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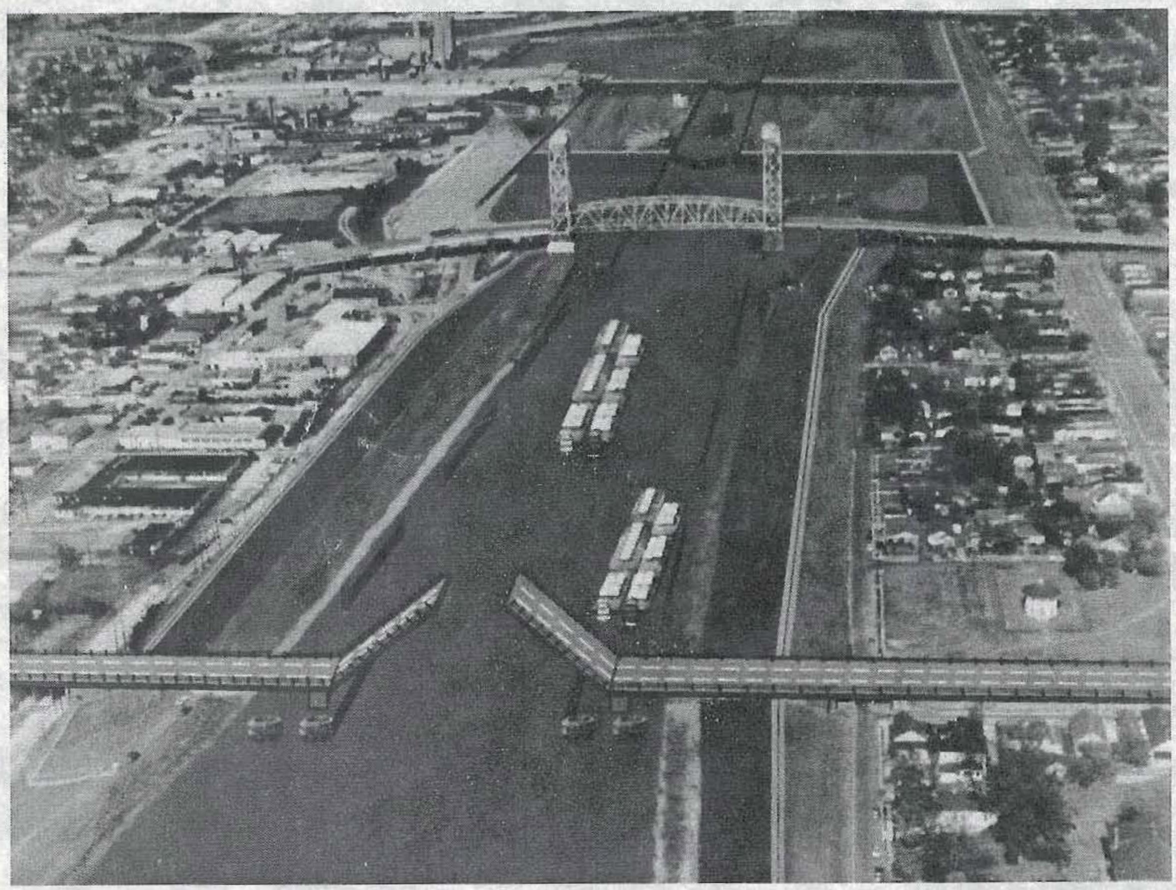
Project Management

Mississippi River - Gulf Outlet

New Lock and Connecting Channels



Evaluation Report

Economic Analysis

Volume 7 of 9

Appendix E

March 1997

MISSISSIPPI RIVER - GULF OUTLET

NEW LOCK

AND

CONNECTING CHANNELS

APPENDIX E

ECONOMIC ANALYSIS

IHNC LOCK REPLACEMENT STUDY
ECONOMICS APPENDIX

SECTION 1 - DESCRIPTION OF PROJECT SETTING

The Inner Harbor Navigation Canal (IHNC) and the IHNC Lock were built during the early 1920's. The canal and lock, which are also known as the Industrial Canal and Lock, intersect the Mississippi River at mile 93 above Head of Passes (AHP). They originally connected only Lake Pontchartrain and the river, and were built by the Board of Port Commissioners of Louisiana (now known as the Board of Commissioners of the Port of New Orleans or Dock Board) in response to a need for more port areas to handle increased water traffic in the port. The canal was initially built 200 feet wide and 20 feet deep with approximately 1,000 feet of land on each side of the canal to be used for port and industrial development. The lock was built to dimensions of 640 by 75 by 31.5 feet. Currently, the land on both sides of the canal is fully developed and devoted to industrial use. During World War II, the Federal Government rerouted the Gulf Intracoastal Waterway (GIWW) so that the IHNC lock connected the eastern and western sections of the GIWW, creating a more direct route to locations on the eastern gulf coast. Concurrent with the relocation of the GIWW-East, the Federal Government leased the IHNC lock and assumed its maintenance and operation. The lock was subsequently purchased by the Federal Government in 1986.

During three decades following construction of the IHNC, the Port of New Orleans continued to experience growth and ultimately congestion in the existing port area and entrances to the port. In 1956 Congress authorized construction of the Mississippi River-Gulf Outlet (MR-GO) to provide a tidewater channel to new harbor facilities that would supplement the existing port facilities as well as an alternate route to the Gulf of Mexico for oceangoing vessels. Intersecting the IHNC about 2.1 miles north of its intersection with the Mississippi River, the MR-GO was completed in 1967 with project dimensions of 500 feet wide by 36 feet deep. The distance to the Gulf of Mexico from the IHNC lock is about 70 miles, or about 50 miles shorter than the 45-foot depth route to the gulf via the Mississippi River. The provision of direct deep water access to the "Tidewater Port", as it came to be called, allowed the port to enter the era of containerization with competitive strengths that would not have been attainable if only the Mississippi River had been available. Containership operations were better suited to the Tidewater Port where the obstructions to efficient container handling presented by levees are not present.

The period following World War II also saw a period of rapid growth in traffic in the nation's inland waterways system as public sector investment in improved waterways and private sector investment in more efficient technology enhanced the competitive advantage of water transportation. Always a dominant transportation alternative along the gulf coast, inland water transport in the New Orleans area grew rapidly.

The GIWW, of which the IHNC is a crucial link, also grew rapidly during this period. The GIWW traces the U.S. coast along the Gulf of Mexico from Apalachee Bay near St. Marks, Florida, to the Mexican border at Brownsville, Texas. Mile 0.0 of the GIWW intersects the Mississippi River at mile 98.2 (AHP), the location of Harvey Lock, and extends eastwardly for approximately 376 miles and westwardly for approximately 690 miles. In addition to the mainstem, the GIWW includes a major alternate channel, 64 miles long, which connects Morgan City, Louisiana to Port Allen, Louisiana at Mississippi River mile 227.6 AHP, and a parallel mainstem channel, 9.0 miles long, which joins the Mississippi River at mile 88.0 AHP, the location of Algiers Lock, to the mainstem at GIWW West mile 6.2. Project dimensions for the mainstem channel and the alternate route are 12 feet deep and 125 feet wide, except for the 150 foot width between the Mississippi River and Mobile Bay portion of the GIWW East. Numerous side channels and tributaries intersect both the eastern and western mainstem channels providing access to inland areas and coastal harbors.

There are five primary GIWW navigation locks on the mainstem west: Algiers, Harvey, Bayou Boeuf, Leland Bowman, and Calcasieu, with Port Allen and Bayou Sorrel on the GIWW Morgan City-Port Allen Alternate Route. West of Calcasieu lock, the westernmost lock identified above, there are four additional navigation structures. These include the East and West Brazos River Floodgates located at GIWW West mile 404.1, and the East and West Colorado River Locks located at GIWW West mile 444.8. There are no navigation structures on the GIWW east of the IHNC lock. Table 1 - 1 describes the physical characteristics and locations of the primary GIWW locks and Figure 1 - 1 maps the area that includes these locks.

Table 1 - 1

System Physical Description of GIWW Locks

Waterway/Lock	GIWW Mile	Miss. River Mile	Length (Feet)	Width (Feet)	Sill Depth (Feet)	Lift (Feet)	Year Opened
GIWW East							
IHNC	0	92.6	640	75	31.5	17	1923
GIWW West							
Algiers	0	88.0	760	75	13	18	1956
Harvey	0	98.2	425	75	12	20	1935
Bayou Boeuf	93.3	n.a.	1156	75	13	11	1954
Leland Bowman	162.7	n.a.	1200	110	15	5	1985
Calcasieu	238.9	n.a.	1206	75	13	4	1950
GIWW Alt. Route M.C. - P.A.							
Port Allen	64.1	227.6	1202	84	14	45	1961
Bayou Sorrel	36.7	n.a.	797	56	14	21	1952

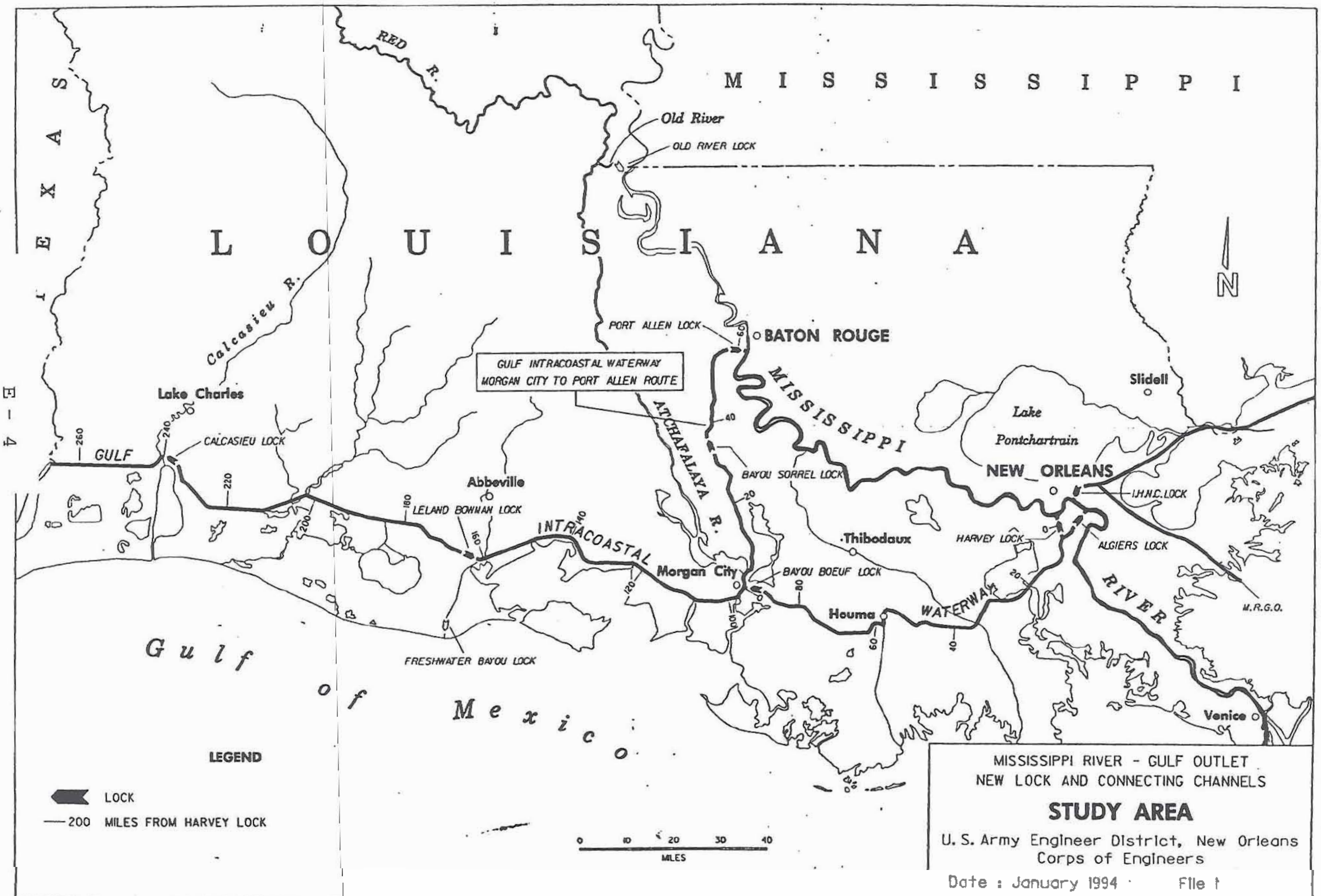


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FIGURE 1-1.

SECTION 2 - EXISTING, HISTORICAL AND PROJECTED TRAFFIC

EXISTING AND HISTORICAL SHALLOW DRAFT TRAFFIC

IHNC LOCK TRAFFIC AND FLOW PATTERNS

Table 2 - 1 displays the distribution of 1989 IHNC Lock traffic by ten major commodity groups and the general direction of the traffic flows. Tables 2 - 2 through 2 - 4 show the distribution of traffic by seven origin and destination regions with each region further broken down by the ten commodity groups. The mapping of this ten commodity group scheme with the 4-digit Waterborne Commerce Statistics Center (WCSC) commodity codes and the Lock Performance Monitoring System (LPMS) commodity codes is shown in table 2 - 5.

As table 2 - 1 shows, approximately 67 percent of the total traffic that moved through the IHNC lock in 1989 consisted of movements with an origin/destination north (the Mississippi River at New Orleans and all waterway system points above) and east of the lock, dominated by coal, and to a lesser extent, petroleum products. The remaining 33 percent of the traffic had an origin/ destination east and west of the lock, comprised mostly of petroleum products, crude petroleum, industrial chemicals and non-metallic minerals. The two largest origin regions, as displayed in table 2 - 2, the GIWW East (West of Mobile) and Ohio River & Tribs, represent 36 and 29 percent of total traffic, respectively. As table 2 - 3 indicates, the commodities that make up the bulk of the traffic volume for the GIWW East region are petroleum products and crude petroleum, while coal dominates the commodities that make up the Ohio River and Tribs origin region.

From the destination perspective, the two GIWW East regions, GIWW East (West of Mobile) and GIWW East (Mobile & East of Mobile) are the two largest regions, representing 33 and 29 percent, respectively, of total traffic. As table 2 - 4 indicates, crude petroleum, coal and petroleum products represent the bulk of GIWW East (West of Mobile) destinations, while coal, and to a lesser extent, petroleum products, dominate the commodities destined for the GIWW East (Mobile & East of Mobile) region.

Table 2 - 6 summarizes IHNC shallow-draft activity for the years 1984 through 1992. Displayed are traffic volumes and average delay per tow estimates.

Table 2 - 1

Commodity Distribution and Flow Pattern for 1989 IHNC Lock Traffic

Commodity Group	Total IHNC Traffic (Tons)	% Of Total Traffic	North/East Traffic (Tons)	% of North/East Traffic	West/East Traffic (Tons)	% of West/East Traffic
Farm Products	498,998	1.9%	480,667	2.8%	18,331	0.2%
Metallic Ores	1,383,955	5.4%	1,237,311	7.2%	146,644	1.7%
Coal	7,438,121	29.0%	7,438,121	43.2%	0	0.0%
Crude Petroleum	3,460,396	13.5%	976,610	5.7%	2,483,787	29.4%
Non-Metallic Minerals	1,443,020	5.6%	869,682	5.1%	573,338	6.8%
Forest Products	160,901	0.6%	159,883	0.9%	1,018	0.0%
Industrial Chemicals	1,598,829	6.2%	1,040,767	6.1%	558,063	6.6%
Agricultural Chemicals	542,787	2.1%	501,034	2.9%	41,753	0.5%
Petroleum Products	7,500,241	29.2%	3,359,578	19.5%	4,140,663	49.0%
All Others	1,619,197	6.3%	1,134,456	6.6%	484,741	5.7%
Total	25,646,445	100%	17,198,109	100%	8,448,338	100%

Source: Waterborne Commerce Of The United States.

Table 2 - 2

1989 IHNC Lock Tonnage
By Origin And Destination Regions

Origin Region	Tons	% Of Total
Upper Mississippi & Missouri	502,395	2.0%
Lower Mississippi	2,733,893	10.7%
Ohio River & Tribs	7,508,291	29.3%
GIWW West (Louisiana Section)	3,733,228	14.6%
GIWW West (Texas Section)	1,462,799	5.7%
GIWW East (West of Mobile)	9,158,369	35.7%
GIWW East (Mobile & East of Mobile)	547,470	2.1%
Total	25,646,445	100%

Destination Region	Tons	% Of Total
Upper Mississippi & Missouri	626,788	2.4%
Lower Mississippi	4,621,126	18.0%
Ohio River & Tribs	1,333,857	5.2%
GIWW West (Louisiana Section)	1,720,377	6.7%
GIWW West (Texas Section)	1,403,729	5.5%
GIWW East (West of Mobile)	8,535,936	33.3%
GIWW East (Mobile & East of Mobile)	7,404,632	28.9%
Total	25,646,445	100%

1989 IHNC Lock Tonnage
By Commodity Group And Origin Region

Origin Region	Commodity Group	Tons	% Of Total
Upper Mississippi & Missouri	Farm Products	129,650	26%
	Metallic Ores	94,155	19%
	Coal	114,568	23%
	Crude Petroleum	0	0%
	Non-Metallic Minerals	28,277	6%
	Forest Products	0	0%
	Industrial Chemicals	65,353	13%
	Agricultural Chemicals	3,209	1%
	Petroleum Products	62,181	12%
	All Others	5,002	1%
	Total	502,395	100%
Lower Mississippi & Missouri	Farm Products	79,120	3%
	Metallic Ores	256,563	9%
	Coal	2,896	0%
	Crude Petroleum	90,200	3%
	Non-Metallic Minerals	53,329	2%
	Forest Products	8,561	0%
	Industrial Chemicals	670,383	[illegible]
	Agricultural Chemicals	123,079	[illegible]
	Petroleum Products	1,415,840	52%
	All Others	33,922	1%
	Total	2,733,893	100%
Ohio River & Tribs	Farm Products	50,816	1%
	Metallic Ores	9,853	0%
	Coal	7,034,672	94%
	Crude Petroleum	0	0%
	Non-Metallic Minerals	237,878	3%
	Forest Products	0	0%
	Industrial Chemicals	39,487	1%
	Agricultural Chemicals	0	0%
	Petroleum Products	135,585	2%
	All Others	0	0%
	Total	7,508,291	100%

Table 2 - 3

1989 IHNC Lock Tonnage
By Commodity Group And Origin Region

Origin Region	Commodity Group	Tons	% Of Total
GIWW West (Louisiana Section)	Farm Products	7,931	0%
	Metallic Ores	16,331	0%
	Coal	0	0%
	Crude Petroleum	2,239,236	60%
	Non-Metallic Minerals	234,351	6%
	Forest Products	587	0%
	Industrial Chemicals	173,301	5%
	Agricultural Chemicals	5,964	0%
	Petroleum Products	846,506	23%
	All Others	209,021	6%
	Total	3,733,228	100%
GIWW West (Texas Section)	Farm Products	6,892	0%
	Metallic Ores	9,562	1%
	Coal	0	0%
	Crude Petroleum	4,762	0%
	Non-Metallic Minerals	56,463	4%
	Forest Products	0	0%
	Industrial Chemicals	258,609	18%
	Agricultural Chemicals	3,906	0%
	Petroleum Products	1,108,374	76%
	All Others	14,231	1%
	Total	1,462,799	100%
GIWW East (West of Mobile)	Farm Products	161,403	2%
	Metallic Ores	875,294	10%
	Coal	151,443	2%
	Crude Petroleum	1,822,844	20%
	Non-Metallic Minerals	543,189	6%
	Forest Products	138,322	2%
	Industrial Chemicals	490,417	5%
	Agricultural Chemicals	400,362	4%
	Petroleum Products	3,227,578	35%
	All Others	1,347,517	15%
	Total	9,158,369	100%

1989 IHNC Lock Tonnage
By Commodity Group And Origin Region

Origin Region	Commodity Group	Tons	% Of Total
GIWW East (Mobile & East of Mobile)	Farm Products	58,120	11%
	Metallic Ores	155,060	28%
	Coal	0	0%
	Crude Petroleum	0	0%
	Non-Metallic Minerals	289,282	53%
	Forest Products	13,434	2%
	Industrial Chemicals	7,363	1%
	Agricultural Chemicals	7,296	1%
	Petroleum Products	16,355	3%
	All Others	560	0%
	Total	547,470	100%

1989 IHNC Lock Tonnage
By Commodity Group And Destination Region

Destination Region	Commodity Group	Tons	% Of Total
Upper Mississippi & Missouri	Farm Products	5,701	1%
	Metallic Ores	165,376	26%
	Coal	0	0%
	Crude Petroleum	0	0%
	Non-Metallic Minerals	5,612	1%
	Forest Products	9,416	2%
	Industrial Chemicals	29,283	5%
	Agricultural Chemicals	185,377	30%
	Petroleum Products	201,292	32%
	All Others	24,731	4%
	Total	626,788	100%
Lower Mississippi & Missouri	Farm Products	201,675	4%
	Metallic Ores	325,820	7%
	Coal	151,443	3%
	Crude Petroleum	870,720	19%
	Non-Metallic Minerals	517,575	11%
	Forest Products	108,218	2%
	Industrial Chemicals	295,681	6%
	Agricultural Chemicals	136,004	3%
	Petroleum Products	927,845	20%
	All Others	1,086,145	24%
	Total	4,621,126	100%
Ohio River & Tribs	Farm Products	9,252	1%
	Metallic Ores	409,036	31%
	Coal	0	0%
	Crude Petroleum	0	0%
	Non-Metallic Minerals	29,715	2%
	Forest Products	32,901	2%
	Industrial Chemicals	45,772	3%
	Agricultural Chemicals	54,285	4%
	Petroleum Products	746,110	56%
	All Others	6,786	1%
	Total	1,333,857	100%

1989 IHNC Lock Tonnage
By Commodity Group And Destination Region

Destination Region	Commodity Group	Tons	% Of Total
GIWW West (Louisiana Section)	Farm Products	0	0%
	Metallic Ores	51,040	3%
	Coal	0	0%
	Crude Petroleum	660,491	38%
	Non-Metallic Minerals	262,826	15%
	Forest Products	0	0%
	Industrial Chemicals	17,980	1%
	Agricultural Chemicals	11,917	1%
	Petroleum Products	497,494	29%
	All Others	218,629	13%
	Total	1,720,377	100%
GIWW West (Texas Section)	Farm Products	2,895	0%
	Metallic Ores	79,082	6%
	Coal	0	0%
	Crude Petroleum	291,633	21%
	Non-Metallic Minerals	16,743	1%
	Forest Products	1,221	0%
	Industrial Chemicals	109,064	
	Agricultural Chemicals	20,075	
	Petroleum Products	871,230	62%
	All Others	11,786	
	Total	1,403,729	100%
GIWW East (West of Mobile)	Farm Products	259,461	3%
	Metallic Ores	322,286	4%
	Coal	2,013,562	24%
	Crude Petroleum	2,331,287	27%
	Non-Metallic Minerals	552,488	6%
	Forest Products	9,148	0%
	Industrial Chemicals	911,620	11%
	Agricultural Chemicals	49,526	1%
	Petroleum Products	1,908,650	22%
	All Others	177,908	2%
	Total	8,535,936	100%

1989 IHNC Lock Tonnage
By Commodity Group And Destination Region

Destination Region	Commodity Group	Tons	% Of Total
GIWW East (Mobile & East of Mobile)	Farm Products	14,948	0%
	Metallic Ores	64,178	1%
	Coal	5,138,574	69%
	Crude Petroleum	2,911	0%
	Non-Metallic Minerals	57,810	1%
	Forest Products	0	0%
	Industrial Chemicals	295,513	4%
	Agricultural Chemicals	86,632	1%
	Petroleum Products	1,659,798	22%
	All Others	84,268	1%
	Total	7,404,632	100%

Table 2 - 5
Commodity Group Definitions
By Waterborne Commerce Statistics Center
And Lock Performance Monitoring System Classifications

	1990 WCSC	1989 WCSC	LPMS
1. FARM PRODUCTS			
Corn	6344	0103	81
Sorghum Grains	6447	0106	80
Wheat	6241	0107	82
Soybeans	6522	0111	83
Grains & Oilseeds NEC	6442,6443,6445,6521, 6534,6590	0102,0104,0105, 0112,0119	84-87
Other Agri Products	6654,6781,6839,6856, 6857,6871,6872,6891, 6893,6899	0101,0121-0191	89
Grain Mill Products	6746,6747	2014,2049	88
Animal Feeds	6782	2042	80
Other Food/Tobacco	6653,6654,6811,6817, 6822,6835,6838,6839, 6858,6861,6865,6885, 6887-6889,6891	2011-2039,2061- 2099,2111	94
2. METALLIC ORES & PROD			
Iron Ores & Conc	4410	1011	42
Other Metallic Ores	4630,4650,4670,4690	1021-1091	40,
Iron & Steel Shapes	5320,5330,5360.5370	3314-3317	43
Other Iron $ Steel Prod	2990,4420,4860, 5312,5315,5390	3311-3313,3318, 3319,4011	44,46
Nonferrous Metal Prod	4680,5421,5422,5429	3321-3324,4012	44
Fabricated Metal Prod	5480	3411	45
3. COAL			
Coal	1100	1121	10,11
4. CRUDE PETRO			
Crude Petroleum	2100	1311	21
5. NONMETALLIC MINERALS			
Limestone	4322	1411	51
Stone, Sand, & Gravel	4310,4331	1412,1442	52
Other Nonmetallic Minerals	3271,4323,4338, 4741,4782,4783,4900	1451,1491-1499	50
Building Cement	5220	3241	61
Lime	5210	3271	62
Stone, Clay, & Glass	5240,5290	3211,3251,3281	60
Waterway Improvemnt Matrl	4335	4118	51
Misc Nonmetallic Minrl Prod	5290	3291	50

Table 2 - 5
Commodity Group Definitions
By Waterborne Commerce Statistics Center
And Lock Performance Monitoring System Classifications

	1990 WCSC	1989 WCSC	LPMS
6. FOREST PRODUCTS & PULP			
Logs	4170	2411	92
Rafted Logs	4170	2412	92
Pulpwood Logs	4170	2415	92
Wood Chips & Staves	4161	2416	92
Forest & Other Timber Prod.	4110,4150,4170, 4190	0841,0861,2413, 2414	91
Lumber Prod & Furniture	4189,5540,7400, 7900	2421-2491,2511	92
Pulp	4225	2611	93
Standard Newsprint Paper	5110	2621	93
Paper & Paperboard	5120	2631	93
Paper Scrap	4225	4024	93
Paper & Paperboard, NEC	5190	2691	93
7. INDUSTRIAL CHEMICALS			
Industrial Chemicals	3211,3212,3219,3220, 3230,3240,3250,3260,3272-3276,3279,3281-3286,3292, 3297-3299,7500,7600	2810-2861,2891	30-34
8. AGRICULTURAL CHEMICALS			
Agricultural Minerals	3190,4327	1471,1479	53
Agricultural Chemical	3110,3120,3130, 3190,3291	2871-2879	35-39
9. PETROLEUM PRODUCTS			
Gasoline	2211	2911	22
Jet Fuel & Kerosene	2211,2221	2912,2913	23
Distillate Fuel Oil	2330	2914	24
Residual Fuel Oil	2340	2915	25
Lubricating Oil & Grease	2350	2916	20
Naptha & Petroluem Solv	2429	2917	26
Asphalt, Tars, & Pitches	2430,5290	2918,2931	26
Coke & Petroleum Coke	1200,2540	2920	26
Liquefied Gases	2640	2921	20
Other Petro & Coal Prod	2410,2990	2991	26

Table 2 - 5
Commodity Group Definitions
By Waterborne Commerce Statistics Center
And Lock Performance Monitoring System Classifications

	1990 WCSC	1989 WCSC	LPMS
10. ALL OTHERS			
Fish & Shellfish	6134,6136	0911-0913	70
Unmanufactured Shells	4515	0931	71
Basic Textile Prod	6894,7500	2211,2212,4022	90
Apparel	7500	2311	90
Rubber,Plastics & Leather	7600,7900	3011,3111	99
Machinery	7110,7120	3511,3611	95
Transportation Equipment	7210,7220,7230,7900	3711-3791	95
Miscellaneous, NEC	3293,4333,6888,7300, 7800,7900,8900,9900	1911,2711,3811, 3911,4029,4111- -4113,4119,9999	99

Table 2 - 6

Shallow-Draft Activity Summary - IHNC Lock
(1984 - 1993)

Year	Total Traffic (1,000 Tons)	Total Number Of Tows	Average Delay Per Tow (Hours)
1993	23,337	9,196	14.6
1992	23,530	10,601	6.3
1991	23,926	9,658	12.3
1990	23,412	9,891	16.2
1989	25,856	10,850	11.6
1988	27,128	11,123	11.9
1987	26,325	11,724	9.2
1986	26,608	11,733	15.8
1985	24,007	12,799	8.5
1984	22,193	12,381	8.3

Source: Lock Performance Monitoring System. (LPMS)

SYSTEM TRAFFIC AND FLOW PATTERNS

Table 2 - 7 displays the distribution of commodity types, aggregated by major groups, for 1989 by the three GIWW segments that include the primary locks. These segments are, 1) the GIWW Mississippi River to Sabine River (GIWW West miles 0 - 240), 2) the GIWW Morgan City - Port Allen Alternate Route, and 3) the GIWW Mobile to New Orleans (GIWW East miles 0 - 134). The importance of the GIWW system to the petrochemical industries of Louisiana and Texas is evident in the commodity mix. For each of the three GIWW segments shown in table 2 - 7, refined petroleum products represents nearly a third or more of total segment traffic. This significance is further illustrated by the fact that the combination of petroleum products, industrial chemicals and crude petroleum account for 79 and 70 percent, respectively, of total traffic for the first two segments. For the third segment, these same three commodity groups represent 55 percent of total segment traffic. Some difference in commodity emphasis does exist between the eastern and western portions of the GIWW. The primary difference between the segments is the prominence of coal and the lesser significance of industrial chemicals on the eastern portion. Virtually nonexistent on the western portion of the GIWW, coal represents 29 percent of the eastern portion traffic.

Table 2 - 8 breaks down the previously displayed commodity group percentages by GIWW segment to the level of the individual lock. Commodity group percentages for individual locks generally reflect the percentages of their respective segments with a few exceptions. First, refined petroleum products represent an even higher percentage of total lock traffic than they do of segment traffic for the locks on the western mainstem. The second exception to similar segment vs individual commodity emphasis is the greater percentage emphasis of crude petroleum and lesser emphasis of industrial chemicals at Algiers and Bayou Boeuf, and the reverse of this condition at Calcasieu and Leland Bowman.

In order to illustrate traffic flow patterns between the primary system locks, table 2 - 9 displays a matrix of traffic flows between locks expressed as a percent of each lock's total traffic volume.

Historical traffic on the three previously described GIWW segments is displayed in table 2 - 10. Traffic volume on these segments has fluctuated significantly over the last 20 years. Traffic for the system, which fell to a 20- year low in 1982, rebounded by the 1988 - 1990 period to new record high levels. Historical average lock delays for the

Table 2 - 7

GIWW Selected Segments
1989 Tonnage by Commodity Group
(Internal Traffic)

Commodities	Mississippi River to Sabine River 1/	% of Total	Morgan City - Port Allen Route	% of Total	Mobile Bay - New Orleans 2/	% of Total
Forest Products	1,578,430	2.4	421,601	1.5	541,129	2.2
Metallic Ores	2,493,862	3.8	1,725,048	6.3	929,733	3.7
Coal	20,415	0.03	19,087	0.1	7,352,313	29.4
Crude Petroleum	14,492,804	21.9	1,593,165	5.8	3,109,001	12.5
Non-Metallic Minerals	6,173,547	9.3	5,089,349	18.7	1,349,286	5.4
Forest Products	30,864	0.05	22,533	0.1	338,136	1.4
Industrial Chemicals	12,262,336	18.5	8,678,216	31.8	2,009,032	8.0
Agricultural Chemicals	877,287	1.3	728,637	2.7	233,828	0.9
Petroleum Products	25,622,554	38.6	8,821,370	32.4	8,699,275	34.8
All Others	2,764,978	4.2	161,288	0.6	407,309	1.6
Total	66,317,077	100	27,260,294	100	24,969,042	100

Source: Waterborne Commerce of the United States, 1989.

1/ Mississippi River to GIWW West mile 266.

2/ Inner Harbor Navigation Canal to GIWW East mile134.

Table 2 - 8

Commodity Group Percentages by Lock - 1989

Group	Port Allen	Bayou Sorrel	IHNC	Algiers	Harvey	Bayou Boeuf	Calcasieu	Leland Bowman
Farm Prod	1.6	1.6	1.9	2.0	9.2	3.9	2.1	2.5
Metalic Ores	6.6	6.1	5.5	0.8	7.5	3.4	4.7	4.7
Coal	0.1	0.0	28.5	0.0	0.0	0.0	0.0	0.0
Crude Petroleum	3.3	3.6	13.3	28.0	12.7	19.3	10.4	6.7
Non-metalic Minerals	19.4	18.0	5.6	9.4	9.3	3.8	3.0	3.1
Forest Products	0.1	0.1	0.6	0.0	0.2	0.1	0.1	0.1
Industrial Chemicals	33.0	33.7	6.6	8.3	9.8	9.5	25.2	25.8
Agricultural Chemicals	2.7	2.8	2.1	2.4	0.8	2.1	1.8	2.9
Petroleum Products	32.6	33.4	29.5	46.5	48.4	50.2	51.5	53.0
All Other	0.6	0.6	6.3	2.6	2.2	7.9	1.2	1.2
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	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Waterborne Commerce Of The United States

Table 2 - 9

Common Traffic Flows Between Locks - 1989

Lock (traffic from)	Percent of Traffic that Uses: Port Allen	Bayou Sorrel	IHNC	Algiers	Harvey	Bayou Boeuf	Calcasieu	Leland Bowman
Port Allen	100.0	97.1	0.3	0.0	0.0	1.5	78.1	78.6
Bayou Sorrel	99.2	100.0	0.4	0.2	0.1	1.8	80.1	80.6
IHNC	0.4	0.4	100.0	24.3	8.1	27.1	23.3	24.6
Algiers	0.0	0.2	28.5	100.0	0.0	74.2	58.8	63.5
Harvey	0.0	0.3	31.4	0.0	100.0	90.7	74.3	79.3
Bayou Boeuf	1.5	1.7	26.0	60.1	22.3	100.0	69.3	74.5
Calcasieu	46.9	47.0	13.6	29.1	11.2	42.4	100.0	100
Leland Bowman	44.8	45	13.6	29.9	11.3	43.3	96.7	100
Total System	32.2	31.5	31.3	26.6	8.1	32.8	54.6	56.4

Table 2 - 10

GIWW Tonnage
Selected Years, Selected Segments, Total Tonnage

Year	Mississppi River to Sabine 1/	Morgan City - Port Allen Alternate Route 2/	Mobile Bay - New Orleans 4/
1992	66,460,000	23,727,000	23,742,000
1991	65,328,000	24,342,000	23,449,000
1990	67,679,000	29,632,000	25,782,000
1989	66,415,798	27,264,185	25,972,550
1988	69,292,154	27,072,639	27,267,590
1987	63,967,724	19,682,861	24,069,572
1986	64,471,662	25,180,797	23,589,414
1985	63,092,992	23,150,132	21,577,873
1984	55,840,086	21,324,578	20,413,239
1983	51,545,852	19,253,008	16,524,665
1982	50,372,504	17,833,864	15,184,211
1981	52,591,854	18,083,914	17,342,703
1980	54,916,394	19,066,976	19,124,329
1979	55,947,248	20,254,735	21,238,833
1978	61,753,493	18,066,503	22,610,406
1977	63,277,175	18,456,491	24,795,828
1976	59,108,942	18,961,414	23,201,285
1975	56,750,361	17,083,459	21,726,203
1974	60,839,703	15,895,856	21,307,231
1973	62,265,498	14,269,832	19,323,261
1972	68,904,972	19,173,890	21,613,217
1971	70,563,298	14,368,939	18,660,228
1970	65,129,464	16,637,934	16,075,626
1960	36,263,828	2,773,826 3/	7,606,145
1950	21,707,241	1,818,760 3/	4,065,913

Source: Waterborne Commerce of the United States

1/Mississippi river to GIWW west mile 266.

2/ Not included in Mississippi River to Sabine traffic.

3/ Via Plaquemine Lock, Bayou Plaquemine, Bayou Sorrel Lock, and the borrow pit of East Atchafalaya Protection Levee.

4/ Inner Harbor Navigation Canal to GIWW East, mile 134.

ten-year period 1993 - 1984 for three GIWW segments are presented in table 2 - 10a.

EXISTING AND HISTORICAL DEEP-DRAFT TRAFFIC

SYSTEM TRAFFIC

The navigation system with respect to deep-draft activity is composed of the two deep-draft channels that exist on either side of the IHNC lock, the Mississippi River and the MR-GO. The Mississippi River, a 45-foot channel, represents the primary route to New Orleans and points upstream to Baton Rouge, La, the upstream end of deep-draft navigation. While the MR-GO provides a second, 36-foot access route to New Orleans. The port facilities served by each channel, while not completely isolated from each other, represent geographically distinct areas. The areas remain distinct because of limited deep-draft traffic interchange. The sole route connecting the two areas requires use of the IHNC Lock which is too restrictive for the vast majority of the calling fleet. Therefore, for most deep-draft vessels, the selection of one of these two channels determine which port facilities can be accessed.

Historically, this system has represented the highest concentration of deep-draft traffic in the U.S. Throughout the 1980's, the Port of New Orleans has ranked as the number one U.S. port in terms of total foreign tonnage, while the Port of Baton Rouge has consistently placed in the top ten by this measure. With the 1990 redefinition of Lower Mississippi River port limits for ranking purposes, the Port of New Orleans has dropped to number six in foreign tonnage (1991). However, the newly defined ports of South Louisiana and Plaquemine have achieved the rankings of one and eight, respectively. With Baton Rouge retaining its top ten status at number five, the Mississippi River/MR-GO system has retained its status as the heaviest U.S. concentration of foreign traffic into the 1990's.

Table 2 - 11 displays a deep-draft commodity breakdown for the Mississippi River in 1991. The most prominent features of this traffic breakdown are the farm products (mostly grain) exports and crude petroleum imports. These two commodity groups represent approximately 72 percent and 62 percent respectively, of the export and import totals. The significance of grain exports is further highlighted by the fact that historically the Mississippi River has handled an average of approximately 45 percent of total U.S. grain exports.

Table 2 - 10a

Average Delay by Lock
1984 - 1993
(Hours)

Lock	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984
Port Allen	2.0	1.5	2.1	2.2	1.2	1.0	1.2	1.2	1.1	1.5
Bayou Sorrel	3.8	2.1	4.9	3.9	3.2	3.7	0.9	1.3	0.9	1.1
IHNC	14.6	6.3	12.3	16.2	11.6	11.9	9.2	15.8	8.5	8.3
Algiers	8.8	4.4	4.9	4.6	4.6	3.2	3.6	3.4	3.1	3.2
Harvey	9.0	2.3	3.2	4.2	2.4	0.8	0.9	0.7	0.5	0.6
Bayou Boeuf	1.6	0.5	0.7	0.4	0.7	0.3	0.2	0.4	0.5	0.5
Calcasieu	1.6	0.8	0.8	1.2	2.7	1.1	1.1	1.7	1.3	1.6
Leland Bowman	1.1	0.5	0.4	1.0	0.8	0.9	0.9	0.6	0.6	NA

Source: Lock Performance Monitoring System (LPMS)

Table 2 - 11

Mississippi River 1991 Deep-Draft Tonnage
By Commodity Group

	Foreign			Coastwise			Total Tonnage
	Imports	Exports	Total	Receipts	Shipments	Total	
Farm Products	1,767,000	78,825,000	80,592,000	181,000	855,000	1,036,000	81,628,000
Metallic Ores & Products	9,863,000	1,476,000	11,339,000	1,000	25,000	26,000	11,365,000
Coal	24,000	15,487,000	15,511,000	0	7,375,000	7,375,000	22,886,000
Crude Petroleum	37,052,000	0	37,052,000	803,000	21,000	824,000	37,876,000
Nonmetallic Minerals	1,827,000	128,000	1,955,000	0	388,000	388,000	2,343,000
Forest Products & Pulp	376,000	1,077,000	1,453,000	2,000	0	2,000	1,455,000
Industrial Chemicals	573,000	2,654,000	3,227,000	50,000	1,074,000	1,124,000	4,351,000
Agricultural Chemicals	1,455,000	2,023,000	3,478,000	7,404,000	62,000	7,466,000	10,944,000
Petroleum Products	7,113,000	8,098,000	15,211,000	1,357,000	11,459,000	12,816,000	28,027,000
All Others	85,000	166,000	251,000	0	0	0	251,000
Total	60,135,000	109,934,000	170,069,000	9,798,000	21,259,000	31,057,000	201,126,000

Source: Waterborne Commerce of the United States

Table 2 - 12 provides the same information for the MR-GO. For the MR-GO, the commodity concentrations are not as pronounced as for the Mississippi River. Metallic ores and nonmetallic minerals each represent approximately 35 percent of import tonnage, while industrial chemicals and farm products represent approximately 27 percent and 23 percent respectively, of export tonnage. In terms of total deep-draft volume, the MR-GO handled less than three percent of the Mississippi River total in 1991.

Table 2 - 13 displays the 1992 distribution of vessel types for the Mississippi River and MR-GO. Reflecting the significance of grain and crude oil, table 2 - 12 shows that dry bulk carriers (56.8 percent) and tankers (29.4 percent) are the dominant vessel types on the Mississippi River. The emphasis on the MR-GO, however, is quite different. The dominant vessel type on the MR-GO is the container vessel, accounting for 54.5 percent of total vessels.

While the MRGO does not represent the primary access route to the Port of New Orleans in terms of draft provided or tonnage handled, it is a critical component of the port in that it provides access to the port's primary container facilities. In fact, the MRGO handles in excess of 90 percent of all container traffic moving through the port. The volume of container traffic through New Orleans has increased in recent years to the extent that for 1990, New Orleans, traditionally a bulk and breakbulk oriented port, ranked as the 14th largest U.S. port, and second largest on the gulf coast (behind Houston, Tx.) in foreign container box volume.

Table 2 - 14 displays historic deep-draft tonnage on the Mississippi River for the period 1974-1992. Traffic has steadily increased since the most recent cyclical low in 1985 to approach the record levels of 1981. Table 2 - 15 displays historic deep-draft tonnage on the MR-GO since its first year of partial operation in 1960 to 1992. Total deep-draft traffic steadily increased from the waterway's 1960 opening through 1980. Traffic on the MR-GO declined in the early 80's, as it did for the Mississippi River and for many of the major waterways across the country. Following this downturn, traffic levels recovered until near record levels were recorded in 1987. Since 1987 traffic has shown a decline to slightly under five million tons in 1991, followed by a modest upturn in 1992.

Tables 2 - 16 and 2 - 17 display fleet distributions by year for the ten year period 1983-1992 for the Mississippi River and MR-GO, respectively. Both distributions show a shift over time reflecting a larger vessel emphasis. For

Table 2 - 12

MRGO 1991 Deep-Draft Tonnage
by Commodity Group

	Foreign			Coastwise			Total Tonnage
	Imports	Exports	Total	Receipts	Shipments	Total	
Farm Products	229,000	431,000	660,000	61,000	315,000	376,000	1,036,000
Metallic Ores & Products	696,000	278,000	974,000	10,000	15,000	25,000	999,000
Coal	0	12,000	12,000	0	0	0	12,000
Crude Petroleum	0	0	0	0	0	0	0
Nonmetallic Minerals	662,000	60,000	722,000	111,000	18,000	129,000	851,000
Forest Products & Pulp	42,000	206,000	248,000	52,000	86,000	138,000	386,000
Industrial Chemicals	124,000	494,000	618,000	18,000	66,000	84,000	702,000
Agricultural Chemicals	152,000	169,000	321,000	0	1,000	1,000	322,000
Petroleum Products	33,000	130,000	163,000	0	11,000	11,000	174,000
All Others	37,000	61,000	98,000	49,000	220,000	269,000	367,000
Total	1,975,000	1,841,000	3,816,000	301,000	732,000	1,033,000	4,849,000

Source: Waterborne Commerce of the United States

Table 2 - 13

1992 Vessel Type Distribution
(in Percent)

Vessel Type	Mississippi River	MR-GO
Container	1.0	54.5
Tanker	29.4	1.5
General Cargo	12.8	23.7
Dry Bulk	56.8	20.3
Total	100.0	100.0

Mississippi River Deep-Draft Tonnage
(1974 - 1992)

	Foreign			Coastwise			
Year	Imports	Exports	Total	Receipts	Shipments	Total	Total Deep-Draft
1992	63,036,000	112,249,000	175,285,000	11,581,000	20,764,000	32,345,000	207,630,000
1991	60,139,000	109,936,000	170,075,000	9,797,000	21,259,000	31,056,000	201,131,000
1990	63,160,000	106,042,000	169,202,000	10,465,000	22,032,000	32,497,000	201,699,000
1989	59,889,679	103,972,049	163,861,728	10,384,467	20,666,767	31,051,234	194,912,962
1988	45,325,616	97,464,079	142,789,695	13,971,968	21,826,430	35,798,398	178,588,093
1987	38,087,066	93,688,556	131,775,622	17,853,348	19,549,195	37,402,543	169,178,165
1986	35,138,022	81,084,796	116,222,818	19,039,077	18,211,912	37,250,989	153,473,807
1985	27,040,313	81,009,372	108,049,685	21,737,400	19,215,546	40,952,946	149,002,631
1984	34,167,226	85,894,311	120,061,537	19,921,173	16,828,915	36,750,088	156,811,625
1983	32,320,125	95,763,623	128,083,748	18,256,055	20,844,285	39,100,340	167,184,088
1982	56,708,090	100,756,368	157,464,458	14,629,231	20,034,834	34,664,065	192,128,523
1981	80,094,423	98,269,761	178,364,184	21,553,015	23,189,745	44,742,760	223,106,944
1980	90,772,105	86,290,660	177,062,765	17,768,198	23,811,964	41,580,162	218,642,927
1979	105,858,988	73,255,062	179,114,050	12,780,791	20,274,910	33,055,701	212,169,751
1978	98,540,849	67,286,151	165,827,000	14,332,003	17,404,538	31,736,541	197,563,541
1977	96,028,423	59,628,562	155,656,985	9,789,919	19,836,015	29,625,934	185,282,919
1976	67,027,258	59,869,890	126,897,148	8,588,222	17,370,125	25,958,347	152,855,495
1975	45,934,905	47,615,390	93,550,295	8,670,706	21,104,606	29,775,312	123,325,607
1974	37,329,279	47,089,746	84,419,025	7,624,355	20,711,578	28,335,933	112,754,958

Source: Waterborne Commerce of the United States

Table 2 - 15

MRGO Deep-Draft Tonnage
(1960 - 1992)

	Foreign			Coastwise			
Year	Imports	Exports	Total	Receipts	Shipments	Total	Total Deep-Draft
1992	2,165,000	1,716,000	3,881,000	364,000	861,000	1,225,000	5,106,000
1991	1,977,000	1,847,000	3,824,000	302,000	734,000	1,036,000	4,860,000
1990	2,795,000	1,790,000	4,585,000	273,000	753,000	1,026,000	5,611,000
1989	2,503,131	2,042,301	4,545,432	299,465	856,757	1,156,222	5,701,654
1988	3,233,962	1,799,982	5,033,944	210,172	633,652	843,824	5,877,768
1987	2,939,344	2,147,160	5,086,504	308,717	651,460	960,177	6,046,681
1986	2,961,669	2,292,251	5,253,920	140,267	618,815	759,082	6,013,002
1985	3,219,223	1,542,749	4,761,972	121,876	591,950	713,826	5,475,798
1984	3,446,207	1,935,075	5,381,282	99,554	461,212	560,766	5,942,048
1983	2,263,788	1,221,212	3,485,000	91,473	487,647	579,120	4,064,120
1982	2,444,099	1,433,762	3,877,861	102,906	339,861	442,767	4,320,628
1981	2,711,084	1,632,862	4,343,946	68,599	328,847	397,446	4,741,392
1980	2,548,379	1,819,406	4,367,785	125,084	311,594	436,678	4,804,463
1979	3,910,761	2,361,658	6,272,419	124,952	393,705	518,657	6,791,076
1978	3,222,259	1,913,680	5,135,939	566,259	823,990	1,390,249	6,526,188
1977	2,320,344	1,887,493	4,207,837	568,372	1,107,358	1,675,730	5,883,567
1976	1,710,152	2,441,668	4,151,820	341,375	560,524	901,899	5,053,719
1975	1,384,065	1,828,622	3,212,687	367,497	569,105	936,602	4,149,289
1974	1,705,093	1,680,734	3,385,827	274,086	286,338	560,424	3,946,251
1973	1,653,084	1,537,021	3,190,105	132,669	146,607	279,276	3,469,381
1972	1,288,854	1,114,819	2,403,673	65,652	179,639	245,291	2,648,964
1971	1,256,729	859,640	2,116,369	94,195	107,164	201,359	2,317,728
1970	1,334,302	1,187,356	2,521,658	85,530	51,985	137,515	2,659,173
1969	936,921	905,911	1,842,832	59,245	37,787	97,032	1,939,864
1968	1,168,685	687,739	1,856,424	92,169	78,221	170,390	2,026,814
1967	793,942	568,545	1,362,487	321,826	105,527	427,353	1,789,840
1966	965,363	177,135	1,142,498	441,048	147,324	588,372	1,730,870
1965	543,656	213,723	757,379	320,210	63,123	383,333	1,140,712
1964	767,548	182,670	950,218	36,006	4,220	40,226	990,444
1963	389,997	44,850	434,847	62,232	2,917	65,149	499,996
1962	300,574	0	300,574	10,431	0	10,431	311,005
1961	42,030	0	42,030	0	0	0	42,030
1960	14,316	0	14,316	0	0	0	14,316

Source: Waterborne Commerce of the United States

Table 2 - 16

Mississippi River Fleet Distribution
Outbound Vessels
(1983 - 1992)

Deadweight Tonnage	1992		1991		1990		1989		1988		1987		1986		1985		1984		1983	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Under 20,000	1,365	29.0	1,538	28.0	1,507	27.5	1,592	28.8	1,693	32.5	1,842	35.2	1,747	34.5	1,951	38.1	2,064	37.5	2,069	36.5
20,000 - 29,999	727	15.4	882	16.1	1,064	19.4	1,065	19.3	955	18.3	957	18.3	900	17.8	909	17.8	1,009	18.3	1,020	18.0
30,000 - 39,999	613	13.0	766	14.0	741	13.5	726	13.1	716	13.7	753	14.4	762	15.1	746	14.6	889	16.2	890	15.7
40,000 - 49,999	347	7.4	414	7.5	355	6.5	342	6.2	300	5.8	263	5.0	324	6.4	308	6.0	304	5.5	288	5.1
50,000 - 59,999	212	4.5	294	5.4	270	4.9	356	6.4	286	5.5	294	5.6	301	6.0	286	5.6	260	4.7	273	4.8
60,000 - 69,999	596	12.7	677	12.3	635	11.6	582	10.5	574	11.0	523	10.0	479	9.5	462	9.0	392	7.1	409	7.2
70,000 - 79,999	235	5.0	269	4.9	281	5.1	256	4.6	215	4.1	244	4.7	255	5.0	226	4.4	257	4.7	290	5.1
80,000 - 89,999	274	5.8	383	7.0	388	7.1	336	6.1	218	4.2	139	2.7	121	2.4	89	1.7	129	2.3	156	2.8
90,000 - 99,999	163	3.5	136	2.5	118	2.2	66	1.2	64	1.2	40	0.8	31	0.6	23	0.4	66	1.2	55	1.0
100,000 - 119,999	55	1.2	49	0.9	49	0.9	71	1.3	61	1.2	75	1.4	62	1.2	49	1.0	65	1.2	101	1.8
120,000 - 139,999	84	1.8	54	1.0	57	1.0	103	1.9	92	1.8	89	1.7	53	1.0	46	0.9	48	0.9	102	1.8
Over 140,000	36	0.8	24	0.4	20	0.4	29	0.5	41	0.8	17	0.3	23	0.5	24	0.5	20	0.4	11	0.2
Total	4,707	100.0	5,486	100.0	5,485	100.0	5,524	100.0	5,215	100.0	5,236	100.0	5,058	100.0	5,119	100.0	5,503	100.0	5,664	100.0

Source: Associated Branch Pilots.

Table 2 - 17

MR-GO Fleet Distribution
Outbound Vessels
(1983 - 1992)

Deadweight Tonnage	1992		1991		1990		1989		1988		1987		1986		1985		1984		1983	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Under 20,000	267	54.2	330	52.1	343	51.7	284	48.8	400	59.1	517	64.5	614	68.4	452	60.8	571	64.7	514	65.9
20,000 - 29,999	112	22.7	168	26.5	215	32.4	216	37.1	209	30.9	205	25.6	188	20.9	215	28.9	231	26.2	210	26.9
30,000 - 39,999	56	11.4	80	12.6	74	11.1	60	10.3	33	4.9	52	6.5	58	6.5	45	6.0	32	3.6	33	4.2
40,000 - 49,999	47	9.5	47	7.4	25	3.8	20	3.4	30	4.4	26	3.2	33	3.7	28	3.8	38	4.3	20	2.6
50,000 - 59,999	1	0.2	2	0.3	6	0.9	2	0.3	4	0.6	0	0.0	5	0.6	1	0.1	5	0.6	2	0.3
60,000 - 69,999	10	2.0	6	0.9	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3	4	0.5	1	0.1
70,000 - 79,999	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1	1	0.1	0	0.0	1	0.1	1	0.1	0	0.0
80,000 - 89,999	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Total	493	100.0	634	100.0	664	100.0	582	100.0	677	100.0	801	100.0	898	100.0	744	100.0	883	100.0	780	100.0

Source: Associated Branch Pilots.

the Mississippi River, vessels greater than 80,000 dwt increased steadily from 1985 (4.5 percent) to 1992 (13.1 percent), while vessels less than 30,000 dwt decreased by approximately the same number of percentage points over the same period (55.9 percent to 44.4 percent). For the MR-GO the same general pattern of change exists, however the break points in the distribution are significantly different, reflecting the overall smaller nature of the MR-GO fleet. Over the 1983 to 1992 period, vessels greater than 30,000 increased from 7.2 percent to 23.1 percent, while vessels less than 30,000 dwt decreased from 92.8 percent to 76.9 percent. Reflecting similar results, tables 2 - 18 and 2 - 19 display vessel trips by draft for the period 1984 - 1989 for the Mississippi River and MR-GO, respectively. As was shown in previous tables, a shift to larger vessels becomes more apparent over time.

IHNC LOCK TRAFFIC

Deep-draft IHNC Lock usage for 1991 is summarized in table 2 - 20. For the year, the lock handled 138 vessels carrying a total of 134,000 tons, an average of less than 1,000 tons per vessel. The table reveals two significant observations. First, the composition of vessel types is overwhelmingly represented by the general cargo classification (96 percent). Dry bulk carriers (4 percent) make up the balance. Container vessels and tankers are completely absent from current usage. Second, deep-draft vessels transiting the lock are concentrated in the extreme low end of the overall vessel size distribution for both the Mississippi River and the MR-GO.

There are economic reasons for the limited number and sizes of deep-draft vessels using IHNC Lock which will be discussed in detail in subsequent sections of this appendix. Generally these reasons include a limited basic need for access to both the Mississippi River and the MR-GO during a single port call, the magnitude of savings associated with lock usage, and vessel itinerary scheduling requirements. However, in addition to these economic reasons, there are absolute physical restrictions that limit the size of vessels using the lock. Given the 75-foot width, the largest dry bulk carrier that can navigate the lock is estimated to be approximately 20,000 deadweight tons (dwt), while the largest general cargo vessel is estimated at approximately 18,000 dwt.

Historically, deep-draft usage at IHNC Lock has been similar to the 1991 profile. Table 2 - 21 summarizes the 1983-1991 deep-draft activity at IHNC lock. Over this period, deep-draft vessels have averaged 171 lockages and 137,000 tons per year.

Table 2 - 18

Vessel Trips By Draft
Miss River (N.O. to Mouth of passes) 1984-1989
(Drafts Greater Than 18 Ft)

	Upbound Trips						Downbound Trips					
Draft (ft)	1989	1988	1987	1986	1985	1984	1989	1988	1987	1986	1985	1984
45	31	10	0	0	0	0	165	134	0	0	0	0
44	13	22	,0	0	0	0	106	104	0	0	0	0
43	15	24	0	0	0	0	121	66	0	0	0	0
42	41	47	0	0	0	0	148	78	0	0	0	0
41	75	106	0	0	0	0	123	117	0	0	0	0
40	256	156	375	367	337	192	710	633	982	881	730	566
39	219	141	165	170	159	192	200	216	285	205	256	222
38	164	76	83	100	131	280	200	133	155	90	209	353
37	128	102	75	116	161	188	174	114	161	233	231	215
36	157	115	92	91	89	155	224	214	189	164	209	303
35	170	111	74	86	152	132	280	191	521	186	211	264
34	206	165	174	158	146	174	342	338	255	216	256	268
33	150	141	153	160	187	167	282	230	612	304	265	232
32	193	189	178	167	197	173	362	291	1,753	193	250	329
31	153	130	145	148	257	300	247	166	196	266	278	199
30	274	284	184	236	258	204	526	430	357	226	344	432
29	194	172	184	192	242	229	258	234	236	342	325	287
28	279	253	227	191	255	262	361	276	201	204	267	252
27	282	274	253	293	370	323	296	346	324	400	364	301
26	318	265	293	308	448	392	286	333	303	350	481	536
25	396	326	322	340	409	418	281	320	306	381	440	393
24	521	428	400	435	514	516	273	286	323	304	409	452
23	507	401	387	425	500	576	211	221	220	283	358	357
22	514	448	418	445	513	532	351	372	331	280	378	372
21	456	414	363	409	381	426	230	237	214	267	222	272
20	401	295	317	615	741	498	199	211	199	464	677	519
19	403	348	327	304	349	330	162	211	181	193	288	301
Sub Total	6,516	5,443	5,189	5,756	6,796	6,659	7,118	6,502	8,304	6,432	7,448	7,425

Source: Waterborne Commerce of the United States

Table 2 - 19

Vessel Trips By Draft
MRGO 1984-1989
(Drafts Greater Than 18 Ft)

	Upbound Trips						Downbound Trips					
Draft (ft)	1989	1988	1987	1986	1985	1984	1989	1988	1987	1986	1985	1984
38	4	5	4	0	1	4	11	6	5	0	3	2
37	6	2	1	0	0	1	1	0	4	5	1	9
36	7	9	9	3	8	7	16	9	11	1	3	4
35	11	10	3	5	7	7	8	3	2	7	2	4
34	13	10	11	7	13	29	7	5	4	5	5	4
33	17	13	19	22	21	40	28	9	8	23	22	14
32	17	13	32	34	25	45	22	16	27	41	44	21
31	20	23	45	45	45	35	39	27	36	50	34	58
30	30	28	55	57	47	43	50	77	47	48	76	54
29	32	49	48	47	60	40	65	74	54	58	97	68
28	30	51	40	32	39	32	76	61	49	74	65	83
27	40	55	50	35	49	53	62	73	70	53	35	64
26	59	78	57	56	62	86	32	43	41	67	52	48
25	46	74	47	51	52	57	40	42	43	69	48	61
24	61	56	54	63	61	72	14	46	32	39	35	55
23	57	34	51	67	49	55	19	37	29	51	55	22
22	44	38	33	77	43	57	21	38	48	50	25	44
21	21	27	37	44	46	61	14	22	45	42	36	46
20	22	45	41	34	37	28	23	26	34	20	22	27
19	18	25	26	31	37	26	17	15	18	26	29	32
Sub Total	555	645	663	710	702	778	565	629	607	729	689	720

Source: Waterborne Commerce of the United States.

Table 2 - 20

Deep-Draft Vessel Lockages
IHNC 1991

Deadweight Tonnage	Dry Bulk	General Cargo	Total
3,000	0	110	110
3,000 - 10,000	1	3	4
10,000 - 20,000	4	20	24
Total	5	133	138

Table 2 - 21

Deep-Draft Traffic Summary - IHNC Lock
(1983 -1991)

Year	Deep-Draft Tonnage (1,000)	Number of Ships
1991	134	138
1990	105	163
1989	76	131
1988	175	168
1987	259	192
1986	152	195
1985	157	192
1984	101	163
1983	75	195

Source: Lockmaster Logs, New Orleans District, U.S. Army Corps of Engineers.

PROJECTED SHALLOW-DRAFT TRAFFIC

OVERVIEW

System traffic was categorized into ten commodity groups. A summary of this classification scheme was presented earlier in table 2 - 5. The level of aggregation represented by the ten categories balances two competing requirements: 1) the need to generalize the specific information within each movement so as to facilitate analysis and, 2) the need to preserve as much as possible those unique attributes of each specific commodity. Tonnage projections are presented in this report according to the ten-group format, although projections for specific commodities were performed at a more detailed level where it was found to be appropriate.

A review of 1990 WCSC data (reconciled tonnage) shows that nearly 78 percent of total tonnage reported for IHNC Lock was associated with coal, crude petroleum, petroleum products and industrial chemicals. Metallic ores and non-metallic minerals accounted for another 15 percent of traffic through the lock. Movements of farm products, forest products, agricultural chemicals and miscellaneous cargoes were each less than 1 million tons--small volumes relative to the 23.5 million tons that passed through the lock in that year. A summary of IHNC Lock traffic in 1990 is presented in table 2 - 22. (A detailed discussion of the reconciliation process is presented in a subsequent section of the report.)

IHNC Lock traffic is only a portion of total system traffic. The two primary inland waterways that serve system traffic are segments of the Gulf Intracoastal Waterway: Mississippi River to Sabine River and Mobile Bay, Alabama to New Orleans, Louisiana. (Although the Gulf Intracoastal Waterway-Morgan City-Port Allen Alternate Route is comparable with the Mobile Bay to New Orleans segment in terms of throughput, most alternate route tonnage is common with the Mississippi River to Sabine segment.) Table 2 - 23 displays the distribution of traffic on these segments by commodity group and compares this distribution with that of the United States as a whole. Two characteristics of system traffic stand out: 1) with respect to the Mississippi River to Sabine River segment of the GIWW, 37 percent of all industrial chemical traffic and 33.5 percent of all crude petroleum traffic that is transported on the U.S. inland system was also routed through this waterway, and 2) with respect to coal, crude petroleum, industrial chemicals, and metallic ores and products, virtually all IHNC Lock traffic is accounted for in traffic recorded for the Mobile Bay to New Orleans

Table 2 - 22

IHNC Lock
1990 Traffic

Commodity	WCSC Unreconciled Tonnage	Percent	WCSC Reconciled Tonnage	Percent
Farm Products	371,118	1.63%	560,011	2.38%
Metallic Ores And Products	1,419,772	6.25%	1,419,772	6.04%
Coal	7,998,709	35.20%	7,998,709	34.05%
Crude Petroleum	2,290,608	10.08%	2,290,608	9.75%
Non-Metallic Minerals and Products	1,494,692	6.58%	2,075,399	8.83%
Forest Products	178,819	0.79%	178,819	0.76%
Industrial Chemicals	1,919,926	8.45%	1,919,926	8.17%
Agricultural Chemicals	500,879	2.20%	500,879	2.13%
Petroleum Products	6,000,634	26.41%	6,000,634	25.54%
Miscellaneous	547,639	2.41%	547,639	2.33%
Total	22,722,796	100.00%	23,492,396	100.00%

Source: Waterborne Commerce of the United States

Table 2 - 23

System Tonnage by Commodity For
Selected Waterway Segments

	U.S. Inland Traffic Total	GIWW: Mississippi River To Sabine River		GIWW: Mobile Bay, Ala., To New Orleans, La.		Innerharbor Navigation Canal Lock		
Commodity	Percent of 1990 Tonnage	Percent of 1990 Tonnage	Percent of U.S. 1990 Tonnage	Percent of 1990 Tonnage	Percent of U.S. 1990 Tonnage	Percent of 1990 Tonnage	Percent of GIWW-East Tonnage	Percent of U.S. 1990 Tonnage
Farm Products	13.1%	2.1%	1.8%	1.7%	0.5%	1.6%	86.3%	0.5%
Metallic Ores And Products	3.4%	5.3%	17.7%	5.9%	7.4%	6.2%	94.1%	6.9%
Coal	30.7%	0.0%	0.0%	31.0%	4.3%	35.2%	100.0%	4.3%
Crude Petroleum	8.4%	25.0%	33.5%	8.9%	4.5%	10.1%	100.0%	4.5%
Non-Metallic Minerals and Products	12.7%	10.9%	9.7%	6.7%	2.3%	6.6%	85.9%	2.0%
Forest Products & Pulp	3.1%	0.1%	0.3%	1.3%	1.8%	0.8%	53.1%	1.0%
Industrial Chemicals	5.2%	17.1%	37.0%	8.9%	7.3%	8.4%	84.1%	6.1%
Agricultural Chemicals	1.9%	1.5%	9.1%	2.0%	4.5%	2.2%	97.9%	4.
Petroleum Products	19.6%	34.1%	19.5%	31.3%	6.8%	26.4%	74.4%	5.1%
Miscellaneous	2.0%	3.9%	22.1%	2.4%	5.2%	2.4%	89.5%	4.6%
Total	100.0%	100.0%	11.2%	100.0%	4.3%	100.0%	88.1%	3.8%

Sources: 1. Waterborne Commerce of the United States
2. The 1992 Inland Waterway Review -- October 1992.

segment of the GIWW. A comparison of traffic for these two segments shows that an overwhelming majority of traffic on the Mobile to New Orleans segment is common to the IHNC Lock. In fact, among the major commodity groups, the lowest level of common traffic is found among petroleum products where nearly 75 percent of GIWW traffic for this group transits the IHNC Lock. Reported traffic for the Mobile to New Orleans segment is strongly representative of traffic through the IHNC Lock.
A review of commodity-specific traffic flows over the last decade on the Mobile to New Orleans segment, as summarized in Table 2 - 24, confirms earlier observation that coal, crude petroleum, petroleum products and industrial chemicals dominate traffic through the IHNC Lock. A similar concentration of traffic in these commodity groups exists for traffic on the Mississippi River to Sabine segment of the GIWW, with the exception of coal which shows insignificant volumes. In view of the fact that these four groups represent a large majority of system traffic, projections for these commodities in large measure dictate the level of total system traffic. Because of their importance, traffic projections for these groups must be regionally focused and specific to existing origin-destination patterns in order to be meaningful.

PROJECTIONS OF COAL TRAFFIC

Background

Waterborne Commerce statistics reported that 7,999,000 tons of coal transited the IHNC Lock in 1990, which represented over 35 percent of shallow-draft traffic through the lock in that year. The volume of coal traffic on the system that does not transit IHNC is negligible. The projection of future coal traffic is, therefore, a very important component of aggregate lock tonnage projections. Of the nearly eight million tons of coal that transited the lock in 1990, 91 percent was destined for four electric utility plants located in Mississippi and Florida. These facilities generate the energy needed to operate steam turbines by burning coal which is currently mined in the North Appalachian, Central Appalachian and Illinois basins and transported by barge via the Ohio and Mississippi Rivers and the Gulf Intracoastal Waterway. Although coal traffic through IHNC is largely dependent upon the demand for energy among a relatively small number of facilities, these utilities seek to ensure future supplies at stable prices by negotiating multi-year contracts. As a result, related coal tonnage through the lock has varied little from year to year. According to WCSC, total annual coal traffic to these specific facilities averaged 7,470,000 tons from 1985 to 1990 and over this period, annual

Table 2 - 24

Historical Traffic
On the Gulf Intracoastal Waterway
1980 Through 1990
(In Thousands of Short Tons)

Gulf Intracoastal Waterway, Mobile Bay, Ala., to New Orleans, La.

Year	Farm Products	Metallic Ores and Products	Coal	Crude Petroleum	Non-Metallic Minerals	Forest Products And Pulp	Industrial Chemicals	Agricultural Chemicals	Petroleum Products	Miscellaneous Products (Marine Shell)	Miscellaneous Products (Non-Shell)	Total
1980	739	418	3,950	1,729	1,512	276	1,420	1,073	6,140	1080	366	18,703
1981	552	859	3,346	999	1,629	239	1,538	906	6,132	979	163	17,342
1982	403	314	3,240	931	1,283	192	1,281	725	5,885	732	198	15,184
1983	517	767	2,978	1,314	1,284	199	1,453	657	6,419	807	130	16,525
1984	654	500	5,956	2,109	1,290	139	1,733	724	6,397	800	111	20,413
1985	694	647	6,086	2,696	1,674	244	1,521	603	6,475	800	137	21,577
1986	685	746	7,546	3,024	1,165	166	1,681	422	7,281	755	118	23,589
1987	530	773	7,332	3,190	982	173	2,125	319	7,818	706	122	24,070
1988	847	1,307	6,661	2,975	1,460	393	3,232	273	8,642	602	281	26,673
1989	543	939	7,352	3,111	1,321	338	2,029	245	9,203	404	135	25,620
1990	430	1,509	8,003	2,291	1,740	337	2,282	512	8,066	431	181	25,782
Avg.	599	798	5,677	2,215	1,395	245	1,845	587	7,133	736	177	21,407
Pct.	2.8%	3.7%	26.5%	10.3%	6.5%	1.1%	8.6%	2.7%	33.3%	3.4%	0.8%	100.0%

Gulf Intracoastal Waterway, Mississippi River, La., to Sabine River, Tex.

Year	Farm Products	Metallic Ores and Products	Coal	Crude Petroleum	Non-Metallic Minerals	Forest Products And Pulp	Industrial Chemicals	Agricultural Chemicals	Petroleum Products	Miscellaneous Products (Marine Shell)	Miscellaneous Products (Non-Shell)	Total
1980	831	3,642	99	12,241	5,289	37	8,494	977	18,532	3651	1059	54,852
1981	880	3,801	121	10,993	4,419	58	8,733	922	18,416	3044	1074	52,461
1982	815	1,926	15	12,263	4,972	30	8,155	968	17,727	2497	920	50,288
1983	922	1,599	60	13,238	4,957	27	8,991	907	17,144	2780	833	51,458
1984	813	2,529	24	14,414	6,103	51	9,898	839	17,480	2737	828	55,716
1985	1210	3,174	64	14,881	7,987	30	9,550	690	19,121	3010	3257	62,974
1986	1642	2,526	72	17,551	6,592	41	11,218	738	20,151	2371	1473	64,375
1987	1579	2,587	34	16,098	6,199	74	12,627	789	20,305	2030	1583	63,905
1988	1428	2,890	8	16,953	6,854	93	12,871	901	23,610	1478	2095	69,181
1989	1680	2,651	20	14,492	6,173	31	12,260	876	25,661	1677	796	66,317
1990	1433	3,614	8	16,882	7,382	65	11,568	1,032	23,046	1194	1429	67,653
Avg.	1,203	2,813	48	14,546	6,084	49	10,397	876	20,108	2,406	1,395	59,925
Pct.	2.0%	4.7%	0.1%	24.3%	10.2%	0.1%	17.3%	1.5%	33.6%	4.0%	2.3%	100.0%

Source: Waterborne Commerce of the United States

deliveries to these locations did not vary by more than eight percent from the average. Approximately 95 percent of this tonnage was routed through IHNC. Of the 133.2 million tons of coal that the U.S. Department of Energy (DOE) reported was transported by barge in 1990 to electric utilities nationwide, 7.3 million (5.5 percent) was routed through the IHNC Lock.

Future Coal Demand

Future coal traffic through the IHNC is largely a function of the projected consumption of coal by four steam plants located in Mississippi and Florida. The factors that affect the long-run demand for coal among the utilities that operate these plants are common to the industry as a whole. Although, utilities' coal demand commonly reflects the regional demand for electricity, the industry-wide demand for coal in the future will be further conditioned by the manner in which utilities comply with the emission standard mandated by the Clean Air Act Amendments of 1990. This standard requires coal-burning facilities to reduce sulphur-dioxide emissions to 2.5 pounds for each one million British Thermal Units (BTUs) of total energy consumed beginning in the year 1995 and to half that amount in the years 2000 and beyond. Efforts to comply with this legislation will effect, on a national level, changes in the demand for coal, the demand for waterborne transportation of coal, and the pattern of coal flows over the nation's waterways.

Of the four facilities previously mentioned, one (Company A) was designed and constructed under stringent regulatory guidelines which ensures that sulphur emissions will be within the range specified in the 1990 legislation. This utility is therefore not required to take any further actions with respect to compliance with the emissions standards. This facility accounts for a considerable portion of all coal traffic through the IHNC lock and thus represents an important factor in the development of traffic projections for coal.

In contrast, the remaining three plants do not currently comply with the sulphur emission standard. These plants currently burn coal that is relatively high in sulphur content while lacking the pollution control devices necessary to bring the quantity of sulphur emissions within the regulatory standard. In order to comply with the emission standard in 1995, two of the remaining utilities (Companies B and C) individually assessed several options which are summarized below.

First, the utilities could substitute low-sulphur coal for high-sulphur coal. The Tennessee Valley Authority and the Institute for Water Resources have indicated that between 25 to 30 percent more low-sulphur coal is required to yield the same BTU output of a given quantity of high-sulphur coal. Low-sulphur coal is mined in the Powder River basin (Montana and Wyoming), Central Appalachia (West Virginia, Kentucky and Tennessee) and, to a much smaller extent, in the Illinois basin (Illinois, Indiana and Kentucky). Low-sulphur coal imported from South America is an alternative to domestic sources, although the utilities have stated that they would not rely on import coal as the sole source of supply. Furthermore, mixing of imported coal with a domestic source may be required which would most likely be conducted at a Lower Mississippi River location where adequate landside space is available for this process. In either case of domestic or imported coal, the strict substitution of low-sulphur for high-sulphur coal would likely generate a net increase in coal traffic through the IHNC lock for the same level of electricity demand. Company B views a switch to low-sulphur coal as its most likely course of action while company C suggests that it will substitute low-sulphur coal for at least a portion of its total energy demand.

Second, natural gas can substitute for coal to reduce annual sulphur emissions to a level within the allowed standard. In this case, Company B would be required to retrofit its electricity generating units with gas-fired burners, an option which the company has stated is not under consideration. In contrast, most units at the plant operated by Company C already possess the capability to switch between coal and natural gas and the company plans to extend this capability to the remaining units. It is possible that coal consumption at this plant will fall and that projections of coal traffic through the IHNC lock would reflect the degree to which this occurs. However, natural gas would not entirely replace coal and a reduction in the sulphur content of the residual coal would still be required. In the past, Company C burned more natural gas and less coal during periods where natural gas prices were comparatively low, reflecting seasonal or cyclical market conditions. To this extent, the demand for coal is inversely related to the demand for natural gas. Actions that are required to conform to the clean air standard will not change the nature of this practice.

Third, burning facilities can be fitted with scrubbers which are designed to remove sulphur particles by treating the pollutants prior to emission. The multi-million dollar cost of these devices represents a very large up-front capital expenditure which must be compared to alternatives that spread the cost of compliance over time. Companies B and C have stated that they do not consider the installation of scrubbers to represent a viable option.

Last, governing legislation allows the marketing of sulphur emission allowances which constitute tangible financial assets of those utilities that succeed in generating sulphur emissions below specifically mandated levels. The market for sulphur emission allowances is in its formative stage. It is expected that the volatility in this market will not be less than in the coal market itself. Given the inherent unpredictability of the value and availability of emission allowances, utilities in general will be hard-pressed to depend upon allowance purchases over the long-run and will resist it as a fundamental means of regulatory compliance. So far, emission allowances have only been used to address short-term supply needs: coal suppliers have purchased a number of allowances from utilities for resale in a package which includes higher sulphur coal. In any event, excessive emissions permitted under the system of marketable allowances may directly conflict with ambient air-quality standards established by independent legislation, particularly at the state level, thus limiting the degree to which allowances can be used. For the industry as a whole, the value of this alternative is likely confined to its use as an intermediate measure which will accommodate utilities that, in the transition, find it in their interest to avoid an immediate commitment to one of the preceding alternatives. Neither Company B nor Company C plan to use emission allowances in their programs to comply with the emissions standards that take effect in 1995.

According to Companies B and C, no decisions have yet been made with respect to a long-term plan to comply with the new emission standard. However, representatives of these utilities have indicated what options they favored during the period of transition. For the two plants operated by the Company B, high-sulphur coal will be replaced with low-sulphur coal which will be mined in Central Appalachia. Although some consideration is being given to importing as much as half of their low-sulphur coal requirement which would be mixed with a domestic source at the port of import, we do not expect this practice to represent a long-term source of coal. In contrast, the Company C will substitute high-sulphur coal with low-sulphur coal and natural gas in proportions which the utility has not yet determined. Projections of coal tonnage for this company will be based on a substitution of low-sulphur for high-sulphur coal but will include a projection scenario which maximizes the substitution of natural gas for coal.

Projections of Coal Traffic Through IHNC Lock

Projections of coal traffic through IHNC Lock were the result of a two-step process. First, the 1990 base tonnage was increased to reflect the shift from high-sulphur to low-sulphur coal by three of the four electricity generating plants, identified in the preceding section, that are required to comply by 1995 with the sulfur emission standard (the remaining plant currently complies with the standard and will continue to use high-sulphur coal). To yield an equal amount of energy, measured in BTUs, 27 percent more low-sulphur coal will be required for every ton of high-sulphur coal that is substituted. Therefore, the 1990 base year tonnage for three of the four facilities was increased by 27 percent to reflect the effect of regulatory compliance.

Second, 1993 DOE regional projections of coal consumption by electricity-generating utilities were used as a basis to project growth in waterborne coal traffic. DOE projections were specific to ten regions of the United States, one of which, the southeast, was found to include the entire area served by the Gulf Intracoastal Waterway east of the Mississippi River. The states included in the southeast region are Mississippi, Alabama, Florida, Georgia, Kentucky, Tennessee, South Carolina and North Carolina. The growth factors for coal consumption by electricity-generating utilities in this region are displayed in table 2 - 25. These growth factors are used to represent the growth in coal traffic on the GIWW. As table 2 - 25 shows, traffic growth rates were developed for the periods 1990 to 2000, and 2000 to 2010.

Table 2 - 25 includes separate sets of growth rates for each of four macroeconomic cases. The economic assumptions that underlie these four cases are summarized in table 2 - 26. The Reference Case is a baseline scenario (or base case) and represents the level of future energy consumption that is consistent with economic conditions that are most likely to prevail in the future. These economic conditions include an annual gross domestic product (GDP) growth rate of 2.0 percent, a world oil price in the $19 to $23 per barrel range through the 1990's (rising to $29 by 2010), and economically recoverable oil and natural gas resources of 94 billion barrels and 892 trillion cubic feet, respectively.

In addition to the Reference Case, three alternative macroeconomic cases are identified (World Oil Prices, Economic Growth and Oil and Gas Recovery) which represent independent conditions that shape the production and

Table 2 - 25

Growth Factors for Coal Consumption
By Electricity-Generating Facilities
Southeastern United States

Case	Scenario	Growth Factors 1990 To 2000	Growth Factors 2000 To 2010	Average Annual Growth 1990 To 2000	Average Annual Growth 2000 To 2010
Reference		1.09	1.16	0.91%	1.52%
World Oil Prices	High	1.10	1.15	0.92%	1.44%
World Oil Prices	Low	1.10	1.17	0.91%	1.54%
Economic Growth	High	1.10	1.20	0.95%	1.87%
Economic Growth	Low	1.09	1.09	0.90%	0.86%
Oil and Gas Recovery	High	1.09	1.17	0.91%	1.54%
Oil and Gas Recovery	Low	1.10	1.21	0.92%	1.96%

Source: Supplement to the Annual Energy Outlook - 1993.
Energy Information Administration
U.S. Department of Energy

consumption of energy and related products. For each case, a high and low growth scenario is specified.

The World Oil Price Case accounts for the effect on the consumption of coal, crude petroleum, and petroleum products of higher or lower world oil prices. The high scenario combines the Reference Case economic growth trend with higher world oil prices starting at $19 per barrel in 1991 and rising gradually to $38 in 2010. The net effect of higher oil prices is a lower level of economic growth over the projection period and a substitution of coal for petroleum-based energy by the year 2010. The low scenario combines the Reference Case economic growth trend with lower world oil prices that will fall to $14 per barrel by 1999 and rise to $18 per barrel by 2010. The effect of lower world oil prices is to increase the level of economic growth in the United States and to encourage the substitution of petroleum-based energy for coal through the year 2010.

The Economic Growth Case reflects the changes in energy demand caused by higher or lower levels of growth in GDP. The high scenario combines the level of world oil prices expected under the Reference Case with economic growth of 2.4 percent. Higher growth is associated with increased industrial production and high levels of energy-related products transported on waterway modes. Under the low scenario, a lower level of energy-related traffic is expected due to economic growth of only 1.6 percent per year.

The Oil and Gas Recovery Case reflects the inherent uncertainties surrounding estimates of domestic oil and gas resource estimates. While the quantity of oil and gas reserves indicated under Reference Case represents the expected value (50th percentile) of a distribution of reserve estimates made by the U.S. Geological Survey, the high scenario represents the quantity of reserves prevailing at the 95th percentile reserve estimate and the low scenario represents the quantity of reserves prevailing at the 5th percentile reserve estimate. The high scenario is consistent with economically recoverable reserves of 126 billion barrels of crude oil and 1,125 trillion cubic feet of natural gas. Under this scenario, coal consumption remains essentially unchanged. The low scenario is consistent with economically recoverable reserves of 75 billion barrels of crude oil and 721 trillion cubic feet of natural gas. Under the low scenario, greater quantities of coal are consumed to compensate for the lower than expected levels of oil and gas resources.

The energy demand growth factors displayed in table 2 - 25 were combined with the low-sulphur demand growth factor of 1.27 (reflecting the consequence of regulatory compliance for relevant coal movements) and applied to the 1990 base tonnage to produce estimates for future tonnage. The results of these calculations appear in table 2 - 27 for the Reference Case and each of the remaining scenarios. Under the Reference Case, the aggregate quantity of coal that will transit the IHNC lock will increase by 28 percent from 1990 to 2000 (an average annual rate of 2.5 percent, although most of the increase will occur in the Clean Air Act compliance year of 1995) and by 16 percent from 2000 to 2010 (an average annual rate of 1.5 percent). The 1.5 percent annual growth rate for the period 2000 to 2010 was carried forward for the remaining years of the project. The tonnages for coal displayed in table 2 - 27 represent coal traffic through IHNC that is unconstrained by lock congestion. Coal traffic through the lock represents virtually all coal traffic through the system.

The growth factors for coal under the high economic growth scenario and the high oil and gas recovery scenario each represent a different response to Clean Air Act requirements by one of the three major utilities that transport coal through the IHNC Lock. One of the utilities has indicated that imports of low-sulphur coal from Venezuela through the Lower Mississippi River represented an alternative to Central Appalachian coal, although the switch to low-sulphur Central Appalachian coal would be the likely form of regulatory compliance. For this utility, the high economic growth scenario represented a set of macroeconomic conditions which would most likely result in higher prices for domestic energy resources and in a subsequent decision by the utility to import additional coal. Under this scenario, half the tonnage associated with this movement consists of high-sulphur coal shipped from Central Appalachia to the Lower Mississippi River where it is blended with an equal quantity of (very) low-sulphur coal that is imported from Venezuela and then shipped through the IHNC to the utility. Another of the three utilities indicated that natural gas represents a preferred energy source to low sulphur coal depending upon the relative prices of the two commodities. Their relative prices, in turn, reflect the relative quantities of these commodities that are available. Under the high oil and gas resource scenario, the abundance of natural gas is highest and natural gas is more price competitive with coal. The possibility that this utility would switch to natural gas, rather than low-sulphur coal, as the fundamental method of regulatory compliance was incorporated into this scenario. Under these circumstances the utility indicated that it would continue to ship 20 percent of the low-sulphur coal

Table 2 - 26

Macroeconomic Assumptions
For Reference Case And Projection Scenarios

Case	Scenario	GDP Annual Growth	World Oil Price Per Bbl		Economically Recoverable: Oil in Billion Bbls	Economically Recoverable: Gas in Trillion Cuft
Reference		2.0	19-23/29	^	94	892
World Oil Prices	High	2.0	19/38	^^	94	892
World Oil Prices	Low	2.0	14/18	^^^	94	892
Economic Growth	High	2.4	19-23/29		94	892
Economic Growth	Low	1.6	19-23/29		94	892
Oil and Gas Recovery	High	2.0	19-23/29		126	1125
Oil and Gas Recovery	Low	2.0	19-23/29		75	721

Notes: ^ $19-23 for the 1990's and rising to $29 by 2010.
^^ $19 in 1991 and rising to 38 in 2010.
^^^ Falling to $14 by 1999 and rising to $18 by 2010.

Source: Supplement to the Annual Energy Outlook - 1993.
Energy Information Administration
U.S. Department of Energy

Table 2 - 27

Projected Coal Traffic
IHNC Lock
(In Thousands of Short Tons)

Projection Scenario	Annual Growth 1990-2000	2000-2010	Projection Years 1990	2000	2010	2020	2030	2040	2050	2060
Reference	2.6%	1.5%	7,999	10,308	11,987	13,940	16,210	18,850	21,920	25,491
Oil Price - High	2.6%	1.4%	7,999	10,320	11,909	13,742	15,858	18,299	21,116	24,366
Oil Price - Low	2.6%	1.5%	7,999	10,314	12,023	14,016	16,338	19,045	22,201	25,879
Econ Growth- High	2.2%	1.9%	7,999	9,964	11,992	14,432	17,369	20,903	25,157	30,276
Econ Growth - Low	2.6%	0.9%	7,999	10,296	11,217	12,220	13,313	14,503	15,800	17,213
O/G Recovery-High	0.2%	1.5%	7,999	8,199	9,554	11,132	12,971	15,114	17,611	20,521
O/G Recovery- Low	2.6%	2.0%	7,999	10,320	12,535	15,225	18,491	22,459	27,279	33,132

that it would consume under the Reference Case, shifting the remainder of their energy requirements to natural gas which would be shipped by pipeline.

PROJECTIONS OF CRUDE PETROLEUM TRAFFIC

Background

a. Gulf Intracoastal Waterway: Mobile Bay, Ala. To New Orleans, La. In 1990, 2,291,000 tons of crude petroleum transited the IHNC Lock, representing nearly ten percent of total lock traffic. Approximately 90 percent of the crude petroleum routed through the IHNC in 1990 was destined for eight specific facilities on the Lower Mississippi River, GIWW-West and in Mobile, Ala. Crude petroleum discharged at these locations are used as feedstock for local refineries which have strict requirements with respect to the grade and composition of the petroleum used in their operations.

The IHNC Lock averaged 2,215,000 tons of crude petroleum for the period 1980 through 1990. This estimate was based on Waterborne Commerce statistics for the Mobile to New Orleans segment of the GIWW since virtually all crude petroleum traffic on this segment also transited the IHNC lock. Table 2-24 shows that crude petroleum traffic on this segment grew steadily from 1982 to 1987 and held constant through 1989 before falling significantly in 1990. An inspection of 1989 Waterborne Commerce detailed records indicates that between 50 and 60 percent of IHNC Lock traffic is common to traffic on the GIWW west of the Mississippi River.

b. Gulf Intracoastal Waterway: Mississippi River To Sabine River. Most crude petroleum transported on waterway system defined for this study is associated with the Louisiana section of the GIWW west of the Mississippi River. As reported by Waterborne Commerce in table 2 - 24, this segment averaged 14.5 million tons from 1980 through 1990. Table 2 - 24 also shows that crude petroleum traffic grew steadily from 1981 to 1986, after which reported tonnage exhibited an erratic pattern, indicating no tendency for growth or decline.

Projections of Crude Petroleum Traffic

a. Crude Traffic Not Common With the IHNC. Because growth in crude petroleum traffic on the GIWW was inconsistent from 1987 through 1990, trend analysis cannot serve as a basis for projecting future traffic. Instead, projections of crude petroleum traffic on the GIWW should reflect the expected level of regional crude petroleum production. Projections of crude petroleum production in the years 2000 and 2010 were prepared by DOE and are used in this analysis to represent future growth in waterborne traffic in crude petroleum.

DOE projections for crude oil production within the continental United States are disaggregated to six regions one of which, the Gulf Coast region (representing Florida, Alabama, Mississippi, Louisiana and Southeastern Texas), was selected to represent activity on the GIWW. In addition to the Reference Case, petroleum supply projections include high and low growth scenarios for each of three macroeconomic cases which were described in detail in the preceding section. DOE also prepared separate projections for onshore and offshore production. Onshore production estimates were chosen to represent future traffic growth on the GIWW since the transportation of petroleum extracted offshore is far more likely to be associated with pipelines. Estimates of the number of barrels of crude oil produced from onshore fields located in the gulf region and the associated growth factors for the Reference Case and all other scenarios are detailed in table 2 - 28. The growth factors that prevail in the year 2010 are used as the growth factors for the remainder of the study period.

b. Crude Traffic Through the IHNC Lock. DOE projections of crude petroleum production in the gulf region were also used to estimate future crude petroleum traffic through the IHNC Lock. It must be recognized, however, that crude traffic through the IHNC Lock is partially independent of the crude traffic through the remainder of the system. This partial independence is reflected, in some measure, in the differential growth rates in crude traffic between the IHNC Lock and the GIWW west of the Mississippi River over the previous decade. As mentioned earlier, crude petroleum traffic through the IHNC Lock grew steadily from 1982 to 1987 and held constant through 1989 before declining significantly in 1990. In contrast, crude petroleum traffic on the Mississippi River to Sabine segment of the GIWW, while growing steadily from 1981 to 1986, fluctuated for the remaining four years of the decade. While the factors that determine the level of regional waterborne transportation in crude petroleum may, in the long run, equally affect traffic through the lock and the remainder of the system, these factors have not resulted, according to recent data, in similar traffic patterns between these two segments.

c. System Traffic for Crude Petroleum. The growth factors appearing in table 2 - 28 were applied to the 1990 base traffic that was routed through both the IHNC Lock and

Table 2 - 28

Crude Oil Production
Gulf of Mexico - Onshore
Gulf Intracoastal Waterway
Mississippi River to Sabine River

	1990	2000	2010
	Millions of Barrels Per Day (Annual Growth Rate)		
Reference Case	1.03	0.71 (-3.7%)	0.91 (2.5%)
World Oil Price Case			
High	1.03	0.84 (-2.0%)	1.04 (2.2%)
Low	1.03	0.48 (-7.4%)	0.66 (3.2%)
Economic Growth Case			
High	1.03	0.70 (-3.8%)	0.89 (2.4%)
Low	1.03	0.71 (-3.7%)	0.89 (2.3%)
Oil & Gas Recovery Case			
High	1.03	0.73 (-3.4%)	0.96 (2.8%)
Low	1.03	0.70 (-3.8%)	0.82 (1.6%)
	Growth Factors		
Reference Case		0.689	1.282
World Oil Price Case			
High		0.816	1.238
Low		0.466	1.375
Economic Growth Case			
High		0.680	1.271
Low		0.689	1.254
Oil & Gas Recovery Case			
High	-	0.709	1.315
Low	-	0.680	1.171

Source: Supplement to the Annual Energy Outlook - 1993
Energy Information Administration
U.S. Department of Energy

the entire system to yield a set of projected tonnages for the years 2000 through 2010. The process was repeated for each of the six DOE scenarios. The results appear in table 2 - 29. These rates show a significant decline in production and traffic between 1990 and 2000. In contrast, tonnage in the year 2010 shows a significant recovery from traffic levels in the year 2000. The relatively high rate of growth for the recovery period 2000-2010 in large measure reflects the effect relatively low growth rate for the period 1990-2000. The percent change in traffic for the period 1990 through 2010 is small. For projected traffic in the years 2020 and beyond, the average annual rate used to grow traffic was based on the 20-year period 1990 through 2010 rather than the 10-year period 2000 through 2010.

PROJECTIONS OF PETROLEUM PRODUCTS TRAFFIC

Background

In 1990, over 6 million tons of petroleum products transited the IHNC, representing a quarter of total lock tonnage and nearly three quarters of all petroleum products traffic on the segment of the GIWW between Mobile, Ala. and New Orleans, La. WCSC reported that nearly 20 percent (23,046 million tons) of all waterborne traffic in petroleum products nationwide used the GIWW from the Mississippi to Sabine Rivers. Petroleum products therefore constitute an important component of system traffic.

Petroleum products as a category represents an aggregate of the following commodity groups: gasoline; jet fuel; kerosene; distillate fuel oil; residual fuel oil; lubricating oil and greases; naphtha and petroleum solvents; asphalt, tars and pitches; coke and petroleum coke; liquefied gasses and other petroleum and coal products. Most of these commodities are produced by refineries that are located in or near Pascagoula, Miss. and Corpus Christi, Tex. and along the Lower Mississippi River, including New Orleans, LA.

Projections of Petroleum Products Traffic

Projections of waterborne traffic associated with petroleum products reflect future levels of product consumption which are expected within those regions of the U.S. that currently receive petroleum products shipped through the IHNC. Future energy consumption by commercial, industrial, residential, transportation and utility sectors of specific regional economies was estimated by the Department of Energy in its Supplement to the Annual Energy Outlook (AEO) which was published in 1993. In using the AEO projections,

Table 2 - 29

Projected Crude Petroleum Traffic
(In Thousands of Short Tons)

	Annual Growth		Projection Years							
Projection Scenario	1990-2000	2000-2010	1990	2000	2010	2020	2030	2040	2050	2060
IHNC Lock Traffic										
Reference	-3.7%	2.5%	2,291	1,578	2,024	1,902	1,787	1,680	1,579	1,484
Oil Price - High	-2.0%	2.2%	2,291	1,869	2,314	2,326	2,338	2,350	2,362	2,374
Oil Price - Low	-7.4%	3.2%	2,291	1,068	1,468	1,175	941	753	603	482
Econ Growth- High	-3.8%	2.4%	2,291	1,558	1,980	1,841	1,711	1,591	1,479	1,375
Econ Growth - Low	-3.7%	2.3%	2,291	1,578	1,979	1,840	1,710	1,590	1,478	1,374
O/G Recovery-High	-3.4%	2.8%	2,291	1,624	2,136	2,062	1,991	1,923	1,857	1,793
O/G Recovery- Low	-3.8%	1.6%	2,291	1,558	1,824	1,628	1,453	1,296	1,157	1,032
System Traffic										
Reference	-3.7%	2.5%	15,286	10,532	13,502	12,690	11,926	11,209	10,535	9,901
Oil Price - High	-2.0%	2.2%	15,286	12,473	15,442	15,521	15,600	15,679	15,759	15,839
Oil Price - Low	-7.4%	3.2%	15,286	7,123	9,795	7,840	6,276	5,024	4,021	3,2
Econ Growth- High	-3.8%	2.4%	15,286	10,394	13,211	12,282	11,418	10,615	9,869	9,175
Econ Growth - Low	-3.7%	2.3%	15,286	10,532	13,207	12,276	11,411	10,607	9,859	9,164
O/G Recovery-High	-3.4%	2.8%	15,286	10,838	14,252	13,761	13,287	12,830	12,388	11,962
O/G Recovery- Low	-3.8%	1.6%	15,286	10,394	12,172	10,862	9,692	8,649	7,718	6,887

changes in the future regional consumption of petroleum products were related to proportional changes in the delivery of these commodities through the waterway mode.

The AEO contains estimates of current and future consumption of gasoline, jet fuel, distillate fuel oil, residual fuel oil, liquefied petroleum gas and other petroleum products expressed in BTUs. Furthermore, the AEO provides individual estimates for each of ten regions in the United States, three of which receive petroleum products that are part of system traffic. These three regions are: South Atlantic (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee), Southwest (Arkansas, Louisiana, New Mexico, Oklahoma, Texas) and Midwest (Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin). From the AEO consumption estimates for each commodity and region, growth factors were calculated for the periods 1990 to 2000 and 2000 to 2010 which represent the Reference Case. These factors were then applied to tonnages for individual commodity movements. The growth factor that was applied to the tonnage within an individual movement corresponded to the region in which the destination port of the movement is associated. Finally, a set of growth factors were derived for each of three macroeconomic cases that appear in the AEO: the Oil Price Case, the Economic Growth Case and the Oil Recovery Case. As with the projections for coal and crude, for each of these cases a high growth and a low growth scenario was considered. The comprehensive set of growth factors derived from the AEO publication appears in table 2 - 30. These growth factors were then multiplied against base tonnages for all cases and for specific movements in order to yield unconstrained tonnage estimates for the system in the years 2000 and 2010. For project years beyond 2010, the rates of traffic growth were held to those prevailing in the year 2010. A summary of system traffic and IHNC Lock traffic in petroleum products is provided in table 2 - 31.

PROJECTIONS OF WATERWAY TRAFFIC IN OTHER COMMODITY GROUPS

Background

Together, coal, crude petroleum and petroleum products accounted for nearly 72 percent of total IHNC Lock traffic in 1990. The remaining 28 percent of lock traffic falls among seven commodity groups: farm products, metallic ores and products, non-metallic minerals and products, forest products, industrial chemicals, agricultural chemicals and miscellaneous cargo. Because coal is not a major component of traffic on the Mississippi River to Sabine River segment of the GIWW, coal, crude and petroleum products constituted

Table 2 - 30

Petroluem Products
Growth Factors

Reference Case	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.13	1.18	1.18	1.36	1.15	0.97
Southwest	1.14	1.31	1.17	1.24	1.28	0.95
Midwest	1.06	1.11	1.15	1.52	1.60	0.95
2000 - 2010						
South Atlantic	1.11	1.27	1.16	1.04	0.97	1.00
Southwest	1.08	1.20	1.15	1.16	1.13	1.01
Midwest	1.02	1.09	1.04	0.76	1.04	1.01

High Oil Price	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.09	1.15	1.15	1.30	1.11	0.95
Southwest	1.10	1.28	1.15	1.20	1.20	0.93
Midwest	1.02	1.08	1.12	1.12	1.54	0.93
2000 - 2010						
South Atlantic	1.07	1.25	1.15	1.06	0.96	1.00
Southwest	1.05	1.19	1.13	1.16	1.11	1.01
Midwest	1.02	1.09	1.04	0.76	1.04	1.01

Low Oil Price	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.19	1.23	1.25	2.58	1.23	1.01
Southwest	1.20	1.37	1.29	1.36	1.47	0.99
Midwest	1.12	1.16	1.22	1.96	1.69	0.98
2000 - 2010						
South Atlantic	1.15	1.28	1.23	0.99	0.99	1.00
Southwest	1.13	1.22	1.20	1.15	1.16	1.01
Midwest	1.06	1.10	1.08	2.16	1.07	1.01

High Economic Growth	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.15	1.28	1.23	1.62	1.16	0.98
Southwest	1.16	1.42	1.22	1.28	1.30	0.95
Midwest	1.08	1.20	1.19	1.46	1.62	0.96
2000 - 2010						
South Atlantic	1.14	1.35	1.19	0.80	0.98	1.01
Southwest	1.12	1.28	1.18	1.17	1.15	1.02
Midwest	1.05	1.16	1.08	0.96	1.06	1.02

Table 2 - 30
(Cont.)

Low Economic Growth	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.11	1.08	1.12	1.15	1.14	0.95
Southwest	1.12	1.20	1.12	1.20	1.26	0.93
Midwest	1.04	1.02	1.10	1.39	1.57	0.93
2000 - 2010						
South Atlantic	1.07	1.18	1.13	1.37	0.95	1.00
Southwest	1.05	1.12	1.11	1.14	1.09	1.01
Midwest	0.99	1.01	1.02	0.82	1.02	1.01

High Oil Recovery	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.13	1.18	1.17	1.36	1.14	0.97
Southwest	1.14	1.31	1.17	1.24	1.27	0.95
Midwest	1.06	1.11	1.15	1.41	1.59	0.95
2000 - 2010						
South Atlantic	1.10	1.27	1.15	1.03	0.96	1.01
Southwest	1.08	1.21	1.14	1.16	1.11	1.01
Midwest	1.01	1.09	1.04	0.94	1.04	1.01

Low Oil Recovery	Gasoline	Jet Fuel	Distillate	Residual	LPG	Other
1990 - 2000						
South Atlantic	1.13	1.18	1.17	1.37	1.16	0.97
Southwest	1.14	1.31	1.17	1.24	1.30	0.95
Midwest	1.06	1.11	1.15	1.34	1.60	0.95
2000 - 2010						
South Atlantic	1.11	1.26	1.16	1.04	0.98	1.00
Southwest	1.08	1.20	1.15	1.16	1.15	1.01
Midwest	1.02	1.09	1.05	0.90	1.06	1.01

Source: Supplement to the Annual Energy Outlook - 1993
Energy Information Administration
U.S. Department of Energy

Table 2 - 31

Projected Petroleum Products Traffic
(In Thousands of Short Tons)

Projection Scenario	Annual Rate of Growth 1990 - 2000	2000 - 2010	Projection Years 1990	2000	2010	2020	2030	2040	2050	2060
IHNC Lock Traffic										
Reference	1.5%	1.0%	6,001	6,963	7,683	8,521	9,497	10,641	12,106	13,571
Oil Price - High	1.1%	0.9%	6,001	6,722	7,338	8,046	8,862	9,806	10,987	12,167
Oil Price - Low	3.4%	1.0%	6,001	8,415	9,311	10,421	11,839	13,736	17,185	20,633
Econ Growth- High	2.1%	0.8%	6,001	7,359	7,964	8,812	9,939	11,398	13,506	15,613
Econ Growth - Low	1.0%	1.2%	6,001	6,607	7,434	8,455	9,728	11,330	13,663	15,995
O/G Recovery-High	1.5%	0.9%	6,001	6,955	7,637	8,427	9,346	10,420	11,786	13,151
O/G Recovery- Low	1.5%	1.0%	6,001	6,982	7,719	8,575	9,573	10,741	12,234	13,727
System Traffic										
Reference	1.1%	0.9%	23,512	26,333	28,794	31,634	34,912	38,696	43,444	48,192
Oil Price - High	2.2%	1.1%	23,512	29,187	32,596	36,857	42,447	50,304	66,443	82,5[illegible]
Oil Price - Low	0.8%	0.8%	23,512	25,536	27,692	30,159	32,984	36,222	40,233	44,[illegible]
Econ Growth- High	1.2%	0.9%	23,512	26,367	28,901	31,811	35,612	39,026	43,863	48,7[illegible]
Econ Growth - Low	1.1%	0.9%	23,512	26,291	28,714	31,489	34,675	38,340	42,903	47,466
O/G Recovery-High	0.8%	0.8%	23,512	25,429	27,580	30,083	33,019	36,489	41,042	45,595
O/G Recovery- Low	1.5%	1.0%	23,512	27,240	30,114	33,605	37,818	42,884	49,573	56,261

only 58 of traffic on this segment of the system in 1990. However, among the remaining commodities on the GIWW-West, industrial chemicals represented over 17 percent of total traffic. In fact, the movement of industrial chemicals on this segment of the GIWW accounted for 37 of all inland movements of this commodity in the United States, reflecting the extensive presence of the petrochemical industry in southern Louisiana and Texas.

Projections of Traffic in Other Commodities

Projections of system traffic for the commodity groups listed in the preceding paragraph were adapted from projections of U.S. inland waterway traffic, by commodity group, that were prepared by a number of public and private agencies and published in the Institute for Water Resources (IWR) report The 1992 Inland Waterway Review. Since the level of traffic among the remaining commodities were minor compared to the groups previously considered, projected traffic for these commodities can be derived through the use of national-level projections. For the exception, industrial chemicals, which showed significant volumes, it was appropriate to use national-level projections since system traffic represented over 37 percent of total U.S. traffic for this commodity. Projected tonnages in these seven groups were made for the years 2000 and 2010. Table 2 - 34 shows both the tonnage estimates and the associated annual growth rates for these commodities. The growth factors corresponding to the annual growth rates displayed in table 2 - 32 were applied to the 1990 base tonnage to yield estimated system tonnage for the same years. For succeeding years, the growth factor associated with the period 2000 to 2010 was carried forward.

Projections of marine shell (a component of the miscellaneous commodity group) was an exception. Over the 1980 to 1990 period, marine shell represented between 3 and 4 percent of system traffic. However, a state regulatory ban on the dredging of clam shell in Lake Pontchartrain and the rapid exhaustion of oyster shell resources in the Atchafalaya Bay will cause waterway traffic to fall to zero by the year 2000. Therefore, tonnage for this commodity group was set to zero over the entire project life. High and low traffic scenarios were prepared for each of the seven commodity groups. The growth factors associated with the scenarios were based on the high and low tonnage projection scenarios that were identified in The 1992 Inland Waterway Review mentioned above. Tonnages and growth rates for the low and high scenarios appear in tables 2 - 33 and 2 - 34, respectively. For marine shell, the preparation of a low scenario was unnecessary. The high scenario for marine shell was based on a more gradual

Table 2 - 32

U.S. Inland Waterway
Commodity Movements

Commodity Group	Commodity Movements (In Millions of Short Tons)			Annual Growth Rate	
	1990	2000	2010	1990 to 2000	2000 to 2010
Farm Products	83.1	102.3	123.5	2.1%	1.9%
Metallic Ores And Products	15.2	13.9	13.5	-0.9%	-0.3%
Non-Metallic Minerals and Products	76.0	79.9	84.0	0.5%	0.5%
Forest Products & Pulp	21.2	24.9	27.0	1.6%	0.8%
Industrial Chemicals	34.7	45.8	54.2	2.8%	1.7%
Agricultural Chemicals	12.9	17.4	20.1	3.0%	1.5%
All Other Commodities Non-Shell	23.2	20.8	22.3	-1.1%	0.7%

Sources: 1. Data Resources (DRI).
2. WEFA Group (formerly Wharton and Chase Econometrics).
3. U.S. Department of Agriculture (USDA).
4. U.S. Department of Energy (DOE).
5. Various trade associations.

Table 2 - 33

U.S. Inland Waterway
Commodity Movements

Low Growth Scenario

Commodity Group	Commodity Movements (In Millions of Short Tons)			Annual Growth Rate	
	1990	2000	2010	1990 to 2000	2000 to 2010
Farm Products	81.6	94.7	109.9	1.5%	1.5%
Metallic Ores And Products.	14.1	13.5	12.1	-0.4%	-1.1%
Non-Metallic Minerals and Products	69.9	69.4	71.5	-0.1%	0.3%
Forest Products & Pulp	20.6	22.7	23.3	1.0%	0.3%
Industrial Chemicals	33.3	39.4	43.9	1.7%	1.1%
Agricultural Chemicals	12.3	15.7	16.1	2.5%	0.3%
All Other Commodities Non-Shell	22.0	17.4	15.6	-2.3%	-1.1%

Sources: 1. Data Resources (DRI).
2. WEFA Group (formerly Wharton and Chase Econometrics).
3. U.S. Department of Agriculture (USDA).
4. U.S. Department of Energy (DOE).
5. Various trade associations.

Table 2 - 34

U.S. Inland Waterway
Commodity Movements

High Growth Scenario

Commodity Group	Commodity Movements (In Millions of Short Tons)			Annual Growth Rate	
	1990	2000	2010	1990 to 2000	2000 to 2010
Farm Products	86.9	112.0	135.2	2.6%	1.9%
Metallic Ores And Products	17.2	17.0	16.6	-0.1%	-0.2%
Non-Metallic Minerals and Products	77.5	81.9	86.1	0.6%	0.5%
Forest Products & Pulp	24.4	26.1	29.2	0.7%	1.1%
Industrial Chemicals	35.7	50.3	66.2	3.5%	2.8%
Agricultural Chemicals	14.4	20.1	23.4	3.4%	1.5%
All Other Commodities Non-Shell	24.9	26.7	28.6	0.7%	0.7%

Sources: 1. Data Resources (DRI).
2. WEFA Group (formerly Wharton and Chase Econometrics).
3. U.S. Department of Agriculture (USDA).
4. U.S. Department of Energy (DOE).
5. Various trade associations.

depletion of shell resources, reflected by a 71 percent decline in tonnage from 1990 to 2000 but falling to zero in the year 2010. Under the high scenario, future clam shell traffic originating from Lake Pontchartrain remains zero.

Projections for both system traffic and IHNC lock traffic under the base case and under the high and low scenarios for the seven commodity groups are presented in table 2 - 35. Tonnage projections for marine shell by year and scenario for the lock and the system are presented in table 2 - 36.

PROJECTIONS OF COMBINED TONNAGE

Tonnage estimates for total IHNC lock traffic for each of the projection years under the Reference Case were prepared by summing the projected tonnages for all commodity groups. These totals appear in table 2 - 37. [Note: Specific tonnage estimates for this and successive tables were generated in other than a spreadsheet environment and may differ from those presented in earlier tables due to the cumulative effects of rounding.]

Projections of total IHNC lock traffic for low and high scenarios were compiled in a similar manner. For coal, crude petroleum and petroleum projects, the low and high scenario tonnages were defined as the lowest and highest tonnages prevailing among the six scenarios constructed by the DOE. The lowest traffic levels for coal, crude petroleum and petroleum products are suggested by DOE's High Oil and Gas Recovery Case, Low World Oil Price Case and High World Oil Price Case, respectively. The highest traffic levels for coal, crude petroleum and petroleum products are represented by DOE's Low Oil and Gas Recovery Case, High World Oil Price Case and Low World Oil Price Case, respectively.

For the remaining commodity groups, the low and high scenario tonnages correspond to the low and high scenarios that were defined in The 1992 Inland Waterway Review. Total lock tonnages by year under the low scenario is presented in table 2 - 38. Total lock tonnage by year under the high scenario appears in table 2 - 39.

Projections of total system traffic under the Reference Case and low and high scenarios were prepared in an identical manner to those for IHNC Lock traffic. Table 2 - 40 summarizes baseline system traffic. Table 2 - 41 presents system traffic under the low scenario while table 2 - 42 describes system tonnage under the high scenario. Table 2 - 43 summarizes the average annual growth rates for total IHNC Lock tonnage in addition to those for individual

Table 2 - 35

Projected Traffic in Other Commodities

Projection Scenario	Projection Years								Growth Factors	
	1990	2000	2010	2020	2030	2040	2050	2060	1990 - 2000	2000 - 2010
IHNC LOCK TRAFFIC				(In Thousands of Short Tons)						
Baseline										
Farm Products	560	689	832	1005	1213	1464	1768	2134	1.23	1.21
Metallic Ores & Mins.	1420	1299	1261	1225	1190	1155	1122	1090	0.91	0.97
Non-Metallic Mins.	2075	2181	2293	2411	2535	2665	2802	2945	1.05	1.05
Forest Products	179	210	228	247	268	291	315	342	1.17	1.08
Industrial Chemicals	1920	2534	2999	3549	4200	4970	5882	6960	1.32	1.18
Agricultural Chemicals	501	676	781	902	1042	1203	1390	1606	1.35	1.16
All Other (Non-Shell)	202	181	194	208	223	239	257	275	0.90	1.07
Low										
Farm Products	560	650	754	875	1016	1179	1368	1588	1.16	1.16
Metallic Ores & Mins.	1420	1360	1219	1092	979	877	786	705	0.96	0.90
Non-Metallic Mins.	2075	2060	2122	2187	2253	2321	2391	2464	0.99	1.03
Forest Products	179	197	202	208	213	219	225	231	1.10	1.03
Industrial Chemicals	1920	2272	2531	2820	3142	3501	3901	4347	1.18	1.11
Agricultural Chemicals	501	639	656	672	690	707	725	744	1.28	1.03
All Other (Non-Shell)	202	160	143	128	115	103	93	83	0.79	0.90
High										
Farm Products	560	722	871	1052	1270	1533	1850	2233	1.29	1.21
Metallic Ores & Mins.	1420	1403	1370	1338	1307	1276	1246	1217	0.99	0.9
Non-Metallic Mins.	2075	2193	2305	2423	2548	2678	2816	2960	1.06	1.0
Forest Products	179	191	214	240	268	300	336	375	1.07	1.12
Industrial Chemicals	1920	2705	3560	4686	6167	8116	10682	14059	1.41	1.32
Agricultural Chemicals	501	699	814	948	1103	1285	1495	1741	1.40	1.16
All Other (Non-Shell)	202	217	232	249	266	285	305	327	1.07	1.07
SYSTEM TRAFFIC										
Baseline										
Farm Products	2,368	2,915	3,519	4,249	5,129	6,192	7,475	9,024	1.23	1.21
Metallic Ores & Mins.	5,153	4,712	4,577	4,445	4,317	4,193	4,072	3,955	0.91	0.97
Non-Metallic Mins.	12,088	12,708	13,360	14,046	14,767	15,525	16,321	17,159	1.05	1.05
Forest Products	244	287	311	337	365	396	430	466	1.17	1.08
Industrial Chemicals	11,830	15,614	18,478	21,867	25,877	30,624	36,240	42,887	1.32	1.18
Agricultural Chemicals	2,777	3,746	4,327	4,998	5,774	6,670	7,705	8,901	1.35	1.16
All Other (Non-Shell)	1,060	950	1,019	1,092	1,171	1,256	1,346	1,443	0.90	1.07
Low										
Farm Products	2,368	2,748	3,189	3,701	4,295	4,985	5,785	6,713	1.16	1.16
Metallic Ores & Mins.	5,153	4,934	4,422	3,963	3,552	3,184	2,854	2,558	0.96	0.90
Non-Metallic Mins.	12,088	12,002	12,365	12,739	13,124	13,521	13,931	14,352	0.99	1.03
Forest Products	244	269	276	283	291	298	306	314	1.10	1.03
Industrial Chemicals	11,830	13,997	15,596	17,377	19,362	21,573	24,037	26,782	1.18	1.11
Agricultural Chemicals	2,777	3,545	3,635	3,728	3,823	3,920	4,020	4,122	1.28	1.03
All Other (Non-Shell)	1,060	838	752	674	604	542	486	435	0.79	0.90
High										
Farm Products	2,368	3,052	3,684	4,447	5,369	6,481	7,823	9,443	1.29	1.21
Metallic Ores & Mins.	5,153	5,093	4,973	4,856	4,742	4,630	4,521	4,415	0.99	0.98
Non-Metallic Mins.	12,088	12,774	13,429	14,118	14,842	15,603	16,403	17,245	1.06	1.0
Forest Products	244	261	292	327	365	409	457	512	1.07	1.12
Industrial Chemicals	11,830	16,668	21,937	28,871	37,997	50,009	65,816	86,621	1.41	1.32
Agricultural Chemicals	2,777	3,876	4,513	5,254	6,116	7,120	8,289	9,650	1.40	1.16
All Other (Non-Shell)	1,060	1,137	1,218	1,304	1,397	1,496	1,603	1,717	1.07	1.07

Table 2 - 36

Projected Traffic Growth
(In Thousands of Short Tons)

Traffic in Marine Shell

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
IHNC Lock Traffic								
Reference	346	0	0	0	0	0	0	0
Low	346	0	0	0	0	0	0	0
High	346	100	0	0	0	0	0	0
System Traffic								
Reference	762	0	0	0	0	0	0	0
Low	762	0	0	0	0	0	0	0
High	762	221	0	0	0	0	0	0

Table 2 - 37

Projected Traffic Growth
(In Thousands of Short Tons)

IHNC Lock Traffic

Reference Case

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	560	689	832	1,005	1,213	1,464	1,768	2,134
Metallic Ores & Mins.	1,420	1,299	1,261	1,225	1,190	1,155	1,122	1,090
Coal	7,999	10,308	11,987	13,940	16,210	18,850	21,920	25,491
Crude	2,291	1,578	2,024	1,902	1,787	1,680	1,579	1,484
Non-Metallic Mins.	2,075	2,181	2,293	2,411	2,535	2,665	2,802	2,945
Forest Products	179	210	228	247	268	291	315	342
Industrial Chemicals	1,920	2,534	2,999	3,549	4,200	4,970	5,882	6,960
Agricultural Chemicals	501	676	781	902	1,042	1,203	1,390	1,606
Petroleum Products	6,001	6,963	7,683	8,521	9,497	10,641	12,106	13,571
Miscellaneous	548	181	194	208	223	239	257	27
Total	23,494	26,619	30,282	33,910	38,165	43,158	49,141	55,898

Table 2 - 38

Projected Traffic Growth
(In Thousands of Short Tons)

IHNC Lock Traffic

Low Scenario

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	560	650	754	875	1,016	1,179	1,368	1,588
Metallic Ores & Mins.	1,420	1,360	1,219	1,092	979	877	786	705
Coal	7,999	8,199	9,554	11,132	12,971	15,114	17,611	20,521
Crude	2,291	1,068	1,468	1,175	941	753	603	482
Non-Metallic Mins.	2,075	2,060	2,122	2,187	2,253	2,321	2,391	2,464
Forest Products	179	197	202	208	213	219	225	231
Industrial Chemicals	1,920	2,272	2,531	2,820	3,142	3,501	3,901	4,347
Agricultural Chemicals	501	639	656	672	690	707	725	744
Petroleum Products	6,001	6,722	7,338	8,046	8,862	9,806	10,987	12,167
Miscellaneous	548	160	143	128	115	103	93	83
Total	23,493	23,327	25,987	28,335	31,182	34,580	38,690	43,332

Table 2 - 39

Projected Traffic Growth
(In Thousands of Short Tons)

IHNC Lock Traffic

High Scenario

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	560	722	871	1,052	1,270	1,533	1,850	2,233
Metallic Ores & Mins.	1,420	1,403	1,370	1,338	1,307	1,276	1,246	1,217
Coal	7,999	10,320	12,535	15,225	18,491	22,459	27,279	33,132
Crude	2,291	1,869	2,314	2,326	2,338	2,350	2,362	2,374
Non-Metallic Mins.	2,075	2,193	2,305	2,423	2,548	2,678	2,816	2,960
Forest Products	179	191	214	240	268	300	336	375
Industrial Chemicals	1,920	2,705	3,560	4,686	6,167	8,116	10,682	14,059
Agricultural Chemicals	501	699	814	948	1,103	1,285	1,495	1,741
Petroleum Products	6,001	8,415	9,311	10,421	11,839	13,736	17,185	20,633
Miscellaneous	548	317	232	249	266	285	305	327
Total	23,493	28,835	33,526	38,908	45,597	54,018	65,556	79,051

Table 2 - 40

Projected Traffic Growth
(In Thousands of Short Tons)

System Traffic

Reference Case

Commodity Group			Projection Years					
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	2,368	2,915	3,519	4,249	5,129	6,192	7,475	9,024
Metallic Ores & Mins.	5,153	4,712	4,577	4,445	4,317	4,193	4,072	3,955
Coal	8,522	10,993	12,862	15,049	17,607	20,600	24,411	28,222
Crude	15,286	10,532	13,502	12,690	11,926	11,209	10,535	9,901
Non-Metallic Mins.	12,088	12,708	13,360	14,046	14,767	15,525	16,321	17,159
Forest Products	244	287	311	337	365	396	430	466
Industrial Chemicals	11,830	15,614	18,478	21,867	25,877	30,624	36,240	42,887
Agricultural Chemicals	2,777	3,746	4,327	4,998	5,774	6,670	7,705	8,901
Petroleum Products	23,512	26,333	28,794	31,634	34,912	38,696	43,444	48,192
Miscellaneous	1,822	950	1,019	1,092	1,171	1,256	1,346	1,443
Total	83,602	88,790	100,749	110,407	121,845	135,360	151,979	170,149

Table 2 - 41

Projected Traffic Growth
(In Thousands of Short Tons)

System Traffic

Low Scenario

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	2,368	3,052	3,684	4,447	5,369	6,481	7,823	9,443
Metallic Ores & Mins.	5,153	4,934	4,422	3,963	3,552	3,184	2,854	2,558
Coal	8,522	8,897	10,415	12,192	14,272	16,706	19,807	22,908
Crude	15,286	7,123	9,795	7,840	6,276	5,024	4,021	3,219
Non-Metallic Mins.	12,088	12,002	12,365	12,739	13,124	13,521	13,931	14,352
Forest Products	244	269	276	283	291	298	306	314
Industrial Chemicals	11,830	13,997	15,596	17,377	19,362	21,573	24,037	26,782
Agricultural Chemicals	2,777	3,545	3,635	3,728	3,823	3,920	4,020	4,122
Petroleum Products	23,512	25,536	27,692	30,159	32,984	36,222	40,233	44,243
Miscellaneous	1,822	838	752	674	604	542	486	435
Total	83,602	80,193	88,632	93,402	99,657	107,471	117,518	128,376

Table 2 - 42

Projected Traffic Growth
(In Thousands of Short Tons)

System Traffic

High Scenario

Commodity Group	Projection Years							
	1990	2000	2010	2020	2030	2040	2050	2060
Farm Products	2,368	3,052	3,684	4,447	5,369	6,481	7,823	9,443
Metallic Ores & Mins.	5,153	5,093	4,973	4,856	4,742	4,630	4,521	4,415
Coal	8,522	11,078	13,405	16,220	19,626	23,748	29,210	34,672
Crude	15,286	12,473	15,442	15,521	15,600	15,679	15,759	15,839
Non-Metallic Mins.	12,088	12,774	13,429	14,118	14,842	15,603	16,403	17,245
Forest Products	244	261	292	327	365	409	457	512
Industrial Chemicals	11,830	16,668	21,937	28,871	37,997	50,009	65,816	86,621
Agricultural Chemicals	2,777	3,876	4,513	5,254	6,116	7,120	8,289	9,650
Petroleum Products	23,512	29,187	32,596	36,857	42,447	50,304	66,443	82,582
Miscellaneous	1,822	1,358	1,218	1,304	1,397	1,496	1,603	1,717
Total	83,602	95,820	111,489	127,775	148,501	175,479	216,324	262,696

Table 2-43

Summary of Annual Commodity Growth Rates
By Projection Scenario

IHNC Lock

	Low		Mid		High	
Group	1990 to 2000	2000 to 2010	1990 to 2000	2000 to 2010	1990 to 2000	2000 to 2010
Farm Products	1.5%	1.5%	2.1%	1.9%	2.6%	1.9%
Metallic Ores & Mins.	-0.4%	-1.1%	-0.9%	-0.3%	-0.1%	-0.2%
Coal	0.2%	1.5%	2.6%	1.5%	2.6%	2.0%
Crude	-7.3%	3.2%	-3.7%	2.5%	-2.0%	2.2%
Non-Metallic Mins.	-0.1%	0.3%	0.5%	0.5%	0.6%	0.5%
Forest Products	1.0%	0.3%	1.6%	0.8%	0.7%	1.1%
Industrial Chemicals	1.7%	1.1%	2.8%	1.7%	3.5%	2.8%
Agricultural Chemicals	2.5%	0.3%	3.0%	1.5%	3.4%	1.5%
Petroleum Products	1.1%	0.9%	1.5%	1.0%	3.4%	1.0%
Miscellaneous	-11.6%	-1.1%	-10.5%	0.7%	-5.3%	-3.1%
Total Tonnage	-0.1%	1.1%	1.3%	1.3%	2.1%	1.5%

commodity groups. These average annual growth rates are also presented by growth scenario. For system traffic, the average annual growth rates for each commodity group is identical to those for the IHNC Lock, with the exception of petroleum products (see table 2 - 31 for a comparison).

PROJECTED DEEP-DRAFT TRAFFIC

OVERVIEW

As previously indicated, not all deep-draft traffic desirous of lock service can be accommodated by the existing lock. Table 2 - 44 identifies the total, or unconstrained, existing deep-draft lockage demand. The derivation of this demand will be detailed in Section 8 of this appendix.

Future unconstrained lockage demand has been developed directly from the estimate of existing unconstrained lockage demand. Existing unconstrained lockage demand has been used as a base, with future unconstrained demand calculated by applying a growth factor to the existing level. As a result, future deep-draft lockages have been estimated directly from the number of existing vessels demanding lockage. Vessel trips and not tons were used as the initial basis of demand projections for several reasons.

The tonnage actually moving through the existing lock in deep-draft vessels is quite low, making the relationship between tonnage and actual lockages less direct. Vessels are typically light-loaded or even empty, having discharged cargo in one section of the port before transiting the lock to reach the other section. This accounts for the low load-to-capacity utilization for locking vessels. Low utilization is also reflected in the unaccommodated portion of existing demand.

The subset of vessels that demand lockage is not a representative cross-section of the overall population of vessels calling at the port. Projecting total port throughput (tonnage) and then converting tonnage to vessel trips is not the most direct or the most accurate way to evaluate this subset of traffic. Because the subset is only a very small portion of the total port traffic, overall trends for the port could easily obscure any trends associated with the smaller subset. Another consideration for not projecting tonnage as an initial step in projecting lock demand is that a significant portion of MR-GO traffic and vessels demanding lockage are ultimately associated with the Mexican/Caribbean/ Central American trade. Small volume and restrictive channel drafts at the foreign end

Table 2 - 44

Unconstrained Deep-Draft Lockage Demand
Lockages by Vessel Type and Deadweight Tonnage
(1991)

Deadweight Tonnage (1,000)	Dry Bulk	General Cargo	Container	Total
3	0	110	0	110
3-10	1	3	0	4
10-20	4	20	2	26
20-30	16	0	23	39
30-40	20	0	3	23
40-50	4	0	0	4
	45	133	28	206

typify many of the ports associated with this trade. As a result, the potential for changes in the fleet that makes up lockage demand will be minimized as the future deep-draft vessel demand for lockage services is likely to continue to be composed of relatively small vessels.

SCENARIO DESCRIPTION

Three separate lockage demand projections, representing low, mid and high scenarios, were developed. These scenarios made use of historical MR-GO and IHNC Lock traffic trends along with econometric studies designed to estimate the future volume of U.S. oceanborne trade. Each scenario was developed and evaluated as a distinctly separate condition, but was constructed with each of the other scenarios in mind, with the explicit intent of covering the reasonable range of possible outcomes.

Projections of U.S. oceanborne trade contained in the 1987 Maritime Administration (MARAD) publication, Forecasting Trade and the Merchant Fleet were reviewed. These projections represent a general indicator of the potential growth in deep-draft activity. This MARAD study drew significantly from the econometric study, Assessment of Maritime Trade and Technology, conducted by Wharton Econometrics for the Office of Technology Assessment. The annual compound growth rates for U.S. oceanborne trade projected in the Wharton study are summarized in table 2 - 45. The Wharton study projected trade by major commodity type (general cargo, dry bulk, and liquids) and foreign trade area (e.g. Latin America, Northern Europe). The summary provided in table 2 - 45 displays the projected compound annual growth rates by major commodity type for each of the individual trading areas and an overall composite for all trading areas.

The relevance of the projected growth rate for any particular trading area to IHNC Lock deep-draft demand is best reflected by the distribution of trading area traffic proportions for the MR-GO. Latin America (Caribbean and South America) represents the single largest aggregate trading area for MR-GO deep-draft traffic accounting for approximately 35 percent of total volume in 1991. Europe and Asia represent the next largest areas accounting for 29 and 14 percent, respectively. In aggregate these three regions account for approximately 78 percent of total MR-GO deep-draft traffic. The MR-GO weighted average composite growth rate that is produced by using the 1991 MR-GO relative trading region traffic shares and the 1990 to 2000 trading region projected growth rates is approximately 3.5 percent.

Table 2 - 45
U.S. Oceanborne Trade
Annual Compound Growth Rates

Trade Region	General Cargo Imports		Dry Bulk Exports		Liquids Imports		Total	
	1985-1990	1990-2000	1985-1990	1990-2000	1985-1990	1990-2000	1990-2000	1990-2000
Japan	3.5	3.1	5.4	3.5	0.0	0.0	5.3	3.7
South Asia	4.3	7.1	7.2	7.2	2.1	2.0	5.5	6.1
C.P. Asia	-9.7	5.2	1.2	2.4	0.0	0.0	1.3	2.4
Oceania	0.0	2.3	1.5	0.4	-	1.5	2.8	2.5
U.K./N. Europe	3.7	2.1	1.9	2.3	3.1	2.6	2.7	2.5
Other Europe	5.1	2.8	3.0	3.3	4.8	3.6	3.3	3.3
Latin America	3.1	2.5	6.0	5.9	1.4	1.2	3.2	3.5
Middle East	2.9	2.0	5.8	5.9	1.4	1.2	2.9	3.1
Africa	3.7	2.5	5.2	5.3	1.5	1.2	2.6	2.6
Overall	4.8	3.3	4.6	4.5	1.8	1.6	3.6	3.6

Source: Wharton Econometrics

In conjunction with the econometric study, trends in MR-GO traffic volume and IHNC Lock deep-draft vessel lockages were analyzed. Over the last ten years of record, 1983-1992, MR-GO deep-draft tonnage has increased from 4.1 million tons in 1983 to 5.1 million tons in 1992. However, the average for the period was approximately 5.5 million tons annually with no discernible trend. Over the same period, deep-draft lockages through IHNC Lock have declined from 195 to 156 while averaging approximately 169 lockages per year. While statistically significant at a high degree of confidence (95 percent), the trend line does a modest job of predicting lockages, explaining slightly less than 50 percent of year to year fluctuations.

Because the growth patterns suggested by the econometric study are not supported by recent MR-GO or IHNC deep-draft traffic activity, the econometric study results were viewed as inappropriate to represent a mid or most probable scenario. However, given the long term requirement of the projection process and the prior periods of sustained significant MR-GO growth, the econometric study results do represent, at a minimum, a legitimate upper bound estimate of the potential for future MR-GO\IHNC traffic. As such, the growth projected in the econometric study was selected to represent the high growth traffic scenario.

The specific value selected to represent the high growth scenario was the 1990 to 2000 overall composite rate for all trade regions. Given the similarity of the MR-GO weighted average rate (3.5 percent) with the econometric model composite average for all trading regions (3.6 percent), the single composite average for all regions was selected for use with all MR-GO traffic. This rate was held constant throughout the projection period.

Determination of the reasonable lower bound traffic activity, representing the low growth scenario, was considered next. Selection of the low growth rate(s) were significantly influenced by recent historical traffic. Past volume in deep-draft vessel lockages at the IHNC Lock has showed a modest, but statistically significant decline over the last 10 years, while MR-GO deep-draft tonnage has shown no statistically significant trend over the period. Continuation of the recent no growth historical pattern was selected to represent the low growth scenario. As such, future activity was held constant at current 1991 levels throughout the projection period.

Taking the midpoint growth rate between the high and low growth scenarios produced a annual growth rate of 1.8 percent. This midpoint rate of 1.8 percent was used to represent the mid growth scenario and was held constant throughout the projection period.

Table 2 - 46 summarizes the compound annual growth rates associated with each scenario. As previously stated each scenario makes use of a constant rate throughout the duration of the projection period.

PROJECTED UNCONSTRAINED LOCKAGE DEMAND

Application of the mid growth scenario rates to the existing unconstrained lockage demand (displayed in table 2 - 44) produces the projected future unconstrained lockage demand. These values are presented in table 2 - 47. The projected values are displayed by vessel type and size in ten year increments over the projection period. Tables 2 - 48 and 2 - 49 display the same information for the low and high growth scenarios, respectively. Table 2 - 50 aggregates total unconstrained lockage demand for all vessel types and sizes by year for each of the growth scenarios.

Table 2 - 46

Unconstrained Deep-Draft Lockage Demand
Annual Compound Growth Rates
Scenario Summary

Period	Low	Mid	High
1991-2000	0.0	1.8	3.6
2000-2060	0.0	1.8	3.6
1991-2060	0.0	1.8	3.6

Table 2 - 47

Unconstrained Projected Deep-Draft Lockage Demand
Lockages by Vessel Type and Deadweight Tonnage
(Mid Growth)

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
Dry Bulk:							
0-10	1	1	1	2	2	2	3
10-20	4	5	6	7	8	10	14
20-30	16	19	23	27	32	38	55
30-40	20	24	28	34	40	48	69
40-50	4	5	6	7	8	10	14
Total	45	54	64	77	90	108	155
General Cargo:							
3	110	129	154	184	220	263	376
3-10	3	4	4	5	6	7	10
10-20	20	24	28	34	40	48	69
Total	133	157	186	223	266	318	455
Containers:							
0-10	0	0	0	0	0	0	0
10-20	2	3	3	4	5	6	8
20-30	23	27	32	39	46	55	79
30-40	3	4	4	5	6	7	10
Total	28	34	39	48	57	68	97

Table 2 - 48

Unconstrained Projected Deep-Draft Lockage Demand
Lockages by Vessel Type and Deadweight Tonnage
(Low Growth)

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
Dry Bulk:							
0-10	1	1	1	1	1	1	1
10-20	4	4	4	4	4	4	4
20-30	16	16	16	16	16	16	16
30-40	20	20	20	20	20	20	20
40-50	4	4	4	4	4	4	4
Total	45	45	45	45	45	45	45
General Cargo:							
3	110	110	110	110	110	110	110
3-10	3	3	3	3	3	3	3
10-20	20	20	20	20	20	20	20
Total	133	133	133	133	133	133	133
Containers:							
0-10	0	0	0	0	0	0	0
10-20	2	2	2	2	2	2	2
20-30	23	23	23	23	23	23	23
30-40	3	3	3	3	3	3	3
Total	28	28	28	28	28	28	28

Table 2 - 49

Unconstrained Projected Deep-Draft Lockage Demand
Lockages by Vessel Type and Deadweight Tonnage
(High Growth)

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
Dry Bulk:							
0-10	1	1	2	3	4	6	12
10-20	4	6	8	11	16	23	46
20-30	16	22	31	45	64	91	184
30-40	20	28	39	56	79	113	230
40-50	4	6	8	11	16	23	46
Total	45	63	88	126	179	256	518
General Cargo:							
3	110	151	215	307	437	622	1263
3-10	3	4	6	8	12	17	34
10-20	20	28	39	56	79	113	230
Total	133	183	260	371	528	752	1527
Containers:							
0-10	0	0	0	0	0	0	0
10-20	2	3	5	7	10	14	28
20-30	23	32	45	64	91	130	264
30-40	3	4	6	8	12	17	34
Total	28	39	56	79	113	161	326

Table 2 - 50

Unconstrained Projected Deep-Draft Lockage Demand
Total Lockages
Scenario Summary

Scenario	1991	2000	2010	2020	2030	2040	2060
Low	206	206	206	206	206	206	206
Mid	206	245	289	348	413	494	707
High	206	285	404	576	820	1169	2371

SECTION 3 - SYSTEM ANALYSIS

INTRODUCTION

A system approach is required to evaluate the National Economic Development (NED) benefits of potential navigation improvements to the Gulf Intracoastal Waterway System. This analytical approach explicitly recognizes that individual locks are only components in a complete navigation system, and that alterations of the traffic processing characteristics of specific components will have impacts throughout the navigation system. The General Equilibrium Model described below is used to perform the systems analysis.

GENERAL EQUILIBRIUM MODEL RATIONALE AND METHODOLOGY

The General Equilibrium Model (GEM) is used to evaluate the existing conditions, the future without-project conditions, and the future conditions with alternative system configurations in effect. GEM is a tool used for the economic evaluation of potential changes to various components of a navigation system. The model estimates the total transportation costs, including congestion costs, incurred by individual movements desirous of using all or portions of a navigation system. System transport costs for these individual movements are then compared to the total transport costs of that movement via the least-cost alternative mode or alternative non-system water route. If the alternative means of transport has lower costs than water system transport for a given movement, then that movement is presumed to be diverted from the navigation system to the alternative mode/non-system route. This potential movement enjoys no transport cost reductions resulting from the navigation system. Conversely, movements enjoying less costly transportation on the navigation system are presumed to use the navigation system, realizing net savings of the difference between the costs of system transport and the next least costly alternative means of movement. The sum of all these transportation costs savings represents the total resource savings to the Nation attributable to the navigation system.

The navigation system transport costs are dependent on three general classes of parameters: first, the operating characteristics of waterway carriers and shippers; second, the operating characteristics of the navigation system itself; and, third, the physical traffic carrying capacities of the components of the navigation system. For the purposes of this study, the first two parametric classes are assumed to be fixed through time. This analytical effort focuses exclusively on the impact on the levels of navigation system transport costs of carrying capacity constraints at system locks.

For a given level of traffic, the greater the carrying capacity of the navigation system the lower the total unit transport costs. This is a consequence of decreased levels of congestion in the system, allowing potential movements quicker and more efficient transport from origin to destination. Hence, the navigation system transportation costs of individual movements are explicitly dependent on total system traffic. In other words, individual movement system transportation costs depend not only on the economics of each individual movement, but also on the levels of congestion on those portions of the transportation system used by each individual movement. The levels of congestion for each component of the navigation system are increasing functions of the total volume of traffic processed by each component of the system.

Each individual potential system movement is assumed to transit the navigation system if, and only if, it has economic incentive to do so. Here, economic incentive to use the navigation system means that a movement is assumed to use the navigation system if system transport provides the least cost total transportation costs including the congestion costs resulting from carrying capacity constraints.

The total real costs of shipping any given movement via alternative non-system means of transportation are assumed to be constant through time. Explicitly modeling the costs of alternative modes of transportation is beyond the scope of this study. In order to reduce the size of the GEM problem to be solved, only those system locks that could possibly sustain significant increases in levels of congestion are explicitly included in the model. Consequently, the 1200 ft x 110 ft Leland Bowman Lock, which was placed into service in 1985, is excluded from the model because projected traffic at this location is not expected to cause significant changes in system congestion costs at any time during the planning horizon. This allows traffic using only this structure to be eliminated from the direct system modeling and reduces the size of the GEM problem with minimal distortion of the analytical results.

The input requirements of the GEM model are as follows:

a. Individual Movement Data: For individual potential system commodity movements, this input requires a waterway routing vector (indicating which system locks the movement will transit if it utilizes the navigation system), the annual volume of the movement measured in kilotons (ktons), the gross transportation cost savings of the movement (defined as the difference between the total uncongested system transportation costs and the total transportation costs of the next least costly non-system alternative means of transit for that movement), and an indication of whether or not alternate system water routings are possible.

b. Congestion Costs: Costs per kton per hour of delay for each commodity movement at each system lock transited are inputs required by the GEM model. The model allows these costs to be input by aggregated commodity groupings for each system lock.

c. Lock Delay Parameters: Capacity in annual ktons and expected delay in hours per ton at 50 percent utilization for each lock in the system are required by the model. For solution, the model requires that delay be an monotonic nondecreasing function of tonnage. The configuration of the delay function used in the model is:

$$D = k * T / (C - T); \text{ where}$$

D = delay per ton in hours; k = delay per ton in hours at 50% utilization of capacity; T = annual lock tonnage; and C = annual lock capacity in tons.

To use this formulation, Capacity (C) and expected delay at 50 percent utilization (k), for each lock in the system, are required input parameters.

Output from the GEM model includes total system transportation costs including congestion costs, expected delay times at each modeled system lock, annual tonnages moved through each lock, and the net system transportation cost savings for each movement. The net system transportation cost savings are defined as the transportation resource cost savings attributable to the navigation system for that movement accounting for the effects of system congestion on system transportation costs.

Benefits for navigation projects consist of two distinct components: first, transportation resource cost savings to existing system traffic from reduced levels of systemic congestion; and, second, transportation savings over an alternative means of transport for movements now induced to utilize the navigation system because of the reduced total transportation costs. This idea is graphically demonstrated in Figure 3 - 1. The demand curve DD shows

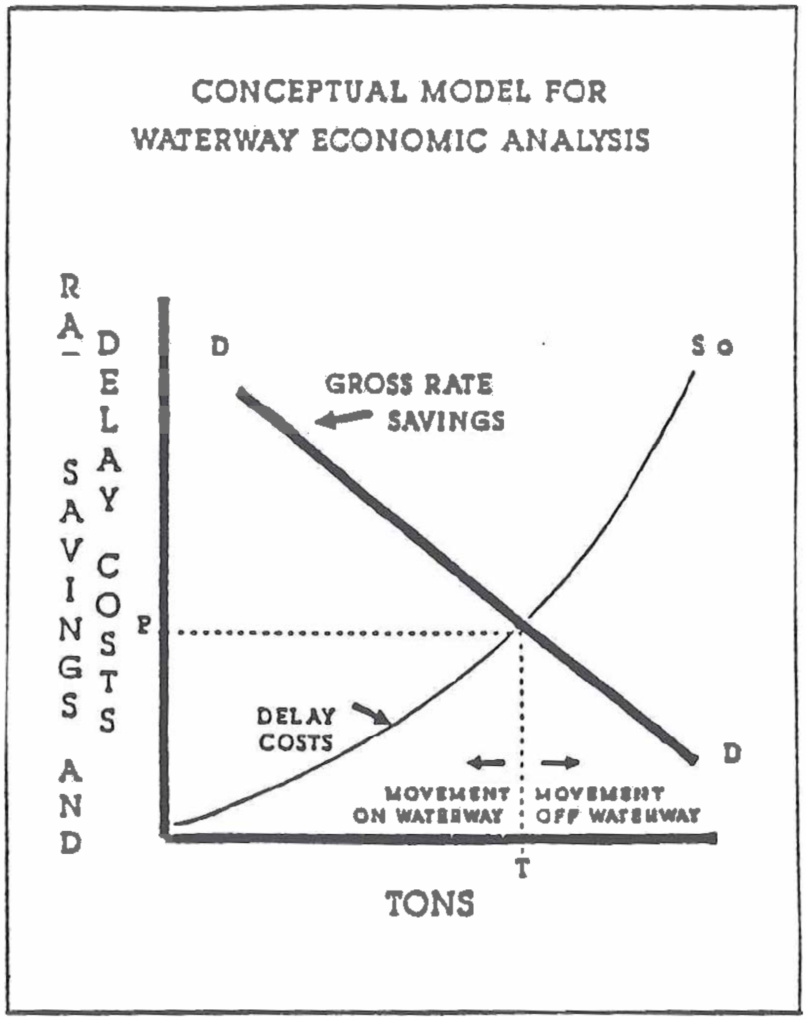

CONCEPTUAL MODEL FOR
WATERWAY ECONOMIC ANALYSIS
RATE SAVINGS AND
DELAY COSTS
D
S o
GROSS RATE
SAVINGS
P
DELAY
COSTS
D
MOVEMENT
ON WATERWAY
MOVEMENT
OFF WATERWAY
T
TONS

Figure 3-1.

for each potential ton of commerce the difference between system total transportation costs (with no congestion costs) and the total costs of movement via the next least costly alternative non-system means of shipment. This difference is termed the gross cost savings of that ton's potential movement via the waterway system. The curve S0 represents the congestion costs incurred by each movement as different levels of tonnage transit the system. It is upward sloping to represent the notion that as more tons pass through the navigation system, greater levels of congestion occur, and, consequently, higher unit costs of transportation are incurred by each ton transiting the system. The system equilibrium congestion cost is given at P with tonnage of T actually transiting the system. All tonnage to the "left" of T find it still cheaper to move on the system than by the next cheapest alternative means, whereas all tonnage to the "right" of T find it economically more advantageous to use some non-system alternative. Hence, in equilibrium, T tons will pass through the lock and incur delay costs of P dollars.

Now, consider the impact of a system change (such as the installation of a new lock chamber at one lock) on the level of system traffic and shipping costs. Figure 3 - 2 illustrates the effect of the change and the measurement of resulting benefits.

The provision of the new chamber increases the carrying capacity of the system and reduces the unit cost of congestion for any given level of system traffic. The curve labeled S1 depicts the with-project relationship between system traffic levels and the reduced with-project levels of congestion. The new equilibrium level of traffic increases from T0 to T1, with a reduction in congestion costs due to the improvement from P0 to P1. The resulting benefits for this system change may be broken into two components: (1) the cost savings on the pre-improvement level of traffic, T0 x (P0 - P1) (the shaded area to the left of T0); and (2) the benefits to the new traffic that can now move on the waterway, [(T1 - T0) x (P0 - P1)] (the shaded triangle to the right of T0).

The difference in the total transportation costs between with and without-project conditions represents the NED benefits of the proposed inland navigation improvement.

The important analytical assumptions employed in this analysis are:

(a) Movements will divert from the waterway when the total system transport costs including expected congestion

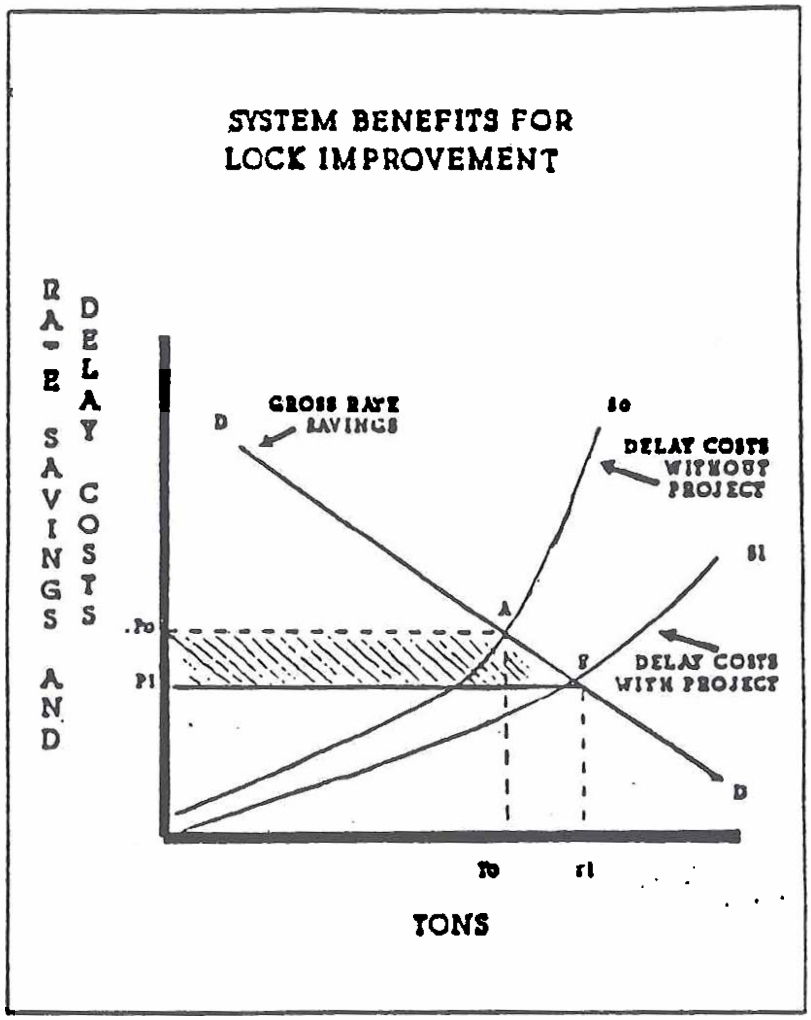

SYSTEM BENEFITS FOR
LOCK IMPROVEMENT
RATE SAVINGS AND
DELAY COSTS
GROSS RATE SAVINGS
DELAY COSTS WITHOUT PROJECT
DELAY COSTS WITH PROJECT
TONS

Figure 3-2.

costs exceed the total costs of shipment via a non-system alternative means; and

(b) The expected levels of delay and traffic for each component for the system must be logically consistent with the delays and traffic computed for all other components in the system. This requires that the equilibrium calculation at all system locks take place simultaneously.

DATA REQUIREMENTS AND SOURCES

COMMODITY MOVEMENT DATA BASE

a. Transportation Cost Analysis: The benefits of a navigation improvement are computed as the difference between the transportation costs to the shipper by the various modes available to the shipper, hence the determination of transportation costs is of the highest importance in this economic study.

In brief, this process involved the development of transportation costs for a sample of movements which traveled any portion of the waterways within the defined system and represented a wide cross section of system movements.

The transportation costs were then expanded to the population of movements. This entailed several levels of matching sample movements to population movements based on common attributes. When a match occurred, the transportation costs associated with the sample movement would be applied to the population movement.

A more detailed discussion of the procedures and methods used in this analysis is contained in Section 4 of this appendix.

b. Reconciliation of LPMS and WCSC: The two primary data sources used in the analysis of inland traffic are the Lock Performance Monitoring System (LPMS) database and the WCSC database. Each of these two databases is essential in evaluating the systems economics of traffic flows because each provides necessary information that is not a feature of the other. LPMS provides information concerning the physical characteristics of lock operations and tow configurations, while WCSC provides origin-destination and route information.

Each data source provides information that allows for the determination of traffic volume through each lock in the system. These traffic volumes at any given lock are invariably different, with WCSC volumes historically below

LPMS volumes. This difference is due primarily to the manner in which each is collected. WCSC data is submitted to the Center from the shippers. Despite the legal requirements of shippers to report to WCSC, the Center must rely, to a significant extent, on the efforts of industry to provide complete reporting. Given the vastness of the inland transportation system, a certain element of underreporting is to be expected. LPMS data, by contrast, are collected at each lock from every user and therefore are, at least, not subject to errors introduced into WCSC data because some shippers fail to report. However, being in a position to record all movements does not alone insure the accuracy of LPMS traffic volumes as will be seen in subsequent discussion.

Table 3 - 1 provides a comparison of LPMS and WCSC total tonnages at each modeled lock for the year 1990. As is readily obvious, there were some significant differences between the data sources. In addition to apparent significant WCSC underreporting at Bayou Sorrel, Algiers, Bayou Boeuf and Calcasieu (25.3, 20.0, 16.0 and 14.8 percent respectively), WCSC traffic at Port Allen exceeded the LPMS totals. In order to have a reliable traffic base that can be used as a starting point in the economic modeling effort, these significant differences in the two data sources first had to be reconciled to insure an accurate and consistent set of model inputs.

Before proceeding with a description of the procedure employed to reconcile the two data sources, it would be useful to describe the overall objective of the reconciliation process. Owing to the fact that WCSC contains origin-destination information necessary for rate assignment, WCSC must be the foundation of the base year traffic. As such, the objective of the reconciliation process was to establish a target tonnage value at each lock and then make adjustments, as necessary, to the WCSC data in an attempt to hit the target values. Adjustments typically take the form of adding constructed movements to the WCSC data in an effort to account for underreporting.

Initial efforts to reconcile LPMS and WCSC focused on the locks where WCSC was significantly lower than LPMS. Investigation of these locations revealed that underreported WCSC traffic was not the only factor at work. At Bayou Sorrel, a comparison of the reported LPMS average load per barge by commodity group with the WCSC average load per barge revealed that the LPMS loads were consistently and significantly higher. The explanation for this condition is in the fact that the exact load is not always known by the carrier. When tonnage is unknown, estimates are submitted at the lock. Estimation of this

Table 3 - 1

Comparison of 1990 WCSC and LPMS Tonnage
(Thousands of Tons)

Lock	WCSC	LPMS	LPMS - WCSC as a Percent of PMS
Port Allen	28,210	27,565	-2.3
Bayou Sorrel	27,781	37,168	25.3
IHNC	22,723	23,414	3.0
Algiers	19,856	24,819	20.0
Harvey	3,538	3,612	2.0
Bayou Boeuf	23,200	27,628	16.0
Calcasieu	39,450	46,301	14.8

type introduces the potential for error, especially when less than a full barge load is involved. At Bayou Sorrel this situation was in evidence. The systematic overestimation of loads, when exact loads were unknown, resulted in an overstatement of the recorded LPMS tonnage.

To address this situation, and to generate a reasonable target tonnage estimate, a convention was adopted that took advantage of the strength of each data source. Because of the manner in which it is collected, the LPMS barge count is considered to be more accurate than WCSC since LPMS is not subject to underreporting. WCSC on the other hand, is much less likely to be subject to load misstatement since this reporting is handled directly by the shipper with the full advantage of all relevant documentation. By taking the LPMS barge count by commodity group, and multiplying by the WCSC commodity group average load per barge, a reasonable estimate of total tonnage can be made. The adjusted tonnage estimate, the target tonnage, for Bayou Sorrel using this procedure yielded 26,401,000 tons. For Bayou Sorrel, the revision represents a 29.0 percent reduction from the original LPMS value, but also a reduction from the original WCSC estimate, equal to 5.0 percent. This result was produced by the fact that the WCSC barge count exceeded the LPMS barge count. This development was related to the case of Port Allen where the WCSC estimate exceeded the LPMS estimate.

Further detailed inspection of the two sources revealed a problem with the WCSC data. The nature of this problem involved the assignment of alt codes. For particular origin-destination combinations, it is not possible to know which lock(s) a movement used without the additional information provided by the alt code. This condition arises when the geography of the system provides for multiple routes. Alt code information submitted to the Center is not always accurate, because while it may be provided as the originally intended route, the actual route selected at times may change in transit. This condition can occur especially if the diversion involves only a minor change in route distance, or if unscheduled or unknown repairs or maintenance require that a lock be taken out of service.

The problem of misassigned alt codes was present at Port Allen, Algiers and Harvey. These are the three locations within the modeled system that, due to multiple routing possibilities, require an alt code to correctly route the movement. It was the misassignment of alt codes within WCSC that caused the WCSC tonnage at Port Allen (and by routing implication at Bayou Sorrel) to exceed the LPMS tonnage. This over-assignment at Port Allen was, conversely, the primary reason for the extreme deficiency of WCSC tonnage at Algiers.

When Port Allen, Algiers and Harvey are considered in aggregate, the magnitude of the LPMS - WCSC difference is modest, approximately 7.8 percent, and the difference is in the relative direction as typically observed, i.e., LPMS higher than WCSC (55,997,000 LPMS tons vs. 51,604,000 WCSC tons).

While comparison of tonnages and barge trips indicated that misassignment of alt codes had occurred, it is impossible to identify which individual movements are misassigned. While this may initially seem to represent a major problem, the consequences of this development are not dire, and indeed, the situation can be handled satisfactorily within the context of the economic modeling. Because most traffic that uses any one of Port Allen, Algiers or Harvey Locks is costed and permitted the option, within the economic model, to use both of the other two locks as an alternate route, it is not necessary that the original route be known. The model, in finding an equilibrium solution, will correctly allocate traffic as long as the relative costs of using each route are properly specified.

For all locks except Bayou Sorrel, the LPMS tonnage was used as the target tonnage. The targets used for Bayou Sorrel were as previously described. For Port Allen, Algiers and Harvey the meaningful target was the aggregate LPMS tonnage for the three for the reason of alt code misassignment described above. With these target tonnage levels established, WCSC traffic volumes and traffic patterns were evaluated for the purpose of constructing movements to make up the difference between the target and WCSC. To reemphasize, this process was undertaken with Port Allen, Algiers and Harvey considered in aggregate. As a result, all constructed movements generated to reconcile Port Allen/Algiers/Harvey were assigned Algiers as an original routing.

The results of the reconciliation process are summarized in table 3 - 2. Added traffic totaled 10.2 million tons for the system and 0.8 million tons at IHNC, representing increases of 13.9 percent and 3.4 percent, respectively, from original WCSC tonnage. Table 3 - 3 shows the added tons by commodity group for the overall system and for IHNC movements only.

c. Alternative System Routes and Movement File **Aggregation:** Due to the configuration of the mainstem GIWW and the GIWW Morgan City - Port Allen Alternate Route, alternate water routings are possible for virtually all

Table 3 - 2

Summary of 1990 WCSC and LPMS Tonnage Reconciliation
(Thousands of tons)

Lock	WCSC	LPMS	Target Tonnage	Added Traffic	Adjusted WCSC	Added Traffic as % of WCSC	Target minus Adjusted as % of Target
Port Allen	28,210	27,565	n.a.	0	28,210	0.0	n.a.
Bayou Sorrel	27,781	37,168	26,401	0	27,781	0.0	-5.2
IHNC	22,723	23,414	23,414	770	23,493	3.4	-0.3
Algiers	19,856	24,819	n.a.	4,772	24,628	24.0	n.a.
Harvey	3,538	3,612	n.a.	0	3,538	0.0	n.a.
Bayou Boeuf	23,221	27,628	27,628	4,624	27,845	19.9	-0.8
Calcasieu	39,450	46,301	46,301	7,051	46,501	17.9	-0.4
P.A./Alg/Hvy	51,604	55,996	55,996	4,772	56,376	9.2	-0.7
Total System	73,400	n.a.	n.a.	10,202	83,600	14	n.a.

Note: Added traffic at each lock does not sum to the total system because of common traffic between locks.

Table 3 - 3

Reconciliation of WCSC and LPMS
Summary of Added Tonnage
(Thousands of Tons)

Commodity Group	Total Added Movements	IHNC Movements
Farm Products	593.002	188.893
Metallic Ores & Products	231.286	0
Coal	150.495	0
Crude Petroleum	4,601.793	0
Non-Metallic Minerals	2,632.951	580.707
Forest Products and Pulp	9.126	0
Industrial Chemicals	0.000	0
Agricultural Chemicals	1,334.434	0
Petroleum Products	0.000	0
All Others	648.666	0
Total	10,201.753	769.600

movements operating on the GIWW west of the Mississippi River and the IHNC.

The waterway "triangle" formed by the Mississippi River between Baton Rouge and New Orleans (approximately 130 miles), the mainstem GIWW between New Orleans and Morgan City (approximately 94 miles) and the GIWW Morgan City - Port Allen Alternate Route between Morgan City and Baton Rouge (approximately 64 miles) provides the basis for multiple routing possibilities for through traffic as well as for traffic that is strictly local. For a local movement, i.e., a movement with an origin or destination on the "triangle", transit can be achieved by two alternate water routes in addition to the original route. This is so because Port Allen, Algiers and Harvey locks all provide for access from the Mississippi River to the western GIWW. For a through movement, i.e., traffic moving between a point above Baton Rouge and west of Morgan City, in addition to Port Allen, Algiers and Harvey routings, the Atchafalaya River also represents a viable alternate route. The Atchafalaya River provides access between the Mississippi River at mile 304, approximately 76 miles above Baton Rouge, and the mainstem GIWW at Morgan City, a distance of approximately 123 miles.

The availability of these alternate routings is important for system modeling. As tonnage in the system increases over time, so will congestion costs. The likely result of increased congestion costs will be a change in the relative desirability of one route over another for at least some movements. If alternative routings are specified for each movement within the movement file, the model will be able to evaluate all possibilities and select a route based on the costs associated with each choice.

In an effort to control the size of the problem to be solved by the model, alternative routings were limited to those that represented the most reasonable candidates; however, all original routes that had potential alternate routes were provided at least one alternate. In constructing the system alternate routings the following rules were used. (1) For through movements using the GIWW Morgan City - Port Allen Alternate Route, one alternate was constructed, the Atchafalaya River. (2) For through movements using the mainstem GIWW via Algiers or Harvey Locks, two alternatives were constructed, one via Harvey Lock and the mainstem GIWW and the other alternate via Port Allen Lock and the GIWW Alternate Route. (3) For GIWW West movements with an original route including Port Allen, Algiers or Harvey Locks, two alternatives were constructed, one each involving the use of either Port Allen, Algiers or Harvey locks depending on the original routing. (4) For local movements with an original route not including Port Allen, Algiers or Harvey Locks, two alternatives were constructed, one each involving the use of Port Allen and either Algiers or Harvey Locks depending on the original routing.

The assignment of transportation cost to the alternate water routings was accomplished in the following manner. Barge costs per mile were calculated for all original movements having alternate routings. This barge cost per mile was multiplied by the mileage associated with the alternate route to produce an adjusted alternate barge cost for the alternate route. Given the mileages of the original routing and the associated alternate, the adjusted alternate barge cost could be higher or lower than the original route barge cost. Using the alternate route barge cost and the same least cost non-system alternative associated with the original movement (since this in unchanged for the system alternate), the transportation cost savings for the system alternate route was computed. When all alternative routings were constructed, the movement file consisted of 16,455 total records representing 7,194 original movements.

The next step in the development of the movement file was to aggregate the file to a level more suitable for the analysis. Reducing the size of the movement file lowers the level of complexity that a large number of records can create for modeling purposes. To accomplish this, while still maintaining a level of detail necessary for realistic traffic routing, movements with common origin Port Equivalent, destination Port Equivalent, 10-group commodity code and system lock usage were aggregated into individual movements, with their transportation rates becoming a weighted average figure. The result of this process was a movement file that consisted of 5,460 total records representing 2,590 unique movements.

To further improve the efficiency of model operation, records of less than 1,000 tons, generally less than one full barge load, were also deleted from the file. These records consisted of a total of 459 records which included 263 alternate system routings and 196 original movements. Removing these movements only reduced lock system tonnage by approximately 80,000 tons. At this level of operation these small movements represented approximately 7.6 percent of original movements but only 0.1 percent of original movement tonnage.

d. Future Traffic Levels: From the final movement file, additional movement files were constructed to estimate future traffic demands by applying commodity group specific high, medium and low annual growth rates, previously discussed in Section 2 of this appendix, to the 1990 movement tonnages. The medium annual rates of growth were used to generate the most likely future system traffic demands at system locks.

CONGESTION COSTS

At this point, the transportation cost savings estimated for each of the movements in the WCSC data base include any congestion costs movements may have encountered as they traveled through the modeled locks. However the GEM requires these gross savings to be delay free, as the model itself calculates these costs. As a result an adjustment needs to be made to these estimates before proceeding any further.

To make the adjustment to gross savings estimates it is necessary to calculate a costs per hour of delay. There are three components that comprise the commodity-specific hourly delay costs at system locks. These components are barge cost, towboat cost, and commodity or inventory cost.

The first component, barge cost, is determined by the tow sizes and barge types employed in the movement of specific commodities. Tow size and barge type affect delay costs due to the differing capital and operating costs of the distinct equipment.

The average number of barges per tow for each commodity type transiting each lock was estimated and hourly barge costs for covered hopper barges, open hopper barges, and tank barges were used for the appropriate commodity groups in determining average barge costs per ton. Hourly barge costs were obtained from the Corps of Engineers Institute for Water Resources shallow draft vessel costs for Fiscal Year 1991.

The second major factor in estimating delay costs is the hourly cost of the towboat. The hourly cost of the towboat is directly related to its horsepower. Therefore, average towboat horsepower for each commodity type transiting each system lock was estimated and the operating costs were obtained from the Corps of Engineers Institute for Water Resources shallow draft vessel costs for Fiscal Year 1991. A significant adjustment to full towboat operating costs was necessary to more accurately estimate towboat costs accrued while waiting. Full operating costs are inappropriate for measuring delay costs since full costs contain a fuel component that reflects underway operations. To adjust for this, the fuel component of towboat costs was reduced by 75 percent for tows idling on the slack water

MR-GO side of the IHNC Lock, while use was made of information provided by towboat industry sources concerning hourly fuel cost of towboats idling against river currents while waiting on the Mississippi River side of the lock. In this instance, the full towboat cost of operation was used. These hourly fuel cost were then averaged to produce an overall estimate. This methodology was also used on Port Allen Lock, Algiers Lock and Harvey Lock, due to the fact that traffic queues waiting at these locks are also affected by Mississippi River currents. Traffic using Bayou Sorrel Lock, Bayou Boeuf lock and Calcasieu Lock are unaffected by river currents, consequently their overall fuel costs were reduced by 75 percent.

Using this information, an average tow operating cost was determined for each system lock for the ten commodity groupings used in this analysis.

The final component of the hourly cost of delay is commodity or inventory costs. These costs are typically such a small percentage of tow operating costs (less than 1 percent) that they have been ignored in this analysis.

For each of the ten commodity groups, barge and towboat cost per tow hour of delay were converted to costs per ton per hour by using average tons per tow. The final step in calculating cost per ton per hour of delay was to adjust for the empty backhauls of dedicated movements. The commodity mix of traffic on the GIWW is heavily weighted towards crude petroleum, refined petroleum products, and chemicals. For these commodities it was assumed that all traffic has empty backhauls. As such, delay costs are incurred twice, once with loaded barges and once with returning empty barges. The cost per ton per hour of delay was therefore doubled to reflect the empty backhaul. A 70 percent empty backhaul was assumed for the rest of the commodities so that delay costs are incurred 1.7 times, therefore the cost per ton per hour of delay was multiplied by 1.7 to reflect the appropriate level of empty backhaul. These calculations represent the estimates utilized by the GEM as it calculates lock congestion costs for each movement transiting each system lock. These hourly cost per kiloton by commodity and lock are shown in table 3 - 4.

In order to calculate delay free gross cost savings for each of the movements in the WCSC file, the original water transportation cost estimates were decreased (which increased the gross cost savings) by the product of these hourly wait cost per ton estimates and the average delay per hour the movement had to incur as it traveled through the modeled locks from its origin to destination.

Table 3 - 4

Hourly Costs of Delay for
Commodities at System Locks
(Dollars per 1,000 Tons)

Commodities	Port Allen	Bayou Sorrel	IHNC	Algiers	Harvey	Bayou Boeuf	Calcasieu
Farm Products	66	63	56	66	66	63	63
Metallic Ores	55	53	55	55	55	53	53
Coal	55	53	55	55	55	53	53
Crude Petroleum	51	49	51	51	51	49	49
Non-Metallic Minerals	49	46	49	49	49	46	46
Forest Products	55	52	55	55	55	52	52
Industrial Chemicals	82	77	82	82	82	77	77
Agricultural Chemicals	75	70	75	75	75	70	70
Petroleum Products	51	49	51	51	51	49	49
All Others	64	61	64	64	64	61	61

LOCK CAPACITY AND DELAY ANALYSIS

Essential to the economic analysis of improvements to the lock structures on the navigation system is the ability to quantify the relationship between tonnage moving through a lock and the resulting delays at the lock. In this study, two methods were employed for this purpose.

Due to the fact that a simulation analysis can be employed to detail the impact of any number of specific operational practices on the traffic - delay relationship, it was decided that this method of estimating lock capacity would be most appropriate to use on the IHNC Lock. As for the rest of the system locks, a more simplified analytical approach was used. The discussion of these two methods can be found in Section 5.

SECTION 4 - TRANSPORTATION RATE ANALYSIS

DEVELOPMENT OF THE RATE SAMPLE

To form the basis of the transportation rate analysis, a sample of aggregated movements was selected from a subset of the 1989 Waterborne Commerce detail records database. Transportation rates were developed for this sample of movements. This process was accomplished as follows.

The records in the WCSC database represented individual barge-level movements that travelled any portion of the GIWW -Mississippi River to Sabine, GIWW - Morgan City to Port Allen Alternate Route, or the Innerharbor Navigation Canal waterways. In addition to tonnage and origin/destination information, these records also include a 4-digit commodity code, and a waterway routing indicator (alt code) for movements where alternative routings are applicable. Records with the same 4-digit commodity code, origin port, destination port and alt code were aggregated to produce annual port-level tonnage flows representing 6,223 records and 75.5 million tons. All subsequent processing was based on these aggregated annual flows.
Separate files were constructed for those movements which used the IHNC lock and those movements which did not. These files were then aggregated into "cells". In the IHNC file these "cells" consisted of movements with a common origin PE, destination PE and 10-group commodity code, with its level of tonnage equal to the sum of those movements. A PE (Port Equivalent) code is defined by ranges of WCSC port-dock codes and represents a waterway section. Similarly, the non-IHNC file was aggregated into "cells", however, in this file the "cells" consisted of movements with a common origin PE, destination PE, and 10-group commodity code but also common alt codes. The alt codes, which indicate waterway use, were used in this file because more than one route over the modelled system was possible between the origin and destination.

At the outset, it was thought possible that a sample could be developed that would provide cell-level coverage of approximately 95 percent of the total system tonnage. To do this, 348 of the largest "cells" (by tonnage) were selected in the IHNC file and 597 of the largest "cells" (by tonnage) were selected in the non-IHNC file. Summing the tonnage in these 945 "cells" produced 71,354,000 million tons which represented 94.5 percent of the total system tonnage of 75,507,000 tons.

Next, within each "cell", individual movements were assigned a weight equal to its own tons divided by the total tonnage in the "cell". These percentages were then transformed into cumulative percentages and multiplied by 100 to produce and integer between 1 and 100 for each movement. Next, using a random number generator, a number between 1 and 100 was assigned to each "cell".

The first movement within each "cell" whose integer was greater than or equal to this random number was selected for the sample. The effect of this procedure was to select a single movement from each "cell" with the probability of selection for a given movement equal to that movement's "cell" tonnage proportion. The final product was a sample of 945 movements with a total of 34,441,000 tons, 46 percent of the total system tonnage. Table 4 - 1 displays the 1989 rate sample tonnage as a percent of 1989 system tonnage by commodity group.

TRANSPORTATION RATE ANALYSIS

The transportation rate analysis was conducted by the Tennessee Valley Authority (TVA) under contract with the New Orleans District. The objective of the study was to calculate line-haul transportation rates and supplemental costs for a sampling of 944 dock-to dock movements taken from the 1989 waterborne traffic base. (One movement in the 945 movement sample was determined to be non-commercial traffic and was removed, leaving 944 movements identified for analysis.)

For each sample movement, a calculation of freight rates was made by a system waterway route, and by one or more land routes utilizing an alternate mode of transportation. Total origin to destination shipping costs were calculated, including loading and unloading costs at origin and destination. The costs of subsequent overland movements and intermodal transfer costs at origin and destination were also calculated. Computations reflect those charges that were in effect during the third quarter of 1992. The following paragraphs detail the study's guidelines, methods of research and supporting assumptions.

ROUTING OPTIONS

With respect to land routes 911, 310 and 9 movements were evaluated for rail, truck, and pipeline rates respectively. As a general rule, all movements of 400 miles or less and less than 100,000 tons were evaluated for truck.

For 60 movements involving Intracoastal Waterway points east of New Orleans and points on the Middle and Upper Mississippi River, Illinois Waterway, Ohio River System, and Tennessee and Cumberland Rivers, an alternate

Table 4 - 1

1989 Rate Sample Tonnage As A Percent
Of 1989 System Tonnage

Commodity group	Sample Tons as a percent of System Tons	Sample Cells as a percent of System Cells	Sample Cell Tonnage as a percent of System Tonnage
Farm Products	33%	27%	77%
Metallic Ores and Products	42%	31%	82%
Coal	89%	58%	99%
Crude Petroleum	51%	68%	98%
Nonmetallic Minerals	48%	42%	93%
Forest products and pulp	82%	44%	87%
Industrial Chemicals	44%	44%	94%
Agricultural Chemicals	19%	24%	71%
Petroleum Products	33%	53%	96%
All Others	46%	41%	95%
Total	46%	42%	95%

non-system waterway routing was calculated via the Tennessee-Tombigbee Waterway.

Table 4-2 summarizes the routing options considered for the 944 movements of the rate sample.

ASSUMPTIONS

Actual shipment costs and supporting information were obtained from shipper, receivers, carriers, and riverport terminals wherever possible. In the absence of specific shipper/receiver information, it was assumed that the river origin and destination were the originating and terminating points for both the river route and alternate mode of transportation.

It was assumed that commodities loaded or unloaded to or from barges could also be loaded or unloaded to or from rail cars or trucks.

It was assumed that the alternate modes of transportation would have the physical capacity to accommodate the tonnages involved for each commodity movement, except that truck transportation was not considered to be a viable option for shipments involving tonnage of 100,000 tons or more.

It was assumed that for movements involving tonnages of less than 100,000 tons, shippers or receivers not served by rail would utilize truck transportation from or to the nearest railhead. It was further assumed that facilities would be available at the rail location to accommodate the transfer. For movements involving tonnages of 100,000 tons or more, it was assumed that rail facilities would be constructed by the carrier, shipper, or receiver. It was assumed that any construction costs incurred by the shipper or receiver would be assigned to the cost of production, rather than to the cost of transportation. While it is possible that construction costs incurred by carriers would be passed on to shippers or receivers in the form of higher rates, these costs were considered to be beyond the scope of this study.

METHODS AND PROCEDURES

As a result of transportation deregulation, it is virtually impossible to determine with absolute precision the exact rate charged by a carrier on a large-tonnage movement. Barge rates are a matter of negotiation between shipper and carrier and are not published in printed tariff form. Each carrier's rates are based on individual costs and will vary from one barge line to another.

Table 4 - 2

Rate Sample Observations by Commodity Group
And Transportation Mode

Commodity Group	Water	Alt Water Tenn-Tom	Rail	Truck	Pipeline
Farm Products	61	11	61	23	0
Metallic Ores	108	7	106	22	0
Coal	31	22	31	2	0
Crude Petroleum	92	0	78	66	0
Non-Metallic Minerals	117	4	114	24	0
Forest Products	7	2	7	4	0
Industrial Chemicals	168	1	167	27	0
Agricultural Chemicals	43	0	41	11	0
Petroleum Products	280	12	274	110	9
All Others	37	1	32	21	0
Total	944	60	911	310	9

Contract rates are prevalent in the rail and trucking industries and are not public knowledge. Rates are published in tariff form on bulk commodities; however it is difficult to determine those movements that are rated on a tariff basis as compared to those movements that are rated on a contractual basis.

Rates provided by carriers, shippers, receivers or riverport terminals were used wherever possible. All other rates were obtained from published sources or were constructed by TVA, depending on the mode of transportation or tonnages involved.

Barge Rates

With the exception of actual rates obtained from shippers, carriers, or riverport terminals, barge rates were calculated using a computerized barge costing model. The model, which was obtained from another government agency and modified by TVA, was programmed to include 1992 fixed and variable costs information obtained from the towing industry.

The costing model contains two modules--a general towing service module and a dedicated towing service module. The general service module calculates rates by simulating the use of general towing service conditions between origin and destination. This includes, among other things, interchange of barges between two or more carriers.

The dedicated service module calculates costs by simulating round-trip movements between origin and destination. This includes the use of the same towboat for the loaded movement from origin to destination and the return of the empty barge(s) from destination back to origin.

Both modules require various inputs, but among the more important are, towboat sizes (horsepower); barge types; shipment weights; and empty return ratios.

Barge rates on dry commodities were calculated using the general towing service costing module. Inputs based on information obtained from carriers and the Corps of Engineers' Lock Performance Monitoring System (LPMS) database were used in the module to simulate the average towboat size (horsepower) and corresponding tow size (barges) for each segment of the inland waterway system. Other inputs included barge types, waterway speeds and horsepower ratios.

Empty return ratios for dry commodity movements were generally calculated at 70 percent; however movements with both origin or destination on the Intracoastal Waterway east of Houston or origins or destinations on the Lower Mississippi south of Baton Rouge were calculated on a round-trip basis.

Depending on the type of movement, tonnage and barge size involved, rates on liquid commodities were calculated with the use of either the general towing service or the dedicated towing service module. For commodities that are normally transported in barges measuring 195 x 35 feet, rates were calculated with the use of the general towing service module. Since barge sizes are compatible, these shipments can be integrated into the same tows with dry commodities. Commodities that are normally transported in general towing service include sodium hydroxide, molasses, tallow, and certain chemical products.

The determination of general or dedicated service calculations for alcohols, benzene, chemicals, and miscellaneous chemical products was based on the volume involved. For movements with tonnages of less than 10,000 tons, rates were calculated with the use of the general towing service module. For movements with tonnages of 10,000 tons or more, rates were calculated with the use of the dedicated towing service module.

All rates on asphalt and crude and refined petroleum products were calculated with the use of the dedicated towing service module. All rates on liquid commodities were calculated on a round-trip basis, whether general or dedicated service towing.

Rail Rates

It was assumed that tariff rates would apply to all rail shipments with annual volumes of less than 5,000 tons. For shipments with annual volumes of 5,000 tons or more, contractual rates were constructed on the basis of a percentage reduction of the tariff rate or with the use of a computerized rail costing model developed by Reebie Associates.

Rates on grain, grain sorghum, and grain mill products were based on a percentage relationship to the published tariff rate. Multiple car or volume rates were utilized wherever possible. It was also assumed that all shipments of grain, grain mill products and rice would move in covered hopper cars owned by the carrier.

Rail rates on all other commodities were calculated with the use of the Reebie Associates costing model. This model identifies the rail carrier's variable and fixed costs between origin and destination and the relationship of these costs to the movement's published tariff rate.

Truck Rates

Actual truck rates were used wherever possible. All other rates were estimated on the basis of a formula derived from a comparison of rates published in tariffs, known contractual rates, costs applicable on an hourly rental basis, and private fleet truck costs.

Pipeline Rates

Published pipeline rates were used wherever possible. A number of movements from or to river terminals were routed via relatively short pipeline systems that were privately owned. Rates for these movements were estimated on the basis of rates published in tariffs for comparable distances.

Handling Charges

Handling charges between modes of transportation were estimated on the basis of information obtained from shippers, receivers, and terminal operators. Handling charges for transfer of commodities from or to ocean vessels were estimated on the basis of information obtained from ocean ports or stevedoring companies. In general, it was assumed that movements of bulk products, (e.g., grain) would be handled through elevator or storage facilities at both origin and destination.

Loading and Unloading Costs

Loading and unloading costs are not normally documented by shippers and receivers. Costs will vary from company to company and are often-times considered as part of the cost of production. A number of sources were utilized in obtaining loading and unloading costs, but for the most part reliance was placed on information obtained from shippers and receivers.

Attachment 1 of the appendix summarizes the results of this study. The attachment consist of the commodity, tons, original water rate, alternate water rate (Tenn-Tom), primary land rate and alternate land rate for each of the 944 sample movements.

EXPANDING THE RATE SAMPLE TO THE POPULATION

ASSIGNMENT PROCESS

As was mentioned previously, the sample movements evaluated by TVA represented 1989 WCSC data. However, after TVA completed their analysis, 1990 traffic was ready for use. In order to work with the most current data available, the decision was made to match the rates TVA calculated in the 1989 sample to the 1990 records. Table 4 - 3 shows how the 1989 rate sample applies to the 1990 system tonnage. Comparison of tables 4 - 3 and 4 - 1 clearly indicates that the origin-destination patterns for 1989 and 1990 traffic are quite similar.

The 1990 traffic file was processed in a manner that was essentially the same as described with the 1989 traffic. Records representing movements that travelled any portion of the GIWW -Mississippi River to Sabine, GIWW - Morgan City to Port Allen Alternate Route, or the Innerharbor Navigation Canal waterway segments were extracted by WCSC from the 1990 data base and provided as a single file. Tonnage with the same 5-digit commodity code (1990 WCSC uses a more detailed 5-digit commodity code rather than the previous 4-digit code used in the 1989 movement file), origin port, destination port and alt code was aggregated to produce annual port-level tonnage flows. At this level, system lock usage was assigned for each movement. The 1990 movement file had a total of 7,174 records and 73.4 million tons, 22.7 million tons of which represented IHNC movements.

To assist with the assignment of rates, the 1989 4-digit commodity code was added to the 1990 movement file, since the 1989 sample rate study only has the 4 digit commodity code. In addition, to facilitate further file processing and aggregation, each record in the 1990 movement file was assigned a commodity group number based on the 10-category classification scheme, described earlier in Section 2.

Records in the 1990 WCSC movement file were divided into two separate files, one representing IHNC traffic and the other representing non-IHNC traffic. As mentioned earlier, the reason for this distinction is due to the fact that alt codes, which indicate waterway use, are required for route identification for non-IHNC traffic since more than one waterway is possible between the origin and destination. The objective then was to match transportation rates from 1989 IHNC sample records to the 1990 IHNC records and non-IHNC 1989 sample records to 1990 non-IHNC records. To accomplish this task, it was necessary to match sampled

Table 4 - 3

1989 Rate Sample Tonnage As A Percent
Of 1990 System Tonnage

Commodity group	Sample Tons as a percent of System Tons	Sample Cells as a percent of System Cells	Sample Cell Tonnage as a percent of System Tonnage
Farm Products	39%	27%	91%
Metallic Ores and Products	32%	28%	63%
Coal	78%	55%	87%
Crude Petroleum	57%	52%	100%
Nonmetallic Minerals	38%	36%	72%
Forest products and pulp	67%	21%	71%
Industrial Chemicals	46%	42%	97%
Agricultural Chemicals	18%	23%	67%
Petroleum Products	37%	52%	100%
All Others	100%	29%	100%
Total	47%	39%	97%

records to the 1990 population at several levels of aggregation.

In the first level matching, records in the IHNC rate sample were matched to the 1990 IHNC records on the basis of common origin port, origin dock, destination port, destination dock, and 4-digit commodity code. The records in the non-IHNC rate sample were matched to 1990 non-IHNC records in the same fashion, but now common alt codes were also used as the basis for comparison. When a match was identified, total transportation costs for the original water route, alternate water route, and primary land route were assigned to the 1990 movement. (With the exception of two movements in the overall rate sample, which represented only 0.2 percent of the total tons in the sample, the primary land route was always less costly than the alternate land route. As a result, matching alternate land costs was considered unnecessary.) To make this assignment, the weighted average cost for IHNC sample movements grouped by origin port, origin dock, destination port, destination dock, and 4-digit commodity code was calculated. When an IHNC sample movement was matched to an IHNC 1990 population movement, the cost, which represent a cost per ton, was assigned to the IHNC 1990 population movement. This same method was employed when matching non-IHNC movements, except the weighted average cost calculation for non-IHNC sample movements included the use of alt codes when movements were grouped. This initial matching assigned costs to 6 percent of the total 1990 population movements representing 28 percent of the total tonnage. In the IHNC section alone, costs were assigned to 9 percent of the total IHNC movements representing 43 percent of the total IHNC tonnage. This degree of coverage is very good considering that at this level of grouping, the matching taking place is essentially on an individual movement basis.

In order to assign costs to those movements not initially matched, several more levels of matching needed to be performed. The second matching was based on common origin PE, destination PE, and 10-group commodity code for IHNC movements with the additional common alt codes for non-IHNC movements. As described in the first level of matching, this procedure assigned weighted average costs from the IHNC sample movements and non-IHNC sample movements, grouped as described for the second matching. When a sample movement was matched to a 1990 population movement, the costs per ton for the various means of transportation were assigned to the WCSC movement. After this second level of matching, 46 percent of the 1990 movements representing 66 percent of the total tonnage was assigned costs. In the IHNC section alone, costs were assigned to

30 percent of the total IHNC movements, representing 60 percent of the total IHNC tonnage.

The third level of matching was based on common waterway segment origin and destination (the 2-digit level of the 4-digit origin and destination PE codes), and 10-group commodity code for IHNC movements with the additional common alt codes for non-IHNC movements. At this level of matching, as well as the following ones, the weighted average costs per mile for the various means of transportation were calculated, grouped as described for this level of matching. Weighted average cost per mile was used instead of weighted average cost per ton, as was the case for level 1 and level 2, because from level 3 on, the potential for substantial mileage variation existed between the sample movement and the population movement matched to it. Since transportation costs are very much a function of distance, it was viewed as necessary to assign a mileage sensitive cost. When a sample movement was matched to a WCSC movement, the cost per ton mile for the sample movement was multiplied by the mileage of the 1990 movement. This product was the cost per ton assigned to the 1990 movement. For example, the weighted average cost per mile of an original water rate from a sample movement was multiplied by the water mileage of the 1990 movement. This method works well for assigning original water cost per ton estimates to 1990 population movements since in the 1990 file, water mileage estimates are already included in the WCSC file. However, when assigning primary land and alternate water cost per ton estimates, the appropriate original land mileage and alternate water mileage in the WCSC file had to be calculated externally.

To estimate primary land mileages and alternate water mileages in the file, a regression analysis was performed using data from the TVA rate sample. The primary objective of regression analysis is to predict the value of one variable (the dependent variable) given that the value of an associated variable (the independent variable) is known. The regression equation is the algebraic formula by which the predicted value of the dependent variable is determined.

Along with transportation costs for each of the sampled movements, TVA also provided estimates on original water mileage, primary land mileage, and alternate water mileage. By running a regression analysis, with original water mileage as the independent variable and land mileage as the dependent variable, the resulting regression equation could be used to predict a land mileage based on the original water mileage estimate in the 1990 file. The regression analysis, performed on the sample movements, was done on the 10-commodity code classification scheme. As a result, each of the 10 commodity codes has an individual regression equation.

The regression equations used to predict primary land mileage estimates, in the 1990 file, are provided in table 4 - 4. Also included, are the coefficient's of determination (R-squared) for each of the 10 equations. This coefficient indicates the proportion of the variance in the dependent variable (land mileage), explained by knowledge of the independent variable (original water mileage). Tests of significance indicate that there is a statistically significant relationship between these two variables.

In order to estimate alternate water mileage for the 1990 movements, another regression analysis was performed on the rate sample using the land mileage as the independent variable and the alternate water mileage as the dependent variable. This formulation for estimating the alternate water mileage was selected from a variety of other investigated specifications, because it produced the greatest degree of explanatory power. (In the sample, only movements with an alternate water mileage were included in the analysis.) The resulting regression equations were then used to predict the alternate water mileage based on the primary land mileage already calculated from the previous regression analysis. (For the 1990 movements, an alternate water mileage was calculated for only those movements where the Tenn-Tom Waterway was considered a reasonable alternate route.)

As before, the regression analysis was performed for each of the 10 commodity groups, however for crude petroleum, forest products, industrial chemicals, agricultural chemicals and the all other commodity group, there were not enough movements in the rate sample to perform a meaningful analysis. Therefore, the decision was made to perform the regression analysis on all the sample movements with an alternate water mileage, disregarding the commodity group distinction. This single regression equation was used to estimate alternate water miles for these five commodity groups. The resulting six different regression equations along with their coefficients of determination are also displayed in table 4 - 4. As with the previous regression equations, test of significance revealed a true relationship between the two variables.

With the above mileage estimates, the primary land and alternate water cost per ton calculations were performed in the same manner as the original water costs per ton. After this third level of matching, 81 percent of the total 1990

Table 4 - 4

Regression Equations Used to Predict
Primary Land Miles and Alternate Water Miles

Commodity	Primary Land Miles	R-Squared	Alternate Water Miles	R-Squared
Farm Products	37.4237 + .7498 x Original Water Miles	0.91	176.6945 + .9544 x Land Miles	0.91
Metallic Ores	176.0323 + .5210 x Original Water Miles	0.76	-195.3749 + 1.490 x Land Miles	0.82
Coal	166.4695 + .4512 x Original Water Miles	0.75	-4.9575 + 1.214 x Land Miles	0.73
Crude Petroleum	-17.2043 + .8719 x Original Water Miles	0.77	143.198 + .666 x Land Miles	0.77
Non-Metallic Minerals	114.1096 + .6871 x Original Water Miles	0.71	-1577.96 + 3.596 x Land Miles	0.46
Forest Products	102.5304 + .5338 x Original Water Miles	0.98	143.198 + .666 x Land Miles	0.77
Industrial Chemicals	102.1856 + .6853 x Original Water Miles	0.91	143.198 + .666 x Land Miles	0.77
Agricultural Chemicals	-6.5211 + .9087 x Original Water Miles	0.70	143.198 + .666 x Land Miles	0.77
Petroleum Products	81.7960 + .6604 x Original Water Miles	0.90	-149.816 + 1.5676 x Land Miles	0.72
All Others	31.7142 + .7048 x Original Water Miles	0.96	143.198 + .666 x Land Miles	0.77

movements, representing 90 percent of the total tonnage, were assigned costs. For the IHNC records only, 65 percent of the IHNC movements, representing 86 percent of the IHNC tonnage, were assigned costs.

The fourth level of matching was based on common waterway segment destination (the 2-digit level of the 4-digit PE code), and 10-group commodity code for both the IHNC movements and non-IHNC movements. As before, this procedure assigned a weighted average cost per mile, for the various means of transportation, to the 1990 movements when a sample movement matched a 1990 movement. This cost per mile was then multiplied by the appropriate mileage figure to produce a cost per ton estimate. After this fourth level of matching, 93 percent of the total 1990 movements, representing 96 percent of the total tonnage, were assigned costs. For the IHNC records only, 83 percent of the movements, representing 92 percent of the tonnage, were assigned costs.

In the fifth and last level of matching, those records that were still unassigned, were matched based only on the 10-group commodity code for both the IHNC movements and non-IHNC movements. As with the third and fourth level of matching, this assignment was accomplished using the product of the costs per mile from the sample movements, now grouped as described in this fifth level of matching, and the appropriate mileage of the movement to be assigned a cost. With this last level of matching, all 7,174 movements in the 1990 file were assigned an original water cost per ton, a land cost per ton, and an alternate water cost per ton.

SUMMARY OF RESULTS

For each of the movements in the 1990 file, an estimate of the difference between total water transportation cost (original water cost per ton) and total cost for the movement via the next least costly non-system alternative means of shipment (i.e., land cost per ton or alternate water cost per ton) was made. This difference is referred to as the net cost savings of the ton's potential movement via the system. These savings are deemed net as opposed to gross because the water costs are inclusive of system lock delays. Savings measured with lock delays taken out of water costs are referred to as gross cost savings. Table 4 - 5 shows the overall distribution of net gross cost savings for the entire system and IHNC movements only. Table 4 - 6 shows the distribution of these net cost savings broken down by the first two levels of matching and then by the next three levels of matching. As can be seen, two percent of the total number of records for the system,

Net Cost Savings Distribution
For the Total System and IHNC Movements
(1992 Prices)

Net Cost Savings ($)	Total System: # Of Records	Total System: Tons	Total System: % Of Total Tons	IHNC Movements: # Of Records	IHNC Movements: Tons	IHNC Movements: % Of Total Tons
<0	144	591,681	0.8%	86	404,143	1.8%
>=0 <1.50	127	2,311,060	3.1%	109	2,184,755	9.6%
>=1.50 <4.00	242	7,420,020	10.1%	149	6,750,406	29.7%
>=4.00 <7.00	800	8,259,138	11.3%	224	1,996,185	8.8%
>=7.00 <11.00	1,187	11,346,176	15.5%	275	1,722,970	7.6%
>=11.00 <16.00	1,314	12,657,176	17.2%	419	3,633,923	16.0%
>=16.00 <24.00	1,408	15,126,602	20.6%	431	4,148,010	18.3%
>=24.00 <31.00	949	8,593,746	11.7%	142	1,177,214	5.2%
>=31.00 <36.00	427	3,154,898	4.3%	61	211,520	0.9%
>=36.00 <42.00	252	2,204,668	3.0%	28	339,245	1.5%
>=42.00 <50.00	141	839,068	1.1%	11	42,343	0.2%
>=50.00 <60.00	91	369,603	0.5%	15	42,715	0.2%
>=60.00 <70.00	51	273,492	0.4%	12	53,413	0.2%
>=70.00 <80.00	30	185,783	0.3%	1	300	0.0%
>=80.00	11	66,271	0.1%	2	15,654	0.1%
Total	7,174	73,399,382	100%	1,965	22,722,796	100%

Table 4 - 6

Net Cost Savings Distribution
by Levels of Matching
(1992 Prices)

Net Cost Savings ($)	Total System Levels of Matching 1 - 2 # Of Records	Tons	% Of Total Tons	Total System Levels of Matching 3 - 5 # Of Records	Tons	% Of Total Tons
<0	11	141,983	0.3%	133	449,698	1.8%
>=0 <1.50	51	1,841,923	3.8%	76	469,137	1.9%
>=1.50 <4.00	80	5,620,556	11.5%	162	1,799,464	7.3%
>=4.00 <7.00	464	6,707,686	13.7%	336	1,551,452	6.3%
>=7.00 <11.00	620	7,603,340	15.6%	567	3,742,836	15.2%
>=11.00 <16.00	572	7,861,151	16.1%	742	4,796,025	19.5%
>=16.00 <24.00	681	10,157,785	20.8%	727	4,968,817	20.2%
>=24.00 <31.00	387	4,652,304	9.5%	562	3,941,442	16.0%
>=31.00 <36.00	203	1,887,887	3.9%	224	1,267,011	5.2%
>=36.00 <42.00	109	1,440,415	3.0%	143	764,253	3.1%
>=42.00 <50.00	63	492,438	1.0%	78	346,630	1.4%
>=50.00 <60.00	47	178,059	0.4%	44	191,544	0.8%
>=60.00 <70.00	18	112,025	0.2%	33	161,467	0.7%
>=70.00 <80.00	18	98,542	0.2%	12	87,241	0.4%
>=80.00	5	30,405	0.1%	6	35,866	0.1%
Total	3,329	48,826,499	100%	3,845	24,572,883	100%

Net Cost Savings ($)	IHNC movements Levels of Matching 1 - 2 # Of Records	Tons	% Of Total Tons	IHNC movements Levels of Matching 3 - 5 # Of Records	Tons	% Of Total Tons
<0	9	105,005	0.8%	77	299,138	3.3%
>=0 <1.50	40	1,773,412	13.0%	69	411,343	4.5%
>=1.50 <4.00	31	5,173,796	37.9%	118	1,576,810	17.4%
>=4.00 <7.00	92	1,457,757	10.7%	132	538,428	5.9%
>=7.00 <11.00	60	556,582	4.1%	215	1,166,388	12.8%
>=11.00 <16.00	122	1,772,873	13.0%	297	1,861,050	20.5%
>=16.00 <24.00	157	1,860,184	13.6%	274	2,287,826	25.2%
>=24.00 <31.00	54	619,419	4.5%	88	557,795	6.1%
>=31.00 <36.00	13	48,901	0.4%	48	162,619	1.8%
>=36.00 <42.00	3	219,153	1.6%	25	120,092	1.3%
>=42.00 <50.00	2	5,687	0.0%	9	36,656	0.4%
>=50.00 <60.00	5	18,880	0.1%	10	23,835	0.3%
>=60.00 <70.00	4	31,573	0.2%	8	21,840	0.2%
>=70.00 <80.00	0	0	0.0%	1	300	0.0%
>=80.00	0	0	0.0%	2	15,654	0.2%
Total	592	13,643,222	100%	1,373	9,079,574	100%

representing one percent of the total tons has a negative net cost savings. This means that for these movements, using a non-system alternative means of transportation appears to be the least costly, suggesting that some shippers are behaving uneconomically. Those movements in the TVA sample with a negative net cost savings were only included in the first level of matching. For all subsequent levels of matching, the effect of the negative net cost savings sample movements were excluded from the calculation and assignment of weighted costs. These movements were excluded in order to minimize the distortions that the negative net cost savings movements produced in the subsequent levels of matching.

As a final illustration of the transportation rate analysis sample and the expansion of this sample to the population of movements, table 4 - 7 displays the weighted average net cost savings and weighted average mileage, for the system as a whole by commodity group.

WITH-PROJECT SAVINGS ADJUSTMENT

When TVA assigned water transportation costs to IHNC traffic, included in these rates is the cost of hiring assist vessels tow operators must incur whenever there is a need to cut the tow to transit the existing IHNC Lock. When analyzing a larger lock in the with project condition, the number of multiple-cut lockages would necessarily decrease. Therefore an adjustment was made to the with-project gross cost savings of IHNC traffic to reflect the corresponding reduction in assist cost.

Local towboat operators provided assist vessel cost information concerning double cut and triple cut lockages at the existing IHNC Lock. Using the percentages of double and triple cut IHNC lockages, provided by LPMS 1990 data, weighted average cost per ton estimates were calculated, by commodity group. The results of which are shown in table 4 - 8.

The simulation model, used in the calculation of capacity estimates, provided percentages of multiple-cut lockages that are likely to occur in the various with-project conditions. Utilizing this information, estimating the reduction in multiple-cut lockages, for the larger IHNC locks, was an easy matter. The gross cost savings of traffic transiting these larger locks were then increased by the product of this percentage reduction and the above calculated assist costs.

Table 4 - 7

Net Cost Savings & Mileage
By Commodity Group
Total System
(1992 Prices)

Commodity Group	Weighted Net Cost Savings ($)	Weighted Mileage
Farm Products	9.22	671
Metallic Ores	25.40	1,132
Coal	2.44	1,244
Crude Petroleum	15.98	237
Non-Metallic Minerals	21.26	977
Forest Products	7.52	884
Industrial Chemicals	18.83	935
Agricultural Chemicals	20.86	765
Petroleum Products	15.44	585
All Others	12.23	525

Table 4 - 8

Tug Assist Costs
for Commodities at IHNC lock
(Dollars per ton)
(1992 Prices)

	Cost per
Farm Products	0.01
Metallic Ores	0.02
Coal	0.01
Crude Petroleum	0.01
Non-Metallic Minerals	0.01
Forest Products	0.02
Industrial Chemicals	0.01
Agricultural Chemicals	0.02
Petroleum Products	0.02
All Others	0.01

SECTION 5 - LOCK CAPACITY AND DELAY FUNCTION ESTIMATION

OVERVIEW

As traffic levels increase on a waterway, the increased traffic creates delays at bottlenecks on the system. Generally, these bottlenecks or constraints occur at navigation locks. Quantifying the relationship between tonnage moving through a lock and the delay at the lock is essential to the economic analysis of the value of the navigation system.

There are two distinct ways to establish the delay-tonnage relationship of lock operations--deterministically or through simulation. In this study, the deterministic approach was used for all system locks except IHNC, whereas for the IHNC lock, simulation was used. Simulation was considered more appropriate for IHNC due mainly to the fact that simulation analysis would be more adept at calculating the impacts of bridge operations on navigation and simulation would also be better suited for measuring the relative efficiencies of chamber packing with different size chambers. The following is a discussion of the deterministic approach and simulation approach selected for this study.

DETERMINISTIC APPROACH

The deterministic technique selected for use in this study is an "engineered" approach which estimates the capacity at a system lock by analyzing the distribution of service times as a function of lock operating procedures and the distribution of tonnage present for processing. This technique was developed by the Rock Island District and has been used in the Upper Mississippi River Navigation Study Reconnaissance Report, the Intracoastal Waterway Locks, Louisiana, Reconnaissance Report, as well as the Inland Navigation Investment Needs Assessment Study.

To determine the delay-tonnage relationship at a navigation lock deterministically, some approximations from queuing theory may be applied. If arrivals for service (locking) follow a Poisson process (i.e., randomly independent), then the expected wait for service (delay at lock) is given by the formula:

D = (U(S^2 + 1)P) / (2(1-U)), where:

D = expected delay;
S = ratio of the standard deviation to the mean processing time;

U = lock utilization defined as the ratio of the mean interarrival time and the mean processing time; and
P = mean processing time.

It can be seen from this formulation that as lock utilization approaches unity the expected delay at the lock grows without bound. The tonnage required to produce 100 percent utilization is defined as the "practical lock capacity."

The above demonstrates that expected delay can be related to lock utilization. It remains, however, to find the relationship between tonnage and expected delay. In order to accomplish this, a simultaneous system of equations was developed which models the relationship between tonnage and utilization. Solving this model for a given level of tonnage allows the corresponding utilization to be found and, hence, expected delay. By solving the model over a range of tonnages, the relationship between tonnage and expected levels of delay can be traced. Further, by "backsolving" the model, the tonnage required to produce any given level of expected delay can be determined.

The system of equations required to accomplish the above tasks is sufficiently complex to warrant a computer for solution. With this in mind, the model was developed using the software package TK Solver. This software's ability to iteratively solve (and backsolve) systems of equations make it a useful tool for developing and solving the model. The following discussion describes the implementation of the model.

STEP 1 - Base year tonnage is specified for each of ten commodity groups both upbound and downbound. The model contains equations specifying tonnage growth for each of the commodity groups. For any given level of total tonnage, these growth equations are solved to yield the tonnage in each commodity group. As a by-product of this solution, the year in which this tonnage is projected to occur is also found.

STEP 2 - The model has, as part of its input, the proportion of upbound and downbound tonnage in each commodity group and tons per barge load by commodity. This information is readily determined from available data sources. Using these inputs, along with the tonnage by commodity group from step 1, the number of loaded barges both upbound and downbound is determined.

STEP 3 - The imbalance between upbound and downbound tonnage necessitates the movement of empty barges. Moreover, even if movements were perfectly balanced, a certain percentage of the barges would still return empty; these are referred to as dedicated movements. The ratios of empty barges in each direction to loaded barge movements in the opposite direction is determined from historical data. These ratios are then applied to the number of empty barges traversing the lock.

At this point, the total number of barges traversing the lock, both upbound and downbound, is known. At sites where no alternate water routes are available these numbers inherently must be roughly equal and, although it is not an explicit requirement of the model, this is the case.

STEP 4 - Average tow size is determined from LPMS data and is held constant as traffic congestion increases. The physical limits of the waterway dictate a constant average tow size.

STEP 5 - Knowing both the total number of barges and average tow size permits the number of tows transiting the lock to be determined.

STEP 6 - The lockages types (i.e. single, double, multi-vessel, etc.) and the relative frequency with which they occur is determined largely from historical LPMS data. At several of the longer chamber locks, the proportion of multi-vessel lockages is projected to increase at higher levels of utilization. With the future proportion of multi-vessel lockages specified, the model determines the number of all other lockage types based upon historical data.

STEP 7 - An important model input is the lockage component times. These component times are input for the various lockage types, and entry/exit types. These were determined from LPMS data.

STEP 8 - The number of lockages of each type (i.e., single, double, etc.) has already been determined. It remains to determine the proportion of lockages that will use fly, turnback, or exchange approach/exits. Since we already assume that arrivals for lockage occur randomly, it follows that the portion of fly approach/exits is given by 1 minus utilization. If the lock utilization is less than .85, the model assumes that the lock operates using a First-Come-First-Serve policy and, hence, the proportion of turnback and exchange approach/exits are both equal to 1/2 of utilization. At higher levels of utilization, the model compares the relative efficiency of turnback versus exchange approach/exits and assigns the appropriate lockage policy--either 1-up 1-down, or k-up k-down. At locks where turnback is more efficient than exchange, the model assumes a gradual implementation of a k-up k-down policy until a 10-up 10-down policy is reached at 100 percent utilization. At locks where exchange is more efficient than turnback, a 1-up 1-down policy is gradually implemented so that it is fully in effect at 100 percent utilization.

STEP 9 - It should be noted that the analysis implies that utilization is known. Utilization, however, cannot be known since it is dependent (among other factors) on the relative proportion of exchange/exit types. This is why the iterative capabilities of TK Solver are essential. The calculations are done using an initial seed value (guess) for utilization. The results of this calculation allow the model to iteratively adjust the utilization value. After a number of iterations, the model converges on a solution which satisfies all the equations.

STEP 10 - Having determined the total number of tows, the proportion of each lockage type, and the proportion of each approach/exit type, the model sums the lockage component times to find the total time devoted to commercial lockages. Also, the average tow processing time, needed for the expected delay calculation, can now be determined.

STEP 11 - The total time used for non-commercial lockages is a model input based on historical data. It was assumed that this input would be constant through the period of analysis.

STEP 12 - The time that the lock will be unavailable for locking of any type (stall time) was determined from historical data and assumed to remain constant.

STEP 13 - Lock utilization is determined by adding the total time the lock is being used for either commercial or non-commercial lockages to the time the lock is unavailable for lockages (stalls) and dividing by the total time in the navigation season.

STEP 14 - Delay is calculated using the queuing theory formulation previously mentioned. The ratio of the standard deviation to mean lockage time is obtained from historical data and assumed to remain constant. If applicable, an adjustment is made to delay to account for open pass conditions.

Although some variables in the above discussion are called input variables, the model is indifferent to which variables are input and which are output. As long as enough variables are specified to define a solution, TK Solver will find the values for the remaining variables.

The form of the delay equation used in the GEM requires capacity and expected delay at 50 percent utilization as input parameters. Lock capacity can be found by this model using 100 percent as an input value for utilization and allowing the model to solve for total tonnage. After capacity is determined, half of this value is input for tonnage and the model solves for the expected delay associated with that level of tonnage.

It should be noted that since the GEM uses a simplified form of the expected delay equation, there is some discrepancy between the expected delay computed in GEM and that found by this model. This difference, however, is well within the inherent uncertainty bounds of the analysis. It is neither possible, not desirable, to account for every phenomenon which affects expected delay at a lock. The model attempts to accommodate the most fundamental parameters.

Table 5 - 1 below displays the estimates of the lock capacities and expected delays at 50 percent utilization derived for the non-IHNC locks explicitly included in the modeled system.

SIMULATION APPROACH

SIMULATION SETTING

The ability of the IHNC lock to process navigation traffic is affected by the presence of two vehicular bridges and one vehicular/railroad bridge that span the Inner Harbor Navigation Canal. Moving south to north, the geographic order of these structures is as follows: the St. Claude Ave. vehicular bridge, the IHNC Lock, the Claiborne Ave. vehicular bridge, and the Florida Ave. vehicular/railroad bridge. Importantly, the St. Claude Ave. Bridge is located between the approach point (waiting point) for vessels ready for lock service entering from the Mississippi River and the lock chamber. The approach point for vessels entering from the MR-GO is located between the Claiborne and Florida Bridges.

Currently, both St. Claude and Florida are low-level bascule bridges that require lifting for the passage of every vessel. The Claiborne bridge is a mid-level that requires lifting for approximately 14 percent of navigation traffic. However, the future without-project condition includes replacement of the existing low-level Florida Bridge with a high-level vehicular bridge and a separate low-level railroad bridge which will remain in the lowered position until navigation requires it to be raised. For with-project conditions the structural configuration of the

Table 5 - 1

Delay Function Parameters
Non-IHNC Locks
(Deterministic Method)

Lock	Capacity (millions of tons)	Delay at 50% Utilization (hours)
Port Allen	40.6	0.80
Bayou Sorrel	31.5	0.90
Algiers	30.4	0.80
Harvey	14.8	0.93
Bayou Boeuf	37.7	0.30
Calcasieu	64.0	0.50

canal would be modified to also include 1) a new low-level bridge at St. Claude and a new chamber located between the Claiborne and the Florida bridges or 2) a new mid-level bridge at St. Claude and no chamber replacement.

MODEL STRUCTURE

The Sim model is written in SIMSCRIPT, a language developed specifically as an aid to simulation analyses. SIMSCRIPT is an event-based language. That is, the program monitors the system being modeled, and identifies the occurrence of the next event. Simulation time is automatically advanced to that next time.

Model Entities

SIMSCRIPT uses 'entities' to model the character of the system. In the current environment, these entities are:
-Vessel types
-Segments
-Locks
-Bridges
-Curfews

The vessel type entity specifies the attributes of the vessel including, arrival rates, physical characteristics, and breakout strategy. A vessel is created as a temporary entity, simulated only for as long as it is impacting on the lock system.

A segment in the system identifies a portion of the region. Segments are distinguished by location and function. The IHNC system is modeled as five segments:
- the westbound arrival queue
- the westbound staging area
- the lock
- the eastbound staging area
- the eastbound arrival queue.

A lock is a special type of segment. Because additional information must be specified for a lock segment, the decision was made to create an additional dual entity, carrying all of the lock-specific information.

A bridge may be created as a means to measure the potential impact of bridge operation policy. One special case of this is the curfew period. The model is written to allow the user to specify for each bridge any number of curfew periods which restrict operation - providing starting and ending times for each.

Model Components

With these entities in mind, a SIMSCRIPT program is written to identify the activity within the system. A typical program consists of three types of components--a preamble, events, and routines.

a. Preamble. The preamble is the core of the simulation, providing the global definitions for each entity class, each event, each routine, and all global variables and arrays.

b. Events. This program consists of five events--Q.ARRIVAL, SEG.ARRIVAL, LOCK.EXIT, NEW.DAY, and NEW.SEASON. These form the core of the simulation, driving the activity of the system.

Q.ARRIVAL simulates the arrival of a vessel to one of the system queues. At this point, the vessel is created, any relevant breakouts (tow cuts) are created and light boats (assist vessels) employed. If the vessel is a priority one, it is placed early in the queue. If the arrival is a fly arrival, the vessel moves immediately to the appropriate staging area--a calculation of travel time is made to determine the time of arrival of the vessel and an event SEG.ARRIVAL is scheduled. The time of the next arrival of a vessel of this type is determined, based on probabilistic methods.

SEG.ARRIVAL simulates the arrival of a vessel to an intermediate segment of the system. If the segment is a lock, a call is made to LOCK.ARRIVAL, a routine which will be described later. Otherwise, time of traversal to the next segment is calculated and another SEG.ARRIVAL is scheduled. If the next segment is a lock, a call is made to LOCK.FILLER, also described later. The departure of a vessel from a segment triggers a second SEG.ARRIVAL for a vessel to fill the vacancy to be created in the current segment.

A LOCK.EXIT simulates the departure of a vessel, or set of vessels, from the lock. Calculations are made to determine the time at which the lock will be available for subsequent service, routine LOCK.MASTER is called, and a SEG.ARRIVAL is scheduled for all vessels leaving the lock. If the lock departure represents the departure of the vessels from the system, routine SYST.EXIT is called instead.

Events NEW.DAY and NEW.SEASON are time monitoring events. NEW.DAY simply flags the start of a new day. NEW.SEASON flags the start of a new season, and initiates the usage of a new season-dependent chambering time.

c. Routines. In addition to the core events, the simulation package also consists of seven routines - MAIN, COLL.STATS, LOCK.ARRIVAL, LOCK.FILLER, LOCK.MASTER, RD.DATA, and SYST.EXIT. These routines, unlike the events, provide support for the events, performing much of the functionality of the system.

MAIN is the driver routine. A call is made to RD.DATA to input the data, and the first set of arrival events are created. In addition, initializations of the day and season are accomplished through MAIN.Simulation is initiated in this routine.

COLL.STATS is the statistics output routine. A call is made to COLL.STATS at the end of every season and at the completion of the iteration.

LOCK.ARRIVAL performs two functions when a SEG.ARRIVAL is identified as a lock arrival. First, usage statistics are tabulated. Second, a service time is calculated, to determine the time of the LOCK.EXIT.

LOCK.FILLER is called from SEG.ARRIVAL to determine a packing for the next usage of the chamber. Vessels are selected from the appropriate waiting queue, in priority order. LOCK.FILLER attempts to pack the chamber as fully as is practical.

LOCK.MASTER is responsible for determining assignments to the lock. Two policies are implementable in the program - first-come first-serve, and k-up k-down. Once LOCK.MASTER has determined which vessel(s) the lock will serve next, a SEG.ARRIVAL is scheduled.

RD.DATA is the data input routine.

SYST.EXIT controls the departure of a set of vessels from the system under study. All light boats are returned to their home base, traversing back through the lock.

MODEL INPUTS

The Sim model requires detailed timing information on all aspects of traffic transiting the system. In general, timing data fall into two categories. One is the "interference" effect of the vehicular bridge structures spanning the canal on traffic being processed through the lock. The other is the duration of the lockage itself which is comprised of several operational components. Finally, the model requires traffic data by different tow size classes in order to accurately estimate the performance and volume of system throughput. The following paragraphs will describe the inputs that were used and how they were developed.

Timing Data

a. Bridge Interference. One way in which a bridge affects navigation is when the bridge must be raised to allow navigation traffic to pass. Unless the operation of the bridge can be perfectly coordinated with the movement of the tow, some interference will result. The bridge operator must first wait for a sufficiently safe break in the vehicular traffic flow, lower the traffic barriers, and then raise the bridge to a safe height for navigation to pass. This operation is required for every vessel wishing to transit the IHNC Lock. Based on data collected specifically designed to measure this interference effect at the St. Claude Bridge, it has been estimated that this interference causes on average a delay per opening of approximately three minutes. This bridge interference estimate is used as an input in the Sim model. Consequently the model effectively adds three minutes to the total lockage time of each lock cycle.

A second way in which a bridge affects navigation is through curfews which prevent the raising of the bridge during selected hours of the day. If navigation requires the bridge to be raised in order to pass, the curfew will temporarily halt the flow of traffic. Currently, curfews exist at each of the three bridges. However, the effect of the St. Claude curfew is most significant given its low-rise elevation and immediate proximity to the lock chamber. Curfew period is an input into the Sim model and its effects are therefore captured by the model.

The future with-project condition, which entails building a larger lock north of Claiborne avenue, requires the St. Claude Avenue Bridge to be replaced for realignment purposes. Since the replacement bridge is proposed as a low-rise, all navigation traffic will require that the bridge be raised, as is the case currently for existing conditions. However, because the new chamber will be relocated northward in the canal from its present location, the approach point for traffic arriving from the Mississippi River would move to a point between the lock chamber and the St. Claude Bridge. As a result, the interference inherent in a low-rise bridge would not impact lock processing time because the interference would occur concurrently with another ongoing lockage. At Claiborne, the bridge level will be the same as it is now, however, with regards to bridge impacts on navigation, the bridge will now disrupt a greater percentage of traffic. By removing the existing lock and constructing a larger one north of Claiborne avenue, stages will necessarily rise under the new Claiborne bridge due to Mississippi River effects. As a result, this will require more bridge openings than is currently necessary to accommodate navigation. Analysis of stage and tow height distributions has shown that approximately 26 percent of navigation traffic would require the Claiborne bridge to open under this with-project condition.

b. Lockage Times. A lockage is comprised of a series of events that are required to transfer a vessel or tow through a lock in a single direction. Timing information for each of these events was calculated using 1988 - 1991 LPMS data and a 50 - year period of record for relevant stage data in order to capture the impact of water levels on lock operations. The following is a brief description of each lockage event.

Approach time: The difference between the time the lock is ready to serve the incoming vessel and the time when the bow of the inbound vessel is abreast of the lock gates and it is in a position parallel to the guide wall to enter the lock chamber. The three possible types of approaches are:

1. Fly Approach: The lock has been idle and the inbound vessel directly enters the chamber.

2. Exchange Approach: The vessel inbound to the chamber passes a vessel outbound from the chamber.

3. Turnback Approach: The proceeding event is a lockage in which no tows were served.

Entry Time: Time from bow over sill to end of entry. Usually the end of entry takes place when the tow or the entering cut is secured within the lock and the gates are clear.

Chambering time: The time required to completely fill or empty the lock chamber.

Exit Time: The time from start of exit to end of lockage. This is the difference between the time when the gates are fully open, and when the indication to proceed is given, and the time when the lock has completed serving a vessel or cut and can be dedicated to another vessel or cut. As with the approach time there are three types of exit.

1. Fly Exit: The lock will be idle following the departure of the outgoing vessel.

2. Exchange Exit: The vessel outbound from the chamber passes a vessel inbound to the chamber.

3. Turnback Exit: The vessel to be served next is going in the same direction as the outbound vessel and the lock must be turned back with no vessels in the chamber.

Added time for Multivessel Lockages: A multivessel lockage occurs when more than one commercial vessel or tow is served in a single lockage cycle. As a result, the additional time it takes to process the additional vessels must be taken into account.

IHNC Lock data was used in the production of these component times for the without-project condition. However, in order to evaluate improved lock conditions, data on the Bayou Boeuf lock (1200 ft long) was used to represent all 1200 ft long lock scenarios for entry and exit times. This adjustment is necessary because entering and exit times, for the most part, are a function of lock length. The midpoint between the Bayou Boeuf lock times and the existing lock (640 ft long) times were used to represent all 900 ft long lock scenarios.

A multivessel lockage occurs when more than one commercial vessel or tow is served in a single lockage cycle. As a result, the additional time it takes to process the additional vessel(s)/tow(s) must be taken into account. Using the same four years of LPMS data, in the manner described above, the additional time for multivessel lockages were calculated for the existing lock (5 minutes), all 900 ft long locks (7.5 minutes) and all 1200 ft long locks (10 minutes).

The Sim model is structured such that the approach, entering and exit times to be used for each tow size class must be exclusive of bridge interference time since this effect is separately entered as a model input. These lockage times by tow class (described in subsequent paragraphs) are presented in table 5 - 2.

Table 5 - 3 displays the estimated chambering times by lock size, broken down into four seasons or quarters. Chambering time varies over the course of a year as a result of changing head conditions produced by Mississippi River stages. Variation in chambering time is the predominate reason for seasonal differences in average delay. In order to capture this seasonal effect, chambering times are specified on a quarterly basis. In developing the chambering times displayed in table 5 - 3, a 50-year period of record for stage data and chamber size

Table 5 - 2

Average Lock Component Times by Lockage Type and Towsize Class
(Single Vessel Lockage)

Tow Sizes				Existing Lock			1200 ft Locks			900 ft Locks		
				Approach	Entry	Exit	Approach	Entry	Exit	Approach	Entry	Exit
Class	Length (ft)	Width (ft)		(minutes)			(minutes)			(minutes)		
1	>=140 and <=223	>=30 and <=40	Fly	8	6	5	8	4	5	8	5	5
			Exchange	8	6	6	8	4	6	8	5	6
			Turnback	4	6	6	4	4	5	4	5	5.5
2	>=140 and <=213	>=41 and <=60	Fly	6	9	7	6	4	6	6	6.5	6.5
			Exchange	9	9	7	9	4	6	9	6.5	6.5
			Turnback	4	9	8	4	4	4	4	6.5	6
	>=224 and <=297	>=30 and <=40	Fly	8	6	5	8	4	6	8	5	5.5
			Exchange	8	6	6	8	4	7	8	5	6.5
			Turnback	4	6	6	4	4	6	4	5	6
4	>=214 and <=299	>=41 and <=60	Fly	6	9	7	6	4	6	6	6.5	6.5
			Exchange	9	9	7	9	4	8	9	6.5	7.5
			Turnback	4	9	8	4	4	7	4	6.5	7.5
5	>=230 and <=319	>=61 and <=70	Fly	6	9	7	6	3	7	6	6	7
			Exchange	9	9	7	9	3	6	9	6	6.5
			Turnback	4	9	8	4	3	0	4	6	8
6	>=298 and <=419	>=30 and <=40	Fly	8	6	5	8	5	6	8	5.5	5.5
			Exchange	8	6	6	8	5	8	8	5.5	7
			Turnback	4	6	6	4	5	6	4	5.5	6
7	>=300 and <=389	>=41 and <=60	Fly	6	9	7	6	5	7	6	7	7
			Exchange	9	9	7	9	5	8	9	7	7.5
			Turnback	4	9	8	4	5	8			
8	>=320 and <=436	>=61 and <=70	Fly	6	9	7	6	15	8	6	12	7.5
			Exchange	9	9	7	9	15	0	9	12	7
			Turnback	4	9	8	4	15	0	4	12	8
9	>=420 and <=469	>=30 and <=40	Fly	8	6	5	8	5	8	8	5.5	6.5
			Exchange	8	6	6	8	5	8	8	5.5	7
			Turnback	4	6	6	4	5	7	4	5.5	6.5
10	>=390 and <=469	>=41 and <=60	Fly	6	9	7	6	6	8	6	7.5	7.5
			Exchange	9	9	7	9	6	8	9	7.5	7.5
			Turnback	4	9	8	4	6	8	4	7.5	8
11	>=437 and <=459	>=61 and <=70	Fly	6	9	7	6	8	9	6	8.5	8
			Exchange	9	9	7	9	8	12	9	8.5	9.5
			Turnback	4	9	8	4	8	10	4	8.5	9

Table 5 - 2

Average Lock Component Times by Lockage Type and Towsize Class
(Single Vessel Lockage)

Tow Sizes				Existing Lock			1200 ft Locks			900 ft Locks		
				Approach	Entry	Exit	Approach	Entry	Exit	Approach	Entry	Exit
Class	Length (ft)	Width (ft)		(minutes)			(minutes)			(minutes)		
12	>=470 and <=619	>=30 and <=40	Fly	8	6	5	8	7	7	8	6.5	6
			Exchange	8	6	6	8	7	9	8	6.5	7.5
			Turnback	4	6	6	4	7	7	4	6.5	6.5
13	>=470 and <=540	>=41 and <=60	Fly	6	9	7	6	6	8	6	7.5	7.5
			Exchange	9	9	7	9	6	9	9	7.5	8
			Turnback	4	9	8	4	6	9	4	7.5	8.5
14	>=460 and <=552	>=61 and <=70	Fly	6	9	7	6	7	8	6	8	7.5
			Exchange	9	9	7	9	7	9	9	8	8
			Turnback	4	9	8	4	7	11	4	8	9.5
15	>=620 and <=650	>=30 and <=40	Fly	4	12	8	4	6	8	4	9	8
			Exchange	9	12	8	9	6	9	9	9	8.5
			Turnback	5	12	9	5	6	8	5	9	8.5
16	>=541 and <=602	>=41 and <=60	Fly	6	9	7	6	7	9	6	8	8
			Exchange	9	9	7	9	7	10	9	8	8.5
			Turnback	4	9	8	4	7	8	4	8	8
17	>=553 and <=619	>=61 and <=70	Fly	6	9	7	6	8	11	6	8.5	9
			Exchange	9	9	7	9	8	21	9	8.5	14
			Turnback	4	9	8	4	8	21	4	8.5	14.5
18	>=603 and <=657	>=41 and <=60	Fly	4	12	8	4	7	8	4	9.5	8
			Exchange	9	12	8	9	7	9	9	9.5	8.5
			Turnback	5	12	9	5	7	10	5	9.5	9.5
19	>=620 and <=640	>=61 and <=70	Fly	4	12	8	4	9	8	4	10.5	8
			Exchange	9	12	8	9	9	11	9	10.5	9.5
			Turnback	5	12	9	5	9	13	5	10.5	11
20	>=641 and <=680	>=61 and <=70	Fly	4	12	8	4	9	8	4	10.5	8
			Exchange	9	12	8	9	9	12	9	10.5	10
			Turnback	5	12	9	5	9	10	5	10.5	9.5

Table 5 - 3

Average Chambering Times by Season
(Minutes)

Locksize	1st Quarter CY	2nd Quarter CY	3rd Quarter CY	4th Quarter CY
Existing Lock	10.3	10.0	7.8	7.5
900 x 90 x 22	7.8	8.2	6.6	6.6
900 x 110 x 22	8.0	8.4	6.8	6.8
900 x 100 x 36	9.1	9.7	6.8	6.7
1200 x 90 x 22	7.8	8.2	6.6	6.6
1200 x 100 x 22	8.0	8.4	6.8	6.8
1200 x 100 x 36	9.1	9.7	6.8	6.7

specific fill/empty times for varying head conditions were used.

Traffic Data

Individual tow sizes were evaluated and grouped into 42 classes. As with the timing information, four year average values (LPMS 1988 -1991), by tow size class, were used in the production of the traffic base. Information for each class consisted of average loads, average number of vessels (upbound and downbound) and, specific to the lock size being studied, the number of cuts that would be required and their dimensions.

Table 5 - 4 displays the 42 towsize classes along with their expected frequency and average loads. The 42 towsize classes represent approximately 93 percent of the total four-year average number of tows and 89 percent of the tonnage. These figures were adjusted upwards prior to input by proportionally scaling the represented classes to reflect a complete 100 percent traffic base.

Along with tows, information on ship traffic was also compiled. The four year average of ship traffic at the IHNC lock equaled 153 ships. All ship traffic was reflected in a single vessel type.

To capture the effects of stall events on lock operation, stall events were analyzed and represented in the model as a vessel type. Stall events also cause the lock to be unavailable for navigation until the event is concluded. Stall events generally fall into 5 conditions. The first is weather conditions which consist of fog, rain, wind etc. The second is surface conditions consisting of river current, flood, etc. The third is tow conditions consisting of interference by other vessels, tow malfunction or breakdown, etc. The fourth is lock conditions consisting of lock hardware malfunction, maintaining lock, etc. The fifth is Other conditions consisting of vehicular bridge delay (vehicular bridge delays resulting from curfews were separated from bridge delays of other causes because the model explicitly deals with bridge curfews.), tow detained by Coast Guard etc. The four year average for stalls at the IHNC lock was divided into two separate categories in order to provide a more accurate representation of lock downtime. One category consisted of typical stall events which had a four year average of 44 events representing approximately 50 minutes each, while the other category consisted of one outage equal to approximately 30 hours.

Table 5 - 4

Average Number of Tows and Loads
By Tow Size Class

Tow Size Class	Length (ft)	Width (ft)	Average # Of Tows	Average Tons
1	>=140 and <=223	>=30 and <=40	704	205
2	>=140 and <=213	>=41 and <=60	216	376
3	>=224 and <=297	>=30 and <=40	1,306	644
4	>=214 and <=299	>=41 and <=60	486	680
5	>=230 and <=319	>=61 and <=70	318	812
6	>=298 and <=419	>=30 and <=40	250	568
7	>=300 and <=389	>=41 and <=60	686	1,196
8	>=320 and <=436	>=61 and <=70	128	1,054
9	>=420 and <=469	>=30 and <=40	328	1,691
10	>=390 and <=469	>=41 and <=60	281	2,147
11	>=437 and <=459	>=61 and <=70	372	2,319
12	>=470 and <=619	>=30 and <=40	101	1,514
13	>=470 and <=540	>=41 and <=60	366	2,863
14	>=460 and <=552	>=61 and <=70	444	2,506
15	>=620 and <=650	>=30 and <=40	48	2,851
16	>=541 and <=602	>=41 and <=60	792	3,162
17	>=553 and <=619	>=61 and <=70	82	2,836
18	>=603 and <=657	>=41 and <=60	294	3,474
19	>=620 and <=640	>=61 and <=70	182	4,990
20	>=641 and <=680	>=61 and <=70	377	3,915
21	>452 and <=460	>80 and <=90	1	3,788
22	>355 and <=455	>91 and <=108	62	3,619
23	=460	>109 and <=140	35	5,956
24	>470 and <=580	>80 and <=90	5	3,096
25	>504 and <=580	>91 and <=108	62	4,666
26	>470 and <=580	>109 and <=140	57	6,364
27	>585 and <=640	>91 and <=108	186	6,144
28	>585 and <=640	>109 and <=140	23	8,204
29	>660 and <=700	>41 and <=60	270	3,992
30	>681 and <=700	=70	10	3,942
31	>700 and <=760	>41 and <=67	105	4,495
32	>700 and <=760	=70	14	3,948
33	>770 and <=870	>41 and <=67	267	4,550
34	>770 and <=870		94	5,183
35	>871 and <=980	>41 and <=67	159	5,087
36	>871 and <=980	=70	83	6,056
37	>985 and <=1285	>41 and <=67	101	7,568
38	>985 and <=1285	=70	91	7,441
39	>527 and <=627	=156	36	7,845
40	>660 and <=985	=140	18	7,841
41	>1286 and <=1530	=70	19	10,737
42	>1180 and <=1530	=104	3	7,775

The last category of vessels, other than tows and ships, that need to be considered, is that of light boats. These are towboats that assist other tows requiring multicut lockages. All tows requiring multiple cuts are required to hire an assist vessel to power each additional cut (ready-to-service policy). When the light boat completes its assignment, it then receives priority as it returns to its home base. The Sim model generates a lightboat lockage(s) every time a tow requiring assistance appears at the lock.

The traffic base, therefore, is comprised of 46 separate classes of traffic. Of these 42 are different tow configurations, one is ship traffic, two are stall events and the last is light boat traffic. Each of these classes is assigned a lock priority status, which enables the model to determine the order of service. The highest priority of "0" is assigned to lightboats, the next highest of "1" is assigned to ships, and status "2" represents a general locking policy for all tow classes and stall types. Each of these classes are assigned the appropriate component lockage times from the "lock time table" section of the input file.

Sample Input File

Table 5 - 5 shows a sample input file, representing a without- project condition, used by the Sim model. A brief description is provided alongside each line. Additional discussion is provided for some key inputs.

a. Seed numbers: The three seed numbers specify a chosen starting point for the arrivals generated randomly by the model. The seeds are used for upbound arrival, downbound arrival, and vessel height.

b. Number of Seasons: The model results represent one 90 day season, which is divided into four separate "mini" seasons. The first three "mini" seasons consist of 23 days with the last consisting of 21 days. In addition, an initial warm-up period of ten days was included which allows the model to begin tabulating results from an already operational lock. As will be discussed later, these results are then adjusted upwards to reflect an annual figure.

c. Number of Days Vessel Arrival Data: Initially set at 365 days, the effect of reducing this variable is the same as increasing the traffic level. As was mentioned previously, the 42 tow size classes represent 93 percent of the total vessel traffic, therefore to reflect existing conditions vessel arrival was reduced to 341 days in order

Table 5 - 5

Sim Model Sample Input File
For Without-Project Conditions

```
---------------------------------------------------------------------------

<lock 640x75<                                ** HEADER
1                                            ** NUMBER OF ITERATIONS
new.seeds                                    ** THE NEXT THREE LINES
34556833                                        SPECIFY AN ARRIVAL PATTERN
94727351
1032
100 5                                        ** # OF DAYS      # OF SEASONS
10 23 23 23 999                              ** LENGTH OF EACH SEASON
                                                (INCLUDES A WARMUP PERIOD)
1                                            ** NUMBER OF LOCKS IN THE SYSTEM

5                                            ** NUMBER OF SEGMENTS IN THE
                                                SYSTEM
QUP 1                                        ** SEGMENT ONE
999                                          ** QUEUE CAPACITY OF SEGMENT ONE
1                                            ** NUMBER OF BRIDGES BELOW
                                                SEGMENT ONE
   FLORIDA  999 0                           ** BRIDGE NAME    % OF TIME BRIDGE DOES
                                                NOT NEED TO BE RAISED      BRIDGE
                                                INTERFERENCE TIME
    0                                           NUMBER OF CURFEW PERIODS
arrival down                                 ** SEGMENT TYPE

STAGE_UP    2                                ** SEGMENT TWO
1                                            ** QUEUE CAPACITY OF SEGMENT TWO
1                                            ** NUMBER OF BRIDGES BELOW
                                                SEGMENT TWO
    CLAIBORNE    .9    0                     ** BRIDGE NAME        % OF TIME
                                                BRIDGE DOES NOT NEED TO BE
                                                RAISED        BRIDGE INTER-
                                                FERENCE TIME

        0                                    ** NUMBER OF CURFEW PERIODS
staging
LOCK_1  3                                    ** SEGMENT THREE
1                                            ** QUEUE CAPACITY OF SEGMENT
                                                THREE
1                                            ** NUMBER OF BRIDGES BELOW
                                                SEGMENT THREE
    ST.CLAUDE    0    3                      ** BRIDGE NAME        % OF TIME
                                                BRIDGE DOES NOT NEED TO BE
                                                RAISED        BRIDGE INTER-
                                                FERENCE TIME
        2                                    ** NUMBER OF CURFEW PERIODS
        6 45    7 45                         ** START AND STOP TIMES OF CURFEW
                                                ONE
        16 30   17 30                        ** START AND STOP TIMES OF CURFEW
```

TWO

```
lock
    640 75  20                          ** LENGTH OF LOCK     WIDTH OF
                                           LOCK      QUEUE SEARCH LIMIT
    10.25 10.25 10.0 7.75 7.5           ** CHAMBER TIMES BY SEASON
                                           (INCLUDES A WARM-UP PERIOD)
    00.0 15.0 0.0                       ** TURNAROUND TIME FOR THE LOCK
    5     0                             ** ADDITIONAL TIME FOR
                                           MULTIVESSEL LOCKAGE
STAGE.DN     4                          ** SEGMENT FOUR
    1                                   ** QUEUE CAPACITY OF SEGMENT FOUR
    0                                   ** NUMBER OF BRIDGES BELOW
                                           SEGMENT FOUR
staging
QDN          5                          ** SEGMENT FIVE
    999
    0
arrival up

341                                     ** NUMBER OF DAYS VESSEL DATA
                                           REFLECTS
46                                      ** NUMBER OF VESSEL CLASSES
1                                       ** PERCENT OF FULL VESSELS
vtI1     1                              ** VESSEL NAME     VESSEL ID
   2     1    170 35   205              ** PRIORITY STATUS   HEIGHT
                                           VESSEL LENGTH AND WIDTH
                                           AVERAGE LOAD (TONS)
         1  170 35  1                   ** NUMBER OF CUTS      LENGTH AND
                                           WIDTH OF CUT     LINE ID # IN
                                           LOCK TIMING TABLE
         352 352                        ** NUMBER OF DOWNBOUND AND
                                           UPBOUND OBSERVATIONS
vtI2     2
    2    1  170 54   376
         1  170 54  1
        108 108
vtII1    3
    2    1   260 35   644
         1  260 35  3
         653  653
vtII2    4
    2    1   250 54   680
         1  250 54  3
         243 243
vtII3    5
    2    1   260 70   812
         1  260 70  5
         159 159
vtIII1   6
    2    1   335 35   568
         1  335 35  6
         125 125
vtIII2   7
    2    1   340 54   1196
```

```
        1  340 54  7
        343 343
vtIII3  8
    2   1   350 70   1054
        1 350 70  8
        64  64
vtIV1   9
    2   1   440 35   1691
        1  440 35  9
        164 164
vtIV2   10
    2   1   425 54   2147
        1  425 54  10
        140 140
vtIV3   11
    2   1   450 70   2319
        1  450 70  11
        186  186
vtV1    12
    2   1   500 35  1514
        1   500 35  12
        51  51
vtV2    13
    2   1   500 54   2863
        1  500 54  12
        183  183
vtV3    14
    2   1   490 70   2506
        1  490 70  14
        222  222
vtVI1   15
    2   1   620 35   2851
        1  620 35  12
        24 24
vtVI2   16
    2   1   570 54   3162
        1  570 54  16
        396  396
vtVI3   17
    2   1   575 70   2836
        1  575 70  17
        41  41
vtVII1  18
    2   1   625 54   3474
        1  625 54  18
        147  147
vtVII2  19
    2   1   620 70   4990
        1  620 70  19
        91  91
vtVIII1 20
    2   1   640 70   3915
        1  640 70  19
        189  189
```

```
vtIX1
    2   1   456 90   3788
        2  456 54    10     456 35     10
        .5  .5
vtIX2   22
    2   1   405 108 3619
        2  405 54    10     405 54     10
        31  31
vtIX3   23
    2   1   460 140 5956
        2  460 70    14     460 70     14
        17  17
vtX1    24
    2   1   525 90   3096
        2   525 54   14     525 35     15
        3  3
vtX2    25
    2   1   540 108 4666
        2   540 54   14     540 54     14
        31  31
vtX3    26
    2   1   525 140 6364
        2   525 70   14     525 70     14
        29  29
vtXI1   27
    2   1   610 108 6144
        2   610 54   18     610 54     18
        93  93
vtXI2   28
    2   1   610 140 8204
        2   610 70   17     610 70     17
        12  12
vtXII1  29
    2   1   680 54   3992
        2   400 54   10     400 54     10
        135  135
vtXII2  30
    2   1   680 70   3942
        2   400 70   8      400 70     8
        5  5
vtXIII1 31
    2   1   730 54   4495
        2   420 54   10     420 54     10
        53  53
vtXIV1  32
    2   1   730 70   3948
        2   420 70   8      420 70     8
        7  7
vtXV1   33
    2   1   810 54   4550
        2   460 54   11     460 54     11
        133 133
vtXV2   34
    2   1   810 70   5183
```

```
          2    460  70   14     460  70     14
          47   47
vtXVI1    35
    2     1    925  54   5087
          2    520  54   13     520  54     13
          79    79
vtXVI2    36
    2     1    925  70   6056
          2    520  70   14     520  70     14
          42   42
vtXVII1   37
    2     1    1140  54   7568
          2    620  54   18     620  54     18
          50   50
vtXVII2   38
    2     1   1140  70   7441
          2    620  70   19     620  70     19
          45   45
vtXVIII1   39
    2     1    575  156  7845
          3    575  52   12     575  52   12    575  52   12
          18   18
vtXIX1    40
    2     1    820  140  7841
          4    465  70   14     465  70   14     465  70   14     465  70    14
          9   9
vtXX1     41
    2     1    1350  70  10737
          3    525  70   14     525  70   14    525  70   14
          10   10
vtXXI1    42
    2     1    1350  104     7775
          5    525  70   14     525  70   14    525  70   14    525  70    14
        525  70   14
          .5   .5
ships     43                                   ** SHIP TRAFFIC
    1     1    620  70   0
          1    620  70   22
          72   72
stall1    44                                   ** STALL EVENT  (TYPE 1)
    2     1    620  70   0
          1    620  70  24
          95   95
stall2    45                                   ** STALL EVENT  (TYPE 2)
    2     1    620   70  0
          1    620   70  25
          1   1
lite      46                                   ** LIGHT BOAT TRAFFIC
    0     1    620  70   0
          1    620  70   23
          0    0
25                                              ** NUMBER OF LINES IN LOCK
                                                   TIME TABLE
    1     5    7    4    2    4    5    5       ** LINE ID #  LK COMPONENT TIMES
```

2	6	9	4	3	6	5	8
3	6	8	4	2	5	5	6
4	5	9	4	4	5	6	7
5	7	10	4	4	5	6	7
6	6	8	4	3	5	6	7
7	7	9	4	4	5	6	7
8	8	10	4	4	6	7	8
9	7	10	4	4	6	7	7
10	6	9	4	5	6	7	7
11	7	12	5	6	6	8	8
12	5	9	4	5	8	7	8
13	7	10	5	6	6	7	8
14	7	11	5	6	7	8	9
15	7	12	5	8	7	7	8
16	7	8	5	6	7	7	8
17	8	11	6	8	9	9	10
18	7	11	5	8	7	8	9
19	8	10	4	8	8	8	8
20	0	20	6	9	0	0	19
21	4	9	5	12	12	12	12
22	39	12	8	21	10	5	12
23	2	2	2	2	2	2	2
24	11	11	11	13	11	11	11
25	605	605	605	605	605	605	605

FCFS 0 ** SPECIFIES LOCKING POLICY

to proportionally scale upward the represented traffic. It is through use of this value that traffic can easily be scaled up or down to reflect runs of different traffic volumes or utilization levels.

d. Locking Policy: There are two separate locking policies the model will analyze. One represents a first-come; first-serve policy (FCFS), which is the current IHNC locking policy. This simply means that the first tow to arrive at the lock is the first considered for service. The other policy is a n-up n-down policy, which specifies how many tows in one direction will be processed before tows in the opposite direction are processed.

MODEL OUTPUT

Table 5 - 6 displays the various information the Sim model produces as its output for without-project conditions at capacity. Under the heading of "Delay Information", the average delay per tow estimates for the initial ten day warm up period and the following four "mini" seasons are presented. As was mentioned earlier, the total average delay per tow figure excludes the warm up period in its calculation. Under the heading of "Vessel Type Data", lockage information for the 42 tow classes are shown in the first 42 "vt types". Information on ship lockages, stalls and light boats are shown in vt 43 through vt 46, respectively. The maximum level of tons processed through the lock is presented under the heading of "Performance Measures". This figure must be annualized and adjusted to correct for the fact that the existing tonnage associated with the 42 tow classes did not fully represent all IHNC tonnage.

DELAY FUNCTION CALCULATION

The delay function used in this analysis is a simple hyperbolic function. The two parameters that define this type of delay function are lock capacity (in terms of tons) and a k-value, which is the average delay per tow at half of lock capacity.

Using the Sim model to calculate lock capacity for a given condition involved a series of model runs with different seed numbers for each. A total of five runs (at existing traffic levels) were made, each resulting in a different average delay per tow estimate. The seed values corresponding to the median delay estimate was then selected to represent a typical tow arrival pattern. Using these seed values, the arrival frequency of traffic was systematically increased until the level of tonnage

Sim Model Sample Output
Without-Project Conditions

Length Of Run 100 days

ARRIVALS

Upward	1641
Downward	1654
Light Boats	588

DELAY INFORMATION

season	ave.delay(mins)	Q up	Q down	curfew inbound (mins)	curfew outbound (mins)
1	987.21	15.5	17.1	2.112	.746
2	3450.91	69.1	68.9	2.287	.525
3	8346.30	93.4	146.2	2.477	.477
4	8093.19	118.8	111.5	2.057	.589
5	5989.70	96.8	88.7	2.340	.395
TOTAL	6540.58	94.3	102.9	2.277	.499

Histogram {hist(i) = #vessels, such that i-1<delay<i, hours}

2	5	5	3	6	8	8	8	3	7	5	8	10	6
11	12	11	8	6	10	8	12	9	4	17	14	9	3
5	8	6	6	10	18	14	16	25	11	10	8	15	8
8	10	13	10	3	11	11	8	18	11	13	17	15	19
17	15	10	9	10	13	8	10	6	10				

VESSEL TYPE DATA

					Unused space in columns					
					large cut			small cut		
Type	proc(hrs)	delay(hrs)	#Arvls	que	max	avg	std	max	avg	std
vt 1	101.36	100.58	245	92	470	64	84	0	0	0
vt 2	102.32	101.59	67	86	220	54	48	0	0	0
vt 3	117.90	117.15	403	89	380	110	82	0	0	0
vt 4	112.40	111.72	131	82	390	94	60	0	0	0
vt 5	111.95	111.26	104	88	380	96	69	0	0	0
vt 6	117.30	116.52	75	91	305	102	103	0	0	
vt 7	121.83	121.14	198	86	300	81	83	0	0	
vt 8	104.19	103.49	43	70	290	60	72	0	0	
vt 9	118.09	117.34	106	75	200	157	74	0	0	
vt 10	118.19	117.52	98	80	215	162	79	0	0	0
vt 11	109.47	108.76	102	90	190	134	80	0	0	0
vt 12	138.38	137.63	47	83	140	140	0	0	0	0
vt 13	127.42	126.77	116	97	140	140	0	0	0	0
vt 14	113.08	112.39	168	83	150	150	0	0	0	0
vt 15	121.70	120.94	17	77	20	20	0	0	0	0
vt 16	120.64	119.96	269	91	70	70	0	0	0	0
vt 17	98.58	97.80	21	81	65	65	0	0	0	0
vt 18	124.87	124.15	112	82	15	15	0	0	0	0
vt 19	104.28	103.57	60	89	20	20	0	0	0	0
vt 20	132.58	131.89	130	91	0	0	0	0	0	0
vt 21	186.03	184.90	1	137	184	184	0	0	0	0

t 22	111.46	110.40	14	109	235	192	74	0	0	0
: 23	121.95	120.93	10	85	180	161	53	0	0	0
vt 24	40.55	36.45	2	48	115	115	0	0	0	0
vt 25	141.05	138.46	16	79	100	100	0	0	0	0
vt 26	114.77	113.66	26	100	115	115	0	0	0	0
vt 27	131.16	128.49	71	102	30	30	0	0	0	0
vt 28	152.97	151.79	7	110	30	30	0	0	0	0
vt 29	123.54	119.76	95	81	240	190	77	0	0	0
vt 30	22.45	21.27	1	23	70	70	0	0	0	0
vt 31	104.06	103.08	31	88	220	186	68	0	0	0
vt 32	209.61	208.25	1	121	220	220	0	0	0	0
vt 33	144.85	142.24	98	83	180	137	74	0	0	0
vt 34	143.30	139.12	30	79	180	124	80	0	0	0
vt 35	112.96	111.85	48	73	120	120	0	0	0	0
vt 36	94.53	93.42	24	70	120	120	0	0	0	0
vt 37	131.51	128.13	34	74	20	20	0	0	0	0
vt 38	110.54	109.45	29	69	20	20	0	0	0	0
vt 39	107.74	106.39	21	70	65	65	0	0	0	0
vt 40	118.89	117.03	7	115	175	154	56	0	0	0
vt 41	92.84	91.39	7	56	115	115	0	0	0	0
vt 42	0.	0.	0	0	0	0	0	0	0	0
vt 43	35.21	34.27	47	10	20	20	0	0	0	0
vt 44	122.39	121.46	70	87	20	20	0	0	0	0
vt 45	68.07	37.39	1	47	20	20	0	0	0	0
vt 46	61.21	60.87	588	16	20	20	0	0	0	0

LOCKAGE INFORMATION - lock 1

Total number of lockages completed 3372
Total upbound 1504
Total downbound 1536

PERFORMANCE MEASURES
Throughout(area) 103445919.00 (season) 103445919.00
Throughout(tons) 6539688.00 6539688.00

HISTOGRAM
{hist(i) = #lockages, such that i-1<#served in lockage<=i}
2420 496 77 43 3

SPATIAL UTILIZATION
average utilization of lock area 71 %
std. dev. utilization 15 %.

HISTOGRAM {hist(i) = #lockages with i-1<(space utilized/100)<i}

< 0	<10	<20	<30	<40	<50	<60	<70	<80	<90	<100
0	1	2	22	255	511	827	482	101	838	0

UNUSED DIMENSION
average unused length 83 (ft.)
std. dev. 74
average unused width 13
std. dev. 8

SOME MORE STATISTICS

average # vessels checked for each lockage	2	
std. dev.	5	
max #	20	
average sum of all lengths of vessels/lock	577	(ft.)
std. dev	125	
max length	1230	
average sum of all widths of vessels/lock	70	
std. dev.	20	
max width	175	
average sum of all areas of vessels/lock	34039	
std. dev	7294	
max area	44800	

processed by the lock no longer increased. This point defined lock capacity.

In order to calculate the corresponding k-values, the model was run at various traffic levels below capacity to provide additional points along the delay function. These estimates of tons processed and average delay per tow, along with the specified capacity, were used to calculate the k-value that generated the "best fit" hyperbola to the model values. The "best fit" function is identified as the function that minimizes the sum of the squared differences between the actual model estimates and the specified function estimate. The measure of the fit is referred to as the coefficient of determination or R-squared.

MODEL RESULTS

Table 5 - 7 provides a summary of model results for the with and without-project scenarios at capacity. The table first displays how multivessel lockages vary with lock size. As expected, the larger the lock size, the greater is the percentage of multivessel lockages. In the existing lock results, note that approximately 79 percent of all lockages are single lockages with practically none in the five tow/lock category, whereas in the 1200 x 110 x 36 ft locksize, almost none of the lockages are single lockages and approximately 44 percent are in the five tow/lock (without curfew) category.

The next section in table 5 - 7 displays how multicut lockages vary with locksize. As expected, the model results show that as the lock size increases, the percentage of multicut lockages decreases to the extent that in the 1200 ft length locks, practically all lockages are single cuts.

The Sim model also provides information on surface area utilization for the various lock dimensions. As table 5 - 7 shows, the range of values for surface area utilization is from approximately 71 percent with the existing and 900 x 90 ft locks, to approximately 85 percent with a 1200 x 110 ft lock.

Finally table 5 - 7 displays tons per lockage and capacity estimates for the various lock sizes. In addition, the percentage increase in capacity by removing bridge curfews is also presented along with the average processing time. As is shown, capacity estimates range from a low of 27.6 million tons for without-project conditions to a high of 74.9 million tons for the 1200 ft x 110 ft x 36 ft lock. The impact of removing bridge curfews on lock capacity is

Table 5 - 7

Simulation Summary Statistics
at Capacity

	640x75x31.5			900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
	with curfew	w/o curfew	Mid St Cl w/o cur	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew
Pct One Tow/Lock	78.9	76.8	79.9	34.0	37.3	17.5	17.3	17.6	15.6	8.4	8.5	0.9	1.4	0.9	0.9
Pct Two Tows/Lock	16.9	18.8	16.5	41.3	38.5	17.2	19.6	18.3	19.8	29.5	30.8	4.2	4.2	4.0	3.2
Pct Three Tows/Lock	2.6	2.7	2.3	18.1	18.5	35.0	32.7	35.1	35.1	27.0	26.7	17.5	17.5	16.4	13.9
Pct Four Tows/Lock	1.5	1.5	1.1	5.6	4.7	27.7	26.3	25.9	26.0	21.7	21.4	39.6	40.5	40.5	37.7
Pct Five Tows/Lock	0.1	0.2	0.2	1.0	1.1	2.7	4.0	3.0	3.5	13.4	12.5	37.8	36.4	38.3	44.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Avg Tows/Lock	1.27	1.29	1.25	1.98	1.94	2.81	2.80	2.78	2.82	3.02	2.99	4.09	4.06	4.11	4.21
Pct Tows 1-cut	83.4	83.4	83.4	92.4	92.4	94.3	94.4	94.1	94.8	99.9	99.9	100.0	100.0	100.0	100.0
Pct Tows 2-cut	16.4	16.4	16.4	7.5	7.5	5.7	5.6	5.9	5.2	0.1	0.1	0.0	0.0	0.0	0.0
Pct Tows 3-cut	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pct Tows 4-cut	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Surface Area Util:															
Pct Util	71	71	69	70	69	82	82	82	82	75	75	85	84	85	87
Util S.D.	15	15	17	19	19	12	12	12	12	13	13	9	10	9	7
Unused Length(ft)	83	84	94	101	106	60	64	62	61	74	73	51	52	51	42
Unused Length S.D.	74	74	86	107	110	73	78	76	73	70	73	47	47	47	36
Unused Width(ft)	13	13	14	14	14	5	5	5	5	10	11	5	5	5	4
Unused Width S.D.	8	8	9	15	15	7	8	8	8	12	12	5	6	6	4
Tons/Lockage	2,152	2,162	2,088	3,961	3,922	5,897	5,827	5,833	5,960	7,019	6,944	9,872	9,845	9,752	10,072
Capacity (mil)	27.6	28.8	29.6	44.8	46.3	57.0	59.4	57.0	59.2	61.3	63.6	73.5	75.7	72.3	74.9
Pct Capacity Imp w/o Curfew	-	4.5	-	-	3.5	-	4.2	-	3.8	-	3.8	-	3.0	-	3.6
Average Processing Time (Minutes)	61	58	56	58	62	68	65	67	65	66	65	69	72	72	74

approximately a three to four percent increase for all sizes.

Table 5 - 8 presents lock capacities and k-values for the first-come; first-serve policy associated with each of the lock sizes that were eventually evaluated in the GEM. In addition, the table also shows a corresponding R-squared value for each estimated equation. The R-squared reflects the degree of "fit" between the model calculated tonnage-delay points and the equation fit to those points.

Also displayed in table 5 - 8 are the capacity and k-values for the existing lock operating under the n-up; n-down policy. Equation parameters are shown for n = 3 and n = 5. With a capacity of 27.1 million tons and a k-value of 3.4, 5-up; 5-down is clearly inferior to the existing first-come first-serve policy. For n = 3, capacity is slightly lower (27.2 million tons) compared to the existing locking policy capacity (27.6 million tons) and the k-value for n = 3 is much higher. As a result, the average delay for a given tonnage level is actually higher with n = 3 than with current policy.

In order to visually highlight the relative differences between alternatives, figures 5 - 1 through 5 - 5 are provided. Figure 5 - 1 displays delay functions for the existing lock, with and without bridge curfews, and with a mid-rise St. Claude Avenue Bridge, without bridge curfews. Figures 5 - 2 and 5 - 3 display delay functions for four improved shallow draft locks with and without bridge curfews, respectively. Figures 5 - 4 and 5 - 5 display delay functions for two deep draft locks with and without bridge curfews, respectively.

Table 5 - 8

Delay Function Parameters
Existing And Improved IHNC Lock
(Simulation Method)

Condition (First-Come;First-Serve)	Capacity (1,000 Tons)	K-Value	R-Square
Existing Lock	27.6	2.05	0.8800
Existing Lock New Bridge w/o curfews	29.6	1.05	0.9462
Existing Lock w/o curfews	28.8	1.56	0.9098
900 x 90 x 22 w/curfews	44.8	0.60	0.9983
900 x 90 x 22 w/o curfews	46.3	0.36	0.9466
1200 x 90 x 22 w/curfews	61.3	0.42	0.9945
1200 x 90 x 22 w/o curfews	63.6	0.43	0.9998
900 x 110 x 22 w/curfews	57.0	0.51	0.9698
900 x 110 x 22 w/o curfews	59.4	0.50	0.9910
1200 x 110 x 22 w/curfews	73.5	0.44	0.9619
1200 x 110 x 22 w/o curfews	75.7	0.42	0.9917
900 x 110 x 36 w/curfews	57.0	0.67	0.9685
900 x 110 x 36 w/o curfews	59.2	0.48	0.9330
1200 x 110 x 36 w/curfews	72.3	0.40	0.9242
1200 x 110 x 36 w/o curfews	74.9	0.42	0.9449
3-Up;3-Down Policy			
Existing Lock	27.2	2.85	0.9344
5-Up;5-Down Policy			
Existing Lock	27.1	3.35	0.9456

FIGURE 5 - 1. DELAY FUNCTIONS
EXISTING LOCK

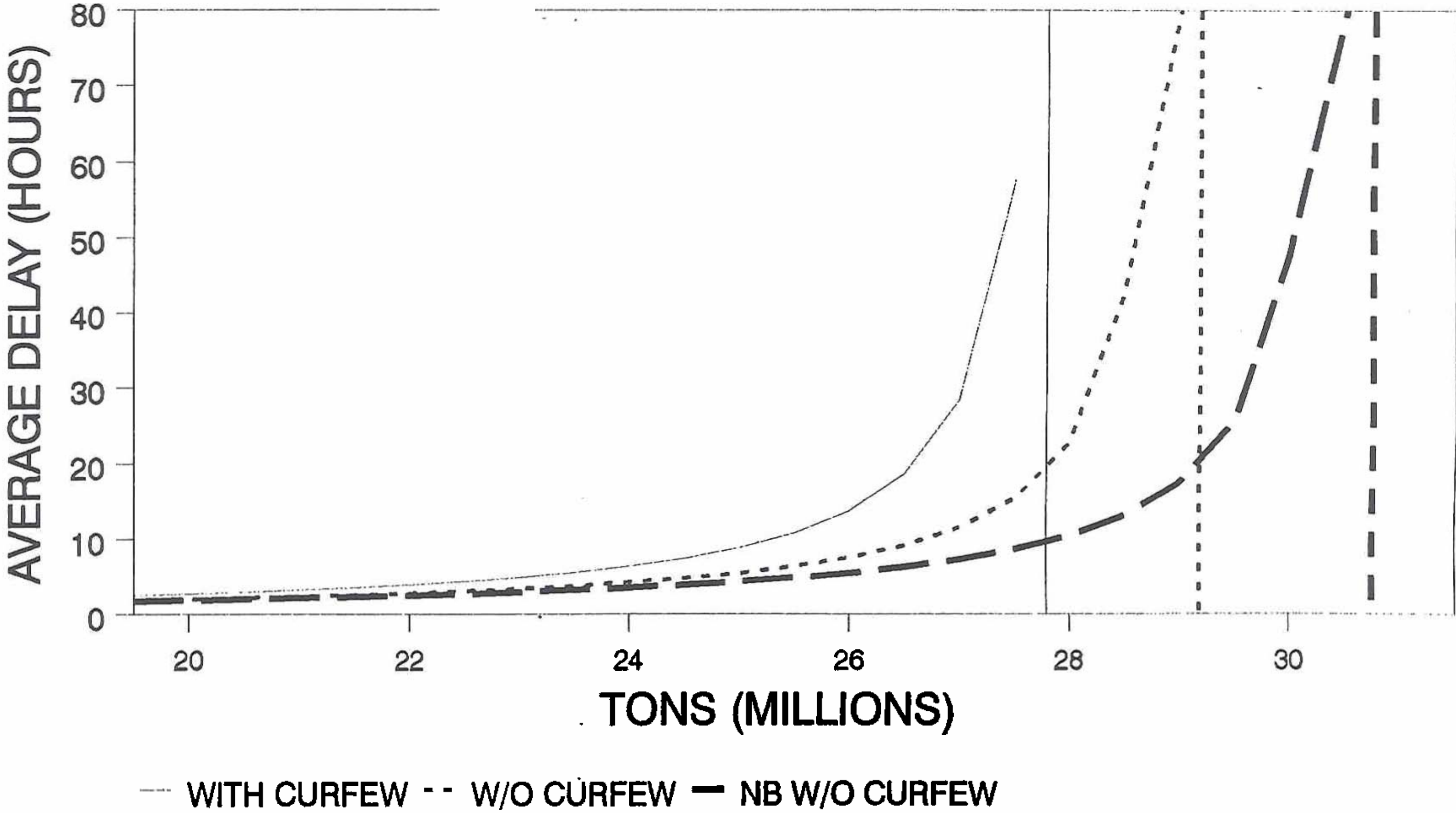


FIGURE 5 - 2. DELAY FUNCTIONS
SHALLOW DRAFT LOCKS WITH CURFEWS

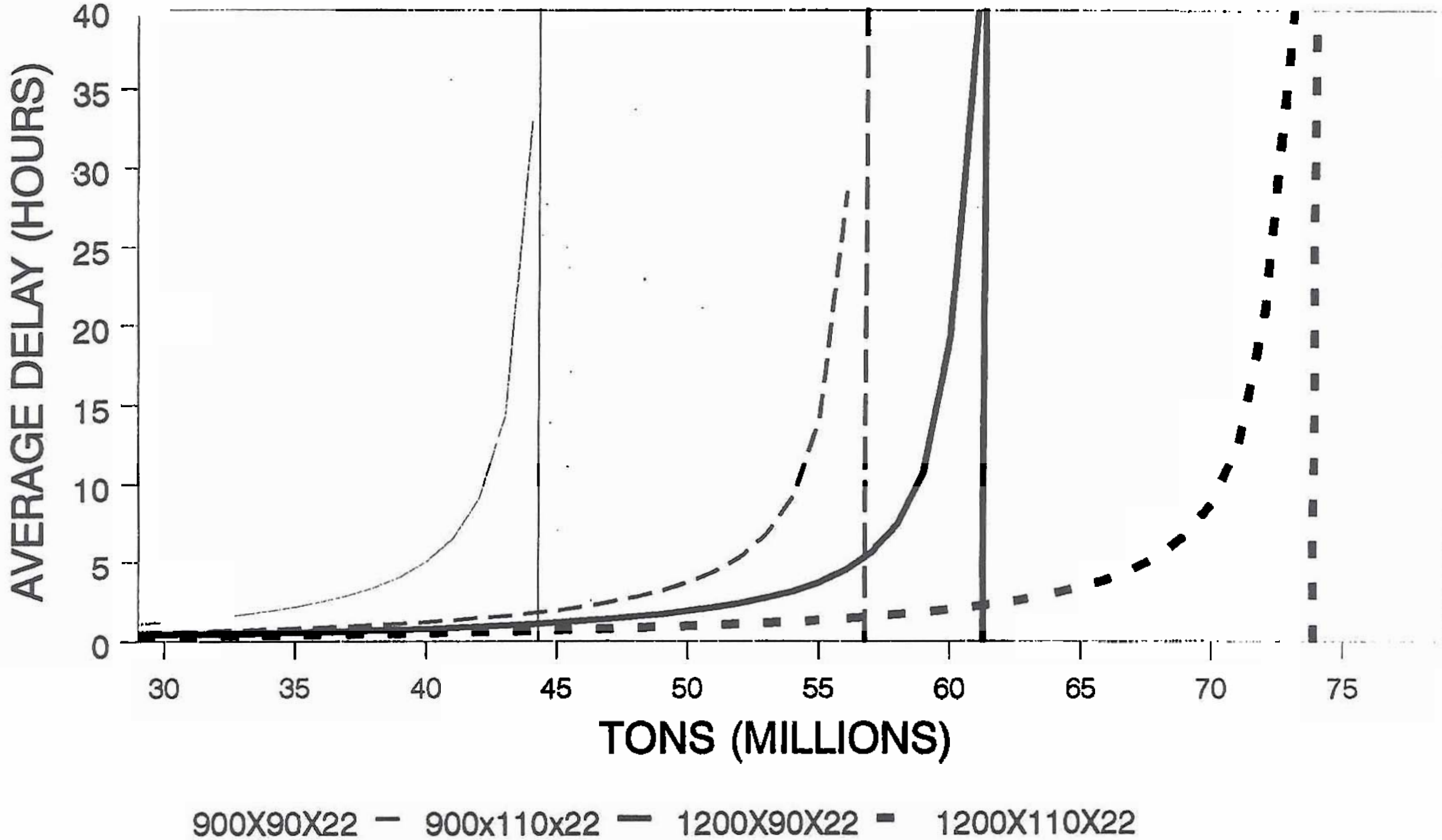
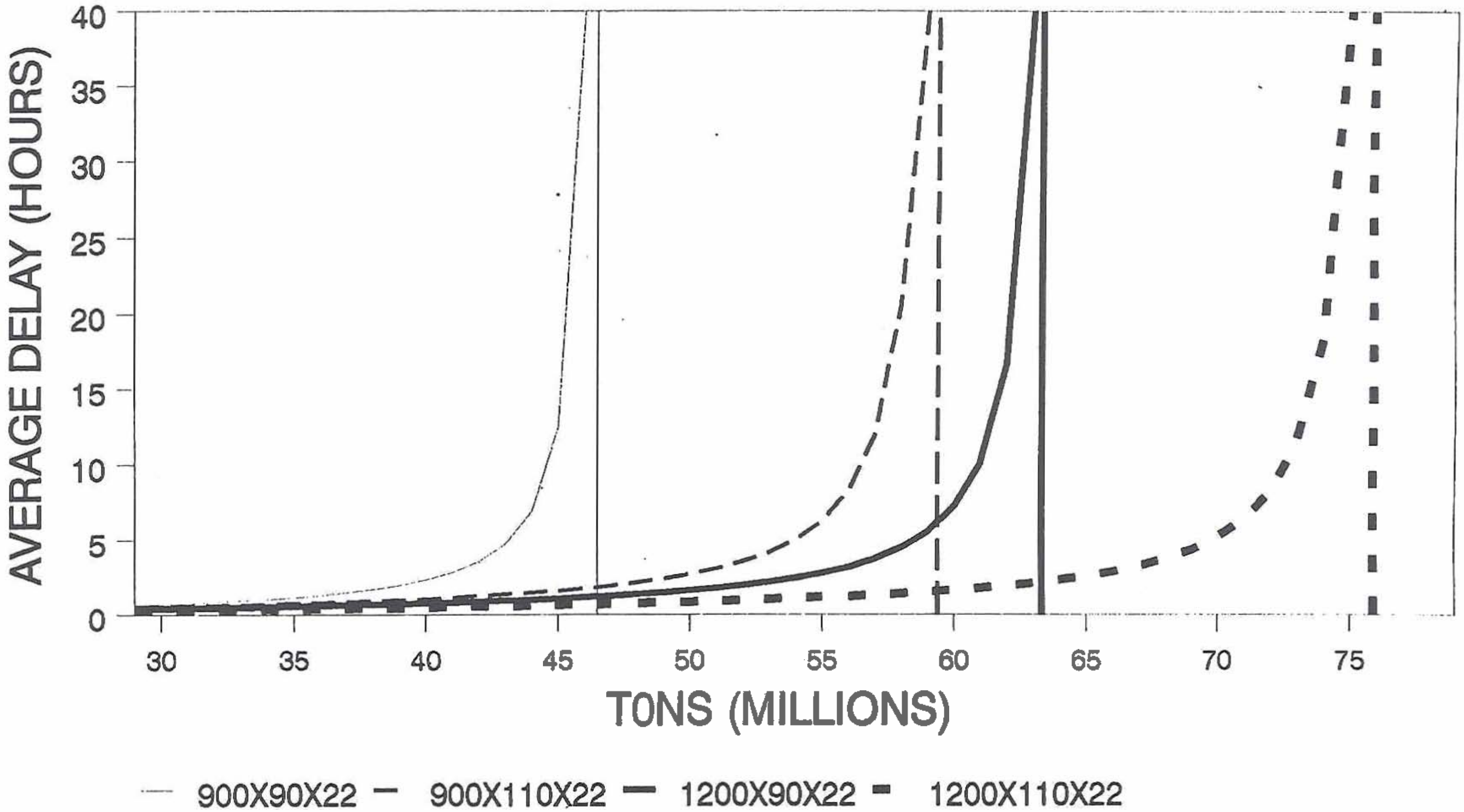


FIGURE 5 - 3. DELAY FUNCTIONS
SHALLOW DRAFT LOCKS WITH NO CURFEWS



MOC,

FIGURE 5 - 4. DELAY FUNCTIONS
DEEP DRAFT LOCKS WITH CURFEWS

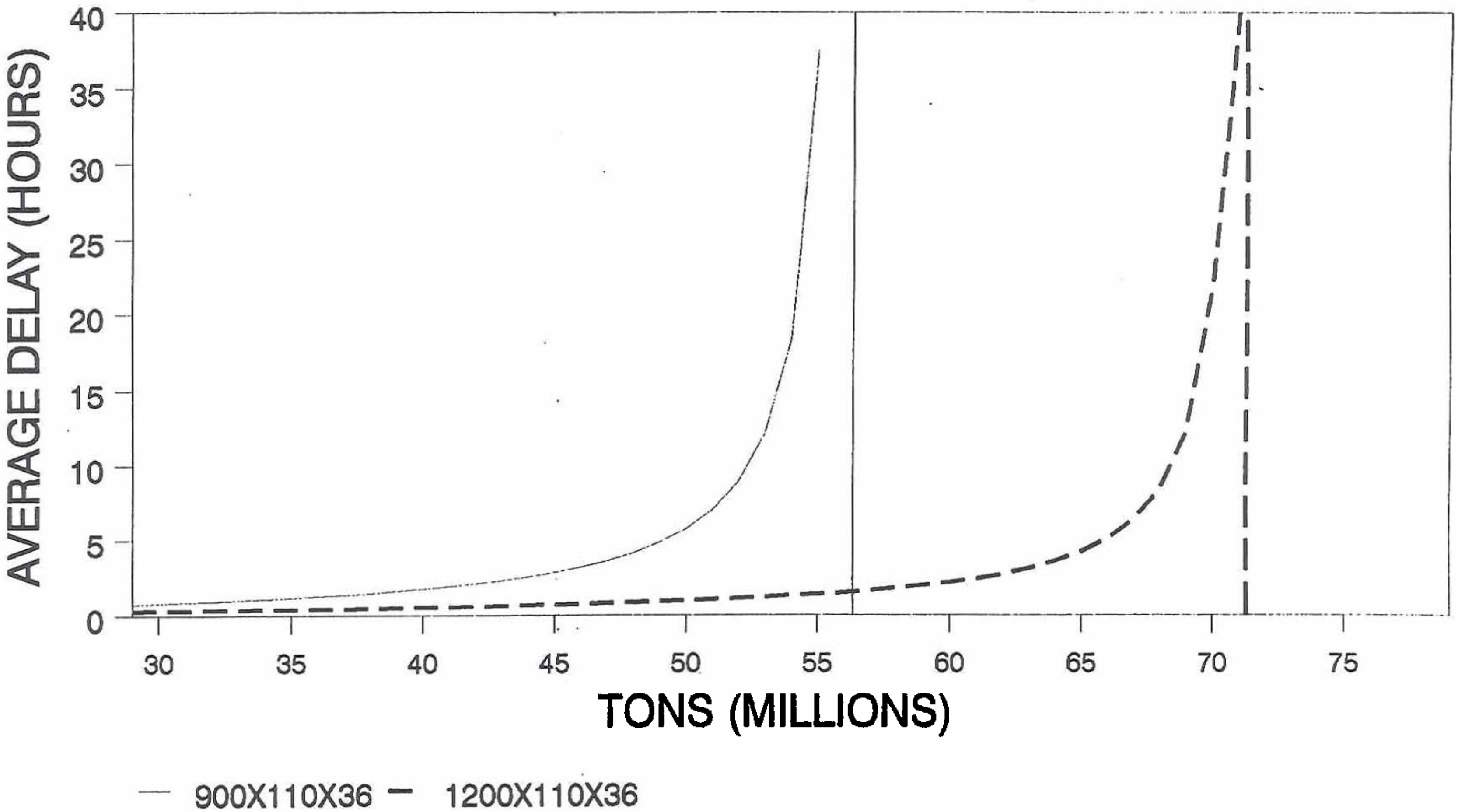
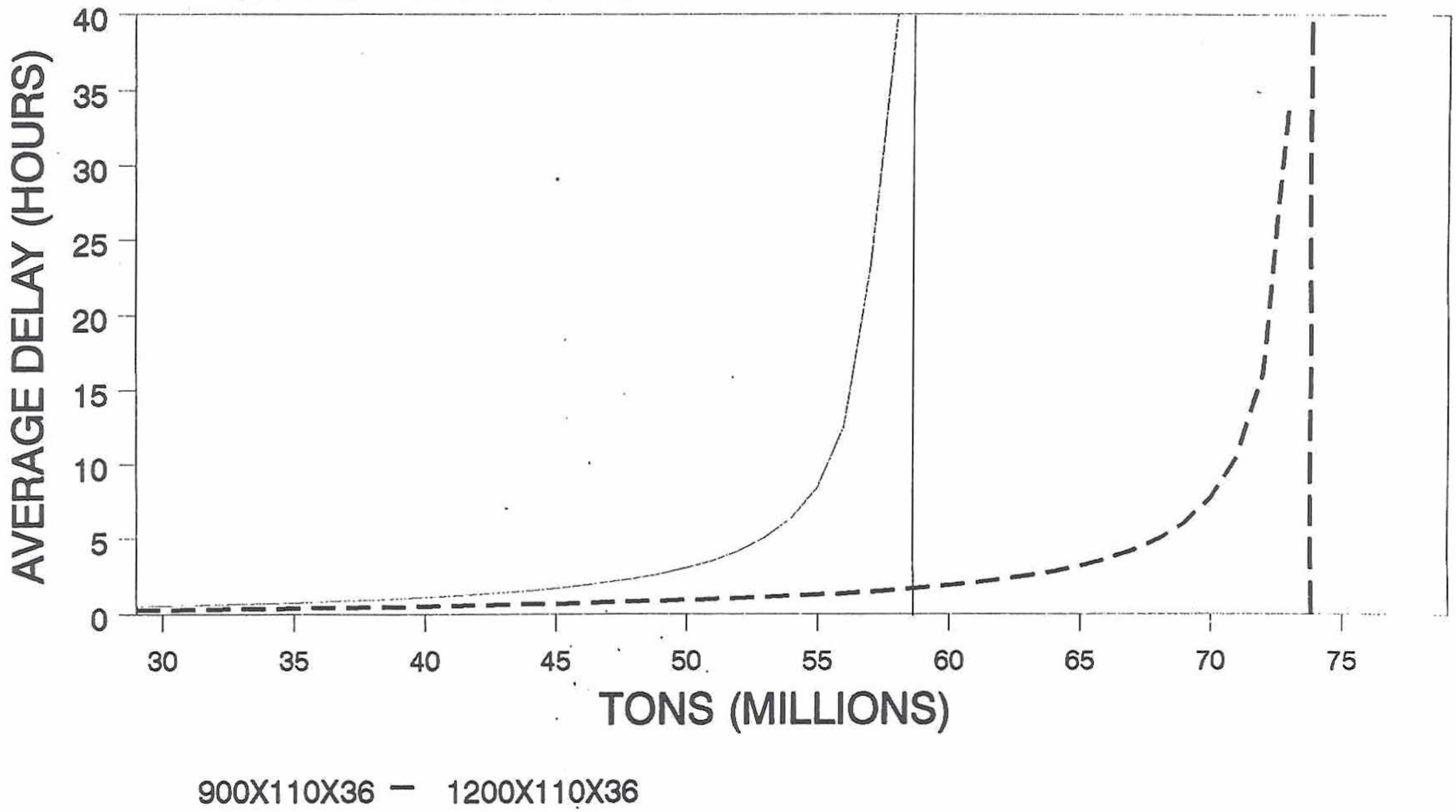


FIGURE 5 - 5. DELAY FUNCTIONS
DEEP DRAFT LOCKS WITH NO CURFEWS



SECTION 6 - WITHOUT-PROJECT CONDITION

OVERVIEW

Identification of the most likely condition expected to exist in the future in the absence of any improvements to the existing navigation system is a fundamental first step in the evaluation of potential improvements. The without-project condition serves as a baseline against which alternative improvements are evaluated. The increment of change between an alternative plan and the without-project condition provides the basis for evaluating the beneficial or adverse economic, environmental, and social effects of the considered plan. Definition of the without-project condition and, where appropriate, the rational for inclusion of a specific assumption are presented below.

DESCRIPTION

The without-project condition identified for use in this study includes the following analytical assumptions:

1. Operation and maintenance of all system locks will be continued through the period of economic analysis to ensure continued navigability.

2. To provide continued service equal to existing levels, it will be necessary to make above normal maintenance expenditures to the existing IHNC lock. The maximum amount of extraordinary maintenance for a specific feature of work is estimated to be $4.5 million. All features will be funded by the operations and maintenance budget. These costs in excess of normal maintenance costs are estimated to total 16.1 million dollars over a 4-year period. The total dollar expenditure schedule by year is given below.

Yr 1 - 1999 $6.3 million

Yr 2 - 2000 $3.8 million

Yr 3 - 2001 $4.5 million

Yr 4 - 2002 $1.5 million

Extraordinary maintenance would include the following items:

a.) Miter Gate Leaves and Miter Gate Machinery - Four single skin gate leaves will be constructed to replace the four main operating gate leaves. Installation of the new gates would be done concurrently with replacement of the existing gate operating machinery for the four main operating gates with hydraulic operating systems. The gate bays will be dewatered for installation and adjustment of the gates. The lock will be closed to navigation for six weeks.

The existing gates are of an obsolete, double skin, riveted design that requires intensive maintenance. The gates are designed with air chambers for flotation which must be kept evacuated at all times. The air chambers leak excessively necessitating frequent pump-out of the gates. The complexity of the internal structure of the gates considerably impacts the repair costs.

In the interest of minimizing lock closure due to repairs, the typical sequence entails substituting the auxiliary gates for the operating gates when the operating gates are removed for repairs. This practice has resulted in a general shuffling of all gates from their original positions. The gates were originally constructed in place, and although the gates are theoretically identical and interchangeable, problems have been experienced with the fit of the gates in various positions. In some cases, all efforts to adjust the gates have failed to draw the gates fully into their recesses in the fully open position. This has introduced the hazard of the gates being hit by tows and the potential for serious damages. Replacement of the existing Panama Canal type gate operating systems, with direct acting hydraulic cylinders would overcome gate adjustment limitations.

The cost of gate leave replacement and operating machinery replacement are estimated to be $4.0 million and $2.3 million, respectively. Both items are scheduled for 1999.

b.) Emergency Dam Crane - The existing emergency dam crane is not considered reliable for emergency closure of the lock. The crane does not afford sufficient capability to manipulate the stoplogs to ensure that they could be lowered in a flowing water condition. Consequently replacement is required. A 175 ton capacity boom type crane or stiff leg derrick will be required. No interruptions to navigation will be required to accomplish this replacement. The cost of this work is estimated to be $3.5 million and is scheduled for the year 2000.

c.) Control Houses - This item will replace the existing prefabricated buildings with permanent masonry concrete structures. The existing control stations consist of small fiberglass booths that house gate and valve control switches. The booths are mounted directly to the lock wall and provide no vantage point for lock operators to observe the progress of vessels entering or exiting the lock. Additionally, the existing booths provide only a marginally suitable work space for the lock operators.

Replacement of the existing booths with raised control houses is necessary to improve visability and provide a suitable working environment for lock operators. No interruptions to navigation will be required for construction of the new control houses. The cost of this work is estimated to be $0.3 million and is scheduled for the year 2000.

d.) Wall Armor Retrofit - Existing lock concrete is heavily spalled and requires retrofit with steel wall armor and/or other cladding materials. The concrete is worn down to the steel reinforcement in many locations. There are numerous cracks in the lock walls that cause leakage into the gallerys during high water seasons. Without repairs the structural integrity of the lock chamber may be compromised, and unacceptable leakage will continue. The eroded surface of the lock walls, and protruding steel reinforcement, could cause damage to vessels transiting the lock. Additionally, there are no mooring pins in the lock walls. Consequently, lock operators must handle lines for vessels transiting the lock. This is particularly dangerous since the operators must walk the wall outside of the protective handrails. A fall from the lock wall has a high potential for fatal injury.

Repair of the concrete chamber would require dewatering of the lock, and a closure of approximately 60 days. Repair costs are estimated at $4.5 million and are scheduled for the year 2001.

e.) Concrete - Repairs are required to the concrete masonry in the upper 12 feet of the lock walls in the vicinity of the machinery rooms. The lock concrete has spalled and some rebar is exposed on overhead beams. Exposed rebar is heavily corroded. Some of the ceiling slab needs repair. Some columns also have exposed rebar. If this work is not done, leakage, corrosion, and failure of the structure will occur. No interruptions to navigation will be required for these repairs. The cost of this work is estimated to be $1.5 million and is scheduled for the year 2002.

3. Lock closure associated with miter gate leaves and machinery, and wall armor retrofitting will be announced in advance to allow navigation interests the opportunity to plan for the outage and to minimize the impacts of closure.

4. All existing waterway projects or those under construction are to be considered in place and will be

operated and maintained through the period of analysis. This includes all shallow-draft lock and channel projects as well as deep-draft channel projects including the Mississippi River-Gulf Outlet.

5. Baptiste Collette is not considered a viable long-term alternative to use of the IHNC Lock. Baptiste Collette is located at mile 11.3 above the Head of Passes on the left descending bank of the Mississippi River. This channel connects the Mississippi River with the Breton Sound area and the Mississippi River-Gulf Outlet. By utilizing this route, which is approximately 160 miles long, it is possible to circumvent the IHNC Lock.

However, Baptiste Collette is not considered to be a viable alternative to the IHNC Lock, except in the case of prolonged lock closure for some parts of the year and then only for certain commodities. The primary problem, beyond the added distance, is the unpredictable weather conditions on the open channel across Breton Sound, particularly during the winter months. The potential for quickly developing bad weather is compounded by the fact that the decision to commit to Baptiste Collette must be made 10 to 12 hours before actual exposure to the open channel. In addition, higher insurance premiums may be required from shippers on shipments routed via Baptiste Collette. Operators contacted during the course of this study indicated that they would prefer facing delays at the IHNC Lock significantly in excess of the implied delay that would equate to the additional travel distance, rather than the uncertainties of Baptiste Collette. In regard to the useability of Baptiste Collette, the American Waterways Operators has taken the position that Baptiste Collette should not be considered as a viable alternative to the IHNC Lock except under the most extreme circumstances. As a result these considerations, use of Baptiste Collette was not considered to represent a viable alternative to IHNC Lock use and therefore was not a factor in determining the least cost non-system route.

6. Delay and congestion costs at other potential system constraint points not directly modeled will not change significantly over the period of analysis.

7. All system locks are using the most efficient locking policies.

8. The State of Louisiana will replace the current low-level Florida Avenue roadway/railway bridge with a new high-level roadway bridge. A new low-level railway/roadway bridge will be constructed under the authority of the Truman Hobbs Act.

9. Alternative non-system transportation means (rail and non-system water) are assumed to have sufficient capacity to move diverted system traffic at current costs over the period of analysis.

10. Waterway user taxes will continue in the form of the towboat fuel tax prescribed by the Water Resources Development Act of 1986, Public Law 99-662.

11. The capacities of system locks are as presented in tables 5 - 1 and 5 - 8.

12. Traffic demands on the system will grow at the mid growth rates.

SECTION 7 - SHALLOW-DRAFT SYSTEM ANALYSIS

OVERVIEW

GEM was run to estimate the total transportation cost savings (NED benefits) attributable to the with and without-project conditions. The model was used to estimate the benefits to the existing and improved systems for calendar years 1990, 2000, 2010, 2020, 2030, 2040, and 2060. For intermediate years, the system transportation benefits are estimated by assuming a constant change in benefits between the years explicitly modeled.

WITHOUT-PROJECT CONDITIONS

Table 7 - 1 summarizes the results of the without-project GEM runs. Displayed are the annual tonnages and expected levels of delay for modeled system locks. Annual tonnage moved on the entire system as well as the annual net transportation cost savings of the system. (Note that system tonnage does not include tonnage that does not transit at least one of the modeled GIWW locks.) The following paragraphs are observations regarding the model results for the without-project condition.

The GEM estimates of system and lock traffic for the existing 1990 conditions agreed with observed data. GEM showed 82.8 million tons of total traffic in the modeled system compared with the WCSC plus constructed movement tonnage estimate of 82.8 million tons (adjusted for the deletion of "small" and negative gross cost savings movements). The results at individual locks were also quite reasonable. However, because of the nature of the reconciliation process that jointly reconciled Port Allen, Algiers and Harvey locks, comparison of "actual" 1990 tonnages and GEM results required some additional treatment.

Table 7 - 2 provides the basis for comparing "actual" 1990 traffic with the model results, by lock. The first column of tonnages shows adjusted WCSC tonnage, i.e., original WCSC tonnage plus constructed movements. The second column of tonnages represents an estimate of adjusted WCSC corrected for alt code misassignment. This adjustment applied to Port Allen, Algiers and Harvey directly, and to Bayou Sorrel and Bayou Boeuf by routing implication. The basis for the estimate of the corrected routings for Port Allen, Algiers and Harvey was the LPMS tonnage for each lock multiplied by the sum of adjusted WCSC for the three locks, divided by the sum of LPMS for the three locks. The third and fourth column of tonnages represent the number of movements deleted from the movement file that had negative

Table 7 - 1

Without-Project Conditions
Tonnage and Delay by Lock

	1990		2000		2010		2020	
Lock	Tons (Millions)	Delay (Hrs)	Tons (Millions)	Delay (Hrs)	Tons (Millions)	Delay (Hrs)	Tons (Millions)	Delay (Hrs)
Port Allen	27.8	1.7	30.8	2.5	31.2	2.6	31.5	2.8
Bayou Sorrel	27.1	5.5	29.8	15.9	30.1	19.6	30.3	22.9
IHNC	23.1	10.4	25.5	25.3	26.3	40.7	26.6	52.5
Algiers	24.5	3.3	24.5	3.3	26.4	5.3	27.0	6.4
Harvey	3.8	0.3	4.3	0.3	6.9	0.8	8.6	1.3
Bayou Boeuf	28.0	0.9	28.6	0.9	32.3	1.8	34.7	3.4
Calcasieu	46.3	1.3	50.2	1.8	56.9	4.0	62.3	18.0
Total Tons	82.8		87.4		96.1		100.8	
Total Net Savings	1,251.5		1,274.9		1,385.0		1,407.0	
Savings per Ton	15.12		14.60		14.42		13.96	

	2030		2040		2060	
Lock	Tons (Millions)	Delay (Hrs)	Tons (Millions)	Delay (Hrs)	Tons (Millions)	Delay (Hrs)
Port Allen	31.7	2.9	31.9	2.9	32.5	3.2
Bayou Sorrel	30.3	22.8	30.3	22.1	30.3	22.8
IHNC	26.6	54.5	26.7	60.2	26.7	60.2
Algiers	27.4	7.3	27.7	8.4	27.7	8.1
Harvey	9.9	1.9	10.2	2.1	9.8	1.8
Bayou Boeuf	36.3	7.9	37.0	16.3	36.6	10.2
Calcasieu	63.4	88.3	63.7	101.3	63.8	182.7
Total Tons	102.3		103.4		104.9	
Total Net Savings	1,225.6		1,250.3		1,153.8	
Savings per Ton	11.98		12.09		11.00	

Table 7 - 2

Comparison of Reported 1990 Traffic and GEM Results
(1,000 Tons)

Lock	Adjusted WCSC	Adjusted WCSC Corrected for Routings	Deleted Negative GCS Movements	Deleted "Small" Movements	Comparison "Actual" 1990	GEM Results	GEM Differences
Port Allen	28,210	27,800	161	13	27,626	27,811	185
Bayou Sorrel	27,781	26,401	225	14	26,162	27,095	933
IHNC	23,493	23,493	405	32	23,056	23,056	0
Algiers	24,628	25,000	71	17	24,912	24,501	(411)
Harvey	3,538	3,600	57	15	3,528	3,780	252
Bayou Boeuf	27,845	27,628	112	33	27,483	27,967	484
Calcasieu	46,501	46,501	152	28	46,321	46,321	0

gross cost savings and those that were relatively "small". The last two columns show the individual lock tonnages from GEM and the difference between GEM and "actual" 1990.

The GEM results are quite reasonable estimates of recorded results for 1990. Given "non-optimal" actual behavior, the fact that "actual" 1990 tonnages are themselves only estimates for certain routes, the assignment of transportation costs to the population of movements from the actually costed movements in the sample, the approximation in delay function estimation in part due to the use of an average head condition, and the loss of some detail in the aggregation of the movement file, the results generated by GEM represent a high degree of calibration of the model for this study where emphasis is on the IHNC Lock.

The without-project condition results displayed in table 7 - 1 assume that all structures continue to provide service at historical levels. The results do not account for the services outages at IHNC Lock that would result from the rehabilitation work described in Section 6. The navigation impacts resulting from these outages are however, quite substantial, and must be taken into account.

To quantify the navigation impacts of these outages, the GEM was run with a modified navigation network specified. The specific modification was to express IHNC Lock capacity as zero. This created a situation that effectively represented lock closure. With IHNC Lock closed within the model logic, traffic with an IHNC routing was forced to seek a non-system alternative (Ten-Tom, rail, or truck) since there are no alternative system routings that involve IHNC Lock specified for any movement.

Several considerations lend support to this formulation of impact measurement. First, the duration of the closures is fairly significant, 30 days per closure. Given durations of this length, users would be motivated to make adjustments to current practices. Second, closures would be announced well in advance of implementation. This would permit users to carefully plan and schedule their actions. Third, the distribution of the gross cost savings for IHNC Lock traffic in the relevant time period is heavily weighted to the lower end of the savings scale relative to the savings that are equivalent to the length of the closures. Approximately 40 percent of tonnage has a gross rate savings equivalent to a wait of up to only three days, 85 percent of tonnage up to 15 days, and 95 percent of tonnage up to only 19 days. Consequently, the likelihood of diversions is great.

The closure scenario was run for the year 2000, the mid-point of the 5-year period during which the rehabilitation work is scheduled. The system transportation savings associated with this condition were subtracted from the without-project system transportation savings in order to measure the impact of closure. Given the non-seasonal nature of tonnage on this system, this annual value was divided by twelve to represent a monthly value.

The navigation system impacts of IHNC Lock closure are summarized in table 7 - 3. This table displays the change in the without-project and lock closure conditions for tonnages and average delays at each system lock. As a result of lock closure, total system tonnage is reduced by an amount equal to the without-project condition IHNC Lock tonnage. Because of the multiple lock use associated with the diverted tonnage, the volume at the other system locks declined as well. The tonnage decline at these other locks produces the beneficial effect of lowering their respective average delays. The traffic that continues to be served by these locks enjoys the advantage of the lower delay. The impact of these lower delays is captured in the system savings for the closure condition and mitigates, to some extent, the negative effect on system savings that results from the diverted traffic. In total, system savings would fall by $242.9 million for a twelve month period ($20.2 million per month), the equivalent of $9.51 per diverted ton.

As described earlier in Section 6, the navigation losses that will result from IHNC Lock closure are part of the without-project condition. However, these losses are not reflected in the without-project condition displayed in table 7 - 1. As such, the system cost savings for the without-project condition are overstated. Therefore, when cost savings for improved conditions that eliminate the need for rehabilitation are subsequently measured, the savings for that improved condition will be understated. To correctly reflect the level of with-project savings and also to help isolate the impacts of lock closure, navigation losses associated with rehabilitation work have been reflected, not as part of the without-project condition, but as a separate impact that can be claimed, as appropriate, as a project savings.

WITH-PROJECT CONDITIONS

The with-project scenarios consist of six larger IHNC Lock sizes built north of the Claiborne Avenue Bridge. For each of these, two separate benefit calculations were done. One assuming that the existing bridge curfews on the Claiborne

Table 7 - 3

IHNC Lock Closure Impacts

	W/O Project (Yr 2000)		IHNC Closure Change In:	
	Tons	Delay	Tons	Delay
Lock	(1,000)	(Hrs)	(1,000)	(Hrs)
Port Allen	30,817	2.5	20	0
Bayou Sorrel	29,808	15.9	9	-0.1
IHNC	25,531	25.3	(25,531)	-25.3
Algiers	24,513	3.3	(3,776)	-1.6
Harvey	4,343	0.3	(2,901)	-0.2
Bayou Boeuf	28,616	0.9	(6,078)	-0.5
Calcasieu	50,164	1.8	(5,451)	-0.6
Total System	87,350		(25,531)	

	W/O Project (Yr 2000)	IHNC Closure Change In:
System Savings ($1,000)	1,274,892	1,032,039

Avenue Bridge will continue, the other assuming that the curfews would be removed. In addition to the alternatives just mentioned, two other with project scenarios were studied. The first analyzed the results of replacing the existing low level St. Claude Avenue Bridge with a mid-level bridge, while still using a "rehabilitated" existing lock. The second studied the effects of removing bridge curfews at the existing St. Claude and Claiborne Avenue Bridge, while retaining the existing "rehabilitated" lock and bridge structures. Focusing on the IHNC Lock, tables 7 - 4 through 7 - 10 display the average delay, traffic processed, and transportation cost savings results of the GEM runs for each scenario, including the without-project condition, by the future years specified above. The following paragraphs are observations regarding the model results.

Table 7 - 4 shows the GEM estimates of average delay per tow for the without-project and various with-project conditions. Table 7 - 4 shows that in the with-project scenarios of replacing the existing St. Claude Avenue Bridge with a mid-level bridge or removing bridge curfews, a significant reduction in IHNC Lock average delay results. However the magnitude of the reduction diminishes over time and finally reaches the point where the delay would return to the level of the without-project condition.

This behavior occurs because as these alternatives are implemented there would be a modest outward shift in the delay function (see figure 5 - 1) reflecting a higher capacity. While modest, the immediate effect of this shift on average delay would be significant because of the general functional form of the relationship. There would be movement from a point representing a high level of utilization on a relatively steep portion of the original function to a point representing a level of utilization on a much flatter portion of the new function. However, because the outward shift in capacity is modest, traffic need only increase modestly before the more steep portion of the new function is encountered where delay is sensitive to a change in traffic volume. Additional traffic is serviced but the system eventually equilibrates at a delay level equal to that of the without-project condition.

For the new lock construction alternatives, the outward shift in the delay function is sufficiently large relative to the traffic demand that delay remains low until the later years of the period of analysis. The same process described above for the "bridge only" alternatives still applies in principle however. As such, the new lock alternative that produces the smallest increase in capacity

Table 7 - 4

IHNC Lock Average Delays
By Alternative and Year
(Hours)

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	10.4	25.3	40.7	52.5	54.5	60.2	60.2
Removal of Bridge Curfews	6.3	15.3	38.2	40.7	54.5	54.5	60.2
Replace St. Claude Bridge	3.7	7.9	27.5	40.7	54.5	54.5	60.2
900 x 90 x 22 ft. (With bridge curfews)	0.6	0.8	1.2	1.7	3.1	10.8	40.7
900 x 90 x 22 ft. (Without bridge curfews)	0.4	0.5	0.7	0.9	1.5	4.0	40.7
900 x 110 x 22 ft. (With bridge curfews)	0.3	0.4	0.6	0.7	1.0	1.5	8.5
900 x 110 x 22 ft. (Without bridge curfews)	0.3	0.4	0.5	0.6	0.9	1.3	4.8
900 x 110 x 36 ft. (With bridge curfews)	0.5	0.6	0.7	0.9	1.3	2.0	11.1
900 x 110 x 36 ft. (Without bridge curfews)	0.3	0.4	0.5	0.6	0.8	1.2	4.7
1200 x 90 x 22 ft. (With bridge curfews)	0.3	0.3	0.4	0.5	0.7	0.9	3.
1200 x 90 x 22 ft. (Without bridge curfews)	0.2	0.3	0.4	0.5	0.6	0.9	2.4
1200 x 110 x 22 ft. (With bridge curfews)	0.2	0.2	0.3	0.4	0.5	0.6	1.2
1200 x 110 x 22 ft. (Without bridge curfews)	0.2	0.2	0.3	0.3	0.4	0.5	1.0
1200 x 110 x 36 ft. (With bridge curfews)	0.2	0.2	0.3	0.3	0.4	0.6	1.2
1200 x 110 x 36 ft. (Without bridge curfews)	0.2	0.2	0.3	0.3	0.4	0.6	1.1

(900 x 90 x 22) is the first to experience significant increases in average delay.

Table 7 - 5 shows the traffic accommodated, or processed, at the IHNC Lock. Table 7 - 6 expresses these same traffic volumes as a percent of total unconstrained demand. Table 7 - 7 displays similar information, but in the form of unaccommodated traffic levels. These three tables demonstrate that all of the new lock construction alternatives accommodated essentially 100 percent of the IHNC Lock traffic demand through the year 2040. Not until 2060 are there any substantial diversions. However, in the without project and rehabilitated existing lock scenarios, significant traffic is diverted as early as 2010.

Tables 7 - 8 and 7 - 9 compare the system tonnage processed in the with and without project conditions. Table 7 - 8 displays the "bridge only" improvement alternatives and the lock improvement with bridge curfews alternatives. Table 7 - 9 displays the lock improvement without bridge curfews alternatives. Presented are the without-project tonnages at each system lock and project-induced changes in traffic, by lock, by year, for the various improved conditions. These improved future conditions begin to show changes in IHNC Lock traffic in the year 2000. These tonnage volumes for IHNC Lock can also be identified by referring back to the with and without-project tonnages in table 7 - 5.

At the other system locks, with-project traffic impacts are non-existent through 2020 for all alternatives. After 2020, induced traffic impacts appear but are minimal. The largest changes occur in 2060 at Harvey and Bayou Boeuf Locks where increases of less than 300,000 tons are indicated. Differences in induced/traffic between lock improvement alternatives are also minimal. No differences are indicated until 2060 and then only between the smallest capacity alternative (900 x 90 x 22) and all other lock improvement alternatives. As a consequence of the virtually identical with and without-project traffic at the other system locks, the with and without-project average delay differences would also be minimal.

Table 7 - 10 displays the total system transportation savings by year for the without-project condition and the total system and incremental transportation savings by year for each with-project alternative. System transportation cost savings represent the total transportation cost savings attributable to the entire modelled system network (existing system elements and all system additions assumed in place). Incremental transportation cost savings represent the portion of total system transportation cost savings attributable to the potential improvement under

IHNC Lock Traffic Accomodated
By Alternative and Year
(1,000 Tons)

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	23,056	25,531	26,277	26,564	26,600	26,691	26,691
Removal of Bridge Curfews	23,056	26,130	27,670	27,738	27,999	27,999	28,072
Replace St. Claude Bridge	23,056	26,135	28,510	28,856	29,041	29,041	29,092
900 x 90 x 22 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,436	44,150
900 x 90 x 22 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	45,894
900 x 110 x 22 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,766
900 x 110 x 22 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,766
900 x 110 x 36 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,766
900 x 110 x 36 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,766
1200 x 90 x 22 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,76
1200 x 90 x 22 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,766
1200 x 110 x 22 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,804
1200 x 110 x 22 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,804
1200 x 110 x 36 ft. (With bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,804
1200 x 110 x 36 ft. (Without bridge curfews)	23,056	26,135	29,811	33,355	37,533	42,503	53,804

IHNC Lock Percent of Total Demand Accomodated
By Alternative and Year

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	100%	98%	88%	80%	71%	63%	48%
Removal of Bridge Curfews	100%	100%	93%	83%	75%	66%	51%
Replace St. Claude Bridge	100%	100%	96%	87%	77%	68%	52%
900 x 90 x 22 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.7%	80%
900 x 90 x 22 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	83%
900 x 110 x 22 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
900 x 110 x 22 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
900 x 110 x 36 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
900 x 110 x 36 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 90 x 22 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 90 x 22 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 110 x 22 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 110 x 22 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 110 x 36 ft. (With bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%
1200 x 110 x 36 ft. (Without bridge curfews)	100%	100%	100%	100%	99.9%	99.8%	97%

Table 7 - 7

IHNC Lock Traffic Unaccomodated
By Alternative and Year
(1,000 Tons)

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	0	604	3,534	6,791	10,973	15,885	28,799
Removal of Bridge Curfews	0	5	2,141	5,617	9,574	14,577	27,418
Replace St. Claude Bridge	0	0	1,301	4,499	8,532	13,535	26,398
900 x 90 x 22 ft. (With bridge curfews)	0	0	0	0	40	140	11,340
900 x 90 x 22 ft. (Without bridge curfews)	0	0	0	0	40	73	9,596
900 x 110 x 22 ft. (With bridge curfews)	0	0	0	0	40	73	1,724
900 x 110 x 22 ft. (Without bridge curfews)	0	0	0	0	40	73	1,724
900 x 110 x 36 ft. (With bridge curfews)	0	0	0	0	40	73	1,724
900 x 110 x 36 ft. (Without bridge curfews)	0	0	0	0	40	73	1,724
1200 x 90 x 22 ft. (With bridge curfews)	0	0	0	0	40	73	1,7.
1200 x 90 x 22 ft. (Without bridge curfews)	0	0	0	0	40	73	1,724
1200 x 110 x 22 ft. (With bridge curfews)	0	0	0	0	40	73	1,686
1200 x 110 x 22 ft. (Without bridge curfews)	0	0	0	0	40	73	1,686
1200 x 110 x 36 ft. (With bridge curfews)	0	0	0	0	40	73	1,686
1200 x 110 x 36 ft. (Without bridge curfews)	0	0	0	0	40	73	1,686

Table 7 - 8

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	Remove Bridge Curfews	Replace St. Claude Bridge	900 x 90 x 22 ft. (With Curfews)	900 x 110 x 22 ft. (With Curfews)
1990					
Port Allen	27,811	0	0	0	0
Bayou Sorrel	27,095	0	0	0	0
IHNC	23,056	0	0	0	0
Algiers	24,501	0	0	0	0
Harvey	3,780	0	0	0	0
Bayou Bouef	27,967	0	0	0	0
Calcasieu	46,321	0	0	0	0
Total System	82,788	0	0	0	0
2000					
Port Allen	30,817	0	0	0	0
Bayou Sorrel	29,808	0	0	0	0
IHNC	25,531	599	604	604	604
Algiers	24,513	0	0	0	0
Harvey	4,343	0	0	0	0
Bayou Bouef	28,616	0	0	0	0
Calcasieu	50,164	0	0	0	0
Total System	87,350	599	604	604	604
2010					
Port Allen	31,174	0	0	0	0
Bayou Sorrel	30,115	0	0	0	0
IHNC	26,277	1,393	2,233	3,534	3,534
Algiers	26,417	0	0	0	0
Harvey	6,920	0	0	0	0
Bayou Bouef	32,318	0	0	0	0
Calcasieu	56,908	0	0	0	0
Total System	96,067	1,392	2,232	3,534	3,534
2020					
Port Allen	31,546	0	0	0	0
Bayou Sorrel	30,308	0	0	0	0
IHNC	26,564	1,174	2,292	6,791	6,791
Algiers	27,029	0	0	0	0
Harvey	8,609	0	0	0	0
Bayou Bouef	34,652	0	0	0	0
Calcasieu	62,271	0	0	0	0
Total System	100,778	1,174	2,293	6,791	6,791

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	Remove Bridge Curfews	Replace St. Claude Bridge	900 x 90 x 22 ft. (With Curfews)	900 x 110 x 22 ft. (With Curfews)
2030					
Port Allen	31,737	0	0	(13)	(13)
Bayou Sorrel	30,303	0	0	(12)	(12)
IHNC	26,600	1,399	2,441	10,933	10,933
Algiers	27,399	0	0	32	32
Harvey	9,850	0	0	151	151
Bayou Bouef	36,313	0	0	182	182
Calcasieu	63,640	0	0	1	1
Total System	102,276	2,441	1,399	10,734	10,734
2040					
Port Allen	31,914	0	0	12	12
Bayou Sorrel	30,267	0	0	12	12
IHNC	26,691	1,308	2,350	15,745	15,812
Algiers	27,745	1	1	(64)	(64)
Harvey	10,236	4	4	87	87
Bayou Bouef	37,018	0	0	19	19
Calcasieu	63,686	11	11	51	52
Total System	103,416	2,165	1,123	14,612	14,613
2060					
Port Allen	32,465	0	0	0	0
Bayou Sorrel	30,304	0	0	0	0
IHNC	26,691	1,381	2,401	17,459	27,075
Algiers	27,664	0	0	8	47
Harvey	9,782	0	0	48	271
Bayou Bouef	36,625	0	0	50	265
Calcasieu	63,825	0	0	0	0
Total System	104,876	2,402	1,382	17,318	26,112

NOTE: Lock totals may not add to system totals due to common traffic betweem locks.

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	900 x 110 x 36 ft. (With Curfews)	1200 x 90 x 22 ft. (With Curfews)	1200 x 110 x 22 ft. (With Curfews)	1200 x 110 x 36 ft. (With Curfews)
1990					
Port Allen	27,811	0	0	0	0
Bayou Sorrel	27,095	0	0	0	0
IHNC	23,056	0	0	0	0
Algiers	24,501	0	0	0	0
Harvey	3,780	0	0	0	0
Bayou Bouef	27,967	0	0	0	0
Calcasieu	46,321	0	0	0	0
Total System	82,788	0	0	0	0
2000					
Port Allen	30,817	0	0	0	0
Bayou Sorrel	29,808	0	0	0	0
IHNC	26,133	604	604	604	604
Algiers	24,513	0	0	0	0
Harvey	4,343	0	0	0	0
Bayou Bouef	28,616	0	0	0	0
Calcasieu	50,164	0	0	0	0
Total System	87,952	604	604	604	604
2010					
Port Allen	31,174	0	0	0	
Bayou Sorrel	30,115	0	0	0	0
IHNC	27,296	3,534	3,534	3,534	3,534
Algiers	26,417	0	0	0	0
Harvey	6,920	0	0	0	0
Bayou Bouef	32,318	0	0	0	0
Calcasieu	56,908	0	0	0	0
Total System	97,086	3,534	3,534	3,534	3,534
2020					
Port Allen	31,546	0	0	0	0
Bayou Sorrel	30,308	0	0	0	0
IHNC	27,296	6,791	6,791	6,791	6,791
Algiers	27,029	0	0	0	0
Harvey	8,609	0	0	0	0
Bayou Bouef	34,652	0	0	0	0
Calcasieu	62,271	0	0	0	0
Total System	101,511	6,791	6,791	6,791	6,791

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	900 x 110 x 36 ft. (With Curfews)	1200 x 90 x 22 ft. (With Curfews)	1200 x 110 x 22 ft. (With Curfews)	1200 x 110 x 36 ft. (With Curfews)
2030					
Port Allen	31,737	(13)	(13)	(13)	(13)
Bayou Sorrel	30,303	(12)	(12)	(12)	(12)
IHNC	27,471	10,933	10,933	10,933	10,933
Algiers	27,399	32	32	32	32
Harvey	9,850	151	151	151	151
Bayou Bouef	36,313	182	182	182	182
Calcasieu	63,640	1	1	1	1
Total System	103,147	10,734	10,734	10,734	10,734
2040					
Port Allen	31,914	12	12	12	12
Bayou Sorrel	30,267	12	12	12	12
IHNC	27,471	15,812	15,812	15,812	15,812
Algiers	27,746	(64)	(64)	(64)	(64)
Harvey	10,240	87	87	87	87
Bayou Bouef	37,018	19	19	19	19
Calcasieu	63,697	52	52	52	52
Total System	104,011	14,613	14,613	14,613	14,613
2060					
Port Allen	32,465	0	0	0	0
Bayou Sorrel	30,304	0	0	0	0
IHNC	27,520	27,075	27,075	27,113	27,113
Algiers	27,664	45	47	54	54
Harvey	9,782	262	271	309	309
Bayou Bouef	36,625	265	265	287	287
Calcasieu	63,825	0	0	0	0
Total System	105,705	26,112	26,112	26,112	26,112

NOTE: Lock totals may not add to system totals due to common traffic betweem locks.

Table 7 - 9

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	900 x 90 x 22 ft. (Without Curfews)	900 x 110 x 22 ft. (Without Curfews)	900 x 110 x 36 ft. (Without Curfews)
1990				
Port Allen	27,811	0	0	0
Bayou Sorrel	27,095	0	0	0
IHNC	23,056	0	0	0
Algiers	24,501	0	0	0
Harvey	3,780	0	0	0
Bayou Bouef	27,967	0	0	0
Calcasieu	46,321	0	0	0
Total System	82,788	0	0	0
2000				
Port Allen	30,817	0	0	0
Bayou Sorrel	29,808	0	0	0
IHNC	25,531	604	604	604
Algiers	24,513	0	0	0
Harvey	4,343	0	0	0
Bayou Bouef	28,616	0	0	0
Calcasieu	50,164	0	0	0
Total System	87,350	604	604	604
2010				
Port Allen	31,174	0	0	0
Bayou Sorrel	30,115	0	0	0
IHNC	26,277	3,534	3,534	3,534
Algiers	26,417	0	0	0
Harvey	6,920	0	0	0
Bayou Bouef	32,318	0	0	0
Calcasieu	56,908	0	0	0
Total System	96,067	3,534	3,534	3,534
2020				
Port Allen	31,546	0	0	0
Bayou Sorrel	30,308	0	0	0
IHNC	26,564	6,791	6,791	6,791
Algiers	27,029	0	0	0
Harvey	8,609	0	0	0
Bayou Bouef	34,652	0	0	0
Calcasieu	62,271	0	0	0
Total System	100,778	6,791	6,791	6,791

Table 7 - 9

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	900 x 90 x 22 ft. (Without Curfews)	900 x 110 x 22 ft. (Without Curfews)	900 x 110 x 36 ft. (Without Curfews)
2030				
Port Allen	31,737	(13)	(13)	(13)
Bayou Sorrel	30,303	(12)	(12)	(12)
IHNC	26,600	10,933	10,933	10,933
Algiers	27,399	32	32	32
Harvey	9,850	151	151	151
Bayou Bouef	36,313	182	182	182
Calcasieu	63,640	1	1	1
Total System	102,276	10,734	10,734	10,734
2040				
Port Allen	31,914	12	12	12
Bayou Sorrel	30,267	12	12	12
IHNC	26,691	15,812	15,812	15,812
Algiers	27,745	(64)	(64)	(64)
Harvey	10,236	87	87	[illegible]
Bayou Bouef	37,018	19	19	
Calcasieu	63,686	52	52	52
Total System	103,416	14,613	14,613	14,613
2060				
Port Allen	32,465	0	0	0
Bayou Sorrel	30,304	0	0	0
IHNC	26,691	19,203	27,075	27,075
Algiers	27,664	8	47	47
Harvey	9,782	48	271	271
Bayou Bouef	36,625	50	265	265
Calcasieu	63,825	0	0	0
Total System	104,876	19,063	26,112	26,112

NOTE: Lock totals may not add to system totals due to common traffic betweem locks

Table 7 - 9

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	1200 x 90 x 22 ft. (Without Curfews)	1200 x 110 x 22 ft. (Without Curfews)	1200 x 110 x 36 ft. (Without Curfews)
1990				
Port Allen	27,811	0	0	0
Bayou Sorrel	27,095	0	0	0
IHNC	23,056	0	0	0
Algiers	24,501	0	0	0
Harvey	3,780	0	0	0
Bayou Bouef	27,967	0	0	0
Calcasieu	46,321	0	0	0
Total System	82,788	0	0	0
2000				
Port Allen	30,817	0	0	0
Bayou Sorrel	29,808	0	0	0
IHNC	25,531	604	604	604
Algiers	24,513	0	0	0
Harvey	4,343	0	0	0
Bayou Bouef	28,616	0	0	0
Calcasieu	50,164	0	0	0
Total System	87,350	604	604	604
2010				
Port Allen	31,174	0	0	0
Bayou Sorrel	30,115	0	0	0
IHNC	26,277	3,534	3,534	3,534
Algiers	26,417	0	0	0
Harvey	6,920	0	0	0
Bayou Bouef	32,318	0	0	0
Calcasieu	56,908	0	0	0
Total System	96,067	3,534	3,534	3,534
2020				
Port Allen	31,546	0	0	0
Bayou Sorrel	30,308	0	0	0
IHNC	26,564	6,791	6,791	6,791
Algiers	27,029	0	0	0
Harvey	8,609	0	0	0
Bayou Bouef	34,652	0	0	0
Calcasieu	62,271	0	0	0
Total System	100,778	6,791	6,791	6,791

Table 7 - 9

Changes In System Traffic
By Alternative and Year
(1,000 Tons)

Lock	W/O Project Traffic	1200 x 90 x 22 ft. (Without Curfews)	1200 x 110 x 22 ft. (Without Curfews)	1200 x 110 x 36 ft. (Without Curfews)
2030				
Port Allen	31,737	(13)	(13)	(13)
Bayou Sorrel	30,303	(12)	(12)	(12)
IHNC	26,600	10,933	10,933	10,933
Algiers	27,399	32	32	32
Harvey	9,850	151	151	151
Bayou Bouef	36,313	182	182	182
Calcasieu	63,640	1	1	1
Total System	102,276	10,734	10,734	10,734
2040				
Port Allen	31,914	12	12	12
Bayou Sorrel	30,267	12	12	12
IHNC	26,691	15,812	15,812	15,812
Algiers	27,745	(64)	(64)	(64)
Harvey	10,236	87	87	[illegible]
Bayou Bouef	37,018	19	19	
Calcasieu	63,686	52	52	52
Total System	103,416	14,613	14,613	14,613
2060				
Port Allen	32,465	0	0	0
Bayou Sorrel	30,304	0	0	0
IHNC	26,691	27,075	27,113	27,113
Algiers	27,664	47	54	54
Harvey	9,782	271	309	309
Bayou Bouef	36,625	265	287	287
Calcasieu	63,825	0	0	0
Total System	104,876	26,112	26,112	26,112

NOTE: Lock totals may not add to system totals due to common traffic betweem locks.

Table 7 - 10

Shallow-Draft
Total & Incremental Transportation Savings
(1992, $1,000, 7.75%)

Condition	1990	2000	2010	2020	2030	2040	2060	Average Annual
Without-Project	1,251,510	1,274,892	1,385,961	1,407,014	1,225,598	1,250,316	1,153,804	
Existing Lock								
Existing Bridge	1,256,850	1,289,462	1,389,911	1,425,148	1,225,598	1,243,889	1,153,804	
w/o curfews at St. **Claude Bridge**	5,339	14,570	3,950	18,134	0	(6,427)	0	9,997 1/
Existing Lock								
Replace St. Claude Bridge	1,260,154	1,300,297	1,406,748	1,425,148	1,225,598	1,243,889	1,153,804	
w/o curfews	8,644	25,404	20,787	18,134	0	(6,427)	0	18,013 2/
900 x 90 x 22	1,264,184	1,310,826	1,450,779	1,496,897	1,324,087	1,276,927	1,195,725	
w/curfew	12,674	35,934	64,818	89,883	98,489	26,611	41,920	82,849 3/
900 x 90 x 22	1,264,544	1,311,377	1,451,694	1,498,453	1,327,423	1,291,192	1,195,725	
w/o curfew	13,034	36,485	65,733	91,439	101,825	40,876	41,920	86,174 3/
900 x 110 x 22	1,264,558	1,311,429	1,451,848	1,498,847	1,328,617	1,297,359	1,283,490	
w/curfew	13,048	36,536	65,887	91,834	103,020	47,043	129,685	90,650 3/
900 x 110 x 22	1,264,596	1,311,486	1,451,942	1,498,997	1,328,885	1,297,937	1,294,826	
w/o curfew	13,085	36,594	65,981	91,984	103,287	47,621	141,022	91,290 3/
900 x 110 x 36	1,264,418	1,311,229	1,451,552	1,498,420	1,327,957	1,296,218	1,275,440	
w/curfew	12,908	36,337	65,591	91,406	102,359	45,902	121,635	89,806 3/
900 x 110 x 36	1,264,610	1,311,506	1,451,970	1,499,037	1,328,942	1,298,025	1,294,894	
w/o curfew	13,100	36,614	66,009	92,023	103,345	47,709	141,090	91,340 3/
1200 x 90 x 22	1,264,909	1,311,866	1,452,419	1,499,594	1,329,678	1,299,112	1,300,789	
w/curfew	13,399	36,974	66,458	92,581	104,080	48,796	146,985	93,688 4/
1200 x 90 x 22	1,264,920	1,311,884	1,452,449	1,499,646	1,329,773	1,299,315	1,302,766	
w/o curfew	13,410	36,992	66,488	92,632	104,175	48,999	148,961	93,849 4/

Table 7 - 10

Shallow-Draft
Total Incremental Transportation Savings
(1992, $1,000, 7.75%)

Condition	1990	2000	2010	2020	2030	2040	2060	Average Annual
1200 x 110 x 22	1,264,976	1,311,969	1,452,583	1,499,852	1,330,115	1,299,955	1,305,484	
w/curfew	13,466	37,076	66,622	92,838	104,517	49,639	151,679	94,248 4/
1200 x 110 x 22	1,264,998	1,312,000	1,452,629	1,499,917	1,330,214	1,300,115	1,306,004	
w/o curfew	13,488	37,108	66,668	92,904	104,616	49,798	152,199	94,353 4/
1200 x 110 x 36	1,264,994	1,311,993	1,452,616	1,499,895	1,330,174	1,300,035	1,305,601	
w/curfew	13,484	37,100	66,655	92,882	104,576	49,719	151,797	94,304 4/
1200 x 110 x 36	1,264,995	1,311,995	1,452,621	1,499,905	1,330,195	1,300,082	1,305,884	
w/o curfew	13,484	37,102	66,660	92,892	104,597	49,766	152,079	94,322 4/

1/ Over the period 1996 - 2045
2/ Over the period 2004 - 2053
3/ Over the period 2011 - 2060
4/ Over the period 2012 - 2061

consideration (measured as the difference between with and without-project total transportation cost savings).

Until alternatives show significant differences in IHNC Lock average delay and traffic diversions, transportation savings are similar. The incremental savings indicate that these are only short to intermediate term savings generated by the "bridge only" improvement alternatives. The incremental transportation savings also indicate that savings for the lock construction plans are similar in magnitude until the later years. This result follows from the fact IHNC Lock traffic diversions are similar, system traffic impacts are similar, and differences in IHNC Lock delays are similar until the later project years.

Also presented in table 7 - 10 is the average annual incremental transportation savings for each alternative. The average annual value is expressed as of the base year for each alternative (discussion of alternative plan base years is provided in Section 10).

Several observations regarding these average annual values are noteworthy. First, the "bridge only" alternatives generate savings that are only about 19 to 22 percent (unadjusted for base year differences) of the lock construction alternatives. Second, the lock construction alternative with the highest savings (1200 x 110 x 22 without bridge curfews) is only about 14 percent greater (unadjusted for base year differences) than the alternative with the lowest level of savings (900 x 90 x 22 with bridge curfews). Third, as the lock capacity of a new lock alternative increases, the differences between with and without bridge curfews decreases. However, even for the lowest capacity alternative, the difference in average annual transportation savings is only about 4.0 percent. The lower the traffic processed relative to lock capacity, the smaller will be the effect of disruptions to navigation as from bridge curfews.

SECTION 8 - DEEP-DRAFT ANALYSIS

OVERVIEW

Benefits to deep-draft navigation arise from two categories of deep-draft vessel activity. The major activity category, in terms of both number and magnitude of savings, is generated by lockages which may be called "intra-harbor" lockages. These lockages result from a vessel's desire to use deep-draft loading and unloading facilities in the two distinct sections that make up the complex of the Lower Mississippi River deep-draft facilities, the riverfront and the tidewater portion of the Port of New Orleans (the IHNC and the MR-GO). The second activity category arises from lockages for vessels departing from the tidewater section of the Port of New Orleans via the passes of the Mississippi River. These "thru" lockages are motivated by potential savings in vessel sailing time.

INTRA-HARBOR LOCKAGES

The major determinant of existing and potential lock usage, as reported from field interviews with industry representatives, is the need for a vessel to be serviced by cargo handling facilities in both deep-draft facility sections. In other words, the major deep-draft vessel use of the lock arises from ships discharging or loading cargo in one section of the port, such as the river, and then discharging or loading cargo in the other section before exiting the port for the next destination. If the vessel can fit through the lock and requires service from both riverfront and tidewater facilities, the vessel will use the lock. Interviews with industry representatives and vessel pilots revealed that vessels that are too large to traverse the existing IHNC Lock, voyage or "loop" from their initial point of cargo handling down the originally used entrance channel into the gulf and then travel up the other entrance channel to their second point of cargo handling. For example, a large vessel initially inbound to the MR-GO, after unloading its cargo at an IHNC facility, would then have to sail back down the MR-GO into the gulf, enter the Mississippi River through Southwest Pass, and subsequently travel to a loading terminal on the river.

Thus, the primary rationale for use of the IHNC Lock, whatever its size, is to facilitate backhauls within the port and to avoid the long loop voyage into the gulf and back up an entrance channel. This implies that the major benefits to the IHNC Lock are the cost-savings associated with avoiding the loop voyage, and that the determination of intra-harbor benefits to the lock will crucially depend upon a forecast of the vessels that will have a demand for backhaul access to both river and tidewater facilities. In addition, the benefits associated with a given lock size will be determined by the proportion of vessels demanding lockage that can meet the dimensional constraints imposed by that lock.

THRU LOCKAGES

While intra-harbor lockages represent the major component of lockage demand, a small number of vessels use the lock to exit tidewater facilities via the Southwest Pass of the Mississippi River. These vessels are typically destined for ports along the Texas coast. Analysis of these vessels indicate that this exit path from the tidewater facilities is taken in order to shorten the transit time by traveling a slightly shorter distance and also to make use of the river current to increase the vessel's relative ground speed. Benefits to these vessels are thus measured as the dollar value of savings in travel time. As is the case for intra-harbor lockages, a forecast of the vessels that will have a demand for this type of access, along with a determination of the proportion of vessels comprising thru lockage demand that meet the dimensional requirements of a given lock size, will determine the thru lockage benefits for each alternative.

EXCLUSION OF LIQUID BULK MOVEMENTS

During the discussion of the procedures that follow, liquid bulk movements by tanker have been excluded from the analysis. For tankers, the historical record indicates a low probability of lock usage. The primary reason for this is the absence of liquid bulk facilities in the tidewater section; and it appears that this situation will continue in the future. The large liquid bulk facilities are located on the river and with the advent of the Louisiana Offshore Oil Port (LOOP) in 1981, some of the larger tankers no longer actually enter the Lower Mississippi, but off-load near the coast of Louisiana. Also, the emphasis of development in tidewater facilities is container oriented. Recent and planned expansion has not included liquid bulk. For these reasons, it has been assumed that no tankers will demand lock use in the future. While perhaps not strictly true, the existing record, the structure of the port, and future investment trends indicate that, at best, only a negligible number of tankers would possibly demand lock use and these have been ignored in this analysis.

UNCONSTRAINED LOCKAGE DEMAND

Having identified the two reasons why a deep-draft vessel would desire lock service, the next step in determining the benefits to improved lock access was to estimate the existing level of potential lockages or unconstrained lockage demand. Unconstrained lockage demand is comprised of not only existing lock usage, but also includes those vessels not able to use the existing lock due to physical constraints. Those vessels that loop constitute a portion of the unsatisfied demand, as do vessels with a western gulf destination that depart the tidewater facilities via the MR-GO because they are too large to use the existing lock.

Available statistical data makes identification of these components of lockage demand fairly straightforward. However, there potentially remains another component of unsatisfied demand that is more difficult to identify. This component is represented by vessels too large to lock but unwilling to loop. Their unwillingness to loop would be explained by the fact that the cost of the approximately 275-mile, 22-hour loop, exceeds the value of access to both the riverfront and tidewater facilities.

In an effort to quantify this unobservable portion of lock demand, extensive interviews were made with knowledgeable industry sources representing shipping lines, steamship agents, stevedoring operations and terminal operators. Based on these industry sources it has been concluded that the amount of unobservable lock demand, i.e., vessels too large to lock but unwilling to loop, is extremely small, essentially zero, and is expected to remain this way over the period of analysis. This conclusion is supported by two factors: 1) industry's inability to identify any component of traffic that is discouraged from looping (due to cost), and 2) the increasing emphasis of tidewater activity on container operations. The second factor requires some elaboration.

There is unanimous industry opinion that container operations do not lend themselves to multiple calls within a port by the same vessel, especially if the additional cargo to be loaded or discharged is small. It is generally more efficient for the vessel to operate from a single point, moving cargo to the vessel instead of vice versa. As the ongoing program of MR-GO container facility expansion proceeds, while the investment in non-container facilities remains static, opportunities for intra-harbor lockages will remain limited to the traffic associated with existing non-container facilities on the MR-GO.

Therefore, because the existing non-container facilities do not generate any intra-harbor lockage demand that does not lock or loop and because discouraged loopers are essentially zero, total intra-harbor demand can be represented by the sum of lockers and observable loopers. Obviously lockers represent the portion of demand that is satisfied by the existing lock while loopers represent that portion of demand that can be satisfied only with a lock of larger dimensions.

The currently unmet portion of lockage demand can be estimated fairly directly by examining vessel itineraries. Bureau of Census records of port entrances and clearances provide the necessary data. Unmet intra-harbor lockage demand is represented by those vessels which enter one section of deep-draft facilities, depart that section by way of the originally used access channel, reenter by way of the other access channel, and finally depart by way of the second access channel. Unmet thru lockage demand can be identified from the same data source as for intra-harbor demand. It is represented by those vessels departing tidewater facilities via the MR-GO with westbound U.S. destinations, usually a Texas port.

Table 8 - 1 details the currently unmet portion of deep-draft lockage demand. The table breaks down the demand by lockage type (intra-harbor and thru), vessel type, and vessel deadweight tonnage (dwt). As the table shows, all unmet intra-harbor lockage demand is composed of dry bulk vessels. There is no unaccommodated intra-harbor lockage demand for general cargo or container vessels. By contrast, table 8 - 1 shows no unmet thru lockage demand for dry bulk vessels but a total of 51 and 32 demanded lock transits for general cargo and container vessels, respectively. However, close inspection of the initially identified thru lockage demand revealed the need to modify the demand estimate.

After comparing actual thru lockages under existing conditions with the initially identified thru lockage demand, and calculating the absolute amount of transportation cost savings associated with a thru lockage, it became apparent that the relatively small time savings associated with thru lockages required that a downward adjustment to the demand estimate be made. On average, vessels making a thru lockage save approximately 2.05 hours of travel time, after taking into account 1.25 hours of lock transit time. However, the gross cost savings associated with this time savings does not account for the tugboats that must be hired to assist the deep-draft vessels with the lockage. Therefore, these tugboat costs must be subtracted from the gross savings. Interviews with

Table 8 - 1

Unaccommodated Deep-Draft Demand
Existing Lock

Deadweight Tonnage (1,000)	Dry Bulk	General Cargo	Container
Intra-Harbor:			
20-30	16	0	0
30-40	20	0	0
40-50	4	0	0
Total	40	0	0
Thru:			
10-20	0	51	6
20-30	0	0	23
30-40	0	0	3
Total	0	51	32

industry sources, revealed the average cost of tug assistance to be approximately $581 dollars per hour. Using this estimate and multiplying it by 1.25 hours of lock transit time produced the per lockage cost of tug assistance of $726.

For some of the smaller vessels, once tug assistance costs are netted from gross savings, the resulting net savings are only slightly positive. To justify the added complication of the lockage logistics, some minimum level of savings is required. A threshold level of savings equal to one hour of vessel operating cost approximates the required inducement. Therefore, demand for a thru lockage results when there is a positive net level of savings over and above one hour of vessel operating costs. Since all vessel sizes save the same amount of time with a thru lockage, the effect of establishing a one hour of equivalent operating cost threshold is to specify a minimum size vessel that finds thru lockages to be economic. The details of this calculation are displayed in table 8 - 2 by vessel type and dwt. The table includes the calculations for dry bulk vessels. These are displayed for illustration purposes only. No dry bulk thru lockage demand was identified in the initial demand estimate.

To illustrate the results of the process discussed above, a 12,000 dwt container vessel, would not be included in thru lockage demand even though there is a positive level of net savings ($547). Only container vessels greater than or equal to approximately 16,000 dwt generate enough savings to be included in lockage demand.

Of note is the 3,000 dwt general cargo vessel. These vessels represent the "miniship" series of oceangoing vessels. Because of the relatively small dimensions (50-foot width and 250-foot length) and greater maneuverability, these vessels do not require tug assistance for lock transit. As a result, the "miniships" are included in total thru lockage demand while larger dwt general cargo vessels that require tug assistance are excluded.

Table 8 - 3 details the currently unmet portion of deep-draft lockage demand after adjusting thru lockage activity as described above. Compared to table 8 - 1, which did not reflect adjustment to thru lockages, table 8 - 3 includes no general cargo vessel demand and slightly lower container vessel demand.

Total deep-draft lockage demand, the sum of existing lockages and unaccommodated adjusted demand, is summarized

Table 8 - 2

Economic Feasibility Of Thru Lockages

DWT	1993 At Sea Oper Cost	Gross Thru Savings (Oper Cost * 2.05 Hrs)	Tug Assist Cost	Gross Thru Savings - Tug Asst Cost	Net Thru Savings - 1.00 Hr Oper Cost	Equivalent Hours Saved	Thru Lock Demand 1/
Container (Foreign)							
12,000	621	1273	726	547	-74	0.88	NO
16,000	723	1482	726	756	33	1.05	YES
20,000	828	1697	726	971	143	1.17	YES
24,000	956	1960	726	1234	278	1.29	YES
28,000	1,057	2167	726	1441	384	1.36	YES
32,000	1,162	2382	726	1656	494	1.43	YES
38,000	1,354	2776	726	2049	695	1.51	YES
42,000	1,460	2993	726	2267	807	1.55	YES
48,000	1,611	3303	726	2576	965	1.60	YES
50,000	1,724	3534	726	2808	1084	1.63	YES
General Cargo (Foreign)							
3,000	308	631	0	631	323	2.05	YES
11,000	473	970	726	243	-230	0.51	NO
14,000	536	1099	726	373	-163	0.70	NO
16,000	578	1185	726	459	-119	0.79	NO
20,000	664	1361	726	635	-29	0.96	NO
24,000	744	1525	726	799	55	1.07	YES
30,000	868	1779	726	1053	185	1.21	YES
Dry Bulk (Foreign)							
15,000	504	1033	726	307	-197	0.61	NO
25,000	559	1146	726	420	-139	0.75	NO
35,000	607	1244	726	518	-89	0.85	NO
40,000	635	1302	726	576	-60	0.91	NO
50,000	681	1396	726	670	-11	0.98	NO
60,000	727	1490	726	764	37	1.05	YES

1/ Assumes vessels would transit the lock if the cost savings of locking are greater than 1.0 hours of operating cost.

Table 8-3

Unaccommodated Deep-Draft Demand
Existing Lock
(Adjusted for Thru Lockage Feasibility)

Deadweight Tonnage (1,000)	Dry Bulk	General Cargo	Container
Intra-Harbor:			
20-30	16.0	0	
30-40	20.0	0	
40-50	4.0	0	
Total	40.0	0	
Thru:			
10-20	0	0	2.4
20-30	0	0	23.0
30-40	0	0	3.0
Total	0	0	28.4

by lockage type, vessel type, and vessel size in table 8 - 4.

UNCONSTRAINED FUTURE LOCKAGE DEMAND

As described in section 2, future unconstrained lockage demand has been developed directly from the estimate of existing unconstrained lockage demand. Existing unconstrained lockage demand has been used as a base, with future unconstrained demand projected by applying an appropriate growth factor to the existing level. By using the mid scenario growth factor and the sum of existing intra-harbor lockages and loopers to represent total demand for intra-harbor lockages, table 8 - 5 displays total demand by vessel type and year assuming the most likely or mid-level growth scenario. In a similar manner, table 8 - 6 displays total thru lockage demand.

LARGEST VESSEL ACCOMMODATED BY ALTERNATIVE

Potential lockages, as previously defined, represent maximum lock usage that would occur assuming that the IHNC Lock was large enough to pass all vessels demanding lock transit. The estimated total lock usage for a given alternative would, therefore, be determined by potential lockages and the largest vessel, by type, that could safely navigate each alternative.

In estimating the largest allowable vessels for each alternative, it was necessary to incorporate the appropriate minimum safety clearances associated with each physical dimension. The values used for clearances were as follows. For width, a total of ten inches or approximately 0.83 feet of difference between chamber width and vessel beam was used. For length, a total of 14 feet between useable chamber length and vessel length was used. And finally, for draft, five feet between the sill elevation and vessel transit draft was used. For length and width the clearances were based on actual experience with the existing lock. It is not anticipated that practices with the larger chambers would be significantly different. For draft, the assumed clearance represents a design standard based on the requirements of safe navigation.

Unfortunately, observation of actual practice at the existing lock does not provide useful information regarding minimum acceptable draft clearance that could be compared to the design standard. The depth of the sill is rarely approached during existing lockages. The combination of the 75-foot width, which limits vessel size and the light-loading practices prevalent with existing lockages, produces the environment which does not push the limits of

Table 8 - 4

Total Deep-Draft Lockage Demand
By Lockage Type, Vessel Type, and Deadweight Tonnage
(1991)

Deadweight Tonnage (1,000)	Dry Bulk	General Cargo	Container
Intra-Harbor:			
3	0	95.0	0
3-10	1.0	3.0	0
10-20	4.0	20.0	0
20-30	16.0	0	0
30-40	20.0	0	0
40-50	4.0	0	0
Total	45.0	118.0	0
Thru:			
3	0	15.0	0
3-10	0	0	0
10-20	0	0	2.4
20-30	0	0	23.0
30-40	0	0	3.0
Total	0	15.0	28.4

Intra-Harbor Lockages
Total Demand

Vessel Type: Dry Bulk

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
0-10	1	1.2	1.4	1.7	2.0	2.4	3.4
10-20	4	4.7	5.6	6.7	8.0	9.6	13.7
20-30	16	18.8	22.5	26.8	32.1	38.3	54.8
30-40	20	23.5	28.1	33.6	40.1	47.9	68.5
40-50	4	4.7	5.6	6.7	8.0	9.6	13.7
50-60	0	0.0	0.0	0.0	0.0	0.0	0.0
60-70	0	0.0	0.0	0.0	0.0	0.0	0.0
70-80	0	0.0	0.0	0.0	0.0	0.0	0.0
80-90	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	45.0	52.8	63.2	75.5	90.2	107.9	154.1

Vessel Type: General Cargo

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
3	95	111.5	133.3	159.4	190.5	227.7	325.3
3-10	3	3.5	4.2	5.0	6.0	7.2	10.3
10-20	20	23.5	28.1	33.6	40.1	47.9	68.5
20-30	0	0.0	0.0	0.0	0.0	0.0	0.0
30-40	0	0.0	0.0	0.0	0.0	0.0	0.0
40-50	0	0.0	0.0	0.0	0.0	0.0	0.0
50-60	0	0.0	0.0	0.0	0.0	0.0	0.0
60-70	0	0.0	0.0	0.0	0.0	0.0	0.0
70-80	0	0.0	0.0	0.0	0.0	0.0	0.0
80-90	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	118.0	138.6	165.6	198.0	236.6	282.8	404.1

Table 8 - 6

Thru Lockages
Total Demand

Vessel Type: Container

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
0-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-20	2.4	2.8	3.4	4.0	4.8	5.8	8.2
20-30	23.0	27.0	32.3	38.6	46.1	55.1	78.8
30-40	3.0	3.5	4.2	5.0	6.0	7.2	10.3
40-50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50-60	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60-70	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70-80	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	28.4	33.3	39.9	47.6	56.9	68.1	97.3

Vessel Type: General Cargo

DWT (1,000)	1991	2000	2010	2020	2030	2040	2060
3	15	17.6	21.1	25.2	30.1	36.0	51.4
3-10	0	0.0	0.0	0.0	0.0	0.0	0.0
10-20	0	0.0	0.0	0.0	0.0	0.0	0.0
20-30	0	0.0	0.0	0.0	0.0	0.0	0.0
30-40	0	0.0	0.0	0.0	0.0	0.0	0.0
40-50	0	0.0	0.0	0.0	0.0	0.0	0.0
50-60	0	0.0	0.0	0.0	0.0	0.0	0.0
60-70	0	0.0	0.0	0.0	0.0	0.0	0.0
70-80	0	0.0	0.0	0.0	0.0	0.0	0.0
80-90	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	15.0	17.6	21.1	25.2	30.1	36.0	51.4

Note: Total demand for thru lockages was revised to reflect the fact that only containerships above the 16,000 DWT class would find it economical to transit the lock. This result occurs after ships take into account the added expense of tug assistance when transiting the lock and the requirement of a minimum level of savings equal to 1.0 hours of operating cost. The 3,000 DWT class among the general cargo vessels refers to miniships that do not require tug assistance when transiting the lock.

the 31.5-foot sill depth. Because it is anticipated that the design standard would be enforced (and this would not be difficult within the controlled access environment of a lock chamber) the design underkeel has been projected to represent actual practice in the with-project condition.

The following is an example of how the maximum allowable vessel dimensions were determined given the minimum clearances described above. A lock 110 feet wide was assumed to be compatible with vessels up to 109.17 feet wide assuming that the other dimensions were not binding. Likewise, a lock 900 feet long could accommodate a vessel with a length of 886 feet. However, treatment of draft was not as straightforward. While it is a simple matter to subtract five feet from the sill elevation in order to identify the maximum draft allowable for a specific alternative, it is not so simple to identify the maximum vessel size associated with a given draft because of vessel light-loading. Existing lockages of light-loaded vessels undoubtedly reflect the rationale that the majority of lock use occurs with vessels having unloaded some portion of their cargo in one section of the port and then, after transiting the lock, loading cargo in the other section of the port.

To account for light-loading, an analysis was performed on existing lockage vessel drafts. The analysis showed that, on average, dry bulk vessels transiting the lock were loaded to 64 percent of their maximum draft, while general cargo vessels were loaded, on average, to 72 percent of their maximum draft. To insure logical consistency with the rationale for intra-harbor lockages and to account for historical light-loading at the lock, these light-loading factors were used in the determination of the maximum vessel draft corresponding to a given lock depth. Because there are no existing lockages of container vessels, it was not possible to calculate an observable average percent of container vessel maximum draft during lockage. As a surrogate measure, the light-loading practices of general cargo vessels were assumed for container vessels.

The relationship between vessel size, measured in dwt, and each physical vessel dimension, including draft adjusted for light-loading, was established using formulas developed by the Institute for Water Resources in their FY 1992 memorandum on deep draft vessel costs. Table 8 - 7 displays these functional relationships. The estimates of the maximum allowable vessels for each dimension produced by these formulas are presented in table 8 - 8.

The first binding constraint among width, length, and draft determines the largest vessel that may transit a lock.

Table 8 - 7

Functional Relationships Between
Vessel Dimensions and Deadweight Tonnage

Vessel Type:	Dry Bulk
Length:	DWT=(Length/28.5457)^3.4129
Width:	DWT=(Width/3.1751)^3.1458
Draft:	DWT=(Draft^3.2047) x .3613
Vessel Type:	Container
Length:	DWT=(Length/11.2363)^2.4992
Width	DWT=(Width/4.2733)^3.3106
Draft:	DWT=(Draft/1.5961)^3.3342
Vessel Type:	General Cargo
Length:	DWT=(Length/22.6103)^3.1179
Width:	DWT=(Width/4.4237)^3.4747
Draft:	DWT=(Draft/1.2551)^3.0516

Table 8 - 8

Estimated Maximum Vessel Accommodated By Lock Dimension
By Vessel Type

Lock Dimensions	DWT (Rounded to the nearest 1,000 DWT) Dry Bulk	General Cargo	Container
Length (ft)			
640	38,000	31,000	23,000
900	124,000	W.F.	55,000
1,200	W.F.	W.F.	W.F.
Width (ft)			
75	20,000	18,000	13,000
90	36,000	34,000	23,000
110	68,000	W.F.	46,000
Draft (ft)			
22	13,000	8,000	8,000
36	91,000	W.F.	59,000

Notes: W.F. = Largest vessel of world fleet
Largest vessel calculations for the draft dimension assume five feet underkeel clearance and a light-loaded vessel.

Table 8 - 9 shows the largest vessel for each vessel type that could transit locks of various sizes. As can be seen in table 8 - 9, 18,000 dwt, 20,000 dwt, and 13,000 dwt, are the largest general cargo, dry bulk, and container vessels, respectively, capable of safely transiting the existing lock. For each of these vessel types, width is the binding constraint. For a lock 1200 x 110 x 36, the world fleet maximum, 68,000 dwt, and 46,000 dwt are the largest general cargo, dry bulk, and container vessels, respectively, capable of safe navigation. For the two limited vessel types, dry bulk and container, width is the binding constraint. For general cargo vessels, the dwt associated with the maximum allowable dimensions for this lock is in excess of the largest dwt general cargo vessel existing in the world fleet.

ESTIMATED LOCKAGES AND BENEFIT DETERMINATION

Given the maximum dwt vessel that can transit a given alternative and unconstrained lockage demand, total lockages by lockage type can be computed. For example, table 8 - 9 shows that for the 900 x 90 x 22 alternative, the largest dry bulk vessel that could use this lock is 13,000 dwt. To find the actual number of dry bulk intra-harbor lockages for this alternative, one needs to view table 8 - 5. In the year 1991, all ships in the 0 - 10,000 dwt category (1 ship) and 30 percent of the ships in the 10,000 - 20,000 dwt category (1.2 ships) would have a demand for intra-harbor lockages. (Uniform vessel distribution within a dwt range was assumed. Therefore, since the largest accommodated vessel, 13,000 dwt, represents 100 percent of the 0 - 10 dwt category and 30 percent of the 10 - 20 dwt category, 100 percent of the total vessels in the 0 - 10 dwt category and 30 percent of the total vessels in the 10 - 20 dwt category were identified as satisfied demand). These calculations were used in table 8 - 11. In addition, estimated demand in tables 8 - 11 through 8 - 16 and 8 - 18 through 8 - 23 were calculated in the same manner.

To convert calculated lockages into benefits, it was necessary to develop an alternative for those ships unable to use the lock, and to assign a cost for this alternative behavior. Based on the rationale presented earlier for intra-harbor lockages, the alternative for this type of lockage is to loop. Based on speeds on the river and the MR-GO, and the distances to be traveled, looping would require approximately 22.85 hours. If all vessels wanting, but unable, to use the lock were to loop, then the total intra-harbor benefits associated with a specific lock alternative would be 21.60 hours (22.85 hours loop time minus 1.25 hours lock time), times the vessel cost per

Table 8 - 9

Maximum Vessel Sizes Accommodated By Alternative
(Rounded to the Nearest 1000 DWT)

Alternative 1/	General Cargo	Constraining Dimension	Dry Bulk	Constraining Dimension	Container	Constraining Dimension
640 x 75 x 31.5	18,000	Width	20,000	Width	13,000	Width
900 x 90 x 22	8,000	Draft	13,000	Draft	8,000	Draft
900 x 110 x 22	8,000	Draft	13,000	Draft	8,000	Draft
900 x 110 x 36	W.F.	-	68,000	Width	46,000	Width
1200 x 90 x 22	8,000	Draft	13,000	Draft	8,000	Draft
1200 x 110 x 22	8,000	Draft	13,000	Draft	8,000	Draft
1200 x 110 x 36	W.F.	-	68,000	Width	46,000	Width

1/ Assumes 5 ft of underkeel clearance is required for all vessels.
W.F. = Accommodates largest vessel of world fleet

hour, minus the cost of tug assistance required for lock transit, times the number of intra-harbor lockages. Incremental benefits, those over and above benefits to the existing lock, are measured as the difference between total benefits for a new lock and total benefits to the existing lock. Tables 8 - 10 through 8 - 16 show estimated intra-harbor lockages by vessel type and year for the existing lock and the various alternatives, along with the associated transportation savings.

For thru lockages, the alternative to locking is to exit the port via the MR-GO. Approximately 2.05 hours, net of 1.25 hours lockage time, can be saved with lockage and exit via the river. Therefore total benefits associated with a specific lock alternative would be 2.05 hours times the vessel cost per hour, minus the cost of tug assistance required for lock transit, times the number of thru lockages. Tables 8 - 17 through 8 - 23 show the estimated thru lockages by vessel type and year for the existing lock and the various alternatives, along with the associated transportation savings.

Table 8 - 24 summarizes the forecasted number of intra-harbor and thru lockages by alternative, while table 8 - 25 summarizes the total and incremental benefits. Table 8 - 26 presents the benefit information as an average annual value. The average annual value is expressed as of the base year for each alternative (discussion of alternative plan base years is provided in Section 10).

The only alternatives that show average annual benefits greater than those in the without-project condition (the existing lock), are alternatives with 36-foot depths. This outcome is the direct result of the fact that the maximum vessel that can be accommodated by any alternative with a 22-foot depth is less than the vessel that can be accommodated by the existing lock. As a consequence, 22-foot depth alternatives generate fewer deep-draft lockages and a lower level of associated savings than compared to the existing lock. However, because of the small size of a portion of the fleet, 22-foot depth alternatives, which were designed strictly for shallow-draft traffic, would accommodate some deep-draft demand. As a result, these shallow-draft alternatives show negative incremental benefits, but a positive level of total benefits.

Intra-Harbor Lockages
Transportation Savings
ALT: Existing Lock
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	4.0	40,987	4.7	48,126	5.6	57,525	6.7	68,760	8.0	82,189	9.6	98,240	13.7	140,361
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		5.0	50,154	5.9	58,889	7.0	70,390	8.4	84,138	10.0	100,570	12.0	120,212	17.1	171,752
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	3.0	22,446	3.5	26,355	4.2	31,503	5.0	37,655	6.0	45,009	7.2	53,800	10.3	76,866
10-20	557	20.0	226,104	23.5	265,484	28.1	317,334	33.6	379,310	40.1	453,390	47.9	541,938	68.5	774,292
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		118.0	880,566	138.6	1,033,932	165.6	1,235,861	198.0	1,477,228	236.6	1,765,734	282.8	2,110,586	404.1	3,015,495
Grand Total			930,720		1,092,821		1,306,252		1,561,366		1,866,304		2,230,798		3,187,247

Intra-Harbor Lockages
Transportation Savings
ALT: 900 x 90 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	1.2	12,296	1.4	14,438	1.7	17,257	2.0	20,628	2.4	24,657	2.9	29,472	4.1	42,108
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		2.2	21,463	2.6	25,201	3.1	30,123	3.7	36,006	4.4	43,038	5.3	51,444	7.5	73,500
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	2.1	15,937	2.5	18,712	3.0	22,367	3.6	26,735	4.3	31,957	5.1	38,198	7.3	54,575
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		97.1	647,953	114.0	760,805	136.3	909,392	162.9	1,086,998	194.8	1,299,292	232.8	1,553,046	332.6	2,218,911
Grand Total			669,416		786,006		939,515		1,123,004		1,342,330		1,604,490		2,292,411

Intra-Harbor Lockages
Transportation Savings
ALT: 900 x 110 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	1.2	12,296	1.4	14,438	1.7	17,257	2.0	20,628	2.4	24,657	2.9	29,472	4.1	42,108
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		2.2	21,463	2.6	25,201	3.1	30,123	3.7	36,006	4.4	43,038	5.3	51,444	7.5	73,500
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	2.1	15,937	2.5	18,712	3.0	22,367	3.6	26,735	4.3	31,957	5.1	38,198	7.3	54,575
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		97.1	647,953	114.0	760,805	136.3	909,392	162.9	1,086,998	194.8	1,299,292	232.8	1,553,046	332.6	2,218,911
Grand Total			669,416		786,006		939,515		1,123,004		1,342,330		1,604,490		2,292,411

Intra-Harbor Lockages
Transportation Savings
ALT: 900 x 110 x 36
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	4.0	40,987	4.7	48,126	5.6	57,525	6.7	68,760	8.0	82,189	9.6	98,240	13.7	140,361
20-30	557	16.0	180,883	18.8	212,387	22.5	253,867	26.8	303,448	32.1	362,712	38.3	433,550	54.8	619,434
30-40	606	20.0	247,272	23.5	290,339	28.1	347,043	33.6	414,821	40.1	495,836	47.9	592,674	68.5	846,782
40-50	656	4.0	53,774	4.7	63,140	5.6	75,472	6.7	90,211	8.0	107,830	9.6	128,889	13.7	184,150
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		45.0	532,084	52.8	624,755	63.2	746,771	75.5	892,618	90.2	1,066,948	107.9	1,275,325	154.1	1,822,118
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	3.0	22,446	3.5	26,355	4.2	31,503	5.0	37,655	6.0	45,009	7.2	53,800	10.3	76,866
10-20	557	20.0	226,104	23.5	265,484	28.1	317,334	33.6	379,310	40.1	453,390	47.9	541,938	68.5	774,292
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		118.0	880,566	138.6	1,033,932	165.6	1,235,861	198.0	1,477,228	236.6	1,765,734	282.8	2,110,586	404.1	3,015,495
Grand Total			1,412,650		1,658,687		1,982,633		2,369,845		2,832,682		3,385,911		4,837,613

Table 8 - 14

Intra-Harbor Lockages
Transportation Savings
ALT: 1200 x 90 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	1.2	12,296	1.4	14,438	1.7	17,257	2.0	20,628	2.4	24,657	2.9	29,472	4.1	42,108
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		2.2	21,463	2.6	25,201	3.1	30,123	3.7	36,006	4.4	43,038	5.3	51,444	7.5	73,500
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	2.1	15,937	2.5	18,712	3.0	22,367	3.6	26,735	4.3	31,957	5.1	38,198	7.3	54,575
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		97.1	647,953	114.0	760,805	136.3	909,392	162.9	1,086,998	194.8	1,299,292	232.8	1,553,046	332.6	2,218,911
Grand Total			669,416		786,006		939,515		1,123,004		1,342,330		1,604,490		2,292,411

Harbor Lockages
Transportation Savings
ALT: 1200 x 110 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	1.2	12,296	1.4	14,438	1.7	17,257	2.0	20,628	2.4	24,657	2.9	29,472	4.1	42,108
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		2.2	21,463	2.6	25,201	3.1	30,123	3.7	36,006	4.4	43,038	5.3	51,444	7.5	73,500
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	2.1	15,937	2.5	18,712	3.0	22,367	3.6	26,735	4.3	31,957	5.1	38,198	7.3	54,575
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		97.1	647,953	114.0	760,805	136.3	909,392	162.9	1,086,998	194.8	1,299,292	232.8	1,553,046	332.6	2,218,911
Grand Total			669,416		786,006		939,515		1,123,004		1,342,330		1,604,490		2,292,411

Intra-Harbor Lockages
Transportation Savings
ALT: 1200 x 110 x 36
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Dry Bulk, Foreign Flag															
0-10	458	1.0	9,167	1.2	10,763	1.4	12,865	1.7	15,378	2.0	18,382	2.4	21,971	3.4	31,392
10-20	508	4.0	40,987	4.7	48,126	5.6	57,525	6.7	68,760	8.0	82,189	9.6	98,240	13.7	140,361
20-30	557	16.0	180,883	18.8	212,387	22.5	253,867	26.8	303,448	32.1	362,712	38.3	433,550	54.8	619,434
30-40	606	20.0	247,272	23.5	290,339	28.1	347,043	33.6	414,821	40.1	495,836	47.9	592,674	68.5	846,782
40-50	656	4.0	53,774	4.7	63,140	5.6	75,472	6.7	90,211	8.0	107,830	9.6	128,889	13.7	184,150
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		45.0	532,084	52.8	624,755	63.2	746,771	75.5	892,618	90.2	1,066,948	107.9	1,275,325	154.1	1,822,118
Vessel Type: General Cargo, Foreign Flag															
3	308	95.0	632,016	111.5	742,093	133.3	887,025	159.4	1,060,263	190.5	1,267,335	227.7	1,514,848	325.3	2,164,336
3-10	380	3.0	22,446	3.5	26,355	4.2	31,503	5.0	37,655	6.0	45,009	7.2	53,800	10.3	76,866
10-20	557	20.0	226,104	23.5	265,484	28.1	317,334	33.6	379,310	40.1	453,390	47.9	541,938	68.5	774,292
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		118.0	880,566	138.6	1,033,932	165.6	1,235,861	198.0	1,477,228	236.6	1,765,734	282.8	2,110,586	404.1	3,015,495
Grand Total			1,412,650		1,658,687		1,982,633		2,369,845		2,832,682		3,385,911		4,837,613

Thru Lockages
Transportation Savings
ALT: Existing Lock
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			10,626		12,477		14,913		17,826		21,308		25,469		36,389

Table 8 - 18

Thru Lockages
Transportation Savings
ALT: 900 x 90 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			10,626		12,477		14,913		17,826		21,308		25,469		36,389

Thru Lockages
Transportation Savings
ALT: 900 x 110 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			10,626		12,477		14,913		17,826		21,308		25,469		36,389

Table 8 - 20

Thru Lockages
Transportation Savings
ALT: 900 x 110 x 36
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20	779	2.4	2,558	2.8	3,003	3.4	3,590	4.0	4,291	4.8	5,129	5.8	6,130	8.2	8,759
20-30	978	23.0	35,038	27.0	41,141	32.3	49,176	38.6	58,780	46.1	70,260	55.1	83,981	78.8	119,988
30-40	1,264	3.0	6,544	3.5	7,683	4.2	9,184	5.0	10,977	6.0	13,121	7.2	15,684	10.3	22,409
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		28.4	44,139	33.3	51,827	39.9	61,949	47.6	74,048	56.9	88,510	68.1	105,796	97.3	151,155
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			54,765		64,304		76,863		91,874		109,817		131,265		187,544

ıble 8 - 21

Thru Lockages
Transportation Savings
ALT: 1200 x 90 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			10,626		12,477		14,913		17,826		21,308		25,469		36,389

Table 8 - 22

Thru Lockages
Transportation Savings
ALT: 1200 x 110 x 22
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			10,626		12,477		14,913		17,826		21,308		25,469		36,389

ıble 8 - 23

Thru Lockages
Transportation Savings
ALT: 1200 x 110 x 36
(Savings in 1993 Dollars)

DWT (1,000)	Hrly Cost	1991 Vessels	1991 Savings	2000 Vessels	2000 Savings	2010 Vessels	2010 Savings	2020 Vessels	2020 Savings	2030 Vessels	2030 Savings	2040 Vessels	2040 Savings	2060 Vessels	2060 Savings
Vessel Type: Container, Foreign Flag															
10-20	779	2.4	2,558	2.8	3,003	3.4	3,590	4.0	4,291	4.8	5,129	5.8	6,130	8.2	8,759
20-30	978	23.0	35,038	27.0	41,141	32.3	49,176	38.6	58,780	46.1	70,260	55.1	83,981	78.8	119,988
30-40	1,264	3.0	6,544	3.5	7,683	4.2	9,184	5.0	10,977	6.0	13,121	7.2	15,684	10.3	22,409
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		28.4	44,139	33.3	51,827	39.9	61,949	47.6	74,048	56.9	88,510	68.1	105,796	97.3	151,155
Vessel Type: General Cargo, Foreign Flag															
3	308	15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
0-10		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
10-20		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
20-30		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
30-40		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
40-50		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
50-60		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
60-70		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
70-80		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
80-90		0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
Total		15.0	10,626	17.6	12,477	21.1	14,913	25.2	17,826	30.1	21,308	36.0	25,469	51.4	36,389
Grand Total			54,765		64,304		76,863		91,874		109,817		131,265		187,544

Table 8 - 24

Total Deep-Draft Lockages

Alternative		1991	2000	2010	2020	2030	2040	2060
Existing:	Intra	123.0	144.5	172.6	206.4	246.6	294.8	421.2
	Thru	15.0	17.6	21.1	25.2	30.1	36.0	51.4
	Total	138.0	162.1	193.7	231.6	276.7	330.8	472.6
900 x 90 x 22	Intra	99.3	116.6	139.4	166.6	199.2	238.1	340.1
	Thru	15.0	17.6	21.1	25.2	30.1	36.0	51.4
	Total	114.3	134.2	160.5	191.8	229.3	274.1	391.5
900 x 110 x 22	Intra	99.3	116.6	139.4	166.6	199.2	238.1	340.1
	Thru	15.0	17.6	21.1	25.2	30.1	36.0	51.4
	Total	114.3	134.2	160.5	191.8	229.3	274.1	391.5
900 x 110 x 36	Intra	163.0	191.4	228.8	273.5	326.8	390.7	558.2
	Thru	43.4	50.9	61.0	72.8	87.0	104.1	148.7
	Total	206.4	242.3	289.8	346.3	413.8	494.8	706.9
1200 x 90 x 22	Intra	99.3	116.6	139.4	166.6	199.2	238.1	340.1
	Thru	15.0	17.6	21.1	25.2	30.1	36.0	51.4
	Total	114.3	134.2	160.5	191.8	229.3	274.1	391.5
1200 x 110 x 22	Intra	99.3	116.6	139.4	166.6	199.2	238.1	340.1
	Thru	15.0	17.6	21.1	25.2	30.1	36.0	51.4
	Total	114.3	134.2	160.5	191.8	229.3	274.1	391.5
1200 x 110 x 36	Intra	163.0	191.4	228.8	273.5	326.8	390.7	558.2
	Thru	43.4	50.9	61.0	72.8	87.0	104.1	148.7
	Total	206.4	242.3	289.8	346.3	413.8	494.8	706.9

Table 8 - 25

Deep-Draft Benefits
($1,000's -- 1993 Price Levels)

Alternative		1991	2000	2010	2020	2030	2040	2060
Existing	Intra	931	1,093	1,306	1,561	1,866	2,231	3,187
	Thru	11	12	15	18	21	25	36
	Total	942	1,105	1,321	1,579	1,887	2,256	3,223
900 x 90 x 22	Intra	669	786	940	1,123	1,342	1,604	2,292
	Thru	11	12	15	18	21	25	36
	Total	680	798	955	1,141	1,363	1,629	2,328
	Incremental	(262)	(307)	(366)	(438)	(524)	(627)	(895)
900 x 110 x 22	Intra	669	786	940	1,123	1,342	1,604	2,292
	Thru	11	12	15	18	21	25	36
	Total	680	798	955	1,141	1,363	1,629	2,328
	Incremental	(262)	(307)	(366)	(438)	(524)	(627)	(895)
900 x 110 x 36	Intra	1,413	1,659	1,983	2,370	2,833	3,386	4,838
	Thru	55	64	77	92	110	131	188
	Total	1,468	1,723	2,060	2,462	2,943	3,517	5,026
	Incremental	526	618	739	883	1,056	1,261	1,803
1200 x 90 x 22	Intra	669	786	940	1,123	1,342	1,604	2,292
	Thru	11	12	15	18	21	25	36
	Total	680	798	955	1,141	1,363	1,629	2,328
	Incremental	(262)	(307)	(366)	(438)	(524)	(627)	(895)
1200 x 110 x 22	Intra	669	786	940	1,123	1,342	1,604	2,292
	Thru	11	12	15	18	21	25	36
	Total	680	798	955	1,141	1,363	1,629	2,328
	Incremental	(262)	(307)	(366)	(438)	(524)	(627)	(895)
1200 x 110 x 36	Intra	1,413	1,659	1,983	2,370	2,833	3,386	4,838
	Thru	55	64	77	92	110	131	188
	Total	1,468	1,723	2,060	2,462	2,943	3,517	5,026
	Incremental	526	618	739	883	1,056	1,261	1,803

Table 8-26

Total and Incremental Average Annual Benefits Deep-Draft Navigation
($1,000's -- 1994 Price Levels, 7.75 Percent)

	Total Benefits		Incremental Benefits	
Existing Lock	1,739	1/	N/A	
	1,771	2/		
900 x 90 x 22	1,257		(483)	1/
900 x 110 x 22	1,257		(483)	1/
900 x 110 x 36	2,712		973	1/
1200 x 90 x 22	1,279		(491)	2/
1200 x 110 x 22	1,279		(491)	2/
1200 x 110 x 36	2,761		990	2/

1/ Average annual equivalents are measured over the period 2011 - 2060.
2/ Average annual equivalents are measured over the period 2012 - 2061.

SECTION 9 - VEHICULAR TRAFFIC ANALYSIS

VEHICULAR TRAFFIC MODEL

OVERVIEW

The IHNC vehicular traffic model is an analytical methodology for estimating the annual transportation costs to landside traffic transiting the IHNC bridge crossings. It facilitates the comparison of costs of landside traffic under without-project conditions to costs of various with-project conditions. In calculating vehicular transportation costs, the model is able to identify that portion of total costs representing delays caused by bridge openings. These costs can be thought of as navigation dependent costs. Because navigation dependent costs are identifiable, it is possible to determine the change in vehicular traffic costs for a given lock size. It is this transportation cost differential that represents the vehicular benefits. The necessity for the vehicular traffic model to interface directly with deep-draft and shallow-draft model calculations for a specific lock size should be apparent since bridge openings occur to accommodate passage of navigation traffic. Therefore, discussion of landside benefits must take place within the context of a particular lock scenario.

Two analytical techniques were considered in the formulation of the IHNC vehicular traffic model. The first technique was based on the more complex queuing methodology and the second on the simpler differential running speed approach. Each will be described in detail and the basis for selection presented.

DEFINITIONS

The following terms are defined to facilitate understanding of subsequent discussion of the techniques considered.

Analysis Section--length in miles over which costs are calculated including bridge span and ramps and, in some cases, level ground approach sections.

Costs--bridge user costs are the sum of (1) auto, truck, and bus vehicle running costs and (2) the value of vehicle user travel time.

a. Vehicle running costs--mileage-dependent costs of operating autos, trucks, and busses on the analysis section including expenses for fuel, tires, oil and maintenance, and mileage-dependent depreciation.

b. Value of travel time--a dollar value of an individual's time while in transit. This value can be differentiated by trip purpose to reflect, at a minimum, the difference between commercial traffic (truck driver's time) and auto user time.

Traffic characteristics--as defined below it includes factors that determine the incidence and magnitudes of user costs associated with vehicle trips which cross the IHNC.

a. Highway capacity--the maximum number of vehicles that can pass over a section of roadway during a given time period under specified roadway and traffic conditions.

b. Traffic volume--the actual number of vehicles that pass over a roadway section during a given time period.

c. Running speed--the speed over a specified section of roadway determined by dividing the distance travelled by the time required to transit the section.

d. Peak-Hour--peak-hour periods refer to those times corresponding to rush hour at which time the traffic flow consists primarily of commuters.

e. Level of Service--a qualitative measure of the traffic flow conditions on a highway section determined by the relationship between traffic volume (V) and highway capacity (C) during the roadway's peak period. If the V/C ratio equals 1.0, a level F condition exists which means that the traffic flow is congested and unable to run freely, resulting in slowdowns and traffic delays. Such a condition would also result from the blockage of traffic flow due to the raising of a bridge's draw span.

QUEUING METHODOLOGY

Level of service F describes a forced flow condition in which the highway stores vehicles backing up from a downstream bottleneck. In other words, physical lines of waiting vehicles (queues) occur upstream from the bottleneck section. Causes of such queues usually involve intersection signalization at near capacity peak-hours, roadway constrictions, or traffic volumes exceeding roadway capacity.

The costs to the highway user are greatly increased when there is queuing due to the additional time delays encountered during such conditions. If queuing occurs at peak-hour periods, when a roadway is carrying heavy volumes, the queues will be lengthy and the time it takes to dissipate them will be long in contrast to periods of low traffic flows.

The method employed in this model for determining queuing time delay and dissipation time delay is the deterministic method for interrupted flow. This method is appropriate for studying intersection delays where signalization cycles result in queuing at peak periods. It is not designed for a bridge opening scenario. However, the deterministic method can be modified to accomplish its principal purpose: to determine average queue length, average queue duration, and average vehicle delay due to the queue--all necessary to assign costs to queuing. The deterministic method described below reflects a simplifying assumption--uniform flow of vehicles rather than random traffic movements--and therefore, tends to underestimate queue buildup. Therefore, the time delay estimates resulting from the analysis should be considered somewhat understated. It also does not account for the possibility that the duration of the queue occurring during a peak-hour period may extend into a non-peak hour while the queue is dissipating. Rather, the peak hour and non-peak hour periods are considered fixed in length and the condition of the queue at the end of one period does not carry over to the start of the next period.

Deterministic queuing has two formulations, one for application where delay is due to demand exceeding capacity, and the other in which delay is caused by signal cycling. This latter approach has been modified by substituting the bridge opening time for the signal cycle time, and assumes that the hourly volume on the roadway is restricted in proportion to the average percent of each hour that the traffic flow is broken by a bridge opening.

In this method, traffic is thought of as a continuous flow arriving at a uniform rate (q), it is released at a rate (q_m), and builds a queue while the arrival rate exceeds the departure rate. At a later point, arrival rates become less than departure rates and the queue dissipates. The vehicle arrival rate is proportional to the density and speed of the arriving vehicles. The back of the queue is extending while demand exceeds capacity. Thus, the relative speed with which arriving vehicles approach the queue is greater than their speed over the ground, and therefore, the maximum density per lane (km) is assumed for all queued vehicles and is based on a spacing of 22 ft/vehicle or 240 veh/mi/lane.

The following equations describe the basic relationships required to calculate delay time to vehicles.

The rate of vehicles arriving in the queue is:

$q = \quad q_1 [1 + (q_1 - q_m) / (NL \times SPD_u \times k_m - q_1)]$, where

q_1 = arrival rate (demand volume)

q_m = release rate (capacity)

NL = number of lanes

SPD_u = average speed of vehicles approaching from upstream

k_m = density of vehicles per lane

Average delay due to the queue is:

$AD = \quad [T (q/q_m - 1) + R] *2$, where

T = duration of analysis time period in minutes

R = average time of bridge opening per hour in minutes

Period Definition

For purposes of user cost calculations on urban highways where hourly travel flows are uneven, it is necessary to evaluate these flows on a separate peak and off-peak hour basis. User costs can be derived for each separate representative hour and factored to the full day according to the hourly distribution of traffic volume. Where such differentiation is unnecessary, (traffic flow is uniform) a representative hour can be analyzed and factored up to the full day without differentiation. As the IHNC bridge crossings are all affected by peak-hour traffic flows, these must be evaluated independently. As the AM peak-hour period is reversed in the PM peak-hour period, the analysis does not have to reflect directional traffic flow differences.

In order to model all-day traffic with peak and off-peak periods, the traffic in the midnight to 6 AM hours is added to the off-peak total, but the hours are excluded from the day leaving an 18-hour period; 4 hours being peak hours and 14 hours being off-peak. On an annual basis, these hours would break down as follows:

4 peak hours x 249 (365 days - 104 weekend days - 12 holidays = 249 weekdays)	=	996 hrs
14 off-peak hours x 249 weekdays	=	3,486 hrs
18 off-peak hours x 104 weekend days		1,872 hrs

18 off-peak hours x 12 holidays	=	216 hrs

Total off-peak hours per year	=	5,574 hrs
Total hours (18 x 365)	=	6,570 hrs

In addition to being calculated on a peak and off-peak period basis, costs are also classified as being either navigation independent or navigation dependent. This basic classification facilitates the following discussion of specific cost calculation routines.

Navigation Independent Costs

Navigation independent costs represent those costs associated with free-flow transit of the analysis section. These costs include running costs of the vehicle and the value of passenger time. To calculate navigation independent costs, the following procedure is employed.

Step 1: Calculate the hourly flow of each vehicle type for peak and off-peak periods. To calculate these flows, the following values must be specified: total daily vehicles for all bridge crossings; each bridge's share of total vehicles; the percent of a bridge's daily volume that represents a single hour of peak and off-peak traffic; and the percentage of each vehicle type for peak and off-peak periods. The product of these values yields hourly flows for each bridge (see tables 9-1 and 9-2).

Step 2: Calculate the running cost per trip for each vehicle type for peak and off-peak periods. To calculate trip running cost, the bridge length, bridge grade, vehicle speed for peak and off-peak periods, and a cost/speed/grade matrix per 1,000 vehicle-miles for each vehicle type is required. When necessary the cost/speed/grade matrix is interpolated to find the appropriate cost for the specified bridge grade and vehicle speed. The length of the analysis section is coterminous with the length of the high-rise bridge. For the lower-level bridges which span shorter distances than the high-rise bridge, level running costs are used for the portion of the analysis section not involving the ramps or span and running costs associated with a given grade (positive grade on the upstroke and negative grade on the downstroke) are used over the actual length of the bridge (see tables 9-3 through 9-7).

Running cost per trip is calculated as the sum of approach cost (cost on level grade x distance) plus positive grade cost (cost on positive grade x distance) plus negative

Table 9-1

Average Daily Traffic and Traffic Splits
Selected Years

Condition	1990 Number	1990 %	2000 Number	2000 %	2020 Number	2020 %
Without-Project						
St.Claude (low)	29,875	35	30,851	33	32,334	34
Claiborne (mid)	43,531	51	42,070	45	39,941	42
Florida (low)	11,950	14	--	--	--	--
(high)	--	--	20,567	22	22,824	24
Total	85,356	100	93,488	100	95,099	100
With-Project						
St.Claude (low)	28,177	28	28,319	28	28,770	28
Claiborne (mid)	34,216	34	34,387	34	34,935	34
Florida (high)	38,241	38	38,432	38	39,044	38
Total	100,634	100	101,138	100	102,749	100
With-Project						
St.Claude (mid)	33,290	39	36,460	39	37,090	39
Claiborne (mid)	33,290	39	36,460	39	37,090	39
Florida (high)	18,776	22	20,568	22	20,919	22
Total	85,356	100	93,488	100	95,099	100

Source: Regional Planning Commission for Jefferson, Orleans, St. Bernard and St. Tammany Parishes, Inner Harbor Navigation Canal. Lock Replacement Project. Traffic Impact Analysis, September 1993.

Notes: Exclusive of busses

Estimates for 2010 were made by interpolating between traffic volume in the years 2000 and 2020, and by using 2020 roadway splits.

The 2020 estimates were held constant for 2030, 2040, and 2060.

The with-project condition that involves a low-mid-high bridge configuration also includes permanent Florida Avenue access road improvements. The with-project condition that involves a mid-mid-high bridge configuration does not include permanent Florida Avenue access roads.

Table 9-2

Distribution of Hourly Traffic Volume
By Bridge, Vehicle Type and Period

(in percent)

Vehicle Type	St. Claude		Claiborne		Florida	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Automobiles	70	90	70	80	70	[illegible]
Single Unit Trucks	20	7	15	10	15	[illegible]
Large Trucks	10	3	15	10	15	[illegible]
	100	100	100	100	100	100
Busses	19	8	14	9	0	

Sources: EDAW Inc., "Transportation, Volume 5" of the Ninth Ward Study.

EDAW Inc., "Highway User Cost Analysis Methodology for IHNC Bridge Crossings" of the Ninth Ward Study, May 1982.

Regional Transit Authority (number of busses).

Notes: Busses are shown as actual vehicles, not in percent.

The Regional Planning Commission estimates that 12 percent of each bridge's average daily traffic volume occurs during each peak hour.

Table 9-3

Bridge Grades and Lengths
By Bridge Crossing

Condition	Grade (in percent)	Length (in miles)
<u>Existing</u>		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (low)	3	0.05
<u>Without-Project</u>		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (high)	5	1.59
<u>With-Project</u>		
St. Claude (low)	3	0.32
Claiborne (mid)	5	0.59
Florida (high)	5	1.59
<u>With-Project</u>		
St. Claude (mid)	4	0.71
Claiborne (mid)	5	0.59
Florida (high)	5	1.59

Table 9-4

Peak Free-Flow
Vehicle Speeds

(in mph)

Condition	1990	2000	2020
Without-Project			
St. Claude (low)	17.0	15.5	14.0
Claiborne (mid)	13.0	12.7	14.0
Florida (low)	17.0	--	--
(high)	--	55.0	55.0
With-Project			
St. Claude (low)	16.5	16.5	16.5
Claiborne (mid)	19.0.	19.0	19.0
Florida (high)	54.0	54.0	54.0
With-Project			
St. Claude (mid)	20.0	15.0	15.0
Claiborne (mid)	20.0	15.0	15.0
Florida (high)	55.0	55.0	55.0

Source: Regional Planning Commission, Inner Harbor Navigation Canal. Lock Replacement Project. Traffic Impact Analysis, September 1993.

USACE (1990 without-project).

Notes: Speeds in the year 2010 use the 2020 estimates

The 2020 speed estimates were also used for 2030, 2040, and 2060.

Table 9-5

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Passenger Cars
(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	183.80	250.59	266.68	290.05	308.20
10	148.41	186.94	201.37	219.88	240.74
15	135.72	168.89	188.15	206.63	226.00
20	129.45	162.66	181.64	199.58	219.58
25	126.24	161.00	177.68	196.78	217.59
30	125.24	161.14	176.19	196.37	216.73
35	125.75	162.86	177.39	196.57	216.82
40	127.62	165.67	180.24	198.04	217.77
45	130.28	168.36	183.24	199.60	219.67
50	133.84	171.35	187.15	202.79	223.20
55	138.19	175.33	191.47	207.58	228.51

Sources: American Association of State Highway and Transportation Officials, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 Consumer Price Index and Producer Price Index.

Note: Passenger car idling cost is $728.45 per 1,000 vehicle miles.

Table 9-6

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Single Unit Trucks

(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	265.46	307.17	369.71	466.98	526.60
10	234.73	281.11	348.18	434.51	515.33
15	211.31	262.38	334.05	408.56	509.16
20	198.54	259.14	339.00	436.32	526.42
25	165.62	268.36	354.39	459.62	566.56
30	170.75	281.64	373.78	492.18	623.15
35	204.09	301.62	401.47	540.95	623.15
40	217.89	321.03	432.93	606.20	623.155
45	217.89	344.45	466.78	606.20	623.15
50	217.89	370.60	502.10	606.20	623.15
55	217.89	395.65	502.10	606.20	623.15

Sources: American Association of State Highway and Transportation Officials, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 Consumer Price Index and Producer Price Index.

Note: Single unit truck idling cost per 1,000 vehicle miles is $646.44.

Table 9-7

Average Running Costs at Uniform Speeds on Level Tangents and Grades for Large Diesel Trucks

(1992 Costs in Dollars per 1,000 Vehicle Miles)

Speed	-5%Grade	Level	+2%Grade	+4%Grade	+6%Grade
5	201.03	621.97	669.68	726.52	780.76
10	192.72	420.19	537.11	656.64	773.71
15	190.64	358.85	502.17	649.91	794.84
20	191.29	335.23	494.01	666.09	848.56
25	196.86	329.41	501.86	701.35	937.92
30	205.65	335.02	521.79	758.12	937.92
35	205.65	348.06	550.74	837.38	937.92
40	205.65	368.00	589.63	837.38	937.92
45	205.65	395.26	641.25	837.38	937.92
50	205.65	436.79	641.25	837.38	937.92
55	205.65	469.64	641.25	837.38	937.92

Sources: American Association of State Highway and Transportation Officials, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977.

USACE Update using U.S. Dept. of Commerce, Bureau of Labor Statistics, 1992 Consumer Price Index and Producer Price Index.

Note: Large truck idling cost is $449.85 per 1,000 vehicle miles.

grade cost (cost on negative grade x distance) divided by 1,000. Division by 1,000 converts the costs in the cost/speed/grade matrix which are per 1,000 miles to a per trip basis.

Step 3: Calculate the value of time per vehicle crossing for each vehicle type for peak and off-peak periods. The value of time per vehicle crossing is equal to [length of analysis section/vehicle speed] times value of passenger time times number of passengers per vehicle (see table 9-8).

Step 4: Calculate navigation independent costs on an hourly and annual basis for each vehicle type for peak and off-peak periods. Navigation independent costs are composed of the relevant running costs plus user costs. Running costs for a representative hour are equal to the number of vehicles times the cost per trip. User costs for a representative hour are equal to the number of vehicles times the value of time per vehicle crossing. Hourly running costs and user costs are summed and converted to an annual basis by multiplying the peak hourly costs by 996 and the off-peak hourly costs by 5,574. (The numbers 996 and 5,574 represent total peak and off-peak hours in a year, respectively.)

Navigation Dependent Costs

Navigation dependent costs represent those costs imposed on vehicular traffic as the result of navigation induced bridge raisings. Unlike the calculation of navigation independent costs, the computation of navigation dependent costs requires an interface with the level of navigation activity. The calculation of navigation dependent costs is as described in the following procedure.

Step 1: Calculate the hourly bridge openings required to serve navigation traffic for peak and off-peak periods. For the peak period, when constraints created by curfews are placed on bridge openings, desired openings per hour are compared to maximum allowable openings. Desired openings are equal to annual barge lockages divided by annual hours available for barge service. Desired openings represent barge lockages per hour assuming a uniform flow of barge traffic. Maximum allowable openings are equal to a specified percentage of a peak hour that a bridge is allowed to be open, as controlled by the curfew, times sixty minutes and divided by the average bridge open time per lockage. The lesser of desired openings and maximum allowable openings is the value used for the peak period. If maximum allowable openings is used during the peak period, then off-peak period openings due to barge traffic

Table 9-8

Vehicle Occupancy, Value of Time, And Bus Operating Costs

(1992 Costs in Dollars)

Item	Auto	Small Truck	Large Truck	Bus Peak	Bus Off-Peak
Persons per vehicle	1.3	1.0	1.0	40.0	10.0
Hourly Value of Occupant Time	$4.00	$10.00	$12.75	$4.00	
Hourly Operating Cost	(1)	(1)	(1)	$56.00	

Sources: EDAW Inc., "Highway User Cost Analysis Methodology for IHNC Bridge Crossings" of the Ninth Ward Study, May 1982 (occupancy levels and passenger time values).

Regional Transit Authority (bus operating cost).

Teamster's Local Union Number 270, 1992 (truck driver hourly earnings).

(1) Operating costs for autos, small trucks, and large trucks are described in tables 9-5, 9-6, and 9-7.

are equal to annual barge lockages minus annual peak hour barge lockages divided by annual off-peak barge hours. If, however, desired openings are used for the peak period, then desired openings are also used for the off-peak period. In addition to bridge openings due to barge traffic, bridge openings due to ship traffic must also be considered. For bridge opening purposes, all ship traffic is assumed to occur during the off-peak period (see tables 9-9 through 9-11).

Step 2: Calculate the percentage of an hour the bridge is in the open condition for peak and off-peak periods. For the peak period, the percentage of an hour a bridge is open is equal to openings per hour times the time that the bridge is open per raising, divided by sixty minutes. For the off-peak period, minutes open per hour due to barge traffic is calculated in the same manner as for the peak period. In addition, open time for ships must be included. Time open per ship lockage is equal to a specified bridge open time times a specified percentage of off-peak period. Thus, the percent of an hour that the bridge is open can now be calculated. It is composed of a weighted average of open time per barge lockage and open time per ship lockage weighted by the percent of annual off-peak hours attributed to barge traffic and ship traffic, respectively.

Table 9-9

Average Bridge Open Time
(in minutes)

Condition	Single Tow	Additional Tow Increment	Deep Draft Vessel
Existing			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.2	0.0	8.5
Florida (low)	5.2	3.6	8.4
Future Without-Project			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.2	0.0	8.5
Florida (high)	0.0	0.0	0.0
With-Project			
St. Claude (low)	7.1	1.6	10.7
Claiborne (mid)	6.5	0.0	9.1
Florida (high)	0.0	0.0	0.0
With-Project			
St. Claude (mid)	6.5	0.0	9.1
Claiborne (mid)	6.5	0.0	9.1
Florida (high)	0.0	0.0	0.0

Sources: USACE from Louisiana Department of Transportation and Development bridge log data (existing condition and without-project).

USACE from USACE river stage data and WCSC towboat height data (with-project).

Table 9-10

Percent of Vessel Requiring
Bridges to Open

Condition	Shallow Draft	Deep Draft
<u>Existing</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	14.2	100.0
Florida (low)	100.0	100.0
<u>Without-Project</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	14.2	100.0
Florida (high)	0.0	0.0
<u>With-Project</u>		
St. Claude (low)	100.0	100.0
Claiborne (mid)	25.8	100.0
Florida (high)	0.0	0.0
<u>With-Project</u>		
St. Claude (mid)	25.8	100.0
Claiborne (mid)	25.8	100.0
Florida (high)	0.0	0.0

Sources: USACE from Louisiana Department of Transportation and Development bridge log data (existing condition and without-project)

USACE from USACE river stage data and WCSC towboat height data (with-project).

Table 9-11

Percent of Time Bridge Are Allowed Open

During Peak Hours With Curfews

(in percent)

Condition	1990	2000	2020
Without-Project			
St. Claude (low)	10.5	10.5	10.5
Claiborne (mid)	0.9	0.9	0.9
Florida (low)	11.5	--	--
(high)	--	--	--
Without-Project			
St. Claude (low)	10.5	10.5	10.5
Claiborne (mid)	0.9	0.9	0.9
Florida (high)		--	
With-Project			
St. Claude (mid)	0.9	0.9	0.9
Claiborne (mid)	0.9	0.9	0.9
Florida (high)	--	--	--

SOURCE: USACE from Louisiana Department of Transportation and Development bridge log data.

Note: Percentages represent actual portions of the peak period that bridges are open. While Claiborne is allowed open a much lower percent of time compared to St. Claude, it does not represent a binding constraint on navigation traffic through the Inner Harbor Navigation Canal, since a large portion of navigation traffic does not require the Claiborne Bridge to be raised.

Total time open in minutes is divided by sixty to express open time as a fraction of an hour.

Step 3: Calculate the hourly flow of each vehicle type for peak and off-peak periods. This is the same method as described for calculating navigation independent costs.

Step 4: Generate queues and average delay for peak and off-peak periods. Demand volume and bridge capacity are required to generate queues and average delay. Demand volume is the hourly flow of all vehicle types as calculated in step 3 above. Bridge capacity is equal to [one minus the percent of time the bridge is open during an hour] times demand volume. The arrival rate and average delay are calculated as described earlier in the queuing methodology portion of this section. Average delay in minutes is converted into average delay as a percent of an hour by dividing by sixty.

Step 5: Calculate navigation dependent costs on an hourly basis for each vehicle type for peak and off-peak periods. Navigation dependent costs consist of two parts: value of passenger time during delay and vehicle idling costs during delay. The value of passenger time is equal to the number of vehicles times the number of passengers per vehicle times the value of passenger time times the average delay as a percent of an hour. Idling costs are equal to a specified cost per vehicle hour times the number of vehicles times the average delay as a percent of an hour. The sum of these two hourly components are converted to an annual basis by multiplying by the annual number of period hours.

DIFFERENTIAL RUNNING SPEED APPROACH

As an alternative to the queuing method, a simpler technique is available with use of the differential running speed approach. The essence of this methodology requires the use of differential average running speeds that characterize the periods inclusive and exclusive of a bridge opening. The use of slower speeds to capture the effects of a bridge opening results in added user costs compared to the higher speed of a free-flow period.

Cost Calculation Procedure

The calculation procedure of the differential running speed approach strongly resembles the procedure used in calculation of navigation independent costs in the queuing method. The following steps are required.

Step 1: Calculate the hourly flow of each vehicle type for peak and off-peak periods in the same manner as described previously.

Step 2: Calculate the running cost per trip for each vehicle type using a weighted speed to reflect average bridge open time for peak and off-peak periods. Running cost per trip is calculated exactly as in the navigation independent costs portion of the queuing method with the exception of the selected speed. In this procedure the speed (transit with no bridge interruption) and the interrupted, or effective, speed assuming an average bridge open time are factored into the average running speeds. These with and without bridge opening speeds are weighted by the percent of an hour a bridge is open for a particular scenario. The bridge open percentage is calculated in exactly the same manner as previously described in the navigation dependent costs portion of the queuing method. Running cost per trip is then calculated using this weighted speed (see table 9-12).

Step 3: Calculate the value of time per vehicle crossing for each vehicle type for peak and off-peak periods. Using the weighted average speed, this step is the same as described earlier.

Step 4: Calculate total cost on an hourly and annual basis for each vehicle type for peak and off-peak periods, same as described earlier.

SELECTION OF METHODS

In order that the difference in peak and off-peak periods be best addressed, a combination of the two approaches has been selected to estimate vehicle costs. Queuing theory for peak-hour periods and average running speed, inclusive of bridge opening delays, for off-peak hours are most sensitive to the traffic conditions peculiar to the different service levels associated with peak and off-peak periods.

The results of test applications showed that for the peak-hour traffic delay estimate, the queuing-based methods yielded a more realistic value compared to the running-time approach. The effect of traffic interruptions from bridge openings during peak periods was not adequately captured by the differential running speed methods. Because of high roadway utilization during this period, interruptions produce a significant impact on delays and costs. The differential running speed method had the effect of averaging out the interrupted and free flow components to

Table 9-12

Off-Peak
Vehicle Speeds and Bridge Open Times

Condition	Bridge Open Time (in minutes)	Speed (in mph)
<u>Existing</u>		
St. Claude (low)		
free-flow	--	28.0
interrupted	7.4	8.0
weighted	--	26.0
Claiborne (mid)		
free-flow	--	26.0
interrupted	6.2	9.0
weighted	--	23.9
Florida (low)		
free-flow	--	24.0
interrupted	6.4	9.0
weighted	--	23.9
<u>Without-Project</u>		
St. Claude (low)		
free-flow	--	28.0
interrupted	7.4	8.0
weighted	--	26.0
Claiborne (mid)		
free-flow	--	26.0
interrupted	6.2	9.0
weighted	--	23.9
Florida (high)		
free-flow	--	55.0

Table 9-12 (continued)

Off-Peak
Vehicle Speeds and Bridge Open Times

Condition	Bridge Open Time (in minutes)	Speed (in mph)
With-Project		
St. Claude (low)		
free-flow	--	28.0
interrupted	7.4	8.0
weighted	--	19.7
Claiborne (mid)		
free-flow	--	26.0
interrupted	6.5	9.0
weighted	--	22.5
Florida (high)		
free-flow		55.0
With-Project		
St. Claude (mid)		
free-flow	--	28.0
interrupted	6.5	8.0
weighted	--	27.5
Claiborne (mid)		
free-flow	--	24.0
interrupted	6.5	9.0
weighted	--	23.6
Florida (high)		
free-flow	--	55.0

such a degree that the impact of the interrupted component was lost.

However, for off-peak analyses, the queuing approach did not appear to generate realistic results. This was primarily due to the low traffic volumes affected by the bridge openings. The queuing method is valid only under conditions where the traffic volume exceeds the practical capacity (inclusive of the bridge opening) of the analysis section. As a result, the queuing method grossly overstated the delay and cost estimates for the off-peak period. Therefore, use of the running-time approach utilizing properly weighted running speeds was selected as the preferred method for off-peak analyses.

MODEL RESULTS

WITHOUT-PROJECT CONDITIONS

The existing conditions for IHNC bridge crossings are described by a low-level bridge at St. Claude Avenue, a mid-level bridge at Claiborne Avenue, and a low-level bridge at Florida Avenue. Each bridge's relative share of 1990 total IHNC crossing traffic, as displayed earlier in table 9-1, shows 35, 51, and 14 percent for St. Claude, Claiborne, and Florida, respectively. The significant differences in relative shares are explained by several factors. As the only mid-level bridge in the three bridge system, Claiborne Avenue suffers fewer interruptions from shallow-draft traffic than does St. Claude Avenue. This fact alone explains the desirability of Claiborne over St. Claude. The extremely low share at Florida is the result of two conditions. The first is the fact that it is a low-level bridge, and therefore suffers significantly from navigation induced delays. The second, and more important consideration is the fact that access to the bridge is limited. Because there is no major traffic corridor associated with either side of the Florida crossing, through-traffic views the inconvenience of limited access as a significant limitation to Florida use. The combined effects of the low-level crossing and limited access make Florida much less desirable in the existing condition than the two alternative IHNC crossings.

The IHNC bridge crossings provide access between St. Bernard Parish and the portion of the City of New Orleans bounded by the Mississippi River, the IHNC, and the Mississippi River Gulf Outlet with the City of New Orleans upriver of the IHNC. The crossings over the IHNC do not provide exclusive access between the described areas. However, for most traffic, they represent the shortest route in terms of both time and distance and, therefore, represent the most efficient route. Alternative routes to the IHNC crossings typically add twenty or more miles one-way to a trip. As a result, most vehicles will incur considerable delay before diverting to alternate routes.

The future without-project condition has the same bridge configuration as described for the existing condition, with the exception of Florida Avenue. The State of Louisiana has authorized a new high-level span to be built at Florida Avenue. Estimates for the impact of this new crossing on relative shares and volumes of traffic captured by the different bridges were prepared by the Regional Planning Commission for Jefferson, Orleans, St. Bernard and St. Tammany Parishes (RPC). The RPC maintains a set of travel demand models for use in maintenance of the region's Long Range Transportation Plan. The travel demand models use socioeconomic information which suggests the number and nature of trips generated in the traffic corridor. They estimate that, as a result of changes in both these socioeconomic variables as well as the structural changes to the roadways, the relative shares of traffic carried by the bridges in the year 2000 would shift to 33, 45, and 22 percent on St. Claude, Claiborne, and Florida, respectively. The majority of the increased traffic on Florida appears to be due to trips formerly located on Claiborne Avenue (see table 9-1) which will now be assured of uninterrupted transit over the IHNC on the high-rise Florida Avenue Bridge. However, the existing constraints on Florida Avenue continue to be present in the without-project condition, namely, poor access, and single lane feeder streets. As a result, the full potential for capturing traffic share by the new high-level Florida Avenue Bridge is not realized.

Future without-project traffic volumes were also generated by the RPC. Limited growth of existing traffic volumes are forecast, based on modest population growth projections and small changes in related variables, such as employment.

Table 9-13 summarizes bridge user costs for the without-project condition. The distribution of costs for each bridge in table 9-13 is a reflection of bridge levels and traffic volume. Bridge specific peak-period navigation independent costs, which represent free-flow running costs, are approximately proportional to relative traffic shares.

This is not the case, however, with respect to peak period navigation dependent costs. St. Claude's share of navigation dependent costs is greatly in excess of its share of traffic volume. The reason for this is that St. Claude is a low-level crossing. While the peak-period bridge curfews prevent St. Claude from being raised as

Table 9-13
Vehicle Costs
Without-Project
(in 1992 $1,000)

	1990	2000	2010	2020	2030	2040	2060
PEAK NAVIGATION DEPENDENT COSTS							
St. Claude	4,929	5,465	6,344	6,444	6,444	6,444	6,444
Claiborne	1,364	1,259	764	783	783	783	783
Florida	1,507	0	0	0	0	0	0
TOTAL	7,800	6,724	7,107	7,227	7,227	7,227	7,227
PEAK NAVIGATION INDEPENDENT COSTS							
St. Claude	3,610	3,978	4,460	4,495	4,495	4,495	4,495
Claiborne	6,765	6,671	5,840	5,886	5,886	5,886	5,886
Florida	1,415	1,553	1,709	1,723	1,723	1,723	1,723
TOTAL	11,790	12,202	12,009	12,104	12,104	12,104	12,104
TOTAL PEAK COSTS	19,589	18,926	19,116	19,332	19,332	19,332	19,332
OFF-PEAK COSTS							
St. Claude	4,100	4,264	4,444	4,478	4,481	4,481	4,481
Claiborne	6,863	6,641	6,275	6,322	6,324	6,324	6,324
Florida	1,706	2,353	2,593	2,619	2,619	2,619	2,619
TOT OFF-PEAK COST	12,669	13,258	13,312	13,419	13,424	13,424	13,424
GRAND TOTAL COST	32,258	32,184	32,428	32,751	32,756	32,756	32,756

NOTE: Columns may not add due to rounding frequently as it would otherwise be raised in the absence of a curfew, it is still raised on average much more often than is the Claiborne Bridge. As a result, St. Claude has a disproportionately high share of navigation dependent costs and Claiborne has a disproportionately small share. The navigation dependent costs for Florida Avenue are similar to those for St. Claude in 1990 only. As of the year 2000, the high-level Florida Bridge will be in place and, therefore, there will no longer be navigation dependent costs for Florida trips.

The distribution of peak-period navigation dependent costs is significant since these costs represent the vast majority of navigation induced delays that could potentially be reduced in a with-project condition. Reductions in navigation dependent costs represent the bulk of vehicular benefits for the peak period.

Costs for the off-peak period are also displayed in table 9-13. As with peak-period navigation independent costs, off-peak costs are approximately proportional to relative traffic share. This is not surprising due to the similarity between the calculation procedure of the free-flow running costs and the differential running speeds method for the off-peak period. Unlike the queuing methodology of the peak period, the differential running speed approach of the off-peak period is unable to differentiate between navigation independent costs and navigation dependent costs.

Table 9-14 displays additional detail relative to vehicle delays. The percent of an hour each bridge is open during the peak period is equal to the maximum percentage implicit in the bridge curfews. The maximum percentage is always reached because the volume of navigation traffic is in excess of that required to reach the maximum allowed open time. Because the restrictive curfews limit the flow of navigation traffic during the peak period, the bridges must be open a greater portion of time in the off-peak period when no restriction exists. This fact is reflected in the percent open time of table 9-14. As discussed earlier, the fact that Claiborne is a mid-level crossing results in relatively low navigation dependent costs. This is reflected in the low open and delay times.

As can be seen in tables 9-13 and 9-14, construction of the high-rise Florida Bridge eliminates all peak navigation dependent costs for Florida Avenue traffic, causing total peak navigation costs to decline from 1990-2000. Increases in both navigation and vehicular traffic volumes are responsible for increases in future without-project costs over the time period. Decreased traffic volumes on

Table 9-14
Vehicle Delays
Without-Project
(in 1992 dollars)

	1990	2000	2010	2020	2030	2040	2060
ST. CLAUDE							
% HR OPEN PEAK	10.5	10.5	10.5	10.5	10.5	10.5	10.5
% HR OPEN OFF-PEAK	18.6	20.7	21.5	21.5	21.6	21.6	21.6
% HR DELAY PEAK	15.8	17.0	19.1	19.2	19.2	19.2	19.2
$ DELAY/VEHICLE/HOUR - PEAK							
AUTOS	0.935	1.007	1.130	1.140	1.140	1.140	1.140
SM TRUCKS	1.692	1.826	2.048	2.064	2.064	2.064	2.064
HVY TRUCKS	2.078	2.241	2.512	2.534	2.534	2.534	2.534
BUSSES	34.053	36.684	41.158	41.526	41.526	41.526	41.526
CLAIBORNE							
% HR OPEN PEAK	0.9	0.9	0.9	0.9	0.9	0.9	0.9
% HR OPEN OFF-PEAK	2.5	2.8	2.8	2.8	2.9	2.9	2.9
% HR DELAY PEAK	3.3	3.1	2.0	2.0	2.0	2.0	2.0
$ DELAY/VEHICLE/HOUR - PEAK							
AUTOS	0.194	0.185	0.119	0.121	0.121	0.121	0.121
SM TRUCKS	0.352	0.336	0.216	0.220	0.220	0.220	0.220
HVY TRUCKS	0.431	0.412	0.265	0.270	0.270	0.270	0.270
BUSSES	3.143	3.000	1.929	1.929	1.929	1.929	1.929
FLORIDA							
% HR OPEN PEAK	11.5	0.0	0.0	0.0	0.0	0.0	0.0
% HR OPEN OFF-PEAK	14.8	0.0	0.0	0.0	0.0	0.0	0.0
% HR DELAY PEAK	13.6	0.0	0.0	0.0	0.0	0.0	0.0
$ DELAY/VEHICLE/HOUR - PEAK							
AUTOS	0.808	0.000	0.000	0.000	0.000	0.000	0.000
SM TRUCKS	1.465	0.000	0.000	0.000	0.000	0.000	0.000
HVY TRUCKS	1.795	0.000	0.000	0.000	0.000	0.000	0.000

Claiborne from 1990 to 2000 are responsible for lower costs for Claiborne and for total costs. This is not the case from 2000 to 2010 when, despite a further decline in Claiborne volume, the increased efficiency of traffic relocated from Claiborne to Florida outweighs Claiborne's decreased traffic and delay costs. Thus, total costs increased from 2000 to 2010.

Costs for Diverted Traffic

Although the RPC's travel demand model accounts for vehicular traffic which crosses the IHNC bridges, it does not explicitly capture the trips that would use these routes if the congestion levels and delays were not present. With-project conditions induce the return of these trips back to the IHNC crossings. Since the cost of these 'diverted' trips was not included in the vehicle model's output of vehicle costs, an adjustment was in order to make without-project costs comparable to with-project costs. According to the RPC model results, in the year 2020 there will be 7,650 more trips which occur in the with-project scenario than will occur in the without-project scenario. This number is used to represent the number of diverted trips which were not originally captured.

The cost of making the diverted trip was estimated using costs derived from the vehicle model calculations. The diverted trip must cost less than the IHNC route in the without-project condition, or it will use one of the IHNC crossings. Similarly, the diverted trip must cost more than the with-project cost of an IHNC trip, or it will not shift to one of the IHNC routes once the with-project improvements are implemented. Since total and diverted traffic volumes for the IHNC crossings were estimated to be the same for all lock construction alternatives, the estimates from the lock scenario with the lowest per trip costs were used to represent minimum diversion costs. This average trip cost was then assigned to each of the 7,650 diverted vehicles and added to without-project costs beginning in the year 2000 in table 9-17 which summarizes with and without-project total vehicle costs.

WITH-PROJECT CONDITIONS

The with-project condition includes the replacement of the existing lock with a new lock located north of Claiborne Avenue. The St. Claude Bridge is replaced with an updated low-rise bridge and Claiborne remains as a mid-rise and is refitted with higher towers. As previously mentioned, the high-rise Florida Avenue Bridge will be built by the State in the without-project condition. An alternate with-

Table 9-15
Vehicle Costs
1200x110x36 Lock with curfew
(in 1992 $1,000)

	1990	2000	2010	2020	2030	2040	2060
PEAK NAVIGATION DEPENDENT COSTS							
St. Claude	2,818	3,236	3,760	4,284	4,752	4,752	4,752
Claiborne	421	425	430	435	435	435	435
Florida	0	0	0	0	0	0	0
TOTAL	3,239	3,661	4,189	4,719	5,187	5,187	5,187
PEAK NAVIGATION INDEPENDENT COSTS							
St. Claude	3,501	3,517	3,542	3,567	3,567	3,567	3,567
Claiborne	4,085	4,104	4,134	4,164	4,164	4,164	4,164
Florida	2,900	2,914	2,938	2,961	2,961	2,961	2,961
TOTAL	10,486	10,535	10,614	10,692	10,692	10,692	10,692
TOTAL PEAK COSTS	13,725	14,196	14,803	15,411	15,880	15,880	15,879
OFF-PEAK COSTS							
St. Claude	3,674	3,713	3,752	3,798	3,819	3,845	3,915
Claiborne	5,438	5,472	5,514	5,559	5,563	5,567	5,579
Florida	4,383	4,409	4,443	4,476	4,476	4,476	4,476
TOT OFF-PEAK COST	13,495	13,594	13,708	13,832	13,857	13,887	13,970
GRAND TOTAL COST	27,220	27,790	28,512	29,244	29,737	29,767	29,849

NOTE: Columns may not add due to rounding

Table 9-16
Vehicle Delays
1200x110x36 Lock with curfew
(in 1992 dollars)

	1990	2000	2010	2020	2030	2040	2060
ST. CLAUDE							
% HR OPEN PEAK	6.60	7.50	8.50	9.50	10.50	10.50	10.50
% HR OPEN OFF-PEAK	6.90	7.70	8.80	9.80	11.00	12.60	16.40
% HR DELAY PEAK	9.50	10.80	12.50	14.10	15.70	15.70	15.70
$ DELAY/VEHICLE - PEAK							
AUTOS	0.56	0.64	0.74	0.84	0.93	0.93	0.93
SM TRUCKS	1.02	0.86	1.34	1.52	1.69	1.69	1.69
HVY TRUCKS	1.25	1.43	1.64	1.87	2.07	2.07	2.07
BUSSES	20.47	23.42	27.00	30.58	33.89	33.89	33.89
CLAIBORNE							
% HR OPEN PEAK	0.90	0.90	0.90	0.90	0.90	0.90	0.90
% HR OPEN OFF-PEAK	1.30	1.50	1.60	1.80	2.00	2.20	2.80
% HR DELAY PEAK	1.30	1.30	1.30	1.30	1.30	1.30	1.30
$ DELAY/VEHICLE - PEAK							
AUTOS	0.08	0.08	0.08	0.08	0.08	0.08	0.08
SM TRUCKS	0.14	0.14	0.14	0.14	0.14	0.14	0.14
HVY TRUCKS	0.17	0.17	0.17	0.17	0.17	0.17	0.17
BUSSES	1.21	1.21	1.21	1.21	1.21	1.21	1.21
FLORIDA							
% HR OPEN PEAK	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% HR OPEN OFF-PEAK	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% HR DELAY PEAK	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$ DELAY/VEHICLE - PEAK							
AUTOS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SM TRUCKS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HVY TRUCKS	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9-17

Total Transportation Costs and Savings Summary
(in 1992 $1,000)

	1990	2000	2010	2020	2030	2040	2060	Average Annual
Without-Project								
w/curfew	32,258	32,184	32,428	32,751	32,756	32,756	32,756	
w/diversion adjustment		34,450	34,694	35,017	35,022	35,022	35,022	
w/o curfew	36,125	39,184	40,586	41,211	41,297	41,297	41,319	
w/diversion adjustment		41,450	42,852	43,477	43,563	43,563	43,585	
Savings		(7,000)	(8,158)	(8,460)	(8,541)	(8,541)	(8,563)	7,506 1/
Bridge Only w/o curfew	22,950	27,142	27,597	27,876	27,895	27,895	27,899	
w/diversion adjustment		29,408	29,863	30,142	30,161	30,161	30,165	
Savings		5,042	4,831	4,876	4,862	4,862	4,858	5,310 2/
900x90x22 w/curfew	29,166	29,370	29,642	29,926	29,978	30,039	30,062	
Savings		5,080	5,052	5,092	5,044	4,983	4,960	5,505 3/
900x110x22 w/curfew	29,340	29,310	29,571	29,842	29,881	29,929	30,043	
Savings		5,140	5,123	5,175	5,142	5,093	4,979	5,596 3/
900x110x36 w/curfew	29,124	29,316	29,579	29,850	29,891	29,939	30,054	
Savings		5,134	5,115	5,167	5,131	5,083	4,968	5,586 3/
1200x90x22 w/curfew	27,889	28,543	29,370	29,755	29,789	29,831	29,935	
Savings		5,907	5,324	5,262	5,233	5,191	5,087	5,722 4/
1200x110x22 w/curfew	27,207	27,777	28,495	29,225	29,733	29,767	29,845	
Savings		6,673	6,199	5,792	5,289	5,255	5,177	6,201 4/
1200x110x36 w/curfew	27,220	27,790	28,512	29,244	29,737	29,767	29,849	
Savings		6,660	6,182	5,774	5,285	5,255	5,173	6,188 4/
900x90x22 w/o curfew	31,155	32,150	33,409	34,685	35,893	37,367	38,405	
Savings		2,300	1,285	333	(871)	(2,345)	(3,383)	(55) 3/
900x110x22 w/o curfew	29,938	30,738	31,748	32,774	33,690	34,807	37,448	
Savings		3,712	2,945	2,244	1,332	215	(2,426)	2,052 3/
900x110x36 w/o curfew	30,051	30,859	31,886	32,924	33,853	34,989	37,675	
Savings		3,591	2,808	2,093	1,170	33	(2,653)	1,883 3/
1200x90x22 w/o curfew	28,084	28,820	29,747	30,685	31,515	32,528	34,923	
Savings		5,630	4,947	4,333	3,507	2,495	99	4,272 4/
1200 x110x22 w/o curfew	27,220	27,847	28,639	29,439	30,122	30,949	32,891	
Savings		6,603	6,054	5,579	4,901	4,073	2,131	5,703 4/
1200x110x36 w/o curfew	27,234	27,860	28,656	29,458	30,143	30,973	32,920	
Savings		6,590	6,037	5,560	4,880	4,049	2,102	5,593 4/

1/Over the period 1996-2045
2/Over the per.od 2004-2053
3/Over the period 2011-2060
4/Over the period 2012-2061

project scenario known as "Bridge Only" calls for the existing lock to be rehabilitated, and to have a new mid-level St. Claude Bridge.

In addition to these improvements, the Project Mitigation Plan will provide a permanent access route which links St. Bernard Highway and West Judge Perez Drive, the two major traffic corridors in St. Bernard Parish, with Florida Avenue. This will address the Florida Avenue access problems and result in the increased utilization of the Florida Avenue crossing. The access route will be constructed in an undeveloped section of land in St. Bernard Parish, near the Orleans Parish line. The permanent access route improvements are not assumed to be part of the Bridge Only plan because they are not necessary for project mitigation and the mid-level St. Claude Bridge effectively addresses the traffic flow situation. However, without the permanent access route improvements, the Bridge Only plan does capture the 7,650 diverted vehicle trips and, therefore, requires the same adjustment to total vehicle costs as was required for the without-project condition. (This adjustment is also required for the Remove Bridge Curfews plan.) For purposes of displaying model results, all project improvements are assumed to be in place throughout the entire period of analysis, beginning with 1990.

Relocation of the lock to a new north-of-Claiborne site has implications for the number of bridge raisings and, therefore, on delays and effective speeds. The current lock is located on the riverside of the Claiborne Bridge which has, for all intents and purposes, a constant forty foot clearance. With the relocation of the new lock to the north of Claiborne Avenue, water levels under the new bridge will now be subject to Mississippi River stage fluctuations. In order to compensate for high river stages, the vertical lift towers for the Claiborne Bridge will be raised to provide the same degree of maximum vertical clearance that currently exists. Additionally, the number of barges needing the bridge to be raised will also increase.

Estimates of additional Claiborne Avenue Bridge raisings resulting from river stages are based on distributions of highest fixed points for towboats and tugboats, and river stage data. Comparisons of vessel height data with the stage data indicate an increase in the Claiborne Bridge openings from 14 percent of all traffic to 26 percent. This negative impact on landside traffic speeds and delays is factored into the with-project cost estimations. Another difference accounted for in the with-project landside cost measurement is the tows per lockage calculation for each lock size and its subsequent impact on the number of bridge openings.

Tables 9-15 and 9-16 illustrate details of the with-project costs and delays for a selected lock size--1200x110x36. Direct comparison to the without-project cost table is hampered by the lack of inclusion of the "diverted traffic" costs added to the without-project detailed costs (table 9-13). However, it can be seen that with-project peak navigation dependent costs are significantly reduced from those in the without-project condition. With-project delays in table 9-16 do not reach the maximum allowable openings for St. Claude until the year 2030, unlike in the without-project scenario. Despite higher navigation traffic volume in the with-project condition , maximum allowable openings are not reached until 2030 because the new lock can accommodate more tows per lockage. The length of time the bridges are open per lockage goes up, but the number of lockages goes down by a greater amount, thereby generating an efficiency for the larger locks with respect to bridge open time.

Table 9-17 displays total landside costs and savings for each with-project alternative, including conditions in which the bridge curfew is removed, both in the without-project condition, and for each with-project alternative. Without-project costs need to include the costs of the diverted traffic in order to make the appropriate comparison to the with-project costs. Savings in table 9-17 represent the difference between the complete without-project costs and the with-project costs for each alternative in both with curfew and without curfew scenarios.

With bridge curfews, there are modest differences in savings between alternatives. Interestingly, savings for the Bridge Only plan are actually lower than the north of Claiborne plans despite the fact that with the Bridge Only, virtually all navigation dependent costs are eliminated with the mid, mid, high configuration of St. Claude, Claiborne, and Florida Bridges. While eliminating navigation dependent costs, the Bridge Only plan does not capture the diverted trips that the north of Claiborne plans do because of the absence of permanent detour routes.

Without bridge curfews, savings for all alternatives are lower than under the with-curfew assumption. In fact, savings actually become negative in the later years for the smaller capacity lock alternatives. This occurs because the positive effect on total bridge open time that is produced by the larger tows-per-lockage number is eventually overcome by the negative effect of more with-project bridge openings. With curfews in place, peak period bridge openings are restricted. For the plan that involves only removing bridge curfews, transportation costs are significantly higher than those associated with the without-project condition. This outcome is expected given that the only impact to vehicular traffic generated by this plan is more bridge openings during the peak traffic periods.

SECTION 10 - PROJECT COSTS, SUMMARY OF BENEFITS, AND ECONOMIC JUSTIFICATION

PROJECT COSTS

FIRST COSTS

Project expenditures by year in 1996 dollars , exclusive of mitigation costs, are displayed in table 10 - 1 for each alternative. Total costs for lock construction alternatives range from $377.7 million for the 900 x 90 x 22 alternative to $460.7 million for the 1200 x 110 x 36 alternative. The 1200 foot length plans or the 36 foot sill plans have a 13-year implementation period. The remaining lock construction alternatives require a 12-year implementation period. The Bridge Only alternative, which requires construction of a new mid-level bridge at St. Claude Ave., has a total construction cost of $42.9 million and a required implementation period of eight years.

In addition to the construction costs described above, total project first costs also include mitigation costs of $33.0 million for the lock construction alternatives and $18.2 million for the Bridge Only plan. Mitigation costs by year are identified in table 10 - 2.

Representing a National Economic Development (NED) cost, and included in total project first costs, are navigation losses during construction. Navigation losses during construction represent the loss of existing deep-draft access that would occur during the last two years of construction for all lock construction plans. Depending on the alternative, these last two years of construction are either 2008-2009 or 2009-2010. Mitigation costs and deep-draft losses during construction, along with project construction costs, are summarized in table 10 - 3.

OPERATIONS MAINTENANCE & REPLACEMENT COSTS

Operations, maintenance, and replacement (OM&R) costs for the lock construction scenarios are based on the following schedule of items. Operations costs for all barge and ship locks are $1,150,000 annually. Minor maintenance for all lock plans is estimated at $150,000 annually. Dewaterings and major repairs would be required every 15 years at a cost of $2,250,000 for the ship locks and $2,200,000 for the barge locks.

Table 10 - 1

Construction Expenditures By Year
Exclusive of Mitigation Cost
(1996 Prices; $1,000's)

Year	Bridge Only	900 x 90 x 22	900 x 110 x 22	900 x 110 x 36	1200 x 90 x 22	1200 x 110 x 22	1200 x 110 x 36
1998	629.8	5,152.4	5,328.4	5,884.1	5,569.9	5,953.5	6,157.2
1999	629.8	31,773.0	31,972.9	32,604.4	30,577.5	32,683.1	32,914.7
2000	678.3	29,819.4	29,952.3	30,302.3	28,324.3	30,274.8	30,490.4
2001	1,573.9	20,067.2	20,173.4	21,180.3	19,570.0	20,917.6	21,576.4
2002	3,165.8	14,026.2	13,205.3	15,154.2	13,745.5	14,692.0	15,513.0
2003	10,497.4	65,592.2	66,171.9	69,928.9	67,704.0	72,366.2	77,053.6
2004	14,086.4	36,948.5	44,288.6	41,739.9	40,550.9	43,343.3	49,056.0
2005	11,638.6	47,556.5	55,864.5	63,917.0	58,195.7	62,203.1	61,626.3
2006		37,688.5	35,382.4	38,368.3	35,263.8	37,692.1	41,247.4
2007		37,224.1	38,592.0	45,935.3	42,420.2	45,341.3	49,461.7
2008		27,504.2	23,488.7	26,996.5	26,365.2	28,180.8	29,674.9
2009		24,347.8	28,079.6	26,364.7	22,402.2	23,944.8	24,816.7
2010				10,924.1	7,210.8	7,707.4	21,111.7
Total	42,900.0	377,700.0	392,500.0	429,300.0	397,900.0	425,300.0	460,700.0

Table 10 - 2

Mitigation Expenditures By Year
(1996 Prices; $1,000's)

Year	Bridge Only	900 ft Length and 22 Foot Sill Construction Alternatives	1200 ft Length or 36 foot Sill Construction Alternatives
1999	300.0	6,570.0	6,570.0
2000	37.5	187.5	187.5
2001	4,978.6	187.5	187.5
2002	4,310.3	6,376.8	6,376.8
2003	2,824.8	6,549.2	6,549.2
2004	2,585.8	332.5	332.5
2005	3,119.4	3,042.5	332.5
2006		1,017.5	3,042.5
2007		4,875.9	1,017.5
2008		2,824.9	4,543.4
2009		1,043.0	2,824.9
2010			1,043.0
Total	18,156.4	33,007.3	33,007.3

Table 10 - 3

Cost Summary
(1996 $1,000, 7.375 Percent)

	Remove Bridge Curfews	Bridge Only	900x90x22	900x110x22	900x110x36	1200x90x22	1200x110x22	1200x110x36
Construction Costs	0	42,900	377,700	392,500	429,300	397,900	425,300	460,700
Mitigation Costs	0	18,156	33,007	33,007	33,007	33,007	33,007	33,007
Nav Losses During Const	0	0	2,546	2,546	2,588	2,588	2,588	2,588
Total Costs	0	61,056	413,253	428,053	464,895	433,495	460,895	496,295
P.V. Const Costs	0	49,581	571,002	592,174	686,322	639,102	683,112	730,426
P.V. Mitigation Costs	0	22,407	51,901	51,901	54,677	54,677	54,677	54,677
P.V. Nav Losses	0	0	2,735	2,735	2,780	2,780	2,780	2,780
Total P.V. Costs	0	71,988	625,638	646,810	743,779	696,559	740,569	787,883
Annual Construction Costs	0	3,764	43,346	44,954	52,101	48,517	51,857	55,449
Annual Mitigation Costs	0	1,701	3,939	3,939	4,150	4,150	4,150	4,150
Annual Nav Losses	0	0	208	208	211	211	211	211
Annual Permanent DD Losses	0	0	477	477	0	486	486	0
Annual O&M Costs	0	0	1,382	1,382	1,384	1,382	1,382	1,384
Induced Vehicular Losses	8,581	0	0	0	0	0	0	0
Total Annual Cost	8,581	5,465	49,352	50,960	57,846	54,745	58,086	61,194
Base Year	1998	2006	2010	2010	2011	2011	2011	2011

AVERAGE ANNUAL COSTS

Table 10 - 3 displays the composition of the total first cost estimates for each alternative, the present value cost necessary to calculate average annual costs, and lastly, the average annual cost associated with each cost item. Annual costs include two items not previously discussed, Permanent Deep-Draft Losses and Induced Vehicular Losses. Permanent Deep-Draft Losses represent the reduction in deep-draft service that would occur over the 50-year project life, and applies to all 22-foot sill alternatives. Induced Vehicular Losses represents the net loss to vehicular traffic. This category applies only to the Remove Bridge Curfew alternative.

All costs in table 10 - 3 represent 1996 price levels. Annual costs were calculated using an interest rate of 7.375 percent, a 50-year project life, and an alternative specific base year as indicated in the table.

BENEFIT PRICE LEVEL UPDATING

OVERVIEW

Price level updating must be employed in order to represent all benefit categories, some of which were originally developed at varying price levels, in the same 1996 dollars used for project costs. As detailed in previous sections of this appendix, shallow-draft, deep-draft, and vehicular benefits were initially computed in 1992, 1993, and 1992 prices, respectively. Navigation Losses Prevented from Rehabilitation Closures were also initially computed in 1992 dollars since this benefit category is based on the initial shallow-draft calculations. Savings to Federal Projects, however, require no price level adjustment since the benefit category is based on OM&R and extraordinary maintenance costs which already reflect 1996 prices. The following paragraphs detail the updating procedure used for each category.

SHALLOW-DRAFT

IWR shallow-draft vessel operating costs were used as the basis for updating the price level of the shallow-draft benefits detailed in Section 7 of this appendix. As a first step, FY 91 and FY 95 IWR costs for individual towboat sizes and barge types were compared, and the percent change for each piece of equipment was calculated. These results are displayed in table 10 - 4. As the table indicates, towboat operating costs over the period showed a decrease of approximately 4.9 percent to an increase of 8.3 percent. Barge costs over the same period showed a

IWR Shallow-Draft Vessel Operating Costs
(Total Hourly Cost)

Towboat Operating Cost

	Horsepower										
	1200	1400 - 1600	1800 - 2000	2200 - 2400	2800 - 3400	4000 - 4400	5000 - 6000	6100 - 7000	7100 - 8000	8100 - 9000	10,000
FY 1991, Int=8.75%	138.2	152.36	182.98	217.46	264.45	316.34	374.62	431.94	457.08	503.53	568.14
FY 1995, Int=7.75%	132.90	154.00	180.95	206.90	256.84	322.71	397.96	457.37	488.88	540.77	615.10
% Change	-3.8%	1.1%	-1.1%	-4.9%	-2.9%	2.0%	6.2%	5.9%	7.0%	7.4%	8.3%

Barge Operating Cost

	Barge Type										
	Deck	**Deck**	**Open Hopper**	**Open Hopper**	**Covered Hopper**	**Tank db skin without coils**	**Tank db skin without coils**	**Tank db skin without coils**	**Tank db skin with coils**	**Tank db skin with coils**	**Tank db skin with coils**
	130x35	195x35	175x26	195x35	195x35	195x35	240x50	290x50	195x35	240x50	290x50
FY 1991, Int=8.75%	2.82	4.11	2.97	3.77	4.49	9.7	16.41	21.24	10.53	17.46	22.54
FY 1995, Int=7.75%	2.31	3.65	2.5	3.23	3.73	10.16	17.61	21.14	10.69	18.27	21.85
% Change	-18.1%	-11.2%	-15.8%	-14.3%	-16.9%	4.7%	7.3%	-0.5%	1.5%	4.6%	-3.1%

decrease of approximately 18.1 percent to an increase of 7.3 percent.

In order to convert these ranges of values to a single value that could be used as an index value to be applied to shallow-draft benefits, a typical tow was constructed for each of the major commodity groups. Using the cost of each typical tow, a weighted average tow cost for each year, FY 91 and FY 95, was calculated using tons of each commodity as the weighting factor. The ratio of the FY 95 weighted tow cost to the FY 91 weighted tow cost was used as the index factor to convert from 1991 to 1995 prices. The calculated index factor was 0.985 representing a 1.5 percent decrease over the four year period. As previously indicated, shallow-draft benefits were calculated in 1992 prices, therefore, three years of price level updating was required to reflect these benefits in 1995 prices. To accomplish this, a straight line change was assumed for the 1991-1995 period, with a 1.125 percent decrease (1.5 percent times 3/4) therefore, representing the 1992-1995 period. As FY 95 IWR cost represented the latest available data at the time of this writing, it was assumed for the purpose of price level updating that the 1992-1995 change was appropriate to reflect the 1992-1996 change.

DEEP-DRAFT

IWR deep-draft vessel operating costs were used as the basis for updating the price level of the deep-draft benefits detailed in Section 8 of this appendix. FY 1993 and FY 1995 IWR operating costs were compared and the percent change was calculated for each dwt class within the vessel types demanding to use an IHNC Lock with no physical constraints. As table 10 - 5 indicates, operating costs over this period showed a decrease of approximately 7 to 28 percent for dry bulk vessels; an increase of approximately 8 percent to a decrease of 13 percent for general cargo vessels and a decrease of approximately 2 to 17 percent for container vessels. (It should be noted that IWR does not report operating costs for general cargo vessels with a dwt less than 11,000 tons even though there are general cargo vessels of this size demanding to use the IHNC Lock. As a result, a simple regression analysis was performed on the reported cost information to calculate the approximate operating costs associated with a dwt class of 3,000 tons and a dwt class having a range of 3,000 tons to 10,000 tons.)

A weighted average of FY 1993 and FY 1995 operating cost was then developed for each of the three vessel types discussed above. The number of ships demanding a lockage within each dwt class was used as the weighting factor. The

IWR Deep-Draft Vessel Operating Costs
(Total At Sea Hourly Cost; DWT In Thousands)

Vessel Type: Dry Bulk, Foreign Flag	Cost DWT 0 - 10	# Ships	Wgt Cost	Cost DWT 10 - 20	# Ships	Wgt Cost	Cost DWT 20 - 30	# Ships	Wgt Cost	Cost DWT 30 - 40	# Ships	Wgt Cost	Cost DWT 40 - 50	# Ships	Wgt Cost	Total # Ships	Total Wgted Cost
FY 1993	$458	1	$10.18	$508	4	$45.16	$557	16	$198.04	$606	20	$269.33	$656	4	$58.31	45	$581.02
FY 1995	$331	1	$7.36	$408	4	$36.27	$485	16	$172.44	$548	20	$243.56	$610	4	$54.18	45	$513.80
% Change	-27.7%			-19.7%			-12.9%			-9.6%			-7.1%				-11.6%

Vessel Type: General Cargo, Foreign F	Cost DWT 3	# Ships	Wgt Cost	Cost DWT 3 - 10	# Ships	Wgt Cost	Cost DWT 10 - 20	# Ships	Wgt Cost	Total # Ships	Total Wgted Cost
FY 1993	$308	110	$254.74	$380	3	$8.57	$557	20	$83.76	$133	$347.07
FY 1995	$333	110	$275.41	$385	3	$8.68	$485	20	$72.93	$133	$357.03
% Change	8.1%			1.3%			-12.9%				2.9%

Vessel Type: Container, Foreign Flag	Cost DWT 10 - 20	# Ships	Wgt Cost	Cost DWT 20 - 30	# Ships	Wgt Cost	Cost DWT 30 - 40	# Ships	Wgt Cost	Total # Ships	Total Wgted Cost
FY 1993	$779	2.4	$65.83	$978	23	$792.04	$1,264	3	$133.52	28.4	$991.39
FY 1995	$648	2.4	$54.78	$951	23	$769.97	$1,235	3	$130.40	28.4	$955.16
% Change	-16.8%			-2.8%			-2.3%				-3.7%

Vessel Type	# of Ships	% of Total	% Change in Costs	Wgted Change in Costs
Dry Bulk	45	21.8%	-11.6%	-2.5%
General Cargo	133	64.4%	2.9%	1.9%
Containers	28.4	13.8%	-3.7%	-0.5%

ratio of the FY 1995 weighted cost to the FY 1993 weighted cost was used as the index factor to convert from 1993 to 1995 prices for each of the vessel types. As table 10 - 5 shows, this resulted in a decrease in cost of approximately 12 percent for dry bulk vessels; an increase in cost of approximately three percent for general cargo vessels and a decrease in cost of approximately four percent for containers.

In order to convert these three index values to a single value that could be used as an overall index factor to be applied to deep-draft benefits, a weighted average value comprising all vessel types was developed using the total number of unconstrained ship demand within each vessel type as the weighting factor. This resulted in a 1.2 percent decrease in deep-draft vessel operating cost from FY 1993 to FY 1995. As the FY 95 IWR costs represented the latest available data at the time of this writing, it was assumed for the purpose of price level updating that the 1993-1995 change was appropriate to reflect the 1993-1996 change.

VEHICULAR

Vehicular benefits were calculated in 1992 prices. To price level update these benefits to 1996 prices, a 11.0 percent increase in the Consumer Price Index for total vehicular transportation during the period 1992 - 1996 was used.

OTHER

As previously indicated, no price level adjustment is required to represent the Savings to Federal Projects benefit category in 1996 dollars. For the benefit category, Navigation Losses Prevented from Rehabilitation Closure, the appropriate price level adjustment is the same as calculated for the shallow-draft benefit category.

SUMMARY OF BENEFITS

Table 10 - 6 displays the composition of total average annual benefits (1996 price level) for each alternative. Benefit estimates for each lock construction alternative are also displayed for with and without the presence of bridge operating curfews. Both shallow-draft and vehicular benefits are sensitive to these curfews.

For a given lock construction alternative, total annual benefits for the with bridge curfew condition are greater than the without bridge curfew condition. This outcome results from the fact that the positive effect of bridge curfews on vehicular benefits exceeds the negative effect

Annual Benefit Summary
(1996 $1,000, 7.375 Percent)

	Remove Bridge Curfews	Bridge Only w/o Curfews	900x90x22 with Curfews	900x90x22 w/o Curfews	900x110x22 with Curfews	900x110x22 w/o Curfews	900x110x36 with Curfews	900x110x36 w/o Curfews	1200x90x22 with Curfews	1200x90x22 w/o Curfews	1200x110x22 with Curfews	1200x110x22 w/o Curfews	1200x110x36 with Curfews	1200x110x36 w/o Curfews
Shallow Draft	**9,497**	15,378	76,815	79,885	83,982	84,569	84,508	86,033	86,880	87,028	87,396	87,493	87,448	87,474
Deep Draft	**0**	0	0	0	0	0	979	979	0	0	0	0	979	979
Vehicular	**0**	5,595	5,814	9	5,909	2,219	5,899	1,941	6,048	4,560	6,577	6,061	6,563	5,947
Savings to Fed Project	**0**	0	4,017	4,017	4,017	4,017	4,194	4,194	4,194	4,194	4,194	4,194	4,194	4,194
Maint Closure - Nav Losses Prevented	**0**	0	10,471	10,471	10,471	10,471	11,243	11,243	11,243	11,243	11,243	11,243	11,243	11,243
Total Annual Benefits	9,497	20,973	97,117	94,382	104,379	101,276	106,823	104,390	108,365	107,025	109,410	108,991	110,427	109,837
Base Year	1998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011

of the curfews on shallow-draft benefits. However, the magnitude of the with curfew advantage diminishes as the scale of the alternative increases. The magnitude of the with curfew advantage falls from approximately $2.7 million for the 900 x 90 x 22 alternative to approximately $0.4 million for the 1200 x 110 x 22 alternative.

The with curfew advantage diminishes with project scale for two reasons. First, the negative effect on shallow-draft benefits is less significant with a larger capacity lock. The larger the capacity, the more negligible the effect of losing a fixed amount of processing time. For the 900 x 90 x 22 alternative, the loss of the shallow-draft processing time associated with bridge curfews is more significant than the loss of the same absolute amount of time from the much larger capacity 1200 x 110 x 22 alternative.

Second, the positive effect on vehicular benefits is less significant with a larger capacity lock. With curfews, vehicular benefits don't vary much as project scale increases because the curfews limit bridge open time during peak periods to roughly the same degree for all alternatives. However, without curfews, vehicular benefits increase with project scale. Without curfews bridge openings are not restricted and bridge open time per ton processed becomes less with an increase in project scale.

Annual shallow-draft, deep-draft and vehicular benefits have already been discussed in detail in previous sections. The two remaining benefit categories, Savings to Federal Projects and Navigation Losses Prevented from Rehabilitation Closures, require additional explanation.

The first of these two items, Savings to Federal projects, refers to cost that would be avoided with project implementation. For the lock construction alternatives, the avoided costs would include the OM&R costs on the existing lock and the existing lock extraordinary maintenance costs that are part of the without-project condition. Annual OM&R costs for the existing lock are $1.6 million, and are claimed from year 2010 or 2011, depending on the alternative, to the end of the 50-year project life. The starting year represents the point when the existing lock would be taken out of service and lock demolition would begin.

The maintenance costs that would be avoided total $16.1 million and are scheduled over a four-year period beginning in 1999 (the schedule is described in Section 6). In calculating the annual value of these two components of Savings to Federal Projects, the expenditure streams described above were discounted to the appropriate base year for each alternative and annualized over a 50-year period.

The second benefit category that requires additional explanation is Navigation Losses Prevented from Maintenance Closures. These losses represent the cost to navigation of a total of nine months of closure during the maintenance phase of the existing lock. These costs would amount to approximately $20.0 million per month and would occur within the 1999-2002 period identified as the time frame for the scheduled maintenance work.

All benefits in table 10 - 6 represent 1996 price levels. Annual benefits were calculated using an interest rate of 7.375 percent, a 50-year project life, and an alternative specific base year as indicated in the table. It should be noted in the previous sections of the appendix detailing shallow-draft, deep-draft, and vehicular benefits, slightly different average annual values are displayed. This is the result of different price level, interest rate, and base year assumptions.

ECONOMIC JUSTIFICATION

Table 10 - 7 summarizes the annual costs, annual benefits, net benefits, and benefit-to-cost ratios (BCR) for each alternative with and without bridge operating curfews. Net benefits represent the difference between total annual benefits and total annual costs. Maximum net benefits define the NED plan.

Because all annual benefits and annual costs reflect the base year (the first year of project operation) of the alternative in question, it is necessary to account for the fact that alternatives have different implementation dates when identifying the alternative that generates the maximum net benefits. To account for this effect of differing base years, the net benefits of each alternative can be shifted forward or backward, using present value techniques, such that all alternatives reflect a common point in time. This adjustment is reflected in table 10 - 7 by using the year 2010 as the common reference point. **For NED identification** purposes, the result of this common reference adjustment is that alternatives with a base year prior to 2010 show a greater value for net benefits than that associated with its actual base year (net benefits are compounded), and alternatives with a base year after 2010 show a lower value for net benefits (net benefits are discounted). It should be noted that the selection of a different common reference point does not affect the relative standing of alternatives, only the absolute amount of the net benefits would be affected. Net benefits are maximized with the 900

Table 10 - 7

Mid Growth Scenario
Alternative Summary
(1996 $1,000, 7.375 Percent)

	Remove	Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
	Bridge Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews
Total Annual Cost	8,581	5,465	49,352	49,352	50,960	50,960	57,846	57,846	54,745	54,745	58,086	58,086	61,194	61,194
Total Annual Benefits	9,497	20,973	97,117	94,382	104,379	101,276	106,823	104,390	108,365	107,025	109,410	108,991	110,427	109,837
Net Benefits	916	15,508	47,765	45,030	53,419	50,316	48,977	46,544	53,620	52,280	51,324	50,905	49,233	48,643
BCR	1.11	3.84	1.97	1.91	2.05	1.99	1.85	1.80	1.98	1.95	1.88	1.88	1.80	1.79
Base Year	1998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	2,151	20,614	47,765	45,030	53,419	50,316	45,613	43,347	49,937	48,689	47,799	47,409	45,851	45,302

x 100 x 22 alternative with bridge operating curfews in place ($53.4 million). This alternative also produces the highest BCR among the lock construction alternatives (2.05 to 1). The Bridge Only alternative produces a higher BCR (3.8 to 1), but it represents a significantly smaller scale project. As a result, the net benefits of the Bridge Only alternative ($20.6 million) are considerably lower than any of the lock construction alternatives.

SECTION 11 - SENSITIVITY ANALYSIS

OVERVIEW

Given the nature and complexity of the benefit measurement procedures, an unavoidable component of uncertainty is implicit in the estimates of project benefits. A single change to any number of parameter values or assumptions holds the potential for significantly affecting benefit estimates, and ultimately, in turn, project formulation. The role of sensitivity analysis is to identify those parameters and assumptions with the greatest potential for project formulation impact and to evaluate the magnitude of those impacts for discrete changes in the key parameters. The parameters identified as potentially significant, and consequently incorporated into the sensitivity analysis, include, shallow-draft traffic projections, deep-draft traffic projections, the assumed timing of project implementation, the discount rate, and alternative design elevations for lock floor/sill construction. In the following paragraphs of this section, the impacts on project benefits and plan formulation resulting from alternative parameter values and assumptions are presented.

ALTERNATIVE TRAFFIC GROWTH

SHALLOW-DRAFT

Low Growth Scenario

Projected shallow-draft traffic volumes and commodity group growth rates reflecting the low growth scenario have been described earlier in Section 2. The result of incorporating those projected traffic volumes into the system modelling on IHNC Lock accommodated traffic, average delay, percent of total demand accommodated, unaccommodated traffic, and system benefits are detailed in tables 11 - 1 through 11 - 5, respectively.

Because of the lower overall system demand, traffic processed at IHNC Lock is consistently lower for the low growth scenario compared to the mid growth scenario. This difference is most pronounced for the lock construction scenarios where virtually all demand, for both the mid and the low scenarios, is accommodated throughout the project life. As a result, the difference between the mid and low scenarios reflects the difference in the overall level of projected traffic. However, for the without-project condition, and to a lesser extent for the bridge improvement plans, the accommodated traffic with the low

Table 11 - 1
Low Growth Scenario
IHNC Lock Traffic Accomodated
(1,000 Tons)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	23,056	22,888	25,122	25,728	26,277	26,277	26,691
Removal of Bridge Curfews	23,056	22,888	25,567	27,042	27,697	27,738	28,072
Replace St. Claude Bridge	23,056	22,888	25,567	27,700	28,510	28,856	29,041
900 x 90 x 22 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,855
900 x 90 x 22 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,861
900 x 110 x 22 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
900 x 110 x 22 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
900 x 110 x 36 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
900 x 110 x 36 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 90 x 22 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 90 x 22 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 110 x 22 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 110 x 22 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 110 x 36 ft. (With bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867
1200 x 110 x 36 ft. (Without bridge curfews)	23,056	22,888	25,567	27,712	30,496	33,924	42,867

Table 11 - 2
Low Growth Scenario
IHNC Lock Average Delays
By Alternative and Year
(Hours)

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	10.4	10.0	20.8	28.2	40.7	40.7	60.2
Removal of Bridge Curfews	6.3	6.0	12.3	24.0	39.2	40.7	60.2
Replace St. Claude Bridge	3.7	3.6	6.7	15.3	27.5	40.7	54.5
900 x 90 x 22 ft. (With bridge curfews)	0.6	0.6	0.8	0.5	1.3	1.8	13.2
900 x 90 x 22 ft. (Without bridge curfews)	0.4	0.4	0.4	0.5	0.7	1.0	4.5
900 x 110 x 22 ft. (With bridge curfews)	0.3	0.3	0.4	0.5	0.6	0.7	1.5
900 x 110 x 22 ft. (Without bridge curfews)	0.3	0.3	0.4	0.4	0.5	0.7	1.3
900 x 110 x 36 ft. (With bridge curfews)	0.5	0.4	0.5	0.6	0.8	1.0	2.0
900 x 110 x 36 ft. (Without bridge curfews)	0.3	0.3	0.4	0.4	0.5	0.6	1.3
1200 x 90 x 22 ft. (With bridge curfews)	0.3	0.3	0.3	0.3	0.4	0.5	1.0
1200 x 90 x 22 ft. (Without bridge curfews)	0.2	0.2	0.3	0.3	0.4	0.5	0.9
1200 x 110 x 22 ft. (With bridge curfews)	0.2	0.2	0.2	0.3	0.3	0.4	0.6
1200 x 110 x 22 ft. (Without bridge curfews)	0.2	0.2	0.2	0.2	0.3	0.3	0.5
1200 x 110 x 36 ft. (With bridge curfews)	0.2	0.2	0.2	0.2	0.3	0.4	0.6
1200 x 110 x 36 ft. (Without bridge curfews)	0.2	0.2	0.2	0.2	0.3	0.3	0.6

Table 11 - 3
Low Growth Scenario
IHNC Lock Percent of Total Demand Accomodated

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	100	100	98.3	92.8	86.2	77.5	62.2
Removal of Bridge Curfews	100	100	100	97.6	90.8	81.8	65.4
Replace St. Claude Bridge	100	100	100	100	93.5	85.1	67.7
900 x 90 x 22 ft. (With bridge curfews)	100	100	100	100	100	100	100
900 x 90 x 22 ft. (Without bridge curfews)	100	100	100	100	100	100	
900 x 110 x 22 ft. (With bridge curfews)	100	100	100	100	100	100	
900 x 110 x 22 ft. (Without bridge curfews)	100	100	100	100	100	100	100
900 x 110 x 36 ft. (With bridge curfews)	100	100	100	100	100	100	100
900 x 110 x 36 ft. (Without bridge curfews)	100	100	100	100	100	100	100
1200 x 90 x 22 ft. (With bridge curfews)	100	100	100	100	100	100	100
1200 x 90 x 22 ft. (Without bridge curfews)	100	100	100	100	100	100	100
1200 x 110 x 22 ft. (With bridge curfews)	100	100	100	100	100	100	100
1200 x 110 x 22 ft. (Without bridge curfews)	100	100	100	100	100	100	100
1200 x 110 x 36 ft. (With bridge curfews)	100	100	100	100	100	100	100
1200 x 110 x 36 ft. (Without bridge curfews)	100	100	100	100	100	100	100

Table 11 - 4
Low Growth Scenario
IHNC Lock Traffic Unaccomodated
(1,000 tons)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	0	0	445	1,984	4,219	7,647	16,234
Removal of Bridge Curfews	0	0	0	670	2,799	6,186	14,853
Replace St. Claude Bridge	0	0	0	12	1,986	5,068	13,884
900 x 90 x 22 ft. (With bridge curfews)	0	0	0	0	0	0	70
900 x 90 x 22 ft. (Without bridge curfews)	0	0	0	0	0	0	64
900 x 110 x 22 ft. (With bridge curfews)	0	0	0	0	0	0	58
900 x 110 x 22 ft. (Without bridge curfews)	0	0	0	0	0	0	58
900 x 110 x 36 ft. (With bridge curfews)	0	0	0	0	0	0	58
900 x 110 x 36 ft. (Without bridge curfews)	0	0	0	0	0	0	58
1200 x 90 x 22 ft. (With bridge curfews)	0	0	0	0	0	0	58
1200 x 90 x 22 ft. (Without bridge curfews)	0	0	0	0	0	0	58
1200 x 110 x 22 ft. (With bridge curfews)	0	0	0	0	0	0	58
1200 x 110 x 22 ft. (Without bridge curfews)	0	0	0	0	0	0	58
1200 x 110 x 36 ft. (With bridge curfews)	0	0	0	0	0	0	58
1200 x 110 x 36 ft. (Without bridge curfews)	0	0	0	0	0	0	58

Table 11 - 5
Low Growth Scenario
Shallow-Draft
Total & Incremental Transportation Savings
(1992, $1,000)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	1,251,510	1,204,232	1,270,643	1,269,453	1,288,546	1,337,355	1,128,953
Removal of Bridge Curfews	1,256,850	1,209,293	1,282,732	1,275,775	1,290,956	1,337,355	1,128,953
	5,339	5,060	12,089	6,321	2,410	0	0
Replace of St. Claude Bridge	1,260,154	1,212,468	1,290,921	1,289,186	1,309,501	1,337,355	1,138,144
	8,644	8,236	20,277	19,733	20,955	0	9,192
900 x 90 x 22 ft.	1,264,184	1,216,371	1,299,459	1,312,506	1,354,392	1,409,445	1,216,871
(With bridge curfews)	12,674	12,139	28,815	43,052	65,846	72,089	87,918
900 x 90 x 22 ft.	1,264,544	1,216,726	1,299,969	1,312,417	1,355,401	1,411,144	1,237,450
(Without bridge curfews)	13,034	12,494	29,325	42,964	66,855	73,789	108,497
900 x 110 x 22 ft.	1,264,558	1,216,738	1,300,011	1,312,502	1,355,587	1,411,600	1,244,580
(With bridge curfews)	13,048	12,506	29,367	43,049	67,041	74,244	115,627
900 x 110 x 22 ft.	1,264,596	1,216,775	1,300,064	1,312,573	1,355,689	1,411,761	1,245,187
(Without bridge curfews)	13,085	12,543	29,421	43,120	67,143	74,406	116,234
900 x 110 x 36 ft.	1,264,418	1,216,600	1,299,823	1,312,265	1,355,269	1,411,148	1,243,403
(With bridge curfews)	12,908	12,368	29,180	42,811	66,723	73,792	114,450
900 x 110 x 36 ft.	1,264,610	1,216,789	1,300,083	1,312,596	1,355,720	1,411,802	1,245,276
(Without bridge curfews)	13,100	12,557	29,439	43,143	67,173	74,447	116,323
1200 x 90 x 22 ft.	1,264,909	1,216,857	1,300,175	1,312,715	1,355,882	1,412,040	1,245,963
(With bridge curfews)	13,399	12,625	29,532	43,262	67,336	74,685	117,010
1200 x 90 x 22 ft.	1,264,920	1,216,868	1,300,192	1,312,738	1,355,916	1,412,096	1,246,175
(Without bridge curfews)	13,410	12,636	29,549	43,284	67,370	74,740	117,222
1200 x 110 x 22 ft.	1,264,976	1,217,152	1,300,526	1,313,118	1,356,366	1,412,655	1,247,267
(With bridge curfews)	13,466	12,920	29,883	43,664	67,820	75,299	118,314
1200 x 110 x 22 ft.	1,264,998	1,217,174	1,300,555	1,313,155	1,356,416	1,412,724	1,247,430
(Without bridge curfews)	13,488	12,942	29,912	43,702	67,870	75,369	118,478
1200 x 110 x 36 ft.	1,264,994	1,217,170	1,300,549	1,313,146	1,356,401	1,412,700	1,247,347
(With bridge curfews)	13,484	12,938	29,905	43,692	67,855	75,345	118,395
1200 x 110 x 36 ft.	1,264,995	1,217,170	1,300,550	1,313,149	1,356,407	1,412,711	1,247,397
(Without bridge curfews)	13,484	12,938	29,907	43,695	67,861	75,356	118,444

scenario is significantly lower than the mid scenario only during the early years of analysis. After a point, even the lower traffic demand of the low growth scenario reaches the level where demand is high relative to capacity and traffic is diverted. In other words, the low growth scenario is able to use up the available capacity, it just takes longer than the mid growth scenario. This overall condition is mirrored in the pattern of average delay. It shows that the low growth average delay for the without-project condition is significantly lower than the mid growth average delay during the early years, but approaches, and finally reaches, the mid growth average delay in the later years.

Table 11 - 5 displays the shallow draft system benefits for the low growth scenario. It reveals that for the lock construction alternatives, low growth average annual savings are approximately 60 percent of mid growth average annual savings. The lower level of traffic demand associated with the low growth scenario generates fewer tons that can benefit from the lower delays that result from additional lock capacity.

However, for the bridge replacement plan, low growth scenario average annual savings are substantially higher vis a via the mid growth scenario. In fact, the low growth average annual savings actually slightly exceed the mid growth annual savings. During the early project years, mid growth savings exceed those of the low growth scenario as more traffic is accommodated due to a higher demand. However, after the additional capacity that is provided by the bridge replacement plan is utilized by the increased demand, system savings are eroded to the point where the savings attributable to the additional traffic is completely offset by the increase in delay at IHNC and other system locks. With the low growth scenario, the slower rate of traffic increase means that the additional capacity is not utilized as quickly and savings are generated for a longer time, albeit, at a lower absolute level than with the mid growth. On an average annual basis, the more steady stream of low growth scenario savings is greater than the faster rising then declining savings stream of the mid growth scenario.

High Growth Scenario

Projected shallow-draft traffic volumes and commodity group growth rates reflecting the high growth scenario have also been described earlier in Section 2. The result of incorporating these projected traffic volumes into the system modelling on IHNC Lock accommodated traffic, average delay, percent of total demand accommodated, unaccommodated traffic, and system benefits are detailed in tables 11 - 6 through 11 - 10, respectively.

Because of the greater overall system demand, traffic processed at IHNC Lock is consistently higher for the high growth scenario compared to the mid growth scenario. Unlike the mid growth scenario where the lock construction plans are able to process virtually all IHNC Lock demand, the high growth scenario generates some minimal diversions early in the project life and significant amounts late in the project life. For the bridge improvement plans, this pattern is magnified, with diversions occurring sooner and in larger quantities vis a vis the mid growth scenario. The modest capacity increases provided by the bridge improvement plans are rapidly consumed by the high growth scenario traffic demand, using up the available capacity more quickly than the mid growth scenario. This overall condition is mirrored in the pattern of average delay. It shows that the high growth average delay for the without-project condition is significantly larger than the mid growth average delay during the early years, but this difference diminishes over time. For the lock improvement plans there are only minor differences in average delay until later in the period of analysis. In the early years the percent of utilized capacity remains sufficiently low even with the high growth scenario to generate substantially different delays among alternatives. Much later in the period of analysis, when traffic demand is higher and capacity begins to be pushed for the smaller lock improvement plans, differences in average delay appear. For the bridge improvement plans, the increases in average delay occur early in the period of analysis and quickly approach the delays of the without project condition.

No Growth After 20 Years

The "No Growth After 20 Years" scenario describes a condition where traffic is projected using the mid growth rates for only twenty years beyond the baseline traffic year. Given the 1990 baseline year, the terminal year of projections, with this scenario, is 2010. Beyond 2010 traffic is held constant at the 2010 level. Because this scenario represents a truncated mid growth projection, traffic accommodated, average delays, unaccommodated traffic, and system savings are identical to the mid growth results for a specific year. However, the average annual savings for each project alternative differ from the mid growth scenario because traffic growth beyond 2010 is not considered. Average annual savings for the "No Growth After 20 Years" scenario are displayed in table 11 - 11.

Table 11 - 6
High Growth Scenario
IHNC Lock Traffic Accomodated
(1,000 Tons)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	23,056	26,277	26,600	26,600	26,691	26,706	27,149
Removal of Bridge Curfews	23,056	27,252	27,738	27,999	28,072	28,072	28,416
Replace St. Claude Bridge	23,056	28,016	28,856	29,041	29,041	29,092	29,302
900 x 90 x 22 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,215	44,150	44,313
900 x 90 x 22 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	45,868	45,996
900 x 110 x 22 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,696	56,295
900 x 110 x 22 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	58,680
900 x 110 x 36 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,696	56,077
900 x 110 x 36 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	58,510
1200 x 90 x 22 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	60,677
1200 x 90 x 22 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	62,836
1200 x 110 x 22 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	69,076
1200 x 110 x 22 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	69,091
1200 x 110 x 36 ft. (With bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	69,076
1200 x 110 x 36 ft. (Without bridge curfews)	23,056	28,392	32,992	38,200	43,315	50,699	69,076

Table 11 - 7
High Growth Scenario
IHNC Lock Average Delays
By Alternative and Year
(Hours)

Condition	1990	2000	2010	2020	2030	2040	2060
Without Project	10.4	40.7	54.5	54.5	60.2	61.2	123.3
Removal of Bridge Curfews	6.3	27.5	40.7	54.5	60.2	60.2	115.4
Replace St. Claude Bridge	3.7	18.6	40.7	54.5	54.5	60.2	103.3
900 x 90 x 22 ft. (With bridge curfews)	0.6	1.0	1.7	3.5	16.4	40.7	54.5
900 x 90 x 22 ft. (Without bridge curfews)	0.4	0.6	0.9	1.7	5.2	38.2	54.5
900 x 110 x 22 ft. (With bridge curfews)	0.3	0.5	0.7	1.0	1.6	4.1	40.7
900 x 110 x 22 ft. (Without bridge curfews)	0.3	0.5	0.6	0.9	1.3	2.9	40.7
900 x 110 x 36 ft. (With bridge curfews)	0.5	0.7	0.9	1.4	2.1	5.4	40.7
900 x 110 x 36 ft. (Without bridge curfews)	0.3	0.4	0.6	0.9	1.3	2.9	40.7
1200 x 90 x 22 ft. (With bridge curfews)	0.3	0.4	0.5	0.7	1.0	2.0	40[illegible]
1200 x 90 x 22 ft. (Without bridge curfews)	0.2	0.3	0.5	0.6	0.9	1.7	35.4
1200 x 110 x 22 ft. (With bridge curfews)	0.2	0.3	0.4	0.5	0.6	1.0	6.9
1200 x 110 x 22 ft. (Without bridge curfews)	0.2	0.3	0.3	0.4	0.6	0.9	4.4
1200 x 110 x 36 ft. (With bridge curfews)	0.2	0.3	0.3	0.4	0.6	0.9	8.6
1200 x 110 x 36 ft. (Without bridge curfews)	0.2	0.3	0.3	0.4	0.6	0.9	5.0

Table 11 - 8
High Growth Scenario
IHNC Lock Percent of Total Demand Accomodated

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	100	92.6	80.6	69.5	59.5	50.3	35.0
Removal of Bridge Curfews	100	96.0	84.1	73.2	62.6	52.9	36.6
Replace St. Claude Bridge	100	98.7	87.5	75.9	64.8	54.8	37.8
900 x 90 x 22 ft. (With bridge curfews)	100	100	100	99.8	96.4	83.2	57.1
900 x 90 x 22 ft. (Without bridge curfews)	100	100	100	99.8	96.6	86.4	59.3
900 x 110 x 22 ft. (With bridge curfews)	100	100	100	99.8	96.6	95.5	72.6
900 x 110 x 22 ft. (Without bridge curfews)	100	100	100	99.8	96.6	95.5	75.6
900 x 110 x 36 ft. (With bridge curfews)	100	100	100	99.8	96.6	95.5	72.3
900 x 110 x 36 ft. (Without bridge curfews)	100	100	100	99.8	96.6	95.5	75.4
1200 x 90 x 22 ft. (With bridge curfews)	100	100	100	99.8	96.6	95.5	78.2
1200 x 90 x 22 ft. (Without bridge curfews)	100	100	100	99.8	96.6	95.5	81.0
1200 x 110 x 22 ft. (With bridge curfews)	100	100	100	99.8	96.6	95.5	89.0
1200 x 110 x 22 ft. (Without bridge curfews)	100	100	100	99.8	96.6	95.5	89.1
1200 x 110 x 36 ft. (With bridge curfews)	100	100	100	99.8	96.6	95.5	89.0
1200 x 110 x 36 ft. (Without bridge curfews)	100	100	100	99.8	96.6	95.5	89.0

Table 11 - 9
High Growth Scenario
IHNC Lock Traffic Unaccomodated
(1,000 tons)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	0	2,115	6,392	11,665	18,135	26,383	50,425
Removal of Bridge Curfews	0	1,140	5,254	10,266	16,754	25,017	49,158
Replace St. Claude Bridge	0	376	4,136	9,224	15,785	23,997	48,272
900 x 90 x 22 ft. (With bridge curfews)	0	0	0	65	1,611	8,939	33,261
900 x 90 x 22 ft. (Without bridge curfews)	0	0	0	65	1,511	7,221	31,578
900 x 110 x 22 ft. (With bridge curfews)	0	0	0	65	1,511	2,393	21,279
900 x 110 x 22 ft. (Without bridge curfews)	0	0	0	65	1,511	2,390	18,894
900 x 110 x 36 ft. (With bridge curfews)	0	0	0	65	1,511	2,393	21,497
900 x 110 x 36 ft. (Without bridge curfews)			0	65	1,511	2,390	19,064
1200 x 90 x 22 ft. (With bridge curfews)	0	0	0	65	1,511	2,390	16,897
1200 x 90 x 22 ft. (Without bridge curfews)	0	0	0	65	1,511	2,390	14,738
1200 x 110 x 22 ft. (With bridge curfews)	0	0	0	65	1,511	2,390	8,498
1200 x 110 x 22 ft. (Without bridge curfews)	0	0	0	65	1,511	2,390	8,483
1200 x 110 x 36 ft. (With bridge curfews)	0	0	0	65	1,511	2,390	8,498
1200 x 110 x 36 ft. (Without bridge curfews)	0	0	0	65	1,511	2,390	8,498

Table 11 - 10
High Growth Scenario
Shallow Draft
Total & Incremental Transportation Savings
(1992, $1,000)

Alternative	1990	2000	2010	2020	2030	2040	2060
Without Project	1,251,510	1,345,946	1,318,124	1,278,015	1,158,490	1,294,706	1,154,217
Removal of Bridge Curfews	1,256,850	1,365,707	1,339,314	1,278,015	1,158,490	1,296,323	1,162,319
	5,339	19,761	21,190	0	0	1,617	8,102
Replace of St. Claude Bridge	1,260,154	1,379,611	1,339,314	1,278,015	1,165,753	1,296,323	1,177,515
	8,644	33,665	21,190	0	7,263	1,617	23,299
900 x 90 x 22 ft.	1,264,184	1,407,694	1,409,846	1,327,869	1,248,771	1,333,789	1,272,469
(With bridge curfews)	12,674	61,748	91,722	49,855	90,281	39,083	118,253
900 x 90 x 22 ft.	1,264,544	1,408,441	1,411,312	1,331,745	1,276,165	1,340,368	1,272,469
(Without bridge curfews)	13,034	62,495	93,188	53,730	117,675	45,662	118,253
900 x 110 x 22 ft.	1,264,558	1,408,544	1,411,670	1,333,189	1,285,054	1,386,432	1,311,513
(With bridge curfews)	13,048	62,598	93,546	55,174	126,565	91,727	157,296
900 x 110 x 22 ft.	1,264,596	1,408,621	1,411,812	1,333,484	1,285,714	1,389,872	1,311,513
(Without bridge curfews)	13,085	62,675	93,688	55,469	127,224	95,166	157,296
900 x 110 x 36 ft.	1,264,418	1,408,290	1,411,259	1,332,479	1,283,807	1,382,707	1,311,513
(With bridge curfews)	12,908	62,344	93,135	54,464	125,317	88,002	157,296
900 x 110 x 36 ft.	1,264,610	1,408,646	1,411,850	1,333,545	1,285,806	1,390,019	1,311,513
(Without bridge curfews)	13,100	62,700	93,726	55,530	127,317	95,313	157,296
1200 x 90 x 22 ft.	1,264,909	1,409,057	14,123,948	1,334,317	1,286,972	1,392,998	1,311,487
(With bridge curfews)	13,399	63,111	12,805,824	56,302	128,482	98,292	157,271
1200 x 90 x 22 ft.	1,264,920	1,409,082	1,412,443	1,334,421	1,287,202	1,393,921	1,331,077
(Without bridge curfews)	13,410	63,136	94,320	56,406	128,712	99,215	176,860
1200 x 110 x 22 ft.	1,264,976	1,409,194	1,412,640	1,334,794	1,287,908	1,395,980	1,440,519
(With bridge curfews)	13,466	63,248	94,516	56,779	129,418	101,274	286,303
1200 x 110 x 22 ft.	1,264,998	1,409,234	14,127,033	1,334,899	1,288,080	1,396,347	1,450,402
(Without bridge curfews)	13,488	63,287	12,808,909	56,884	129,590	101,641	296,185
1200 x 110 x 36 ft.	1,264,994	1,409,223	1,412,682	1,334,855	1,287,991	1,396,095	1,433,734
(With bridge curfews)	13,484	63,277	94,558	56,840	129,501	101,389	279,517
1200 x 110 x 36 ft.	1,264,995	1,409,227	1,412,692	1,334,879	1,288,044	1,396,265	1,448,058
(Without bridge curfews)	13,484	63,281	94,568	56,864	129,555	101,560	293,841

Comparison of Average Annual Shallow Draft Savings
by Traffic Growth Scenario
(1996 $1,000, 7.375 Percent)

	Average Annual Savings					Percent Advantage VS Mid Growth				
Alternative	Mid	Low	High	No Growth After 20 Yrs	South American Coal	Mid	Low	High	No Growth After 20 Yrs	South American Coal
Removal of Bridge Curfews	9,497	6,967	14,444	8,055		0	-27	52	-15	-
Replace of St Claude Bridge	15,378	18,016	13,164	21,615		0	17	-14	41	-
900 x 90 x 22 (With Bridge Curfews)	76,815	48,381	73,263	66,427	73,297		-37	-5	-14	-5
900 x 90 x 22 (Without Bridge Curfews)	79,885	49,591	80,896	67,365	-	0	-38	1	-16	-
900 x 110 x 22 (With Bridge Curfews)	83,885	49,964	89,625	67,522	78,319	0	-40	7	-20	-7
900 x 110 x 22 (Without Bridge Curfews)	84,569	50,065	90,283	67,619	-	0	-41	7	-20	-
900 x 110 x 36 (With Bridge Curfews)	84,508	51,312	88,222	67,219	-	0	-39	4	-20	-
900 x 110 x 36 (Without Bridge Curfews)	86,033	51,754	90,072	67,647	-	0	-40	5	-21	-
1200 x 90 x 22 (With Bridge Curfews)	86,880	51,914	91,110	68,108	-	0	-40	5	-22	-
1200 x 90 x 22 (Without Bridge Curfews)	87,028	51,949	92,082	68,138	-	0	-40	6	-22	-
1200 x 110 x 22 (With Bridge Curfews)	87,396	52,389	96,923	68,276	-	0	-40	11	-22	-
1200 x 110 x 22 (Without Bridge Curfews)	87,493	52,436	97,444	68,323	-	0	-40	11	-22	-
1200 x 110 x 36 (With Bridge Curfews)	87,448	52,421	96,725	68,309	-	0	-40	11	-22	
1200 x 110 x 36 (Without Bridge Curfews)	87,474	52,427	96,931	68,315	-	0	-40	11	-22	

South American Coal Imports Scenario

This scenario reflects the recent partial shift of one utility to low sulphur South American coal imports as a response to the Clean Air Act requirements. This switch, which was initiated in mid 1993, is expected to remain in effect as an extended trial for the next several years. In order to address the sensitivity of this switch as a potential long term outcome, the total coal volume shipped through IHNC Lock to this utility was assumed to be eliminated for the entire period of analysis. This traffic amounted to approximately 1.1 million tons in the 1990 baseline traffic. With this traffic eliminated, all other traffic was projected using the mid growth scenario rates.

Using the modified traffic volumes described above, system savings were calculated over the period of analysis for two lock construction alternatives, 900 x 110 x 22 ft lock with curfews, and 900 x 90 x 22 ft lock with curfews. These two sizes were selected because they represent the NED Plan and the next smallest increment, respectively. For all of the lock construction plans, reductions in traffic of this magnitude will consistently result in lower average annual savings. Therefore, to evaluate project formulation impacts, it was not necessary to consider alternatives larger in scope than the NED Plan. However, it was necessary to consider plan(s) of lesser scale. The average annual savings for the two alternatives described above are displayed in table 11 - 11. As the table shows, the reductions in average annual shallow-draft savings are five and seven percent, respectively, for the 900 x 90 x 22 ft and 900 x 110 x ft locks.

Comparison Summary

Table 11 - 11 provides a summary of the average annual shallow-draft savings by project alternative for each of the traffic growth scenarios.

DEEP-DRAFT

Low Growth Scenario

As described previously in Section 2, the low growth scenario for deep-draft traffic reflects no change in traffic activity from the baseline 1990 volumes. Therefore, the unconstrained total demand, lockages, and savings for all future years are identical to those described for the 1990 condition for each respective alternative.

High Growth Scenario

Projected deep-draft growth rates reflecting the high growth scenario have also been described earlier in Section 2. The resultant number of projected lockages and the associated savings from use of these high growth rates are detailed in tables 11 - 12 and 11 - 13, respectively.

No Growth after 20 Years

As was described earlier, the "No Growth After 20 Years" scenario reflects a condition where traffic is projected using the mid growth rates for only twenty years beyond the baseline traffic year. Given the 1990 baseline year, the terminal year of projections is 2010 for this alternative. Beyond 2010, traffic is held constant at the 2010 level. Because this scenario represents a truncated mid growth projection, demand, lockages, and savings are identical to the mid growth results for a specific year. However, the average annual savings for each project alternative differ from the mid growth scenario because traffic changes beyond 2010 are not considered. Average annual savings for the "No Growth After 20 Years" scenario are displayed in table 11 - 14.

Comparison Summary

Table 11 - 14 provides a summary of the average annual deep-draft savings by project alternative for each of the traffic growth scenarios.

For each of the 22-foot sill alternatives, the low growth scenario results in a smaller negative value, i.e., a smaller loss, than the mid growth scenario. This follows from the fact that the 22-foot sill alternatives provide a lesser level of deep-draft service than the existing lock. Therefore, with lower future demand, the low growth scenario results in a smaller loss for these alternatives compared to mid growth. This result does not hold for the 36-foot sill alternatives, however. For these alternatives, a lower level of demand produces a smaller savings compared to the mid growth since deep-draft service is enhanced with the 36-foot alternatives.

With the high growth scenario, the 22-foot sill alternatives produce a substantially greater loss than with the mid growth scenario. This occurs because of higher demand and the lower level of deep-draft service compared to the existing lock. For the 36-foot sill alternatives, the higher demand of the high growth scenario produces significantly higher savings than the mid growth scenario.

Table 11 - 12

High Growth Scenario
Total Deep Draft Lockages

Alternative		2000	2010	2020	2030	2040	2060
Existing	Intra	169.1	240.9	343.0	488.6	695.9	1,411.7
	Thru	20.6	29.4	41.8	59.6	84.9	172.2
	Total	189.7	270.3	384.8	548.2	780.8	1,583.9
900 x 90 x 22	Intra	136.5	194.5	277.0	394.5	561.9	1,139.9
	Thru	20.6	29.4	41.8	59.6	84.9	172.2
	Total	157.1	223.9	318.8	454.1	646.8	1,312.1
900 x 110 x 22	Intra	136.5	194.5	277.0	394.5	561.9	1,139.9
	Thru	20.6	29.4	41.8	59.6	84.9	172.2
	Total	157.1	223.9	318.8	454.1	646.8	1,312.1
900 x 110 x 36	Intra	224.1	319.2	454.6	647.4	922.2	1,870.8
	Thru	59.6	85.0	121.0	172.4	245.6	498.1
	Total	283.7	404.2	575.6	819.8	1,167.8	2,368.9
1200 x 90 x 22	Intra	136.5	194.5	277.0	394.5	561.9	1,139.9
	Thru	20.6	29.4	41.8	59.6	84.9	172.2
	Total	157.1	223.9	318.8	454.1	646.8	1,312.1
1200 x 110 x 22	Intra	136.5	194.5	277.0	394.5	561.9	1,139.9
	Thru	20.6	29.4	41.8	59.6	84.9	172.2
	Total	157.1	223.9	318.8	454.1	646.8	1,312.1
1200 x 110 x 36	Intra	224.1	319.2	454.6	647.4	922.2	1,870.8
	Thru	59.6	85.0	121.0	172.4	245.6	498.1
	Total	283.7	404.2	575.6	819.8	1,167.8	2,368.9

Table 11 - 13

Deep Draft Benefits
High Growth Scenario
($1,000's - 1993 Price Levels)

Alternative		1991	2000	2010	2020	2030	2040	2060
Existing	Intra	931	1,280	1,822	2,596	3,697	5,266	10,682
	Thru	11	15	21	30	42	60	122
	Total	942	1,295	1,843	2,626	3,739	5,326	10,804
900 x 90 x 22	Intra	669	920	1,311	1,867	2,659	3,787	7,683
	Thru	11	15	21	30	42	60	122
	Total	680	935	1,332	1,897	2,701	3,847	7,805
	Incremental	(262)	(360)	(511)	(729)	(1,038)	(1,479)	(2,999)
900 x 110 x 22	Intra	669	920	1,311	1,867	2,659	3,787	7,683
	Thru	11	15	21	30	42	60	122
	Total	680	935	1,332	1,897	2,701	3,847	7,805
	Incremental	(262)	(360)	(511)	(729)	(1,038)	(1,479)	(2,999)
900 x 110 x 36	Intra	1,413	1,942	2,766	3,940	5,611	7,992	16,213
	Thru	55	75	107	153	218	310	629
	Total	1,468	2,017	2,873	4,093	5,829	8,302	16,842
	Incremental	526	722	1,030	1,467	2,090	2,976	6,03[illegible]
1200 x 90 x 22	Intra	669	920	1,311	1,867	2,659	3,787	7,683
	Thru	11	15	21	30	42	60	122
	Total	680	935	1,332	1,897	2,701	3,847	7,805
	Incremental	(262)	(360)	(511)	(729)	(1,038)	(1,479)	(2,999)
1200 x 110 x 22	Intra	669	920	1,311	1,867	2,659	3,787	7,683
	Thru	11	15	21	30	42	60	122
	Total	680	935	1,332	1,897	2,701	3,847	7,805
	Incremental	(262)	(360)	(511)	(729)	(1,038)	(1,479)	(2,999)
1200 x 110 x 36	Intra	1,413	1,942	2,766	3,940	5,611	7,992	16,213
	Thru	55	75	107	153	218	310	629
	Total	1,468	2,017	2,873	4,093	5,829	8,302	16,842
	Incremental	526	722	1,030	1,467	2,090	2,976	6,038

Table 11 - 14

Comparison of Deep-Draft Incremental Benefits
(1996, $1,000, 7.375%)

Alternative	Average Annual Benefits				Percent Advantage vs Mid Growth			
	Mid	Low	High	No Growth After 20 Yrs	Mid	Low	High	No Growth After 20 Yrs
900 x 90 x 22	(477)	(268)	(892)	(375)	0	45	(82)	23
900 x 110 x 22	(477)	(268)	(892)	(375)	0	45	(82)	23
900 x 110 x 36	979	539	1,862	757	0	(45)	91	(22)
1200 x 90 x 22	(486)	(268)	(925)	(375)	0	45	(91)	23
1200 x 110 x 22	(486)	(268)	(925)	(375)	0	45	(91)	23
1200 x 110 x 36	979	539	1,862	757	0	(45)	91	(22)

Compared to the mid growth scenario, the "No Growth After 20 Years" scenario, produces smaller losses for the 22-foot sill alternatives and smaller savings for the 36-foot sill alternatives. As before, the amount of savings compared to the mid growth scenario depends on the relative magnitudes of demand and deep-draft service provided.

PROJECT FORMULATION

To explore the implications of alternative traffic growth rate assumptions on project formulation, the average annual net benefits for each alternative plan were determined using the low and high growth scenarios previously described. The results of these low and high growth scenarios are displayed in table 11 - 15 and table 11 - 16, respectively. Table 11 - 17 provides the same information for the "No Growth After 20 Years" scenario.

Comparing the results of the alternative growth scenarios with the results of the mid growth scenario reveals that the NED plan is sensitive to traffic growth projections. As is shown in table 11 - 15, with the low growth scenario, the NED plan nearly shifts to the next smallest scale alternative, the 900 x 90 x 22 ft lock. The high growth scenario in table 11 - 16 reveals no change in the NED plan (900 x 110 x 22 ft lock) as compared to the mid growth projections. There are higher annual benefits associated with the larger alternative lock sizes when high growth is assumed, but not by enough to change the NED plan. Table 11 - 17 reveals that the "No Growth After 20 Years" scenario results in a 900 x 90 x 22 ft lock NED plan.

Tables 11 - 15 through 11 - 17 also reveal that despite the variation in savings associated with the different growth scenarios, all the with-project plans would be economically justified in the low and high growth scenarios. In the "No Growth After 20 Years" scenario, only the bridge curfew removal alternative would be economically unjustified.

<u>TIMING</u>

PHASED CONSTRUCTION

Reviewing table 7 - 4, which displays projected average delay per tow estimates for the alternative plans, reveals that if the existing low-rise St. Claude Avenue Bridge is replaced with a mid-rise structure, while keeping the existing lock in place, short term reductions in average delays per tow compared to the without-project condition would result. This in turn would produce short term

Low Growth Scenario
Alternative Summary
(1996 $1,000, 7.375 Percent)

	Remove Bridge Curfews	Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
		w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew
Annual Construction Costs	0	3,764	43,347	43,347	44,954	44,954	52,101	52,101	48,516	48,516	51,857	51,857	55,449	55,449
Annual Mitigation Costs	0	1,701	3,939	3,939	3,939	3,939	4,150	4,150	4,150	4,150	4,150	4,150	4,150	4,150
Annual Nav Losses	0	0	152	152	152	152	152	152	152	152	152	152	152	152
Annual Permanent DD Loss	0	0	268	268	268	268	0	0	268	268	268	268	0	0
Annual O&M Costs	0	0	1,382	1,382	1,382	1,382	1,384	1,384	1,382	1,382	1,382	1,382	1,384	1,384
Induced Vehicular Losses	6,135	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	6,135	5,465	49,088	49,088	50,695	50,695	57,787	57,787	54,469	54,469	57,809	57,809	61,135	61,135
Annual S.D. Benefits	6,967	18,016	48,381	49,591	49,964	50,065	51,312	51,754	51,914	51,949	52,389	52,436	52,421	52,427
Annual D.D. Benefits	0	0	0	0	0	0	539	539	0	0	0	0	539	539
Annual Vehicular Benefits	0	6,195	5,876	1,830	5,955	3,680	5,951	3,462	6,500	5,926	7,364	7,179	7,347	7,160
Annual Savings to Fed Proj	0	0	4,017	4,017	4,017	4,017	4,194	4,194	4,194	4,194	4,194	4,194	4,194	4,194
Annual Maint Closure - Nav Losses Prevented	0	0	10,471	10,471	10,471	10,471	11,243	11,243	11,243	11,243	11,243	11,243	11,243	11,243
Total Annual Benefits	6,967	24,211	68,745	65,909	70,407	68,233	73,239	71,192	73,851	73,312	75,190	75,052	75,744	75,563
Net Benefits	832	18,746	19,657	16,821	19,712	17,538	15,452	13,406	19,382	18,843	17,381	17,243	14,609	14,428
BCR	1.14	4.43	1.40	1.34	1.39	1.35	1.27	1.23	1.36	1.35	1.30	1.30	1.24	1.24
Base Year	1998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	1,954	24,919	19,657	16,821	19,712	17,538	14,391	12,485	18,051	17,549	16,187	16,058	13,606	13,437

Table 11 - 16

High Growth Scenario
Alternative Summary
(1996 $1,000, 7.375 Percent)

		Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
	Remove Bridge Curfews	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew
Annual Construction Costs	0	3,764	43,347	43,347	44,954	44,954	52,101	52,101	48,516	48,516	51,857	51,857	55,449	55,449
Annual Mitigation Costs	0	1,701	3,939	3,939	3,939	3,939	4,150	4,150	4,150	4,150	4,150	4,150	4,150	4,150
Annual Nav Losses	0	0	284	284	284	284	292	292	292	292	292	292	292	292
Annual Permanent DD Losses	0	0	892	892	892	892	0	0	925	925	925	925	0	0
Annual O&M Costs	0	0	1,382	1,382	1,382	1,382	1,384	1,384	1,382	1,382	1,382	1,382	1,384	1,384
Induced Vehicular Losses	8,190	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	8,190	5,465	49,844	49,844	51,451	51,451	57,928	57,928	55,266	55,266	58,607	58,607	61,276	61,276
Annual S.D. Benefits	14,444	13,164	73,263	80,896	89,625	90,283	88,222	90,072	91,110	92,082	96,923	97,444	96,725	96,931
Annual D.D. Benefits	0	0	0	0	0	0	1,862	1,862	0	0	0	0	1,862	1,862
Annual Vehicular Benefits	0	5,353	5,756	(1,379)	5,854	977	5,948	5,843	5,956	3,360	6,191	5,031	6,182	5,005
Annual Savings to Fed Proj	0	0	4,017	4,017	4,017	4,017	4,194	4,194	4,194	4,194	4,194	4,194	4,194	4,194
Annual Maint Closure - Nav Losses Prevented	0	0	10,471	10,471	10,471	10,471	11,243	11,243	11,243	11,243	11,243	11,243	11,243	11,243
Total Annual Benefits	14,444	18,517	93,507	94,005	109,967	105,748	111,469	113,214	112,503	110,879	118,551	117,912	120,206	119,235
Net Benefits	6,254	13,052	43,663	44,161	58,516	54,297	53,541	55,286	57,237	55,613	59,944	59,305	58,930	57,959
BCR	1.76	3.39	1.88	1.89	2.14	2.06	1.92	1.95	2.04	2.01	2.02	2.01	1.96	1.95
Base Year	1998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	14,689	17,350	43,663	44,161	58,516	54,297	49,864	51,489	53,306	51,793	55,827	55,232	54,883	53,978

Table 11 - 17

No Growth After 2010
Alternative Summary
(1996 $1,000, 7.375 Percent)

	Remove Bridge Curfews	Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
		w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew	with curfew	w/o curfew
Annual Construction Costs	0	3,764	43,347	43,347	44,954	44,954	52,101	52,101	48,516	48,516	51,857	51,857	55,449	55,449
Annual Mitigation Costs	0	1,701	3,939	3,939	3,939	3,939	4,150	4,150	4,150	4,150	4,150	4,150	4,150	4,150
Annual Nav Losses	0	0	208	208	208	208	211	211	211	211	211	211	211	211
Annual Permanent DD Losses	0	0	375	375	375	375	0	0	375	375	375	375	0	0
Annual O&M Costs	0	0	1,382	1,382	1,382	1,382	1,384	1,384	1,382	1,382	1,382	1,382	1,384	1,384
Induced Vehicular Losses	8,479	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Cost	8,479	5,465	49,250	49,250	50,858	50,858	57,846	57,846	54,634	54,634	57,975	57,975	61,194	61,194
Annual S.D. Benefits	8,055	21,615	66,427	67,365	67,522	67,619	67,219	67,647	68,108	68,138	68,276	68,323	68,309	68,315
Annual D.D. Benefits	0	0	0	0	0	0	757	757	0	0	0	0	757	757
Annual Vehicular Benefits	0	5,573	5,811	1,478	5,892	3,387	5,883	3,230	6,124	5,690	7,130	6,963	7,111	6,944
Annual Savings to Fed Proj	0	0	4,017	4,017	4,017	4,017	4,194	4,194	4,194	4,194	4,194	4,194	4,194	4,194
Annual Maint Closure - Nav Losses Prevented	0	0	10,471	10,471	10,471	10,471	11,243	11,243	11,243	11,243	11,243	11,243	11,243	11,243
Total Annual Benefits	8,055	27,188	86,726	83,331	87,902	85,494	89,296	87,071	89,669	89,265	90,843	90,723	91,614	91,453
Net Benefits	(424)	21,723	37,476	34,081	37,044	34,636	31,450	29,225	35,035	34,631	32,868	32,748	30,420	30,259
BCR	0.95	4.98	1.76	1.69	1.73	1.68	1.54	1.51	1.64	1.63	1.57	1.56	1.50	1.49
Base Year	1,998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	(996)	28,876	37,476	34,081	37,044	34,636	29,290	27,218	32,629	32,252	30,610	30,499	28,330	28,180

increases in shallow-draft navigation benefits (shown in table 7 - 10). However, because the increased processing capability represented by bridge replacement is modest, delays per tow would once again become serious after traffic grows to a certain level. The question then arises as to the economic implications of replacing the existing St. Claude Avenue Bridge with a mid-rise structure in the near-term, producing short term improvements, and then replacing the existing lock at a future point when delays at the lock warrant the investment in additional capacity. Because the significant costs associated with lock replacement would be delayed until some future year, the economic efficiency, measured in terms of average annual net benefits over the project life, of a phased bridge/lock construction alternative could prove to be superior to the non-phased construction approach. There are two primary questions that must be addressed: 1.) would the overall average annual net benefits associated with a phased bridge/lock approach be greater than the NED North of Claiborne Avenue plan, and 2.) would a lock different than the NED lock size of 900 x 110 x 22 ft be optimal in a phased construction approach and at what point in time. In order to address the first question, the second question must be answered first.

In order to determine both the optimal lock size and the optimal time when a new lock should be operational, both the project costs and the stream of future benefits associated with various lock plans have to be considered. In this analysis, costs were developed only for the shallow-draft lock alternatives because of the limited prospect of the deep-draft plans becoming optimal in the phased approach. Therefore, construction, operations and maintenance, and mitigation costs for a phased bridge/lock plan were considered (over a 50 year period using a 7.375 percent discount rate) for each of the shallow-draft lock alternatives. On the benefit side, since only shallow-draft lock alternatives were analyzed, the focus was limited to shallow-draft navigation benefits. Vehicle benefits were not applicable, since in the phased approach, the mid-rise replacement of the St. Claude Avenue Bridge is assumed to be already in place. In a similar manner, benefits associated with avoiding the losses associated with rehabilitation closures are also not relevant because the rehabilitation work will be required as scheduled due to the delay and the uncertainty associated with replacing the existing structure.

Future streams of net transportation cost savings were developed representing the difference in transportation cost savings between the "Bridge Only" alternative and each of the shallow-draft lock alternatives. This difference represents the appropriate measure of shallow-draft savings that would result from the construction of a new lock in the future given that the St. Claude Avenue Bridge has already been improved. The year in which the net transportation cost savings of a particular lock plan exceeded the average annual cost of the plan determined the optimal time when the new lock should be operational. The net transportation cost savings from this year forward were then annualized over a 50 year period for each of the lock plans and then subtracted from the respective average annual cost to produce an average annual net benefit estimate. These results are shown in table 11 - 18. After adjusting the average annual net benefits for each of the lock plans to a common base year, the optimal lock size was determined by selecting that plan which produced the highest average annual net benefits.

As table 11 - 18 shows, the optimal lock size was determined to be a 900 x 110 x 22 ft lock, operational by the year 2011 (only 1 year later than the NED North of Claiborne Avenue plan) assuming the mid growth scenario in traffic projections. Using the same method as discussed above, table 11 - 19 shows that a 900 x 110 x 22 ft lock was also determined to be the optimal lock size assuming the low growth scenario, but because delays at the existing lock never become serious until many years later due to the lower growth in traffic, the replacement lock need not be in place until the year 2032. The high growth scenario was also evaluated. The results in terms of lock size and time were the same as the NED North of Claiborne Avenue plan in that a 900 x 110 x 22 ft replacement lock should be constructed as soon as possible.

Having determined the optimal lock size and when it should be operational, the next task in this analysis was to determine the average annual net benefits for the overall phased bridge/lock plan. To do so required the estimation of all average annual benefits and costs for the phased approach. In the phased approach, the mid-rise replacement for the existing low-rise St. Claude Avenue Bridge is scheduled to be in place and fully operational by the year 2007, hence this becomes the base year and assuming a 50 year project life, benefits were analyzed over the period 2007 - 2056. As determined above, assuming a mid growth in traffic, the optimal time for a 900 x 110 x 22 ft North of Claiborne Avenue lock to be operational is in the year 2011. Consequently, shallow-draft navigation benefits from 2007 to 2010 represent the difference in total cost savings between future without-project conditions and those resulting from a mid-rise replacement of the St. Claude Avenue Bridge while keeping the existing lock in place. From 2011 to 2056, with the new lock in place, shallow-

Table 11 - 18

Phased Bridge/Lock Plan
Optimal Lock Size and Timing

Mid Growth - Average Annual Net Benefits
(1996, $1,000, 7.375 Percent)

Lock Alternative	Average Annual Net Benefits	Base Year	Average Annual Net Benefits Adjusted to 2011
900 x 90 x 22	23,696	2011	23,696
900 x 110 x 22	27,278	2011	27,278
1200 x 90 x 22	27,429	2012	25,545
1200 x 110 x 22	26,608	2013	23,078

NOTE: Net benefits reflect shallow-draft benefits and lock construction costs only.

Table 11 - 19

Phased Bridge/Lock Plan
Optimal Lock Size and Timing

Low Growth - Average Annual Net Benefits
(1996, $1,000, 7.375 Percent)

Lock Alternative	Average Annual Net Benefits	Base Year	Average Annual Net Benefits Adjusted to 2032
900 x 90 x 22	27,608	2030	31,830
900 x 110 x 22	32,423	2032	32,423
1200 x 90 x 22	29,955	2032	29,955
1200 x 110 x 22	29,472	2033	27,448

NOTE: Net benefits reflect shallow-draft benefits and lock construction costs only.

draft navigation benefits are represented by the difference in cost savings between future without-project conditions and those resulting from the replacement of the existing lock with a North of Claiborne Avenue 900 x 110 x 22 ft lock.

In addition to shallow-draft benefits, vehicle benefits, resulting from the mid-rise replacement of the existing low-rise St. Claude Avenue Bridge were calculated as well as the benefits from discontinuing O&M expenditures on the existing lock, once the replacement lock is operating. Vehicle benefits, representing the difference in total vehicle cost savings between future without-project conditions and a mid-rise St. Claude Avenue Bridge while keeping the existing lock in place were calculated over the full 50 year period from 2007 to 2056. Savings from avoiding existing O&M would not begin to accrue until the year 2011, when the new lock is in place, hence these benefits were assumed over the period from 2011 to 2056. These benefit streams along with the shallow-draft benefits were then discounted back to the base year (2007) and average annual benefit estimates for each of these categories were calculated using a discount rate of 7.375 percent and a 50 year project life. Summing these average annual benefit estimates provided the total average annual benefits associated with the overall phased approach.

The final step in this analysis was to calculate the average annual costs associated with the phased approach. Total costs are comprised of seven categories: the construction and mitigation costs associated with the new bridge and lock, the operation and maintenance costs for the new lock, the existing deep-draft benefits that are lost when the existing lock is taken out of service and the permanent deep-draft losses that begin to occur once the new shallow-draft lock is in place and operating.

The construction and mitigation costs for the new St. Claude Avenue Bridge were compounded forward to the base year of 2007, whereas the costs for the new lock were either compounded forward or discounted back to the base year since some of these expenditures would occur either before or after 2007. Once the new lock begins to operate in the year 2011, permanent deep-draft losses, representing the difference in deep-draft cost savings between existing conditions and a 900 x 110 x 22 ft North of Claiborne lock, also would begin to occur. These were calculated for the years 2011 to 2056 and discounted back to the base year. Along with these losses, during the same time period (2011 - 2056), operation and maintenance expenditures for the new lock were also discounted back to the base year. The final cost item, the existing deep-draft benefits that are lost when the existing lock is taken out of service, is scheduled to occur during the last two years of constructing the replacement lock in the years 2009 and 2010. Like the previous estimates, these were also discounted back to the base year. Each of these cost categories were then annualized and summed to provide the average annual costs associated with the phased approach.

Table 11 - 20 compares the total first cost (comprised of construction and mitigation costs) and the composition of total average annual benefits and average annual costs of the phased approach to the NED North of Claiborne Avenue 900 x 100 x 22 ft lock plan assuming the mid growth traffic scenario. As is shown in the table, the phased approach is clearly inferior to the non-phased plan with total average annual net benefits of the phased approach (after adjusting to a common base year) representing only 77 percent of the total average annual net benefits of the NED North of Claiborne Avenue plan.

Table 11 - 20 highlights that the main reason for this result lies in the assumptions regarding the maintenance work associated with the existing lock. In the NED North of Claiborne Avenue plan, the existing lock in scheduled to be replaced as soon as possible. Under this situation, it was reasonable to assume that plans to make extraordinary maintenance expenditures for the existing lock would be canceled. As a result, these maintenance expenditures, and the high cost to navigation that would result from the lock being closed during the maintenance, would be avoided. As such, both were claimed as benefits in the non-phased replacement plan. However, in the phased approach, even though construction of the replacement lock is scheduled only one year later than the NED plan, the inherent uncertainty as to when the replacement lock will actually become economically feasible dictates that scheduled maintenance work be pursued as currently scheduled. Consequently, in the phased approach, benefits from the avoided effects of the maintenance work were not claimed. If the benefits from avoided maintenance work are claimed for the phased approach, the phased approach would generate a higher level of average annual net benefits than the non-phased approach. However, it is worth emphasizing that if the assumption that the maintenance work would proceed as scheduled with the phased approach was changed, the difference in optimal implementation of the new lock is only one year between the phased and non-phased approaches.

Table 11 - 21 displays similar information for the low growth traffic scenario. As is shown, with the additional delay in the need for lock replacement, the non-phased approach becomes inferior to the phased 900 x 110 x 22 ft

Table 11 - 20

Benefit - Cost Summary
Mid Growth Scenario
(1996, $1,000, 7.375%)

	900 x 110 x 22	Phased Approach *
Total First Cost	425,507	435,078
Annual Construction Costs	44,954	38,024
Annual Mitigation Costs	3,939	3,168
Annual Nav Losses	208	159
Annual Permanent DD Losses	477	359
Annual O&M Costs	1,382	1,067
Total Annual Costs	50,960	42,777
Annual S.D. Benefits	83,982	69,314
Annual D.D. Benefits	0	0
Annual Vehicular Benefits	5,909	5,590
Annual Savings to Fed Proj	4,017	1,207
Annual Maint Closure - Nav Losses Prevented	10,471	0
Total Annual Benefits	104,379	76,111
Net Benefits	53,419	33,334
BCR	2.05	1.78
Base Year	2010	2007
~~Net Benefits adj.~~ to 2010	53,419	41,266

* Mid-rise 300-ft horizontal clearance twin tower St. Claude Bridge operational in 2007 and a 900 x 110 x 22 new chamber north of Claiborne Ave operational in 2011.

Table 11 - 21

Benefit - Cost Summary
Low Growth Scenario
(1996, $1,000, 7.375%)

	900 x 110 x 22	Phased Approach *
Total First Cost	425,507	435,078
Annual Construction Costs	44,954	11,680
Annual Mitigation Costs	3,939	2,084
Annual Nav Losses	152	26
Annual Permanent DD Losses	268	38
Annual O&M Costs	1,382	200
Total Annual Costs	50,695	14,028
Annual S.D. Benefits	49,964	28,841
Annual D.D. Benefits	0	0
Annual Vehicular Benefits	5,955	6,203
Annual Savings to Fed Proj	4,017	234
Annual Maint Closure - Nav Losses Prevented	10,471	0
Total Annual Benefits	70,407	35,278
Net Benefits	19,712	21,250
BCR	1.39	2.51
Base Year	2010	2007
Net Benefits adj. to 2010	19,712	26,307

* Mid-rise 300-ft horizontal clearance twin tower St. Claude Bridge operational in 2007 and a 900 x 110 x 22 new chamber north of Claiborne Ave operational in 2032.

lock plan with total average annual net benefits of the non-phased approach (after adjusting to a common base year) representing 75 percent of the total average annual net benefits resulting from the phased North of Claiborne Avenue plan.

DELAYED IMPLEMENTATION

In order to consider if project implementation has been optimally timed for the non-phased construction alternatives, an analysis of alternative base years (the point of an operational project) was conducted. Because the non-phased alternatives would result in an operational project at the earliest possible date, questions of enhanced timing need only consider delaying implementation. The potential for improvement from delaying implementation comes primarily from two effects. By delaying project implementation, the 50 years of project life are shifted outward. Because certain benefit categories increase over time, the 50-year stream starting from a more future point can reflect higher absolute numbers. Also, by delaying implementation, project expenditures would be delayed. While by no means a certainty, given the rate of growth in benefits, and the interest rate used to discount future costs and benefits, it is possible that by delaying implementation a superior position (defined by a higher present value of average annual net benefits) could be identified.

In order to investigate this possibility, the original base year for each of the alternative non-phased with-project plans was delayed by five years. Assuming the mid growth traffic projections, table 11 - 22 displays the total average annual net benefits (adjusted to a common base year of 2010) for each of the alternative plans at their original base year and a base year five years later. For the lock replacement plans only the with-curfew plans were analyzed.

As table 11 - 22 shows, increasing the original base year by five years had the effect of reducing the total average annual net benefits for each of the alternative plans. (The 900 x 110 x 22 ft replacement lock remained the NED plan). Additional delay in project implementation was also evaluated. The outcome (not displayed) of delaying project implementation by 10 years was to generate an even more inferior position than that of the five year delay.

INTEREST RATES

Table 11 - 22

Non - Phased
Optimal Timing of Alternative With Project Scenarios
(1996 prices, $1,000's, 7.375 Percent)

With-Project Alternative	Original Base Year	Average Annual Net Benefits	Average Annual Net Benefits (Adjusted to 2010)	Base Year Increased by 5 years	Average Annual Net Benefits	Average Annual Net Benefits (Adjusted to 2010)
Remove Bridge Curfews	1998	916	2,151	2003	(1,294)	(2,129)
Replace Bridge Only	2006	15,508	20,614	2011	12,249	11,408
900 x 90 x 22	2010	47,765	47,765	2015	55,240	38,702
900 x 110 x 22	2010	53,419	53,419	2015	64,533	44,691
900 x 110 x 36	2011	48,977	45,613	2016	59,730	38,974
1200 x 90 x 22	2011	53,620	49,937	2016	65,122	42,492
1200 x 110 x 22	2011	51,324	47,799	2016	62,856	41,014
1200 x 110 x 36	2011	49,233	45,851	2016	60,931	39,758

Throughout this study an interest rate of 7.375 percent was used in determining average annual costs and benefits. In order to explore the implications of alternative interest rates on NED plan selection, three additional values (2.625 percent, 3.75 percent and 10 percent) will be presented. Tables 11 - 23 to 11 - 25 summarize the results for each of the alternative with-project plans assuming mid growth in traffic for 2.625 percent, 3.75 percent, and 10 percent, respectively.

Table 11 - 23 shows that an interest rate of 2.625 percent caused significant impacts with regards to NED plan determination. Lowering the interest rate resulted in the current NED plan (900 x 110 x 22 ft lock) shifting more towards the larger scale alternatives. At an interest rate of 2.625 percent, total average annual net benefits (adjusted to a base year of 2010) are maximized at $77.4 million by replacing the existing lock with a 1200 x 110 x 36 ft North of Claiborne Avenue lock. An interest rate of 2.625 percent was selected for display in this sensitivity analysis because it represents the authorized project interest rate.

In an attempt to determine the point at which a change in the current NED plan occurs as a result of lowering the interest rate, several interest rates between the current 7.375 interest rate and 2.625 percent were evaluated. Working from 7.375 percent and moving downward, a rate of 3.75 percent was identified as the point where a shift occurs. Table 11 - 24 shows the results caused by a 3.75 percent interest rate. Unlike table 11 - 23, average annual net benefits are maximized with a 1200 x 90 x 22 ft lock replacement at $71.5 million.

Table 11 - 25 shows the plan formulation consequences of a 10 percent interest rate. Unlike the previous two tables, no changes in the current NED plan occurred. At $35.4 million, total average annual net benefits are maximized with a 900 x 110 x 22 ft replacement lock.

ALTERNATIVE FLOOR DEPTHS

The current NED plan involves a 900 x 110 x 22 ft North of Claiborne Avenue replacement lock. In order to verify that the 22- foot depth is optimal, two additional floor depths were investigated, one more shallow than the 22-foot depth, at 18 feet, and the other deeper than the 22-foot depth at 25 feet. Table 11 - 26 shows the economic comparison of these two floor depths along with the 22-foot lock floor.

Table 11 - 23

Interest Rate Sensitivity

Alternative Summary
(1996 $1,000, 2.63 Percent)

	Remove Bridge Curfews	Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
		w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews
Total Annual Cost	8,035	2,340	19,220	19,220	19,629	19,629	21,238	21,238	20,473	20,473	21,645	21,645	22,516	22,516
Total Annual Benefits	7,219	15,020	79,014	77,010	95,121	92,219	95,847	94,429	99,515	97,676	100,837	100,070	101,991	100,824
Net Benefits	(816)	12,680	59,794	57,790	75,292	72,390	74,609	73,191	79,042	77,203	79,192	78,425	79,475	78,308
BCR	0.90	6.42	4.11	4.01	4.80	4.65	4.51	4.45	4.86	4.77	4.66	4.62	4.53	4.48
Base Year	*1998*	*2006*	*2010*	*2010*	*2010*	*2010*	*2011*	*2011*	*2011*	*2011*	*2011*	*2011*	*2011*	*2011*
Net Benefits Adj. to 2010	(1,204)	14,085	59,794	57,790	75,292	72,390	72,701	71,319	77,020	75,228	77,166	76,419	77,442	76,305

Table 11 - 24

Interest Rate Sensitivity

Alternative Summary
(1996 $1,000, 3.75 Percent)

	Remove	Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
	Bridge Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews
Total Annual Cost	7,959	2,958	24,599	24,599	25,392	25,392	27,650	27,650	26,461	26,461	28,014	28,014	29,309	29,309
Total Annual Benefits	7,945	16,618	83,283	81,112	96,655	93,664	97,687	95,925	100,676	98,975	101,901	101,238	103,016	102,026
Net Benefits	(14)	13,660	58,684	56,513	71,263	68,272	70,037	68,275	74,215	72,514	73,887	73,224	73,707	72,717
BCR	1.00	5.62	3.39	3.30	3.81	3.69	3.53	3.47	3.80	3.74	3.64	3.61	3.51	3.48
Base Year	1998	2006	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	(22)	15,827	58,684	56,513	71,263	68,272	67,506	65,807	71,533	69,893	71,216	70,577	71,043	70,089

Table 11 - 25

Interest Rate Sensitivity

Alternative Summary
(1996 $1,000, 10 Percent)

		Bridge Only	900x90x22		900x110x22		900x110x36		1200x90x22		1200x110x22		1200x110x36	
	Remove Bridge Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o. Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews	with Curfews	w/o Curfews
Total Annual Cost	7,592	7,700	75,242	75,242	77,662	77,662	90,344	90,344	85,263	85,263	90,531	90,531	95,393	95,393
Total Annual Benefits	10,306	23,272	108,217	105,150	113,092	110,001	117,156	114,521	118,173	117,013	119,178	118,861	120,152	119,719
Net Benefits	2,714	15,572	32,975	29,908	35,430	32,339	26,812	24,177	32,910	31,750	28,647	28,330	24,759	24,326
BCR	1.36	3.02	1.44	1.40	1.46	1.42	1.30	1.27	1.39	1.37	1.32	1.31	1.26	1.26
Base Year	1998	2008	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
Net Benefits Adj. to 2010	8,518	22,799	32,975	29,908	35,430	32,339	24,375	21,979	29,918	28,864	26,043	25,755	22,508	22,115

The rational for the changes in costs that occur as the floor elevation changes is straightforward and relates to the changes in physical dimensions and the associated construction requirements. The changes in benefits occur because as the floor elevation becomes more shallow, fill and empty times must be slowed so as to not violate design safety parameters relative to turbulence within the chamber. A slower fill/empty time will produce a longer processing time which ultimately translates to a lower level of service. Importantly, the impact on the level of service is not linear as the floor elevation is raised. Across the range of head differentials, the expected value increase in processing time would be 0.8 minutes when moving from the 25-foot floor to the 22-foot floor. However, the move from 22 feet to 18 feet would result in a 4.1 minute increase in processing time. It is these longer processing times that are responsible for the reduction in benefits as the lock floor is raised.

Comparing the economics of the 22 and 25-foot floor depths shows that the total average annual net benefits for the 22-foot floor depth is slightly higher than the 25-foot floor depth. In addition, constructing the lock at a floor depth of 25 feet would cost approximately $3.1 million (in total first cost) more than the 22- foot floor depth. Consequently, from an economic standpoint, it would be more rational to build the replacement lock at a floor depth of 22 feet.

By constructing the lock to 18 feet, table 11 - 26 shows that even though it would cost (in total first cost) approximately $2.1 million less to build compared to 22 feet, total average annual net benefits would decline by approximately $1.9 million. Consequently, the move to an 18-foot depth is not supported by economic criteria.

Table 11 - 26

Benefit - Cost Comparison
18, 22, and 25 foot Floor Elevations

(1996 $1,000, 7.375 Percent)

	900 x 110 x 18	900 x 110 x 22	900 x 110 x 25
Total Annual Benefits	102,267	104,379	104,549
Total First Cost	423,408	425,508	428,608
Total Annual Costs	50,747	50,960	51,220
Net Benefits	51,520	53,419	53,329

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
1	CORN	1,348	14.65	16.66	34.94	
2	CORN	1,624	19.56	20.53	50.09	
3	CORN	7,211	19.56	20.64	37.56	
4	CORN	3,220	14.41	15.38	21.44	
5	CORN	13,695	23.93		36.63	
6	CORN	13,953	17.16	17.98	37.90	
7	CORN	5,922	17.77	18.57	26.02	
8	CORN	4,660	18.91	19.55	29.22	
9	OATS	1,488	17.48		29.37	
10	OATS	2,855	17.68		25.70	
11	OATS	1,485	17.68		26.63	
12	RICE	67,885	12.53		20.50	23.96
13	RICE	16,968	18.28		26.58	
14	RICE	17,679	20.10		26.73	
15	RICE	12,164	18.20		26.99	
16	RICE	1,495	21.31		31.57	
17	RICE	6,646	19.69		30.63	
18	RICE	11,047	19.67		30.63	
19	RICE	2,880	11.50		28.37	32.28
20	RICE	11,433	18.28		24.54	
21	SORGHUM GRAINS	18,695	6.28		11.80	14.47
22	SORGHUM GRAINS	9,538	7.38		14.28	19.10
23	WHEAT	1,110	7.66		12.56	17.03
24	WHEAT	16,192	12.69		17.62	19.74
25	WHEAT	10,225	12.69		18.54	22.34
26	WHEAT	2,938	11.87	12.92	18.36	
27	WHEAT	17,736	10.62		16.27	16.37
28	WHEAT	4,568	14.51	16.68	42.99	
29	WHEAT	1,441	15.44	16.28	24.18	
30	WHEAT	2,820	7.09		13.50	
31	WHEAT	5,171	9.08		17.66	
32	WHEAT	6,853	11.06		16.54	
33	WHEAT	6,273	17.45	16.72	25.14	
34	SOYBEANS	1,057	15.91		25.15	
35	SOYBEANS	1,509	14.95		22.29	25.20
36	SOYBEANS	10,745	11.20	12.33	18.15	
37	SOYBEANS	24,830	12.28		11.11	16.16
38	SOYBEANS	28,540	13.45		14.34	14.51
39	SOYBEANS	3,278	8.90		15.86	18.64
40	SOYBEANS	1,731	13.88		18.13	
41	SOYBEANS	3,157	16.88	18.48	37.20	
42	TALLOW	1,591	13.85		38.25	
43	TALLOW	10,139	22.78		62.74	
44	PREPARED ANIMAL FEEDS	5,101	9.42		16.83	25.83

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
45	PREPARED ANIMAL FEEDS	1,200	8.53		13.39	22.30
46	GRAIN MILL PRODUCTS	7,810	11.91		11.95	16.60
47	GRAIN MILL PRODUCTS	17,214	12.81		15.51	
48	SUGAR	17,285	5.48		13.96	26.96
49	SUGAR	1,120	6.35		13.60	44.85
50	SUGAR	47,666	15.83		19.46	30.01
51	SUGAR	20,300	4.91		12.40	22.44
52	SUGAR	9,912	8.68		52.22	
53	SUGAR	29,334	11.33		17.00	19.29
54	SUGAR	4,355	11.33		17.00	41.30
55	SUGAR	9,156	26.59		46.47	
56	SUGAR	89,650	26.59		46.47	
57	MOLASSES	4,273	13.98		23.39	
58	MOLASSES	9,368	9.07		22.03	30.39
59	VEGETABLE OILS	3,993	14.15		39.05	
60	VEGETABLE OILS	3,260	12.10		36.50	
61	MISC FOOD PRODUCTS	15,390	7.22		10.19	16.08
62	IRON ORE	4,201	24.16	24.83	44.67	
63	IRON ORE	10,767	20.02		51.88	
64	IRON ORE	9,464	10.07		17.08	17.49
65	BAUXITE	13,132	15.75		25.57	
66	MANGANESE ORES	3,453	10.48		33.51	
67	NONFERROUS METAL ORES	5,541	9.50		30.26	
68	NONFERROUS METAL ORES	16,143	13.09	14.53	29.92	
69	NONFERROUS METAL ORES	13,424	10.56		15.28	18.92
70	PIG IRON	1,555	10.94		31.25	
71	PIG IRON	1,707	11.36		28.27	
72	PIG IRON	2,994	12.83		44.03	
73	PIG IRON	3,104	18.69		42.95	
74	SLAG	3,050	18.92		42.50	
75	SLAG	11,400	8.73		25.22	
76	SLAG	9,306	16.50		28.55	
77	SLAG	12,232	17.21		33.43	
78	SLAG	10,634	10.97	11.36	21.83	
79	SLAG	9,263	12.11		32.28	
80	SLAG	9,446	12.52		29.10	
81	IRON & STEEL INGOTS	7,518	20.83		40.07	
82	IRON & STEEL INGOTS	10,289	26.08		35.84	
83	IRON & STEEL INGOTS	1,242	24.00		57.90	
84	IRON & STEEL INGOTS	45,562	24.48		33.22	
85	IRON & STEEL INGOTS	2,218	28.35		62.26	
86	IRON & STEEL INGOTS	4,329	34.90		93.90	
87	IRON & STEEL INGOTS	1,351	14.84		35.29	
88	IRON & STEEL INGOTS	11,806	15.64		41.64	

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
89	IRON & STEEL INGOTS	8,400	23.32		42.50	
90	IRON & STEEL BARS	2,969	13.74		38.50	
91	IRON & STEEL BARS	9,215	21.94		29.67	
92	IRON & STEEL BARS	3,949	18.63		25.95	40.25
93	IRON & STEEL BARS	31,334	34.20		45.86	
94	IRON & STEEL BARS	35,457	20.04		56.42	
95	IRON & STEEL BARS	6,759	17.07		33.49	
96	IRON & STEEL BARS	6,750	16.08		34.74	
97	IRON & STEEL BARS	29,135	25.74		58.60	
98	IRON & STEEL BARS	18,934	19.56		68.17	
99	IRON & STEEL BARS	13,574	14.00		36.84	
100	IRON & STEEL BARS	36,636	16.53		36.56	
101	IRON & STEEL BARS	11,121	19.28		49.03	
102	IRON & STEEL BARS	2,899	20.96		64.20	
103	IRON & STEEL PLATE	11,474	20.70		34.92	35.10
104	IRON & STEEL PLATE	10,164	20.40		28.22	
105	IRON & STEEL PLATE	17,534	28.37	29.34	52.30	
106	IRON & STEEL PLATE	11,600	20.26	18.97	37.80	
107	IRON & STEEL PLATE	17,061	16.39		49.52	
108	IRON & STEEL PIPE	186,524	21.96		29.71	
109	IRON & STEEL PIPE	5,744	16.98		22.95	24.33
110	IRON & STEEL PIPE	22,400	20.75		51.86	
111	IRON & STEEL PIPE	1,989	30.09		82.65	
112	IRON & STEEL PIPE	6,580	21.96		30.44	
113	IRON & STEEL PIPE	75,089	16.78		NONE	
114	FERRO ALLOYS	10,135	19.50	26.06	51.12	
115	FERRO ALLOYS	5,970	18.77	18.85	40.79	
116	FERRO ALLOYS	5,133	8.97		24.10	
117	FERRO ALLOYS	7,647	8.50		30.31	
118	FERRO ALLOYS	4,162	11.20		40.67	
119	FERRO ALLOYS	4,881	13.85		42.11	
120	FERRO ALLOYS	2,800	10.85		51.89	
121	FERRO ALLOYS	1,400	18.74		54.16	
122	FERRO ALLOYS	9,276	16.44		49.45	
123	FERRO ALLOYS	43,712	19.50		56.23	
124	FERRO ALLOYS	1,400	14.44		46.30	
125	FERRO ALLOYS	5,625	11.17		22.70	
126	FERRO ALLOYS	1,210	19.50		60.82	
127	FERRO ALLOYS	1,480	23.64		76.58	
128	IRON & STEEL PDS, NEC	11,433	23.00		31.28	35.89
129	IRON & STEEL PDS, NEC	33,850	24.28		58.42	
130	IRON & STEEL PDS, NEC	13,154	19.00		57.82	
131	METAL CONTAINERS	13,300	10.98		18.30	27.89
132	METAL CONTAINERS	1,557	22.63		94.35	

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
133	METAL CONTAINERS	3,560	13.58		NONE	
134	METAL CONTAINERS	3,945	29.65		58.06	
135	IRON AND STEEL SCRAP	99,108	21.01		33.78	36.50
136	IRON AND STEEL SCRAP	6,076	22.86		30.38	
137	IRON AND STEEL SCRAP	1,433	22.38		45.68	
138	IRON AND STEEL SCRAP	6,137	18.73		25.75	32.85
139	IRON AND STEEL SCRAP	4,753	21.07		39.00	43.77
140	IRON AND STEEL SCRAP	2,934	19.83		38.29	46.05
141	IRON AND STEEL SCRAP	1,400	20.44		44.09	50.16
142	IRON AND STEEL SCRAP	4,886	19.91		29.00	37.27
143	IRON AND STEEL SCRAP	9,225	19.21		33.49	35.53
144	IRON AND STEEL SCRAP	40,507	19.27		26.50	27.70
145	IRON AND STEEL SCRAP	1,450	21.46		41.05	44.41
146	IRON AND STEEL SCRAP	19,808	20.52		29.77	
147	IRON AND STEEL SCRAP	7,814	24.00		62.50	
148	IRON AND STEEL SCRAP	4,135	18.14		32.50	45.82
149	IRON AND STEEL SCRAP	113,168	17.73		24.00	25.17
150	IRON AND STEEL SCRAP	1,450	20.60		67.34	
151	IRON AND STEEL SCRAP	15,932	13.29		35.56	
152	IRON AND STEEL SCRAP	16,726	17.43		37.29	
153	IRON AND STEEL SCRAP	11,426	19.61		47.35	
154	IRON AND STEEL SCRAP	11,616	19.61		47.35	
155	IRON AND STEEL SCRAP	59,279	21.00		61.05	
156	IRON AND STEEL SCRAP	18,903	17.58		41.05	
157	IRON AND STEEL SCRAP	5,360	11.54		29.15	
158	IRON AND STEEL SCRAP	12,978	18.84		42.94	
159	IRON AND STEEL SCRAP	12,733	24.50		35.02	
160	IRON AND STEEL SCRAP	3,134	12.33		24.87	38.37
161	IRON AND STEEL SCRAP	11,168	16.76		40.28	
162	IRON AND STEEL SCRAP	4,635	23.72		39.32	53.30
163	IRON AND STEEL SCRAP	9,653	21.75		33.77	
164	IRON AND STEEL SCRAP	2,184	7.66		23.00	37.49
165	IRON AND STEEL SCRAP	45,770	10.00		14.50	26.93
166	IRON AND STEEL SCRAP	7,500	15.00		36.38	
167	IRON AND STEEL SCRAP	1,648	14.86		56.07	
168	IRON AND STEEL SCRAP	4,200	16.02		58.64	
169	IRON AND STEEL SCRAP	4,740	14.84		56.07	
170	COAL	6,885	6.36		12.38	19.35
171	COAL	10,[illegible]	6.85		10.41	16.35
172	COAL	11[illegible]	14.10		21.44	
173	COAL	9,705	14.10		18.24	
174	COAL	3,000	15.51		17.52	
175	COAL	22,500	14.57		20.39	
176	COAL	43,211	14.77	17.94	22.61	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
177	COAL	37,535	22.07	22.94	35.59	
178	COAL	583,192	11.53	13.35	22.27	
179	COAL	356,812	11.95	14.20	23.88	
180	COAL	998,485	11.89	12.87	20.95	
181	COAL	530,207	11.51	13.33	23.60	
182	COAL	117,417	8.31	10.13	23.03	
183	COAL	2,740,843	20.44	24.72	23.11	
184	COAL	10,398	16.27	18.88	19.75	
185	COAL	9,417	16.69	19.30	19.75	
186	COAL	12,953	13.48		22.11	
187	COAL	191,511	24.40	28.44	26.16	
188	COAL	53,692	18.46	20.66	27.04	
189	COAL	100,707	20.06	20.32	23.44	
190	COAL	25,373	22.79	25.15	27.84	
191	COAL	75,466	23.04	24.50	31.52	
192	COAL	3,201	23.91	22.01	34.65	
193	COAL	8,013	28.94	25.89	31.34	
194	COAL	44,548	22.22	23.56	30.77	
195	COAL	7,681	18.58		20.70	
196	COAL	35,402	18.43	17.19	21.42	
197	COAL	139,912	18.42	18.11	20.11	
198	COAL	269,796	17.04	17.46	17.87	
199	COAL	69,376	15.93	17.11	21.89	
200	COAL	4,806	15.84		26.23	
201	CRUDE PETROLEUM	3,743	10.79		34.54	
202	CRUDE PETROLEUM	18,916	6.33		13.61	15.86
203	CRUDE PETROLEUM	222,607	9.15		15.66	
204	CRUDE PETROLEUM	337,785	9.64		30.33	
205	CRUDE PETROLEUM	6,128	9.55		18.75	20.86
206	CRUDE PETROLEUM	219,593	10.70		28.60	
207	CRUDE PETROLEUM	157,619	8.51		22.95	
208	CRUDE PETROLEUM	157,619	6.89		23.50	
209	CRUDE PETROLEUM	29,502	9.35		23.29	
210	CRUDE PETROLEUM	127,307	5.89		23.44	
211	CRUDE PETROLEUM	6,556	22.43	28.98	40.97	
212	CRUDE PETROLEUM	13,112	22.23	28.63	34.43	37.89
213	CRUDE PETROLEUM	16,454	3.76		11.01	
214	CRUDE PETROLEUM	11,117	3.55		10.30	25.09
215	CRUDE PETROLEUM	7,084	2.56		8.13	
216	CRUDE PETROLEUM	6,128	9.56		29.47	33.78
217	CRUDE PETROLEUM	23,914	8.07		35.76	
218	CRUDE PETROLEUM	2,154	6.82		15.06	26.32
219	CRUDE PETROLEUM	226,280	3.45		9.85	
220	CRUDE PETROLEUM	10,216	7.75		25.12	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
221	CRUDE PETROLEUM	18,384	3.38		9.08	10.53
222	CRUDE PETROLEUM	39,525	5.58		20.68	26.26
223	CRUDE PETROLEUM	54,468	3.19		7.65	20.91
224	CRUDE PETROLEUM	240,187	5.26		25.10	
225	CRUDE PETROLEUM	156,973	5.40		24.97	
226	CRUDE PETROLEUM	81,196	7.32		30.65	
227	CRUDE PETROLEUM	9,503	3.19		10.41	
228	CRUDE PETROLEUM	43,355	2.38		5.51	12.09
229	CRUDE PETROLEUM	41,744	5.64		22.38	24.73
230	CRUDE PETROLEUM	492,534	2.54		16.71	
231	CRUDE PETROLEUM	38,200	7.11		37.83	38.98
232	CRUDE PETROLEUM	8,408	5.01		8.54	13.35
233	CRUDE PETROLEUM	12,122	4.73		10.05	20.93
234	CRUDE PETROLEUM	36,074	1.95		8.11	
235	CRUDE PETROLEUM	15,472	3.30		12.38	15.30
236	CRUDE PETROLEUM	22,058	6.46		20.86	31.85
237	CRUDE PETROLEUM	13,224	4.14		7.21	
238	CRUDE PETROLEUM	83,341	5.71		16.93	17.58
239	CRUDE PETROLEUM	17,632	6.05		10.52	21.80
240	CRUDE PETROLEUM	6,894	2.85		10.44	
241	CRUDE PETROLEUM	16,546	2.17		7.74	
242	CRUDE PETROLEUM	172,810	2.00		18.17	
243	CRUDE PETROLEUM	27,738	1.52		4.43	
244	CRUDE PETROLEUM	7,352	2.76		9.43	14.11
245	CRUDE PETROLEUM	20,957	3.49		10.06	17.36
246	CRUDE PETROLEUM	83,488	5.86		10.16	26.47
247	CRUDE PETROLEUM	84,411	13.36		26.76	28.90
248	CRUDE PETROLEUM	25,584	7.16		15.16	30.63
249	CRUDE PETROLEUM	152,304	8.72		17.87	
250	CRUDE PETROLEUM	31,482	8.02		28.90	37.47
251	CRUDE PETROLEUM	6,440	4.72		21.40	26.76
252	CRUDE PETROLEUM	39,281	5.87		28.94	32.72
253	CRUDE PETROLEUM	33,444	8.68		24.08	37.61
254	CRUDE PETROLEUM	8,197	4.79		14.97	24.83
255	CRUDE PETROLEUM	59,215	4.43		14.08	18.75
256	CRUDE PETROLEUM	6,088	5.05		14.23	15.68
257	CRUDE PETROLEUM	9,136	9.59		22.74	23.10
258	CRUDE PETROLEUM	201,762	8.70		32.10	
259	CRUDE PETROLEUM	32,784	9.83			30.8824.18
260	CRUDE PETROLEUM	36,632	7.12		35.77	38.68
261	CRUDE PETROLEUM	16,083	10.12		28.43	28.99
262	CRUDE PETROLEUM	2,412	10.12		23.02	32.45
263	CRUDE PETROLEUM	6,878	10.51		23.21	23.55
264	CRUDE PETROLEUM	5,904	6.51		18.63	26.22

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES WATER	ALT WATER	LAND	ALT LAND
265	CRUDE PETROLEUM	11,528	7.14		15.95	17.92
266	CRUDE PETROLEUM	4,749	4.01		16.70	18.81
267	CRUDE PETROLEUM	26,862	8.44		13.93	22.65
268	CRUDE PETROLEUM	31,971	9.76		24.32	
269	CRUDE PETROLEUM	6,128	13.73		30.26	
270	CRUDE PETROLEUM	13,216	14.34		35.58	
271	CRUDE PETROLEUM	8,426	9.73		29.98	
272	CRUDE PETROLEUM	134,251	4.17		14.85	
273	CRUDE PETROLEUM	6,664	2.29		7.38	17.22
274	CRUDE PETROLEUM	551,775	2.19		10.00	
275	CRUDE PETROLEUM	25,678	4.84		6.59	26.46
276	CRUDE PETROLEUM	132,023	4.55		23.58	
277	CRUDE PETROLEUM	17,338	5.31		6.50	25.32
278	CRUDE PETROLEUM	18,164	6.24		24.48	28.27
279	CRUDE PETROLEUM	16,083	6.14		20.86	31.85
280	CRUDE PETROLEUM	2,204	1.39		4.43	
281	CRUDE PETROLEUM	35,264	1.28		3.66	4.43
282	CRUDE PETROLEUM	59,754	5.44		16.50	22.65
283	CRUDE PETROLEUM	21,708	2.85		9.31	12.20
284	CRUDE PETROLEUM	321,467	4.64		18.16	
285	CRUDE PETROLEUM	10,211	4.19		10.51	21.38
286	CRUDE PETROLEUM	189,387	5.82		25.17	
287	CRUDE PETROLEUM	170,443	5.95		18.56	
288	CRUDE PETROLEUM	5,510	2.19		6.13	
289	CRUDE PETROLEUM	12,036	12.87		43.82	45.09
290	CRUDE PETROLEUM	7,452	7.58		17.57	31.88
291	CRUDE PETROLEUM	25,153	5.00		20.15	21.23
292	CRUDE PETROLEUM	109,998	6.26		19.30	
293	LIMESTONE	7,200	9.82		22.65	
294	LIMESTONE	7,942	10.10		44.81	
295	LIMESTONE	12,440	9.07	9.35	28.32	
296	LIMESTONE	53,930	10.27		33.06	
297	LIMESTONE	15,240	9.82	9.55	24.30	
298	LIMESTONE	11,225	11.68		45.90	
299	LIMESTONE	11,326	8.43		40.64	
300	LIMESTONE	6,806	11.83	12.50	36.60	
301	LIMESTONE	11,081	8.37	10.10	22.51	
302	LIMESTONE	5,872	7.55		24.77	
303	LIMESTONE	3,137	6.78		51.43	
304	LIMESTONE	15,619	8.37		40.33	
305	LIMESTONE	6,458	9.39		40.01	
306	LIMESTONE	87,726	9.72		40.41	
307	LIMESTONE	22,661	9.15		51.60	
308	LIMESTONE	8,421	7.75		39.09	

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
309	LIMESTONE	105,926	7.75		37.18	
310	LIMESTONE	11,920	7.85		44.44	
311	LIMESTONE	42,940	8.00		21.30	
312	LIMESTONE	30,000	8.00		21.30	
313	LIMESTONE	20,000	8.00		20.78	
314	LIMESTONE	22,961	8.00		34.59	
315	LIMESTONE	9,297	8.58		36.41	
316	LIMESTONE	5,300	8.94		41.80	
317	LIMESTONE	18,855	8.00		21.30	
318	SAND AND GRAVEL	8,928	10.25		10.61	13.93
319	SAND ANO GRAVEL	3,078	6.97		11.66	15.94
320	SAND AND GRAVEL	10,491	10.59		30.11	
321	SAND AND GRAVEL	17,187	9.25		37.63	
322	SAND AND GRAVEL	18,319	10.58		34.36	
323	SAND AND GRAVEL	48,976	10.73		34.36	
324	SAND AND GRAVEL	10,653	11.09		36.59	
325	SAND AND GRAVEL	14,050	10.13		23.96	
326	SAND AND GRAVEL	12,093	7.25		31.48	
327	CLAY	19,991	20.70		22.05	31.41
328	CLAY	3,980	9.61		11.52	22.31
329	CLAY	11,525	7.91		7.54	14.80
330	CLAY	23,415	9.27		11.52	17.25
331	CLAY	4,115	10.50		15.22	24.99
332	CLAY	21,777	5.49		9.89	15.72
333	CLAY	27,901	6.63		10.83	17.32
334	CLAY	4,560	5.38		13.54	
335	CLAY	1,389	28.69		57.24	
336	SALT	69,959	10.27		23.45	34.76
337	SALT	25,480	6.79		12.15	14.04
338	SALT	243,200	6.79		13.42	
339	SALT	21,700	7.78		29.75	
340	SALT	21,332	8.00		39.33	
341	SALT	20,131	12.74		36.73	
342	SALT	4,543	13.11		83.60	
343	SALT	21,567	14.71		45.92	
344	SALT	33,869	10.21		32.02	
345	SALT	25,842	11.84		36.09	
346	SALT	1,684	15.18		97.45	
347	SALT	36,338	10.25		27.55	
348	SALT	4,362	11.34		66.62	
349	SALT	9,316	11.47		36.19	
350	SALT	11,795	12.41		43.27	
351	SALT	33,709	12.69		35.97	
352	SALT	11,823	9.38		35.22	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES WATER	ALT WATER	LAND	ALT LAND
353	SALT	161,942	8.75		32.02	
354	SALT	17,224	8.50		45.33	
355	SALT	7,411	8.50		45.33	
356	SALT	44,091	9.84		42.53	
357	SALT	1,368	12.97		70.10	
358	SALT	15,556	20.69		42.69	
359	SALT	11,059	8.35		34.13	
360	SALT	2,852	12.62		85.90	
361	SALT	9,278	10.75		45.53	
362	SALT	18,656	13.73		45.57	
363	SALT	112,671	15.10		44.42	
364	SALT	6,144	17.05		47.26	
365	SALT	21,381	11.26		29.62	
366	SALT	191,181	9.05		28.60	
367	SALT	13,623	11.21		33.98	
368	SALT	7,757	14.00		26.71	
369	SALT	1,532	10.46		49.10	
370	SALT	4,610	17.19		77.00	
371	SALT	97,430	8.25		49.80	
372	SALT	8,050	18.66		31.61	
373	SALT	7,188	15.96	16.89	24.94	
374	SALT	3,188	10.03		58.60	
375	SALT	11,206	13.32		41.26	
376	SALT	50,355	13.66		44.51	
377	SALT	32,085	14.00		44.42	
378	SALT	90,294	20.37		41.97	
379	SALT	12,472	14.34		43.69	
380	SALT	13,948	12.90		41.31	
381	SALT	93,236	15.41		48.40	
382	SALT	2,933	15.62		97.55	
383	SALT	29,308	12.00		25.23	
384	SALT	8,806	27.44		41.68	
385	SALT	105,450	15.61		28.65	
386	SALT	8,002	20.57		39.71	
387	SALT	4,550	12.31		74.40	
388	SULPHUR, LIQUID	260,560	31.18		35.00	
389	SULPHUR, LIQUID	32,295	11.50		19.32	23.01
390	SULPHUR, LIQUID	10,865	8.85		10.91	20.83
391	SULPHUR, LIQUID	25,666	9.60		19.32	23.01
392	SULPHUR, LIQUID	90,300	13.00		29.65	31.96
393	SULPHUR, LIQUID	31,206	19.00		26.74	
394	SULPHUR, LIQUID	18,139	54.31		58.71	
395	SULPHUR, LIQUID	36,163	52.25		57.70	
396	SULPHUR, LIQUID	9,583	54.76		46.94	121.33

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
397	NONMETALLIC MINERALS	69,705	6.40		9.73	14.96
398	BUILDING CEMENT	30,274	10.33		12.46	
399	BUILDING CEMENT	22,261	6.11		11.43	
400	BUILDING CEMENT	2,463	9.41		24.60	19.54
401	BUILDING CEMENT	9,933	12.02		19.04	36.57
402	BUILDING CEMENT	14,437	14.21		35.18	
403	BUILDING CEMENT	17,122	16.75		20.50	
404	BUILDING CEMENT	27,322	7.50		NONE	NONE
405	LIME	18,525	6.00		10.58	14.12
406	LIME	147,198	8.50		23.90	
407	WATERWAY IMPROV MTL	2,000	3.90		9.69	13.71
408	WATERWAY IMPROV MTL	7,000	4.38		12.27	12.99
409	WATERWAY IMPROV MTL	23,758	7.25	7.91	33.15	
410	VENEER OR PLYWOOD	2,610	24.05		36.89	38.30
411	PULP	93,330	19.75		26.16	28.64
412	PULP	8,285	20.52		28.39	29.89
413	NEWSPRINT PAPER	13,607	38.15		47.96	
414	PAPER AND PAPERBOARD	13,434	21.32		36.17	36.68
415	PAPER AND PAPERBOARD	10,544	28.77	28.15	58.76	
416	PAPER AND PAPERBOARD	16,339	22.12		49.41	
417	SODIUM HYDROXIDE	29,231	7.33		25.31	34.77
418	SODIUM HYDROXIDE	2,100	11.03		53.82	
419	SODIUM HYDROXIDE	3,826	8.86		30.35	51.27
420	SODIUM HYDROXIDE	112,790	8.64		9.48	
421	SODIUM HYDROXIDE	13,229	11.57		15.65	
422	SODIUM NYDROXIDE	6,000	6.38		11.34	28.63
423	SODIUM HYDROXIDE	1,400	11.54		42.84	
424	SODIUM HYDROXIDE	5,081	9.32		16.85	32.31
425	SODIUM HYDROXIDE	8,400	11.79		24.90	
426	SODIUM HYDROXIDE	3,924	6.51		29.92	30.40
427	SODIUM HYDROXIDE	12,642	9.40		24.85	54.81
428	SODIUM HYDROXIDE	2,837	6.53		18.96	26.31
429	SODIUM HYDROXIDE	6,038	9.93		18.53	
430	SODIUM HYDROXIDE	4,093	15.11		28.31	38.17
431	SODIUM HYDROXIDE	12,934	9.45		16.48	
432	SODIUM HYDROXIDE	13,507	11.57		17.19	
433	SODIUM HYDROXIDE	2,754	9.32		25.16	35.17
434	SODIUM HYDROXIDE	2,995	9.79		32.09	
435	SODIUM HYDROXIDE	10,435	11.25		26.73	
436	SODIUM HYDROXIDE	14,683	6.42		10.95	26.58
437	SODIUM HYDROXIDE	21,392	8.63		21.61	
438	SODIUM HYDROXIDE	13,491	8.65		21.61	
439	SODIUM HYDROXIDE	83,604	15.83		39.59	
440	SODIUM HYDROXIDE	17,831	8.90		17.21	55.22

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
441	CRUDE PETRO PRODUCTS	6,147	3.86		11.16	12.92
442	CRUDE PETRO PRODUCTS	9,097	4.45		9.59	12.20
443	CRUDE PETRO PRODUCTS	4,590	25.12		74.26	
444	CRUDE PETRO PRODUCTS	58,530	32.54		85.71	
445	CRUDE PETRO PRODUCTS	11,226	19.98		54.58	
446	CRUDE PETRO PRODUCTS	1,770	8.13		33.61	
447	CRUDE PETRO PRODUCTS	4,126	24.38		45.30	
448	CRUDE PETRO PRODUCTS	6,618	25.29		42.93	
449	CRUDE PETRO PRODUCTS	15,403	27.27		52.01	
450	CRUDE PETRO PRODUCTS	11,355	24.74		43.48	
451	CRUDE PETRO PRODUCTS	16,786	25.70		47.00	
452	CRUDE PETRO PRODUCTS	9,198	28.78		50.45	
453	CRUDE PETRO PRODUCTS	10,915	28.99		66.75	
454	ALCOHOLS	1,435	8.93		13.79	25.19
455	ALCOHOLS	74,978	7.60		23.14	
456	ALCOHOLS	5,600	9.91		19.04	
457	ALCOHOLS	3,343	18.69		58.96	
458	ALCOHOLS	10,572	24.42		42.20	
459	ALCOHOLS	1,439	18.44		64.46	
460	ALCOHOLS	9,701	17.00		60.03	
461	ALCOHOLS	4,397	8.99		27.30	38.69
462	ALCOHOLS	4,496	9.85		23.19	34.33
463	ALCOHOLS	35,472	27.06		65.55	
464	ALCOHOLS	125,006	28.33		63.54	
465	ALCOHOLS	1,168	18.34		56.35	
466	ALCOHOLS	4,530	21.40		87.70	
467	ALCOHOLS	2,824	13.32		69.90	
468	ALCOHOLS	2,807	14.30		48.90	
469	ALCOHOLS	1,341	22.02		79.50	
470	ALCOHOLS	15,400	36.77		67.71	
471	ALCOHOLS	15,400	36.77		67.71	
472	ALCOHOLS	4,048	15.67		48.90	
473	ALCOHOLS	4,112	17.07		48.90	
474	ALCOHOLS	10,888	29.71		48.90	
475	ALCOHOLS	1,328	22.62		87.70	
476	ALCOHOLS	75,871	29.20		66.11	
477	ALCOHOLS	10,516	29.71		48.30	
478	ALCOHOLS	7,957	15.68		47.09	
479	ALCOHOLS	40,100	26.71		49.21	
480	BENZENE	6,280	8.82		22.56	
481	BENZENE	6,172	8.85		22.04	
482	BENZENE	27,858	3.69		9.64	11.49
483	BEN2ENE	4,192	8.82		37.00	
484	BENZENE	7,187	4.85		11.94	16.04

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
485	BENZENE	78,556	7.54		16.69	31.22
486	BENZENE	41,088	21.90		54.76	
487	BENZENE	4,153	17.76		61.78	
488	BENZENE	39,836	9.80		23.24	
489	BENZENE	3,095	8.62		34.00	
490	BENZENE	13,780	21.88		37.41	
491	BENZENE	171,454	6.37		22.65	
492	BENZENE	1,458	17.76		46.91	
493	BENZENE	52,913	7.80		15.57	20.42
494	SULFURIC ACID	118,120	4.40		10.79	
495	SULFURIC ACID	116,995	4.40		10.79	
496	SULFURIC ACID	70,802	10.84		19.04	
497	BASIC CHEMICALS, NEC	17,195	8.64		29.63	
498	BASIC CHEMICALS, NEC	20,012	11.46		25.14	
499	BASIC CHEMICALS, NEC	7,500	14.31		40.16	
500	BASIC CHEMICALS, NEC	13,930	7.37		20.28	
501	BASIC CHEMICALS, NEC	2,817	12.90		53.20	
502	BASIC CHEMICALS, NEC	9,190	8.31		24.25	
503	BASIC CHEMICALS, NEC	5,000	9.55		34.74	37.59
504	BASIC CHEMICALS, NEC	10,000	14.50		27.16	
505	BASIC CHEMICALS, NEC	20,286	9.23		26.02	
506	BASIC CHEMICALS, NEC	122,082	8.81		20.97	
507	BASIC CHEMICALS, NEC	10,341	8.81		20.97	
508	BASIC CHEMICALS, NEC	10,000	8.81		22.02	
509	BASIC CHEMICALS, NEC	10,000	8.27		20.07	
510	BASIC CHEMICALS, NEC	3,012	7.96		24.51	42.90
511	BASIC CHEMICALS, NEC	4,800	10.35		42.90	
512	BASIC CHEMICALS, NEC	16,129	8.60		11.22	17.96
513	BASIC CHEMICALS, NEC	95,450	7.12		18.28	34.05
514	BASIC CHEMICALS, NEC	5,000	23.94		44.94	
515	BASIC CHEMICALS, NEC	44,211	19.44		35.98	
516	BASIC CHEMICALS, NEC	31,475	17.38		50.19	
517	BASIC CHEMICALS, NEC	6,392	9.49		16.65	
518	BASIC CHEMICALS, NEC	7,500	11.41		22.05	47.42
519	BASIC CHEMICALS, NEC	11,407	29.02		70.58	
520	BASIC CHEMICALS, NEC	6,926	19.38		59.26	
521	BASIC CHEMICALS, NEC	3,832	19.00		76.50	
522	BASIC CHEMICALS, NEC	15,798	35.12	31.00	47.30	
523	BASIC CHEMICALS, NEC	1,516	21.46		64.59	
524	BASIC CHEMICALS, NEC	24,413	9.81		35.95	
525	BASIC CHEMICALS, NEC	8,918	7.19		18.05	
526	BASIC CHEMICALS, NEC	12,505	13.04		31.43	
527	BASIC CHEMICALS, NEC	7,412	16.50		47.56	
528	BASIC CHEMICALS, NEC	12,704	22.23		70.45	

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES WATER	ALT WATER	LAND	ALT LAND
529	BASIC CHEMICALS, NEC	49,219	26.08		43.47	
530	BASIC CHEMICALS, NEC	11,540	20.55		46.42	
531	BASIC CHEMICALS, NEC	6,040	13.46		42.09	
532	BASIC CHEMICALS, NEC	16,846	11.34		17.01	
533	BASIC CHEMICALS, NEC	12,853	26.14		62.08	
534	BASIC CHEMICALS, NEC	10,188	36.51		67.25	
535	BASIC CHEMICALS, NEC	14,509	30.22		54.27	
536	BASIC CHEMICALS, NEC	113,185	23.93		45.96	
537	BASIC CHEMICALS, NEC	30,168	23.27		69.71	
538	BASIC CHEMICALS, NEC	28,420	36.59		65.11	
539	BASIC CHEMICALS, NEC	52,086	15.10		56.34	
540	BASIC CHEMICALS, NEC	47,718	15.10		56.34	
541	BASIC CHEMICALS, NEC	54,073	18.05		55.08	
542	BASIC CHEMICALS, NEC	49,052	18.74		49.50	
543	BASIC CHEMICALS, NEC	196,657	25.39		50.12	
544	BASIC CHEMICALS, NEC	12,950	19.31		59.39	
545	BASIC CHEMICALS, NEC	1,396	18.12		55.50	
546	BASIC CHEMICALS, NEC	37,067	15.10		32.49	
547	BASIC CHEMICALS, NEC	1,952	10.63		49.30	
548	BASIC CHEMICALS, NEC	213,275	24.17		38.32	
549	BASIC CHEMICALS, NEC	30,980	24.17		38.32	
550	BASIC CHEMICALS, NEC	12,731	18.07		40.14	
551	BASIC CHEMICALS, NEC	53,637	23.12		51.92	
552	BASIC CHEMICALS, NEC	40,814	18.86		62.89	
553	BASIC CHEMICALS, NEC	18,435	14.35		39.50	
554	BASIC CHEMICALS, NEC	107,843	24.67		43.66	
555	BASIC CHEMICALS, NEC	69,489	11.83		30.53	
556	BASIC CHEMICALS, NEC	27,541	14.12		26.35	
557	BASIC CHEMICALS, NEC	36,961	13.60		35.71	
558	BASIC CHEMICALS, NEC	593,096	15.45		39.38	
559	BASIC CHEMICALS, NEC	19,723	11.03		25.29	
560	BASIC CHEMICALS, NEC	22,957	11.03		25.29	
561	BASIC CHEMICALS, NEC	20,403	13.61		33.20	
562	BASIC CHEMICALS, NEC	14,930	13.22		30.27	
563	BASIC CHEMICALS, NEC	10,130	21.15		32.05	
564	BASIC CHEMICALS, NEC	15,066	16.00		69.98	
565	BASIC CHEMICALS, NEC	103,412	16.00		69.98	
566	BASIC CHEMICALS, NEC	22,176	32.88		52.06	
567	BASIC CHEMICALS, NEC	94,421	12.40		27.01	
568	BASIC CHEMICALS, NEC	129,280	14.34		34.78	
569	BASIC CHEMICALS, NEC	12,468	17.12		39.78	
570	BASIC CHEMICALS, NEC	4,532	11.34		40.71	
571	BASIC CHEMICALS, NEC	34,668	13.17		39.38	
572	BASIC CHEMICALS, NEC	241,185	15.60		54.92	

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
573	BASIC CHEMICALS, NEC	77,057	4.49		NONE	NONE
574	BASIC CHEMICALS, NEC	32,981	16.00		58.05	
575	BASIC CHEMICALS, NEC	71,148	16.00		58.05	
576	SYNTHETIC RUBBER	8,790	13.63		18.80	27.01
577	SYNTHETIC RUBBER	21,145	12.81		16.57	21.98
578	GUM AND WOOD PRODUCTS	2,761	10.60		77.75	
579	GUM AND WOOD PRODUCTS	15,120	8.46		14.38	
580	GUM AND WOOD PRODUCTS	50,960	9.99		15.77	
581	GUM AND WOOD PRODUCTS	11,200	6.90		14.38	
582	MISC CHEMICAL PDS, NEC	19,494	13.29		30.68	
583	MISC CHEMICAL PDS, NEC	5,332	10.25		35.66	
584	MISC CHEMICAL PDS, NEC	9,190	25.29		71.78	
585	NITROGENOUS FERTILIZER	8,887	7.00		9.92	11.73
586	NITROGENOUS FERTILIZER	1,626	11.70		32.47	
587	NITROGENOUS FERTILIZER	4,603	7.80		19.45	22.94
588	NITROGENOUS FERTILIZER	3,046	6.30		9.92	13.14
589	NITROGENOUS FERTILIZER	1,384	10.09		23.04	25.36
590	NITROGENOUS FERTILIZER	2,952	7.80		19.45	22.94
591	NITROGENOUS FERTILIZER	1,630	8.44		29.77	
592	NITROGENOUS FERTILIZER	1,435	8.69		35.80	
593	NITROGENOUS FERTILIZER	23,939	12.53		31.55	
594	NITROGENOUS FERTILIZER	3,000	11.54		45.56	
595	NITROGENOUS FERTILIZER	1,650	6.80		17.28	34.11
596	NITROGENOUS FERTILIZER	21,054	13.00		26.71	
597	NITROGENOUS FERTILIZER	36,802	12.00		24.81	
598	NITROGENOUS FERTILIZER	18,138	10.00		36.79	
599	NITROGENOUS FERTILIZER	1,426	13.50		40.07	
600	NITROGENOUS FERTILIZER	2,993	8.86		27.75	
601	POTASSIC CHEM FERT	1,711	12.42		55.02	
602	POTASSIC CHEM FERT	4,541	5.34		7.98	13.02
603	POTASSIC CHEM FERT	4,313	9.07		14.03	20.77
604	POTASSIC CHEM FERT	1,497	50.28		64.71	
605	POTASSIC CHEM FERT	5,781	44.30		75.94	
606	POTASSIC CHEM FERT	4,489	50.25		87.22	
607	PHOSPHATIC CHEM FERT	20,254	29.31		34.84	
608	PHOSPHATIC CHEM FERT	2,848	29.42		37.05	
609	PHOSPHATIC CHEM FERT	2,950	22.45		44.29	
610	PHOSPHATIC CHEM FERT	1,249	32.00		36.16	
611	PHOSPHATIC CHEM FERT	10,407	27.20		40.20	
612	PHOSPHATIC CHEM FERT	7,557	17.67		24.01	
613	FERTILIZERS, NEC	2,800	12.44		45.43	
614	FERTILIZERS, NEC	3,337	10.26		36.28	
615	FERTILIZERS, NEC	4,517	13.59		59.56	
616	FERTILIZERS, NEC	8,541	6.80		14.67	19.42

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
617	FERTILIZERS, NEC	1,477	10.53		44.60	
618	FERTILIZERS, NEC	2,796	12.37		52.42	
619	FERTILIZERS, NEC	5,988	9.50		33.14	
620	FERTILIZERS, NEC	4,361	28.81		51.19	
621	FERTILIZERS, NEC	1,418	28.29		46.35	
622	FERTILIZERS, NEC	3,012	27.00		47.11	
623	FERTILIZERS, NEC	8,678	12.43		31.85	
624	FERTILIZERS, NEC	8,399	27.00		32.00	
625	FERTILIZERS, NEC	2,815	31.12		34.35	
626	FERTILIZERS, NEC	1,631	9.13		33.61	
627	FERTILIZERS, NEC	2,966	8.55		35.45	
628	GASOLINE	17,324	4.63		17.58	18.61
629	GASOLINE	146,491	4.55		8.56	
630	GASOLINE	67,921	17.74		31.77	
631	GASOLINE	5,800	32.34	29.03	49.99	
632	GASOLINE	36,023	8.30		30.31	
633	GASOLINE	12,350	9.87		26.04	
634	GASOLINE	15,996	13.74		18.31	
635	GASOLINE	12,659	22.35	19.03	28.81	
636	GASOLINE	45,444	20.06	16.72	35.41	
637	GASOLINE	3,113	8.97		35.46	36.20
638	GASOLINE	11,673	4.28		14.48	16.46
639	GASOLINE	26,219	3.12		9.48	10.03
640	GASOLINE	27,365	9.07		31.13	32.82
641	GASOLINE	7,782	6.45		29.20	29.39
642	GASOLINE	132,672	5.25		16.60	
643	GASOLINE	199,592	7.79		18.13	
644	GASOLINE	24,812	10.48		25.48	
645	GASOLINE	4,021	12.57		81.86	
646	GASOLINE	4,150	15.74		84.63	
647	GASOLINE	46,030	3.54		6.05	6.20
648	GASOLINE	33,747	4.99		8.03	10.08
649	GASOLINE	8,233	7.25		16.90	25.94
650	GASOLINE	2,630	8.06		26.71	
~~651~~	~~GASOLINE~~	~~18,000~~	~~5.97~~		~~9.55~~	~~10.08~~
652	GASOLINE	6,486	5.97		9.55	10.08
653	GASOLINE	12,618	3.02		7.49	15.79
654	GASOLINE	1,400	3.00		7.32	19.10
655	GASOLINE	11,488	2.86		6.12	16.01
656	GASOLINE	33,804	5.43		17.43	18.70
657	GASOLINE	10,111	7.02		22.29	25.51
658	GASOLINE	4,602	8.99		44.05	48.19
659	GASOLINE	67,590	5.19		13.70	20.29
660	GASOLINE	2,583	7.19		21.12	27.19

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
661	GASOLINE	2,596	6.21		11.29	13.83
662	GASOLINE	6,000	9.58		25.27	39.99
663	GASOLINE	2,935	5.60		17.49	22.44
664	GASOLINE	12,882	5.46		13.74	13.82
665	GASOLINE	10,719	4.56		10.08	15.91
666	GASOLINE	2,607	7.76		26.61	34.74
667	GASOLINE	19,624	19.78		42.05	
668	GASOLINE	8,358	22.55		41.42	
669	GASOLINE	6,356	15.74		40.78	
670	GASOLINE	5,540	19.41		44.61	
671	GASOLINE	10,584	30.44		70.88	
672	GASOLINE	2,996	15.93		46.69	
673	GASOLINE	86,806	4.37		18.87	19.27
674	GASOLINE	9,922	7.81		18.76	
675	GASOLINE	7,671	9.50		23.81	
676	GASOLINE	23,889	8.26		17.71	
677	GASOLINE	27,742	30.28		51.81	
678	GASOLINE	24,022	8.16		18.80	
679	GASOLINE	11,778	21.75		8.25	35.01
680	GASOLINE	33,223	22.11		8.25	39.24
681	GASOLINE	40,884	11.52		44.96	
682	GASOLINE	34,081	9.79		33.59	
683	GASOLINE	10,896	12.63		31.32	
684	GASOLINE	19,455	15.46		10.70	27.83
685	GASOLINE	9,612	22.08		13.30	41.32
686	GASOLINE	15,324	9.68		14.00	21.20
687	GASOLINE	3,892	23.76		13.30	46.01
688	GASOLINE	11,805	25.27		36.65	
689	GASOLINE	129,000	11.78		35.59	
690	GASOLINE	2,615	13.14		46.87	
691	GASOLINE	179,740	12.94		50.15	
692	GASOLINE	156,849	8.82		23.47	
693	GASOLINE	73,670	13.28		38.58	
694	GASOLINE	160,255	13.28		36.88	
695	GASOLINE	29,961	28.72		53.50	
696	GASOLINE	34,112	28.72		53.50	
697	GASOLINE	35,853	8.43		21.45	30.94
698	GASOLINE	3,413	8.35		21.20	21.33
699	GASOLINE	3,100	24.51		59.04	
700	GASOLINE	13,287	31.74		54.07	
701	JET FUEL	57,695	26.45	23.49	33.79	
702	JET FUEL	134,053	24.04	21.07	29.53	
703	JET FUEL	25,454	6.10		22.79	25.08
704	JET FUEL	46,954	10.48		25.27	32.58

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TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
705	JET FUEL	9,243	20.89		38.16	
706	JET FUEL	19,197	23.59		35.08	
707	JET FUEL	9,243	23.59		35.08	
708	JET FUEL	24,885	9.54		38.25	
709	JET FUEL	9,243	21.35		34.28	
710	JET FUEL	12,087	21.35		34.28	
711	JET FUEL	15,642	21.35		34.01	
712	JET FUEL	6,000	11.84		36.96	
713	JET FUEL	23,815	9.35		18.27	32.15
714	JET FUEL	7,110	26.62		27.91	
715	JET FUEL	9,243	29.38		29.77	
716	JET FUEL	10,243	14.74		39.87	
717	KEROSENE	11,396	35.88		67.64	
718	KEROSENE	20,249	32.15		58.37	
719	DISTILLATE FUEL OIL.	3,656	7.58		34.64	
720	DISTILLATE FUEL OIL	7,595	4.50		9.21	13.99
721	DISTILLATE FUEL OIL	9,036	4.49		10.99	13.81
722	DISTILLATE FUEL OIL	20,250	8.24		22.18	22.38
723	DISTILLATE FUEL OIL	28,137	25.79	23.99	38.92	
724	DISTILLATE FUEL OIL	53,255	18.03	15.07	27.30	
725	DISTILLATE FUEL OIL	1,265	2.97		11.49	18.46
726	DISTILLATE FUEL OIL	30,682	1.73		6.40	15.20
727	DISTILLATE FUEL OIL	2,954	8.61		37.02	61.73
728	DISTILLATE FUEL OIL	10,417	7.18		25.71	
729	DISTILLATE FUEL OIL	9,159	5.96		20.80	25.51
730	DISTILLATE FUEL OIL	10,458.	7.66		20.70	
731	DISTILLATE FUEL OIL	9,397	2.15		4.19	4.43
732	DISTILLATE FUEL OIL	2,772	4.63		10.77	12.74
733	DISTILLATE FUEL OIL	263,783	3.84		21.91	
734	DISTILLATE FUEL OIL	1,509	1.66		4.43	
735	DISTILLATE FUEL OIL	14,894	5.70		16.67	23.28
736	DISTILLATE FUEL OIL	691,626	7.89		13.48	
737	DISTILLATE FUEL OIL	4,431	3.52		8.54	15.75
738	DISTILLATE FUEL OIL	11,509	1.94		8.12	
739	DISTILLATE FUEL OIL	6,714	4.67		19.17	19.85
740	DISTILLATE FUEL OIL	4,651	7.14		14.17	20.60
741	DISTILLATE FUEL OIL	36,283	4.14		7.92	
742	DISTILLATE FUEL OIL	9,600	24.40		47.78	
743	DISTILLATE FUEL OIL	48,963	35.09		17.61	61.22
744	DISTILLATE FUEL OIL	97,633	24.10		43.94	
745	DISTILLATE FUEL OIL	5,206	28.13		12.44	45.10
746	DISTILLATE FUEL OIL	8,049	12.39		32.83	
747	DISTILLATE FUEL OIL	25,701	15.22		9.87	31.61
748	DISTILLATE FUEL OIL	11,310	25.84		50.04	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
749	DISTILLATE FUEL OIL	37,841	2.14		8.89	
750	DISTILLATE FUEL OIL	95,683	2.14			
751	DISTILLATE FUEL OIL	3,324	10.10		31.53	
752	DISTILLATE FUEL OIL	10,090	19.55		50.43	
753	DISTILLATE FUEL OIL	1,242	17.92		57.22	
754	DISTILLATE FUEL OIL	3,524	31.61		67.53	
755	RESIDUAL FUEL OIL	9,389	6.42		18.81	24.38
756	RESIDUAL FUEL OIL	22,288	11.87		41.19	
757	RESIDUAL FUEL OIL	6,580	9.20		27.40	
758	RESIDUAL FUEL OIL	3,555	8.37		33.79	
759	RESIDUAL FUEL OIL	127,423	6.29		28.43	
760	RESIDUAL FUEL OIL	11,100	32.77	20.85	35.80	
761	RESIDUAL FUEL OIL	9,522	3.57		8.69	11.22
762	RESIDUAL FUEL OIL	169,409	8.19		21.94	
763	RESIDUAL FUEL OIL	10,245	3.47		11.93	12.84
764	RESIDUAL FUEL OIL	13,900	4.36		10.88	13.99
765	RESIDUAL FUEL OIL	9,389	6.08		17.50	
766	RESIDUAL FUEL OIL	14,117	3.61		9.90	11.40
767	RESIDUAL FUEL OIL	39,780	1.96		4.18	4.43
768	RESIDUAL FUEL OIL	3,060	4.36		14.02	14.79
769	RESIDUAL FUEL OIL	9,284	6.93		26.42	
770	RESIDUAL FUEL OIL	18,200	6.83		29.04	
771	RESIDUAL FUEL OIL	8,701	7.08		28.07	32.02
772	RESIDUAL FUEL OIL	2,960	1.93		4.43	11.48
773	RESIDUAL FUEL OIL	11,313	7.53		21.01	
774	RESIDUAL FUEL OIL	9,389	7.77		23.52	
775	RESIDUAL FUEL OIL	18,138	3.92		8.83	12.65
776	RESIDUAL FUEL OIL	6,910	3.36		8.98	9.35
777	RESIDUAL FUEL OIL	65,624	6.93		22.66	
778	RESIDUAL FUEL OIL	24,597	3.38		9.08	10.54
779	RESIDUAL FUEL OIL	14,472	3.38		9.08	10.54
780	RESIDUAL FUEL OIL	21,866	5.58		20.42	22.92
781	RESIDUAL FUEL OIL	92,125	5.58		20.42	22.92
782	RESIDUAL FUEL OIL	6,756	6.02		29.79	
783	RESIDUAL FUEL OIL	20,134	5.19		18.81	31.09
784	RESIDUAL FUEL OIL	38,725	4.43		10.98	15.42
785	RESIDUAL FUEL OIL	9,393	10.79		25.52	
786	RESIDUAL FUEL OIL	5,846	11.01		25.13	
787	RESIDUAL FUEL OIL	12,100	7.90		3.99	28.94
788	RESIDUAL FUEL OIL	15,731	4.01		17.87	23.03
789	RESIDUAL FUEL OIL	9,780	2.89		9.17	14.62
790	RESIDUAL FUEL OIL	9,687	4.96		10.32	10.77
791	RESIDUAL FUEL OIL	6,388	5.24		20.23	29.54
792	RESIDUAL FUEL OIL	5,188	5.72		17.86	23.10

ATTACHMENT 1
TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

			SUMMARY OF CHARGES			
REF	COMMODITY	TONS	WATER	ALT WATER	LAND	ALT LAND
793	RESIDUAL FUEL OIL	69,935	6.57		15.65	18.18
794	RESIDUAL FUEL OIL	52,225	3.28		10.20	13.27
795	RESIDUAL FUEL OIL	5,319	20.66	16.47	26.92	
796	RESIDUAL FUEL OIL	7,806	6.97		10.18	17.65
797	RESIDUAL FUEL OIL	9,850	32.08		49.06	
798	RESIDUAL FUEL OIL	12,103	26.30		42.54	
799	RESIDUAL FUEL OIL	157,046	8.02		31.76	
800	RESIDUAL FUEL OIL	636,606	7.89		17.75	
801	RESIDUAL FUEL OIL	6,846	7.68		16.44	
802	RESIDUAL FUEL OIL	35,471	5.58		23.66	24.43
803	RESIDUAL FUEL OIL	8,260	9.01		16.92	
804	RESIDUAL FUEL OIL	37,643	25.04		69.00	
805	RESIDUAL FUEL OIL	2,859	35.19		76.03	
806	RESIDUAL FUEL OIL	10,508	24.96		57.51	
807	RESIDUAL FUEL OIL	44,519	7.44		21.25	
808	RESIDUAL FUEL OIL	12,308	35.73		65.91	
809	RESIDUAL FUEL OIL	9,389	7.19		23.90	
810	RESIDUAL FUEL OIL	1,687	6.96		38.29	
811	RESIDUAL FUEL OIL	10,313	7.27		21.05	
812	RESIDUAL FUEL OIL	45,790	10.35		35.70	
813	RESIDUAL FUEL OIL	3,094	9.98		31.22	35.76
814	RESIDUAL FUEL OIL	9,488	35.10		69.00	
815	RESIDUAL FUEL OIL	13,754	9.38		24.20	
816	RESIDUAL FUEL OIL	28,140	12.11		30.22	
817	RESIDUAL FUEL OIL	1,939	4.35		21.93	27.22
818	RESIDUAL FUEL OIL	9,389	11.01		36.65	
819	RESIDUAL FUEL OIL	21,247	5.85		17.97	25.06
820	RESIDUAL FUEL OIL	18,288	5.85		17.97	25.06
821	RESIDUAL FUEL OIL	10,792	5.86		24.68	25.24
822	RESIDUAL FUEL OIL	28,267	5.85		24.68	25.24
823	RESIDUAL FUEL OIL	25,477	5.84		17.97	25.15
824	RESIDUAL FUEL OIL	3,074	5.97		31.19	31.38
825	RESIDUAL FUEL OIL	17,155	27.49		60.01	
826	LUBRICATING OILS	56,379	1.37		10.33	4.43
~~827~~	~~LUBRICATING OILS~~	~~23,962~~	~~21.08~~		~~49.43~~	
828	LUBRICATING OILS	19,672	33.30		65.19	
829	LUBRICATING OILS	67,575	22.59		52.26	
830	LUBRICATING OILS	7,995	29.36		60.30	
831	LUBRICATING OILS	2,829	20.14		89.47	
832	LUBRICATING OILS	11,100	20.13		37.06	
833	LUBRICATING OILS	16,327	32.50		68.72	
834	LUBRICATING OILS	40,674	26.53		46.56	
835	LUBRICATING OILS	71,047	25.30		58.09	
836	LUBRICATING OILS	58,460	31.24		62.32	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
837	LUBRICATING OILS	6,839	34.63		66.55	
838	LUBRICATING OILS	17,278	35.35		64.60	
839	LUBRICATING OILS	13,775	28.33		49.99	
840	LUBRICATING OILS	5,445	15.26		41.15	
841	LUBRICATING OILS	7,226	7.55		22.21	
842	LUBRICATING OILS	32,446	10.16		40.72	
843	LUBRICATING OILS	16,528	33.09		74.81	
844	NAPHTHA	4,770	4.64		13.20	15.21
845	NAPHTHA	9,758	21.28	17.25	31.45	
846	NAPHTHA	37,475	7.99		21.34	
847	NAPHTHA	4,576	6.13		24.91	30.66
848	NAPHTHA	43,695	5.00		10.61	11.01
849	NAPHTHA	9,341	5.00		10.61	11.01
850	NAPHTHA	12,278	4.40		9.71	13.16
851	NAPHTHA	7,777	9.92		15.21	20.25
852	NAPHTHA	15,217	4.71		7.99	18.03
853	NAPHTHA	1,400	25.90		73.26	
854	NAPHTHA	4,089	10.91		36.99	
855	NAPHTHA	2,727	4.99		23.06	
856	NAPHTHA	59,673	21.46		38.95	
857	NAPHTHA	13,335	21.46		38.95	
858	NAPHTHA	50,166	21.46		38.95	
859	NAPHTHA	4,369	6.38		17.58	23.26
860	NAPHTHA	12,718	26.96		48.38	
861	NAPHTHA	6,016	7.31		20.02	
862	NAPHTHA	10,632	29.35		46.79	
863	NAPHTHA	5,951	30.49		57.66	
864	NAPHTHA	8,582	31.16		56.90	
865	NAPHTHA	6,000	9.43		26.74	
866	NAPHTHA	5,452	25.47		48.27	
867	NAPHTHA	14,816	6.44		17.07	23.36
868	ASPHALT	6,235	13.50		29.02	
869	ASPHALT	15,206	30.16	18.35	25.26	
870	ASPHALT	17,270	11.17		20.07	
871	ASPHALT	11,066	17.34		32.45	
870	ASPHALT	11,760	13.50		29.02	
873	ASPHALT	11,540	9.73		16.10	
874	ASPHALT	6,364	14.40		30.60	
875	ASPHALT	1,308	18.66		52.99	
876	ASPHALT	17,977	19.85		32.87	
877	ASPHALT	17,117	12.00		40.16	
878	ASPHALT	4,615	12.00		42.03	
879	PETROLEUM COKE	6,000	7.46		14.71	15.53
880	PETROLEUM COKE	11,037	12.50		26.77	

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES			
			WATER	ALT WATER	LAND	ALT LAND
881	PETROLEUM COKE	5,003	8.37		14.23	15.03
882	PETROLEUM COKE	224,449	8.12		12.39	14.93
883	PETROLEUM COKE	21,895	11.50		28.43	
884	PETROLEUM COKE	4,889	11.61		9.13	14.00
885	PETROLEUM COKE	1,574	11.53		9.13	10.23
886	PETROLEUM COKE	70,245	11.53		9.13	10.23
887	PETROLEUM COKE	8,915	16.87		27.06	
888	PETROLEUM COKE	3,018	14.32		14.88	22.28
889	PETROLEUM COKE	36,677	9.82		24.02	
890	PETROLEUM COKE	59,620	19.66		40.76	
891	PETROLEUM COKE	16,171	29.46	24.82	31.34	
892	PETROLEUM COKE	23,107	18.76		29.83	
893	PETROLEUM COKE	3,213	21.77		42.94	
894	PETROLEUM COKE	53,866	7.50		18.77	34.48
895	PETROLEUM COKE	6,408	7.50		18.77	34.48
896	PETROLEUM COKE	54,219	20.38		19.54	
897	PETROLEUM COKE	3,302	15.56		50.28	
898	LIQUIFIED PETROLEUM	117,354	5.69		23.44	27.35
899	LIQUIFIED PETROLEUM	28,516	5.76		23.26	27.35
900	LIQUIFIED PETROLEUM	19,592	3.57		8.77	10.65
901	LIQUIFIED PETROLEUM	82,697	6.54		17.08	23.66
902	LIQUIFIED PETROLEUM	15,708	8.90		17.98	32.08
903	LIQUIFIED PETROLEUM	58,410	6.67		16.76	26.84
904	LIQUIFIED PETROLEUM	13,315	6.32		14.90	23.74
905	LIQUIFIED PETROLEUM	14,926	15.68		42.24	
906	PETROLEUM PBS, NEC	10,632	9.01		24.45	
907	PETROLEUM PBS, NEC	145,304	3.91		18.78	20.57
908	MARINE SHELL	1,358	13.47	13.99	43.48	
909	MARINE SHELL	16,448	3.61		3.08	7.71
910	MARINE SHELL	5,997	3.48		2.70	7.19
911	MARINE SHELL	70,100	3.46		5.38	6.60
912	MARINE SHELL	16,209	3.93		7.68	8.16
913	MARINE SHELL	74,650	3.60		9.40	
914	MARINE SHELL	1,984	4.72		10.06	21.00
915	MARINE SHELL	4,729	4.79		10.86	21.00
916	MARINE SHELL	17,500	5.90		10.23	15.02
917	MARINE SHELL	7,523	7.19		14.78	18.75
918	MARINE SHELL	28,542	3.99		5.43	19.23
919	MARINE SHELL	28,542	3.99		5.43	19.23
920	MARINE SHELL	7,000	10.01		27.57	
921	MARINE SHELL	11,150	10.14		17.89	22.30
922	MARINE SHELL	4,500	12.21		31.24	36.22
923	MARINE SHELL	502,580	6.67		7.86	
924	MARINE SHELL	30.412	10.12		18.59	20.30

ATTACHMENT 1

TRANSPORTATION RATE ANALYSIS FOR INNER HARBOR NAVIGATION CANAL STUDY

REF	COMMODITY	TONS	SUMMARY OF CHARGES WATER	ALT WATER	LAND	ALT LAND
925	MARINE SHELL	5,277	6.92		12.34	15.56
926	MARINE SHELL	8,054	8.91		17.59	21.25
927	MARINE SHELL	15,123	10.12		19.78	21.10
928	MARINE SHELL	6,430	10.12		16.03	21.73
929	MARINE SHELL	274,377	6.92		7.70	
930	BASIC TEXTILE POS	1,350	9.94		47.64	
931	MISC POS OF MFG	35,475	7.54		13.93	
932	WASTE AND SCRAP, NEC	4,010	14.51		38.23	
933	WASTE AND SCRAP, NEC	9,819	10.48		16.59	
934	WASTE AND SCRAP, NEC	11,529	7.84		20.01	
935	WASTE AND SCRAP, NEC	12,433	9.02		17.07	
936	WASTE AND SCRAP, NEC	9,515	24.09		40.62	
937	WASTE AND SCRAP, NEC	33,426	57.87		91.25	
938	WASTE AND SCRAP, NEC	20,637	35.26		63.93	
939	WASTE AND SCRAP, NEC	11,480	14.29		43.61	
940	WASTE AND SCRAP, NEC	10,336	7.99		18.42	39.24
941	WASTE AND SCRAP, NEC	5,926	17.86		47.39	
942	WASTE AND SCRAP, NEC	16,931	29.61		49.08	
943	WATER	6,213	2.77			
944	MISC. SHIPMENTS	35,570	9.62		26.29	