT RIA BRAZIL.SA  50% UTILIZATION
[illegible]99999999999999999999999
[illegible]9999999999999999
A 5744 [illegible]
 [illegible]
 [illegible] 19606
 [illegible] 2736 2744
[illegible] 19520 19900
 [illegible] 2735 2744
[illegible] 19990
[illegible] COMPOSITE OF EARNINGS IN PRIMARY METALS FOR U.S.
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AND BEA 045 AND AN INDEX OF U.S. PRODUCTION OF IRON AND STEEL. APPLICABLE
ON IRON ORE FROM PUERTO ORDAZ.VENZ.S.A.
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AL=SAME AS M EXCEPT APPLICABLE ON IRON ORE IMPORTS FROM PORT CARTIER
  QUBEC.CANADA.
====
====
====
AM= SAME AS M EXCEPT APPLICABLE ON IRON ORE IMPORTS FROM VITORIA(TUBARO)
  BRAZIL.SA.
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MOBILE HARBOR.AL SHIP CHANNEL   WITH EXISTING CHANNEL DEPTH OF 40 FEET   1/10/78

WEIGHTED AVERAGE CAPABILITY OF VESSELS IN DRY BULK SHIP-FOR.FLAG- 50% UTILIZED

FLEET SIZE (DWT)	NUMBER OF VESSELS IN FLEET	PAYLOAD PER VESSEL (SHORT TONS)	CAPABILITY FACTOR- TOTAL PAYLOAD (SHORT TONS)
15000.	194.	16128.	3128832.
17000.	177.	18278.	3235277.
20000.	222.	21504.	4773888.
23000.	245.	24730.	6058752.
26000.	282.	27955.	7883366.
29000.	306.	31181.	9541325.
32000.	334.	34406.	11491737.
36000.	247.	38707.	9560678.
39000.	151.	41933.	6331853.
43000.	105.	46234.	4854528.
47000.	90.	50534.	4548096.
52000.	83.	55910.	4640563.
56000.	89.	60211.	5358797.
61000.	92.	65587.	6034022.
65000.	86.	69888.	6010368.
70000.	80.	75264.	6021120.
75000.	62.	80640.	4999680.
81000.	40.	87091.	3483648.
86000.	29.	92467.	2681549.
92000.	30.	98918.	2967552.
98000.	31.	105370.	3266458.
104000.	31.	111821.	3466445.
110000.	31.	118272.	3666432.
117000.	28.	125798.	3522355.
123000.	25.	132250.	3306240.
130000.	24.	139776.	3354624.
137000.	22.	147302.	3240653.
144000.	20.	154829.	3096576.
151000.	21.	162355.	3409459.
159000.	19.	170957.	3248179.
166000.	15.	178483.	2677248.
174000.	10.	187085.	1870848.
182000.	3.	195686.	587059.
TOTAL	3224.	2967552.	152318180.

MOBILE HARBOR,AL SHIP CHANNEL WITH EXISTING CHANNEL DEPTH OF 40 FEET 1/10/78

VESSEL SIZE (DWT)	DRAFT (FT)	TRAVEL TIME (HRS)	HOURLY SEA COST ($)	PORT TIME (HRS)	HOURLY PORT COST ($)	TOTAL VESSEL OPERATING COSTS ($)	IMMERSION FACTOR TON/FT	NET-TON COSTS (DOLLARS) FULL LOAD	LIGHT-LOADED BY 1-FT	2-FT	3-FT	4-FT	5-FT
15000	29	288	364	101	282	133314.	811	8.27	8.71	9.20	9.74	10.35	11.05
17000	30	288	378	101	292	138256.	914	7.57	7.97	8.42	8.91	9.47	10.10
20000	31	288	401	102	309	147006.	1017	6.84	7.13	7.56	7.97	8.44	9.04
23000	32	288	427	103	327	156667.	1120	6.34	6.64	6.97	7.34	7.74	8.19
26000	33	288	455	104	345	166520.	1224	5.98	6.25	6.55	6.88	7.24	7.65
29000	34	288	483	105	363	177219.	1327	5.69	5.94	6.22	6.52	6.85	7.22
32000	35	288	509	106	379	186766.	1430	5.43	5.67	5.93	6.21	6.52	6.86
36000	36	288	540	107	395	198213.	1533	5.13	5.34	5.57	5.82	6.09	6.39
39000	37	288	554	108	411	205092.	1630	4.90	5.09	5.31	5.54	5.80	6.09
43000	38	288	577	109	424	212392.	1739	4.60	4.78	4.97	5.18	5.41	5.66
47000	39	288	594	110	436	219032.	1842	4.34	4.50	4.68	4.87	5.08	5.31
52000	40	288	619	112	451	228784.	1945	4.10	4.24	4.40	4.57	4.75	4.96
56000	41	288	645	113	465	238305.	2048	3.95	4.10	4.25	4.41	4.59	4.77
61000	42	288	667	114	483	247158.	2151	3.77	3.90	4.04	4.18	4.34	4.51
65000	43	288	700	116	495	259020.	2254	3.71	3.83	3.97	4.11	4.26	4.42
70000	44	288	721	117	507	266967.	2357	3.55	3.67	3.79	3.92	4.05	4.21
75000	45	288	738	118	518	273665.	2460	3.40	3.51	3.62	3.74	3.87	4.01
81000	46	288	760	120	533	282640.	2563	3.25	3.35	3.46	3.57	3.69	3.81
86000	47	288	783	122	549	292482.	2666	3.17	3.26	3.36	3.47	3.59	3.70
92000	48	288	814	124	572	305360.	2769	3.09	3.18	3.28	3.37	3.48	3.59
98000	49	288	845	125	594	317610.	2872	3.02	3.10	3.19	3.29	3.39	3.49
104000	50	288	873	127	614	329402.	2975	2.95	3.03	3.12	3.21	3.30	3.40
110000	51	288	898	129	631	340023.	3078	2.88	2.96	3.04	3.12	3.21	3.31
117000	52	288	923	131	649	350712.	3181	2.79	2.87	2.94	3.02	3.11	3.20
123000	53	288	942	133	661	359209.	3284	2.72	2.79	2.86	2.94	3.02	3.11
130000	54	288	962	135	673	367911.	3387	2.64	2.70	2.77	2.84	2.92	3.00
137000	55	288	980	137	685	376055.	3490	2.56	2.62	2.69	2.75	2.83	2.90
144000	56	288	998	139	696	384168.	3593	2.49	2.55	2.61	2.67	2.74	2.81
151000	57	288	1015	141	706	391966.	3696	2.42	2.47	2.53	2.60	2.66	2.73
159000	58	288	1109	143	753	427071.	3800	2.50	2.56	2.62	2.68	2.75	2.82
166000	59	288	1142	145	759	438806.	3902	2.46	2.52	2.58	2.64	2.70	2.77
174000	60	288	1181	148	765	453348.	4006	2.43	2.48	2.54	2.59	2.66	2.72
182000	61	288	1219	150	783	468522.	4109	2.40	2.45	2.50	2.56	2.62	2.69

COMMODITY IRON ORE(IMP)
DRY BULK SHIP-FOR.FLAG- 50% UTILIZED
VESSEL SPEED 15.0 KNOTS
WEIGHTED AVERAGE DISTANCE OF HAUL 4320NAUTICAL MILES

[illegible] WITH EXISTING CHANNEL DEPTH OF 40 FEET 7/10/78

VESSEL SIZE (DWT)	VESSEL DRAFT (FT)	TRAVEL TIME (HRS)	HOURLY SEA COST ($)	PORT TIME (HRS)	HOURLY PORT COST ($)	TOTAL VESSEL OPERATING COSTS ($)	IMMERSION FACTOR TON/FT	NET-TON COSTS (DOLLARS) FULL LOAD	LIGHT-LOADED BY 1-FT	2-FT	3-FT	4-FT	5-FT
15000	29	347	364	101	282	154669.	811	9.50	10.10	10.67	11.30	12.01	12.82
17000	30	347	378	101	292	160532.	914	8.79	9.25	9.76	10.34	10.98	11.72
20000	31	347	401	102	309	170531.	1017	7.94	8.33	8.76	9.25	9.79	10.39
23000	32	347	427	103	327	181708.	1120	7.35	7.70	8.08	8.51	8.98	9.50
26000	33	347	455	104	345	193613.	1224	6.93	7.25	7.60	7.98	8.40	8.87
29000	34	347	483	105	363	205555.	1327	6.60	6.89	7.21	7.56	7.95	8.38
32000	35	347	509	106	379	216627.	1430	6.30	6.57	6.87	7.20	7.56	7.95
36000	36	347	540	107	399	229893.	1533	5.94	6.19	6.46	6.75	7.06	7.41
39000	37	347	558	108	411	237828.	1630	5.69	5.91	6.15	6.43	6.72	7.04
43000	38	347	577	109	424	246243.	1739	5.33	5.54	5.76	6.01	6.27	6.56
47000	39	347	594	110	436	253800.	1842	5.03	5.22	5.42	5.65	5.89	6.15
52000	40	347	619	112	451	265099.	1945	4.75	4.92	5.10	5.30	5.51	5.74
56000	41	347	645	113	465	276145.	2048	4.59	4.75	4.93	5.11	5.31	5.53
61000	42	347	667	114	483	286289.	2151	4.37	4.52	4.68	4.85	5.03	5.23
65000	43	347	700	116	495	300087.	2254	4.30	4.44	4.59	4.76	4.93	5.12
70000	44	347	721	117	507	309266.	2357	4.11	4.25	4.39	4.54	4.70	4.88
75000	45	347	738	118	518	316944.	2460	3.94	4.06	4.19	4.33	4.48	4.64
81000	46	347	760	120	533	327427.	2563	3.76	3.88	4.00	4.13	4.27	4.41
86000	47	347	783	122	549	338418.	2666	3.66	3.77	3.89	4.01	4.14	4.28
92000	48	347	814	124	572	353115.	2769	3.57	3.68	3.79	3.90	4.02	4.16
98000	49	347	845	125	594	367183.	2872	3.49	3.59	3.69	3.80	3.92	4.04
104000	50	347	873	127	616	380618.	2975	3.41	3.50	3.60	3.70	3.81	3.93
110000	51	347	898	129	631	392706.	3078	3.33	3.41	3.51	3.61	3.71	3.82
117000	52	347	923	131	648	404861.	3181	3.22	3.31	3.39	3.49	3.59	3.69
123000	53	347	942	133	661	414473.	3284	3.14	3.22	3.30	3.39	3.48	3.58
130000	54	347	962	135	673	424348.	3387	3.04	3.12	3.20	3.28	3.37	3.46
137000	55	347	980	137	685	433578.	3490	2.95	3.02	3.09	3.17	3.26	3.34
144000	56	347	998	139	696	442717.	3593	2.86	2.93	3.00	3.08	3.16	3.24
151000	57	347	1015	141	706	451413.	3696	2.79	2.85	2.92	2.99	3.06	3.14
159000	58	347	1109	143	753	492132.	3800	2.88	2.95	3.02	3.09	3.16	3.24
166000	59	347	1142	145	758	505803.	3902	2.84	2.90	2.97	3.04	3.1.	3.19
174000	60	347	1181	148	765	522633.	4006	2.80	2.86	2.92	2.99	3.06	3.13
182000	61	347	1219	150	783	540037.	4109	2.76	2.82	2.89	2.95	3.02	3.09

COMMODITY IRON ORE(IMP)
DRY BULK SHIP-FOR.FLAG- 50% UTILIZED
VESSEL SPEED 15.0 KNOTS
WEIGHTED AVERAGE DISTANCE OF HAUL 5200NAUTICAL MILES

MOBILE HARBOR,AL SHIP CHANNEL   WITH EXISTING CHANNEL DEPTH OF 40 FEET   1/10/78

VESSEL SIZE (DWT)	DRAFT (FT)	TRAVEL TIME (HRS)	HOURLY SEA COST ($)	PORT TIME (HRS)	HOURLY PORT COST ($)	TOTAL VESSEL OPERATING COSTS ($)	IMMERSION FACTOR TON/FT	NET-TON COSTS (DOLLARS)					
								FULL LOAD	LIGHT-LOADED BY 1-FT	2-FT	3-FT	4-FT	5-FT
15000	29	638	364	101	282	260665.	811	16.17	17.02	17.97	19.04	20.24	21.60
17000	30	638	378	101	292	270606.	914	14.81	15.59	16.45	17.42	18.51	19.75
20000	31	638	401	102	309	287303.	1017	13.37	14.03	14.75	15.57	16.48	17.50
23000	32	638	427	103	327	306050.	1120	12.38	12.97	13.61	14.33	15.12	15.00
26000	33	638	455	104	345	326109.	1224	11.67	12.20	12.79	13.43	14.15	14.94
29000	34	638	483	105	363	345205.	1327	11.11	11.60	12.14	12.73	13.39	14.11
32000	35	638	509	106	379	364646.	1430	10.61	11.07	11.57	12.12	12.72	13.39
36000	36	638	540	107	399	387141.	1533	10.01	10.42	10.87	11.36	11.89	12.48
39000	37	638	554	108	411	4[illegible]316.	1630	9.55	9.94	10.36	10.81	11.31	11.85
43000	38	638	577	109	424	41[illegible]265.	1739	8.97	9.32	9.69	10.10	10.55	11.04
47000	39	638	594	110	436	[illegible]6853.	1842	8.45	8.77	9.12	9.49	9.89	10.33
52000	40	638	619	112	451	445351.	1945	7.97	8.26	8.57	8.90	9.26	9.65
56000	41	638	645	113	465	463969.	2048	7.71	7.98	8.27	8.59	8.92	9.29
61000	42	638	667	114	483	48[illegible]519.	2151	7.33	7.58	7.85	8.13	8.44	8.77
65000	43	638	700	116	495	503927.	2254	7.22	7.46	7.71	7.99	8.28	8.60
70000	44	638	721	117	507	519221.	2357	6.90	7.13	7.36	7.62	7.89	8.18
75000	45	638	738	118	518	531870.	2460	6.60	6.81	7.03	7.27	7.52	7.79
81000	46	638	760	120	533	548739.	2563	6.31	6.50	6.70	6.92	7.15	7.39
86000	47	638	783	122	549	566428.	2666	6.13	6.31	6.51	6.71	6.93	7.16
92000	48	638	814	124	572	590151.	2769	5.97	6.14	6.32	6.52	6.72	6.94
98000	49	638	845	125	594	613247.	2872	5.82	5.99	6.16	6.34	6.54	6.74
104000	50	638	873	127	614	634536.	2975	5.68	5.84	6.00	6.17	6.35	6.55
110000	51	638	898	129	631	654203.	3078	5.54	5.68	5.84	6.00	6.18	6.36
117000	52	638	923	131	648	673639.	3181	5.35	5.50	5.65	5.80	5.96	6.13
123000	53	638	942	133	661	688783.	3284	5.21	5.35	5.49	5.63	5.79	5.95
130000	54	638	962	135	673	704483.	3387	5.05	5.17	5.30	5.44	5.59	5.74
137000	55	638	980	137	685	718694.	3490	4.89	5.00	5.13	5.26	5.40	5.54
144000	56	638	998	139	696	733335.	3593	4.74	4.85	4.97	5.10	5.23	5.36
151000	57	638	1015	141	706	746981.	3696	4.61	4.71	4.83	4.94	5.07	5.20
159000	58	638	1109	143	753	815073.	3800	4.77	4.88	4.99	5.11	5.24	5.37
166000	59	638	1142	145	758	838354.	3902	4.70	4.81	4.92	5.03	5.15	5.28
174000	60	638	1181	148	765	866541.	4005	4.64	4.74	4.84	4.95	5.07	5.19
182000	61	638	1219	150	783	895004.	4108	4.58	4.68	4.78	4.89	5.00	5.12

COMMODITY   IRON ORE(IMP)
DRY BULK SHIP-FOR.FLAG- 50% UTILIZED
VESSEL SPEED 15.0 KNOTS
WEIGHTED AVERAGE DISTANCE OF HAUL   9568NAUTICAL MILES

MOBILE HARBOR,AL SHIP CHANNEL   WITH EXISTING CHANNEL DEPTH OF 40 FEET   1/10/78

SUMMARY OF NET-TON COST FOR DRY BULK SHIP-FOR.FLAG- 50% UTILIZED

NAME OF COMMODITY	40-FT	41-FT	42-FT	43-FT	44-FT	45-FT	46-FT	47-FT	48-FT	49-FT	50-FT	51-FT	52-FT	53-FT	54-FT	55-FT
IRON ORE(IMP)	5.66	5.52	5.40	5.29	5.19	5.11	5.04	4.98	4.92	4.86	4.80	4.74	4.69	4.64	4.59	4.54
IRON ORE(IMP)	6.56	6.40	6.27	6.13	6.01	5.92	5.84	5.77	5.70	5.63	5.56	5.50	5.43	5.37	5.31	5.26
IRON ORE(IMP)	11.04	10.77	10.54	10.32	10.12	9.96	9.83	9.71	9.58	9.47	9.35	9.24	9.13	9.03	8.93	8.83

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                    MOBILE HARBOR,AL SHIP CHANNEL   WITH EXISTING CHANNEL DEPTH OF 40 FEET        1/10/78

                               SUMMARY OF NET-TON COST FOR DRY BULK SHIP-FOR.FLAG- 50% UTILIZED
                               ****************************************************************
NAME OF
COMMODITY            56-FT  57-FT  58-FT  59-FT  60-FT

 IRON ORE(IMP)       4.49   4.44   4.40   4.38   4.36

 IRON ORE(IMP)       5.20   5.15   5.10   5.07   5.06

 IRON ORE(IMP)       8.73   8.64   8.57   8.51   8.49
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SECTION G

DIVISION OF PLAN RESPONSIBILITIES

SECTION G

DIVISION OF PLAN RESPONSIBILITIES

1. Responsibility for development of the selected plan is divided between Federal and non-Federal interests in accordance with established policy and guidelines. The Federal government may construct or improve channels and harbors to meet the requirements of shipping, while non-Federal interests are responsible for terminal facilities, berthing areas, certain other components, and specified items of local cooperation.

2. The United States would design and prepare detailed plans, dredge the improved gulf and bay channels and turning and anchorage basins, and maintain the improvement to project dimensions, after Congressional authorization and funding.

3. Local interests would provide all lands, easements and rights-of-way; all relocations and alterations of utilities; all retaining works and stabilization measures required for disposal of dredged material; and depths in all berthing areas commensurate with those provided in related project areas.

4. Total average annual benefits for the 55-foot selected plan are evaluated at $33,130,000 including $30,433,000 navigation benefits and $2,697,000 land enhancement benefits. Navigation benefits are considered to be of a general nature and land enhancement is considered local. The benefits are summarized and allocated in table G-1.

TABLE G-1

ALLOCATION OF BENEFITS

Type of Benefit	Average Annual Value Total	General	Local
Navigation	$30,433,000	$30,433,000	-
Land Enhancement	$ 2,697,000	-	$2.697,000
Total	$33,130,000	$30,433,000	$2,697,000
Percent	100	91.9	8.1

5. The first cost of general navigation facilities for the selected 55-foot channel plan considered herein for the Mobile segment, excluding navigation aids, is to be borne jointly by the United States and local interests. The apportionment is based on the ratios of "general" to "local benefits". According to the ratio of general to local benefits derived heretofore, 91.9 percent of the first cost of general navigation facilities would be borne by the Corps of Engineers and 8.1 percent by local interests.

6. The President, in his June 1978 water policy message to Congress, proposed several changes in cost-sharing for water resources projects to allow states to participate more actively in project implementation decisions. These changes include a cash contribution from benefiting states of 5 percent of first costs of construction assigned to nonvendible project purposes and 10 percent of costs assigned to vendible project purposes.

7. Application of this policy to the Mobile Harbor project requires a contribution from the state of Alabama of an estimated $14,232,000 in cash (5 percent of $284,635,000 total estimated project first costs

assigned to nonvendible project purposes, based on 1978 price levels). Other items of local cooperation would not be affected by this additional requirement. I recommend construction authorization for the selected plan in accordance with the President's proposed cost-sharing policy. The allocation of financial first cost between Federal and non-Federal interests is shown in table G-2.

TABLE G-2

APPORTIONMENT OF FIRST COST
(OCT. '78 PRICE LEVEL)

Federal first cost	
Corps of Engineers (91.9% of $276,653,000)	$254,244,000
U.S. Coast Guard (Aids to navigation)	93,000
Non-Federal Cash Contribution	-14,232,000
Total Federal First Cost	$ 240,105,000
Non-Federal first cost	
Cash contribution (8.1% of $276,653,000)	$22,409,000
Dredging and Dike Construction	$ 7,889,000
Cash Contribution (5% of $284,635,000)	14,232,000
Total non-Federal First Cost	44,530,000
Total Project First Cost	$284,635,000

8. The presently estimated additional Federal annual maintenance is $1,424,000 which includes annual costs to the U.S. Coast Guard of $4,000 for maintenance of navigation aids. The estimated non-Federal average annual maintenance is $304,000.