DELAWARE RIVER
COMPREHENSIVE NAVIGATION STUDY

SALEM RIVER, NEW JERSEY
FINAL INTERIM FEASIBILITY REPORT

ECONOMIC APPENDIX

MAY 1991

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SALEM RIVER, NJ INTERIM FEASIBILTY REPORT
ECONOMIC APPENDIX

INTRODUCTION

This economic appendix presents an analysis of the benefits that would result from deepening the Salem River, NJ federal navigation project. The Philadelphia District is analyzing deepening the Salem River navigation channel from its current authorized and maintained project depth of 12 feet to the following depths: 14 feet, 16 feet, 18 feet, 20 feet, 22 feet, and 24 feet. This range of depths was selected to establish, in conjunction with costs, the plan of improvement that maximizes net benefits. The economic analysis estimates the benefits that are anticipated to result from deepening the channel from 12 feet to the with-project condition alternative depths. Benefits will result from the decrease in the cost per ton of shipping commodities into or out of the port of Salem. These cost savings will occur in two ways: 1) a deeper channel depth will allow current vessels to carry more cargo, thus apportioning their operating costs over more tons, and 2) larger vessels with lower costs per ton will be able to call on the port.

In accord with ER 1105-2-100, Chapter 6, Section 7, the application of the nine-step procedure for the estimation of deep-draft navigation benefits has been followed in this economic appendix.

The port of Salem has been in operation only since 1982 and, thus, does not provide a lengthy historical record to analyze. A total of 183,400 short tons of cargo have been handled by the port from 1982 to 1989. There have been a total of 218 vessel movements into or out of the port over that same period.

The major commodities that moved through the port during its first eight years included general cargo/containers, grain, fertilizer, chemicals, peat moss, perishables, frozen food, scrap iron and steel, lumber, wastepaper, wire coils, and fish meal. During the first three years, barges were the primary vessel type; particularly of significance were grain barge movements. Over the next five years, only one barge shipment occurred, and the remainder of vessel trips have been by general cargo/container vessels and bulk vessels. Grain movements stopped in 1984 because of operational problems with the grain elevator. Funding is anticipated in the near future which will be used to repair the grain elevator.

The benefits calculated in this analysis were based on a projection and annualization of commodity flows over the 50-year project life, which extends from 1994 through 2044. A number of different data sources were referenced (Port of Salem, Philadelphia Maritime Exchange, Mid-Atlantic, the terminal operator, Voigt Maritime, the shipping agent for the line using Mid-Atlantic's terminal, Waterborne Commerce Statistics Center, and PIERS, a computerized data base of import/export data). Data from the year 1989 has been selected to represent the baseline, existing condition from which tonnage has been projected and benefits estimated. Growth in general cargo/container traffic has been projected for the first 20 years of the project life (1994-2014) and then held constant for the remainder of the project life. Bulk movements are anticipated to grow at 2% per year from 1989, onwards, based on anticipated growth in income for the study area as reported by OBERS projection service. (Projections of future commerce are discussed in detail later in this appendix.) Commodity flows will not vary by channel depth. A discount rate of 8 3/4% and an April 1990 price level were applied for the calculations.

ECONOMIC STUDY AREA

This section presents a summary of the commodities (with trade routes) which historically have used the Salem River:

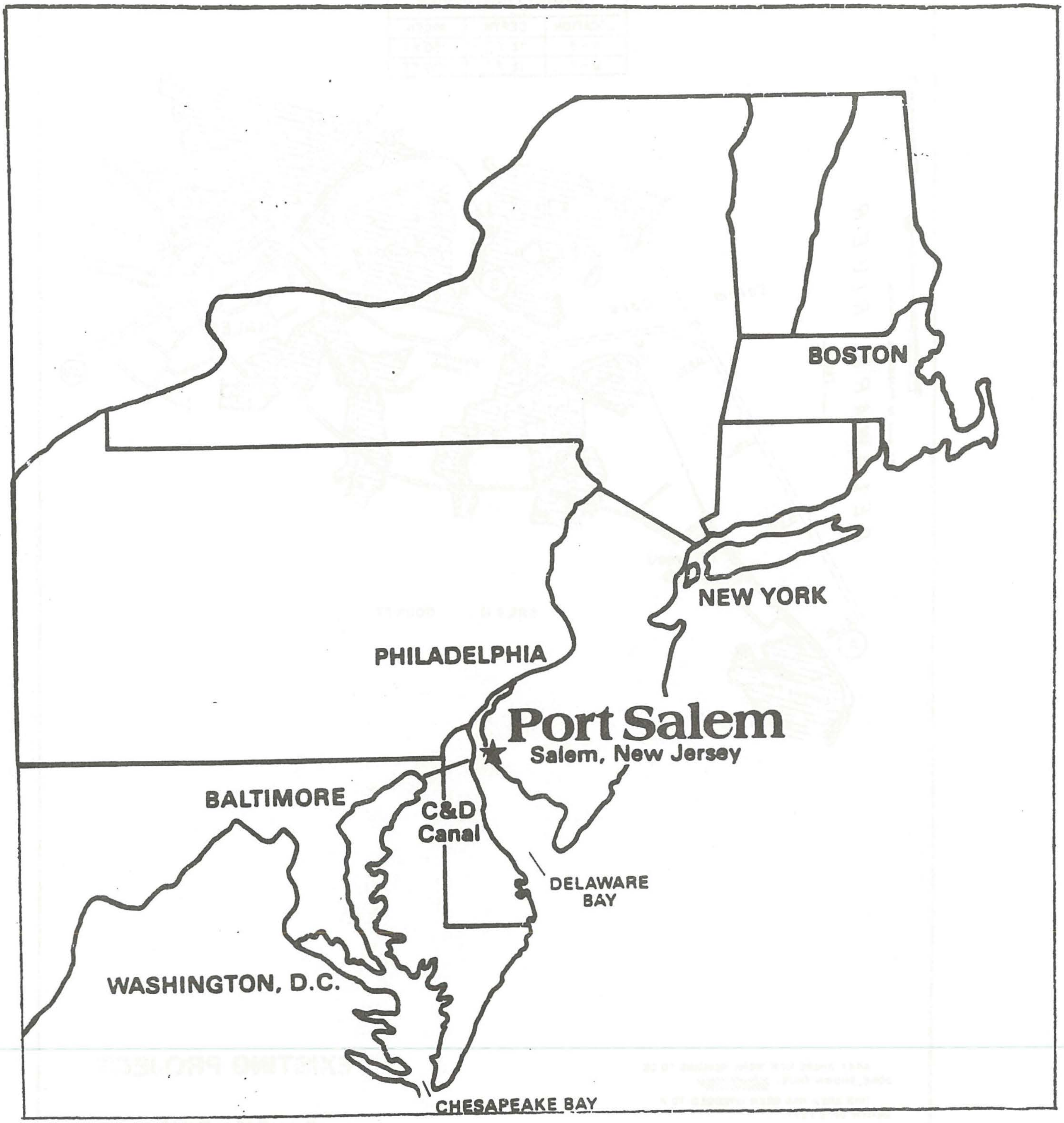
a. General Cargo/Containers
   (1) Salem to Bermuda
   (2) Salem to Jamaica
   (3) Salem to Trinidad
   (4) Salem to Barbados
b. Grain (originating from southern New Jersey agricultural region)
   (1) Salem to Jamaica
   (2) Salem to Nova Scotia
c. Fertilizer (destined for use in southern New Jersey agricultural region)
   (1) South Carolina to Salem
   (2) Nova Scotia to Salem
d. Perishables (originating from southern New Jersey agricultural region; processed in local irradiation facility; shipped to foreign destinations)
   (1) Salem to Trinidad
   (2) Salem to East Germany
   (3) Salem to United Kingdom
e. Scrap Iron/Steel (used locally in the manufacture of finished steel products)
   (1) Nova Scotia to Salem
f. Lumber (used in local construction industry)
   (1) Brazil to Salem
g. Fish Meal (used locally)
   (1) Maryland to Salem
h. Other Miscellaneous Bulk Commodities
   (1) Salem from Trinidad
   (2) Salem from Brazil
   (3) Salem from Mexico

General cargo/containers to Bermuda is currently the most significant commodity and the route to the local port facility, in concert with its shipping agent, has carved out a successful niche market for moving commodities that move through the port. Cargo is transported to Salem mostly by truck and/or container for shipment on a weekly basis. Shipments originate predominantly from the local market, mostly New Jersey, Delaware and Pennsylvania (although shipments from further origin points such as the U.S. Midwest and Canada are not unusual). Types of export cargo include transportation equipment, chemicals, electrical equipment, machinery, construction materials, foodstuffs, consumer durable goods, and hotel products. Salem has achieved a niche to handle these small lots principally because it has been able to successfully make great use of its capability to efficiently and quickly handle tonnage, no matter how relatively small the individual lots might be. Bulk tonnage is also an important commodity type moving through the port. Specific examples in 1989-1990 are exports of wastepaper to Guatemala and Ecuador, steel coil exports to Jamaica, and the import of cocoa butter from Mexico.

Maritime Exchange, Mid-Atlantic, the terminal operator, Voigt Maritime, the shipping line using Mid-Atlantic's

EXISTING CONDITION

The port of Salem is located in Salem County, NJ. As shown in Figure B-1 (regional map), the port is located approximately 50 miles south/southeast of the city of Philadelphia, PA. The port is located at almost exactly the same latitude as the Chesapeake and Delaware (C&D) Canal. As shown in Figure B-2, the port of Salem is located approximately two statute miles inland from the eastern shore of the Delaware River, and approximately 5 statute miles from



SALEM RIVER, NEW JERSEY
INTERIM FEASIBILITY REPORT

GEOGRAPHIC STUDY AREA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE B-1

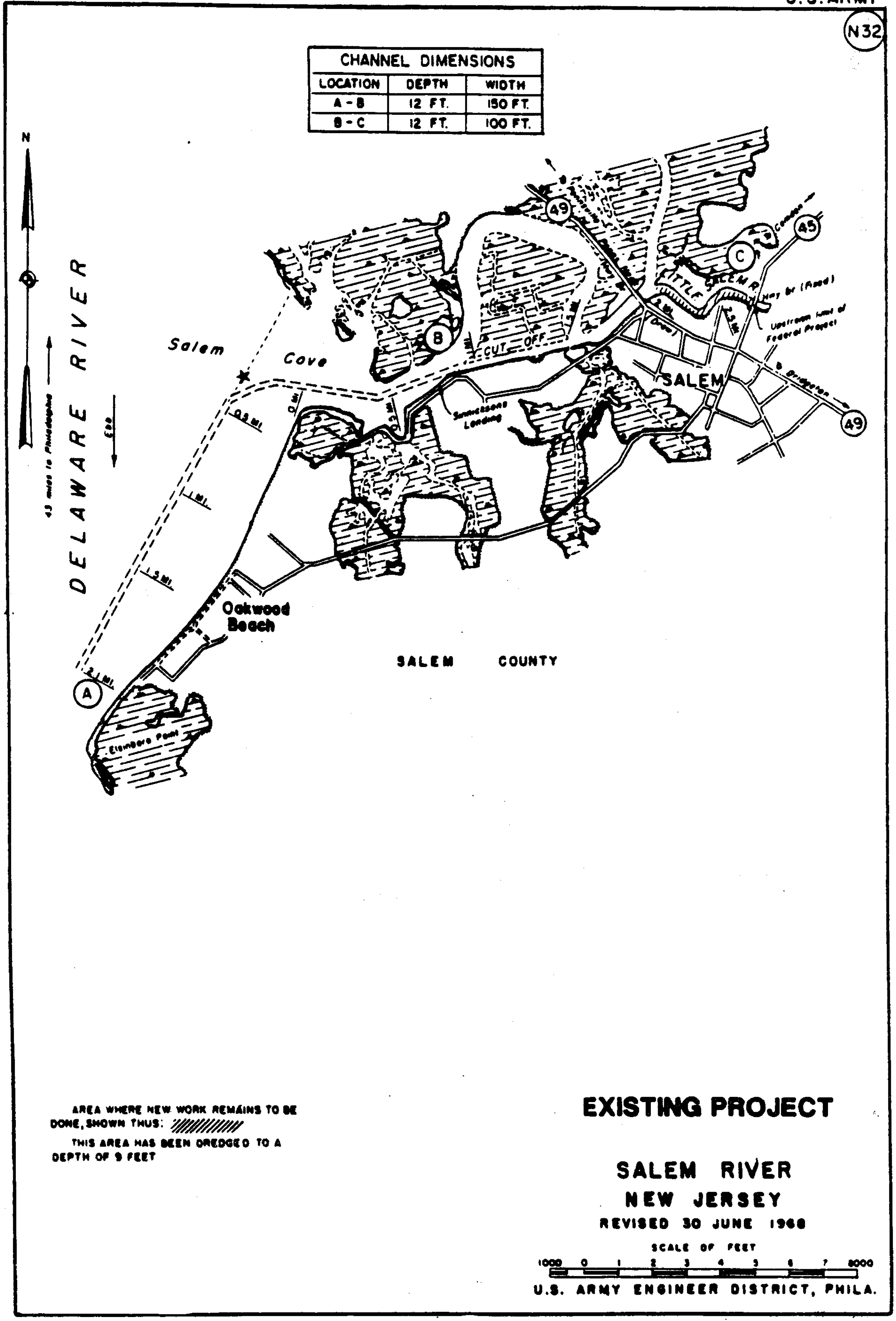

N32
CHANNEL DIMENSIONS
LOCATION | DEPTH | WIDTH
A - B | 12 FT. | 150 FT.
B - C | 12 FT. | 100 FT.
N
DELAWARE RIVER
Ebb
Salem
Cove
Oakwood
Beach
SALEM COUNTY
SALEM
CUT-OFF
LITTLE SALEM R.
A
B
C
49
45
AREA WHERE NEW WORK REMAINS TO BE DONE, SHOWN THUS:
THIS AREA HAS BEEN DREDGED TO A DEPTH OF 9 FEET
EXISTING PROJECT
SALEM RIVER
NEW JERSEY
REVISED 30 JUNE 1968
SCALE OF FEET
U.S. ARMY ENGINEER DISTRICT, PHILA.

FIGURE B-2

where the navigation channel leading to the port branches off from the main Delaware River channel.

The authorized Salem River federal navigation project includes an entrance channel and a cutoff (as shown in Figure B-2). The project covers a distance of approximately 5 miles (entrance to the port of Salem). The authorized and currently maintained channel depth is 12 feet mean low water. The authorized and maintained width of the entrance channel is 150 feet (approximately 3 miles), with the remainder of the channel (approximately 2 miles) having an authorized and maintained width of 100 feet.

EXISTING FACILITIES

Figure B-3 shows the layout and boundaries of the port of Salem. The current berthing facility owned by the Salem Port Authority consists of a wharf 120 feet long and 100 feet wide. A work barge measuring 240 feet long and 48 feet wide is moored alongside the wharf. Another berth is situated at the Mid-Atlantic Shipping property directly downriver from the Salem Port Authority facilities. Below is a description of study area facilities.

A bulk crane located on the crane barge has a 100 ton lift capacity. The bulk crane is capable of making six lifts per hour, and is equipped with a three cubic yard bucket that can be lifted 10-12 times per hour.

Container cranes are leased on an as-needed basis. Three capacities of cranes have been used, 22 ton, 65 ton, and 100 ton. The cranes are self-propelled and mounted on rubber tires.

Storage facilities for cargo include a 60,000 square foot

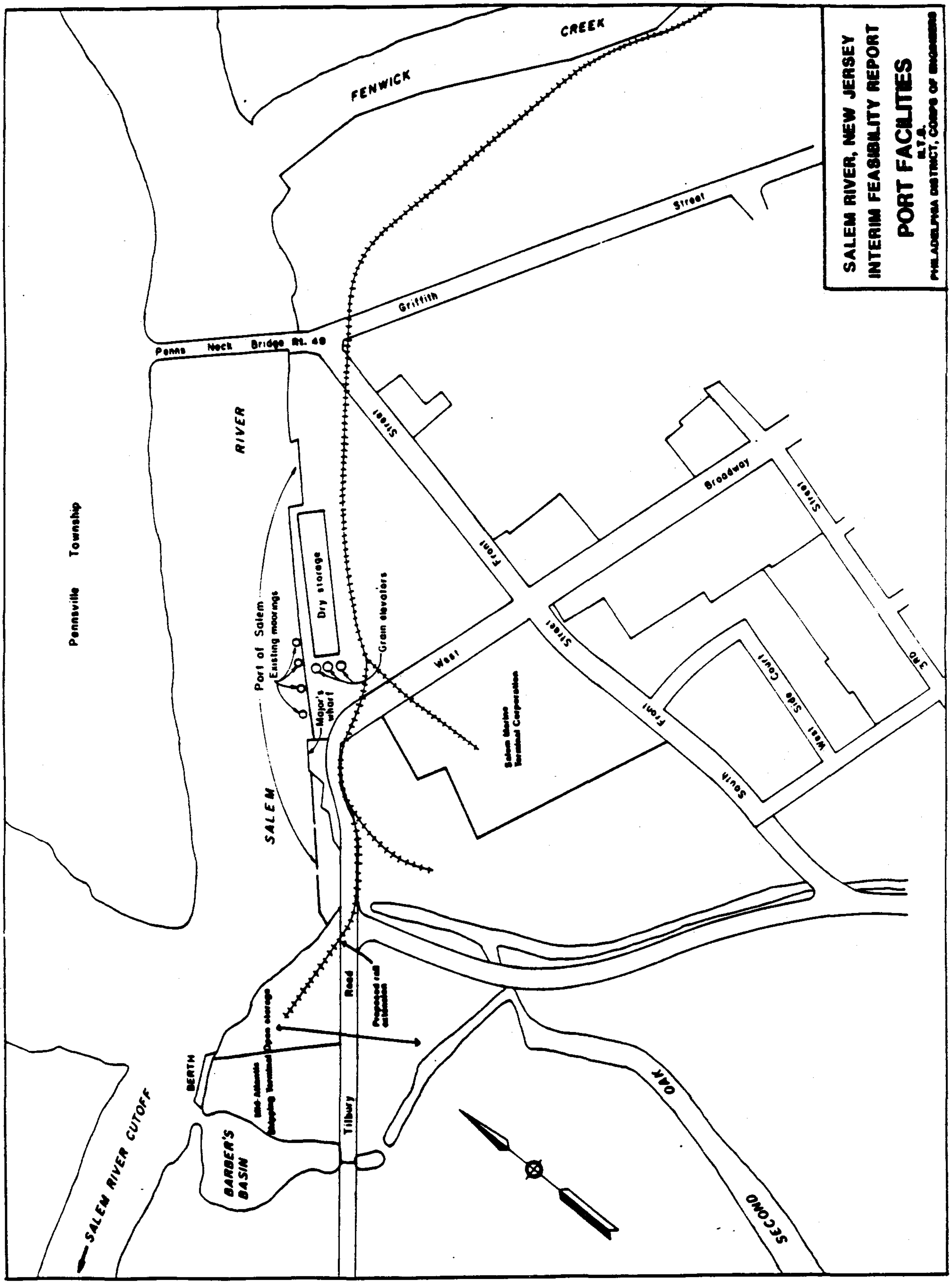

SALEM RIVER, NEW JERSEY
INTERIM FEASIBILITY REPORT
PORT FACILITIES
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
FENWICK
CREEK
Street
Griffith
Penns Neck Bridge Rt. 49
RIVER
Pennsville Township
Port of Salem
Existing moorings
Dry storage
Grain elevators
Major's wharf
SALEM
Street
Front
Broadway
Street
West
Street
Front
South
West Side Court
3RD
Salem Marine Terminal Corporation
Road
Proposed rail extension
Open storage
Tilbury
BERTH
BARBER'S BASIN
SALEM RIVER CUTOFF
OAK
SECOND

FIGURE B-3

transit shed, a 28,000 square foot bulk warehouse, three dry grain tanks with a 1,700 ton capacity, and one wet grain tank that holds about 220 tons. Additional storage facilities include 190,000 square feet of open space for storing containers.

The design capacity of the Port's grain elevator is five million bushels, or 125,000 tons, per year. Its storage capacity is 85,000 bushels (2575 short tons). Approximately 8,000 bushels per hour of grain can be loaded into a ship at port. The Port's grain dryer has a capacity of 65 tons per hour, and sits alongside the grain storage tank.

The port has direct rail access via a rail spur of the West Jersey Short Line whose usable rail line ends just past the cold storage facility. Remnants of the rail spur extend to near the end of the Fire Parcel property (see Figure B-3) but would have to be reconstructed before being usable. This line is owned by Salem County and consists of 18 miles of rail line. The line is operated for the county by the West Jersey Short Line Railroad and connects to Conrail. The siding in the Port of Salem's boundaries has the capacity for ten cars, with additional capacity for 100 railcars present in the Short Line's yards which are located about ten minutes travel time from the port. The Short Line indicates that there is sufficient room available within the port for providing additional rail sidings.

An additional need to supplement the port's ability to handle bulk commodity shipments by rail is the development of a permanent, in-place means for transferring commodities between the rail cars and either the grain elevator or an awaiting ship. Vacuum hoses or portable conveyors have been used for these movements.

A representative of the West Jersey Short Line said the company was prepared to install an additional siding at the port alongside the grain elevator with room for ten cars, if demand warrants. An unloading pit would be capable of sending 100 tons/hour of grain from the rail cars directly to the grain elevators.

The rail line has been used for shipments going through the port such as soybeans, scrap iron and steel, and fishmeal. For example, the shipment of fishmeal was vacuumed from the ship directly into waiting rail cars, a distance of approximately 50 yards. Three or four cars were loaded at a time and then pulled to the Short Line's rail siding and another three or four empty cars were brought to the port's siding. Each car carried about 100 tons of fishmeal, and 20 cars were needed for the shipment.

EXISTING VESSEL OPERATING PRACTICES

PILOT RESTRICTIONS

Salem is a relatively new port. In 1985, as the port was just commencing operations, the pilots did not have experience in navigating the channel. The deepest draft of a vessel during initial operations was approximately 16 feet. Over time, with further experience, the pilots limited the maximum draft of vessels under existing conditions to approximately 15.5 feet. The 12 foot (MLW) without project condition provides approximately 17.5 feet of depth at high tide. An allowance for two feet of underkeel clearance is based on the experience and professional expertise of the pilots. The actual operating practice of vessels based on data from the pilots logs has been incorporated into the economic analysis.

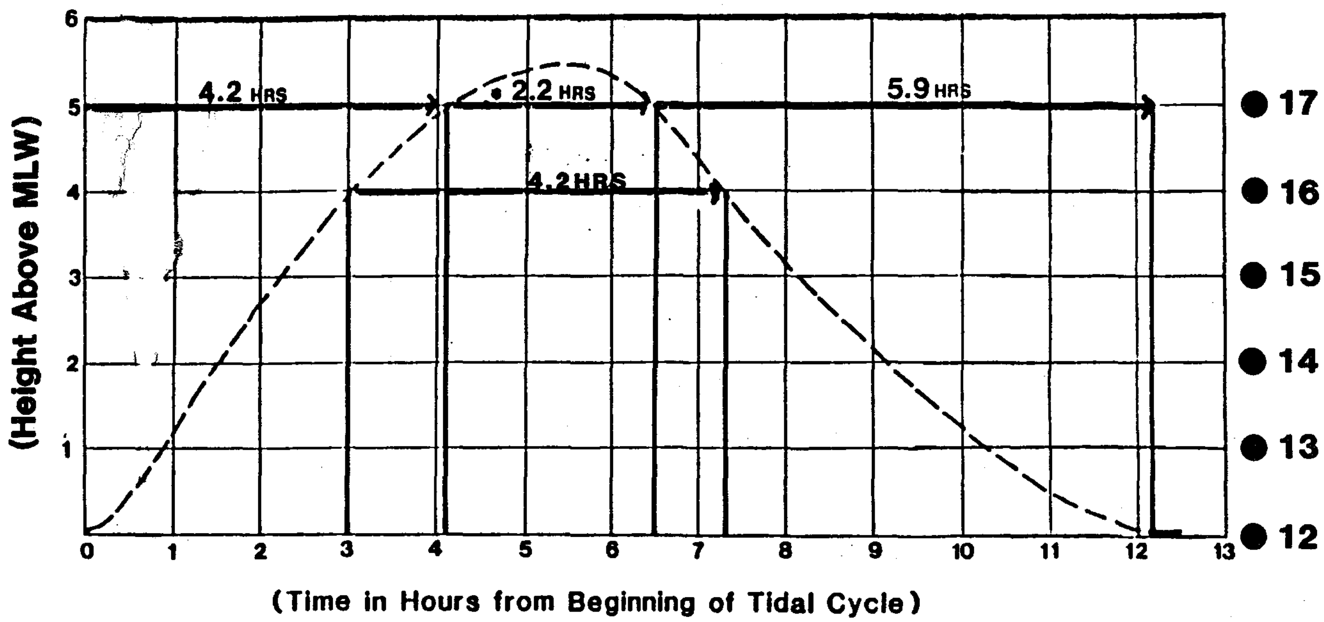
TIDAL USE

Vessels currently using the port of Salem operate using the tide, if necessary, based on the consideration of vessel draft versus channel depth. That is, based on discussions with the pilots, some ships transit the Salem River navigation channel only during periods of high tide. Figure B-4 presents a tidal chart for the port of Salem. The tidal fluctuation at Salem is 5.5 feet, meaning that ships using the channel at high tide have approximately 17.5 feet of depth with which to work. The time of the tidal cycle is approximately 12.4 hours.

Figure B-4 indicates the tidal "window" that is currently available for ships using the Salem channel whose required draft (vessel sailing draft plus 2 feet of underkeel clearance) exceeds the MLW channel depth. For example, a ship requiring a 17 foot channel depth has approximately 2.2 hours during which the channel is at least that deep. If the vessel misses its "window" it has to wait 10.1 hours for its next opportunity. Similarly, a vessel requiring a 16-foot channel depth has a "window" of 4.2 hours during which it could use the channel.

TUG USE

The current practice is to use one 525 horsepower tug, with a length of 46 feet, draft of six feet, and a beam of ten feet. This



● Indicates Channel Depth (MLW)

SALEM RIVER, NEW JERSEY
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Tidal Rise and Depth of the Salem River Navigation Channel

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

FIGURE B-4

practice is expected to continue in the future at all potential channel depths. On an inbound trip, the tug precedes a ship up the Salem navigation channel and then ties onto it at the point where the channel width narrows from 150 feet to 100 feet. Until that point, the vessel has been proceeding under its own power. The tug is then positioned on the starboard side of the ship's bow. When the pair reach the turning basin, the tug positions itself perpendicular to the keel and turns the ship to the left (i.e., counter clockwise, with the bow turning to the left and the stern to the right). The ship is rotated 180 degrees until it is facing downstream. Turning ships to the left is required because of the unique dimensional and tidal characteristics of the port of Salem, even though most ships are "right propellered", and turn more easily to the right. The ship is then pushed into position with its port side next to the wharf. Tug costs are incorporated into the transportation cost model.

The pilots prefer to bring ships up the channel on the flood tide as the increasing depth provides more maneuverability for the ships.

EXISTING VESSEL USE

The number of vessel trips (including backhaul movements) historically through the port of Salem is shown in Table B-1. Barge movements predominated in 1982-1984. A significant change occurred during 1985-1986, in which there were 49 vessel trips, only two of which were by barge. In 1987 through 1989, there were 146 vessel trips through Salem, all of which were by ship. A

TABLE B-1
HISTORIC PORT OF SALEM VESSEL TRIPS (INBOUND AND OUTBOUND)
1982-1989

VESSEL TYPE AND COMMODITY	1982	1983	1984	1985	1986	1987	1988	1989 1]	TOTAL
SHIPS									
CONTAINER (BERMUDA TRADE)	0	0	0	0	0	0	0	68	68
GENERAL CARGO/CONTAINER	0	0	0	24	21	26	18	0	89
BULK COMMODITIES	0	0	1	2	0	0	0	34	37
SUBTOTAL	0	0	1	26	21	26	18	102	194
BARGES									
GRAIN	3	0	11	0	0	0	0	0	14
FERTILIZER	0	4	2	0	1	0	0	0	7
CHEMICALS	2	0	0	0	0	0	0	0	2
SCRAP IRON & STEEL	0	0	0	1	0	0	0	0	1
SUBTOTAL	5	4	13	1	1	0	0	0	24
TOTAL	5	4	14	27	22	26	18	102	218

SOURCES: PORT OF SALEM, PORTS OF PHILADELPHIA MARITIME EXCHANGE, MID-ATLANTIC, WCSC, PIERS

1] MOST MOVEMENTS INVOLVE EMPTY OR INSIGNIFICANT TONNAGE ON INBOUND LEG; ONLY TWO VESSELS IN 1989 INVOLVED SIGNIFICANT BACKHAUL

2] PRIOR TO 1989, CONTAINERS WERE NOT A MAJOR FACTOR IN SALEM TRAFFIC AND ARE INSEPARABLE FROM GENERAL CARGO TRIPS. TRAFFIC IN 1989 MARKED THE BEGINNING OF THE CONTAINER TRADE TO BERMUDA. ALTHOUGH THEY ARE REPORTED SEPARATELY FOR 1989, IT SHOULD BE NOTED THAT "CONTAINER" TRIPS MAY ALSO CARRY GENERAL CARGO TONNAGE AND VICE VERSA.

vessel trip is defined as either an inbound or outbound usage of the Salem River channel. Barge movements have stopped because of operational problems with the grain elevator. Grain movements are expected to recommence once the grain elevator becomes operational again.

COMMODITY MOVEMENTS-HISTORICAL TONNAGE

The Salem City Council voted in 1982 to create a Municipal Port Authority to oversee the redevelopment of the port area and the construction of port facilities.

The first modern day shipment through the port of Salem occurred in May 1982, when 1,500 short tons of soybeans travelled by barge down the Salem River channel en route to Norfolk, VA, by way of the Chesapeake and Delaware Canal. Four additional barge shipments occurred that year, two for soybeans and two for chemicals. A summary of historical general cargo/container and bulk commodity movement categories from 1982-1989 is given in Table B-2. Preliminary data estimated that general cargo/container tonnage in 1990 was equal to 22,900 tons.

Grain shipments comprised the majority of tonnage between 1982 and 1984. In 1985, the leading commodity, in terms of tonnage, was scrap iron and steel imported from Nova Scotia. The second largest commodity movement was wastepaper. General cargo amounted to 4,400 short tons and comprised the third largest commodity volume.
Also, in 1986, general cargo/containers and lumber comprised the two largest commodity groups. Frozen food was the third largest

TABLE B-2
HISTORIC PORT OF SALEM TONNAGE
1982-1989

COMMODITY	1982	1983	1984	1985	1986	1987	1988	1989	
GENERAL CARGO/CONTAINERS	0	0	0	4,400	5,200	32,600	22,600	14,400	1]
BULK	7,700	6,000	22,300	25,100	11,100	0	0	24,800	
TOTAL 2]	7,700	6,000	22,300	29,500	16,300	32,600	22,600	39,200	

SOURCES: PORT OF SALEM, PORTS OF PHILADELPHIA MARITIME EXCHANGE, MID-ATLANTIC, PIERS, WCSC

1] ALL GENERAL CARGO/CONTAINER TONNAGE MOVED PRIOR TO 1989 WAS ON TRADE ROUTES OTHER THAN BERMUDA; ALL GENERAL CARGO/CONTAINER TONNAGE FOR 1989 IS FOR BERMUDA TRADE ROUTE COMMENCED IN APRIL 1989; BASED ON SAME RATE OF TONNAGE FOR THIS TRADE ROUTE, PRORATION FOR FULL YEAR= 21,600, TONNAGE FOR 1990 FOR GENERAL CARGO/CONTAINERS TO BERMUDA=22,900

2] STRICTLY BARGE MOVEMENTS 1982-1984, ONLY ONE BARGE MOVEMENT IN BOTH 1985 AND 1986 (REMAINDER OF MOVEMENTS IN VESSELS); STRICTLY VESSEL MOVEMENTS 1987-1989

3] TOTAL TONNAGE FOR 1987-1988 REPORTED BY PORT OF SALEM IS CORRECT, HOWEVER BULK TONNAGE MOVED IS NOT CLEARLY SEPARABLE FROM THE GENERAL CARGO/CONTAINER CATEGORY IN THE DATA SOURCES.

commodity. Scrap iron and steel imports were fourth in significance. The years 1987 and 1988 were reported as entirely general cargo/container movements. The year 1989 showed approximately 50% of total movements as general cargo/container movements to Bermuda, with the other half consisting of bulk movements of stone, paper, and cement. Bermuda traffic is port to port, and 3% of bulk movements involve topping-off at Salem. Table B-3 presents vessel movements by trade route for 1989.

FUTURE PORT IMPROVEMENTS

Port officials and the individual companies shipping out of Salem were contacted to identify planned expansions in port facilities and equipment. The facilities anticipated to be in place at the port by the base year, 1994, are shown in Table B-4. One berth is currently operational and managed by the Salem Port Authority under lease to Salem Marine Terminal Corp. A second berth, constructed by Mid-Atlantic Shipping, became operational in April 1989. Salem Marine Terminal is currently arranging for financing to build an additional berth on leased port property. Also, the company is actively developing plans for construction of another berth on additional port property. Thus, the project will have a total of four berths available for usage by vessels by the project base year. Further, the County of Salem Economic Development Authority and Salem Port Authority are working together to expand the foreign trade zone (FTZ) designation. The impact of the FTZ, considered speculative at this time, has not been included in the projection of commodities.

TABLE B-3

VESSEL MOVEMENTS BY TRADE ROUTE

(INBOUND AND OUTBOUND)

TRADE ROUTE	1989 1]
BERMUDA	80 2]
JAMAICA	0
GUATEMALA	6
NEW YORK	4
FLORIDA	3
HONDURAS	2
MEXICO	1
COLOMBIA	1
NOVA SCOTIA	1
SAVANNAH	0
BALTIMORE	1
EQUADOR	1
CANARY ISLANDS	1
VENEZUELA	1
TOTAL	102

SOURCE: PORTS OF PHILADELPHIA MARITIME EXCHANGE, WCSC, PIERS

1] MOST MOVEMENTS INVOLVE EMPTY OR INSIGNIFICANT TONNAGE ON BACKHAUL; ONLY TWO VESSELS IN 1989 INVOLVED SIGNIFICANT BACKHAUL

2] 68 OF THESE MOVEMENTS WERE FOR CONTAINERS TO AND FROM BERMUDA

TABLE B-4
LOADING/UNLOADING AND STORAGE FACILITIES, 1994
(ALL CHANNEL DEPTHS)

Berths
-Three berths at the Salem Municipal Port Authority location
-One berth at the Mid-Atlantic Shipping location

General Cargo/Container and Bulk
-88,000 sq. ft. of warehouse covered space
-190,000 sq. ft. of uncovered space available for staging containers
-Access to unlimited crane capacity on a lease basis. Current capacity of 180 tons per hour, and an available 3 cubic yard bucket which can be lifted 10-12 times per hour

Grain
-Three dry storage tanks holding a total of 1,700 tons
-One tank holding 220 tons of wet or dry grain
-Grain dryer with a capacity of 25 tons per hour
-Stack and reclaim capacity of 200 tons per hour

Rail
-Rail facility capable of handling 10,000 tons per month

COMMODITY PROJECTIONS

Estimates of future commodity movements through the Port of Salem were based on the historical data base of vessel movements and tonnage, interviews with the local users and port authority, and economic growth projections from a consulting firm service.

General Cargo/Container Exports to Bermuda. No single data source will capture traffic for a port in its entirety; errors in reporting and collection distort any data base. Also, different sources are interested in different measurements, for instance, one may focus on TEU's (twenty-foot equivalent units, the standard measure for container box size) while another is concerned with tonnage. Therefore, figures for Salem were collected from several sources.

Data collected for Salem indicated that its share of the North Atlantic-Bermuda trade was approximately 20% or 19,400 short tons in 1989. This figure was used as the basis for computing savings in the transportation cost model. A closer check of shipping records, however, indicated that Salem's traffic was somewhat higher for 1989 than the market share estimate revealed, or 21,600 short tons. Projected traffic, as explained in more detail below, was based on the slightly higher tonnage and TEU figures for 1989 and 1990 obtained when additional data sources were consulted.

Projected growth of container traffic was obtained from two sources. The DRI/TBS World Sea Trade Service has been used as the major source for the projections of export tonnage from the U.S. North Atlantic Coast to Bermuda through the year 2000. Table B-5

TABLE B-5

U.S. NORTH ATLANTIC EXPORTS OF GENERAL CARGO/CONTAINERS TO BERMUDA
SALEM RIVER PROJECTIONS
GROWTH FOR FIRST 20 YEARS OF PROJECT LIFE (TO YEAR 2014)

	TOTAL MARKET: U.S. NORTH ATLANTIC			SALEM:		
YEAR	DRI/TBS CONTAINER S.T.	DRI/TBS CONTAINER TEUS	DRI/TBS TONS PER TEU	CONTAINER TONS	CONTAINER TEUS	TONS PER TEU
1989	96,973 *	9,733 *	9.96	19,400 *1]	2,058 2]	9.43
1990	105,902 *	10,850 *	9.76	21,200 *1]	2,489 2]	8.52
1991	113,507 *	11,727 *	9.68	30,432	3,804 3]	8.00
1992	123,856 *	12,763 *	9.70	32,200	4,025 3]	8.00
1993	137,429 *	14,117 *	9.74	34,688	4,336 3]	8.00
1994	149,710 *	15,370 *	9.74	38,080	4,760 3]	8.00
1995	160,859 *	16,575 *	9.70	41,904	5,238 3]	8.00
1996	173,515 *	17,943 *	9.67	53,040	6,630	8.00
1997	186,608 *	19,361 *	9.64	57,418	7,177	8.00
1998	199,758 *	20,810 *	9.60	61,955	7,744	8.00
1999	213,047 *	22,315 *	9.55	66,592	8,324	8.00
2000	225,654 *	23,822 *	9.47	71,408	8,926	8.00
2001	243,706	25,847	9.43	76,230	9,529	8.00
2002	263,203	28,044	9.39	82,710	10,339	8.00
2003	284,259	30,428	9.34	89,740	11,218	8.00
2004	307,000	33,014	9.30	97,368	12,171	8.00
2005	331,560	35,820	9.26	105,645	13,206	8.00
2006	358,085	38,865	9.21	114,624	14,328	8.00
2007	386,731	42,168	9.17	124,367	15,546	8.00
2008	417,670	45,753	9.13	134,939	16,867	8.00
2009	451,083	49,642	9.09	146,408	18,301	8.00
2010	487,170	53,861	9.04	158,853	19,857	8.00
2011	526,144	58,439	9.00	172,356	21,544	8.00
2012	568,235	63,407	8.96	187,006	23,376	8.00
2013	613,694	68,796	8.92	202,901	25,363	8.00
2014	662,790	74,644	8.88	220,148	27,519	8.00

AVG ANN TONS 113,000

*: DATA PROVIDED BY DRI/TBS, OTHER YEARS CALCULATED FROM PROVIDED YEARS
1] FOR 1989-1990, BASED ON 20% MARKET SHARE FOR SALEM;
ACTUAL TONNAGE SLIGHTLY HIGHER (1989=21,600; 1990=22,900)
2] SOURCE: VOIGT MARITIME, HISTORIC TEU DATA
3] SOURCE: VOIGT MARITIME, PROJECTED TEU DATA

presents DRI/TBS projections for the total market in the left-hand columns. This analysis extrapolates DRI's figures from the year 2000 to the year 2014 to anticipate continued growth for the first 20 years of the project life. Tonnage has then been held constant in the benefit analysis for the remaining 30 years of the project life.

Specific projections for Salem, shown in the right-hand columns, relied on a combination of DRI data and projections made by the shipping agent (Voight Maritime) for the carrier (Bermuda International Shipping Ltd. or BISL) using Mid-Atlantic terminal. Prior to 1990, as noted above, Salem had an approximate 20% share of the total U.S. North Atlantic market. However, Salem's market share has increased to 21.2% for the full year of 1990, with the market share in the second half of 1990 rising to 24.4%. Also, in late 1990, Lloyd Bermuda, one of the two North Atlantic competitors to the Mid-Atlantic/BISL/Voigt operation, ceased operations. The Mid-Atlantic market share has continued to increase, reaching 28.7% by January-February 1991.

By 1995, Mid-Atlantic is projected by the shipping agent, Voigt, to split the 25% market share vacated by Lloyd Bermuda with its one competitor, Bermuda Container Lines (which operates out of the port of New York) and reach a 40% market share. This projection developed by Voigt is based on the reasonable expectation of Mid-Atlantic being able to capture half of the open market share as well as in-depth knowledge of the promising market conditions for the Bermuda market. The figures on Table 8 reflect Voight's TEU projections, converted to short tons using an average of 8 tons per TEU (historic average from 1989-90 data). By 1995, the figures reflect a 40% market share of DRI's projection for the total market. From 1996 on, the growth rate incorporated in DRI's projections has been used to forecast Salem's TEU's which were then converted to tonnage using the aforementioned 8 tons per TEU. Average annual tonnage for this commodity and trade route is equal to 113,000 tons.

Bulk Movements. Bulk tonnage through the port of Salem in 1989 was equal to 24,800 tons. The major commodity moved was wastepaper to the Caribbean and Central America. Also important were cocoa butter from Central America, and cement blocks to the Caribbean. Growth in tonnage, applying OBERS, will be at 2% per annum. The OBERS projections for the region from the U.S. Dept. of Commerce, Bureau of Economic Analysis, 1985 OBERS Projections, Volume 2, "Metropolitan Statistical Area Projections to 2035", were applied. THe most narrowly defined level of economic activity and population, the Wilmington, DE-NJ-MD PMSA, which includes Salem County, NJ, was used. Application of a linkage of bulk commodities with OBERS growth in personal income was utilized. This decision was made because total personal income was considered a reasonable indicator of bulk commodity growth at Salem. The bulk commodities moving through Salem are indirect goods that will ultimately be converted into consumer goods. Economic theory holds that consumption is a function of income. Thus, using personal income should give a reasonable indicator of growth for bulk commodities moving through Salem. Average annual bulk tonnage is equal to

31,000 tons.

Commodity projections are anticipated to be the same for the without and with project condition channel depths. The port plans for additional berths to be available by the project base year will significantly increase the port's annual throughput capacity and assure that the growth in tonnage can be handled by the port users.

In order to independently assess the level of potential future commodity movements, two ports located on the east coast of the U.S. with 24-foot channel depths were contacted (Port Royal, SC, and Richmond, VA). Discussions with representatives from both ports indicated that they are more heavily oriented towards bulk cargo than Salem is anticipated to be. However, the annual tonnage of these ports did provide excellent assurance on the potential for future tonnage that is projected to pass through the port of Salem. For example, Port Royal, in operation for only a couple of years, has already handled in excess of 170,000 tons. Also, average annual tonnage through the port of Richmond was 2.1 million tons. By comparison, the average annual tonnage through the port of Salem is projected to be 144,000 tons.

The analysis of commodity projections for Salem was based only on existing commodities (with relevant trade routes) that have moved through the port historically. As stated, the commodity projections will be the same for all depths. No new commodities or diversions are included in the analysis, although a list of potential additional commodities were identified in the economic investigation and are discussed in the Risk and Uncertainty

Analysis section of this economic appendix. There will not be a throughput capacity constraint over the project life. This was determined by comparing projected tonnage to the capability of the port to handle this amount of tonnage over the project life.

WITH PROJECT CONDITION

The project improvements studied consist of MLW channel depths of 14 feet, 16 feet, 18 feet, 20 feet, 22 feet, and 24 feet. This range was selected to bracket the optimum channel depth. The with-project condition designed channel width will be sufficient to fully accomodate one-way ship traffic for the projected design vessels. The turning basin will also be enlarged as required to handle the dimensions of the design vessels. Berth depths will be sufficiently deeper than the channel depth to assure no constraint on vessel loading and unloading because of the tidal range. Commodity projections will be the same as for the 12 foot (MLW) without project condition channel depth.

The benefits from the proposed with project condition alternatives are defined as the transportation cost savings that would result primarily because of the following factors with a deeper channel:

-Ships will be loaded more fully, thus spreading costs over a larger load

-Cost savings will be achieved since larger ships offer economies of scale in shipping costs

-For the larger vessels, the amount of shutout tonnage (i.e., amount of a ship's load capacity that cannot be carried) is reduced as the channel is deepened

FLEET DISTRIBUTION

A fleet distribution is influenced by many factors. The criteria for selecting ship sizes include the volume of trade, distance of transport, controlling depths at both the loading and discharge ports, and cargo handling and storage facilities. Generally, the most efficient vessel size for any trade route tends to be one of the largest, if not the largest, ship that can be accomodated on that route. So, as the Salem River is deepened, a gradual shift to a larger weighted fleet size is projected in order to take advantage of cost efficiencies provided by the deeper navigational channel. For general cargo/container vessels, the fleet distributions were based on operating costs as a criteria and assumed a normal distribution using the optimal vessel as the mean. Any vessel which had an operating cost greater than one standard deviation was dropped from the distribution for the considered channel depth. The maximum general cargo/container vessel class that will use the Salem River channel is projected to be 5000 DWT. For bulk commodities, fleet distributions again used operating costs as a criteria but were adjusted based on a combination of interviews and professional judgement regarding shifts in costs per ton among vessel classes with channel improvements.

A referral to world and regional fleet statistics developed by the IWR MARDATA Ship Library verified that there are sufficient vessels of pertinent size to handle the tonnage projected to be moved through Salem over the project life.

As the channel becomes deeper a larger proportion of commodities would move by larger vessel classes. This assumption for the channel deepening is based on traditional navigational vessel operating decisions. As stated in Step 5 of ER 1105-2-100, Chapter 6, Section 7, "Transportation costs with a plan should reflect any efficiencies that can be reasonably expected such as use of larger vessels, increased load reductions in transit time and delays, etc."

The primary sources for vessel information included the two companies operating facilities on the Salem River, the Corps' Institute for Water Resources, Port of Salem officials, the pilots association, and the local tug and launch company. Additional sources of information included shipping companies and ship brokers using the port of Salem. These sources were asked to identify the most likely and maximum vessel dimensions for both ships and barges for each of the channel depths.

Table B-6 presents the fleet distributions for general cargo/container vessels for each level of current actual operating practice defined by data from the pilots logs(i.e., fully loaded, 1.5 feet lightloaded, and 2.5 feet lightloaded), and for each channel depth. The largest vessel size anticipated is 5000 DWT. Table B6-A presents the fleet distribution for bulk vessels. The largest vessel size anticipated is 10,000 DWT. The fleet distributions will not shift over the project life.

TABLE B-6

FLEET DISTRIBUTION BY CHANNEL DEPTH FOR GENERAL CARGO/CONTAINER VESSELS
ACTUAL OPERATING PRACTICE: DESIGN DRAFT AND CARRYING CAPACITY ADJUSTMENT
FLEET DISTRIBUTIONS BY CHANNEL DEPTH ESTIMATED BASED ON NORMAL DISTRIBUTION
FOR VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN

VESSEL CLASS	A]	B]	C]
12 FT CHANNEL			
1000 DWT			
1500 DWT	10.0%	2.9%	0.5%
2000 DWT		11.4%	20.4%
3000 DWT	60.0%	45.7%	40.8%
4000 DWT	30.0%	40.0%	38.3%
5000 DWT			
14 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	8.1%	1.4%	14.4%
3000 DWT	46.3%	37.5%	28.8%
4000 DWT	45.6%	38.9%	29.5%
5000 DWT		22.2%	27.3%
16 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.1%	1.1%	16.9%
3000 DWT	32.6%	30.4%	26.5%
4000 DWT	35.8%	33.7%	27.7%
5000 DWT	30.5%	34.8%	28.9%
18 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.2%	0.4%	4.3%
3000 DWT	27.9%	31.3%	30.0%
4000 DWT	34.9%	33.6%	31.4%
5000 DWT	36.0%	34.7%	34.3%

FOOTNOTES:

A] VESSELS OPERATING >15 FT SAILING DRAFT CURRENTLY (UNCONSTRAINED)

B] VESSELS OPERATING WITH 14 FT SAILING DRAFT CURRENTLY (1.5 FT CONSTRAINT)

C] VESSELS OPERATING WITH 13 FT SAILING DRAFT CURRENTLY (2.5 FT CONSTRAINT)

TABLE B-6 (CONT.)

VESSEL CLASS	A]	B]	C]
20 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.2%	0.4%	4.3%
3000 DWT	27.9%	31.3%	30.0%
4000 DWT	34.9%	33.6%	31.4%
5000 DWT	36.0%	34.7%	34.3%
22 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.2%	0.4%	4.3%
3000 DWT	27.9%	31.3%	30.0%
4000 DWT	34.9%	33.6%	31.4%
5000 DWT	36.0%	34.7%	34.3%
24 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.2%	0.4%	4.3%
3000 DWT	27.9%	31.3%	30.0%
4000 DWT	34.9%	33.6%	31.4%
5000 DWT	36.0%	34.7%	34.3%

FOOTNOTES:

A] VESSELS OPERATING >15 FT SAILING DRAFT CURRENTLY (UNCONSTRAINED)

B] VESSELS OPERATING WITH 14 FT SAILING DRAFT CURRENTLY (1.5 FT CONSTRAINT)

C] VESSELS OPERATING WITH 13 FT SAILING DRAFT CURRENTLY (2.5 FT CONSTRAINT)

TABLE B-6

FLEET DISTRIBUTION BY CHANNEL DEPTH FOR GENERAL CARGO/CONTAINER VESSELS

FLEET DISTRIBUTION: NORMAL DISTRIBUTION

VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN

12 FT CHANNEL	
2000 DWT	5%
4000 DWT	44%
5000 DWT	
6000 DWT	44%
10000 DWT	
BARGES	7%
14 FT CHANNEL	
2000 DWT	2%
4000 DWT	39%
6000 DWT	52%
10000 DWT	
BARGES	7%
16 FT CHANNEL	
2000 DWT	1%
4000 DWT	32%
6000 DWT	60%
10000 DWT	
BARGES	7%
18 FT CHANNEL	
2000 DWT	
4000 DWT	29%
6000 DWT	64%
10000 DWT	
BARGES	7%
20 FT CHANNEL	
2000 DWT	
4000 DWT	17%
6000 DWT	73%
10000 DWT	3%
BARGES	7%
22 FT CHANNEL	
2000 DWT	
4000 DWT	16%
6000 DWT	66%
10000 DWT	11%
BARGES	7%
24 FT CHANNEL	
2000 DWT	
4000 DWT	15%
6000 DWT	66%
10000 DWT	12%
BARGES	7%

TABLE B-6A

FLEET DISTRIBUTION BY CHANNEL DEPTH FOR DRY BULK COMMODITIES

ACTUAL OPERATING PRACTICE: DESIGN CARRYING CAPACITY ADJUSTMENT

GRAINS, PETROCHEMICALS, FERTILIZER, LUMBER, IRON/STEEL, STONE

VESSEL CLASS	A]	B]	C]
12 FT CHANNEL			
1000 DWT			
1500 DWT	10.0%	2.9%	0.5%
2000 DWT		11.4%	20.4%
3000 DWT	60.0%	45.7%	40.8%
4000 DWT	30.0%	40.0%	38.3%
5000 DWT			
14 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	8.1%	1.4%	14.4%
3000 DWT	46.3%	37.5%	28.8%
4000 DWT	45.6%	38.9%	29.5%
5000 DWT		22.2%	27.3%
16 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.1%	1.1%	16.9%
3000 DWT	32.6%	30.4%	26.5%
4000 DWT	35.8%	33.7%	27.7%
5000 DWT	30.5%	34.8%	28.9%
18 FT CHANNEL			
1000 DWT			
1500 DWT			
2000 DWT	1.2%	0.4%	4.3%
3000 DWT	27.9%	31.3%	30.0%
4000 DWT	34.9%	33.6%	31.4%
5000 DWT	36.0%	34.7%	34.3%

FOOTNOTES:

A] VESSELS OPERATING >15 FT SAILING DRAFT CURRENTLY (UNCONSTRAINED)

B] VESSELS OPERATING WITH 14 FT SAILING DRAFT CURRENTLY (1.5 FT CONSTRAINT)

C] VESSELS OPERATING WITH 13 FT SAILING DRAFT CURRENTLY (2.5 FT CONSTRAINT)

General Cargo/Container Benefits: Exports to Bermuda. A transportation cost model was developed to analyze the actual operating practices of outbound general cargo/container vessels to Bermuda (determined from the sailing drafts listed by the Salem River pilot logs). Vessel movements on this trade route are port to port. The current vessel used on this trade route is the "Bermuda Islander", with a design draft of 16.33 feet, design deadweight tonnage of 2650 short tons, length of 262 feet, and beam of 43 feet. 11.8% of vessel movements have operated making full channel use, 44.1% have operated 1.5 feet lightloaded, and 41.2% have operated 2.5 feet lightloaded. 2.9% of the fleet have operated greater than 2.5 feet lightloaded and are not included in the benefit analysis. The transportation cost model adjusted the design draft of lightloaded vessels to analyze the constraint of actual vessel operating practice versus channel depth on the cost of tonnage being moved. Thus, for example, 1.5 feet of lightloading is equivalent to a 1.5 foot reduction of vessel design draft, or a 1.5 foot operational constraint in the transportation cost model.

Table B-7 presents the transportation cost model for the unconstrained vessels in the fleet. General cargo/container vessels in the fleet can load to a weight maximum of 76% of the design deadweight tonnage carrying capacity (including TEU box weight). This percentage nets out carrying capacity tonnage that must be allocated for ballast, fuel, freshwater tanks, stores, and

TABLE B-7

TRANSPORTATION COST MODEL
SALEM RIVER
VESSEL CLASSES ADJUSTED BASED ON 76% CARRYING CAPACITY FOR BERMUDA ISLANDER

	General Cargo and Container Vessels:					
VESSEL/CHANNEL CHARACTERISTICS						
Design Deadweight Tonnage (tonnes)	1000	1500	2000	3000	4000	5000
Vessel Carried Tonnage Capacity (S.T.)	838	1257	1675	2513	3351	4189
Design Draft	12.8	14.6	17.7	18	19	22
Immersion Factor (M.T.)	18.0	19.0	20.0	21.0	36.0	39.0
Tidal Allowance	5.5	5.5	5.5	5.5	5.5	5.5
Required Keel Clearance	2	2	2	2	2	2
Required Channel Depth	14.8	16.6	19.7	20	21	24
Shut Out Tonnage to Port (By Depth)						
12	0	0	582	694	1668	3352
14	0	0	53	139	715	2321
16	0	0	0	0	0	1289
18	0	0	0	0	0	258
20	0	0	0	0	0	0
22	0	0	0	0	0	0
24	0	0	0	0	0	0
	0	0	0	0	0	0
Cargo Tonnage (S.T.)-Net Box Wgt						
12	609	914	796	1323	1224	608
14	609	914	1180	1727	1917	1359
16	609	914	1219	1828	2437	2109
18	609	914	1219	1828	2437	2859
20	609	914	1219	1828	2437	3046
22	609	914	1219	1828	2437	3046
24	609	914	1219	1828	2437	3046
OCEAN VOYAGE PARAMETERS						
Cruising Speed (Statute MPH)	16	16	16	17	17	18
Cruising Speed (Nautical MPH)	13.9	13.9	13.9	14.8	14.8	15.7
Hourly Operating Cost at Sea	$338	$344	$356	$374	$397	$421
CARGO TRANSFER COSTS						
In-Port						
In-Port Waiting Hours	9	9	9	9	9	9
In-Port Transfer Hours (180 TPH)	3	5	7	10	14	16
Hourly In-Port Operating Cost	$262	$264	$272	$282	$296	$309
In-Port Cargo Transfer Cost	$887	$1,340	$1,839	$2,864	$4,001	$4,900
In-Port Waiting Time Cost	$2,358	$2,376	$2,445	$2,538	$2,669	$2,777
Dockage						
Vessel Length	187	254	257	268	332	353
24 Hour Dockage Fee	$374	$508	$514	$536	$664	$706
Days in Port	1	1	1	1	1	1
Dockage Costs	$374	$508	$514	$536	$664	$706
Wharfage Fee per Net Ton	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Wharfage Costs						
12	$762	$1,142	$994	$1,654	$1,530	$761
14	$762	$1,142	$1,475	$2,159	$2,397	$1,698
16	$762	$1,142	$1,523	$2,285	$3,046	$2,636
18	$762	$1,142	$1,523	$2,285	$3,046	$3,574

TABLE B-7 (CONT.)

20	$762	$1,142	$1,523	$2,285	$3,046	$3,808
22	$762	$1,142	$1,523	$2,285	$3,046	$3,808
24	$762	$1,142	$1,523	$2,285	$3,046	$3,808
Total In-Port Costs						
12	$4,380	$5,367	$5,792	$7,592	$8,855	$9,143
14	$4,380	$5,367	$6,273	$8,096	$9,721	$10,080
16	$4,380	$5,367	$6,321	$8,222	$10,371	$11,018
18	$4,380	$5,367	$6,321	$8,222	$10,371	$11,956
20	$4,380	$5,367	$6,321	$8,222	$10,371	$12,190
22	$4,380	$5,367	$6,321	$8,222	$10,371	$12,190
24	$4,380	$5,367	$6,321	$8,222	$10,371	$12,190
In-Port Travel Costs						
Tidal Delays						
Avg. Hrs. of Maximum Tidal Delay	6	6	6	6	6	6
Avg. Feet of Tidal Delay Per Depth						
12	2.8	4.6	5.5	5.5	5.5	5.5
14	0.8	2.6	5.5	5.5	5.5	5.5
16	0.0	0.6	3.7	4.0	5.0	5.5
18	0.0	0.0	1.7	2.0	3.0	5.5
20	0.0	0.0	0.0	0.0	1.0	4.0
22	0.0	0.0	0.0	0.0	0.0	2.0
24	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Hrs. of Tidal Delay Per Depth						
12	3.13	4.25	6.00	6.00	6.00	6.00
14	1.50	2.75	6.00	6.00	6.00	6.00
16	0.00	0.75	3.50	3.90	4.90	6.00
18	0.00	0.00	1.75	2.25	3.13	6.00
20	0.00	0.00	0.00	0.00	1.50	3.90
22	0.00	0.00	0.00	0.00	0.00	2.25
24	0.00	0.00	0.00	0.00	0.00	0.00
Delay for Tide:						
Operating Cost at Sea	$338	$344	$356	$374	$397	$421
Operating Cost at Port	$262	$254	$272	$282	$296	$309
Tidal Delay Costs						
12	$819	$1,080	$1,632	$1,692	$1,776	$1,854
14	$393	$699	$1,632	$1,692	$1,776	$1,854
16	$0	$191	$952	$1,100	$1,450	$1,854
18	$0	$0	$476	$635	$925	$1,854
20	$0	$0	$0	$0	$444	$1,205
22	$0	$0	$0	$0	$0	$695
24	$0	$0	$0	$0	$0	$0
Pilotage						
Vessel Length	187	254	257	268	332	353
Vessel Beam	36	39.7	43	44	59	60
Vessel Draft	12.8	14.6	17.7	18	19	22
Pilotage Units	67.32	100.838	110.51	117.92	195.88	211.8
C&D Use Flag						
Delaware River Pilot Fee	$1,320	$1,331	$1,459	$1,557	$2,586	$2,796
C&D Canal Fee (if applicable)	$500	$500	$500	$500	$500	$500
Tug Costs						
Number of Tugs Used	1	1	1	1	1	1
Tug Rate	$650	$650	$650	$650	$650	$650

TABLE B-7 (CONT.)

	Tug Costs	$650	$650	$650	$650	$650	$650
In-Port & Cargo Transfer Costs							
	12	$7,169	$8,427	$9,533	$11,490	$13,866	$14,442
	14	$6,743	$8,046	$10,014	$11,995	$14,733	$15,380
	16	$6,350	$7,538	$9,382	$11,529	$15,057	$16,318
	18	$6,350	$7,348	$8,906	$11,063	$14,531	$17,255
	20	$6,350	$7,348	$8,430	$10,429	$14,050	$16,841
	22	$6,350	$7,348	$8,430	$10,429	$13,606	$16,331
	24	$6,350	$7,348	$8,430	$10,429	$13,606	$15,636

TOTAL COST AND COST PER NET CARGO TON BY TRADE ROUTE:

Bermuda							
Total Cost:	12' Channel Depth	$48,641	$51,766	$55,195	$58,704	$65,653	$66,864
	14' Channel Depth	$47,790	$51,004	$56,157	$59,713	$67,386	$68,739
	16' Channel Depth	$47,004	$49,988	$54,893	$58,781	$68,034	$70,615
	18' Channel Depth	$47,004	$49,607	$53,941	$57,850	$66,983	$72,490
	20' Channel Depth	$47,004	$49,607	$52,989	$56,581	$66,021	$71,661
	22' Channel Depth	$47,004	$49,607	$52,989	$56,581	$65,133	$70,641
	24' Channel Depth	$47,004	$49,607	$52,989	$56,581	$65,133	$69,251
Cost Per Ton:	12' Channel Depth	$79.83	$56.64	$69.38	$44.36	$53.63	$109.90
	14' Channel Depth	$78.44	$55.81	$47.59	$34.58	$35.15	$50.60
	16' Channel Depth	$77.15	$54.70	$45.05	$32.16	$27.92	$33.49
	18' Channel Depth	$77.15	$54.28	$44.27	$31.65	$27.48	$25.36
	20' Channel Depth	$77.15	$54.28	$43.49	$30.96	$27.09	$23.52
	22' Channel Depth	$77.15	$54.28	$43.49	$30.96	$26.73	$23.19
	24' Channel Depth	$77.15	$54.28	$43.49	$30.96	$26.73	$22.73

Distances to Ports-Nautical Miles
Bermuda 706

crew. Based on historical movements, the average weight per container box is estimated to be three tons, and the average cargo carried per box equal to a weight of eight tons. Taken together, the 76% cargo capacity and the cargo weight per box determine the maximum cargo tonnage on board for given drafts.

Vessel classes range from 1000 to 5000 DWT. The immersion factors were developed by applying a U.S. Maritime Administration equation provided by IWR. The tidal allowance is 5.5 feet with required underkeel clearance of 2 feet. Shut-out tonnage is determined by netting out constrained tonnage (based on the immersion factor) from the available channel depth in comparison to the maximum vessel carrying capacity of 76%. Cargo tonnage carried nets out from the calculation the weight of the TEU boxes that hold the commerce. Cruising speeds (in knots) used were checked and appear reasonable compared to data provided by IWR. Loading, dockage, wharfage, and tug costs are based on coordination with representatives of the Salem River facility. Operating costs at sea and in port appear reasonable compared to a regression model that used FY 1990 IWR Foreign Flag Container vessel operating cost data. Tidal delays are defined based on the channel depth, vessel characteristics, range of tide, and underkeel clearance. Pilotage costs, obtained from coordination with the local pilots, are calculated applying vessel design characteristics for length, beam, and draft. Round trip distances were checked with the publication, <u>Distances Between Ports</u> (Dept. of the Navy), and appear reasonable. Total transportation costs are a summation of the total costs for a round-trip movement. Backhauling is a very insignificant part of the operations for this trade route. Ships to Bermuda are not always loaded to cubic capacity. Transportation costs per ton are determined by dividing total transportation costs by the amount of tons carried for each channel depth and vessel class. Total trip costs from the model appear reasonable when compared to revenues per box obtained from the shipping line on the Bermuda trade route. For example, the "Bermuda Islander" can carry a maximum of approximately 75 boxes currently. The tariff rate assessed by the shipping line averages $1700 per box, which translates into total revenues for a fully loaded trip of $127,500. The transportation cost model estimated a combination of water transport and port costs of $57,000 for this vessel size for the current 12 foot channel.

The transportation savings model for unconstrained vessels, Table B-8, incorporated the cost per ton data from Table B-7, the fleet distributions by channel depth from Table B-6, and the commodity projections from Table B-5. Average annual cumulative transportation savings, by channel depth, are displayed in the last row of the table.

Tables B-9 and B-10 represent comparable transportation cost models to Table B-7. The impact of 1.5 and 2.5 foot constraints on actual operating practice have been incorporated into these models. The greater the constraint, the less tonnage that is carried per channel depth.

Tables B-11 and B-12 are comparable transportation savings models to Table B-8. However, the transportation costs per ton and fleet distributions are different in order to incorporate the shift

TABLE B-8

SALEM RIVER
TOTAL TRANSPORTATION SAVINGS DISCOUNT RATE= 8.750% PRICE LEVEL= APRIL 1990
TRADE ROUTE: GENERAL CARGO/CONTAINERS-BERMUDA
VESSEL CLASSES GREATER THAN 5000 DWT DELETED
REVISED TRANS. COST MODEL INCORPORATING 11/23/90 WLRC COMMENTS AND FRC COMMENTS (F:VC5A3ARR)
APPLYING REVISED HISTORIC AND REVISED COMMODITY DATA FROM F:DRIBDA1
TRANS COST MODEL ADJUSTED BASED ON 76% CARRYING CAPACITY INCLUDING WEIGHT OF BOXES
FLEET DEFINED BY NORMAL DISTRIBUTION FOR VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN

	12 FEET:		12 FEET:		14 FEET:	% OF	
		PCT.	AVG	TOTAL	AVG	TOTAL FLEET	TOTAL
DESDWT	DDRAFT	OF FLEET	$/TON	TRANS COSTS	$/TON	$/TON	TRANS COSTS
1,000	12.8	0.0%	$79.83	$0	$78.44	0.00%	$0
1,500	14.6	10.0%	$56.64	$109,882	$55.81	0.00%	$0
2,000	17.7	0.0%	$69.38	$0	$47.59	8.10%	$74,783
3,000	18.0	60.0%	$44.36	$516,350	$34.58	46.30%	$310,604
4,000	19.0	30.0%	$53.63	$312,127	$35.15	45.60%	$310,951
5,000	22.0	0.0%	$109.90	$0	$50.60	0.00%	$0
TOTAL SHORT TONS (1989) 1]	19,400	100.0%				100.0%	
				$938,359			$696,338
CUMULATIVE SAVINGS							$242,020

1] SOURCE: WLRC & MID-ATLANTIC SHIPPING CORP

TABLE B-8 (Cont.)

16 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	18 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	20 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$77.15	0.00%	$0	$77.15	0.00%	$0	$77.15	0.00%	$0
$54.70	0.00%	$0	$54.28	0.00%	$0	$54.28	0.00%	$0
$45.05	1.10%	$9,614	$44.27	1.20%	$10,306	$43.49	1.20%	$10,124
$32.16	32.60%	$203,393	$31.65	27.90%	$171,309	$30.96	27.90%	$167,574
$27.92	35.80%	$193,910	$27.48	34.90%	$186,056	$27.09	34.90%	$183,416
$33.49	30.50%	$198,160	$25.36	36.00%	$177,114	$23.52	36.00%	$164,264
	100.0%			100.0%			100.0%	
		$605,077			$544,785			$525,378
		$333,282			$393,573			$412,981

TABLE B-8 (Cont.)

22 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	24 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$77.15	0.00%	$0	$77.15	0.00%	$0
$54.28	0.00%	$0	$54.28	0.00%	$0
$43.49	1.20%	$10,124	$43.49	1.20%	$10,124
$30.96	27.90%	$167,574	$30.96	27.90%	$167,574
$26.73	34.90%	$180,978	$26.73	34.90%	$180,978
$23.19	36.00%	$161,959	$22.73	36.00%	$158,746
	100.0%			100.0%	
		$520,636			$517,423
		$417,723			$420,936

TABLE B-8 (CONT.)

PREDICTED TONNAGE:		PERIOD	AVG ANN GROWTH/YR FOR PERIOD
1989	19,400		
1994	38,080	1989-1994	14.40%
2001	76,230	1994-2001	10.40%
2011	172,356	2001-2011	8.50%
2014	220,148	2011-2014	8.50%
2031	220,148	2014-2031	0.00%
2044	220,148	2031-2044	0.00%

YEAR	CUMULATIVE TRANS COSTS 12 FT		PRESENT WORTH TRANS COSTS 12 FT	PRESENT WORTH TRANS COSTS 14 FT	PRESENT WORTH TRANS COSTS 16 FT	PRESENT WORTH TRANS COSTS 18 FT	PRESENT WORTH TRANS COSTS 20 FT	PRESENT WORTH TRANS COSTS 22 FT	PRESENT WORTH TRANS COSTS 24 FT
1994	$1,841,892	1.00000	$1,841,892	$1,366,833	$1,187,697	$1,069,352	$1,031,257	$1,021,949	$1,015,643
1995	$2,033,448	0.91954	$1,869,837	$1,387,571	$1,205,717	$1,085,576	$1,046,904	$1,037,454	$1,031,052
1996	$2,244,927	0.84555	$1,898,207	$1,408,624	$1,224,011	$1,102,047	$1,062,788	$1,053,195	$1,046,696
1997	$2,478,399	0.77752	$1,927,008	$1,429,996	$1,242,582	$1,118,768	$1,078,913	$1,069,174	$1,062,577
1998	$2,736,153	0.71496	$1,956,245	$1,451,693	$1,261,435	$1,135,742	$1,095,283	$1,085,396	$1,078,699
1999	$3,020,713	0.65744	$1,985,926	$1,473,719	$1,280,574	$1,152,974	$1,111,901	$1,101,864	$1,095,065
2000	$3,334,867	0.60454	$2,016,057	$1,496,078	$1,300,003	$1,170,467	$1,128,771	$1,118,582	$1,111,680
2001	$3,681,693	0.55590	$2,046,646	$1,518,778	$1,319,728	$1,188,226	$1,145,897	$1,135,554	$1,128,547
2002	$4,064,589	0.51117	$2,077,698	$1,541,821	$1,339,751	$1,206,255	$1,163,283	$1,152,783	$1,145,670
2003	$4,487,306	0.47004	$2,109,222	$1,565,214	$1,360,078	$1,224,556	$1,180,933	$1,170,274	$1,163,052
2004	$3,687,169	0.43222	$1,593,677	$1,182,638	$1,027,642	$925,245	$892,284	$884,230	$878,774
2005	$4,000,578	0.39745	$1,590,014	$1,179,919	$1,025,280	$923,118	$890,233	$882,198	$876,754
2006	$4,340,627	0.36547	$1,586,358	$1,177,207	$1,022,923	$920,996	$888,187	$880,170	$874,738
2007	$4,709,581	0.33606	$1,582,712	$1,174,501	$1,020,571	$918,879	$886,145	$878,146	$872,728
2008	$5,109,895	0.30902	$1,579,073	$1,171,801	$1,018,225	$916,766	$884,108	$876,128	$870,721
2009	$5,544,236	0.28416	$1,575,443	$1,169,107	$1,015,884	$914,659	$882,075	$874,113	$868,720
2010	$6,015,496	0.26130	$1,571,821	$1,166,419	$1,013,549	$912,556	$880,047	$872,104	$866,723
2011	$6,526,813	0.24027	$1,568,208	$1,163,738	$1,011,219	$910,458	$878,024	$870,099	$864,730
2012	$7,081,593	0.22094	$1,564,603	$1,161,063	$1,008,894	$908,365	$876,006	$868,099	$862,742
2013	$7,683,528	0.20316	$1,561,006	$1,158,393	$1,006,575	$906,277	$873,992	$866,103	$860,759
2014	$8,336,628	0.18682	$1,557,418	$1,155,731	$1,004,261	$904,194	$871,983	$864,112	$858,780
2015	$8,336,628	0.17179	$1,432,108	$1,062,741	$923,459	$831,443	$801,823	$794,586	$789,683
2016	$8,336,628	0.15796	$1,316,881	$977,233	$849,157	$764,545	$737,309	$730,654	$726,145
2017	$8,336,628	0.14525	$1,210,925	$898,605	$780,834	$703,030	$677,985	$671,866	$667,720
2018	$8,336,628	0.13357	$1,113,494	$826,303	$718,009	$646,464	$623,435	$617,807	$613,995
2019	$8,336,628	0.12282	$1,023,903	$759,819	$660,238	$594,450	$573,273	$568,099	$564,593
2020	$8,336,628	0.11294	$941,520	$698,684	$607,115	$546,621	$527,148	$522,390	$519,166
2021	$8,336,628	0.10385	$865,765	$642,468	$558,267	$502,640	$484,734	$480,358	$477,394

TABLE B-8 (CONT.)

2022	$8,336,628	0.09549	$796,106	$590,775	$513,349	$462,197	$445,732	$441,709	$438,983
2023	$8,336,628	0.08781	$732,052	$543,242	$472,045	$425,009	$409,869	$406,169	$403,663
2024	$8,336,628	0.08075	$673,151	$499,533	$434,064	$390,813	$376,891	$373,489	$371,184
2025	$8,336,628	0.07425	$618,989	$459,340	$399,140	$359,368	$346,566	$343,438	$341,319
2026	$8,336,628	0.06828	$569,186	$422,382	$367,025	$330,453	$318,681	$315,805	$313,856
2027	$8,336,628	0.06278	$523,389	$388,397	$337,494	$303,865	$293,040	$290,395	$288,603
2028	$8,336,628	0.05773	$481,277	$357,147	$310,339	$279,416	$269,462	$267,030	$265,383
2029	$8,336,628	0.05309	$442,554	$328,411	$285,370	$256,935	$247,782	$245,545	$244,030
2030	$8,336,628	0.04881	$406,946	$301,987	$262,409	$236,262	$227,845	$225,789	$224,395
2031	$8,336,628	0.04489	$374,203	$277,689	$241,295	$217,252	$209,513	$207,622	$206,341
2032	$8,336,628	0.04128	$344,095	$255,346	$221,881	$199,772	$192,655	$190,916	$189,738
2033	$8,336,628	0.03795	$316,409	$234,801	$204,028	$183,698	$177,154	$175,555	$174,472
2034	$8,336,628	0.03490	$290,951	$215,909	$187,612	$168,918	$162,901	$161,430	$160,434
2035	$8,336,628	0.03209	$267,541	$198,537	$172,517	$155,327	$149,794	$148,442	$147,526
2036	$8,336,628	0.02951	$246,015	$182,563	$158,636	$142,829	$137,741	$136,498	$135,656
2037	$8,336,628	0.02714	$226,221	$167,874	$145,873	$131,337	$126,659	$125,515	$124,741
2038	$8,336,628	0.02495	$208,019	$154,367	$134,136	$120,770	$116,468	$115,416	$114,704
2039	$8,336,628	0.02294	$191,282	$141,947	$123,343	$111,053	$107,097	$106,130	$105,475
2040	$8,336,628	0.02110	$175,891	$130,526	$113,419	$102,118	$98,480	$97,591	$96,989
2041	$8,336,628	0.01940	$161,739	$120,024	$104,293	$93,901	$90,556	$89,739	$89,185
2042	$8,336,628	0.01784	$148,726	$110,366	$95,902	$86,346	$83,270	$82,518	$82,009
2043	$8,336,628	0.01640	$136,759	$101,486	$88,186	$79,399	$76,570	$75,879	$75,411
2044	$8,336,628	0.01508	$125,756	$93,321	$81,090	$73,010	$70,409	$69,774	$69,343
CUMULATIVE PRES WORTH: TRANS COSTS			$61,060,118	$45,311,571	$39,373,065	$35,449,824	$34,186,963	$33,878,386	$33,669,336
CRF, 50 YRS			0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN CUMULATIVE TRANS COSTS			$5,424,581	$4,025,480	$3,497,903	$3,149,362	$3,037,170	$3,009,756	$2,991,184
AVG ANN CUMULATIVE TRANS SAVINGS				$1,399,101	$1,926,678	$2,275,219	$2,387,411	$2,414,825	$2,433,397

TABLE B-9

TRANSPORTATION COST MODEL
SALEM RIVER
ACTUAL OPERATING PRACTICE: 1.5 FOOT CONSTRAINT
VESSEL CLASSES ADJUSTED BASED ON 76% CARRYING CAPACITY FOR BERMUDA ISLANDER
AND ADJUSTED FOR IMPACT OF CONSTRAINT ON CARRYING CAPACITY

	General Cargo and Container Vessels:					
VESSEL/CHANNEL CHARACTERISTICS						
Design Deadweight Tonnage (tonnes)	1000	1500	2000	3000	4000	5000
Vessel Carried Tonnage Capacity (S.T.)	481	880	1279	2097	2637	3415
Design Draft	11.3	13.1	16.2	16.5	17.5	20.5
Immersion Factor (M.T.)	18.0	19.0	20.0	21.0	36.0	39.0
Tidal Allowance	5.5	5.5	5.5	5.5	5.5	5.5
Required Keel Clearance	2	2	2	2	2	2
Required Channel Depth	13.3	15.1	18.2	18.5	19.5	22.5
Shut Out Tonnage to Port (By Depth)						
12	0	0	185	277	953	2579
14	0	0	0	0	0	1547
16	0	0	0	0	0	516
18	0	0	0	0	0	0
20	0	0	0	0	0	0
22	0	0	0	0	0	0
24	0	0	0	0	0	0
	0	0	0	0	0	0
Cargo Tonnage (S.T.)-Net Box Wgt						
12	350	640	795	1323	1224	608
14	350	640	930	1525	1918	1358
16	350	640	930	1525	1918	2109
18	350	640	930	1525	1918	2484
20	350	640	930	1525	1918	2484
22	350	640	930	1525	1918	2484
24	350	640	930	1525	1918	2484
OCEAN VOYAGE PARAMETERS						
Cruising Speed (Statute MPH)	16	16	16	17	17	18
Cruising Speed (Nautical MPH)	13.9	13.9	13.9	14.8	14.8	15.7
Hourly Operating Cost at Sea	$338	$344	$356	$374	$397	$421
CARGO TRANSFER COSTS						
In-Port						
In-Port Waiting Hours	9	9	9	9	9	9
In-Port Transfer Hours (180 TPH)	2	4	5	8	11	14
Hourly In-Port Operating Cost	$262	$264	$272	$282	$296	$309
In-Port Cargo Transfer Cost	$509	$938	$1,403	$2,389	$3,148	$4,257
In-Port Waiting Time Cost	$2,358	$2,376	$2,445	$2,538	$2,660	$2,777
Dockage						
Vessel Length	187	254	257	268	332	353
24 Hour Dockage Fee	$374	$508	$514	$536	$664	$706
Days in Port	1	1	1	1	1	1
Dockage Costs	$374	$508	$514	$536	$664	$706
Wharfage Fee per Net Ton	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Wharfage Costs						
12	$437	$800	$994	$1,654	$1,531	$760
14	$437	$800	$1,162	$1,906	$2,397	$1,698

TABLE B-9 (Cont.)

16	$437	$800	$1,162	$1,906	$2,397	$2,636
18	$437	$800	$1,162	$1,906	$2,397	$3,104
20	$437	$800	$1,162	$1,906	$2,397	$3,104
22	$437	$800	$1,162	$1,906	$2,397	$3,104
24	$437	$800	$1,162	$1,906	$2,397	$3,104
Total In-Port Costs						
12	$3,678	$4,622	$5,356	$7,117	$8,002	$8,499
14	$3,678	$4,622	$5,525	$7,369	$8,869	$9,437
16	$3,678	$4,622	$5,525	$7,369	$8,869	$10,375
18	$3,678	$4,622	$5,525	$7,369	$8,869	$10,844
20	$3,678	$4,622	$5,525	$7,369	$8,869	$10,844
22	$3,678	$4,622	$5,525	$7,369	$8,869	$10,844
24	$3,678	$4,622	$5,525	$7,369	$8,869	$10,844
In-Port Travel Costs						
Tidal Delays						
Avg. Hrs. of Maximum Tidal Delay	6	6	6	6	6	6
Avg. Feet of Tidal Delay Per Depth						
12	1.3	3.1	5.5	5.5	5.5	5.5
14	0.0	1.1	4.2	4.5	5.5	5.5
16	0.0	0.0	2.2	2.5	3.5	5.5
18	0.0	0.0	0.2	0.5	1.5	4.5
20	0.0	0.0	0.0	0.0	0.0	2.5
22	0.0	0.0	0.0	0.0	0.0	0.5
24	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Hrs. of Tidal Delay Per Depth						
12	1.8	3.1	6.0	6.0	6.0	6.0
14	0.0	1.5	3.9	4.3	6.0	6.0
16	0.0	0.0	2.3	2.8	3.5	6.0
18	0.0	0.0	0.3	0.8	1.8	4.3
20	0.0	0.0	0.0	0.0	0.0	2.8
22	0.0	0.0	0.0	0.0	0.0	0.8
24	0.0	0.0	0.0	0.0	0.0	0.0
Delay for Tide:						
Operating Cost at Sea	$338	$344	$356	$374	$397	$421
Operating Cost at Port	$262	$254	$272	$282	$296	$309
Tidal Delay Costs						
12	$459	$794	$1,632	$1,692	$1,776	$1,854
14	$0	$381	$1,061	$1,199	$1,776	$1,854
16	$0	$0	$612	$776	$1,036	$1,854
18	$0	$0	$82	$212	$518	$1,313
20	$0	$0	$0	$0	$0	$850
22	$0	$0	$0	$0	$0	$232
24	$0	$0	$0	$0	$0	$0
Pilotage						
Vessel Length	187	254	257	268	332	353
Vessel Beam	36	39.7	43	44	59	60
Vessel Draft	12.8	14.6	17.7	18	19	22
Pilotage Units	67.32	100.838	110.51	117.92	195.88	211.8
C&D Use Flag						
Delaware River Pilot Fee	$1,320	$1,331	$1,459	$1,557	$2,586	$2,796
C&D Canal Fee (if applicable)	$500	$500	$500	$500	$500	$500

TABLE B-9 (Cont.)

Tug Costs						
Number of Tugs Used	1	1	1	1	1	1
Tug Rate	$650	$650	$650	$650	$650	$650
Tug Costs	$650	$650	$650	$650	$650	$650
In-Port & Cargo Transfer Costs						
12	$6,106	$7,397	$9,097	$11,015	$13,014	$13,799
14	$5,648	$6,984	$8,694	$10,774	$13,880	$14,737
16	$5,648	$6,603	$8,245	$10,351	$13,140	$15,674
18	$5,648	$6,603	$7,715	$9,787	$12,622	$15,603
20	$5,648	$6,603	$7,633	$9,575	$12,104	$15,139
22	$5,648	$6,603	$7,633	$9,575	$12,104	$14,521
24	$5,648	$6,603	$7,633	$9,575	$12,104	$14,289

TOTAL COST AND COST PER NET CARGO TON BY TRADE ROUTE:

Bermuda

Total Cost:	12' Channel Depth	$46,515	$49,705	$54,324	$57,754	$63,948	$65,577
	14' Channel Depth	$45,598	$48,880	$53,518	$57,271	$65,681	$67,453
	16' Channel Depth	$45,598	$48,118	$52,620	$56,425	$64,201	$69,328
	18' Channel Depth	$45,598	$48,118	$51,560	$55,297	$63,165	$69,184
	20' Channel Depth	$45,598	$48,118	$51,396	$54,874	$62,129	$68,257
	22' Channel Depth	$45,598	$48,118	$51,396	$54,874	$62,129	$67,021
	24' Channel Depth	$45,598	$48,118	$51,396	$54,874	$62,129	$66,558
Cost Per Ton:	12' Channel Depth	$133.08	$77.70	$68.30	$43.65	$52.22	$107.81
	14' Channel Depth	$130.46	$76.41	$57.55	$37.56	$34.25	$49.66
	16' Channel Depth	$130.46	$75.22	$56.58	$37.01	$33.48	$32.88
	18' Channel Depth	$130.46	$75.22	$55.44	$36.27	$32.94	$27.86
	20' Channel Depth	$130.46	$75.22	$55.27	$35.99	$32.40	$27.48
	22' Channel Depth	$130.46	$75.22	$55.27	$35.99	$32.40	$26.99
	24' Channel Depth	$130.46	$75.22	$55.27	$35.99	$32.40	$26.80

Distances to Ports-Nautical Miles	
Bermuda	706

TABLE B-10

TRANSPORTATION COST MODEL
SALEM RIVER
ACTUAL OPERATING PRACTICE: 2.5 FOOT CONSTRAINT
VESSEL CLASSES ADJUSTED BASED ON 76% CARRYING CAPACITY FOR BERMUDA ISLANDER
AND ADJUSTED FOR IMPACT OF CONSTRAINT ON CARRYING CAPACITY

	General Cargo and Container Vessels:					
VESSEL/CHANNEL CHARACTERISTICS						
Design Deadweight Tonnage (tonnes)	1000	1500	2000	3000	4000	5000
Vessel Carried Tonnage Capacity (S.T.)	243	628	1014	1819	2161	2899
Design Draft	10.3	12.1	15.2	15.5	16.5	19.5
Immersion Factor (M.T.)	18.0	19.0	20.0	21.0	36.0	39.0
Tidal Allowance	5.5	5.5	5.5	5.5	5.5	5.5
Required Keel Clearance	2	2	2	2	2	2
Required Channel Depth	12.3	14.1	17.2	17.5	18.5	21.5
Shut Out Tonnage to Port (By Depth)						
12	0	0	0	0	477	2063
14	0	0	0	0	0	1031
16	0	0	0	0	0	0
18	0	0	0	0	0	0
20	0	0	0	0	0	0
22	0	0	0	0	0	0
24	0	0	0	0	0	0
	0	0	0	0	0	0
Cargo Tonnage (S.T.)-Net Box Wgt						
12	176	457	738	1323	1225	608
14	176	457	738	1323	1571	1358
16	176	457	738	1323	1571	2108
18	176	457	738	1323	1571	2108
20	176	457	738	1323	1571	2108
22	176	457	738	1323	1571	2108
24	176	457	738	1323	1571	2108
OCEAN VOYAGE PARAMETERS						
Cruising Speed (Statute MPH)	16	16	16	17	17	18
Cruising Speed (Nautical MPH)	13.9	13.9	13.9	14.8	14.8	15.7
Hourly Operating Cost at Sea	$338	$344	$356	$374	$397	$421
CARGO TRANSFER COSTS						
In-Port						
In-Port Waiting Hours	9	9	9	9	9	9
In-Port Transfer Hours (180 TPH)	1	3	4	7	9	12
Hourly In-Port Operating Cost	$262	$264	$272	$282	$296	$309
In-Port Cargo Transfer Cost	$257	$670	$1,113	$2,072	$2,580	$3,614
In-Port Waiting Time Cost	$2,358	$2,376	$2,445	$2,538	$2,660	$2,777
Dockage						
Vessel Length	187	254	257	268	332	353
24 Hour Dockage Fee	$374	$508	$514	$536	$664	$706
Days in Port	1	1	1	1	1	1
Dockage Costs	$374	$508	$514	$536	$664	$706
Wharfage Fee per Net Ton	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Wharfage Costs						
12	$220	$571	$922	$1,653	$1,531	$760
14	$220	$571	$922	$1,653	$1,964	$1,698

TABLE B-10 (Cont.)

16	$220	$571	$922	$1,653	$1,964	$2,635
18	$220	$571	$922	$1,653	$1,964	$2,635
20	$220	$571	$922	$1,653	$1,964	$2,635
22	$220	$571	$922	$1,653	$1,964	$2,635
24	$220	$571	$922	$1,653	$1,964	$2,635
Total In-Port Costs						
12	$3,209	$4,125	$4,994	$6,800	$7,434	$7,856
14	$3,209	$4,125	$4,994	$6,800	$7,867	$8,794
16	$3,209	$4,125	$4,994	$6,800	$7,867	$9,732
18	$3,209	$4,125	$4,994	$6,800	$7,867	$9,732
20	$3,209	$4,125	$4,994	$6,800	$7,867	$9,732
22	$3,209	$4,125	$4,994	$6,800	$7,867	$9,732
24	$3,209	$4,125	$4,994	$6,800	$7,867	$9,732
In-Port Travel Costs						
Tidal Delays						
Avg. Hrs. of Maximum Tidal Delay	6	6	6	6	6	6
Avg. Feet of Tidal Delay Per Depth						
12	0.3	2.1	5.2	5.5	5.5	5.5
14	0.0	0.1	3.2	3.5	4.5	5.5
16	0.0	0.0	1.2	1.5	2.5	5.5
18	0.0	0.0	0.0	0.0	0.5	3.5
20	0.0	0.0	0.0	0.0	0.0	1.5
22	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Hrs. of Tidal Delay Per Depth						
12	0.3	2.3	4.9	6.0	6.0	6.0
14	0.0	0.1	3.1	3.5	4.3	6.0
16	0.0	0.0	1.5	1.8	2.8	6.0
18	0.0	0.0	0.0	0.0	0.8	3.5
20	0.0	0.0	0.0	0.0	0.0	1.8
22	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0
Delay for Tide:						
Operating Cost at Sea	$338	$344	$356	$374	$397	$421
Operating Cost at Port	$262	$254	$272	$282	$296	$309
Tidal Delay Costs						
12	$66	$572	$1,333	$1,692	$1,776	$1,854
14	$0	$25	$850	$987	$1,258	$1,854
16	$0	$0	$408	$494	$814	$1,854
18	$0	$0	$0	$0	$222	$1,082
20	$0	$0	$0	$0	$0	$541
22	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0
Pilotage						
Vessel Length	187	254	257	268	332	353
Vessel Beam	36	39.7	43	44	59	60
Vessel Draft	12.8	14.6	17.7	18	19	22
Pilotage Units	67.32	100.838	110.51	117.92	195.88	211.8
C&D Use Flag						
Delaware River Pilot Fee	$1,320	$1,331	$1,459	$1,557	$2,586	$2,796
C&D Canal Fee (if applicable)	$500	$500	$500	$500	$500	$500

TABLE B-10 (Cont.)

Tug Costs							
	Number of Tugs Used	1	1	1	1	1	1
	Tug Rate	$650	$650	$650	$650	$650	$650
	Tug Costs	$650	$650	$650	$650	$650	$650
	In-Port & Cargo Transfer Costs						
	12	$5,245	$6,678	$8,435	$10,698	$12,446	$13,156
	14	$5,179	$6,132	$7,953	$9,993	$12,361	$14,094
	16	$5,179	$6,106	$7,511	$9,500	$11,917	$15,031
	18	$5,179	$6,106	$7,103	$9,006	$11,325	$14,259
	20	$5,179	$6,106	$7,103	$9,006	$11,103	$13,718
	22	$5,179	$6,106	$7,103	$9,006	$11,103	$13,177
	24	$5,179	$6,106	$7,103	$9,006	$11,103	$13,177

TOTAL COST AND COST PER NET CARGO TON BY TRADE ROUTE:

Bermuda							
Total Cost:	12' Channel Depth	$44,792	$48,268	$53,000	$57,120	$62,812	$64,291
	14' Channel Depth	$44,661	$47,175	$52,035	$55,710	$62,642	$66,166
	16' Channel Depth	$44,661	$47,125	$51,151	$54,723	$61,754	$68,042
	18' Channel Depth	$44,661	$47,125	$50,335	$53,736	$60,570	$66,497
	20' Channel Depth	$44,661	$47,125	$50,335	$53,736	$60,126	$65,415
	22' Channel Depth	$44,661	$47,125	$50,335	$53,736	$60,126	$64,334
	24' Channel Depth	$44,661	$47,125	$50,335	$53,736	$60,126	$64,334
Cost Per Ton:	12' Channel Depth	$253.97	$105.63	$71.86	$43.18	$51.29	$105.72
	14' Channel Depth	$253.23	$103.24	$70.55	$42.12	$39.87	$48.71
	16' Channel Depth	$253.23	$103.13	$69.35	$41.37	$39.30	$32.27
	18' Channel Depth	$253.23	$103.13	$68.25	$40.62	$38.55	$31.54
	20' Channel Depth	$253.23	$103.13	$68.25	$40.62	$38.27	$31.03
	22' Channel Depth	$253.23	$103.13	$68.25	$40.62	$38.27	$30.51
	24' Channel Depth	$253.23	$103.13	$68.25	$40.62	$38.27	$30.51

Distances to Ports-Nautical Miles

Bermuda 706

TABLE B-11

SALEM RIVER
TOTAL TRANSPORTATION SAVINGS DISCOUNT RATE= 8.750% PRICE LEVEL= APRIL 1990
TRADE ROUTE: GENERAL CARGO/CONTAINERS-BERMUDA 3/5/91
VESSEL CLASSES GREATER THAN 5000 DWT DELETED
1.5 FT CONSTRAINT
REVISED TRANS. COST MODEL INCORPORATING 11/23/90 WLRC COMMENTS AND FRC COMMENTS (F:VC2A)
APPLYING REVISED HISTORIC AND REVISED COMMODITY DATA FROM F:DRIBDA1
TRANS COST MODEL ADJUSTED BASED ON 76% CARRYING CAPACITY (WLRC EQUATION) INCLUDING WEIGHT OF BOXES
FLEET DEFINED BY NORMAL DISTRIBUTION FOR VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN

	12 FEET:		12 FEET:		14 FEET:	% OF	
		PCT.	AVG	TOTAL	AVG	TOTAL FLEET	TOTAL
DESDWT	DDRAFT	OF FLEET	$/TON	TRANS COSTS	$/TON	$/TON	TRANS COSTS
1,000	12.8	0.0%	$133.08	$0	$130.46	0.00%	$0
1,500	14.6	2.9%	$77.70	$43,714	$76.41	0.00%	$0
2,000	17.7	11.4%	$68.30	$151,052	$57.55	1.40%	$15,631
3,000	18.0	45.7%	$43.65	$386,992	$37.56	37.50%	$273,249
4,000	19.0	40.0%	$52.22	$405,227	$34.25	38.90%	$258,471
5,000	22.0	0.0%	$107.81	$0	$49.66	22.20%	$213,876
TOTAL SHORT TONS (1989) 1]	19,400	100.0%				100.0%	
				$986,986			$761,226
CUMULATIVE SAVINGS							$225,759

1] SOURCE: WLRC & MID-ATLANTIC SHIPPING CORP

TABLE B-11 (Cont.)

16 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	18 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	20 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$130.46	0.00%	$0	$130.46	0.00%	$0	$130.46	0.00%	$0
$75.22	0.00%	$0	$75.22	0.00%	$0	$75.22	0.00%	$0
$56.58	1.10%	$12,074	$55.44	0.40%	$4,302	$55.27	0.40%	$4,289
$37.01	30.40%	$218,270	$36.27	31.30%	$220,239	$35.99	31.30%	$218,538
$33.48	33.70%	$218,886	$32.94	33.60%	$214,716	$32.40	33.60%	$211,196
$32.88	34.80%	$221,979	$27.86	34.70%	$187,548	$27.48	34.70%	$184,990
	100.0%			100.0%			100.0%	
		$671,209			$626,805			$619,013
		$315,776			$360,181			$367,972

TABLE B-11 (Cont.)

22 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	24 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$130.46	0.00%	$0	$130.46	0.00%	$0
$75.22	0.00%	$0	$75.22	0.00%	$0
$55.27	0.40%	$4,289	$55.27	0.40%	$4,289
$35.99	31.30%	$218,538	$35.99	31.30%	$218,538
$32.40	33.60%	$211,196	$32.40	33.60%	$211,196
$26.99	34.70%	$181,691	$26.80	34.70%	$180,412
	100.0%			100.0%	
		$615,715			$614,436
		$371,271			$372,550

TABLE B-11 (Cont.)

PREDICTED TONNAGE:		PERIOD	AVG ANN GROWTH/YR FOR PERIOD
1989	19,400		
1994	38,080	1989-1994	14.40%
2001	76,230	1994-2001	10.40%
2011	172,356	2001-2011	8.50%
2014	220,148	2011-2014	8.50%
2031	220,148	2014-2031	0.00%
2044	220,148	2031-2044	0.00%

YEAR	CUMULATIVE TRANS COSTS 12 FT	SPPW,8 3/4%	PRESENT WORTH TRANS COSTS 12 FT	PRESENT WORTH TRANS COSTS 14 FT	PRESENT WORTH TRANS COSTS 16 FT	PRESENT WORTH TRANS COSTS 18 FT	PRESENT WORTH TRANS COSTS 20 FT	PRESENT WORTH TRANS COSTS 22 FT	PRESENT WORTH TRANS COSTS 24 FT
1994	$1,937,341	1.00000	$1,937,341	$1,494,201	$1,317,508	$1,230,347	$1,215,053	$1,208,578	$1,206,068
1995	$2,138,824	0.91954	$1,966,735	$1,516,872	$1,337,498	$1,249,014	$1,233,489	$1,226,916	$1,224,367
1996	$2,361,262	0.84555	$1,996,575	$1,539,886	$1,357,791	$1,267,965	$1,252,204	$1,245,531	$1,242,943
1997	$2,606,833	0.77752	$2,026,868	$1,563,250	$1,378,392	$1,287,203	$1,271,202	$1,264,429	$1,261,802
1998	$2,877,944	0.71496	$2,057,621	$1,586,968	$1,399,305	$1,306,733	$1,290,490	$1,283,613	$1,280,946
1999	$3,177,250	0.65744	$2,088,840	$1,611,046	$1,420,536	$1,326,559	$1,310,070	$1,303,088	$1,300,381
2000	$3,507,684	0.60454	$2,120,532	$1,635,490	$1,442,089	$1,346,686	$1,329,946	$1,322,859	$1,320,111
2001	$3,872,483	0.55590	$2,152,706	$1,660,304	$1,463,969	$1,367,119	$1,350,125	$1,342,930	$1,340,141
2002	$4,275,222	0.51117	$2,185,368	$1,685,495	$1,486,181	$1,387,861	$1,370,610	$1,363,306	$1,360,474
2003	$4,719,845	0.47004	$2,218,525	$1,711,068	$1,508,730	$1,408,918	$1,391,405	$1,383,991	$1,381,116
2004	$3,878,243	0.43222	$1,676,264	$1,292,842	$1,139,960	$1,064,545	$1,051,312	$1,045,710	$1,043,538
2005	$4,207,894	0.39745	$1,672,410	$1,289,870	$1,137,339	$1,062,097	$1,048,895	$1,043,306	$1,041,139
2006	$4,565,565	0.36547	$1,668,566	$1,286,904	$1,134,725	$1,059,656	$1,046,484	$1,040,907	$1,038,745
2007	$4,953,638	0.33606	$1,664,730	$1,283,946	$1,132,116	$1,057,220	$1,044,078	$1,038,515	$1,036,357
2008	$5,374,697	0.30902	$1,660,903	$1,280,994	$1,129,513	$1,054,789	$1,041,678	$1,036,127	$1,033,975
2009	$5,831,546	0.28416	$1,657,085	$1,278,050	$1,126,917	$1,052,365	$1,039,283	$1,033,745	$1,031,598
2010	$6,327,228	0.26130	$1,653,275	$1,275,112	$1,124,326	$1,049,945	$1,036,894	$1,031,369	$1,029,226
2011	$6,865,042	0.24027	$1,649,475	$1,272,180	$1,121,742	$1,047,532	$1,034,511	$1,028,998	$1,026,860
2012	$7,448,571	0.22094	$1,645,683	$1,269,256	$1,119,163	$1,045,124	$1,032,132	$1,026,632	$1,024,500
2013	$8,081,699	0.20316	$1,641,900	$1,266,338	$1,116,590	$1,042,721	$1,029,760	$1,024,272	$1,022,145
2014	$8,768,644	0.18682	$1,638,125	$1,263,427	$1,114,023	$1,040,324	$1,027,392	$1,021,918	$1,019,795
2015	$8,768,644	0.17179	$1,506,322	$1,161,772	$1,024,389	$956,620	$944,729	$939,694	$937,742
2016	$8,768,644	0.15796	$1,385,124	$1,068,296	$941,967	$879,650	$868,716	$864,087	$862,292
2017	$8,768,644	0.14525	$1,273,677	$982,341	$866,177	$808,874	$798,819	$794,563	$792,912
2018	$8,768,644	0.13357	$1,171,197	$903,302	$796,484	$743,792	$734,546	$730,632	$729,114
2019	$8,768,644	0.12282	$1,076,963	$830,623	$732,399	$683,947	$675,445	$671,846	$670,450
2020	$8,768,644	0.11294	$990,311	$763,791	$673,471	$628,917	$621,099	$617,789	$616,506
2021	$8,768,644	0.10385	$910,631	$702,336	$619,283	$578,314	$571,125	$568,082	$566,902

TABLE B-11 (CONT.)

2022	$8,768,644	0.09549	$837,361	$645,827	$569,456	$531,783	$525,173	$522,374	$521,289
2023	$8,768,644	0.08781	$769,988	$593,864	$523,638	$488,996	$482,918	$480,344	$479,346
2024	$8,768,644	0.08075	$708,035	$546,081	$481,506	$449,651	$444,062	$441,696	$440,778
2025	$8,768,644	0.07425	$651,066	$502,144	$442,764	$413,473	$408,333	$406,157	$405,313
2026	$8,768,644	0.06828	$598,682	$461,741	$407,139	$380,205	$375,479	$373,478	$372,702
2027	$8,768,644	0.06278	$550,512	$424,590	$374,381	$349,613	$345,268	$343,428	$342,714
2028	$8,768,644	0.05773	$506,218	$390,427	$344,258	$321,484	$317,487	$315,796	$315,140
2029	$8,768,644	0.05309	$465,488	$359,014	$316,559	$295,617	$291,943	$290,387	$289,784
2030	$8,768,644	0.04881	$428,035	$330,128	$291,089	$271,832	$268,453	$267,022	$266,468
2031	$8,768,644	0.04489	$393,595	$303,566	$267,668	$249,960	$246,853	$245,538	$245,028
2032	$8,768,644	0.04128	$361,926	$279,141	$246,132	$229,849	$226,991	$225,782	$225,313
2033	$8,768,644	0.03795	$332,806	$256,681	$226,328	$211,355	$208,728	$207,616	$207,184
2034	$8,768,644	0.03490	$306,028	$236,029	$208,118	$194,349	$191,934	$190,911	$190,514
2035	$8,768,644	0.03209	$281,405	$217,038	$191,373	$178,712	$176,491	$175,550	$175,186
2036	$8,768,644	0.02951	$258,764	$199,575	$175,975	$164,333	$162,290	$161,425	$161,090
2037	$8,768,644	0.02714	$237,944	$183,517	$161,816	$151,111	$149,232	$148,437	$148,129
2038	$8,768,644	0.02495	$218,799	$168,752	$148,796	$138,952	$137,225	$136,494	$136,210
2039	$8,768,644	0.02294	$201,194	$155,174	$136,824	$127,772	$126,184	$125,512	$125,251
2040	$8,768,644	0.02110	$185,006	$142,689	$125,815	$117,492	$116,031	$115,413	$115,173
2041	$8,768,644	0.01940	$170,121	$131,208	$115,692	$108,038	$106,696	$106,127	$105,907
2042	$8,768,644	0.01784	$156,433	$120,651	$106,384	$99,346	$98,111	$97,588	$97,385
2043	$8,768,644	0.01640	$143,846	$110,943	$97,824	$91,352	$90,217	$89,736	$89,550
2044	$8,768,644	0.01508	$132,272	$102,017	$89,953	$84,002	$82,958	$82,516	$82,345
CUMULATIVE PRES WORTH: TRANS COSTS			$64,224,340	$49,533,908	$43,676,396	$40,786,945	$40,279,947	$40,065,304	$39,982,075
CRF, 50 YRS			0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN CUMULATIVE TRANS COSTS			$5,705,690	$4,400,592	$3,880,211	$3,623,512	$3,578,470	$3,559,402	$3,552,008
AVG ANN CUMULATIVE TRANS SAVINGS				$1,305,098	$1,825,479	$2,082,178	$2,127,220	$2,146,289	$2,153,683

TABLE B-12

SALEM RIVER
TOTAL TRANSPORTATION SAVINGS DISCOUNT RATE= 8.750% PRICE LEVEL= APRIL 1990
TRADE ROUTE: GENERAL CARGO/CONTAINERS-BERMUDA 3/5/91
VESSEL CLASSES GREATER THAN 5000 DWT DELETED
2.5 FT CONSTRAINT
REVISED TRANS. COST MODEL INCORPORATING 11/23/90 WLRC COMMENTS AND FRC COMMENTS (F:VC3A)
APPLYING REVISED HISTORIC AND REVISED COMMODITY DATA FROM F:DRIBDA1
TRANS COST MODEL ADJUSTED BASED ON 76% CARRYING CAPACITY (WLRC EQUATION) INCLUDING WEIGHT OF BOXES
FLEET DEFINED BY NORMAL DISTRIBUTION FOR VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN

	12 FEET:		12 FEET:		14 FEET:	% OF	
		PCT.	AVG	TOTAL	AVG	TOTAL FLEET	TOTAL
DESDWT	DDRAFT	OF FLEET	$/TON	TRANS COSTS	$/TON	$/TON	TRANS COSTS
1,000	12.8	0.0%	$253.97	$0	$253.23	0.00%	$0
1,500	14.6	0.5%	$105.63	$10,246	$103.24	0.00%	$0
2,000	17.7	20.4%	$71.86	$284,393	$70.55	14.40%	$197,088
3,000	18.0	40.8%	$43.18	$341,778	$42.12	28.80%	$235,333
4,000	19.0	38.3%	$51.29	$381,095	$39.87	29.50%	$228,176
5,000	22.0	0.0%	$105.72	$0	$48.71	27.30%	$257,978
TOTAL SHORT TONS (1989) 1]	19,400	100.0%				100.0%	
				$1,017,513			$918,575
CUMULATIVE SAVINGS							$98,937

1] SOURCE: WLRC & MID-ATLANTIC SHIPPING CORP

TABLE B-12 (Cont.)

16 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	18 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS	20 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$253.23	0.00%	$0	$253.23	0.00%	$0	$253.23	0.00%	$0
$103.13	0.00%	$0	$103.13	0.00%	$0	$103.13	0.00%	$0
$69.35	16.90%	$227,371	$68.25	4.30%	$56,934	$68.25	4.30%	$56,934
$41.37	26.50%	$212,683	$40.62	30.00%	$236,408	$40.62	30.00%	$236,408
$39.30	27.70%	$211,190	$38.55	31.40%	$234,831	$38.27	31.40%	$233,126
$32.27	28.90%	$180,925	$31.54	34.30%	$209,873	$31.03	34.30%	$206,480
	100.0%			100.0%			100.0%	
		$832,169			$738,047			$732,948
		$185,343			$279,465			$284,565

TABLE B-12 (Cont.)

22 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$253.23	0.00%	$0
$103.13	0.00%	$0
$68.25	4.30%	$56,934
$40.62	30.00%	$236,408
$38.27	31.40%	$233,126
$30.51	34.30%	$203,020
	100.0%	
		$729,488
		$288,025

24 FEET: AVG $/TON	% OF TOTAL FLEET $/TON	TOTAL TRANS COSTS
$253.23	0.00%	$0
$103.13	0.00%	$0
$68.25	4.30%	$56,934
$40.62	30.00%	$236,408
$38.27	31.40%	$233,126
$30.51	34.30%	$203,020
	100.0%	
		$729,488
		$288,025

TABLE B-12 (Cont.)

PREDICTED TONNAGE:		PERIOD	AVG ANN GROWTH/YR FOR PERIOD
1989	19,400		
1994	38,080	1989-1994	14.40%
2001	76,230	1994-2001	10.40%
2011	172,356	2001-2011	8.50%
2014	220,148	2011-2014	8.50%
2031	220,148	2014-2031	0.00%
2044	220,148	2031-2044	0.00%

YEAR	CUMULATIVE TRANS COSTS 12 FT	SPPW,8 3/4%	PRESENT WORTH TRANS COSTS 12 FT	PRESENT WORTH TRANS COSTS 14 FT	PRESENT WORTH TRANS COSTS 16 FT	PRESENT WORTH TRANS COSTS 18 FT	PRESENT WORTH TRANS COSTS 20 FT	PRESENT WORTH TRANS COSTS 22 FT	PRESENT WORTH TRANS COSTS 24 FT
1994	$1,997,262	1.00000	$1,997,262	$1,803,059	$1,633,454	$1,448,703	$1,438,694	$1,431,902	$1,431,902
1995	$2,204,977	0.91954	$2,027,565	$1,830,416	$1,658,238	$1,470,683	$1,460,522	$1,453,627	$1,453,627
1996	$2,434,295	0.84555	$2,058,328	$1,858,188	$1,683,397	$1,492,997	$1,482,682	$1,475,682	$1,475,682
1997	$2,687,461	0.77752	$2,089,558	$1,886,381	$1,708,938	$1,515,649	$1,505,178	$1,498,072	$1,498,072
1998	$2,966,957	0.71496	$2,121,262	$1,915,002	$1,734,867	$1,538,646	$1,528,015	$1,520,801	$1,520,801
1999	$3,275,521	0.65744	$2,153,446	$1,944,057	$1,761,189	$1,561,990	$1,551,198	$1,543,875	$1,543,875
2000	$3,616,175	0.60454	$2,186,119	$1,973,553	$1,787,911	$1,585,690	$1,574,734	$1,567,300	$1,567,300
2001	$3,992,257	0.55590	$2,219,288	$2,003,497	$1,815,038	$1,609,748	$1,598,626	$1,591,079	$1,591,079
2002	$4,407,452	0.51117	$2,252,960	$2,033,894	$1,842,576	$1,634,172	$1,622,881	$1,615,220	$1,615,220
2003	$4,865,827	0.47004	$2,287,143	$2,064,754	$1,870,532	$1,658,966	$1,647,504	$1,639,727	$1,639,727
2004	$3,998,195	0.43222	$1,728,110	$1,560,078	$1,413,329	$1,253,475	$1,244,815	$1,238,938	$1,238,938
2005	$4,338,041	0.39745	$1,724,137	$1,556,491	$1,410,080	$1,250,593	$1,241,953	$1,236,090	$1,236,090
2006	$4,706,775	0.36547	$1,720,173	$1,552,913	$1,406,838	$1,247,719	$1,239,098	$1,233,248	$1,233,248
2007	$5,106,851	0.33606	$1,716,219	$1,549,343	$1,403,604	$1,244,850	$1,236,249	$1,230,413	$1,230,413
2008	$5,540,933	0.30902	$1,712,274	$1,545,782	$1,400,378	$1,241,988	$1,233,407	$1,227,585	$1,227,585
2009	$6,011,912	0.28416	$1,708,337	$1,542,228	$1,397,158	$1,239,133	$1,230,572	$1,224,763	$1,224,763
2010	$6,522,925	0.26130	$1,704,410	$1,538,683	$1,393,947	$1,236,285	$1,227,743	$1,221,947	$1,221,947
2011	$7,077,374	0.24027	$1,700,492	$1,535,146	$1,390,742	$1,233,443	$1,224,921	$1,219,138	$1,219,138
2012	$7,678,950	0.22094	$1,696,583	$1,531,617	$1,387,545	$1,230,607	$1,222,105	$1,216,335	$1,216,335
2013	$8,331,661	0.20316	$1,692,683	$1,528,096	$1,384,355	$1,227,778	$1,219,295	$1,213,539	$1,213,539
2014	$9,039,852	0.18682	$1,688,791	$1,524,583	$1,381,173	$1,224,956	$1,216,492	$1,210,749	$1,210,749
2015	$9,039,852	0.17179	$1,552,912	$1,401,915	$1,270,044	$1,126,396	$1,118,614	$1,113,333	$1,113,333
2016	$9,039,852	0.15796	$1,427,965	$1,289,117	$1,167,856	$1,035,767	$1,028,610	$1,023,754	$1,023,754
2017	$9,039,852	0.14525	$1,313,071	$1,185,395	$1,073,891	$952,429	$945,848	$941,383	$941,383
2018	$9,039,852	0.13357	$1,207,422	$1,090,019	$987,486	$875,797	$869,746	$865,640	$865,640
2019	$9,039,852	0.12282	$1,110,273	$1,002,316	$908,033	$805,330	$799,766	$795,991	$795,991
2020	$9,039,852	0.11294	$1,020,941	$921,670	$834,973	$740,534	$735,417	$731,945	$731,945
2021	$9,039,852	0.10385	$938,796	$847,513	$767,791	$680,950	$676,246	$673,053	$673,053

TABLE 12 (CONT.)

2022	$9,039,852	0.09549	$863,261	$779,322	$706,015	$626,161	$621,835	$618,899	$618,899
2023	$9,039,852	0.08781	$793,803	$716,618	$649,209	$575,781	$571,802	$569,103	$569,103
2024	$9,039,852	0.08075	$729,934	$658,959	$596,974	$529,453	$525,795	$523,313	$523,313
2025	$9,039,852	0.07425	$671,203	$605,939	$548,942	$486,854	$483,490	$481,207	$481,207
2026	$9,039,852	0.06828	$617,198	$557,186	$504,774	$447,682	$444,588	$442,490	$442,490
2027	$9,039,852	0.06278	$567,539	$512,354	$464,160	$411,661	$408,817	$406,887	$406,887
2028	$9,039,852	0.05773	$521,875	$471,131	$426,814	$378,539	$375,924	$374,149	$374,149
2029	$9,039,852	0.05309	$479,885	$433,224	$392,472	$348,082	$345,677	$344,045	$344,045
2030	$9,039,852	0.04881	$441,273	$398,366	$360,894	$320,075	$317,864	$316,363	$316,363
2031	$9,039,852	0.04489	$405,769	$366,314	$331,857	$294,322	$292,289	$290,909	$290,909
2032	$9,039,852	0.04128	$373,121	$336,840	$305,156	$270,641	$268,771	$267,502	$267,502
2033	$9,039,852	0.03795	$343,099	$309,738	$280,603	$248,865	$247,146	$245,979	$245,979
2034	$9,039,852	0.03490	$315,494	$284,817	$258,026	$228,842	$227,261	$226,188	$226,188
2035	$9,039,852	0.03209	$290,109	$261,901	$237,265	$210,429	$208,975	$207,989	$207,989
2036	$9,039,852	0.02951	$266,767	$240,828	$218,175	$193,498	$192,161	$191,254	$191,254
2037	$9,039,852	0.02714	$245,303	$221,451	$200,620	$177,929	$176,700	$175,866	$175,866
2038	$9,039,852	0.02495	$225,566	$203,633	$184,478	$163,613	$162,483	$161,716	$161,716
2039	$9,039,852	0.02294	$207,417	$187,249	$169,635	$150,449	$149,409	$148,704	$148,704
2040	$9,039,852	0.02110	$190,728	$172,183	$155,987	$138,344	$137,388	$136,739	$136,739
2041	$9,039,852	0.01940	$175,382	$158,329	$143,436	$127,213	$126,334	$125,737	$125,737
2042	$9,039,852	0.01784	$161,271	$145,590	$131,895	$116,977	$116,169	$115,620	$115,620
2043	$9,039,852	0.01640	$148,295	$133,876	$121,283	$107,565	$106,822	$106,318	$106,318
2044	$9,039,852	0.01508	$136,363	$123,104	$111,524	$98,911	$98,227	$97,763	$97,763
CUMULATIVE PRES WORTH: TRANS COSTS			$66,210,760	$59,772,792	$54,150,260	$48,025,615	$47,693,798	$47,468,640	$47,468,640
CRF, 50 YRS			0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400	0.0888400
AVG ANN CUMULATIVE TRANS COSTS			$5,882,164	$5,310,215	$4,810,709	$4,266,596	$4,237,117	$4,217,114	$4,217,114
AVG ANN CUMULATIVE TRANS SAVINGS				$571,949	$1,071,455	$1,615,568	$1,645,047	$1,665,050	$1,665,050

in operational cost efficiencies between vessel classes due to the actual operating practice constraints.

<u>Bulk Benefits.</u> This benefit estimation has applied, as a base, tonnage at the 1989 level (with 2% per annum growth). The transportation cost model for bulk vessels anticipated that the fleet would load as deeply as possible based on the channel depth available. A cargo carrying capacity of aproximately 95% was applied for bulk vessels. The transportation savings model incorporates the fleet distributions from Table B6-A with the operating costs per ton for the bulk vessel classes determined in the transportation cost model. Historically, in 1989-1990, a minimal 3% of total bulk movements through Salem involved topping off. The average annual benefits are estimated as follows:

12 to 14 feet:	$148,100
12 to 16 feet:	$183,300
12 to 17 feet:	$192,200
12 to 18 feet:	$201,100
12 to 19 feet:	$207,200
12 to 20 feet:	$213,400
12 to 22 feet:	$225,000
12 to 24 feet:	$241,100

LEAST-COST PORT ANALYSIS

Dr. Russell Harrison, a professor at the Rutgers University-Camden campus, in a 1989 study, <u>Identifying Key Target Opportunities For The Port of Salem</u>, tabulated data to help identify the countries, commodities, and types of vessels that define key market niches for terminal operations at the Port of Salem. Dr. Harrison stated in the study that, "Any specific terminal operation in the North Atlantic port region, in general, or in South Jersey, in particular, can succeed. It can do so to the extent that it positions itself to capture certain targets of opportunity, which may be a niche defined by target countries and target products, bolstered by a willingness to provide competitive service at competitive prices". The data collected by Dr. Harrison for comparative shipping costs for the ports in the competitive market area extending from Boston, Massachusetts to Norfolk, Virginia were of particular use in conducting a least-cost analysis in this study for "niche" tonnage being moved through Salem. Table B-13 presents a port by port cost analysis for the movement of general cargo/container tonnage by the potentially competing ports (Salem, Philadelphia, Boston, New York, Baltimore, and Norfolk) for the Bermuda trade route. There are no plans for ILA unionization of labor at the port of Salem. This example considers tonnage being handled by the 5000 DWT vessel class. The results in the table verify that vessel movements for this "niche" market are accomplished more efficiently by the port of Salem than through the potentially competing larger North Atlantic ports.

RESULTS OF ECONOMIC ANALYSIS

Average annual costs have been annualized in Table B-14. Table B-15 presents average annual benefits, average annual costs, and the economic optimization for the project. Average annual

TABLE B-13

COMPARATIVE TRANSPORTATION COSTS FOR POTENTIALLY COMPETING PORTS

5000 DWT VESSEL CLASS

SOURCE: "IDENTIFYING KEY TARGET OPPORTUNITITES FOR THE PORT OF SALEM", DR. RUSSELL S. HARRISON, RUTGERS UNIVERSITY-CAMDEN, AUGUST 1989

TRADE ROUTE EXAMPLE: BERMUDA

COST CATEGORY	SALEM	PHILADELPHIA	BOSTON	NEW YORK	BALTIMORE	NORFOLK
NAVIGATIONAL SERVICES:						
TUGS	$1,000	$575	$1,472	$1,780	$670	$954
PILOTAGE	$2,800	$2,500	$1,144	$1,255	$2,900	$1,150
LINE RUNNING	$0	$575	$384	$1,725	$454	$575
SURVEYORS	$0	$287	$287	$287	$287	$460
DOCKAGE	$200	$575	$748	$575	$438	$287
OTHER	$0	$635	$138	$460	$230	$230
GOVT. REQUIREMENT COSTS:						
ENTRANCE/CLEARANCE	$551	$551	$551	$551	$551	$551
IMMIGRATION/CUSTOMS	$115	$115	$115	$115	$115	$115
MISCELLANEOUS	$115	$115	$115	$115	$115	$115
VESSEL OPERATING COSTS (ROUND TRIP)	$63,071	$63,695	$67,749	$62,551	$62,828	$55,447
LOADING & DISCHARGING:						
STEVEDORING	$22,848	$30,464	$30,464	$30,464	$30,464	$30,464
CLERKING	$100	$500	$303	$303	$606	$303
SUPPLIES	$2,645	$2,645	$2,645	$2,645	$2,645	$2,645
WHARFAGE	$5,331	$5,758	$6,093	$4,265	$4,265	$4,661
TRUCK LOADING	$36,556	$39,542	$50,265	$39,542	$39,542	$50,113
TOTAL	$135,300	$148,500	$162,500	$146,600	$146,100	$148,100

TABLE B-14

REVISION TO COSTS, 3/7/91

F:SALCA1RB

SALEM RIVER COST ANNUALIZATION 1)
DISCOUNT RATE= 8.750%
PRICE LEVEL= APRIL 1990

	12 FT	14 FT	16 FT	17 FT	18 FT	19 FT	20 FT	22 FT	24 FT
FIRST COST:									
PROJECT	$0	$4,330,000	$7,071,000	$8,914,000	$9,974,000	$14,493,000	$17,747,000	$23,431,000	$26,736,000
ASSOC. COSTS	$0	$164,000	$222,000	$239,000	$266,000	$276,000	$299,000	$398,000	$452,000
SUBTOTAL	$0	$4,494,000	$7,293,000	$9,153,000	$10,240,000	$14,769,000	$18,046,000	$23,829,000	$27,188,000
INT DURING CONSTR 2)	$0	$160,605	$260,634	$327,106	$365,952	$527,808	$644,920	$851,590	$971,632
TOTAL	$0	$4,654,605	$7,553,634	$9,480,106	$10,605,952	$15,296,808	$18,690,920	$24,680,590	$28,159,632
CRF	0.08884	0.08884	0.08884	0.08884	0.08884	0.08884	0.08884	0.08884	0.08884
AVG ANN FIRST COSTS	$0	$413,515	$671,065	$842,213	$942,233	$1,358,968	$1,660,501	$2,192,624	$2,501,702
MAINTENANCE COSTS:									
DREDGING CYCLE-YEARS	4	4	3	3	3	3	3	3	3
PROJECT	$1,394,000	$1,905,000	$1,909,000	$2,060,000	$2,215,000	$2,557,000	$2,865,000	$3,438,000	$3,794,000
ASSOC COSTS	$0	$88,000	$81,000	$86,000	$92,000	$91,000	$89,000	$90,000	$103,000
TOTAL	$1,394,000	$1,993,000	$1,990,000	$2,146,000	$2,307,000	$2,648,000	$2,954,000	$3,528,000	$3,897,000
SFF	0.219477	0.219477	0.305796	0.305796	0.305796	0.305796	0.305796	0.305796	0.305796
AVG ANN MAINT COSTS	$305,951	$437,418	$608,534	$656,238	$705,471	$809,748	$903,321	$1,078,848	$1,191,687
AVG ANN COSTS (12 FT)	$306,000								
CUMULATIVE AVG ANN COSTS		$851,000	$1,280,000	$1,498,000	$1,648,000	$2,169,000	$2,564,000	$3,271,000	$3,693,000
CUMULATIVE AVG ANN COSTS (NETTING OUT 12 FT AVG ANN COSTS)		$545,000	$974,000	$1,192,000	$1,342,000	$1,863,000	$2,258,000	$2,965,000	$3,387,000

1)INCLUDES MITIGATION, REPLACEMENT, AND NAVIGATION AID COSTS
2)NINE MONTH CONSTRUCTION PERIOD;FIRST COST APPORTIONED UNIFORMLY

EXAMPLE:
INTEREST DURING CONSTRUCTION CALCULATION (18 FEET):

MONTH 1-	$1,137,778	1.06493	$1,211,656
MONTH 2-	$1,137,778	1.05752	$1,203,219
MONTH 3-	$1,137,778	1.05015	$1,194,835
MONTH 4-	$1,137,778	1.04283	$1,186,512
MONTH 5-	$1,137,778	1.03557	$1,178,247
MONTH 6-	$1,137,778	1.02835	$1,170,039
MONTH 7-	$1,137,778	1.02119	$1,161,889
MONTH 8-	$1,137,778	1.01408	$1,153,796
MONTH 9-	$1,137,778	1.00701	$1,145,759
TOTAL	$10,240,000		$10,605,952 TOTAL INV. COST
			$10,240,000 MINUS FIRST COST

			$365,952 INT. DURING CONSTR.

TABLE B-15

SALEM RIVER ECONOMIC OPTIMIZATION F:SRRRB1
GENERAL CARGO/CONTAINER & BULK BENEFIT REASSESSMENT
HIGHEST NET BENEFIT DEPTH FOR EACH SENSITIVITY NOTED BY ASTERISK
APPLYING TRANSPORTATION COST MODEL WITH IMPACT OF ACTUAL OPERATING PRACTICES
REVISION TO COSTS, 3/7/91
CONTAINER: MID-ATLANTIC SHIPPING, INC. BERMUDA TRADE USING REVISED HISTORIC TONNAGE AND MID-ATL/VOIGT PROJECTIONS
BULK: REVISED TO APPLY 1989 TONNAGE WITH 2% GROWTH
TRANS COST MODEL ADJUSTMENT BASED ON REVISED 76% CARRYING CAPACITY FOR ALL VESSEL CLASSES INCLUDING BOX WEIGHT
VESSEL CLASSES GREATER THAN 5000 DWT DELETED, REVISED IMMERSION FACTORS
FLEET DEFINED BY NORMAL DISTRIBUTION FOR VESSEL CLASSES <1 STANDARD DEVIATION FROM MEAN
REVISION TO CARRYING CAPACITY BASED ON WLRC DEFINITION
DISCOUNT RATE= 8.750%
PRICE LEVEL= APRIL 1990

CHANNEL IMPROVEMENT	CUMULATIVE AVG ANN BENEFITS	CUMULATIVE AVG ANN COSTS	BENEFIT-COST RATIO	NET BENEFITS	GENERAL CARGO/ CONTAINER BENEFITS	BULK BENEFITS
12 TO 14 FT	$1,124,000	$545,000	2.1	$579,000	$976,300	$148,100
12 TO 16 FT	$1,657,000	$974,000	1.7	$683,000	$1,473,800	$183,300
12 TO 17 FT	$1,855,000	$1,192,000	1.6	$663,000	$1,663,050	$192,200
12 TO 18 FT	$2,053,000	$1,342,000	1.5	$711,000 *	$1,852,300	$201,100
12 TO 19 FT	$2,082,000	$1,863,000	1.1	$219,000	$1,874,950	$207,200
12 TO 20 FT	$2,111,000	$2,258,000	0.9	($147,000)	$1,897,600	$213,400
12 TO 22 FT	$2,143,000	$2,965,000	0.7	($822,000)	$1,917,500	$225,000
12 TO 24 FT	$2,164,000	$3,387,000	0.6	($1,223,000)	$1,922,900	$241,100

PESSIMISTIC SCENARIO: BULK BENEFITS DELETED, SALEM STRICTLY A GENERAL CARGO/CONTAINER PORT:

CHANNEL IMPROVEMENT	CUMULATIVE AVG ANN BENEFITS	CUMULATIVE AVG ANN COSTS	BENEFIT-COST RATIO	NET BENEFITS	GENERAL CARGO/ CONTAINER BENEFITS
12 TO 14 FT	$976,000	$545,000	1.8	$431,000	$976,300
12 TO 16 FT	$1,474,000	$974,000	1.5	$500,000	$1,473,800
12 TO 17 FT	$1,663,000	$1,192,000	1.4	$471,000	$1,663,050
12 TO 18 FT	$1,852,000	$1,342,000	1.4	$510,000 *	$1,852,300
12 TO 19 FT	$1,875,000	$1,863,000	1.0	$12,000	$1,874,950
12 TO 20 FT	$1,898,000	$2,258,000	0.8	($360,000)	$1,897,600
12 TO 22 FT	$1,918,000	$2,965,000	0.6	($1,047,000)	$1,917,500
12 TO 24 FT	$1,923,000	$3,387,000	0.6	($1,464,000)	$1,922,900

TABLE B-15 (Cont.)

SENSITIVITY ANALYSIS (AVG ANN BENEFITS):

	F:S91D7RR1	F:S8RRA	F:S9RRA
12 TO 14 FT	$1,399,101	$1,305,098	$571,949
12 TO 16 FT	$1,926,678	$1,825,479	$1,071,455
12 TO 18 FT	$2,275,219	$2,082,178	$1,615,568
12 TO 20 FT	$2,387,411	$2,127,220	$1,645,047
12 TO 22 FT	$2,414,825	$2,146,289	$1,665,050
12 TO 24 FT	$2,433,397	$2,153,683	$1,665,050

PCT. OF GENERAL CARGO/CONTAINER OUTBOUND FLEET SAILING DRAFTS(SOURCE:BEEBE PILOT LOG):

F:SCTCMR9:>15 FT	11.8%
F:SCTCMR12:14 FT	44.1%
F:SCTCMR13:13 FT	41.2%
OTHER:12 FT	2.9%
TOTAL	100.0%

benefits for general cargo/containers have been determined by taking a weighted average of the transportation savings quantified in Tables B-8, B-11,and B-12, based on an apportionment of the fleet for actual operating practice constraints (i.e., 11.8%: unconstrained, 44.1%: 1.5 foot constraint, and 41.2%: 2.5 foot constraint). Bulk benefits are based on 2% growth in tonnage per annum beyond the existing 1989 level. The optimal channel depth plan (at an 8 3/4% discount rate) is 18 feet, with a benefit-cost ratio (BCR) of 1.5 and net benefits of $711,000, with both general cargo/container and bulk benefits included. With bulk benefits deleted, the project remains at 18 feet, has a BCR of 1.4 and net benefits of $510,000.

A multiport analysis is not necessary for Salem because of the procedure applied in the study. Salem must be recognized as a "niche" market which has targeted a specific strategy for bringing certain commodities through the port. The analysis has only evaluated commodities that have historically moved through the port and are expected to continue to do so in the future. The actual movement of these commodities through Salem at the present time clearly delineates the economic viability and cost competitiveness of Salem versus other competing ports. An increase in berths and facilities at Salem will continue to increase the capability of the port to handle the same commodities at an increased level of tonnage. No new commodities, diversions, or induced tonnage are claimed in the analysis, which precludes the need to undertake a multiport analysis for the movement of commerce through the port of Salem. Based on tonnage projections, the port/landside facilities will be sufficient to handle projected throughput capacity.

RISK AND UNCERTAINTY ANALYSIS

A risk and uncertainty analysis was conducted to vary the key parameter of tonnage growth to determine the impact that this would have on project justification. A breakeven analysis of growth in tonnage for the selected plan was accomplished, and potential new tonnage as a result of the project is also discussed.

A. NO GROWTH IN TONNAGE OVER PROJECT LIFE

Transportation savings have been quantified with tonnage held constant at the level for year one of the project, 1994 (general cargo/containers=38,080 tons and bulk=27,200 tons). The results are as follows:

Channel Depth Increment	G.C./Container Trans Savings	Bulk Trans Savings	Total Trans Sav	BCR
12-14 feet	$412,600	$130,600	$ 543,000	0.9
12-16 feet	$622,800	$161,600	$ 784,000	0.8
12-18 feet	$782,800	$177,300	$ 960,000	0.7
12-20 feet	$801,900	$188,200	$ 990,000	0.4
12-22 feet	$810,300	$198,400	$1,009,000	0.3
12-24 feet	$812,600	$212,600	$1,025,000	0.3

With no growth in general cargo/container and bulk tonnage over the project life, the project would not be justified.

B. NO GROWTH IN TONNAGE BEYOND THE EXISTING YEAR

Transportation savings have been quantified with no growth in tonnage beyond the level of the existing year, 1989 (general cargo/containers=19,400 tons, bulk=24,600 tons). The results are as follows:

Channel Depth Increment	G.C./Container Trans Savings	Bulk Trans Savings	Total Trans Sav	BCR
12-14 feet	$209,900	$118,300	$328,000	0.6
12-16 feet	$316,900	$146,400	$463,000	0.5
12-18 feet	$398,300	$160,600	$559,000	0.4
12-20 feet	$408,000	$170,500	$579,000	0.3
12-22 feet	$412,300	$179,700	$592,000	0.2
12-24 feet	$413,400	$192,600	$606,000	0.2

With no growth in tonnage beyond the existing year level, the project would not be justified.

C. GROWTH IN GENERAL CARGO/CONTAINER TONNAGE TO THE YEAR 2000

Transportation savings have been quantified with growth in general cargo/container tonnage to the final year projected by DRI/TBS, the year 2000, or 71,400 tons. Bulk tonnage has been allowed to grow at 2% per annum over the project life. The results are as follows:

Channel Depth Increment	G.C./Container Trans Savings	Bulk Trans Savings	Total Trans Sav	BCR
12-14 feet	$ 674,000	$148,100	$ 822,000	1.5
12-16 feet	$1,017,500	$183,300	$1,201,000	1.2

12-18 feet	$1,278,800	$201,100	$1,480,000	1.1
12-20 feet	$1,310,100	$213,400	$1,524,000	0.7
12-22 feet	$1,323,800	$225,000	$1,549,000	0.5
12-24 feet	$1,327,100	$241,100	$1,568,000	0.4

With growth in general cargo/container tonnage only to the year 2000 (covering the first six years of the project life), the project depth would optimize at 14 feet.

D. BREAKEVEN ANALYSIS

Growth in tonnage through year 17 of the project life is required to remain above the breakeven point of economic optimization for the selected 18 foot plan.

E. INDUCED TONNAGE

New commodities were identified during the study investigation that could potentially move through Salem over the project life based on discussions with Port of Salem officials, shippers, and local industries. The potential commodities and trade routes are as follows:

a. Rolled Newsprint (for needs of local newspapers)

(1) New Brunswick, Canada to Salem

b. Polyvinyl Chloride (used as a raw material by local plant to make vinyl resilient floor coverings)

(1) Canada to Salem

(2) Chile to Salem

c. New Perishables (originating from southern New Jersey agricultural region; processed in local irradiation facility; shipped to foreign destinations)

(1) Salem to Trinidad

(2) Salem to United Kingdom

(3) Salem to Brazil

d. Wood Pulp (for local paper needs)

(1) Georgia to Salem

(2) Chile to Salem

(3) Sweden to Salem

e. Cement Clinker (raw material used to make building products locally)

(1) Spain to Salem

f. Bauxite (raw material used by local plant in the manufacturing of rubber, plastics)

(1) Jamaica to Salem

g. Magnesium Oxide (raw material used by local plant to make magnesium oxide hybrid slurry for utility systems)

(1) Greece to Salem

(2) United Kingdom to Salem

(3) Mexico to Salem

h. Copper (raw material used by local plant for mineral processing)

(1) Canada to Salem

(2) Chile to Salem

i. Zircon (raw material used by local plant for mineral processing)

(1) Brazil to Salem

j. Epsom Salt (raw material used by local plant for mineral processing)

(1) Mexico to Salem

k. Furniture (Swedish furniture manufacturer has distribution warehouse situated near port)

(1) Sweden to Salem

If this tonnage were to become reality in moving through Salem, total benefits for the project could be higher than the benefits as quantified for the commodities in Table B-15. However, due to the speculative nature of these new commodities, it is not considered appropriate to include them in the benefit analysis.

APPENDIX D

ENVIRONMENTAL DOCUMENTATION

Cultural Resource Investigation at New Cut, Salem River,

in connection with

Proposed dredging of Salem River, City of Salem, Elsinboro Township, and Pennsville Township, Salem County, New Jersey

Philadelphia District, Corps of Engineers
Contract DACW 61-86-M-0211, task B

BY
Edward F. Heite and Louise B. Heite
SOPA

P. O. Box 53
Camden, Delaware 19934

August 1986

Louise B Heite
Edward Heite

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FIGURES

ABSTRACT

This is a report of a cultural resource survey in New Cut, on the Salem River in Salem County, New Jersey. The Corps of Engineers proposes to widen the channel through this artificial cut.

The authors were engaged to conduct a pedestrian survey of the island that was created when New Cut was dredged. The objective of the survey was to determine if a previously-reported prehistoric site exists and, if possible, to estimate its significance.

A small peninsula in Pennsville Township, adjacent to the Penns Neck Bridge, also was included in the project. The authors found evidence of human occupation on the island, but the previously reported site was not evident in the cut banks. No further archæological surveys are recommended in connection with the channel work. This study was carried out to satisfy provisions of the Environmental Policy Act, Executive Order 11593, and 36CFR 50, 66, and 800, and other applicable laws and regulations that require public agencies to consider prehistoric and historic resources.

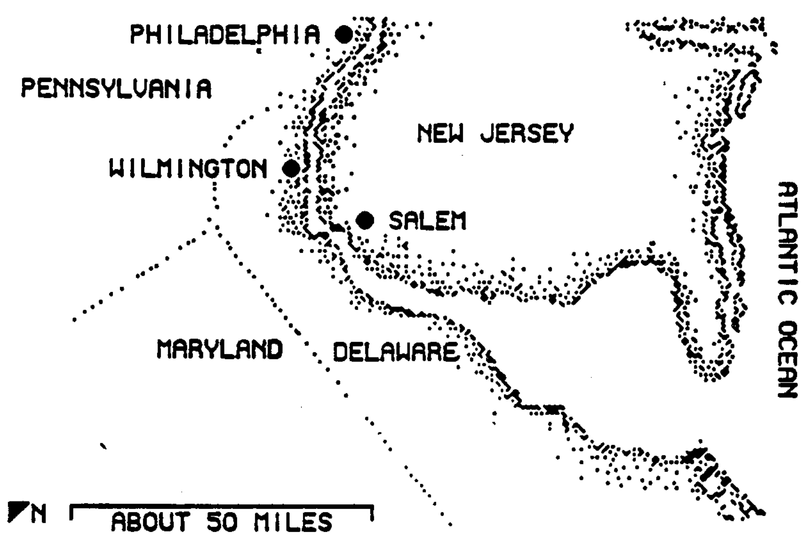
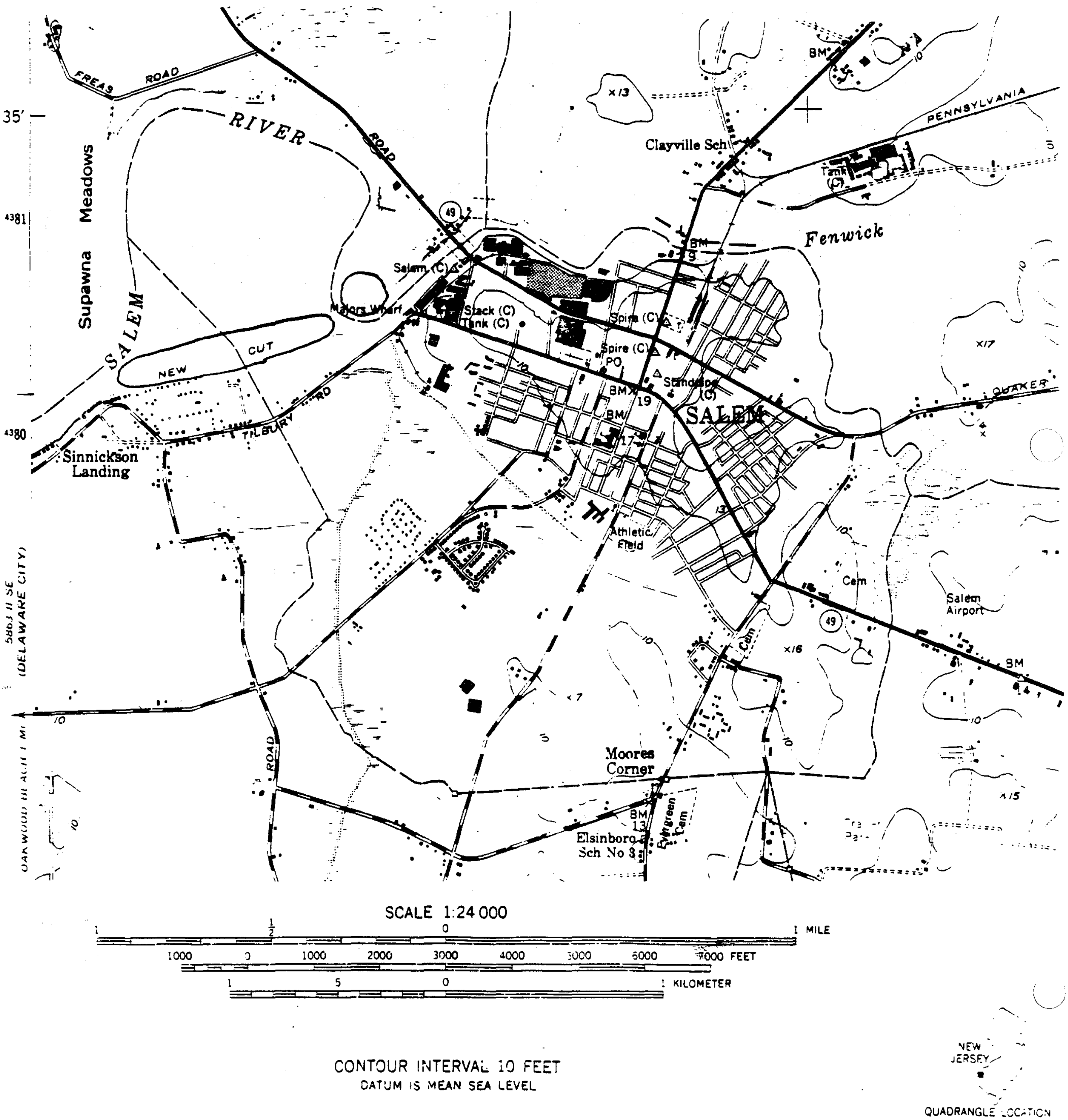


Figure 1

Regional map

Figure 2
General location map

Detail of U. S. Geological Survey Salem quadrangle, 7.5' series, 1948, photorevised 1970, showing the project area outlined.



INTRODUCTION

United States Army, Corps of Engineers, proposes to widen the channel of Salem River betwen Salem and the Delaware River. Pursuant to the National Historic Preservation Act of 1966 as amended, Environmental Policy Act, Executive Order 11593, and 36CFR 50, 66, and 800, and other applicable laws and regulations that require public agencies to consider prehistoric and historic resources, several cultural resource investigations have been conducted.

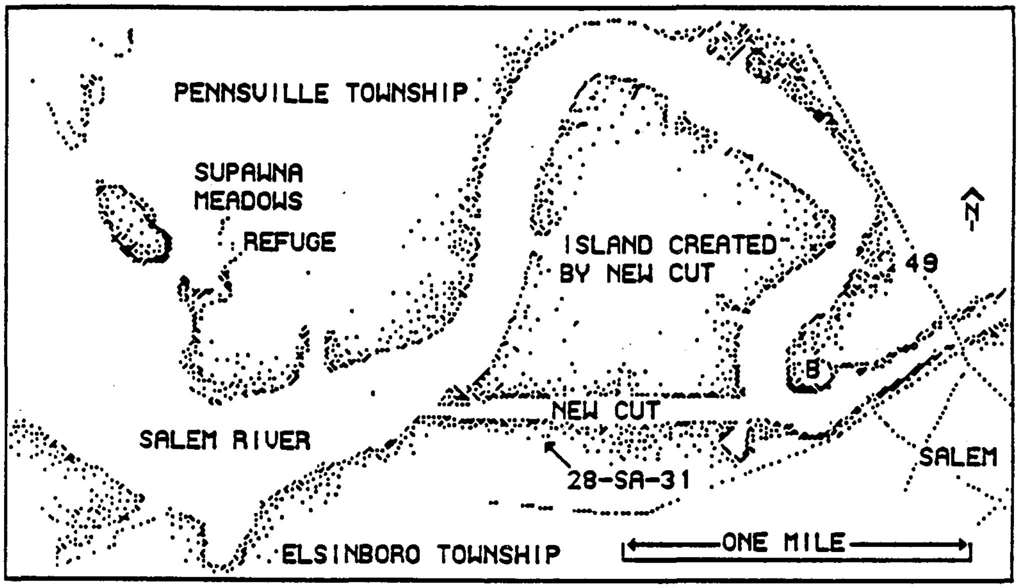


Figure 3

Location sketch map, showing the features discussed.

In May 1985, the present authors conducted a reconnaissance-level assessment of cultural resources in the vicinity of this project, including several designated disposal areas (Heite and Heite May 1985). That study uncovered hearsay evidence of prehistoric finds along the course of the New Cut. One site, designated in the New Jersey State Museum survey as 28-Sa-31, is reported to have been in the New Cut vicinity. The authors visited the islands of the study area twice during 1986, on June 27 and July 19, to conduct pedestrian survey.

PROJECT LOCATION AND LAND USE

The project area lies in Salem city and in Pennsville and Elsinboro townships, Salem County. It consists of the New Cut and a small peninsula, marked B on the map, Figure 3. The island on the north bank of the cut was created when the river was shortened around 1926. Dredged material from that project was deposited along the south bank of the cut, creating a tract of high ground that is now a residential neighborhood. The eastern end of the south bank is undeveloped except for the Barber's Basin marina.

Across the river, at a place marked B on figure 3, is a marshy peninsula that may be removed as part of the project. It is included in the study.

PREHISTORIC AND HISTORIC OVERVIEW

Man has lived on the shores of the Delaware River and its tributaries for at least ten millenia, possibly longer. Previous studies have shown that all possible disposal areas must be considered potentially significant until proven otherwise (McHugh 1983). Custer (1984) has published an ecological model for prehistoric settlement in Delaware, which probably is equally applicable for New Jersey. The shore zone's prehistory, according to Custer's model, was affected most significantly by fluctuations in sea level, which has generally risen since the end of the Pleistocene. During twelve millenia, the Delaware has evolved from a flowing fresh river in late Pleistocene times to the present drowned estuary.

When the Paleo people first entered the present Delaware estuary, the climate was far different from the present. Glaciers were retreating, pouring masses of debris and floods of fresh water onto the plains that now constitute South Jersey and Delmarva. The streams that were to become the Delaware and the Susquehanna writhed and twisted, cutting new channels and blocking old ones as they pushed the South Jersey and Delmarva landmasses farther into the rising ocean.

Glacial streams, as the Delaware was, can be unpredictable. Instead of gradually sending a regular seasonal supply of meltwater into the lowlands below, glaciers store meltwater in huge lakes, breaking forth every few years in massive surges, known in Iceland as *jökulhlaups*. When a *jökulhlaup* comes down the valley, pent-up water, ice, sand and boulders sweep all before them. Great blocks of ice are swept down the river, to be buried for years before they finally melt away entirely. A valley subject to such devastating periodic floods is not particularly inviting to settlement.

The frigid dry ground around a glacier supports only a fragile groundcover of grasses. Overgrazing, floods, fire, or even the hoofprints of animals, can expose the ground to wind erosion of the most violent kind (Gudmundsson and Kjartansson 1984; Williams 1985: 33). Throughout the region, deposits of æolian soils testify to great wind-borne soil movements that occurred before the forest cover developed.

Into this hostile environment came the region's first people, stalking the great Pleistocene herbivores. Their spearpoints and other debris can be found most commonly along ridgetops throughout the area. Fluted points of the Paleo people have been found along the main river, but there are no reports of Paleo period sites in the tidal wetlands, which were dry land during those times, when the ocean lay eighty miles eastward of its present shore (Chesler 1982:32, 56).

The region's present estuarine resources had not yet developed during much of the Archaic period, which coincides with the Atlantic climatic episode (6540-3110 BC), the transition between Pleistocene and Holocene environments (Custer 1984: 63). Most reported sites of the Archaic period in South Jersey are found along bodies of water, as are sites of later origin. Multicomponent sites characterize the lower river and bay environments (Chesler 1982: 72).

Archaic people began to use the diverse lithic sources that are found as cobbles among the riverside gravels. Whereas the Paleo hunters went to great pains to find quality cryptocrystaline silicates, their Archaic successors were satisfied with quartz, quartzite and rhyolite (Custer 1984: 67). Archaic people were beginning the long progress toward a sedentary lifestyle, establishing base camps in resource-rich areas where they could live for much of the year.

Custer hypothesizes that macro-band base camps of the Archaic period may have been located at the confluences of tributaries with the Delaware in places now deeply buried in silt and covered by the waters of the river and bay (Custer 1984: 73).

Sites of the Woodland period Riggins Complex of Salem and Cumberland counties are concentrated in the Cohansey and Maurice river drainages, often on sandy islands in salt marshes (Chesler 1982:66). Late Woodland sites in New Jersey tend to cluster along the rivers, with larger sites on the main trunks of the Delaware's tributaries.

Early Woodland people in Delaware tended to establish their macro-band base camps along rivers where fresh and salt waters meet. From these sites they would seasonally migrate in small bands to the bayside marshes (Custer 1984:132). The late Woodland period in Delaware was characterized by increasingly sedentary village life and incipient agriculture, still centered in mid-drainage. On the coastal marshes Delaware Woodland sites tend to be smaller than the ones in mid-drainage.

The Delaware Bay region was initially settled by Dutch traders during the first quarter of the seventeenth century. The Dutch settlements were limited to a short-lived whaling station at Zwaanendael, near the present Lewes, Delaware, and to a somewhat later fort and trading station at Fort Nassau in the present state of New Jersey, near Gloucester. The whaling station, which was established in 1631, was destroyed within the year by hostile Indians.

The Dutch monopoly on Delaware Bay settlement ended in 1638, when a band of Swedish settlers under the leadership of Peter Minuit established a community on the banks of the Christina River in the vicinity of present-day Wilmington. Minuit had been in the New World before this time, and probably had seen the area during a trading or exploratory venture. The Swedish colony was the brainchild of the Swedish king Gustavus Adolphus, but he died before colonizing actually began. His daughter and heir, Christina, under the guidance of her chief minister Axel Oxenstierna, continued her father's effort. Because her interests lay elsewhere, Christina approached colonization without much energy. The Swedish colony survived nevertheless, although it received virtually no support from its mother country .

In 1641 a small group of Englishmen from New Haven settled on Varckens Kill (Salem River) in the vicinity of the present Salem, foreshadowing Fenwick's colony there by thirty-five years. The Dutch governor Stuyvesant protested this incursion, but the New Englanders remained. Later that year, the Swedish government chose an experienced military leader, Johann Printz, to be their colony's governor. He was instructed to win the new English settlers to acceptance of Swedish rule (Johnson 1930: 68).

Printz tried the English for trespass in 1643. They exhibited Indian deeds to much of the east bank of the river and to some of the west as well, which Printz chose not to recognize. In spite of being found guilty of trespass, the English stayed on (Johnson 1930: 230-233). Near the English colony, Printz built Fort Elfsborg on a point in the river that would effectively control the channel. During its eight-year effective life, Elfsborg was able to force Dutch ships to strike their flags (Myers 1912: 27).

On another occasion, the same year, Elfsborg was visited by mutineers from the party of Sir Edmund Plowden, who held a dubious English grant to the Delaware drainage, which he called New Albion. When he came to settle in 1643, some of his men mutinied and went over to the Swedes. The Swedes returned the mutineers, but were unwilling to recognize the New Albion grant. Despite vigorous Dutch protests, Elfsborg was ultimately defeated by mosquitoes, who made it uninhabitable.

Although the New Sweden colony received at best sporadic support from Sweden, the Dutch perceived it as a threat to their control of Delaware Bay. In 1651, the Dutch moved their main fortification on the Delaware from New Jersey to Fort Casimir at the present site of New Castle, Delaware. The reason given for this move was to allow closer monitoring of the Swedes, whom the Dutch suspected of draining off the fur trade. Actually, the fur trade was more probably dwindling as a result of depletion of the wildlife resources; the Swedish colony did not receive enough support from home to make effective trading competitors.

The Swedes captured the Dutch fort in 1654 without incident, but the following year Peter Stuyvesant personally not only recaptured the Dutch fort, but also took control of Christinaham and terminated New Sweden. This action also was without incident. The Swedish colonists were encouraged to stay, with the promise of religious toleration and confirmation in their land and property in exchange for political loyalty to the Dutch. Most stayed.

Dutch control lasted until 1663, when the English attacked the Dutch holdings in the New World as part of the larger Anglo-Dutch Wars. Charles II granted to his brother James, Duke of York, all the territory from Maine to the east bank of the Delaware. James promptly dispatched a loyal supporter, Richard Nicholls, as Deputy Governor, to take and administer the territory.\

In September of 1664, after they had occupied New Amsterdam, Nicholls and the other commissioners sent Captain John Carr to the Delaware to subdue the Dutch. Carr's instructions required him to act with great restraint, and to use force only as a last resort. He was to offer the people all the liberties enjoyed by the English on English lands, and also freedom of conscience in religion and a continuance for at least six months of their civil government, provided that they take an oath of allegiance to England. Only Vice-Director Alexander d'Hinojossa, the commander of the Dutch forces in Fort Casimir, and a handful of soldiers resisted. Carr reduced them handily.

The colony fell, without much in the way of military action. The English offered generous terms of surrender to all settlers, including again promises of religious toleration and confirmation of their landholdings.The New Jersey proprietary was established on the southern part of the Duke's grant, but actually in the middle of the land under his courts' jurisdiction. The courts at New Castle and Upland [now Chester, Pennsylvania] continued to exercise jurisdiction over the territory that is now New Jersey until after the colonists there had established themselves. Overall, the transition from New York administration to New Jersey went smoothly except in the Salem Tenth.

Major John Fenwick, a New Jersey proprietor, came to America with a group of followers and promptly established a government based at Salem. New York's Governor Sir Edmund Andros, also an old soldier, was unwilling to share power with a part-owner of the new proprietary. Fenwick settled at Salem and began granting lands and holding courts, in defiance of Andros and the courts at New Castle. In the ensuing power struggle, Andros jailed Fenwick.

Ultimately Andros was obliged to recognize the new colony, but only after more regular government had been established by the other New Jersey proprietors. William Penn, a New Jersey proprietor, got his first taste of New World administration when he helped Fenwick financially in return for the tract known today as Penn's Neck between the Salem and Delaware rivers.

By the 1680's, landholding patterns in the area had taken on a characteristic configuration: farms consisted of long, narrow tracts running across the necks from riverbank to riverbank, or from riverbank to the ridge between streams, often a nominal mile deep. Each neck consitituted a kind of *de facto* political subdivision. But the compact settlements of continental European immigrants of the middle seventeenth century had been replaced by the time of Penn's grant (1682) by a dispersed rural settlement of mostly native-born residents with a common mixed but not yet homogenous ethnic heritage.

Penn's receipt of the Delaware counties in 1682 changed the orientation of the nearby countryside away from New Castle and towards Philadelphia.The New Jersey, proprietary, without a metropolis of its own, looked to the other Quaker colony for commercial services. Water transportation remained the main means of commerce between Philadelphia and the rest of the Delaware Valley for another two and a half centuries. The Penn family continued to hold large tracts in Penn's Neck, Salem County, into the eighteenth century; some areas of good farmland near the project area were not granted until the third decade of the eighteenth century.

A second era of fort-building began early in the nineteenth century, with construction of batteries on Pea Patch Island and later on the New Jersey and Delaware shores. Chastened by the ease with which the British had attacked our major cities during the War of 1812, the United States embarked upon a program of coast defense, much of which was never tried in combat. To protect Philadelphia and the Chesapeake and Delaware Canal, batteries were built on the New Jersey and Delaware shores. The battery on Pea Patch Island, which grew to become the great Fort Delaware, was constantly modernized into the twentieth century. Forts Mott and duPont on the shores facing the island were among the last coast defense installations erected. Although the forts never fired on an enemy, they remained government installations until after World War II.

MEADOW BANKS

Marshes, or meadowlands, were among the most valuable resources for the first European settlers. Each Dutch grant to a farm included proportions of meadow and of upland. In some cases the meadow portion of a farm was separated from the upland, but the two parts were regarded as a single entity.

New Castle and Salem, the first substantial settlements on the river, both were built on sandspits in the midst of tide marshes. Both communities had, from the beginning, town marsh lands held in common by the townspeople. Both communities erected communal dykes to drain the fens and keep out the river.

Meadowlands were the source of hay and grazing for livestock. Cattle thrived on the rich, fine freshwater marsh grasses which were the dominant plant species at higher elevations, while the saltier grasses were used as bedding. Even today, some riverfront hay meadows in South Jersey are divided into small tracts of ten acres or so. These small holdings are a legacy of the day when landlocked farmers needed the salt hay for livestock bedding, and so owned and maintained hayfields that sometimes were far from the home farms. Surplus hay was sent upriver, to be used as horse bedding, as packing material, or as core material for hollow iron castings. Salt marsh hay was a truly versatile and profitable agricultural product.

People on the east and west sides of the Delaware used the marshlands differently. During the latter part of the eighteenth century, thousands of acres of formerly undeveloped wetlands on both sides of the river were dyked and drained. A fad for meadow draining developed around the 1750's, when meadows along the Schuylkill at Philadelphia were successfully drained for cultivation. Farmers throughout the valley saw such successes and tried to emulate them at home.

A New Jersey act in 1788 permitted local farmers to form companies to drain meadows. Groups of landowners could incorporate to reclaim the lowgrounds and assess the affected properties for the cost of maintaining the drainage works.

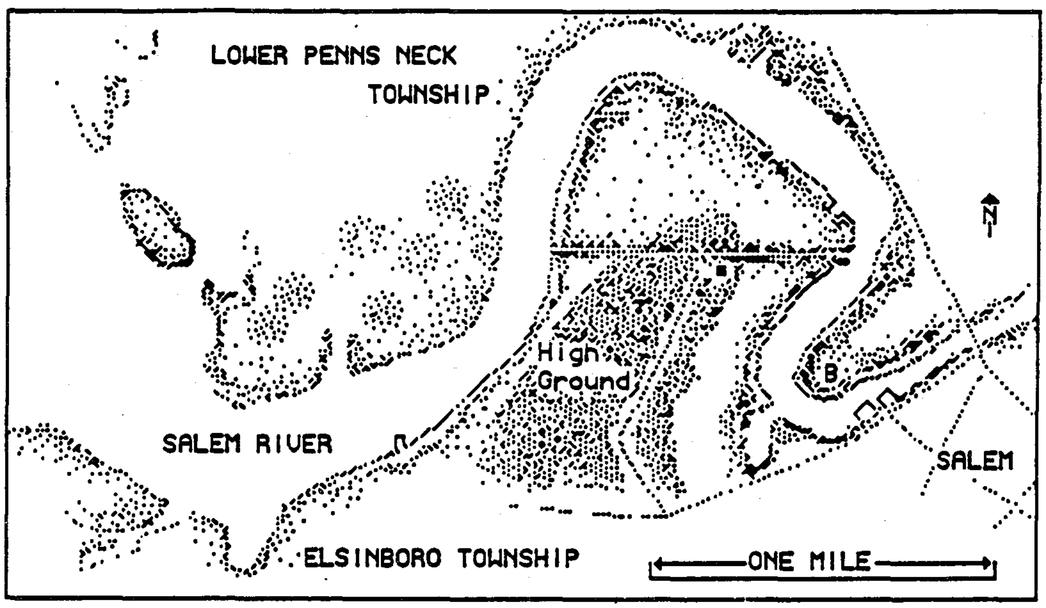


Figure 4

Project area before New Cut

This sketch map is based upon the 1848 Coast and Geodetic Survey *Map of Delaware Bay and River* (Heite and Heite June 1986, Figure 3) The high ground, through which the cut now passes, supported crops. The entire peninsula was banked. Sluice gate sites are marked by piles of crushed rock and occasional waterlogged timbers at the mouths of streams along the old course of the river.

The farmers of Salem and Cumberland Counties set out to reclaim their broad meadowlands with ambitious systems of private dykes and sluice gates. In Salem County alone, there were 71 meadow bank companies, the earliest chartered in 1794. Meadow banking and swamp draining continued through the nineteenth century, until thousands of acres were under control. Only constant maintenance could hold back the water, and maintenance was expensive. Laborers, called "mud men," were needed to keep the dykes in repair.

By the 1930s, experienced mud men were becoming hard to find and money was even scarcer. When the banks began to wash out, the bank companies had no money to repair them. The once rich Mannington Meadow grasslands are now a huge pond, crisscrossed by old dykes.

During the Depression, the Civilian Conservation Corps went to work draining the marshes to help reduce the mosquito population. Soon after the CCC left, muskrat trappers began destroying the drainage works. The trappers reasoned that their "marsh rabbits" preferred wetter marshes. Since trapping was a major source of income, the marshes remained undrained for a while.

NAVIGATION

The Delaware of the Pre-Revolutionary period was busy with shallops carrying farm goods and grain bound for Philadelphia and returning with the treasures of Europe and the Orient. Farmers in central Delaware and South Jersey could take their tea from Chinese porcelain thanks to the shallopmen. Shallopmen and bay pilots were bankers, commercial agents, and news-carriers of the wider world to the farmers and small merchants who lived along the tidal streams and congregated at the landings. The shallop trip from Kent County, Delaware, to Philadelphia took five days, but the ordeal was considered commonplace and acceptable.

Sailing vessels from down the bay carried farm products to Philadelphia even after the steamboats were introduced early in the nineteenth century. A steamer could carry passengers swiftly, but sailboats could carry bulk goods more cheaply. Each river had its line of regular packets converging on Philadelphia. Steamboats gradually displaced sailing vessels in the bay trade, but both schooners and steamers were still routinely carrying freight along the rivers as late as World War II. The last was the Wilson Line, which ended its days as a purely excursion line from Wilmington to Riverview Park to Philaelphia.

Salem played an important role in the bay trade. Because of its location off the end of the Chesapeake and Delaware Canal, Salem's captains were keenly interested in that project. A typical steamer line of the nineteenth century would run from Philadelphia, to Salem, through the canal to Baltimore or other Chesapeake ports.

PHYSICAL GEOGRAPHY AND ENVIRONMENT OF THE PROJECT AREA

The project area consists of a tongue of high ground, surrounded by salt marsh. Until the present century, the Salem River looped northward around this peninsula. The marshes were banked, reclaiming considerable acreage. At least half of the peninsula was planted in crops, and a farmstead was located near its center.

A wharf, near the present west end of New Cut, was the first fast ground inside Salem River. The 1848 chart shows a wharf on this site, and the authors found pilings on the island just north of the mouth of the new cut. Such a geographical advantage would have been a strong inducement for early settlers.

Except for the natural high ground, most of the study area has been tide marsh since first settlement. While the meadow banks were in place, the arable land expanded, only to shrink again when the banks broke.

Attempts to make landfall on the peninsula in Pennsville Township below the bridge (B on the sketch maps) were unsuccessful because of the current. The islands that make up this peninsula are subject to intense tidal action, even at the time when slack water is alleged to be due. Although these islands were shown as banked meadow in the 1848 map, no signs of riprap, gates, or banks survive. The county assessment map shows the peninsula as subidvided into many parcels, seven of which would be included in the projected removal. Today they are considerably smaller than the acreages shown on the maps.

FINDINGS

Prehistoric site 28-Sa-31, if it ever existed, could not be confirmed. An adequate view of the surface did not reveal any evidence of either a prehistoric site or an historic site along the north bank of New Cut. The peninsula in Pennsville Township is entirely saltmarsh and is unlikely to contain any archæological sites.

These negative findings do not apply to the high ground on the island, which is designated as salt marsh on virtually all the maps. Because it was the first high ground to be encountered by people coming upriver, this site has a high probability of having been settled during the seventeenth century. Such sites elsewhere in the Delaware valley have yielded extremely early settlers' sites.

No sites potentially eligible for the National Register are likely to be affected by the proposed dredging.

RECOMMENDATIONS

We do not recommend any further archæological and historical investigations in connection with the dredging, provided that work is confined to the present cut and its adjacent beaches. If the high ground on the island should be chosen as a disposal area for dredged material, we recommend a thorough phase II survey of that site. Because the island is infested with rank growth and a vigorous insect population, we recommend late fall, winter, or spring excavations there.

REFERENCES

Chesler, Olga, *editor*
1982

New Jersey's Cultural Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities. Office of Cultural and Environmental Services, Trenton.

Cox, J. Lee
1986

A sensitivity level investigation for cultural resources in the vicinity of the main navigational channel, Delaware River, Wilmington to the sea, and a proposed deepwater port. Submitted to Philadelphia District, Corps of Engineers.

Cross, Dorothy
1941
Archæology of New Jersey, volume 1. Archæological Society of New Jersey and New Jersey State Museum, Trenton.

Custer, Jay F.
1984
Delaware Preshistoric Archæology: An Ecological Approach. University of Delaware Press, Newark.

Gudmundson, Ari, and Halldor Kjartansson
1984
Guide to the Geology of Iceland. Bokautgafan Orn Og Orlygur, Reykjavik.

Heite, Edward F., Louise B. Heite, and R. Alan Mounier
April 1985
Cultural Resources Investigation on Tindal Island, Cumberland COunty, New Jersey, 28-Cu-99 in connection with maintenance dredging, Cohansey River. Prepared for Philadelphia District, Corps of Engineers.

Heite, Edward F., and Louise B. Heite
May 1985
Cultural Resources Assessment in connection with Proposed Channel Modifications of the Salem River, Salem COunty, New Jersey and Harbor of Refuge, Sussex County, Delaware. Prepared for Philadelphia District, Corps of Engineers.

Heite, Edward F., and Louise B. Heite
January 1986
Fort Elfsborg 1643: a background study of the history of Elsinboro Point or Fort Elfsborg, Elsinboro Township, Salem County, New Jersey and New Castle County, Delaware. Prepared for Philadelphia District, Corps of Engineers.

Heite, Edward F., and Louise B. Heite
May 1986
Preliminary Cultural Resource Reconnaissance Investigation in connection with Comprehensive Navigation Study, Delaware River, Delaware and New Jersey. Prepared for Phildadelphia District, Corps of Engineers.

Heite, Edward F., and Louise B. Heite
June 1986
Phase I Cultural Resource Investigation, Proposed Disposal Area at Supawna, Pennsville Township, Salem County, New Jersey. Prepared for Philadelphia District, Corps of Engineers.

Johnson, Amandus
1930
The Instruction for Johan Printz. Swedish Colonial Society, Philadelphia.

McHugh, William P.
1983
Delaware River Comprehensive Navigation Study (interim): Cultural Resources Sensitivity Reconnaissance. Submitted to Phildelphia District, Corps of Engineers.

Myers, Albert Cook, *editor*
1912
Narratives of Early Pennsylvania, West New Jersey and Delaware 1630-1701. Scribners, New York.

Powley, Van R.
1969
Soil Survey of Salem County, New Jersey. Soil Conservation Service, USDA.

United States Coast and Geodetic Survey
1848
Map of Delaware Bay and River. Photocopied from an original at the Hagley Museum and Library, Greenville, Delaware.

Williams, David
1985
Iceland :the Visitor's Guide. Stacey International, London.

MANUSCRIPTS AND OFFICIAL RECORDS

Salem County Clerk's Office:

Deed books
Banks and Roads books

Salem County Historical Society:

Deed files

Salem County Planning Commission:

Cultural Resources Survey compiled by John M. Dickey

New Jersey State Historic Preservation Officer

New Jersey State Museum

HEITE CONSULTING
FIRM PROFILE AND QUALIFICATIONS

Heite Consulting is a two-person archæological and historical research firm. They specialize in historical background studies and in reconnaissance-level archæological surveys. During the past five years, the Heites have completed contracts in Delaware, New Jersey, Pennsylvania, Maryland, and Virginia.

Louise Heite, principal investigator for historical background studies, is both an historian and an archæologist, specializing in social history. Her doctoral dissertation, to be completed in 1986, is a study of neighborhood development in Wilmington, Delaware. Her MA thesis was a history of New Castle's formative period, 1651-1681.

Her previous historical studies include Wilmington Boulevard (1980-1982) and the Mary C. I. Williams School site (1984). Mrs. Heite recently completed an historical and archæological study of the duPont Station community at Denney's Road, Kent County, for the Delaware Department of Transportation.

Edward Heite has served as Historic Registrar and Chief of the Bureau of Archives and Records Management for the State of Delaware. He was previously archæological historian for the Virginia Historic Landmarks Commission. Recent clients include the United States Army Corps of Engineers, Delaware Department of Transportation, and the Borough of West Conshohocken, Pennsylvania.

Both are members of the Society of Professional Archæologists, certified in theoretical/archival research and historical archæology. Edward Heite is also certified by SOPA in field research and cultural resource management. They meet the professional standards for historians and archæologists set forth in the Secretary of the Interior's standards and guidelines for archæology and historic preservation (*Federal Register*, Vol. 48, No. 190, Thursday, September 29, 1983, pages 44716 - 44742).

APPENDIX D

WATER QUALITY STANDARDS

Water Quality Standards

A.1 NJDEP Surface Water Quality Criteria for SE waters (Salem River)

A.2 Delaware River Basin Commission Water Quality Regulations (Zones 5 and 6, Delaware River and Bay)

A.3 Delaware (DNREC) Water Quality Standards (Zones 5 and 6, Delaware River and Bay)

A.4 State of Delaware Surface Water Criteria Guidelines for Heavy Metals and Toxic Substances to Protect Saltwater Aquatic Life Based on USEPA Criteria

NEW JERSEY DEPARTMENT OF
ENVIRONMENTAL PROTECTION
Surface Water Quality Criteria for SE Waters
7:9-4.14(c)

(Expressed as maximum concentrations unless otnerwise noted)

Substance		Criteria
1. Bacterial quality (Counts/100 ml)	i.	Fecal Coliforms: (1) Fecal coliform levels snall not exceed a geometric average of 200/100 ml nor should more tnan 10 percent of tne total samples taken during any 30-day period exceed 400/100 ml.
	ii.	Samples shall be obtained at sufficient frequencies and at locations during periods wnicn will permit valid interpretation of laboratory analyses. As a guideline and for tne purpose of these regulations, a minimum of five samples taken over a 30-day period should be collected, however, tne number of samples, frequencies and locations will be determined by tne department or other appropriate agency in any particular case.
3. Dissolved oxygen (mg/l)	i.	24 hour average not less tnan 5.0, but not less than 4.0 at anytime (see paragraph viii below).
	ii.	Supersaturated dissolved oxygen values snall be expressed as their corresponding 100 percent saturation values for purposes of calculating 24 hour averages.
4. Floating, colloidal, color and settleable solids; petroleum hydrocarbons and other oils and grease	i.	None noticeable in tne water or deposited along tne snore or on tne aquatic substrata in quantities detrimental to tne natural biota. None of which would render the waters suitable for tne designated uses.
	ii.	For "Petroleum Hydrocarbons" tne goal is none detectable utilizing tne Federal EPA environmental Monitoring and Supprot Laboratory Method (Freon Extractable - Silica Gel Adsorption - Infrared Measurament); the present criteria, however, are tnose of paragrapn i. above.

5.	pH (Standard Units)	i. 6.5-8.5
6.	Radioactivity	i. Prevailing regulations adopted by the U.S. Environmental Protection Agency pursuant to Sections 1412, 1445, and 1450 of the Public Health Services Act, as amended by the Safe Drinking Water Act (PL 93-523).
7.	Solids, Suspended (mg/l) (Non-filterable residue)	i. Noone which would render the waters unsuitable for the designated uses.
8.	Solids, Total Dissolved (Filterable Residue) (mg/l)	i. None which would render the water unsuitable for the designated uses.
9.	Taste and odor producing substances	i. None offensive to humans or which produce offensive taste or odoors in water supplies and biota used for human consumption. None which would render the waters unsuitable for the designated uses.
10.	Temperature and Heat Dissipation Areas	i. Thermal Alterations (Temperatures shall be measures outside of heat dissipation areas)

(i) No thermal alterations which owuld cause temperatures to deviate from ambient by more than 2.2°C (4°F), from September through May, nor more than 0.8°C (1.5°F) from June through August, nor cause temperatures to exceed 29.4°C (85°F).

ii. Heat Dissipation Areas

(1) Streams

(i) Not more than one-quarter (1/4) of the cross section and/or volume of the water body at any time.

(ii) Not more than two-thirds (2/3) of the surface from shore too shore at any time.

(iii) These limits may be exceeded by special permission, on a case-by-case basis, when a discharger can demonstrate that a larger heat dissipation area meets the tests for a waiver under Section 316 of the Federal Clean Water Act.

(2) Lakes, Ponds, Reservoirs, Bays or Coastal

Waters: Heat dissipation areas will be developed on a case-by-case basis.

10. Toxic Substances (General)

i. None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota, produce undesirable aquatic life, or which would render the waters unsuitable for the designated uses.

iii. Toxic substances shall not be present in concentrations that cause acute or chronic toxicity toa quatic biota, or bioaccumulate within an organism to concentrations tant exert a toxic effect on that organism or render it unfit for consumption.

iv. The concentrations of nonpersistent toxic substances in the State's waters shall not exceed one-twentieth (0.05) of the acute definitive LC50 or EC50 value, as determined by appropriate bioassays conducted in accordance with N.J.A.C. 7:18.

v. The concentration of persistent toxic substances in the State's waters shall not exceed one-hundredtn (0.01) of the acute definitive LC50 or EC50 value, as determined by appropriate bioassays conducted in accordance with N.J.A.C. 7:18.

11. Toxic Substances (ug/l):

i. Aldrin/Dieldrein	(1)	0.0019
ii. Ammonia, un-ionized (24 hr. average)	(2)	0.1 of acute definitive LC50 or EC50
iii. Benzidine	(1)	0.1
iv. Chlordane	(1)	0.0040
v. Chlorine, Total Residual (TRC)	(1)	10.0
vi. DDT and Metabolites	(1)	0.0010
vii. Endosulfan	(1)	0.0087
viii. Endrin	(1)	0.0023
ix. Heptachlor	(1)	0.0036

	x. Lindane	(1)	0.004
	xi. Polychlorinated biphenyls (PCB's)	(1)	0.030
12.	Turbidity (Nephelometric Turbidity Unit-NTU)	ii.	Maximum 30-day average of 10 NTU, a maximum of 30 NTU at any time.

DELAWARE RIVER BASIN COMMISSION
WATER QUALITY REGULATIONS

Description. Zone 5 is that part of the Delaware River extending from R.M. 78.8 to R.M. 48.2, Liston Point, including the tidal portions of the tributaries thereof.

Zone 6 is Delaware Bay extending from R.M. 48.2 to R.M. 0.0, the Atlantic Ocean, including the tidal portions of the tributaries thereof.

Stream Quality Objectives

A. Limits

1. The waters of the Basin shall not contain substances attributable to minicipal, industrial, or other discharges in concentrations or ammounts sufficient to preclude the specified water uses to be protected. Within this requirement:

   a. the waters shall be substantially free from unsightly or malodorous nuisances due to floating solidds, sludge deposits, debris, oil, scum, substances in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life, or that produce color, taste, odor of the water or taint fish or shellfish flesh;
   b. the concentration of total dissolved solids, except intermittent streams, shall not exceed 133 percent of background.

2. In no case shall concentrations of substances exceed thosoe values given for rejection of water supplies in the United States Public Health Service Drinking Water Standards.

B. Nondegradation of Interstate Waters. It is the policy of the Commission to maintain the quality of interstate waters, where existing quality is better than the established stream quality objectives, unless it can be affirmatively demonstrated to the Commission that such change is justifiable as a result of necessary economic or social development or to improve significantly another body of water. In implementing this policy, the Commission will require the highest degree of waste treatment determined to be practicable. No change will be considered which would be injurious to any designated present or future use.

* NJDEP standards for zone 5 are the same as DRBC regulations.

C. Stream quality objectives

1. Zone 5

Dissolved oxygen

a. 24-hour average concentration shall not be less than
   1) 3.5 mg/l at R.M. 78.8,
   2) 4.5 mg/l at R.M. 70.0,
   3) 6.0 mg/l at R.M. 59.5.
b. During the periods from April 1 to June 15, and September 16 to December 31, the dissolved oxygen shall notn ave a seasonal average less than 6.5 mg/l in the entire zone.

Zone 6
a. 24-hour average concentration shall not be less than 6.0 mg/l;
b. not less than 5.0 mg/l at any time unless due to natural conditions.

2. Temperature
   a. Shall not be raised above ambient by more than
      1) 4^{o} F (2.2^{o} C) during September through May, nor
      2) 1.5^{o} F (0.8^{o} C) during June through August;
   b. nor shall maximum temepratures exceed 86^{o}F (30.0^{o}C) in zone 5 or 85^{o}F (29.4^{o}C) in zone 6 measured outside of designated heat dissipation areas as described in 4.30.6.F.

3. pH. Between 6.5 and 8.5.

4. Phenols. Maximum 0.01 mg/l, unless exceeded due to natural conditions.

5. Threshold odor number. Not to exceed 24 at 60^{o}C.

6. Synthetic detergents (M.BB.A.S.). Maximum 30-day average 1.0 mg/l.

7. Radioactivity.
   a. alpha emitters - maximum 3 pc/l (picocuries per liter)
   b. beta emitters - maximum 1,000 pc/l.

8. Zone 5

Fecal coliform. Maximum geometric average
a. 770 per 100 milliliters from R.M. 78.8 to R.M. 59.5,
b. 200 per 100 milliliters from R.M. 59.5 to R.M. 48.2.
Samples shall be taken at such frequency and location as to permit valid interpretation.

Zone 6. Maximum geometric average 200 per 100 milliliters. Samples shall be taken at such frequency and location as to permit valid interpretation.

9. Zone 6 Only

Coliform. MPN (most probable number) not to exceed U.S. Public Health Services shellfish standards in designated shellfish areas.

10. Turbidity. Unless exceeded due to natural conditions
   a. maximum 30-day average 40 units,
   b. maximum 150 units.

11. Alkalinity. Between 20 and 120 mg/l.

12. Heat dissipation areas. The limitations specified above may be exceeded by special permit in heat dissipation areas designated on a case-by-case basis, subject to the following conditions:

   a. Maximum length. As a guideline, heat dissipation areas shall not be longer than 3500 feet, measured from the point where the waste discharge enters the stream.

13. Adjacent heat dissipation areas. Where waste discharges would result in heat dissipation areas in such close proximity as to impair protected uses, additional limitations may be prescribed to avoid such impairment.

14. Other considerations.

   a. The rate of temperature change in designated heat dissipation areas shall not cause mortality of fish or shellfish.

   b. The determination of heat dissipation areas in tidal waters shall take into special consideration the extent and nature of the recieving waters so as to meet the intent and purpose of the criteria and standards, including provisions for the passage of free-swimming and drifting organisms so that negligible or no effects are produced on their populations.

DELAWARE WATER QUALITY STANDARDS

1. General criteria for all tidal portions of stream basins (includes DRBC zones 5 and 6)

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
Temperature	Same as DRBC Regulations	
Dissolved Oxygen	Same as DRBC Regulations	
pH	Same as DRBC Regulations	
Total Alkalinity	mg/L as $CaCO_3$	Shall not be less than 20 mg/L at any time.
Total Acidity	mg/L as $CaCO_3$	Shall not exceed alkalinity by 20 mg/L at any time.
Alpha Emitters	Same as DRBC Regulations	
Beta Emitters	Same as DRBC Regulations	
Taste, Odor & Color Causing Substances		None in concentrations which cause tastes, odors, color, or impact tastes to edible fish flesh and aquatic and marine life.
Toxic Substances	mg/L	None in concentrations harmful (synergistically or otherwise) to humans, fish, wildlife and aquatic life. The Environmental Protection Agency's Water Quality Criteria Series published in October of 1980 shall be used as guidelines for determining harmful concentration levels.

(Continued)

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
Specific Toxic Substances		
DDT	g/L	0.001 g/L
Toxaphene	g/L	0.70 g/L
Endrin	g/L	0.0023 g/L
PCB's	g/L	0.030 g/L
Lindane	g/L	0.004 g/L
Methoxychlor	g/L	0.04 g/L
Total Residual Chlorine	mg/L	0.01 mg/L
Phenolic Compounds	mg/L	Shall not exceed 0.01 mg/L
Turbidity	Nephelometric or Formazine Turbidity Units	Shall not exceed 150 units.
Fecal Coliform	Colonies/100 mL	Based on five or more consecutive samples taken on separate days, the fecal coliform bacterial level should not exceed a geometric mean of 200/100 mL nor should more than 10 percent of the total samples taken during a 30 day period exceed 400/100 mL.

2. Tidal portions of stream basins designated as a source of shellfish

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
Total Coliform	MPN/100 mL	The following standards of the State Board of Health will govern: The coliform median MPN of the water shall not exceed 70/100 mL, and not have more than 10 percent of the samples ordinarily exceed an MPN of 330/100 mL for a 3 decimal dilution test (or 230/100 mL where the 5 tube decimal test is used) in those portions of the area most

(Continued)

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
		probably exposed to fecal contamination during the most critical hydrographic and pollution condition in designated shellfish areas. Sample shall be taken at such frequency and location as to permit valid interpretation.
Total Residual Chlorine	mg/L	None.

3. Delaware River (PA-DE line, RM 78.8 to Liston Point, RM 48.2).

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
Fecal Coliform (above RM 59.5)	Colonies/100 mL	Based on a minimum of not less than five consecutive samples taken on separate days, the fecal coliform bacterial level should not exceed a geometric mean of 770/100 mL.
Fecal Coliform (below RM 59.5)	Colonies/100 mL	Based on a minimum of not less than five consecutive sample taken on separate days, the fecal coliform bacterial level should not exceed a geometric mean of 200/100 ml, nor should more than 10 percent of the total samples taken during a 30 day period exceed 400/100 mL.

(Continued)

INDICATOR	UNIT OF MEASUREMENT	CRITERIA
Dissolved Oxygen (This criteria is subject for review pending the outcome of the model. Analysis of Delaware Estuary Dissolved Oxygen Objectives conducted by DRBC.)	mg/L	During April 1 - June 15 and Sept. 16 - Dec. 31 seasonal average concentration shall not be less than 6.5 mg/L in the entire zone. At no time shall the daily average concentration be less than 3.5 mg/L at Mile 78.8(A), 4.5 mg/L at Mile 70.0(B), and 6.0 mg/L at Mile 59.5(C). Note: (A) PA-DE line (B) 3/4 mile south of the mouth of the Christina River (C) 1/2 mile north of the Chesapeake and Delaware Canal
Temperature	^{o}F	No heat may be added except in designated mixing zones which would cause temperature to exceed 86^{o}F (30^{o}C) or which would cause the temperature to be raised more than 4^{o}F (2.2^{o}C) during September through May or to be raised by more than 1.5^{o}F (0.83^{o}C) during June through August.

STATE OF DELAWARE SURFACE WATER CRITERIA GUIDELINES FOR HEAVY METALS AND TOXIC SUBSTANCES TO PROTECT SALTWATER AQUATIC LIFE BASED ON USEPA CRITERIA*

Substance (μg/l unless otherwise noted)	Saltwater Criteria	
	Max. Permissible	24-hr. Avg.
Metals		
Arsenic(trivalent inorganic)	508	---
Beryllium	---	---
Cadmium	59	4.5
Chromium (hexavalent)	1,260	18
(trivalent)	10,300(t)	---
Copper	23	4.0
Lead	668(t)	25(c)
Mercury	3.7	.025
Nickel	140	7.1
Selenium(inorganic selenite)	410	54
(inorganic selenate)		
Zinc	170	58
Toxics		
Benzene	5,100(t)	700(c)
Carbon tetrachloride	50,000(t)	---
Chlorobenzene	160(t)	129(c)
Chloroform	---	---
Cyanide (free)	30(t)	2.0(c)
DDT & Metabolites	0.13	.0010
Phenol	5,800(t)	---
Phthalate Esters	2,944(t)	3.4(c)
PCB	10(t)	.030

* Delaware Water Quality Standards reference the EPA publication "Quality Criteria for Water" (1976) for many heavy metals and toxic substances criteria. The EPA updated and amended its criteria in November 1980 (45 FR 79318).

(c) Indicates chronic toxicity concentration for selected organisms based on limited data.

(t) Indicates acute toxicity concentration based on limited data.

(e) Indicates criterion is calculated based on hardness of 50 mg/l $CaCo_3$.

B. Effluent Quality Requirements

(1) Public safety.

a. Temperature. Maximum 110°F (43.3°C) where readily accessible to human contact.

(2) Limits.

a. Oil. Not to exceed 10 mg/l; no readily visible oil.

b. Debris, scum, or other floating materials. None.

c. Toxicity.

(i) Not more than 50 percent mortality in 96 hours in an appropriate bioassay test with a 1:1 dilution. Wastes containing chlorine may be dechlorinated prior to the bioassay test.

(ii) Notwithstanding the results of the tests prescribed in paragraph (i) above, the substances listed below being accumulative or conservative, shall not exceed the following specified limits in an effluent.

	limit mg/l
Arsenic	0.1
Barium	2.0
Cadmium	0.02
Chromium (hexavalent)	0.10
Copper	0.20
Lead	0.10
Mercury	0.01
Selenium	0.02
Zinc	0.60

(iii) Persistent pesticides - not to exceed one one-hundredth of the TL_{50} value at 96 hours as determined by appropriate bioassay.

d. Odor. Not to exceed a threshold number of 250.

e. BOD. In Zones 2, 3, 4 and 5 a waste shall receive not less than zone percent reduction in addition to meeting allocation requirements.

On January 26, 1972 the Delaware River Basin Commission adopted Interpretive line No. 1, as Resolution No. 72-1, directing that the following numerical ions be used as guidelines by the Commission staff in administering Sections 3.10.3.A, 4.A, 3.10.4.C, and 3.10.4.D of the Water Quality Standards, and that they be stered in accordance with the procedures of the Basin Regulations - Water Quality.

ream Quality Objectives

) Limits.

a. Toxic substances.

(i) The concentration of a toxic substance in Basin waters shall not exceed one-twentieth of the TL_{50} value at 96 hours, as determined by appropriate bioassays, except in designated mixing areas. Criteria for combinations of toxic substances will be based upon the same principle.

(ii) The substances listed below shall not exceed the specified limits or one-twentieth of the TL_{50} value at 96 hours, whichever is lower.

	limit mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Lead	0.05
Mercury	0.005
Selenium	0.01
Silver	0.05

(iii) The concentration of a persistent pesticide[1] in Basin waters shall not exceed one one-hundredth of the TL_{50} value at 96 hours, as determined by appropriate bioassay.

b. Oil. No readily visible oil.

istent pesticides are defined as natural and synthetic materials having a half-life of ter than 96 hours, which are used to control unwanted or noxious animals or plants. y include fungicides, herbicides, insecticides, fumigants and rodenticides.

Table D-1 TIDAL RANGE AND TIDAL CURRENT DATA

	Tidal Range[1]				Average Tidal Current Speed and Direction[2]					
	Location		Mean	Spring	Location		Maximum flood tide		Maximum ebb tide	
	Lat	Long	Ft	Ft	Lat	Long	Knots	Degrees	Knots	Degrees
Salem River Project										
	(At Salem)				(Entrance)					
Salem River	39° 35°	75° 28°	5.6	6.1	39° 34.2°	75° 30.1°	1.5	062	1.6	245
					(1.1 mi. E of)					
Reedy Point	39° 34°	75° 34°	5.5	6.0	39° 33.58°	75° 32.47°	1.8	354	1.7	179

Source: 1 USDOC, NOAA, NOS, 1984
2 USDOC, NOAA, NOS, 1983

Table D-2

Violations of Stream Water Quality Criteria
Salem River Watershed

Waterways	Sampling Station	Milepoint	Parameters						
			DO	F. Coliform	TDS	pH	BOD_5 (1)	NH_3-N (2)	Total PO_4^{-3} as P (4)
Salem River	SAM 010	26.30	1/41 (3)	0/3	0/2	0/4	10/40	0/4	20/27
Salem River	SAM 020	25.80	1/6	1/1	0/2	0/3	2/5	1/3	5/5
Salem River	SAM 030	24.00	3/20	3/3	0/2	0/4	7/7	0/1	6/6
Salem River	SAM 031	23.50	13/51	2/2	*	0/2	10/43	0/2	3/3
Salem River	SAM 040	21.70	4/6	1/1	0/2	0/4	2/6	0/3	5/5
Salem River	SAM 050	20.80	19/36	3/4	0/3	0/3	11/19	0/2	16/17
Salem River	SAM 060	14.50	2/5	0/1	0/3	2/5	6/6	**	6/6
Major Run	SAT 010	22.90, 0.5	1/2	0/1	0/2	0/2	0/2	0/2	2/2
Game Creek	SAT 020	16.00, 0.3	3/4	2/2	0/2	0/2	1/3	0/2	1/2
Percentage of stations violating Criteria			100%	67%	0%	11%	89%	12.5%	100%

Note: (1) BOD_5 Criterion is based on California Water Quality Criteria (5 mg/l).

(2) Analyzed for freshwater area, based on unionized NH_3 Criterion (0.02 mg/l).

(3) a/b, a - Number of samples which violated Criteria, b - Total number of samples.

(4) Total PO_4^{-3} as P should not exceed 0.1 mg/l in streams not discharging directly to lakes or impoundments, 0.05 mg/l in any stream at the point where it enters any lake or reservoir, or 0.025 mg/l within a lake or reservoir.

* No available information.

** Tidal Water Area.

Source: NJDEP, 1979.

Table D-3

NPDES Listed Municipal and Institutional Dischargers

Map #	NPDES Permit #	Discharger	Municipality	Receiving Waters	Treatment Process	Design Capacity mgd	1977-78 Avg. Flow mgd	1977-78 Average Daily Effluent Quality BOD_5 mg/l	BOD_5 kg/day	S.S. mg/l	S.S. kg/day
P9	0028797	Salem Co. Vo-Tech. School	Mannington	Major Run Creek	Primary Extended Aeration	0.015	0.003*	203	5.1	13	0.3
P6	0024856	City of Salem	Salem	Salem River	Primary	1.25	0.591	75.5	162.2	26.9	58.6
P5	0022250	Woodstown Sewerage Authority	Woodstown	Trib. to Salem River	Secondary Standard Trickling Filter	0.300	0.260	31	29.8	19	18.9
P3	0020761	N.J. Turnpike Authority	Oldmans	Layton Lake	Secondary High Rate Trickling Filter	0.15	0.064	8.1	1.95	2.95	0.71

* 5 mo. period in 1977

NPDES Listed Industrial Dischargers

Map #	NPDES Permit #	Discharger	Municipality	Receiving Waters	Treatment Process	Design Capacity mgd	Discharge Serial #	1977-78 Avg. Flow mgd	1977-78 Average Daily Effluent Quality BOD_5 mg/l	BOD_5 kg/day	S.S. mg/l	S.S. kg/day
P4	0004308	Richman Ice Cream	Pilesgrove	Salem River	Industrial	0.03	001	0.027	2670	241.6	570	53.6
P8	0005614	Mannington Mills	Salem	Pledger Creek	Process Cooling	-	001	0.179	-	-	59.7	40.0
P7	0005151	Anchor Hocking Corp.	Salem	Fenwick Creek		-	002	0.02	-	-	20.6	0.71
							001	0.15	-	-	10.7	6.7

Table D-4

DELAWARE RIVER BASIN COMMISSION
SUMMARY OF 1982 AND 1983 WATER QUALITY - ZONE 5

Parameter		Marcus Hook RM 78	Oldmans RM 75	Cherry Is. RM 71	New Castle RM 66	Pea Patch RM 61	Reedy Is. RM 55	Appoquinimink RM 51
Dissolved Oxygen (mg/l)	Ave	5.9	5.9	6.4	6.7	7.1	7.6	7.5
	Max	11.5	11.3	11.6	10.7	11.0	11.6	11.7
	Min	1.6	2.6	2.4	3.2	4.2	4.8	5.3
	#	35	35	35	36	36	34	32
Fecal Coliform (#/100ml)	Ave*	131	82	69	52	33	25	16
	Max	5100	3700	3900	3600	260	480	70
	Min	10	10	10	10	5	10	10
	#	35	32	35	34	35	36	31
Total Phosphate (mg/l)	Ave	0.13	0.14	0.12	0.16	0.13	0.13	0.12
	Max	0.20	0.21	0.25	1.0	0.30	0.45	0.30
	Min	0.02	0.10	0.02	0.02	0.02	0.01	0.02
	#	31	19	32	32	30	32	29
Nitrate nitrogen (mg/l)	Ave	1.9	1.9	1.9	1.8	1.8	1.6	1.4
	Max	2.9	2.7	2.7	2.7	2.4	2.2	1.9
	Min	1.0	1.1	1.1	0.07	1.1	0.8	0.6
	#	35	19	35	36	36	35	32
Ammonia Nitrogen (mg/l)	Ave	0.30	0.28	0.28	0.3	0.27	0.26	0.24
	Max	0.90	0.75	1.05	1.1	0.95	1.15	0.[illegible]
	Min	0.10	0.10	0.10	0.1	0.01	0.10	[illegible]
	#	35	19	35	36	36	35	32
pH	Ave	7.2	7.4	7.3	7.3	7.3	7.4	7.4
	Max	7.8	7.8	7.8	8.2	8.3	8.3	8.0
	Min	6.2	6.7	6.3	6.3	6.1	6.0	6.5
	#	35	24	35	36	36	34	31
Alkalinity	Ave	418	42	41	41	42	46	50
	Max	51	58	59	60	61	77	77
	Min	26	19	27	23	24	23	25
	#	35	19	35	36	36	35	32
Phenols	Ave	0.007	0.03	0.011	0.020	0.045	0.130	0.124
	Max	0.052	0.255	0.165	0.210	0.330	0.830	0.460
	Min	0.005	0.005	0.011	0.005	0.005	0.003	0.005
	#	34	18	34	33	34	33	31
BOD_5	Ave	2.6	2.5	2.5	2.5	2.4	2.4	2.4
	Max	4.6	3.5	3.7	3.8	3.0	2.4	2.4
	Min	2.4	2.1	2.4	2.4	2.4	2.4	2.4
	#	35	20	35	35	36	35	32
Chlorophyll	Ave	10	9	8	9	7	6	5
	Max	24	21	41	34	21.0	21	15
	Min	0	0	0	0	0	0	0
	#	34	19	35	34	36	35	3[illegible]

* Geometric Mean

Source: DRBC, 1984

Table D-5

DELAWARE RIVER BASIN COMMISSION
SUMMARY OF 1982 AND 1983 WATER QUALITY - ZONE 6

Parameter		Smyrna (RM 44)	Ship John (RM 37)	Mahon (RM 31)
Dissolved Oxygen (mg/l)	Ave	7.7	7.6	7.6
	Max	12.1	11.9	12.8
	Min	5.2	5.3	5.1
	#	32	32	32
Fecal Coliform (#/100ml)	Ave*	12	12	11
	Max	60	60	60
	Min	10	10	10
	#	33	33	30
Total Phosphate (mg/l)	Ave	0.11	0.16	0.16
	Max	0.23	0.60	0.30
	Min	0.01	0.04	0.04
	#	30	29	29
Nitrate Nitrogen (mg/l)	Ave	1.2	1.0	0.7
	Max	1.9	2.0	1.0
	Min	0.4	0.6	0.3
	#	31	32	32
Ammonia Nitrogen (mg/l)	Ave	0.23	0.20	0.24
	Max	0.90	0.80	0.60
	Min	0.10	0.10	0.10
	#	32	32	32
pH	Ave	7.4	7.4	7.3
	Max	8.0	7.9	7.8
	Min	6.5	6.1	5.6
	#	31	31	31
Alkalinity (mg/l)	Ave	56	61	74
	Max	77	86	93
	Min	29	60	47
	#	32	32	32
Phenols (mg/l)	Ave	0.160	0.201	0.270
	Max	0.430	0.370	0.920
	Min	0.005	0.020	0.010
	#	31	31	31
BOD_5 (mg/l)	Ave	2.4	2.4	2.5
	Max	2.4	2.4	3.4
	Min	2.4	2.4	2.4
	#	32	32	32
Chlorophyll a (mg/l)	Ave	4	7	19
	Max	13	29	55
	Min	0	0	0
	#	32	32	32

* Geometric mean

Source: DRBC, 1984

Table D-6

FISHES KNOWN OR LIKELY TO OCCUR IN THE SALEM RIVER PROJECT AREA

Common Name	Scientific Name
Atlantic sturgeon	*Acipenser oxyrhynchus*
Shortnose sturgeon	*A. Brevirostrum*
Atlantic tomcod	*Microgadus tomcod*
American eel	*Anguilla rostrata*
Alewife	*Alosa pseudoharengus*
Blueback herring	*A. aestivalis*
American shad	*A. sapidissima*
Atlantic menhaden	*Brevoortia tyrannus*
Gizzard shad	*Dorosoma cepedianum*
Bay anchovy	*Anchoa mitchilli*
Northern pipefish	*Syngnathus fuscus*
Summer flounder	*Paralichthys dentatus*
Silvery minnow	*Hybognathus nuchalis*
Satinfin shiner	*Notropis analostanus*
Spottail shiner	*N. hudsonius*
Carp	*Cyprinus carpio*
Creek chubsucker	*Erimyzon oblongus*
White catfish	*Ictalurus catus*
Brown bullhead	*I. nebulosus*
Channel catfish	*I. punctatus*
Mumichog	*Fundulus heteroclitus*
Banded killifish	*F. diaphanus*
Atlantic silverside	*Menidia menidia*
Tidewater silverside	*M. peninsulae*
Striped bass	*Morone saxatilis*
White perch	*M. americana*
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*L. gibbosus*
Bluefish	*Pomatomus saltatrix*
Spot	*Leiostomus xanthurus*
Hogchoker	*Trinectes maculatus*

Sources: U.S. Fish and Wildlife Service, 1981
Tyrawski 1979
U.S. Army Corps of Engineers, 1981

Table D-7

FISH CAUGHT BY OTTER TRAWL IN DELAWARE BAY

Sand tiger shark	Odontaspis taurus
Sandbar shark	Carcharhinus milberti
Smooth dogfish	Mustelus canis
Spiny dogfish	Squalus acanthias
Atlantic angel shark	Squatina dumerili
Clearnose skate	Raja eglanteria
Little skate	Raja erinacea
Winter skate	Raja ocellata
Roughtail stingray	Dasyatis centroura
Bluntnose stingray	Dasyatis sayi
Smooth butterfly ray	Gymmura micrura
Spiny butterfly ray	Gymmura altavela
Bullnose ray	Myliobatis freminvillei
Cownose ray	Rhinoptera bonasus
Atlantic sturgeon	Acipenser oxyrhyncnus
Conger eel	Conger oceanicus
American shad	Alosa sapidissima
Blueback herring	Alosa aestivalis
Hickory shad	Alosa mediocris
Alewife	Alosa pseudonarengus
Atlantic menhaden	Brevoortia tyrannus
Atlantic herring	Clupea narengus narengus
Gizzard shad	Dorosoma cepedianum
Striped ancnovy	Ancnoa hepsetus
Bay ancnovy	Anchoa mitchilli
Inshore lizardfish	Synodus foetens
Oyster toadfish	Opsanus tau
Goosefish	Lophius americanus
Silver hak	Merluccius bilinearis
Red hake	Urophycis chuss
Spotted hake	Urophycis regius
Striped cusk-eel	Rissola marginata
Ocean pout	Macrozoarces americanus
Striped killifish	Fundulus majalis
Threespine sticklee back	Gasterosteus aculeatus
White perch	Morone americana
Striped bass	Morone saxatilis
Black seabass	Centropristis striata
Snowy grouper	Epinephelus niveatus
Bluefish	Pomatomus saltatrix
Florida pompano	Trachinotus carolinus
Crevalle jack	Caranx hippos
Blue runner	Caranx crysos
Lookdown	Selene vomer
Atlantic moonfish	Vomer setapinnis
Pigfish	Orthopristis chrysoptera
Scup	Stenotomus chrysops
Silver perch	Bairdiella chrysoura

Table D-7 (Continued)

Weakfish	*Cynoscion regalis*
Northern kingfish	*Menticirrhus saxatilis*
Spot	*Leiostomus xanthurus*
Black drum	*Pogonias cromus*
Atlantic croaker	*Micropogonias undulatus*
Atlantic spadefish	*Chaetodipterus faber*
Tautog	*Tautoga onitis*
Striped mullet	*Mugil cephalus*
Northern stargazer	*Astroscopus guttatus*
Harvestfish	*Peprilus alepidotus*
Butterfish	*Peprilus triacanthus*
Northern searobin	*Prionotus carolinus*
Striped searobin	*Prionotus evolans*
Sea raven	*Hemitripterus americanus*
Grubby	*Myoxocephalus aenaeus*
Longhorn sculpin	*Myoxocephalus octodecemspinosus*
Seasnail	*Liparis atlanticus*
Fringed flounder	*Etropus crossotus*
Smallmouth flounder	*Etropus microstomus*
Summer flounder	*Paralichthys dentatus*
Fourspot flounder	*Paralichthys oblongus*
Windowpane flounder	*Scophthalmus aquosus*
Winter founder	*Pseudopleuronectes americanus*
Hogchoker	*Trinectes maculatus*
Orange filefish	*Aluterus schoepfi*
Planehead filefish	*Monacanthus hispidus*
Northern puffer	*Sphoeroides maculatus*
Striped burrfish	*Chilomycterus schoepfi*

Source: Smith, 1982

Table D-8

SALEM RIVER BENTHIC COMMUNITY STRUCTURE
PAS APRIL 1985 SURVEY

Species	SS 1 #	SS 1 %	density /m^2	SS 2 #	SS 2 %	density /m^2	SS 3 #	SS 3 %	density /m^2	SS 4 #	SS 4 %	density /m^2
Corophium lacustre	1183	98.8	22,358.7	200	61.7	3780.0				23	43.4	434.7
Corophium sp.				4	1.2	75.6	330	94.0	6237.0	1	1.9	18.9
Polydora sp.				43	13.3	812.7						
Polydora ligni				8	2.5	151.2				6	11.3	113.4
Gammarus oceanicus	8	0.7	151.2	3	0.9	56.7				4	7.5	75.6
Gammarus sp.				7	2.1	132.3	1	0.3	18.9			
Cyathura polita	1	0.1	18.7	10	3.1	189.0	1	0.3	18.9	11	20.8	207.9
Cassidisea lunifrons	1	0.1	18.9	1	0.3	18.9	1	0.3	18.9			
Nais sp.				22	6.8	415.8	1	0.3	18.9			
Family Tubificidae				14	4.3	264.6				2	3.8	37.8
Microdeuptus sp.				9	2.8	170.1						
Polypedilum sp.	1	0.1	18.9	1	0.3	18.9	1	0.3	18.9			
Rhithropanopens harrisii	3	0.2	56.7									
Class Hirudinea				1	0.3	18.9						
Edotea triloba				1	0.3	18.9						
Melita sp.							14	4.0	264.6			
Scolecolepides viridis							1	0.3	18.9	3	5.7	56.7
Phylum Nemertea							1	0.3	18.9			
Lembos sp.										3	5.7	56.7

	SS 1	SS 2	SS 3	SS 4
	1197	324	351	53
# species	6	14	9	8
$\bar{H}$	0.078	1.435	0.304	1.654
e	0.044	0.544	0.138	0.796
H_{max}	1.792	2.639	2.197	2.079

$\bar{H}$ = Shannon-Weiner Index of Diversity ((McIntire and Overton, 1971)

e - Evenness Index (Pielou, 1966)

H_{max} = Potential Maximum Diveristy (L_n Species) (Shannon and Weaver, 1949; Margalef 1968)

Table D-9

RESULTS OF BCM MACROINVERTEBRATE SURVEY
OF OVERBOARD DISPOSAL SITE IN
SALEM COVE
JULY 26, 1983

Classification*	Sampling Stations BCM- 6 Grab A	Grab B	BCM- 7 Grab A	Grab B	BCM-8 Grab A	Grab B
NEMERTEA (proboscis worms)						
Anopla						
Paleonemerta						
TUBULANIDAE						
Tubulanus pellucidus	--	1	2	1	--	--
ANNELIDA						
Polychaeta (aquatic worms)						
Spionida						
SPIONIDAE						
Scolecolepides viridis	3	2	3	4	1	--
Oligochaeta (aquatic earthworms)						
Haplotaxida						
ENCHYTRAEIDAE						
Enchytraeus	--	2	--	1	--	--
ARTHROPODA						
Crustacea						
Isopoda (sow bugs)						
ANTHURIDAE						
Cyathura polita	--	2	1	--	51	44
Amphipoda (scuds)						
GAMMARIDAE						
Gammarus daeberi	7	5	5	10	--	--
COROPHIIDAE						
Corophium	--	--	--	--	1	1
Insecta						
Diptera						
CHIRONOMIDAE (midges)	--	--	--	1	1	--

Table D-9 (Continued)

Classification*	Sampling Stations BCM-6 Grab A	BCM-6 Grab B	BCM-7 Grab A	BCM-7 Grab B	BCM-8 Grab A	BCM-8 Grab B
MOLLUSCA						
Bivalvia						
Pelecypoda						
MACTRIDAE						
Rangia cuneata	--	--	--	1	--	--
Total number of individuals	10	12	11	16	54	45
Total number of species	2	5	4	6	4	2

*Classification system used is as follows:

PHYLUM
Class
Order
Family
Genus species

Source: BCM Eastern Inc.

Table D-10

SEDIMENT CHEMICAL LEACHATE ANALYSIS

PARAMETER (All units are mg/ℓ unless stated)	SEDIMENT SAMPLING SITES [1]					
	Salem River				Detectable Limit	Toxicity [2] Standards
	1	2	3	4		
Cyanide Total	BDL	BDL	BDL	BDL	0.02-0.03	0.2
Arsenic	BDL	BDL	BDL	BDL	0.01	5.0
Barium	0.5	BDL	0.3	BDL	0.05	100.0
Cadmium	BDL	BDL	BDL	BDL	0.0008	1.0
Chromium Total	0.03	BDL	BDL	BDL	0.01	5.0
Lead	BDL	BDL	BDL	BDL	0.008	5.0
Mercury	BDL	BDL	BDL	BDL	0.002	0.2
Nickel	BDL	BDL	BDL	BDL	0.006	-
Selenium	BDL	BDL	BDL	BDL	0.001	1.0
Oil and Grease (Soxhlet extraction)	BDL	8	13	9	0.05	-
Copper	BDL	BDL	BDL	0.006	0.0015	-
Zinc	0.02	0.02	0.01	0.1	0.007	-
Benzene					0.001	-
Carbon tetrachloride					0.001	-
Chlorobenzene					0.001	-
Chloroform					0.001	-
PCB					0.005	-
DDT and Metabolites					0.001	-
Phenolic Compounds (as phenols)	.003	.022	.005	.005	0.002	-
bis (2-ethylhexyl) phthalate					0.01	-
pH	6.86	4.35	7.2	7.05		
Total Organic Carbon	7	157	86	51		
Sulfate	34	64	22	34		

(1) See Figures 6 & 7 for sampling station

(2) Source: 40 CFR 261-24

BDL - Below Detectable Limit

Table D-11

SALEM COVE CHANNEL WATER AND SEDIMENT TESTING RESULTS
EPA ELUTRIATE
BCM JULY 26, 1983 SURVEY

Parameters and Units	Water Column Composite	Sampling Stations				
		BCM-1	BCM-2	BCM-3	BCM-4	BCM-5
PESTICIDES & PCB (mg/1)						
PCB A-1016	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
PCB A-1221	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
PCB A-1232	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PCB A-1242	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
PCB A-1248	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCB A-1254	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
PCB A-1260	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
a-BHC	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
b-BHC	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
d-BHC	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
g-BHC	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chlordane	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
4,4'-DDD	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4,4'-DDE	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4,4'-DDT	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Dieldrin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Endosulfan I	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Endosulfan II	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Endosulfan sulfate	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Endrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Endrin aldehyde	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Heptachlor	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor epoxide	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Toxaphene	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

Table D-11 (Continued)

Parameters and Units	Water Column Composite	Sampling Stations BCM-1	BCM-2	BCM-3	BCM-4	BCM-5
PURGEABLE HALOCARBONS (mg/l)						
Chloromethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromomethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vinyl chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methylene chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Trichlorofluoromethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,1-Dichloroethene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,1-Dichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
trans-1,2-Dichloroethene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2-Dichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,1,1-Trichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbon tetrachloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromodichloromethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2-Dichloropropane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Trans-1,3-Dichloropropene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Trichloroethene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibromochloromethane and/or 1,1,2-Trichloroethane and/or cis-1,3-Dichloropropene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bromoform	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-Tetrachloroethane and/or Tetrachloroethene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table D-11 (Continued)

Parameters and Units	Water Column Composite	Sampling Stations BCM-1	BCM-2	BCM-3	BCM-4	BCM-5
PURGEABLE AROMATICS (mg/l)						
Benzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ethyl benzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,3-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,4-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2-Dichlorobenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
METALS AND MISCELLANEOUS (mg/l)						
Di-2-Ethy-hexylphthalate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (GF)	0.006	0.008	0.011	0.006	0.004	0.005
Barium (GF)	0.013	0.202	0.188	0.318	0.176	0.150
Cadmium (GF)	<0.0005	0.0009	0.0005	0.0005	0.0007	0.0008
Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium (GF)	0.005	<0.002	<0.002	<0.002	<0.002	<0.002
Copper	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Mercury	0.0007	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Oil & grease (Sox)	2	2	<1	<1	<1	2
Lead (GF)	<0.002	0.014	0.012	0.013	0.015	0.018
Phenols, as Phenol	0.062	0.183	<0.002	0.02	0.032	0.032
Selenium (GF)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	0.05	<0.01	0.03	0.13	0.10	0.09
Dissolved oxygen*	6.6	--	--	--	--	
Temperature*	27.0	--	--	--	--	
pH (field)*	7.4	--	--	--	--	

*Average of 5 readings

Source: ᴗCM Eastern, 1984

Table D-5

DELAWARE RIVER BASIN COMMISSION
SUMMARY OF 1982 AND 1983 WATER QUALITY - ZONE 6

Parameter		Smyrna (RM 44)	Ship John (RM 37)	Mahon (RM 31)
Dissolved Oxygen (mg/l)	Ave	7.7	7.6	7.6
	Max	12.1	11.9	12.8
	Min	5.2	5.3	5.1
	#	32	32	32
Fecal Coliform (#/100ml)	Ave*	12	12	11
	Max	60	60	60
	Min	10	10	10
	#	33	33	30
Total Phosphate (mg/l)	Ave	0.11	0.16	0.16
	Max	0.23	0.60	0.30
	Min	0.01	0.04	0.04
	#	30	29	29
Nitrate Nitrogen (mg/l)	Ave	1.2	1.0	0.7
	Max	1.9	2.0	1.0
	Min	0.4	0.6	0.3
	#	31	32	32
Ammonia Nitrogen (mg/l)	Ave	0.23	0.20	0.24
	Max	0.90	0.80	0.60
	Min	0.10	0.10	0.10
	#	32	32	32
pH	Ave	7.4	7.4	7.3
	Max	8.0	7.9	7.8
	Min	6.5	6.1	5.6
	#	31	31	31
Alkalinity (mg/l)	Ave	56	61	74
	Max	77	86	93
	Min	29	60	47
	#	32	32	32
Phenols (mg/l)	Ave	0.160	0.201	0.270
	Max	0.430	0.370	0.920
	Min	0.005	0.020	0.010
	#	31	31	31
BOD_5 (mg/l)	Ave	2.4	2.4	2.5
	Max	2.4	2.4	3.4
	Min	2.4	2.4	2.4
	#	32	32	32
Chlorophyll a (mg/l)	Ave	4	7	19
	Max	13	29	55
	Min	0	0	0
	#	32	32	32

* Geometric mean

Source: DRBC, 1984