APPENDIX C ECONOMICS SAVANNAH HARBOR EXPANSION FEASIBILITY STUDY

Georgia Ports Authority

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BOOZ·ALLEN & HAMILTON

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Exhibits

1. INTRODUCTION

This appendix presents the issues, methodologies, data and detail behind the economic analyses completed for the Savannah Harbor Expansion Study. These analyses cover commodity and vessel fleet forecasting methodology and results; multi-port analysis; benefits and cost of alternative deepening projects; and risk and uncertainty associated with the assumptions used in the analyses. Each of these topics are addressed in a series of chapters:

- Chapter 2 presents an overview of the economic environment, port infrastructure. It also introduces some problems and opportunities for improving the transportation infrastructure that will provide economic benefits, and presents the alternatives that are being analyzed in this Feasibility Study.
- Chapters 3 and 4 present the trade and fleet forecasts that are used in the analysis to determine the level of NED benefits for each alternative. Additional details of the methodologies used to derive these forecasts are provided in Chapters 9 through 12.
- Chapter 5 presents the results of a multi-port analysis completed to show Savannah's competitive position against other ports in the South Atlantic region, and the U.S. as a whole.
- Chapter 6 presents the results of the benefit-cost analysis, an analytical method, used by the U.S. Army Corps of Engineers in deep draft navigation studies, for determining the most effective solution for improving the transportation infrastructure and providing economic benefit to the nation.
- Chapter 7 illustrates the sensitivity of the assumptions used in the economic analysis on the results of the benefit-cost analysis.
- Chapter 8 concludes the main portion of this appendix with a summary of the benefit cost analysis, highlighting the preferred alternative deepening project for the Savannah Harbor Expansion Study.

1.1 Study Authority

The Savannah Harbor Expansion Study is being conducted by the Georgia Ports Authority as authorized by Section 203 of the Water Resources Development Act of 1992.

1.2 Study Purpose and Scope

The Port of Savannah has experienced increasing demand for improving capacity to accommodate the commercial vessel fleet calling on the Port. This economic appendix details the investigation of the costs and benefits of solutions that will improve capacity of Savannah Harbor. The objective of the economic analysis is to determine if there are economically feasible solutions for accommodating projected increases in vessel sizes, and if so, to select the recommended alternative in accordance with Federal requirements for analysis of potential national participation in water resources projects. The selected Federal harbor expansion alternative is the economically justified plan that maximizes National Economic Development benefits.

This appendix provides a detailed report covering three topics: the current condition of the federally maintained Savannah Harbor shipping channel, an economic analysis of the potential navigation improvements to the channel, and an evaluation of the improvements' impact on trade and transportation costs. The scope of the economic analysis for this feasibility study is detailed in the analysis of alternatives and inputs. This economic assessment, in conjunction with the geotechnical, cultural, environmental, and engineering investigations, is an essential part of the evaluations for the feasibility study report. The outcome of this feasibility-level analysis is a substantive evaluation and presentation of the economic feasibility of implementing plans to improve Savannah Harbor.

1.3 Evaluation Criteria

The evaluation criteria used in this study are those contained in the U.S. Water Resource Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies for deep draft navigation projects.

1.4 Prior Studies

The current Savannah Harbor Federal Project is the culmination of all past harbor improvement and modification projects. These projects, collectively, influence and define the existing conditions for this project and the currently authorized channel dimensions. Studies supporting the implementation of these projects included an evaluation of the economics and/or other factors affecting the economic and commercial use of the channel. Several Environmental Impact Statements that address past Savannah Harbor modifications are listed below:

- Final EIS, Savannah Harbor Sediment Basin Project, 1974
- Final EIS, Savannah Harbor Widening and Deepening, 1974
- Final EIS, Savannah Harbor Operation and Maintenance, 1975
- Final EIS, Savannah Harbor Widening Project, 1978
- Final Supplement to Final EIS, Savannah Harbor Modifications, 1979.
- Final EIS, Savannah Harbor Deepening Project, 1993.

Other earlier studies examining the economics of vessel activity in Savannah Harbor include:

- Savannah Harbor Deepening Feasibility Report, 1991
- South Atlantic Container Study, 1992
- Reconnaissance Report, Savannah Harbor Expansion, 1996

Each of the above studies was reviewed during the conduct of the study.

1.5 Assumptions

The period of analysis for this study was 50 years, 2000 to 2050. The base year for data is 1996. The federal discount rate used is 7.125 percent. Specific assumptions related to the forecasts of trade and fleet growth are detailed in the respective sections of this economic appendix.

2. ECONOMIC ANALYSIS

The Port of Savannah is experiencing continued rapid growth in commercial vessel traffic. Although a wide variety of commodities are handled by the port, the principal growth is in cargoes that are shipped in containers. Based upon commodity and vessel fleet forecasts, demand for containerized cargo passing through Savannah continues to grow, and is estimated to reach over six million Twenty Foot Equivalent Unit containers (TEUs) by 2050. The vessel fleet forecast also shows containership sizes continuing to increase in size, resulting in greater demand on the channel.

2.1 Overview

In order to accommodate larger vessels requiring more depth than the existing 42-foot navigation channel, there are several options for expanding channel capacity by deepening. The Georgia Ports Authority desires to provide a deeper navigation channel to provide unconstrained transit of current and future shipping lines (i.e., ocean carriers) serving the Port. This section presents the existing conditions and environment from which deepening alternatives are defined for evaluation.

2.2 Economic Environment

2.2.1 Commerce

The Port of Savannah handles container, breakbulk, and bulk cargoes and serves local, regional, and national markets. The containers handled at the Port of Savannah transport consumer and industrial goods for local, regional, and national importers and exporters. Major breakbulk cargoes handled at the Port include kaolin, forest products, and iron and steel. These cargoes typically originate in or are destined for local or regional markets and are critical raw materials supporting production industries throughout the southeast. Other breakbulk cargoes such as automobiles are handled for regional and nationwide markets. Most bulk cargoes handled at Savannah tend to be to or from local or statewide markets. Some bulk cargoes, such as grain, were shifted to Georgia Ports Authorities facilities at Brunswick, during 1996 and 1997.

Additional information on the Port of Savannah's links to surface transportation is located in the main report.

2.2.2 Economic Impact

There is a significant economic impact from the Port of Savannah on its surrounding area and the state of Georgia. Economic impacts can be measured in terms of both direct and indirect employment, income, and industry revenues. The impacts are greatest in Chatham and Jasper counties yet affect the entire surrounding region. In 1997, Booz·Allen & Hamilton Inc. conducted an Economic Impact Study for the Georgia Ports Authority's Savannah facilities. This study found that the number of employees in organizations that are connected with commerce from the Port of Savannah exceeds 67,000. The economic impact to the region is greatest for containerized cargo as this high value cargo represents a very large share of the value of commodities handled at the Port. Exhibit 2-1 summarizes the impact of cargo activity from the Port of Savannah, breaking out the impacts of container cargoes from other cargoes and the total.

Exhibit 2-1
Direct, Induced and Related Economic Impact
from Savannah Harbor by Cargo Type
(1997 Dollars in Thousands where indicated)

Economic Impact	Containers		Other Cargo		Total	
	No.	Percent of Total	No.	Percent of Total	No.	Percent of Total
Jobs	58,220	86%	9,416	14%	67,636	100%
Wages	$1,272	84%	$236	16%	$1,508	100%
Sales/Revenue	$16,437	84%	$3,025	16%	$19,462	100%
State & Local Taxes	$420	85%	$76	15%	$496	100%

Source: Booz·Allen survey analysis, 1997.

The Port of Savannah's container activity produces about 84 percent of the Ports' total economic impact to the State and broader region. Total economic impact consists of direct, indirect, and secondary benefits. Secondary impacts are developed using a multiplier, which relates direct and indirect economic activity generated by the Port, to the secondary effects of that activity in the economy. Economic impact multiples and multipliers can be used to assess the impact of near term cargo growth on the incremental gains in regional economic activity.

Using data from an extensive large-sample survey, Booz·Allen calculated multiples for cargo handled by Savannah. Containers contribute roughly five times the value provided by a ton of break-bulk cargo (such as paper products) handled and ten times the value provided by a ton of bulk products (such as grain) handled by the Port. These multiples are shown in Exhibit 2-2.

Exhibit 2-2
Direct and Induced Impact Multiples for Port Cargo
(Jobs per Thousand Cargo Tons; Dollars per Cargo Ton)

Economic Impact	Cargo Category		
	Containers	Breakbulk	Bulk
Jobs	4.08	.72	.26
Wages	$91.10	$21.02	$7.83
Sales/Revenue	$743.76	$172.77	96.81
State & Local Taxes	$20.01	$4.33	$2.45

Source: Booz·Allen survey analysis, 1997.

The container multiples for Savannah are higher than those found in other studies. This is directly attributable to the direct survey methodology employed which demonstrated that a sizable number of manufacturers are dependent upon Georgia's container facilities. This underscores the important role played by the Port of Savannah and particularly its Garden City Container Terminal in the economy of the region.

2.3 Port Facilities

2.3.1 Landside

Material on the landside infrastructure supporting the Port of Savannah is located in the main report.

2.3.2 Terminals

Existing Savannah Harbor terminals include facilities that handle containers, breakbulk, dry bulk, liquid bulk, roll-on/roll-off, and general cargoes. The Georgia Ports Authority's Garden City Terminal, located at River Mile 24.7, is primarily used for containers, but also supports breakbulk, liquid bulk, and roll on/roll off cargoes. The terminal currently encompasses 838 acres. All current expansion efforts associated with the Georgia Ports Authority container liner operations are located at the Garden City Terminal.

The Garden City Terminal has 6,526 linear feet of contiguous container and roll on/roll off berthing. Ongoing expansion efforts associated with the new Container Berth #7 is scheduled for completion in early 1998. This berth will add 1,200 linear feet of berthing space, include 147 acres of adjacent storage/staging area. The new berth is contiguous with current facilities. For current and new facilities, apron width varies up to 196 feet and depth alongside berths is 42 feet mean low low water (MLLW), the lowest of the average low tide observed in the Savannah River system). Mechanical handling equipment includes 11 gantry cranes, 12 rubber-tired gantries, 19 top-lifters, three 5-high empty reach-stackers, and several dozen yard tractors. There are over 24,000 TEU stack slots on 323 acres of container field. The gate operations include two interchange gates with 24 lanes plus a bypass for a total of 25 lanes.[1]

General cargo is also handled at the GPA's Ocean Terminal and at several private terminals that handle primarily bulk and breakbulk commodities. The private terminals are typically proprietary facilities owned by industrial companies handling bulk products integral to their production processes. These companies usually own the facilities because the terminals are a critical link in their supply or distribution chains. Examples of such private terminals include East Coast Terminals, Inc. (Conbulk), Firestone Rubber & Latex Company, and Savannah Sugar Refinery.

2.3.3 Navigation Channel

Material on the navigational characteristics and design of the Savannah Harbor navigation channel is provided in the main report. Extensive details of the channel are provided in the Engineering Appendix.

2.4 Problems and Opportunities

The initial stage of the economic evaluation identified the problems, needs, and opportunities associated with existing and future conditions at Savannah Harbor. Sustained growth in traded commodity volumes passing through the port presents an ongoing challenge to planners attempting to assure continued efficient transportation capacity. Potential solutions to provide needed capacity were then defined and evaluated for their economic feasibility.

2.4.1 Transportation Efficiencies and Delays

Increasing commodity trade volume provides opportunities for vessel operators (i.e., steamship lines, ocean carriers), their customers (shippers), and consumers to benefit from the increasing returns to economies-of-scale that exist in maritime transportation. As cargo volumes increase, vessel operators can justify building larger, more efficient ships with lower per unit cargo operating costs. In the 1990s, the construction and operation of large container vessels by carriers has been pursued as a matter of necessity to remain competitive, lower per unit operating costs, and support growing cargo volumes on major trade routes. This competitive environment has resulted in rate competition among carriers and led to shipping cost (i.e., rate) reductions for customers of steamship lines and consumers.

Large vessels can operate on routes that include ports that lack needed channel depth if vessel operators take advantage of high tides to access berths of sufficient depth. Operations that depend on ocean and river tides to provide port access, however,

[1] *These figures are based on information gathered in late 1997 and early 1998.*

incur delays when vessels must wait for high tide to enter or depart a port. These delays reduce the economic efficiency of the vessel and ultimately raise costs to vessel operators and shippers.

Additionally, ship managers have operated their vessels in light loaded conditions, where the ships not loaded with sufficient cargo in order to immerse to their design drafts). The variation in type and densities of cargoes moved by containerships makes light loading a nearly constant occurrence for these vessels. Correspondingly, the cargo capacity of containerships can "cube out" (all cellular slots are filled with loaded or empty containers), before the vessels immerse to design draft.

In the alternatives considered in this feasibility study, increments of additional depth were analyzed for both their effect on the capability for larger ships to call at Savannah and for vessels to reduce the delays associated with using high tide for access. Light loading characteristics have been used to determine the costs of operating the vessels and the impact of light loading on transportation costs.

2.4.2 Planning Considerations

The economic feasibility analysis was coordinated with parallel assessments of engineering, environmental, and cultural factors influencing potential project solutions. The determination of the preferred project was influenced, therefore, by other factors in addition to economics. These other factors are discussed in other appendices and the Main Report of this Study.

2.5 Formulation of Alternatives

In the formulation of alternatives for further evaluation, consideration was given to all possible measures or alternatives for improvement. Possible improvements were systematically screened for potential with those alternatives meeting initial screening criteria analyzed in greater detail.

2.5.1 Without Project Condition

One option considered is the adoption of the "no action" or without project alternative. Under the without project alternative, no future action will be taken to change the existing channel -42 foot MLLW depth of the navigation channel for the Savannah Harbor. For the balance of this appendix, this will be called the without project condition.

To ensure that none of the benefits of the without project condition have been discounted, an analysis has been completed of the current without project condition to previous forecasts. The projected fleet identified with the without project alternative includes larger vessels than those previously forecasted. The future without project condition does incorporate deeper draft vessels into the fleet mix. Shipping statistics for the Port show that deeper draft vessels than previously predicted are already utilizing the channel. In addition, the design vessel used in the last deepening study is already being superceded by larger vessels, showing that the channel is being fully utilized with a considerable degree of light loading.

2.5.2 Channel Modifications

There is sufficient area for the channel to be modified to accommodate vessels comprising the future world fleet. These modifications are detailed in the Engineering Appendix. An engineering decision has been made to mitigate channel widening impacts on cultural resources and manage land acquisition costs. The current design alternatives call for deepening the channel without increasing the width of the channel. This will effectively narrow the channel at the bottom. This could in turn increase vessel delays (vessel operating costs) caused by one-way traffic flow. However, Savannah Pilots have stated that uni-directional traffic flow already exists in the channel. Traffic simulation modeling has been completed to estimate the delay costs imposed by the engineering design.

2.5.3 Channel Deepening

The existing Savannah Harbor channel could be deepened to accommodate the larger vessels in the current and future world fleet, some with fully loaded operating drafts of 46 feet or greater. The alternatives investigated included harbor deepening in one-foot increments up to 50 feet[2]. Details on the physical design of channel alternatives are contained in the Engineering Appendix.

2.5.4 Non-Structural Alternatives

Vessel operators are expected to maximize use of non-structural alternatives to minimize transportation costs. Pilots are expected to operate the vessels to maximize efficiency and safety, subject to regulations and standards, such as minimum underkeel for safe operation. It is possible that these standards could be changed; however, they have been established with safety and efficiency of operation in mind. Modifications to guidelines for maximum length, vessel draft, and combined beam transits have been made through the years as a means of increasing efficiency. These non-structural approaches have already been implemented by carriers and pilots and, therefore, will not be addressed.[3]

It is also possible that vessels could be designed or modified to carry cargoes as an alternative to channel improvements. The Panama Canal is the best example of vessel design being adapted to fit available waterway dimensions rather than the other way around. However, it is unlikely that shipping lines will modify their vessels to accommodate an individual port, given the competitive nature of the business, but rather will seek a port that can accept their vessels. For these reasons, vessel

2 *43 and 49 foot alternatives were not calculated.*

3 *Underkeel clearance is addressed in sensitivity and risk analysis.*

modifications were not considered viable alternatives to meet the needed demand for future channel capacity.

2.5.5 Infrastructure and Facilities

The Georgia Ports Authority and private transportation firms such as the railroads and trucking companies have continually planned and invested in infrastructure and facility improvements over time to provide needed increases in landside capacity necessary for current and expected increases in cargo volumes. As such, there is no expectation that there will be insufficient landside port infrastructure to handle the increased cargo volumes forecast to move through the Port of Savannah during the study period.

For example, the current Garden City Terminal berth and acreage expansion project is one part of a longer term plan to expand the landside infrastructure of the GPA and the Port of Savannah to support greater cargo volumes. GPA has indicated that long range plans include expanding its current facilities by an additional 1,200 acres, although where and when have not been determined. As part of ongoing infrastructure improvements, it is acquiring larger Post-Panamax capable cranes for its container handling facilities.

These improvements are not a substitute for, but complementary to, investments in waterside infrastructure. Landside infrastructure and facility improvements are already being implemented by the Port to maintain efficiency and productivity in loading and unloading vessels, and support near term growth in cargo volumes.

3. HISTORICAL AND PROJECTED COMMODITY VOLUMES

In this chapter, the historical and long-term forecasts for commodity trade are presented for the United States, the South Atlantic Port region of the United States, and the Port of Savannah. Specifically, this chapter covers the history of commodity movements through Savannah Harbor, the commodity forecast methodology and assumptions, the long-term commodity forecast, and the macroeconomic and international trade forecasts. Additional background data and detailed forecast methodologies are contained in Chapters 9 and 10 of this Appendix.

3.1 Overview

Savannah is a top tier port gateway for U.S. import and export cargo supporting trade between the U.S. and its major foreign trade partners. Historical trade volumes through Savannah place it in the top tier of U.S. ports serving domestic and foreign customers. Among the U.S. ports handling the highest value and fastest growing imports and exports, those moving in containers, Savannah ranked in the top ten in 1997. The rankings of the top 15 U.S. container ports, in combined TEU throughput, are presented in Exhibit 3-1.

Exhibit 3-1
1997 U.S. Container Trade Throughput
(in TEUs)

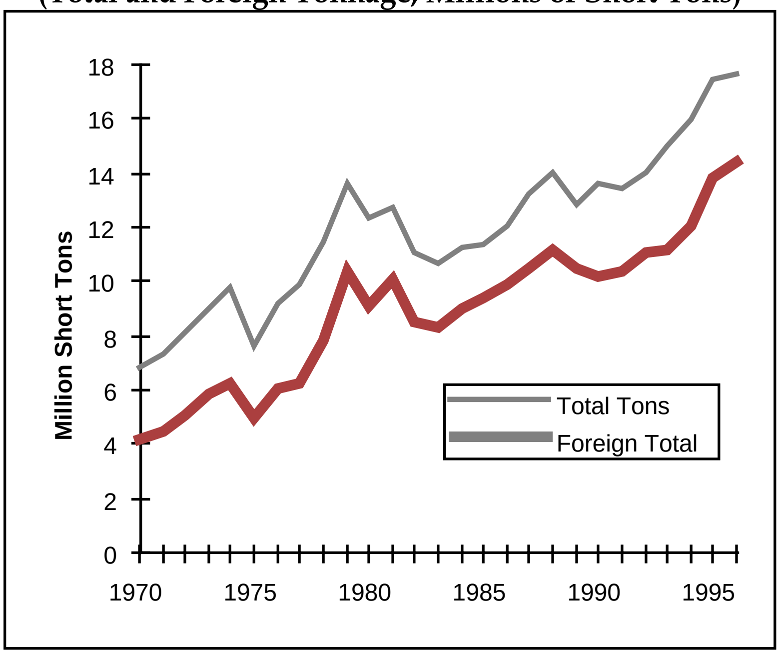
Rank	Harbor	TEUs
1	LA/Long Beach	6,464,318
2	Seattle/Tacoma	2,633,964
3	New York/New Jersey	2,456,886
4	Oakland	1,433,249
5	Hampton Roads	1,232,725
6	Charleston	1,217,544
7	Houston	935,600
8	Miami	761,183
9	**Savannah**	**734,724**
10	Port Everglades	719,326
11	Jacksonville	675,196
12	Baltimore	476,012
13	Honolulu	477,776
14	Anchorage	341,509
15	Portland (OR)	294,930

Source: AAPA Survey, April 1998

3.2 Historical Trade and Commodity Volumes

Existing conditions for trade flows moving through the Port of Savannah are increasingly characterized by cargoes supporting foreign trade. Containerized cargo volumes have increased for each of the last nine years. Total tons through the port have increased for each of the last six years, reaching a total of 17.6 million short tons of waterborne commerce during the calendar year 1996, as reported by the U.S. Army Corps of Engineers (USACE). Of the 1996 total tonnage, 82 percent (14.4 million short tons) was foreign cargo. As shown in Exhibit 3-2, the foreign tonnage share of Savannah Harbor waterborne commerce has increased for over twenty-five years. Foreign tonnage growth has averaged 9.5 percent per year over this period.

Exhibit 3-2
Savannah Harbor Waterborne Commerce, 1970 - 1996
(Total and Foreign Tonnage, Millions of Short Tons)



Source: USACE Waterborne Commerce Statistics

Domestic shipments have increased slowly over this period, with growth in coastwise shipments averaging 1.7 percent per year. Petroleum and petroleum products comprise 70 percent of domestic tonnage. For foreign trade, crude materials except fuels make up the largest share (43 percent) of tonnage. GPA reports handling 650,253 TEUs though Savannah Harbor in 1996 accounting for 5 million of the 18 million cargo tons through the port. Furthermore, Savannah's container TEU volumes have increased over 200 percent during the last 13 years as summarized in Exhibit 3-3. Historical Savannah Harbor waterborne commerce tonnage statistics for each of the last 27 years is detailed in Chapter 9 of this Appendix.

Exhibit 3-3
Savannah Harbor Container Volumes, 1983 - 1997
(Total of Domestic and Foreign Twenty Foot Equivalent Units)

Year	TEUs	Year	TEUs
1983	216,088	1991	474,299
1984	355,078	1992	517,277
1985	368,773	1993	536,362
1986	501,445	1994	562,266
1987	362,350	1995	626,151
1988	365,850	1996	650,253
1989	376,295	1997	734,724
1990	419,079	1998	?

Source: GPA

3.3 Containerized Commodity Trade Forecasts

The need for additional channel depth is driven primarily from increasing vessel operating draft requirements of containerships calling the Port. In earlier deepening studies for Savannah Harbor, non-containerized cargoes, such as grain and kaolin clay, benefited from deepening the channel from 40 or 42 feet. In this study, non-containerized commodity use of deeper channel alternatives is limited to a small portion of the fleet. One of the contributing factors has been the shift of Savannah's grain export volumes to GPA facilities at Brunswick to make room for additional GPA container berth expansion in Savannah Harbor. Therefore, the primary focus of the commodity trade analysis addresses containerized cargo. Non-containerized trade is addressed in Section 3.4 of this Chapter.

For evaluation of the benefits from the proposed infrastructure project, the trade forecasts cover the period from 2000 to 2050. The commodity trade demand forecast produces estimates of container trade volumes that are the same under both with and without project conditions. As discussed later in the multiport analysis in Chapter 5, the cost differentials between vessel operations under the various with project and without project channel alternatives are not sufficient (as a percentage of the total containerized transportation cost) to induce or inhibit trade through Savannah. Discussions with shippers and steamship lines reveal that service frequency and service quality are significant decision factors unless total transportation cost differentials are substantial.

3.3.1 Methodology and Assumptions

For thoroughness of trade analysis for this study, commodity trade forecasts have been acquired from ICF Kaiser's Trade and Transportation Group. ICF Kaiser is one of the primary commercial providers of detailed ocean borne trade forecasts. The ICF

Kaiser trade modeling system forecasts trade through a structure of global commodity models that capture individual country demand for imports, linked to economic growth and domestic production within each country[4]. The macroeconomic forecasts used in this system are sourced from the country and regional economic models produced by the WEFA Group, an economic forecasting firm associated with the University of Pennsylvania. The trade model output includes individual commodity movements, both in terms of U.S. dollars and metric tons. For liner trades, the model also produces trade volumes in TEUs. For the United States, trade is further disaggregated by port range, including the South Atlantic.

As the study period extends a full fifty years, ICF Kaiser prepared a long-term global trade forecast that expands their standard twenty-five year forecast horizon out to 2050. A very long-term global macroeconomic growth model combining production and consumption trends with the existing long-term demographic and productivity forecasts was used to produce the trade for the latter decades of the period[5].

The commodity trade modeling system builds upon a base of detailed historical commodity trade data and individual macroeconomic country model forecasts to develop a global model for each commodity group. These global commodity models have a pooled cross sectional least squares regression structure that captures as much predictive capability as possible from historical commodity trade data. An expert system tests the estimated models for robustness and substitutes a propensity to import model forecast where necessary. For the portion of liner trade that is containerized, tonnage forecasts are transformed into TEU volume measures using commodity, route, and direction-specific conversion factors. The TEU forecasts represent movements of containers loaded with cargo between countries – not the repositioning of empty containers or the transfers, via domestic barge or feeder vessel, between domestic ports of international containers. However, the carriage of empties is reflected in both the utilization of vessels and the light loading patterns used in the fleet forecast and transportation costs analysis. A summary of the trade flow modeling process is presented in Exhibit 3-4.

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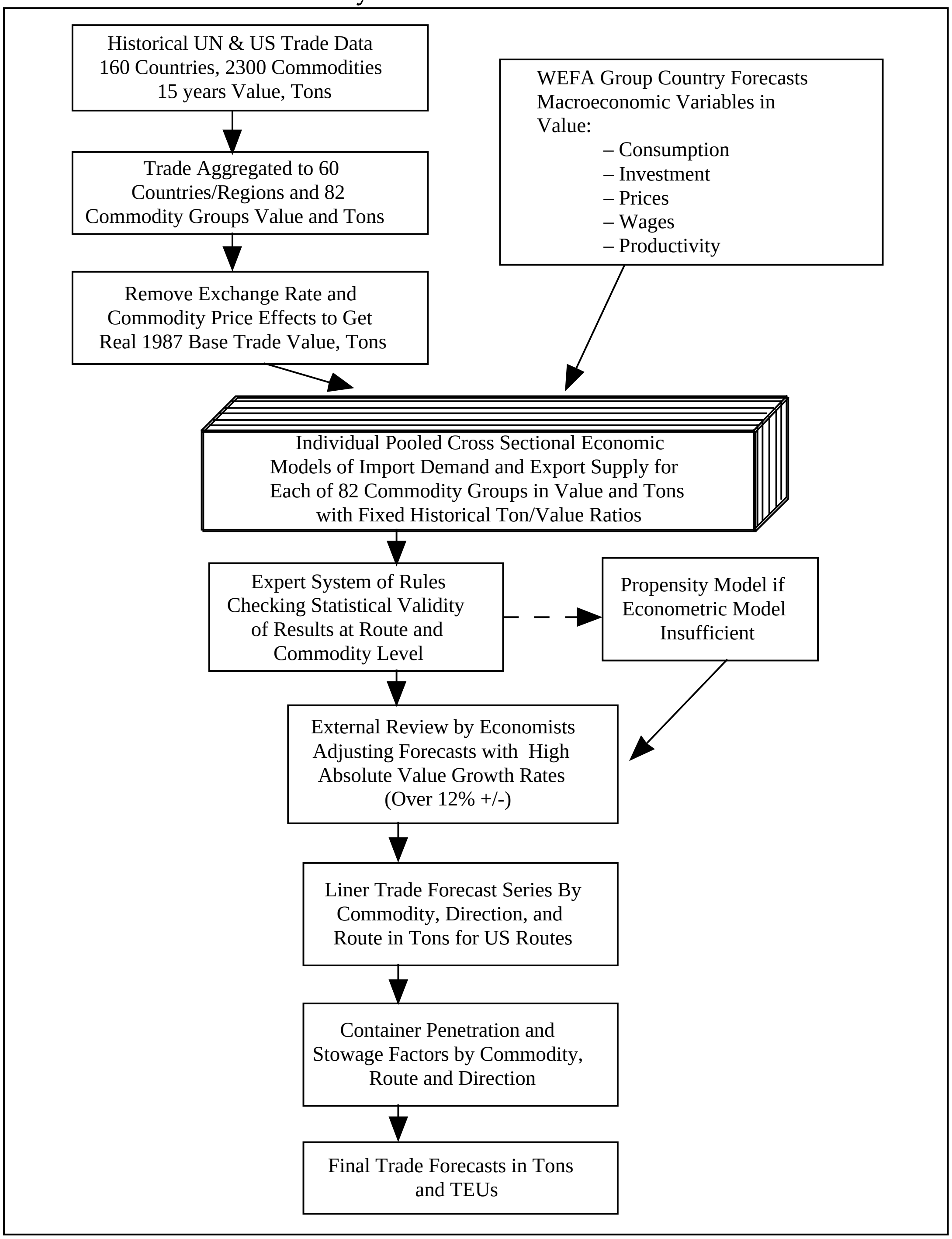
4 *The ICF Kaiser trade models were developed under the direction of Dr. David Blond. Earlier versions of his trade modeling system have been used in deep draft navigation Feasibility Studies for the US Army Corps of Engineers for over ten years.*

5 *An extensive explanation of the global trade model forecasting methodology, as used in this study, is found in Chapters 9 and of this Appendix. As documented in those chapters, the trade forecasting methodology uses an advanced trade model structure, extensive historical data from multiple sources, and a rule-based expert system to produce complete global forecasts of 82 individual commodity categories in value and volume.*

Exhibit 3-4
Commodity Trade Forecast Model Process



There are several assumptions used in order to produce the long-term commodity trade forecasts. Though many assumptions relate to discrete judgments about model and forecast specifications, there are also some fundamental assumptions that affect the magnitude and path of the baseline forecasts. These assumptions are held constant under without and with project conditions. Primary assumptions utilized in the macroeconomic and trade forecasts include the following:

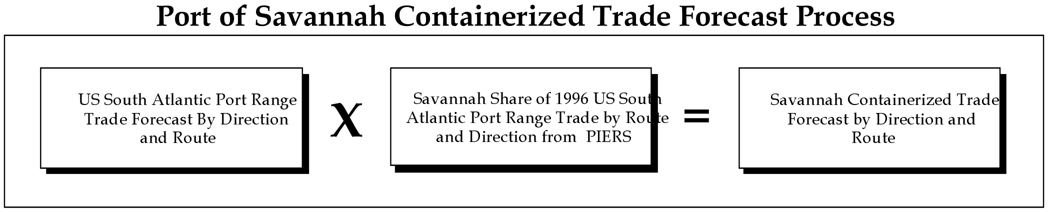
- The study period is 2000 to 2050, with base year of 1996.
- Landside infrastructure and land transportation capacity will be expanded to accommodate increased volumes of trade over the entire forecast period.
- There will be no significant changes to cabotage rules. The Jones Act and the anti-trust immunity for industry rate setting conferences continues for the purposes of our analysis. Similarly, labor work rules for port operations are assumed to remain relatively constant throughout the forecast period, though technology improvements will continue to enhance long run worker productivity.
- The definition of commodity flow is based on counting each import or export movement one time for trade forecasting purposes. Over the long-term, it is assumed that demand for transportation is observed only for efficient movement of cargoes (and the positioning of transportation equipment to service this demand.) It is possible that carriers may choose to handle cargo in a way that incurs double handling charges by moving through multiple ports. However, this operational pattern will not change the underlying factors influencing demand for country-to-country international trade movement, and the forecast does not capture such double handling movements.
- The fundamental economic development perspective of the WEFA Group and ICF Kaiser economic forecasts utilized is based on a belief in continued economic growth. It is assumed that developing country economies follow a long-term growth path towards industrialization and higher standards of living – and that political institutions remain stable enough to permit development over the long run. As this is a long run forecast analysis, short-term business cycle fluctuations are not modeled here.
- World demand for agricultural products and food products will remain high. There will be a steady increase in global agriculture demand due to increasing population and increasing affluence.

- Real energy prices that increase mildly through 2020 and improvements in efficiency in the use of raw materials lead to a reduction in overall energy demand per dollar of output over time. This is a continuation of the energy efficiency trend observed today. Though individual real energy commodity price indexes are used for imports and exports of crude petroleum, coal, natural gas, and refined petroleum products, the average annual increase in these series is 2.7 percent through 2020. This is consistent with long-term commercial energy price forecasts used by the U.S. Department of Energy.
- Revolutionary fast cargo vessel design technologies are prevented from capturing any significant share of the market due to the real energy price increases forecast and the high capital cost of such ships.

For the purposes of this study the definition of the South Atlantic Port region includes Norfolk. This is consistent with the definition used for the South Atlantic in previous regional trade studies performed for the U.S. Army Corps of Engineers.

The Savannah container trade forecast was produced using detailed U.S. port trade data from the *Journal of Commerce* PIERS database in conjunction with the South Atlantic forecast described above. The trade for container traffic through the South Atlantic port range was apportioned to Savannah based on route and direction (import and export) specific factors obtained from the 1996 PIERS data. These factors are fixed across the study period, therefore Savannah is assumed to maintain its current share of South Atlantic trade on a direction-of-trade, route-by-route basis. The growth rates of imports and exports across trade lanes vary, causing the aggregate Savannah share of the South Atlantic trade to change. This in turn is reflected in the changing mix of trade through the South Atlantic region. As PIERS does not have complete value data, only the quantity of container trade in tons and TEUs was forecast for Savannah. Exhibit 3-5 illustrates the methodology utilized to develop Savannah's containerized trade forecast from the South Atlantic forecast.

Exhibit 3-5
Port of Savannah Containerized Trade Forecast Process



This methodology permits the aggregate Savannah share of trade to reflect the differential rates of growth in different world trade partner regions. This approach also allows the balance of trade between imports and exports to change as the U.S.

demand for imports and world demand for U.S. exports follow different growth paths. Alternative forecast approaches fixing shares at a more aggregate level such as total of all trade by direction for the South Atlantic or even a fixed share of total U.S. trade were also tested for their impact on the resulting forecast. These alternative approaches are less robust (e.g., less accurate) than approaches grounded in the more detailed recent historical data. These alternatives are addressed in the discussion of uncertainty in Chapter 7.

Non-containerized commodities moving through Savannah were also forecast to complete the description of existing and future conditions in Savannah Harbor. The U.S. Army Corps of Engineers Waterborne Commerce Statistics tonnage data for Savannah Harbor was used as the basis for these forecasts because both domestic and international shipments by commodity group are included. Because the volume of domestic tonnage through Savannah is significant for many non-containerized commodities (e.g., gasoline, asphalt, and sugar), individual non-containerized commodity group forecasts were estimated that include total domestic and international tonnage. These forecasts were estimated as functions of projected macroeconomic variables including regional industrial output and commodity production as published by the U.S. Department of Commerce, Bureau of Economic Analysis, and the U.S. Department of Energy and the U.S. Department of Agriculture.

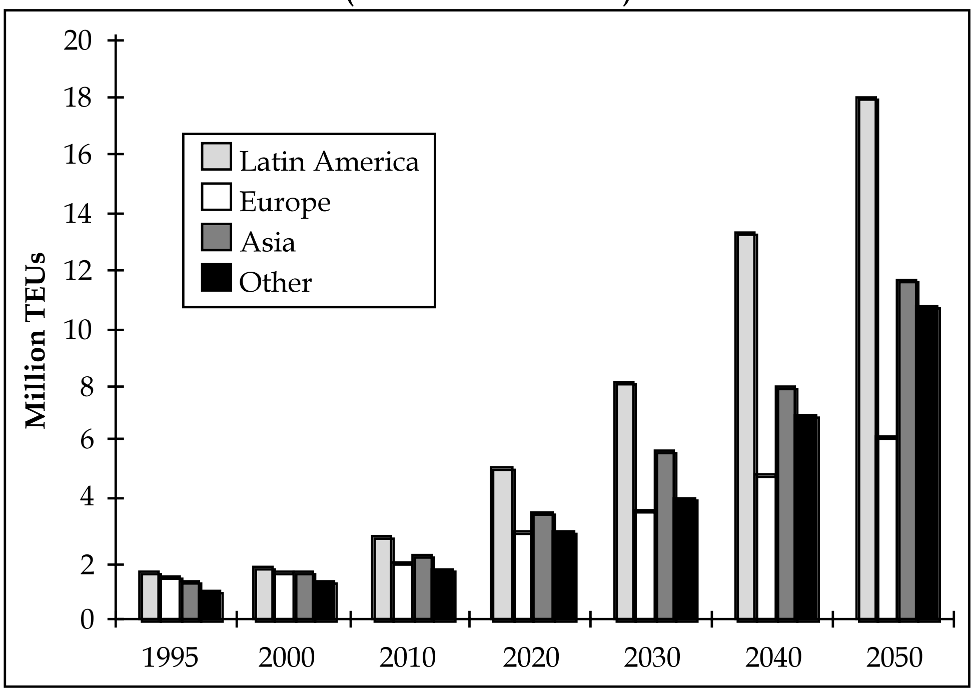
With the above assumptions and methodologies, trade forecasts were produced that are the same under without project and with project conditions, for the U.S., the South Atlantic port range, and for Savannah for the study period from 2000 to 2050. In the next sections, we present the forecast developed – beginning with the South Atlantic Port Range and U.S. forecast and ending with the long-term forecast developed for the Port of Savannah.

For purposes of sensitivity and risk assessment, the USACE requested an alternative trade forecast, where trade volumes are estimated to grow at 4.0 percent per year from 1996 through 2000, at 3.0 percent from 2001 to 2010, and at 2.0 percent per year from 2011 through 2050. This sensitivity analysis is presented in Chapter 7 of this appendix.

3.3.2 South Atlantic Container Forecast – Trade Partner

Containerized trade through the South Atlantic port range increases with all foreign trade partner regions, though at different rates. While the volume of trade with Europe is still growing (and triples through 2020), the share of trade with Europe through the South Atlantic shrinks, dropping from the second largest in the region to fourth. Correspondingly, faster growing trade with other regions results in Latin American trade growing to over 19 million TEU by 2050 – compared with European trade of roughly 6 million TEUs over the same time period. Asian trade through the South Atlantic port range overtakes European trade volumes by 2010 and grows to over 10 million TEU by 2050. The levels of South Atlantic container trade by foreign trade partner regions are presented graphically in Exhibit 3-6.

Exhibit 3-6
South Atlantic Port Range Containerized Trade by Partner Region, 2000 - 2050
(in Millions of TEUs)

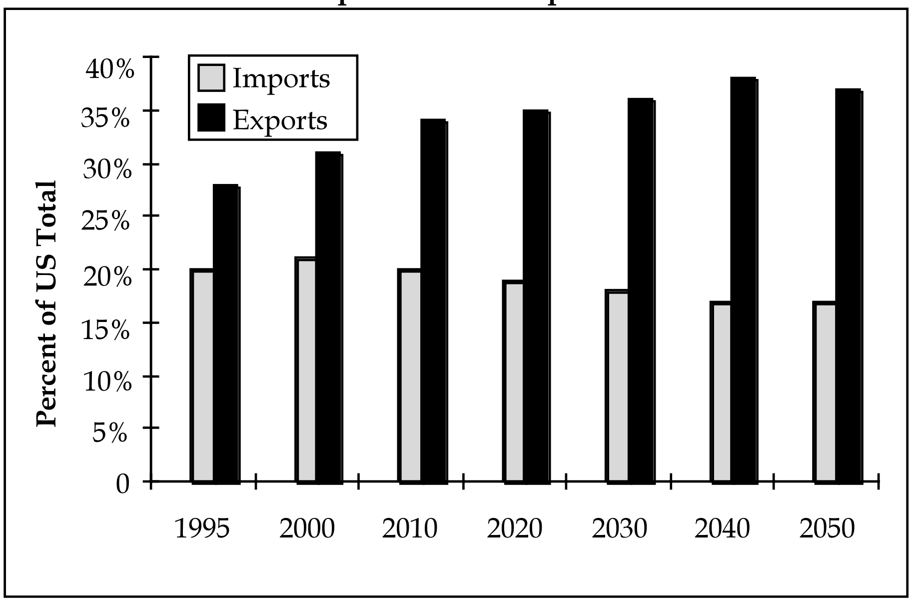


Source: ICF Kaiser Global Trade Forecast, 1997

Import/Export

From 2000 to 2050, the South Atlantic region's share of U.S. exports will increase while the share of U.S. imports decreases. The forecast shares reflect the differences between the U.S. import supplier regions and export markets, and the geographic proximity of the South Atlantic to these markets. The imbalance in South Atlantic port share of U.S. imports and exports grows substantially over the study period, as shown in Exhibit 3-7.

Exhibit 3-7
South Atlantic Region Share of U.S. Container Trade, 2000 - 2050
Imports Versus Exports



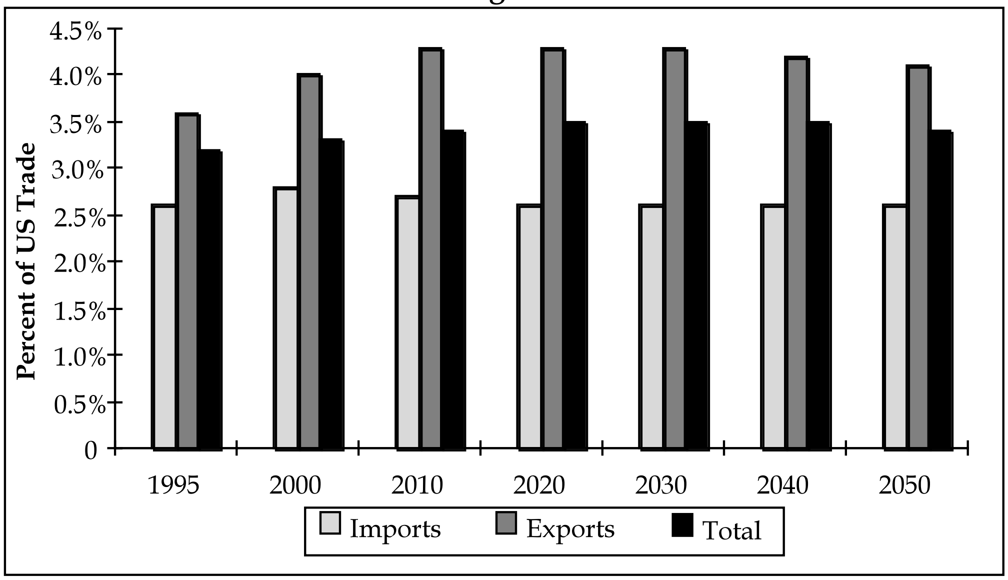
Source: ICF Kaiser Global Trade Forecast, 1997

Though a significant factor in determining the future pattern of South Atlantic trade, the forecast pattern of trade through Savannah Harbor is not identical to that of the region as a whole.

3.3.3 Savannah Container Forecast

Savannah's container trade growth is estimated to average 4.8 percent per year in TEUs over the study period. Savannah's share of the country's container trade reflects the South Atlantic's advantage and geographic proximity to support this trade. Over the forecast period, Savannah increases its share of total U.S. imports and exports. The increase reflects a small loss of share from the Great Lakes and North Atlantic port ranges. Savannah's container trade shares, represented as percent of total U.S. TEU volumes, are presented in Exhibit 3-8.

Exhibit 3-8
Savannah Containerized Trade as a Share of U.S. Total
Percentage of TEUs

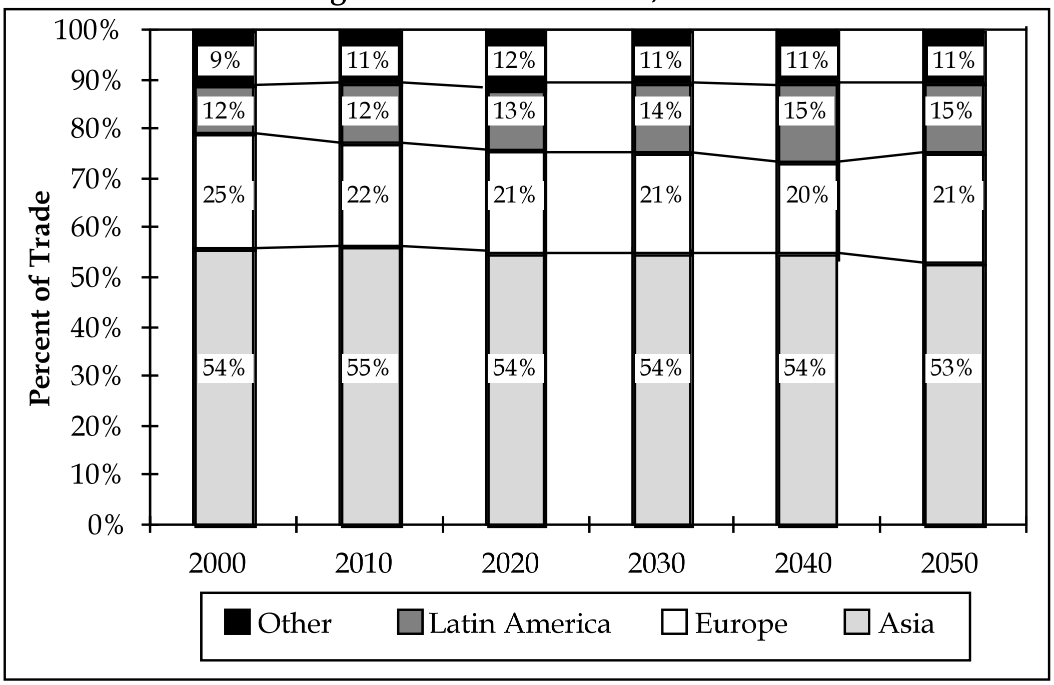


Source: Booz·Allen analysis and ICF Kaiser Trade Forecast, 1997

Trade Partners

The future pattern of trade through Savannah is strongly influenced by differences in foreign trade partner region economic performance. Developing countries of Latin America and Southeast Asia are forecast to increase trade through Savannah faster than the developed economies of Europe and northern Asia. Asian containerized trade volumes through Savannah remain the highest through the port. Correspondingly, Latin America gains share from Europe over the study period. Savannah's export trade to the Japan-Taiwan-Korea region will fall from being the number one destination for Savannah exports to fifth by 2050. Recent financial market and economic disruptions in some Asian countries are not expected to significantly affect long-term trade demand from these countries. The needed Asian economic restructuring and market liberalization is expected to be hastened by the recent events, and will place these economies on track to their long-term growth potential very early in the study period. Accordingly, Asia as a whole still remains the largest partner region for trade through Savannah, as shown in Exhibit 3-9.

Exhibit 3-9
Distribution of Trade Region Share in Containerized Cargo Through the Port of Savannah, 2000 - 2050

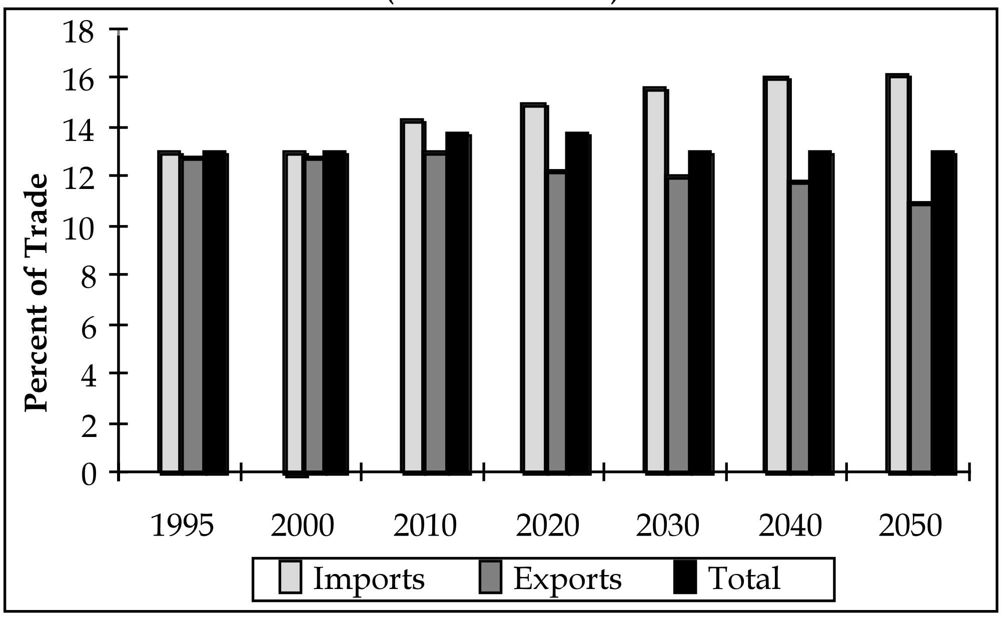


Source: Booz·Allen analysis
Note: Numbers may not add due to rounding.

Import/Export

Savannah's share of total South Atlantic port range containerized trade decreases slightly over the forecast period from 13.2 percent to 12.8 percent. This decrease is due to the difference in the mix of trade partners and commodities between Savannah and the South Atlantic port range as a whole. As shown in Exhibit 3-10, the loss of share is entirely from exports as Savannah's import share increases three full percentage points from 13.2 percent to 16.2 percent. While the level of imports and exports through Savannah is growing, its exports grow at a slower rate than that of the combined exports of Savannah's competitor South Atlantic ports.

Exhibit 3-10
Containerized Trade Through Savannah as a Share of South Atlantic Port Range, 1995 - 2050
(Percent of TEUs)



Source: Booz·Allen Analysis, ICF Kaiser Global Trade Forecast, 1997

The Port of Savannah, like the South Atlantic port range, will see its growth in container trade driven by exports much more than by imports, and above the average for the nation. As shown in Exhibit 3-11, Savannah's containerized export cargo grows to 3.7 million TEUs by 2050 with imports increasing to 2.3 million TEUs over the same period.[6] This directional difference is shown graphically in Exhibit 3-12. By 2020, the projected Savannah Harbor import TEU volumes are only 72 percent of the one million export TEUs, with export TEUs at more than triple today's volume. This growth reflects the strong demand for U.S. products from developing regions. Though growing slower than exports, Savannah's import TEU volume growth averages 4.3 percent over the entire 2000 - 2050 forecast period. The import and export forecasts together total over 6 million TEUs by 2050.

6 *The Savannah Harbor container forecast is measured here in loaded TEUs of international cargo, not total TEUs lifted at the port. Adding the handling of repositioned empties would increase these forecast TEU volumes.*

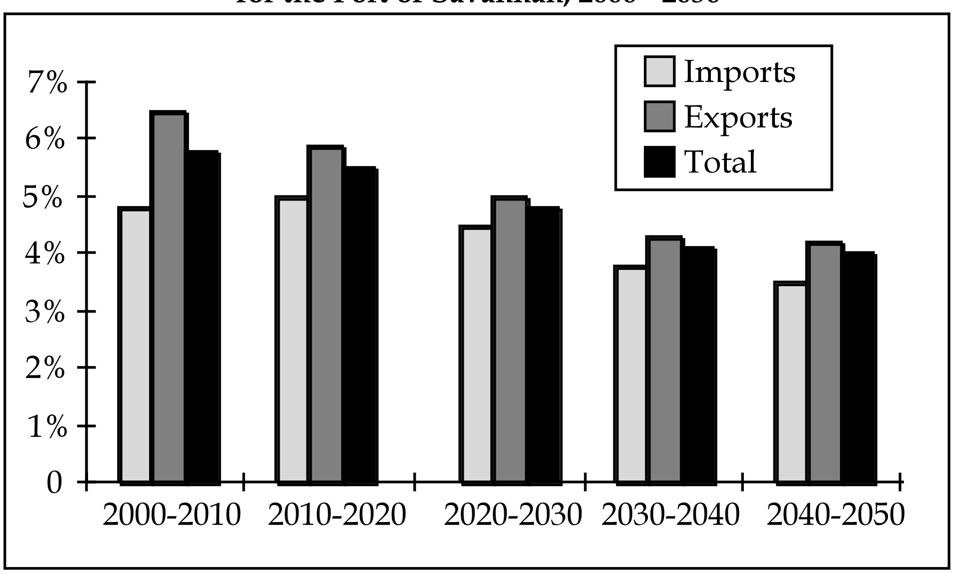
Exhibit 3-11
Forecast of TEU Volumes On Major Trade Lanes
Through the Port of Savannah , 2000 - 2050

TEUs	2000	2010	2020	2030	2040	2050
Imports	283,932	446,568	724,863	1,101,28	1,659,016	2,325,342
Exports	308,431	580,584	1,013,374	1,625,41	2,448,593	3,691,532
Total	**592,362**	**1,027,152**	**1,738,237**	**2,726,69**	**4,107,609**	**6,016,874**

Source: ICF Kaiser Global Trade Forecast, 1997, Booz·Allen analysis

The long-term growth pattern of Savannah's containerized trade declines. This slowing of trade growth reflects an eventual maturation of goods markets and the shift to services in economies as they develop.

Exhibit 3-12
Average Annual Containerized Trade Growth
for the Port of Savannah, 2000 - 2050



Source: Booz·Allen Analysis

Additional containerized trade forecast detail is presented in Chapter 9. Though containerized trade will be the significant cargo growth category for Savannah Harbor, non-containerized trade volumes will continue to be handled through Savannah and are addressed next.

3.4 Non-Containerized Trade

Growth in non-containerized trade through the Port of Savannah will be considerably slower than for container commodities over the study period. This forecast is consistent with the recent growth statistics of non-containerized cargo, which has been much less than for containers. The industrial sectors trading in these goods are not growing as fast as those that move containerized goods. In Savannah Harbor, many of these non-containerized goods are not handled by GPA-owned facilities, so volumes are tied to specific company needs which can be fixed or limited by facility storage or production capacity. Container penetration of traditional general cargo and even bulk markets has continued to increase in Savannah and around the world. The non-containerized commodity forecasts for the Savannah Harbor are presented in Exhibit 3-13.

Exhibit 3-13
Annual Non-Containerized Trade by Commodity
Through the Port of Savannah, 1995 - 2050
(Thousands of Short Tons)

Commodity	1995	2000	2010	2020	2030	2040	2050
Crude Petroleum	1,053	1,112	1,241	1,384	1,544	1,723	1,922
Gasoline	899	936	1,013	1,097	1,188	1,287	1,393
Fuel Oil	1,183	1,250	1,394	1,555	1,735	1,953	2,159
Asphalt, Tar & Pitch	406	447	498	547	593	638	684
Fertilizers, Chemicals & Related Products	1,608	1,817	2,350	2,073	3,416	3,948	4,481
Wood Chips	323	339	374	414	457	505	557
Lumber & Primary Wood Products	306	370	501	632	764	895	1,026
Pulp & Paper Products	882	953	1,113	1,300	1,518	1,772	2,071
Gypsum	237	275	335	408	497	606	739
Metallic Ores & Scrap	468	509	562	622	689	761	837
Clay & Refractory Materials	2,439	2,802	3,695	4,588	5,481	6,375	7,268
Cement & Concrete	341	129	173	233	313	420	565
Non-Metallic Minerals & Products	129	192	280	368	456	544	632
Primary Iron & Steel Products	523	520	530	544	574	618	665
Grains & Oilseeds	291	0	0	0	0	0	0
Sugar	646	760	1,023	1,286	1,548	1,811	2,073
Other Agricultural Products	128	166	230	295	359	424	488
Textile Products	26	26	30	34	38	41	45
Manufactured Products	199	213	277	334	401	480	569
Other Commodities	659	832	1,024	1,180	1,433	1,658	1,899
Total Non-Containerized Trade	**12,745**	**13,647**	**16,643**	**18,894**	**23,003**	**26,440**	**30,072**

Source: Booz·Allen analysis

Total non-containerized metric tons grow from 12.7 to 30.1 million short tons over the study period. The average rate of volume growth is less than one half of one percent per year, reflecting the maturity of markets for non-containerized goods handled in Savannah Harbor.

3.4.1 General Cargo

Commodity categories that primarily move as general break bulk cargo includes iron and steel products, and non-containerized clay, textile, wood, paper, and other manufactured products.

The largest single tonnage commodity category moving through Savannah Harbor is clay and refractory minerals consisting primarily of kaolin. Kaolin is used primarily as a pigment or extender in coating and filling applications. It is sold for manufacturing applications including paper, refractories, fiberglass, ceramics, paint, and rubber. Georgia accounts for over 85 percent of U.S. kaolin production, with the neighboring states of South Carolina and Alabama together accounting for another six percent. The majority of U.S. kaolin exports are sold for use in paper coating and filling in Japan, Canada, Finland, Mexico, and Italy. U.S. imports of kaolin are insignificant in comparison. Kaolin is handled in Savannah at GPA's Ocean Terminal and at the private terminals including Southern Bulk Industries (Conbulk) and Colonial Terminals. Total tonnage in Savannah in 1996 was 2,809,000 tons, 96 percent of which was exported overseas. Kaolin represents 16 percent of total cargo tonnage through Savannah Harbor. Kaolin tonnage demand is expected to grow at an average annual rate of five percent over the study period. It should be noted that Kaolin is also shipped in containers and therefore, the export container forecasts also include some Kaolin trade.

Pulp and paper products are handled at GPA's Garden City and Ocean Terminal facilities. Wood pulp and liner board are also handled in Savannah Harbor at private terminals owned by Stone Savannah River Pulp and Paper Corp., Georgia Pacific, Union Camp, and East Coast Terminal (Conbulk). Most of this tonnage (2,046,000 short tons in 1996) is exported, accounting for almost 12 percent of total tonnage moved through Savannah Harbor. For all pulp and paper products, 51 percent was categorized as pulp and waste paper, all of which was exported abroad. Additionally, paper and paperboard accounted for 47 percent of the category, 99 percent which was exported overseas. Containers carry some of this commodity group as well, with non-containerized paper and paperboard tonnage estimated to increase at an average annual rate of 1.6 percent over the study period.

In Savannah, lumber and primary wood is handled at GPA's Garden City and Ocean Terminals in addition to various private terminals. Private terminals include those of Georgia Pacific, Atlantic Wood, and East Coast Terminal, which is part of Conbulk Marine Terminals Group Inc. Plywood was one of GPA's leading non-containerized cargoes in Savannah in fiscal year 1996. Softwood lumber production is forecast to grow at an average annual rate of 0.96 percent, and hardwood lumber production is forecast to grow at a rate of 1.04 percent per annum. Softwood production outnumbers that of hardwood by an average factor of 2.8 over the period. This category includes raw lumber and wood products such as plywood, veneer, and other worked wood. Tonnage for lumber and wood products was 450,000 in 1996, consisting of 200,000 tons of lumber (44 percent) and foreign imports accounting for 55 percent of lumber tonnage. The remaining 250,000 tons (56 percent) was categorized as primary wood products, with 70 percent of this amount imported from abroad and 24 percent shipped out internally.

Textile products include basic textiles, apparel, synthetic fibers, or textile waste. All commodities in this category are processed goods, either for end-use, for use as an input in further processing, or as a by-product. As finished goods, most textile products moving through Savannah Harbor are handled at the Garden City facility. In 1996, Savannah handed approximately 325,000 tons of textile products. All of this trade was foreign, split 58 percent and 42 percent for exports and imports, respectively. Though Savannah Harbor textile product volumes have varied considerably from year to year, the long-term trend is for very modest growth over historical averages, trading 45,000 metric tons by the end of the study period.

3.4.2 Dry Bulk Commodities

Commodity categories that primarily move as dry bulk cargo through Savannah Harbor include wood chips, pulp, grains and oilseeds, sugar, metallic ores and scrap, gypsum, cement, non-metallic minerals and products, and some kaolin clay.

Wood chips are handled in Savannah Harbor at the GPA's facilities and also at the private terminal of Savannah River Wharf Co., part of Conbulk Marine Terminals Group. Almost all (99 percent) wood chips handled via Savannah Harbor are exported abroad. Wood chip tonnage through Savannah, which is partly correlated to lumber production, is forecast to grow at an average annual rate of one percent over the study period.

The metallic ores and scrap category includes iron, manganese, copper, aluminum ores, iron and steel scrap, and slag. These products are handled through Savannah Harbor at various terminals. For perspective on this category, as handled through Savannah Harbor, recent tonnage was composed of 20 percent aluminum ore (imported from abroad), 32 percent various non-ferrous scrap (mostly imported), and 30 percent slag (imported from abroad and from Canada). The remaining 18 percent includes various non-ferrous ores, and iron and steel scrap. Consistent with the U.S. Department of the Interior and IISI (International Institute of Iron and Steel) forecasts for these commodities, annual tonnage growth is expected to decline from 1.7 percent to 1.0 percent over the study period.

Grains and oilseeds became a less significant commodity to Savannah Harbor in 1996, in comparison to earlier years, due to the moving of GPA's primary grain handling facilities to the Port of Brunswick. In 1996, there were 127,000 short tons shipped from Savannah, composed mainly of peanut, soybean, and wheat exports. This shifting of GPA's grain cargo facilities to Brunswick was made in order to make room for the construction of container berth #7 at GPA's Garden City Terminal. The grain and oilseed trade shifting to Brunswick is not expected to return to Savannah. Thus, current and future volumes of grains and oilseeds movements through Savannah Harbor are expected to be negligible.

Gypsum tonnage is primarily an import commodity. Canada is the source of 63 percent of imported gypsum and the remaining 37 percent of gypsum tonnage is imported from overseas. Construction industry demand for gypsum has been healthy for the last several years – with the South Atlantic being the leading region nationally for sales of gypsum-related products. Additionally, Canada and Mexico are the leading exporters of gypsum to the United States. The U.S. Department of the Interior, U.S. Geological Survey, forecasts national gypsum demand to increase by 3.0 percent annually through the year 2000, driven primarily by the construction industry. Over the study period, the annual growth rate for gypsum is forecast to average 2 percent.

3.4.3 Liquid Bulk Commodities

Commodity categories that primarily move as liquid bulk include crude petroleum, motor gasoline, fuel oil, other petroleum products, asphalt, tar, and pitch and chemicals. Fertilizers, chemicals, and related products were aggregated into one large category to maintain consistent groupings.

Crude petroleum is imported into Savannah for refining into gas, oil, naphtha, asphalt and other petroleum products. Crude petroleum in Savannah Harbor is handled at the private terminals of Stewart Petroleum and Citgo. Citgo imports crude oil from Venezuela for refining at its Savannah facility; correspondingly, there is no exported crude oil. Crude oil imports were 916,000 short tons in 1996. The long-term forecast is for crude import tonnage to increase at an average annual growth rate of 1.1 percent for the study period. This is consistent with the 1997 Department of Energy Information Administration long-term forecast average annual growth in petroleum consumption for the US.

The gasoline category consists of both gasoline for general consumption and jet fuel, both of which are refined products of crude petroleum and are primarily used for transportation-related purposes. Most gasoline cargoes are motor gasoline for general consumption. In Savannah Harbor, gasoline is handled at Citgo's Asphalt Refining & Gasoline Terminal and at Colonial Oil's terminal. Almost all gasoline tonnage through Savannah Harbor is domestic receipts. In 1996, gasoline shipments were

809,000 tons. Of this total, the bulk of the amount, 92 percent, was received domestically; seven percent was imported from abroad and one percent was shipped out to a domestic destination. The forecast in gasoline tonnage is 0.8 percent over the study period, consistent with the U.S. Department of Energy's forecast growth rate of 0.8 percent for U.S. motor gasoline consumption.

Fuel oil moving through Savannah includes distillate and residual fuel oils. These products are used primarily by manufacturing firms, the trucking industry, and oceangoing ships. Fuel oil is handled in Savannah Harbor at Paktank Corp., Union Oil Co., and Stewart Petroleum private terminals. Of the 1,423,000 tons of fuel oil in 1996, 47 percent was distillate fuel oil and 53 percent was residual. The aggregate fuel oil category tonnage makes up 8 percent of all commodity tonnage traded in Savannah. Only 24 percent of total fuel oil tonnage in 1995, largely residual, was imported from abroad. Of total fuel oil tonnage, 44 percent, is inbound shipments from elsewhere in the country, and most of this is distillate. Another 17 percent is shipped to domestic destinations. As fuel oil tonnage through Savannah Harbor has shown relative stability over the past 20 years, the forecast is for 1.1 percent average annual growth from 2000 to 2050.

Fertilizers, chemicals, and plastics classified in this group make up over 10 percent of total cargo tonnage through Savannah Harbor. Demand for many of the chemicals and chemical products in this category have agricultural applications, such as ammonia, sulfuric acid, and liquid sulfur. In the past, ammonia was handled at a dedicated terminal in the Garden City facility; this terminal's use was discontinued in order to allow construction of Container Berth #7. Ammonia, all imported, is now handled at GPA's Ocean Terminal. In 1996, 530,000 tons were handled through Savannah. Fertilizers and related chemicals are handled at the facilities of ST Services, formerly Powell Duffryn. Union Camp handles chemicals at its facility, which are used in connection with the manufacture of paper products. Almost all sodium hydroxide handled through Savannah Harbor is received domestically. Plastics tend to be an export for Savannah, with over 80 percent of plastic tonnage exported.

3.4.4 Other Commodities

Commodities classified as "Other" are not classified elsewhere and tend to be specialized. One example of an other commodity is liquefied gases. For Savannah Harbor, the size and impact of this category historically has fluctuated between 4 percent and 20 percent of total Savannah Harbor tonnage. This proportion reached 20 percent only in 1979 due to a large shipment of liquefied gases. Over the past 20 years, other commodities have accounted for, on average, 7 percent of total Savannah Harbor cargo tons. In comparison, between 1983 and 1995, other commodities accounted for only an average of 5 percent of total cargo tons. The non-containerized forecast for other commodities assumes that maintains a constant percentage of total Savannah cargo tonnage of 5 percent over the study period.

3.5 Summary and Conclusions

The TEU volume and tonnage of Savannah Harbor containerized cargo will continue to grow at rates higher than that of non-commodities under with and without project conditions. The rate of growth for Savannah containerized cargo is higher than that of the country as a whole due to the fact that Savannah is forecast to have a greater share of trade with developing regions of the world than other ports. Containerized Savannah commodity trade, like container trade throughout the South Atlantic and U.S. as a whole, will be driven by strong growth in exports over the fifty-year study period. General cargo and bulk commodity tonnage through Savannah Harbor will grow at lower rates that more closely track U.S. domestic, Southeastern U.S. and regional economic growth.

For calculation of economic benefits accrued to alternative deepening studies both containerized and non-containerized cargo transportation costs were determined. For this study only containerized cargoes are included in the benefit calculations for the channel since non-containerized berth dredging costs have not been estimated and were not included in the alternative project cost estimates.

4. FLEET AND VESSEL OPERATIONS FORECAST

4.1 Introduction

This chapter presents the methodology and resulting forecasts of expected vessel calls to the Port of Savannah over the study period. These fleet forecasts are used in conjunction with the trade forecast presented in Chapter 3 to determine transportation cost benefits, which are covered in Chapter 6 of this Appendix. The initial focus of economic study was on determination of future containership activities; this was subsequently changed to include liquid and dry bulk vessels. Review of the material determined that any benefits accrued from bulk vessels and should not be counted in the benefit-cost analysis, due to the lack of water depth at bulk cargo loading facilities in Savannah Harbor. For completeness, the bulk vessel forecast is provided.

4.1.1 Overview

The Port of Savannah is a major port on the East Coast of the United States, serving three main trade lanes between the U.S. and its foreign trade partners. Historical vessel call statistics place Savannah in the top tier of U.S. ports serving foreign trade. According to the Georgia Ports Authority (GPA) and Savannah Pilot Association data, over 2,100 vessels – including almost 700 containerships – called the Port in 1996. Exhibit 4-1 presents by type, the number of cargo vessels that entered Savannah in 1996.

Exhibit 4-1
Vessel Calls, by Type and Draft, Port of Savannah, 1996

Design Draft	Container	General Cargo*	Roll-on / Roll-off	Tanker	Bulker	Barge**	Total
<38	326	456	160	160	259	139	1,500
38	62	14	6	29	10	9	130
39	58	21	25	7	10	0	121
40	116	27	0	24	1	5	173
41	0	1	0	11	1	11	24
42	96	1	0	7	9	0	113
43	25	0	0	4	1	0	30
44	0	0	0	4	1	0	5
45	0	0	0	1	0	0	1
>45	0	0	0	2	3	0	5
Total	**683**	**520**	**191**	**249**	**295**	**164**	**2,102**

Source: Savannah Pilots Association Logs, Georgia Ports Authority
Note(*): Includes semi-containerships and combination general cargo/semi-containerships.
Note(**): Includes integrated tug-barges.

Over 55 percent of these vessels were either containerships or general cargo ships. Port calls by other vessel types account for the remaining 45 percent. Due to the relocation of GPA's grain handling capability to the Port of Brunswick in 1996, it is expected that the number of dry and liquid bulk vessel calls will decline, and the share of vessels that are containerships will increase. In addition, GPA has improved the automobile import/export facilities in Brunswick. This will impact the number of Ro/Ro vessels calling the Port. According to GPA data, Europe, the Far East (via the Suez Canal or Panama Canal), and South America are the primary overseas trade partner origins/destinations, accounting for over 90 percent of the nearly 700 containerships calling Savannah in 1996. The water depth at several partner ports is illustrated in Exhibit 4-2.

Exhibit 4-2
Channel and Berth Depths of Selected Foreign Ports, 1997
(Feet at Mean Low Water)

Foreign Port	Country	Channel Depth* (Feet)	Berth Depth (Feet)
Far East:			
- Hong Kong	China	47.5	40-47.5
- Singapore	Singapore	49.0	46.0
- Kaoshiung	Taiwan	46.0	34-46
- Busan (Pusan)	South Korea	42.5	41-42.5
- Yokohama	Japan	46.0	39-42.5
- Keelung	Taiwan	43.0	33-42
Europe/Mideast:			
- Rotterdam	Netherlands	48.0	35-45
- Hamburg	Germany	49.0	36-47.5
- Antwerp	Belgium	50.0	39-50
- Dubai	U.A.E.	46.0	42.0
- Felixstowe	U.K.	46.0	32-46
- Algeciras	Spain	50.0	42.5-52.5
- Mina Raysut	Oman	50.0	46.0
South America:			
- Santos	Brazil	>39.4	44.0
- Valparaiso	Chile	>50.0	32.0
- Cartagena	Colombia	38.7	37.7

Source: *US Army Corps of Engineers, Waterborne Commerce Statistics Center, Navigation Analysis News, Vol. 2, No. 2. 1997-1998, Lloyd's Ports of The World.*
Note (*): *Maximum channel depth to container terminal facilities. Port entrance channel and berthing depths may not be the same.*

In the fleet forecasts, no restrictions were placed on sailing drafts of the Savannah fleet. Major foreign ports supporting deep draft vessel operations currently have deeper water than most U.S. ports. Correspondingly, it is assumed that foreign ports will continue to invest in and expand infrastructure as required over the study period, including dredging of shipping channels and vessel berths.

For comparison, the channel dimensions of several North American ports are provided in Exhibit 4-3. Some of these ports serve the same markets as Savannah and as such are competitors. Vessel rotations normally include calls at multiple Atlantic coast ports, usually ones listed here. Consequently, ship managers are presented with operating vessels in a variety of channel depths.

Exhibit 4-3
Channel and Berth Depths of Selected
North American Ports, 1997
(Feet at Mean Low Water)

Port	Channel Depth	Berth Depth
East Coast:		
– Halifax	60.0	46.9*
– New York**	35.0-45.0	35.0-45.0
– Norfolk	50.0	45.0
– Charleston**	40.0→45.0	40.0→45.0
– Savannah**	42.0→?	42.0→?
– Jacksonville	38.0	38.0
West Coast:		
– Long Beach	76.0	46.6*
– Oakland**	42.0→50.0*	42.0→50.0
– Seattle	100.0+	49.2

Note(*): Available water depth is determined by berth depth. Additional channel depth will permit additional dredging at minimal costs.
Note(**): Ports that have or are seeking federal approval and/or funding for deepening.

4.1.2 The Relationship Between World Trade, Containerships, and Economies Of Scale

In this study, economic development benefits accrue to consumers and producers of goods alike. Competition, through the price mechanism, is how benefits are distributed, but original cost savings comes from vessel operators' ability to use vessels more efficiently. Efficiency is improved by spreading fixed costs over larger volumes of cargo, thereby lowering the unit costs of cargo transportation. With increases in trade, sufficient demand exists to fill even larger vessels while maintaining service frequency. Vessel operators achieve the highest impact on costs when they operate large vessels on high volume trade lanes, such as the Europe to Far East, and the emerging markets between Southeast Asia and the United States. As vessel capacity increases, physical dimensions of the vessels increase. Therefore fleet forecasts detailing vessel size and frequency of port call becomes the basis for forecasting cost saving benefits and ultimately, the selected NED plan alternative project depth for the Savannah Harbor Expansion Study.

4.1.3 Forecast Study Period

For evaluation of the benefits from the proposed infrastructure project, the fleet forecast study period coincides with the trade forecast period from 2000 to 2050. For Savannah Harbor traffic, the need for additional channel depth due to increasing vessel operating draft requirements is primarily needed for containerships. Forecasts of non-containerized dry and liquid bulk ships will be presented.

4.2 World and Savannah Fleet Forecast Approach

This section summarizes the methodology used to develop the world and Savannah fleet forecasts. The fleet forecasts are in turn used to determine the transportation cost savings benefits for the with and without project conditions of deepening the Savannah Harbor. Additional background data and detailed forecast methodology are contained in Chapter 11 of this Appendix.

The outlook for the world container fleet is important to the container fleet forecast for Savannah because the vessels operate in a system of ports around the world. Since container trades operate in liner service calling many world ports, trends in the world fleet directly affect the fleet calling Savannah Harbor. For the analysis of vessels in Savannah, the forecast for the world fleet was prepared first.

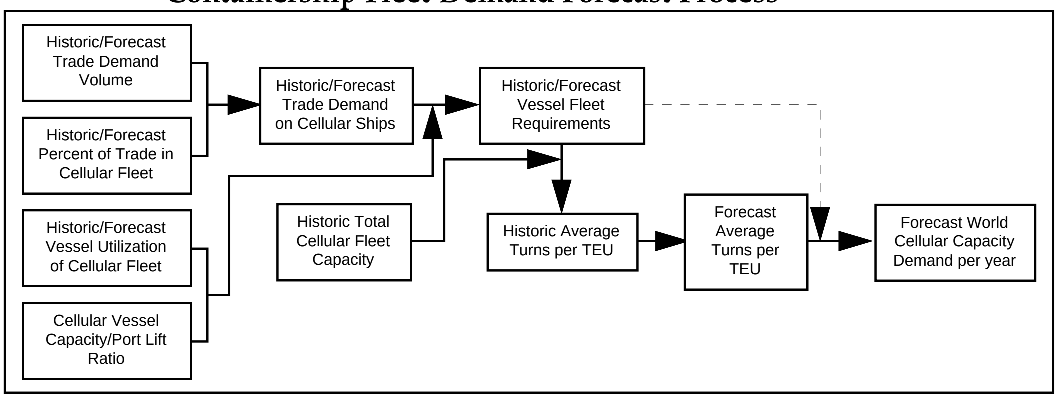
4.2.1 World Fleet Forecast Methodology

The world container fleet forecast uses a market equilibrium methodology, where the world supply of TEU transportation capacity is set equal to the world demand for TEU container movements. This methodology is implemented through a Booz·Allen forecast model which incorporates supply trends in vessel size, number, deployment strategy, capacity, construction/scrapping trends, and utilization to estimate world fleet capacity which is then balanced against commodity transportation demand forecasts.

First, total demand for TEU ocean transportation capacity was calculated. Using this demand, the distribution of how world TEU demand is carried by the world container fleet – segmented by vessel design draft – was estimated. Subsequently, TEU demand and available vessel capacity supply were compared over the study period, by year, to quantify additional fleet capacity needed to support growing container volumes and replace scrapped vessels. The methodology for determining both the demand for and supply of fleet capacity (in TEUs by draft category) is discussed below.

Exhibit 4-4 summarizes the methodology utilized to determine demand for TEU capacity in the fleet forecast and presents a flowchart of the process for calculating world demand for TEU transportation capacity.

Exhibit 4-4
Containership Fleet Demand Forecast Process



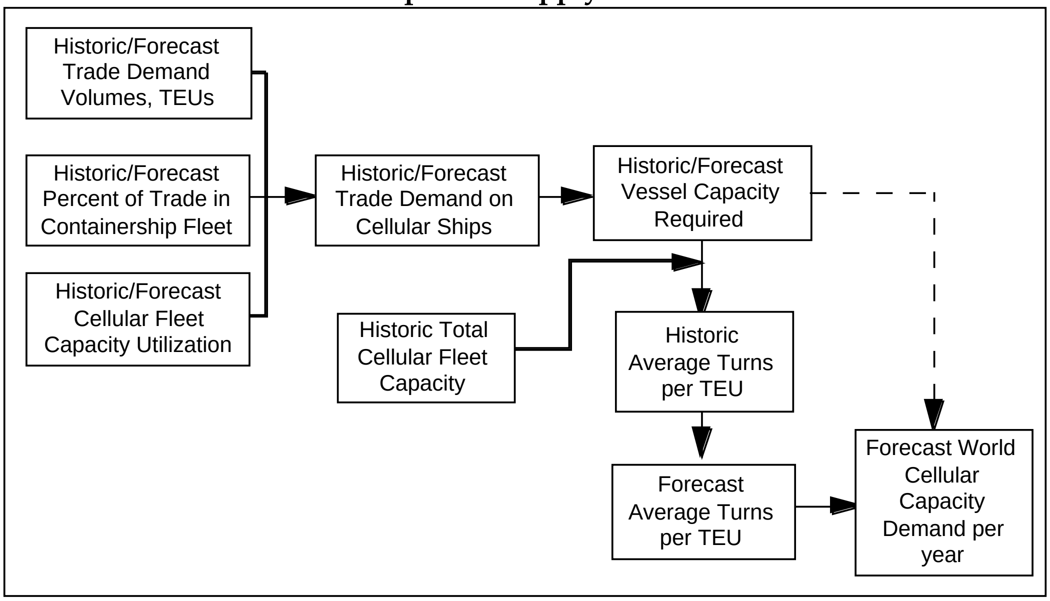
Source: Booz·Allen & Hamilton

The demand for TEU transportation capacity is forecast using the following inputs:

- Forecast of world general cargo trade tonnage
- Forecast of general cargo tonnage expected to be moved via container
- Forecast of containership utilization
- Historic yearly world container capacity
- Forecast of average slot utilization

The supply side of the forecast contains several analytical steps, including an iterative step to model the scrapping or retirement of old vessels, replacing them with new vessels, and adding new capacity to meet demand. Exhibit 4-5 presents the flowchart of the process that forecasts supply of TEU transportation capacity in the world fleet.

Exhibit 4-5
Containership Fleet Supply Forecast Process



Source: Booz·Allen & Hamilton

The supply of TEU capacity on vessels in the world fleet forecast is determined using the following inputs:

- Historic and forecast orderbook of vessels and total capacity, by draft class (<38′ to >46′)
- Forecast of average capacities of vessels in each draft class
- Forecast of the retired and replacement fleet, based on a 20 year vessel life span
- Expected additional capacity required after vessel retirement and/or replacement, to meet demand.

4.2.2 Savannah Fleet Forecast Methodology

The purpose of the world fleet forecast is in order to develop a baseline from which the Savannah fleet forecast can be developed. One assumption applied in the Savannah forecast is that the Savannah fleet is a microcosm of the world fleet. It is projected that as trade volumes increase through Savannah and the port grows to accommodate the increased traffic and trade, the Savannah fleet will evolve more closely to resemble the world fleet in terms of fleet mix. The fleet mix is the distribution of ships across design draft categories (e.g., 40 ft., 42 ft., 44 ft., etc.).

The Savannah fleet forecast is similar to the methodology used to develop the world fleet forecast, in that it uses a trade forecast to determine the demand for TEU transportation, then calculates the required vessel supply and fleet mix needed to meet demand. The model evaluates trade and vessels serving the Europe-North America, Latin America-North America, and the Asia-North America trade lanes separately. This approach mirrors the general deployment of containerships on rotations serving North America.

The supply of TEU capacity in the Savannah fleet forecast is determined using the following major inputs:

- Historical vessel calls to the port of Savannah, including total capacity, and capacity distribution, by draft class (<38 ft. to >46 ft.)
- Forecast of average capacities of vessels in each draft class, based on historical trends
- Forecast average TEU lifts per draft category
- Forecast of the number of ships required to handle the forecast TEU trade levels based on TEU lift forecast
- Expected number of additional ships deployed on the Savannah trade lanes over the study period.

Details of the methodology for determining the supply of TEU capacity are presented in Chapter 11 of this Appendix.

4.3 Results Of The World And Savannah Containership Fleet Forecasts

This section presents the results of the world and Savannah fleet forecasts. These forecasts project the number of ships and total capacity of those ships, by design draft categories, incrementally from 38 feet in draft to greater than 46 feet (e.g., 38, 39, 40, etc.). To understand the results of these forecasts an important first step is to describe the historic and existing containership fleet conditions.

4.3.1 Historic Savannah Containership Fleet Profile

The historic Savannah containership fleet reflects past increases in channel depth at Savannah and the increase in vessels sizes and capacities. The last ten years have seen dramatic changes in the size and capacity of the fleet calling Savannah, which has followed those changes experienced in the world fleet. Liner operators serving the Port have been steadily increasing their level of service over the last several years – and since the last deepening project – through a combination of operating larger, higher capacity vessels and increasing the number of port calls and services through the Port. Exhibit 4-6 presents the number of containership calls by draft, at GPA facilities over the last ten years.

Exhibit 4-6
Containership Calls to the Port of Savannah, 1987-1996

Design	Number of Vessel Calls per Year									
Drafts	**1987**	**1988***	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
<38	249	292	176	189	273	213	187	222	232	326
38-39	195	183	222	207	195	161	123	117	112	120
40-41	0	7	8	20	51	98	116	126	125	116
42-43	0	0	6	49	32	58	69	84	108	121
44+	0	0	0	0	0	0	0	0	0	0
Total	**444**	**482**	**412**	**465**	**551**	**530**	**495**	**549**	**577**	**683**

Source: GPA, USACE data, Booz·Allen analysis.
Note: Data is based on GPA fiscal year, July 1 through June 30
Note (*): 1988 data from USACE, all other data from GPA

The number of containerships with design drafts over 38 feet calling the Port has increased over 145 percent during this period and exceeds the predicted fleet mix detailed in the 1991 Savannah Harbor Deepening Study by 10 years. In 1996, 121 ships, representing 18 percent of the calls, had design drafts in excess of the Port's 42-foot channel depth. Taking into account required underkeel clearance for safe navigation, the number of vessels with design drafts of 38 feet or greater, increased from 195 in 1987 to 345 in 1996, or 77 percent. Due to draft restrictions at the Panama Canal, the vessels with design drafts of 40 feet operate in a light loaded condition if they transit the canal. There are no operating draft limitations for the containerships transiting the Suez Canal. It is assumed that vessels with Panama Canal limitations, and are transiting that canal, are operating with at least 1 or more feet of light loading.

4.3.2 Existing World and Savannah Fleet

The existing world and Savannah fleet has grown considerably to where much of the fleet capacity is in deeper draft vessels. Information on the world fleet was compiled and used as input to the world and Savannah fleet forecasts. Exhibit 4-7 presents the number of vessels, total capacity, and average ship size of vessels in the world containership fleet, in 1997, by design draft.

Exhibit 4-7
World Cellular Containership Fleet Capacity, by Design Draft, 1997
(in TEUs)

Vessel Draft (in feet)	Number of Vessels	Total Capacity	Average Capacity
<38	1,599	1,539,420	963
38	141	312,385	2,215
39	118	332,411	2,817
40	102	301,538	2,956
41	19	48,431	2,549
42	105	378,447	3,604
43	89	336,825	3,785
44	8	22,210	2,776
45	47	206,460	4,393
46	16	86,719	5,420
>46	9	43,280	4,809
Total	**2,253**	**3,608,126**	**1,601**

Source: Clarkson Research Services Containership Registry, Booz·Allen analysis

The exhibit shows that the majority of container vessels operating in the world are shallower draft, feeder to handymax sized vessels, designed for the shallower depth of ports in the past. These vessels would not benefit from channel deepening alternatives and typically serve shorter haul regional trades and niche markets. However, when considering vessel capacity in the fleet, the majority of total fleet capacity is found in those deeper draft vessels with design drafts of 38 feet and greater. As should be expected, these vessels typically serve the world's high volume and longer haul trade routes. Correspondingly, the latest data available on the containership fleet calling the Port of Savannah is illustrated in Exhibit 4-8.

Exhibit 4-8
Savannah Cellular Containership Fleet Capacity, by Draft, 1996
(in TEUs)

Vessel Draft (in feet)	Number of Vessels	Total Capacity	Average Capacity
<38	266	368,392	1,385
38	62	164,863	2,659
39	58	170,112	2,933
40	116	341,537	2,944
41	0	0	0
42	96	279,922	2,916
43	25	100,600	4,024
44	0	0	0
45	0	0	0
46	0	0	0
>46	0	0	0
Total	**623**	**1,425,426**	**2,288**

Source: Savannah Pilots Association, Georgia Ports Authority, Clarkson Research Studies, Booz·Allen analysis

In recent years, ocean carriers have ordered and placed into operation increasingly larger vessels. As owners have invested in larger vessels, they have sought improved stability, cargo capacity, and operating flexibility for their vessels. These larger vessels typically have resulted in increases in design and operating draft requirements. As larger global vessel operators and members of alliances deploy these vessels, it is expected that they will make fleet deployment decisions and select to serve ports which minimize operating disruptions and costs, while processing the larger cargo volumes that these vessels carry through the port efficiently and effectively. With respect to the marine characteristics of a port, this relates to available channel and berth depths.

4.3.3 Vessel Operations in Savannah

To analyze change within the Savannah containership fleet since the last deepening of the Savannah Harbor, the fleet as it existed in 1988 was compared with the fleet that served the Port in 1996. Additionally, interviews were conducted with several carriers calling Savannah and other ports in the region and United States.

Over half of the containerships calling Savannah were draft constrained in 1996. Vessels are considered draft constrained when the sum of their design draft plus the required under keel clearance (Savannah Harbor pilots use 4 feet of clearance) exceeds available channel depth. Under a constrained operating scenario, vessels calling the port must operate at load levels less than design draft and/or incur delays to time arrival and departure to coincide with ocean/river tides. Using this definition,

Exhibit 4-9 illustrates the increase in the constrained Savannah fleet as it existed in 1988 and 1996, by design draft and vessel class.

Exhibit 4-9
Distribution of Containership Calls to Savannah, 1988 and 1996

Fleet Category by Design Draft in Feet and (Vessel Type)	1988 (38 Ft. Channel)		1996 (42 Ft. Channel)	
	Ships	% of Total	Ships**	% of Total
Unconstrained Fleet	143	29.7%		
Constrained Fleet:				
34 Feet (Handy)	13	9.8		
35 Feet (Handy)	38	7.9%	326	47.7%
36 Feet (Sub-Panamax)	58	12.0%		
37 Feet (Sub-Panamax)	40	8.3%		
38 Feet (Sub-Panamax)*	63	13.0%	31	4.5%
38 Feet (Panamax)*	62	13.0%	31	4.5%
39 Feet (Panamax)	58	12.0%	58	8.5%
40 Feet (Panamax)	7	1.5%	116	17.0%
41 Feet (Post-Panamax)	0	0.0%	0	0.0%
≥42 Feet (Post-Panamax)	0	0.0%	121	17.7%
Subtotal	339	70.3%	357	52.3%
Total	**482**	**100.0%**	**683**	**100.0%**

Sources: 1988 data from Table 32, USACE Savannah Harbor Georgia, Comprehensive Study, Appendix A, Revised, March 1992; Table B-3, USACE Savannah Harbor Georgia, Reconnaissance Report, July 1996; GPA and Savannah Pilots Association vessel call data for 1996; Booz·Allen analysis
Note(*): Assumed that one-half of the vessels identified with a draft of 38 feet are classified as Panamax vessels
Note(**): Excludes 219 unconstrained semi-containerships and 58 constrained semi-containerships serving other facilities at the Port of Savannah

The number of containerships calling GPA facilities grew from 482 vessel calls in 1988 to 683 in 1996 – an average annual growth of 4.5 percent. The use of larger (greater than 37 foot draft) containerships by the carriers serving Savannah increased dramatically during this period. Specifically, the Port of Savannah experienced significant growth in the use of Panamax and Post-Panamax vessel – increasing from 127 vessel calls (26 percent of the Savannah fleet) in 1988 to 357 vessel calls (52 percent of the Savannah fleet) in 1996. This rapid growth in the use of Panamax and Post-Panamax vessels and the percentage of deployed fleet capacity is consistent with world fleet trends.

4.3.3.1 Light Loading Practices

Carrier interviews indicate there is continued pressure to introduce larger vessels in services calling Savannah to take advantage of economies of scale. Chartering and new building orders by carriers support this conclusion. The introduction of these new vessels will increase further pressure to deepen the navigation channel.

Vessel transit data, including date, vessel name, and inbound and outbound drafts were matched with vessel name and design draft data from Lloyd's Ship Register and Clarkson Research Studies Registry of Containerships. Segmenting the data by design and operating draft, we determined the light loading distribution of vessels by design draft upon arrival and departure from Savannah. This distribution, of depth constrained containerships (with design drafts of 38 feet or more) calling Savannah in 1996 are presented in Exhibit 4-10.

Exhibit 4-10
Inbound and Outbound Light Loaded Containership Trips, Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total	Percent
	0	1	2	3	4	5	6	7	8+		
38	18	17	16	12	19	17	8	8	5	120	17%
39	4	9	12	6	17	25	13	21	13	120	17%
40	2	2	8	17	26	29	34	32	82	232	32%
41	0	0	0	0	0	0	0	0	0	0	0%
42	0	0	2	8	9	9	28	25	111	192	27%
43	0	0	0	0	2	6	4	6	32	50	7%
44	0	0	0	0	0	0	0	0	0	0	0%
45	0	0	0	0	0	0	0	0	0	0	0%
46	0	0	0	0	0	0	0	0	0	0	0%
47	0	0	0	0	0	0	0	0	0	0	0%
Total	**24**	**28**	**38**	**43**	**73**	**86**	**87**	**92**	**243**	**714**	**100%**
Percent	3%	4%	5%	6%	10%	12%	12%	13%	34%	100%	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

The exhibit illustrates that of 714 transits of the Savannah River navigation channel by constrained containerships in 1996, more than 58 percent of the transits were of vessels operating with 5 feet or more of light loading. Examination of the light loading data on both the inbound and outbound transits reveals that containerships rotating through Savannah and very similar operating characteristics regardless of which direction they are heading. Exhibit 4-11 presents the light loading statistics for inbound transits of containerships.

Exhibit 4-11
Inbound Light Loaded Containership Trips, Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total	Percent
	0	1	2	3	4	5	6	7	8+		
38	9	9	8	6	11	8	5	3	1	60	17%
39	2	5	6	3	9	12	7	10	6	60	17%
40	1	1	4	9	14	14	17	16	40	116	32%
41	0	0	0	0	0	0	0	0	0	0	0%
42	0	0	1	4	5	5	14	14	53	96	27%
43	0	0	0	0	1	3	2	4	15	25	7%
44	0	0	0	0	0	0	0	0	0	0	0%
45	0	0	0	0	0	0	0	0	0	0	0%
46	0	0	0	0	0	0	0	0	0	0	0%
47	0	0	0	0	0	0	0	0	0	0	0%
Total	**12**	**15**	**19**	**22**	**40**	**42**	**45**	**47**	**115**	**357**	**100%**
Percent	3%	4%	5%	6%	11%	12%	13%	13%	32%	100%	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

The exhibit shows that of the 357 containerships calling the port that are considered constrained due to their design draft, 70 percent of the vessels arrived with 5 feet or more of light loading. Exhibit 4-12 presents the light loading statistics for outbound transits.

Exhibit 4-12
Outbound Light Loaded Containership Trips, Savannah Harbor, 1996

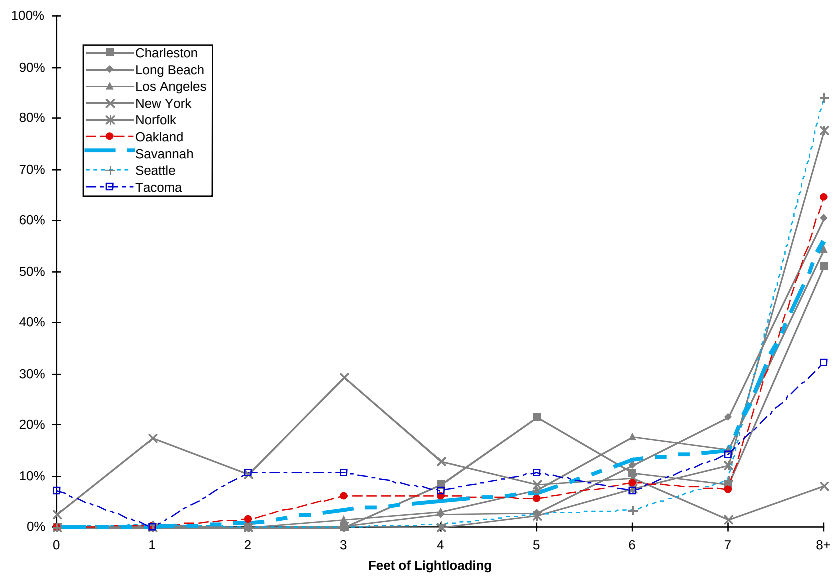
Design Draft (ft)	Number of Feet Light Loaded									Total	Percent
	0	1	2	3	4	5	6	7	8+		
38	9	8	8	6	8	9	3	5	4	60	17%
39	2	4	6	3	8	13	6	11	7	60	17%
40	1	1	4	8	12	15	17	16	42	116	32%
41	0	0	0	0	0	0	0	0	0	0	0%
42	0	0	1	4	4	4	14	11	58	96	27%
43	0	0	0	0	1	3	2	2	17	25	7%
44	0	0	0	0	0	0	0	0	0	0	0%
45	0	0	0	0	0	0	0	0	0	0	0%
46	0	0	0	0	0	0	0	0	0	0	0%
47	0	0	0	0	0	0	0	0	0	0	0%
Total	**12**	**13**	**19**	**21**	**33**	**44**	**42**	**45**	**128**	**357**	**100%**
Percent	3%	4%	5%	6%	9%	12%	12%	13%	36%	100%	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

The exhibit illustrates that 73 percent of the containerships departing Savannah were light loaded 5 feet or more. This statistic mirrors the operational characteristics of the inbound transits presented above. These light loading distributions are used in calculations to determine the transportation costs. Those calculations will be presented in Chapter 6 of this appendix.

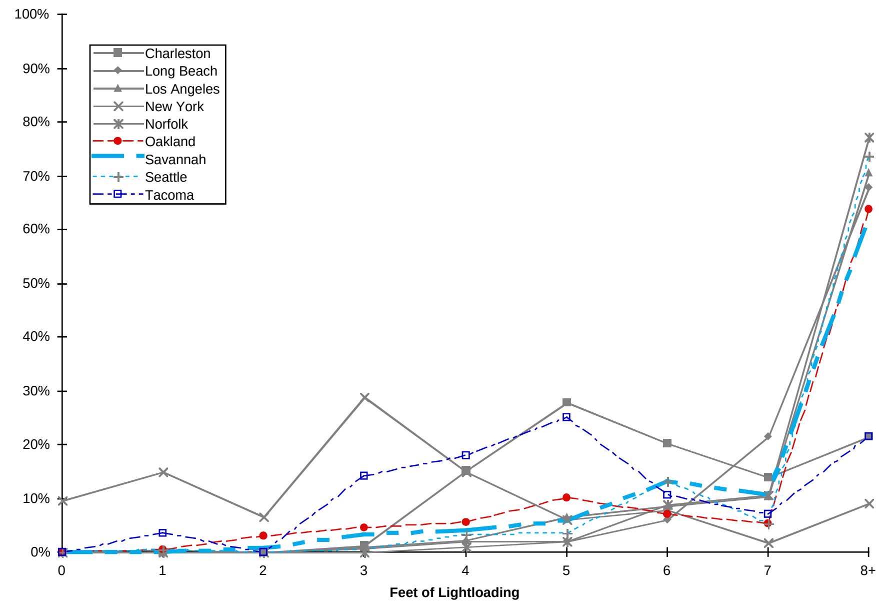
To compare the behavior of deep draft containerships at Savannah versus at other ports in the U.S., trips and draft data for 1996 (the latest year available) was queried from a USACE database. The data was analyzed to determine the light loading characteristics of Post-Panamax containerships as they entered and departed the ports. Results of the analysis show that constrained vessels calling at Savannah have very similar light loading characteristics to the Post-Panamax containerships using the other ports. Exhibits 4-13 and 4-14 present the inbound and outbound light loading curves for the seven ports on the east and west coast of the United States. The inbound and outbound light loading distribution for Savannah is overlaid on each exhibit.

Exhibit 4-13
Inbound Light Loading Characteristics of
Deep Draft Containerships at Major U.S. Ports, 1996



Source: Waterborne Commerce Statistics Center, Booz·Allen analysis

Exhibit 4-14
Outbound Light Loading Characteristics of
Deep Draft Containerships at Major U.S. Ports, 1996



Source: *Waterborne Commerce Statistics Center, Booz·Allen analysis*

These last two exhibits show that deep draft containerships calling at several ports throughout the U.S. are operated with considerable light loading.

4.3.4 World and Savannah Fleet Forecast Results

This section presents a summary of the world and Savannah fleet forecasts. The details of the forecast methodology are presented in Attachment C of this document and a compilation of spreadsheet printouts provided by upon request. Exhibit 4-15 presents the number of vessels, by design draft category, from the world fleet forecast.

Exhibit 4-15
World Containership Fleet Forecast, 2000-2050
(Number of Fully Cellular Vessels by Draft Category)

Design Draft (ft)	Forecast Study Period 2000	2010	2020	2030	2040	2050
<38	1,925	2,798	3,246	3,384	3,348	3,175
38	209	382	473	514	621	718
39	124	140	141	156	175	198
40	113	145	63	165	192	216
41	22	28	31	31	31	34
42	159	312	392	486	590	683
43	111	173	205	242	290	332
44	8	7	6	5	5	4
45	55	72	81	97	116	130
46	47	121	195	260	321	373
>46	11	18	22	25	31	35
Total	**2,784**	**4,196**	**4,955**	**5,365**	**5,720**	**5,898**

Source: Booz·Allen's World Containership Fleet Forecast Model (WCFFM)

The exhibit shows that the number of containerships in the world fleet will increase by over 210 percent over the study period. Following recent trends, it is expected there will be significant growth in the number of deep draft containerships during the first half of the next century. Projections estimate the need for almost 1,600 Post-Panamax vessels in the world fleet, a 400 percent increase over today's levels. The results of the Savannah fleet forecast were aggregated across the three major trade lanes serving Savannah, Europe/Mediterranean, Latin America, and the Far East. It is expected that current and future carriers serving the Port will optimize the deployment of their vessels across trade lanes to maximize service and minimize costs. For international carriers and those operating as part of global alliances, operating deeper draft, high capacity container vessels will be a key part of their deployment strategy, provided there is adequate water depth to access ports served by the carriers. The size of the Savannah Fleet and the number of Post-Panamax containerships forecast to call the Port will increase depending on the selected alternative deepening project.

The Savannah fleet forecast was bifurcated across the three trade lanes, due to the distinct differences of the fleets operating on each lane. In addition, the Far East fleet was bifurcated to distinguish between services through the Panama and Suez Canals. Using statistics and professional opinion of the ability for the Panama Canal to handle increased traffic loads over the course of the forecast period, a 70/30 (Suez/Panama) split was incorporated for vessels with drafts less than the maximum allowable through the Panama Canal. All vessels with drafts greater than the Panama Canal limit were subject to transit through the Suez Canal. With these distributions, a calculation of the transportation cost savings of the alternative deepening projects was completed. Transportation costs are discussed in Chapter 6 of this appendix.

Under without project conditions, the number of Post-Panamax vessels calling the port will increase over the study period; however, due to the high level of light loading it is not expected that the carriers will have many more deep draft containerships calling Savannah. This will effectively raise the costs of operations under the without project condition, compared to the alternative with project conditions. To model this assumption, growth in the Post-Panamax portion of the fleet has been restricted to vessels representative of the largest vessels currently serving the port for each trade. Following past experience, it is expected that as the channel is deepened, carriers will increasingly deploy higher capacity, deeper draft Post-Panamax ships to leverage the economies of deeper water available at the Port. Exhibit 4-16 presents the fleet capacity distribution of fully cellular containerships serving the Port under without, or existing, project condition.

Exhibit 4-16
Projected Containership Fleet Capacity Distribution -
42′ Project Fleet Forecast
Europe/Mediterranean Trade Lane

Design	Fleet Capacity Distribution					
Draft (ft)	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
<38	20%	19%	18%	18%	19%	20%
38	13%	12%	13%	14%	14%	14%
39	16%	17%	16%	13%	10%	8%
40	22%	13%	22%	20%	16%	13%
41	0%	1%	0%	1%	1%	1%
42	25%	19%	24%	22%	20%	19%
43	0%	25%	6%	13%	20%	25%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Far East Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
<38	9%	9%	9%	9%	9%	9%
38	13%	12%	13%	14%	15%	16%
39	9%	9%	9%	7%	6%	5%
40	28%	29%	27%	21%	17%	15%
41	0%	0%	0%	1%	1%	1%
42	25%	23%	21%	20%	20%	19%
43	17%	18%	21%	27%	32%	35%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Latin America Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
<38	79%	81%	76%	64%	56%	51%
38	3%	2%	3%	5%	7%	7%
39	1%	1%	1%	1%	2%	2%
40	5%	6%	6%	6%	6%	6%
41	1%	1%	1%	1%	1%	1%
42	1%	1%	3%	7%	10%	11%
43	10%	8%	10%	15%	20%	22%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Booz·Allen analysis

Under the without project condition, it is assumed that trade handled via Savannah is carried on containerships with design drafts of 43 feet or less, due to the continuation of the light loading practices currently observed.

Preliminary analysis covered alternative deepening projects of 44- to 50-feet at two foot intervals. Following that analysis, forecasts for 45- and 47-foot projects were developed. In accordance with previous studies conducted by the USACE, and the lack of vessels with drafts greater than 46-feet in draft, it was assumed that the deepest assumption that the deeper alternative projects have the same fleet distribution, for the Savannah Harbor Expansion Project, it was assumed the 47-, 48-, and 50-foot projects were equivalent to the 46-foot project.

Exhibits 4-17 through 4-19 present the fleet capacity distribution forecast for the of containerships for each alternative project, by trade lane.

Exhibit 4-17
Projected Containership Fleet Capacity Distribution - 44′ Project Fleet Forecast

Europe/Mediterranean Trade Lane

Design	Fleet Capacity Distribution					
Draft (ft)	2000	2010	2020	2030	2040	2050
<38	20%	19%	18%	18%	19%	20%
38	13%	12%	13%	14%	14%	14%
39	16%	17%	16%	13%	10%	8%
40	22%	23%	22%	20%	16%	13%
41	0%	0%	0%	1%	1%	1%
42	25%	25%	24%	22%	20%	19%
43	1%	1%	2%	5%	8%	10%
44	0%	0%	0%	0%	0%	0%
45	2%	2%	4%	8%	12%	16%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Far East Trade Lane

Design	Fleet Capacity Distribution					
Draft (ft)	2000	2010	2020	2030	2040	2050
<38	9%	9%	9%	9%	9%	9%
38	13%	12%	13%	14%	15%	16%
39	9%	9%	9%	7%	6%	5%
40	28%	29%	27%	21%	17%	15%
41	0%	0%	0%	1%	1%	1%
42	25%	23%	21%	20%	20%	19%
43	15%	16%	16%	16%	16%	16%
44	0%	0%	0%	0%	0%	0%
45	2%	2%	5%	11%	16%	19%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Latin America Trade Lane

Design	Fleet Capacity Distribution					
Draft (ft)	2000	2010	2020	2030	2040	2050
<38	79%	81%	76%	64%	56%	51%
38	3%	2%	3%	5%	7%	7%
39	1%	1%	1%	1%	2%	2%
40	5%	6%	6%	6%	6%	6%
41	1%	1%	1%	1%	1%	1%
42	1%	1%	3%	7%	10%	11%
43	3%	2%	4%	6%	7%	8%
44	1%	1%	1%	0%	0%	0%
45	6%	5%	6%	9%	12%	13%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Booz·Allen analysis

Exhibit 4-18
Projected Containership Fleet Capacity Distribution - 45′ Project Fleet Forecast

Europe/Mediterranean Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	20%	19%	18%	18%	19%	20%
38	13%	12%	13%	14%	14%	14%
39	16%	17%	16%	13%	10%	8%
40	22%	23%	22%	20%	16%	13%
41	0%	0%	0%	1%	1%	1%
42	25%	25%	24%	22%	20%	19%
43	1%	1%	2%	5%	8%	10%
44	0%	0%	0%	0%	0%	0%
45	1%	1%	1%	2%	4%	4%
46	2%	1%	3%	6%	9%	11%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Far East Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	9%	9%	9%	9%	9%	9%
38	13%	12%	13%	14%	15%	16%
39	9%	9%	9%	7%	6%	5%
40	28%	29%	27%	21%	17%	15%
41	0%	0%	0%	1%	1%	1%
42	25%	23%	21%	20%	20%	19%
43	15%	16%	16%	16%	16%	16%
44	0%	0%	0%	0%	0%	0%
45	0%	0%	1%	3%	4%	5%
46	1%	1%	3%	8%	11%	14%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Latin America Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	79%	81%	76%	64%	56%	51%
38	3%	2%	3%	5%	7%	7%
39	1%	1%	1%	1%	2%	2%
40	5%	6%	6%	6%	6%	6%
41	1%	1%	1%	1%	1%	1%
42	1%	1%	3%	7%	10%	11%
43	3%	2%	4%	6%	7%	8%
44	1%	1%	1%	0%	0%	0%
45	2%	1%	2%	3%	3%	4%
46	4%	4%	3%	6%	9%	9%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Booz·Allen analysis

Exhibit 4-19
Projected Containership Fleet Capacity Distribution -
46′ and 47′ Project Fleet Forecast
Europe/Mediterranean Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	20%	19%	18%	18%	19%	20%
38	13%	12%	13%	14%	14%	14%
39	16%	17%	16%	13%	10%	8%
40	22%	23%	22%	20%	16%	13%
41	0%	0%	0%	1%	1%	1%
42	25%	25%	24%	22%	20%	19%
43	1%	1%	2%	5%	8%	10%
44	0%	0%	0%	0%	0%	0%
45	1%	1%	1%	2%	4%	4%
46	1%	1%	1%	3%	5%	7%
47	1%	1%	1%	2%	3%	4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Far East Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	9%	9%	9%	9%	9%	9%
38	13%	12%	13%	14%	15%	16%
39	9%	9%	9%	7%	6%	5%
40	28%	29%	27%	21%	17%	15%
41	0%	0%	0%	1%	1%	1%
42	25%	23%	21%	20%	20%	19%
43	15%	16%	16%	16%	16%	16%
44	0%	0%	0%	0%	0%	0%
45	0%	0%	1%	3%	4%	5%
46	1%	1%	2%	5%	7%	8%
47	1%	0%	1%	3%	4%	5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Latin America Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	79%	81%	76%	64%	56%	51%
38	3%	2%	3%	5%	7%	7%
39	1%	1%	1%	1%	2%	2%
40	5%	6%	6%	6%	6%	6%
41	1%	1%	1%	1%	1%	1%
42	1%	1%	3%	7%	10%	11%
43	3%	2%	4%	6%	7%	8%
44	1%	1%	1%	0%	0%	0%
45	2%	1%	2%	3%	3%	4%
46	2%	2%	2%	4%	5%	6%
47	2%	2%	1%	2%	3%	4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Booz·Allen analysis

Following preliminary analysis, review by USACE staff, and examination of the Oakland Harbor Navigation Improvement Project, a methodology was developed to compensate for a lack of a fleet forecast for vessels calling channel depths greater than 46 feet. Using the Oakland study fleet forecast, an enhanced fleet forecast for the Savannah study was completed. The enhanced forecast only applies to the Far East trade lane, a long haul lane, where larger Post-Panamax vessels accrue economies of scale over smaller vessels. The forecast incorporates the Oakland 48-foot forecast with a lag of 20 years for full cascading effects to occur. Exhibit 4-20 illustrates the enhanced fleet forecast used for the Far East trade lane serving Savannah, for the 48- and 50-foot projects.

Exhibit 4-20
Projected Containership Fleet Capacity Distribution -
48′ and 50′ Project Fleet Forecast*
Far East Trade Lane

Design	Fleet Capacity Distribution					
Draft (Ft.)	2000	2010	2020	2030	2040	2050
<38	9%	9%	9%	9%	9%	9%
38	13%	12%	12%	12%	12%	12%
39	9%	11%	12%	12%	12%	12%
40	28%	18%	8%	8%	8%	8%
41	0%	4%	8%	8%	8%	8%
42	25%	16%	8%	8%	8%	8%
43	15%	16%	16%	16%	16%	16%
44	0%	8%	16%	16%	16%	16%
45	0%	2%	4%	4%	4%	4%
46	1%	2%	4%	4%	4%	4%
47	1%	2%	3%	3%	3%	3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Booz·Allen analysis
Note(*): Europe/Mediterranean and Latin American trade lane forecasts are same as 46′ and 47′ project forecasts

The need for an enhanced forecast was necessary to maintain accuracy in the fleet forecast, transportation cost, and benefit-cost analysis. Since the initial forecasts were completed, the rapid change in the makeup of the world container fleet has continued.[7] The deployment of larger Post-Panamax vessels on Far East-Europe and

[7] *The* Sovereign Maersk *and its nine sister ships are delivered or on order. These modified versions of the* Regina Maersk, *have rated capacities of between 7,060 and 8,400 TEUs, and design drafts of 47.5 feet. Following delivery of the* Regina Maersk, *P&O/Nedlloyd contracted for at least four vessels of nearly 6,700 TEU capacity. Most other carriers are currently acquiring vessels of between 5,000 and 5,500 TEU capacity, well within the boundaries of the fleet forecasts used in this study.*

Far East-USWC trade lanes will induce not only other carriers or consortiums to build similar sized vessels, but also will induce redeployment (cascading) of containerships into other trade lanes, effecting the fleet calling Savannah. Exhibit 4-21 illustrates the effect of redeployment patterns of major carriers serving Savannah.

Exhibit 4-21
Comparison of Largest Containerships Deployed in Savannah and World Fleet, 1991 and 1997

Savannah Carriers	Savannah Fleet			World Fleet			Carrier Plans to Deploy Larger Vessels
	1991	1997	% of Increase	1991	1997	% of Increase	
Zim	3,029	3,500	16%	3,039	3,500	15%	No
DSR-Senator	3,467	3,765	9%	3,467	4,545	31%	Yes; 4,545 within 5 years
Hapag-Lloyd	2,803	3,010	7%	4,422	4,422	0%	Unknown
Cho Yang	2,850	2,941	3%	2,850	4,545	60%	Yes; 4,545 within 5 years
NYK	2,568	2,832	10%	3,618	4,743	31%	Yes;
Hanjin	2,668	4,024	51%	4,024	5,300	32%	Yes; 5,300 within 5 years
YangMing	3,266	3,604	10%	3,604	3,725	3%	Yes;
NOL	N/A	2,966	N/A	3,327	4,918	48%	Yes (5-10 years)

Source: Booz·Allen analysis

The exhibit shows the increase in the carriers' largest vessel serving Savannah and the world between 1991 and 1997. It is only a matter of time before the largest vessels in individual carrier's current fleet will be deployed on routes serving Savannah. These larger vessels provide carriers the opportunity to gain the economies of scale on the long haul voyages. An example of the economies of scale gained by the Post-Panamax containerships is illustrated in Exhibit 4-22.

Exhibit 4-22
Comparison of Transportation Costs and Savings for All-Water Versus Mini-Landbridge Service to Savannah

Cost Components	Transportation Cost Summary		
	Mini-Landbridge via Los Angeles	All-Water Service to Savannah	
	6,000 TEU	4,000 TEU via Panama Canal	6,000 TEU via Suez Canal
Transport Costs per Box:			
- Marine Costs	$271	$608	$504
- Port Costs	$230	$207	$205
- Intermodal Costs	$1,200	$250	$250
Subtotal	*$1,701*	*$1,065*	*$959*
Inventory Costs:			
- Days En route	20 days	25 days	23 days
- Inventory Carrying Costs*	$1,000	$1,250	$1,150
Total Costs (Transport + Inventory)	$2,701	$2,315	$2,109
Savannah All-Water Advantage:			
- Cost Savings per Box	-	$386	$592
- Cost Savings per TEU	-	*$282*	*$432*

Source: USACE Vessel Operating Costs analysis, port, truck and rail tariff schedules, Booz·Allen analysis
Note(*): Inventory costs of $50 per day

The exhibit presents the comparison in total transportation costs (per box and per TEU) for moving cargo between Singapore and Atlanta, Georgia, using both a 4000 and 6000 TEU vessel while either shipping via Los Angeles, or the all water routes through the Panama and Suez canals. The comparison shows that carriers and shippers save over $280 per TEU by shipping via the Panama Canal on a 4000 TEU ship compared to a 6000 TEU ship calling the West Coast. This savings increases to over $430 if the cargo is moved on a 6000 TEU ship via the Suez Canal. Shippers would save $150 dollars by shipping through the Suez Canal compared to the Panama Canal.

Savings of these magnitudes will induce carriers to increase the future level of their service through the Suez Canal to the US East Coast, and consequently increase the size of the largest vessels calling the ports along the eastern seaboard.

In conclusion, the Savannah fleet forecast predicts that:

- Due to increased trade with developing markets, vessels with design drafts will continue to increase
- However, because of increased trade with major trade partners in the Far East, deep draft vessel calls will increase by over 445 percent

- The first Post-Panamax II vessel, with a capacity equal to or greater than 6000 TEUs, will call Savannah within the next decade if the channel is deepened to 46 feet in depth or greater
- These second generation Post-Panamax vessels are not expected to be placed in services calling Savannah unless the channel depth is increased to over 44 feet MLLW.
- Overall vessel calls will increase by over 530 percent, averaging almost 4 percent per year.

To complete this chapter, a short discussion is presented on the methodology and results of forecasting the liquid and dry bulk vessel fleet calling the Port of Savannah.

4.4 Savannah Liquid and Dry Bulk Fleet Forecast

The initial work of the fleet forecast and benefits study for the Savannah Harbor Expansion Project focused only on containerized cargoes. After preliminary analysis was completed, direction was given to examine if any non-containerized cargo benefits would accrue to any of the alternative deepening projects. Results of forecast and benefits analysis shows that some benefits accrue from these vessels. However, no benefits accrued from bulk vessels is counted in the analysis. Data presented on non-containerized vessel forecasts is provided for information only. If cost estimates are completed in the future for these bulk cargo berths, the information provided herein will assist in reincorporating the benefits accruing from non-containerized cargo.

Non-containerized vessels consist of liquid bulk tankers (oil product carriers, crude oil tankers, chemical tankers, integrated tug-barge vessels, etc.) and dry bulkers (ore carriers, wood chip, gypsum, etc.). General cargo and vehicle carriers are not included since these vessels presently are not draft constrained vessels and are not expected to become draft constrained over the study period.

4.4.1 Methodology, Assumptions and Results

A fleet forecast of tankers and dry bulkers was developed using the forecast of non-containerized cargo tonnage, and data on the number of these vessel calling, by draft, at the Port of Savannah during 1996. A key assumption in this forecast is that the capacity distribution of the vessels will remain constant over the forecast period. This assumption is based on three factors:

- The liquid and dry bulk vessel is a relatively mature vessel type compared to containerships. Compared to the high growth rates capacity for containerships, tankers and bulkers have relatively stable capacities within draft ranges, and capacity limits have been met, given current and expected future design and construction technology. [8]
- The forecast growth rate for non-containerized tonnage through the Port of Savannah is low. The need for bulker operators to expand capacity or number of vessels is not high
- There are no known plans to upgrade the bulk tonnage handling facilities at private terminals in Savannah Harbor. These terminal facilities will be expanded or upgraded to meet the tonnage demands place upon them.

Exhibit 4-23 presents the distribution by design draft of tanker and dry bulk vessels calling Savannah in 1996.

Exhibit 4-23
Fleet Distribution of Liquid and Dry Bulk Vessels,
Port of Savannah, 2000 - 2050

Design Draft (ft)	Liquid Bulk	Dry Bulk
<38	65.2%	80.1%
38	11.1%	5.9%
29	2.8%	3.1%
40	9.5%	1.9%
41	4.3%	3.7%
42	2.8%	2.8%
43	1.6%	0.3%
44	1.6%	0.3%
45	0.4%	0.0%
46+	0.8%	2.7%

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

The forecast of liquid and dry bulk vessels was determined using the direct relationship between non-containerized tonnage growth forecast and the total number of each type of vessel that called the Port in 1996. The total number of vessels

8 *The 1970s and early 1980s saw rapid change in vessel size and technology of tankers and dry bulkers. However, the pace of this development has been minor in recent years. In contrast, containership technology and size has and continues to experience rapid change. There are no expectations that Panamax (50,000 dwt - 80,000 dwt) bulkers, Capesize (>80,000 dwt) bulkers, tankers (Aframax and above), or chemical product tankers (>50,000 dwt) will serve the Port of Savannah over the study period.*

for each type was then distributed over the draft categories, using the distributions presented in Exhibit 4-23. Exhibits 4-24 and 4-25 presents the results of the forecast of liquid and dry bulk vessel calls to Savannah from 2000 to 2050.

Exhibit 4-24
Forecast of Liquid Bulk Vessel Calls, Port of Savannah, 2000 - 2050

Design Draft (ft)	2000	2010	2020	2030	2040	2050
<38	177	211	210	285	325	364
38	30	36	36	49	56	62
29	0	9	9	13	14	16
40	26	31	31	42	48	53
41	12	15	14	19	22	25
42	8	9	9	13	14	16
43	5	6	6	7	8	9
44	5	6	6	7	8	9
45	2	2	2	2	2	3
>46	3	3	3	4	4	5
Total	**271**	**323**	**322**	**437**	**497**	**557**

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

Exhibit 4-25
Forecast of Dry Bulk Vessel Calls, Port of Savannah, 2000 - 2050

Design Draft (ft)	2000	2010	2020	2030	2040	2050
<38	281	366	452	542	634	731
38	21	27	34	40	47	54
29	11	15	18	21	25	29
40	7	9	11	13	15	17
41	14	17	22	26	30	34
42	10	13	16	19	23	26
43	2	2	2	3	3	3
44	2	2	2	3	3	3
45	–	–	–	–	–	–
>46	13	15	18	22	24	27
Total	**271**	**323**	**322**	**437**	**497**	**557**

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

To calculate the transportation benefits accrued to alternative projects from liquid and bulk vessels, light loading distributions for these vessels were determined. Constraints in channel depth have not allowed many bulk vessel operators from using the maximum operating drafts of their largest vessels. Exhibits 4-26 and 4-27 illustrate the inbound and outbound light loading statistics for dry bulk vessels calling the Port of Savannah in 1996.

Exhibit 4-26
Inbound Dry Bulk Vessel Trips Light Loaded, Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total Trips	Percent
	0	1	2	3	4	5	6	7	8+		
38	1	0	0	1	1	4	2	0	10	19	28%
39	0	0	0	0	0	1	1	0	8	10	15%
40	0	0	0	0	1	0	0	0	5	6	9%
41	0	0	0	0	1	0	2	5	4	12	18%
42	0	0	0	0	2	0	1	0	6	9	13%
43	0	0	0	0	0	0	0	0	1	1	1%
44	0	0	0	0	0	0	0	0	1	1	1%
45	0	0	0	0	0	0	0	0	0	0	0%
46	0	0	0	0	0	0	0	0	3	3	5%
47	0	0	0	0	0	0	0	0	0	0	0%
48	0	0	0	0	0	0	0	0	3	3	5%
>48	0	0	0	0	0	0	0	0	3	3	5%
Total	**1**	**0**	**0**	**1**	**5**	**5**	**6**	**5**	**44**	**67**	**100%**
Percent	**1%**	**0%**	**0%**	**1%**	**7%**	**7%**	**9%**	**7%**	**66%**	**100%**	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis
Note: Figures may not add due to rounding

Exhibit 4-27
Outbound Dry Bulk Vessel Trips Light Loaded, Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total Trips	Percent
	0	1	2	3	4	5	6	7	8+		
38	0	8	2	0	1	1	0	0	7	19	29%
39	0	0	1	0	1	0	0	0	7	9	14%
40	0	0	0	0	0	0	1	0	5	6	9%
41	0	0	1	1	6	0	0	1	3	12	18%
42	0	0	0	0	0	0	0	0	9	9	14%
43	0	0	0	0	0	0	0	0	0	1	1%
44	0	0	0	0	0	0	0	0	1	1	1%
45	0	0	0	0	0	0	0	0	0	0	0%
46	0	0	0	0	0	0	0	0	3	3	4%
47	0	0	0	0	0	0	0	0	0	0	0%
48	0	0	0	0	0	0	0	0	3	3	4%
>48	0	0	0	0	0	0	0	0	3	3	4%
Total	**0**	**8**	**4**	**1**	**8**	**1**	**1**	**1**	**42**	**66**	**100%**
Percent	**0%**	**12%**	**6%**	**1%**	**12%**	**1%**	**1%**	**1%**	**64%**	**100%**	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

Note: Figures may not add due to rounding

Comparing the inbound and outbound statistics illustrates the ballast moves occurring for bulk vessels using the Port. In 1996, inbound calls predominantly were four feet or more light loaded, with the majority eight feet or more light loaded. However, outbound vessels calls show some shift toward the lower end of the light loading scale (1 to 4 feet) for several of the vessels. Exhibits 4-28 and 4-29 illustrate the inbound and outbound light loading statistics for tankers calling the Port of Savannah in 1996.

Exhibit 4-28
Inbound Liquid Bulk Vessel Trips Light Loaded,
Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total Trips	Percent
	0	1	2	3	4	5	6	7	8+		
38	0	4	2	0	2	3	1	2	14	28	32%
39	0	0	0	1	1	0	0	1	4	7	8%
40	0	0	1	2	0	0	0	1	20	24	27%
41	0	0	0	0	2	0	3	1	5	11	12%
42	0	0	0	0	0	1	1	1	4	7	8%
43	0	0	0	0	0	0	1	0	3	4	4%
44	0	0	0	0	0	0	1	1	2	4	4%
45	0	0	0	0	0	0	0	0	1	1	1%
46	0	0	0	0	0	0	0	0	2	2	2%
Total	**0**	**4**	**3**	**3**	**5**	**4**	**7**	**7**	**55**	**88**	**100%**
Percent	**0%**	**4%**	**3%**	**3%**	**6%**	**4%**	**8%**	**8%**	**63%**	**100%**	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis
Note: Figures may not add due to rounding

Exhibit 4-29
Outbound Liquid Bulk Vessel Trips Light Loaded, Savannah Harbor, 1996

Design Draft (ft)	Number of Feet Light Loaded									Total Trips	Percent
	0	1	2	3	4	5	6	7	8+		
38	0	0	0	1	2	2	2	0	21	28	32%
39	0	0	0	0	0	1	2	0	4	7	8%
40	0	0	0	0	0	0	0	5	19	24	27%
41	0	0	0	0	0	0	0	0	11	11	12%
42	0	0	0	0	0	0	0	0	7	7	8%
43	0	0	0	0	0	0	0	0	4	4	5%
44	0	0	0	0	0	0	0	0	4	4	5%
45	0	0	0	0	0	0	0	0	1	1	1%
46	0	0	0	0	0	0	0	0	2	2	2%
Total	**0**	**0**	**0**	**1**	**2**	**3**	**4**	**5**	**73**	**88**	**100%**
Percent	**0%**	**0%**	**0%**	**1%**	**2%**	**3%**	**4%**	**6%**	**83%**	**100%**	

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis
Note: Figures may not add due to rounding

Comparing the inbound and outbound statistics illustrates the ballast moves occurring for tankers. In 1996, 63 percent of the inbound tankers were light loaded eight feet or more, with the remainder spread relatively evenly from one to seven feet. However, on the outbound leg, light loading increased significantly, and was not distributed as evenly. Over 80 percent of the outbound tankers were light loaded eight feet or more with the remainder tapering off at three feet. Comparing tankers to bulkers, it should be noted that bulker light loading improved on the outbound voyage, whereas for tankers, the reverse is true.

4.5 Conclusions

The Savannah fleet of the future will be larger than under existing conditions as driven by growth in trade. The characteristics of the fleet depend, in part, on the available depth of channel. Specific conclusions from the analysis of world and Savannah fleet forecasts include:

- The world containership fleet will have a large number of deeper draft post-Panamax container vessels in service by 2050.
- Container vessel operators have introduced deeper draft vessels into port rotations with Savannah calls following previous Savannah Harbor channel deepening.

- The largest Post-Panamax vessels, are expected in Savannah in the first half of the study period. Fully loaded to their design draft, these largest vessels cannot be accommodated by the existing Savannah Harbor channel unless light loaded eight feet or more.
- Project alternatives of 46 to 50 feet can accommodate the largest fully loaded vessels in the forecast when transiting with the tide.
- Bulk cargo vessels will continue serve dedicated production facilities and distributions networks – with vessel size and fleet mix remaining constant over the study period.

5. MULTIPORT COMPETITIVE ANALYSIS

This chapter presents results of the multiport competitive analysis completed as part of the economic analysis. The multiport analysis evaluates the total transportation cost from origin to destination of shipments with alternative routings through various port gateways. Components of total transportation costs include overland, port and maritime costs. The analysis here evaluated routings to discretionary markets across trade lanes through Savannah and competitor ports.

5.1 Overview

In this chapter, Savannah is measured against its competitor ports in terms of landside (including port) infrastructure and competitive cost position. Competitive costs are the transportation costs for cargoes shipped to/from Savannah Harbor's competitive hinterlands through Savannah and competing ports to/from oversee trade partners. The objective of this multiport analysis is to assess the potential for the with project condition alternatives to affect traffic through competing ports (e.g., cargo diversion).

As one of North America's top tier container ports, Savannah has shown to be the choice of many shippers as the entry/exit point to the U.S. for their import and export goods. The evidence to support this conclusion is the volume of containers that shippers retain ocean carriers to ship through the Port each year. In order to be selected as the port of choice, each shipper (or their agent) must have decided to use Savannah over its competitor ports, given the combination of cost and service available from the Port. Inland distribution statistics from the *Journal of Commerce* Port Import/Export Reporting System (PIERS) data show that Savannah serves markets that overlap with other U.S. container ports. This chapter analyzes the effect that deepening the Savannah Harbor navigation channel may have on cargo volumes through competitor ports.

5.2 Infrastructure

The landside, port, and waterside infrastructure contributes significantly to the service and operational competitiveness of a container port. As trade volumes have increased, carriers have demanded modern equipment and adequate space to match their own significant investments in vessels and management systems. Correspondingly, as shippers pressure carriers for competitive rates with high quality service, carriers look to ports for commitment in providing required infrastructure to make low cost efficient service possible. During the last several decades, Savannah and competitor ports have addressed this need through investments in infrastructure to keep up with the increased size of trade and vessels. The infrastructure of Savannah and its competitor ports is an important measure of competitiveness, especially for containerized cargoes.

The competitive position of Savannah can be evaluated from both a financial and physical perspective. Though a port's financial investment in infrastructure to implement long-term development plans can demonstrate its commitment to staying competitive, it is the current physical dimensions of a port's infrastructure that impacts ocean carriers cost and operating practices on a day-to-day basis. Hence, the physical capability of a ports' infrastructure to its competitors was one dimension considered in determining the competitive position of Savannah. On the waterside, the characteristics of infrastructure that are most important are channel dimensions and berth capacity (indicated by number, length, and water depth). Within the port, the number and size of cranes, container storage capacity, and connections to inland transportation are important infrastructure measures. From the carriers perspective, more and bigger are better across all these measures. Potentially lower unit costs and or faster or more reliable service are implied from increases to these measures, potentially increasing a port's competitiveness.

The infrastructure characteristics are summarized for Savannah and it's competitor ports in Exhibit 5-1. Data has been aggregated across all container terminals in a port for a composite picture of each port as a whole.

Exhibit 5-1
Comparison of Port Infrastructure, South Atlantic Port Range, 1997

Infrastructure Characteristic	Savannah, GA	Wilmington, NC	Charleston, SC***	Hampton Roads, VA	Jacksonville, FL
Number of Terminals	2	1	3	3	2
Berths:					
- Number	7	9	9	11	9
- Total Berth Length (ft.)	8,700	6,768	7,940	12,250	8,737
Container Crane Number:					
- Total	12	5	18	18	9
- Port Panamax (≥145')	6	0	8	3	1
Available Water Depth (ft.):					
- Channel	42 → ?	40	40 → 45	50	38
- Berths	42 → ?	40	40	35 - 45	38
Paved Acreage (acres)	533*	100	451	872	739
Storage (TEU)	24,042	65,000**	26,000	48,268	5,100
No. of Class 1 Railroads	2	2	2	2	2

Source: Containerization International Yearbook, 1998
Note(*): Includes new Container Berth #7 currently under construction and does not include multiple general use berths located at Ocean Terminals.
Note (**): Includes unpaved acreage.
Note(***): Charleston is currently implementing plans to construct a fourth terminal at Daniel's Island, providing an additional 1,300 acres of terminal space, and 7,900 feet of berthing.

In general, the exhibit shows that the Port of Savannah is relatively comparable or advantaged to other ports in the South Atlantic. The Port of Savannah currently maintains the longest contiguous dock of ports in the South Atlantic, with most all facilities and capacity concentrated at its Garden City terminal. This compares favorably to most other South Atlantic ports whose container facilities are allocated over two or more facilities, and allows greater operational flexibility to carriers and terminal operators. Correspondingly, Savannah's Garden Facility terminal is comparable to or exceeds most South Atlantic container terminals in the number and length of berths (Savannah's average berth length is second highest in the region) available to vessels calling the port.

Examination of storage capacity shows that Savannah has sufficient capacity to handle the expected near term cargo growth without suffering decreases in transportation efficiencies. Together with Post-Panamax crane capabilities[9], comparable berth water depth, and adequate berth length, Savannah compares favorably to all by the Hampton Roads in supporting larger, deep draft Post-Panamax containerships currently being introduced into the world fleet.

Each port has hinterland access through two class I railroads – CSX and Norfolk Southern. Rail access and competition is important to insure competitive rail rates connect the port to inland markets cost effectively. If the proposed split of Conrail by these two railroads is approved, the service territory reachable via through service on one railroad from these ports will increase. One of the benefits to the public from the takeover, as argued by CSX and Norfolk Southern, may be reduced cost of north-south rail service in the eastern part of the United States. Since the split, and therefore the rate reductions are still hypothetical, the reduced cost benefits have not been included in the analysis. This situation is a potential uncertainty factor that may benefit South Atlantic ports, in terms of higher container volumes, at the expense of some North Atlantic ports.

5.3 Delivered Transportation Cost

Shippers make decisions based on service and more importantly, price (i.e., cost) of transportation. Thus, to determine the competitive position of routing cargoes through the Port of Savannah and its competitor ports, it is constructive to evaluate total transportation costs to shippers transporting cargoes between the Savannah hinterlands and various overseas trade regions. Total transportation cost is comprised of marine, port, and landside transport costs. Under various project deepening alternatives, maritime costs will vary according to operating and fleet deployment alternatives ocean carriers may consider. In this section, we develop each

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[9] *Post-Panamax cranes are required to support the efficient loading and unloading of wider beam Post-Panamax vessels.*

of the primary cost components contributing to total transportation cost in order to assess the competitive position of Savannah and other ports in serving various hinterland markets currently served by Savannah.

5.3.1 Methodology and Assumptions

For purposes of this competitive analysis, Savannah's major container port competitors are defined by the geographic areas (i.e., hinterland markets) that are currently served. Viable competitor ports can vary for each hinterland and oversees trade region (origin-destination) pair. For most trade routes, competitive ports are other container ports within the South Atlantic port range – including the ports of Hampton Roads, Charleston, and Jacksonville. As the distance from the South Atlantic coast increases however, the range of potential competitor ports expands to include ports within other coastal ranges, including west coast and North Atlantic ports. In our transportation cost analysis, Los Angeles and New York have been included as representative competitors from each of these port ranges.

Maritime, port, and landside transportation costs are detailed in Exhibit 5-5 through Exhibit 5-9. Each exhibit has imbedded into it several assumptions utilized to expedite the analysis. Later, the impact that total transportation cost plays in the competitive position of Savannah versus its competitors is analyzed in Section 5.3.2.

Maritime costs for containerized cargo were prepared by summing at-sea voyage costs of a containership voyage and maneuvering costs. Maritime cost for each container moved was calculated by dividing total maritime costs (in $/ton) for each voyage by the number of containers carried on the vessel. For purposes of this analysis, we utilize the operating cost structure of a sample 4000 TEU Panamax containership. Exhibit 5-2 details the total at-sea cost calculations for this containership on a route between Rotterdam and four U.S. South Atlantic ports.

Exhibit 5-2
Calculation of Total Voyage Costs, Rotterdam to U.S. South Atlantic
(1997 Dollars where indicated)

U.S. Port	Total Daily Cost at Sea	Distance (Miles)	Transit Days	Total Voyage Cost
Norfolk	$42,791	3,613	6.60	$282,536
Charleston	$42,791	3,869	7.07	$302,555
Savannah	$42,791	3,969	7.25	$310,375
Jacksonville	$42,791	4,018	7.34	$314,207

Source: Booz·Allen analysis

The exhibit show for this route, that total at-sea maritime transportation cost is correlated to port to post distance – with Norfolk being in closest proximity to Europe.

Daily At-sea costs were developed using the U.S. Army Corps of Engineers Institute for Water Resources Vessel Operating Costs.[10] The categories of vessel operating and capital costs, and their value for the sample container vessel are detailed in Exhibit 5-3.

Exhibit 5-3
Components of At-Sea Vessel Operating Costs
(1997 Dollars, 4000 TEU Containership)

Cost Category	Cost
Annual Capital Cost	$7,251,628
Crew Cost	$1,146,520
Lubes & Stores	$387,437
Maintenance & Repair	$664,439
Insurance	$496,721
Administration	$116,070
Daily Fuel at Sea	$14,040
Daily Fuel in Port	$778
Total Daily Cost at Sea	$42,791

Source: USACE IWR Vessel Operating Costs, Booz·Allen analysis

The sample vessel is representative to large containerships currently serving Savannah and its competitor ports. To determine cost per container or per cargo ton ($/TEU and $/ton respectively), additional assumptions addressing cargo capacity utilization, lifts per call, cargo tons per container, and cargo density were developed. These assumptions are presented in Exhibit 5-4.

10 *Operating and capital cost data are for a fully cellular Panamax containership currently serving the U.S. with a capacity of 4,024 TEU.*

Exhibit 5-4
Sample Containership Vessel Characteristics
(Used in Vessel Cost Calculation)

Vessel Characteristic	Value Used
Max. Capacity (TEUs)	4,024
Gross Registered Tons	51,299
Deadweight Tons	62,681
Net Registered Tons	22,189
Length Overall (Ft.)	949.8
Length Overall (m)	289
Beam (Ft.)	105.6
Design Draft (Ft.)	42.7
Depth (Ft.)	70.5
Max. Speed (Knots)	24.0
Avg. Speed (Knots)	22.8
Max. Capacity (Containers)	2515
Avg. TEU/Call	700
Avg. Containers/Call	438
Avg. TEUs/Container	1.6
Avg. Tons/TEU	9

Source: *Booz·Allen analysis*
Note: *Maximum TEU capacity is not the same as the maximum container capacity which accounts for a mix of twenty and forty foot equivalent unit containers (TEUs and FEUs respectively). Maximum capacity based on 80 percent utilization of maximum capacity.*

The calculation of the costs of vessel maneuvering were made from pilot estimates of the time it takes to transit a containership from the sea buoy to each ports' main container berth. Similar to the at-sea cost calculation earlier, the calculation of the maneuvering costs incorporates maneuvering cost, distance, transit time, and operating speed. are shown for the example vessel in Exhibit 5-5.

Exhibit 5-5
Calculation of Vessel Maneuvering Costs for Example Containership
(1997 Dollars)

U.S. Port	Nautical Miles	Hours	Speed (knots)	Cost
Norfolk	24.5	2.5	9.8	$4,457
Charleston	17.0	2.0	8.5	$3,566
Savannah	29.4	3.0	9.8	$5,349
Jacksonville	12.5	1.3	10.0	$2,229

Source: Booz·Allen analysis

The sum of the at-sea and maneuvering costs is the total maritime cost per voyage. From the total maritime cost, the maritime cost per container is calculated by dividing maritime cost by the containers per call. Total maritime cost and cost per container for our sample vessel are shown in Exhibit 5-6.

Exhibit 5-6
Comparison of Maritime Transportation Costs per Container
(1997 Dollars)

U.S. Port	Total Voyage	Maneuvering	Total Marine	Total per Container
Norfolk	$282,536	$4,457	$286,993	$656
Charleston	$302,555	$3,566	$306,121	$700
Savannah	$310,375	$5,349	$315,724	$722
Jacksonville	$314,207	$2,229	$316,435	$723

Source: Booz·Allen analysis

The method to calculate maritime costs for vessels on other routes is identical except for those on Southeast Asia, Indian Subcontinent, West Coast of Latin America, and Middle Eastern routes. These routes require a vessel to transit either the Panama Canal or Suez Canal, thus incurring additional cost. Similar to maritime costs developed earlier, Exhibits 5-7 through 5-9 show maritime cost calculations for the same vessel operating on a route between Singapore and select U.S. South Atlantic, North Atlantic and West Coast container ports.

Exhibit 5-7
Calculation of Voyage Costs, Singapore to U.S. Ports
(1997 Dollars)

U.S. Port	Total Daily Cost at Sea	Nautical Miles	Computed Days	Total Voyage Cost
Los Angeles	$42,791	7,867	14.38	$615,197
New York(Pan)	$42,791	12,523	22.89	$979,295
New York(Suez)	$42,791	10,164	18.57	$794,822
Norfolk(Pan)	$42,791	12,327	22.53	$963,968
Norfolk(Suez)	$42,791	10,311	18.84	$806,318
Charleston(Pan)	$42,791	12,112	22.13	$947,155
Charleston(Suez)	$42,791	10,564	19.31	$826,102
Savannah(Pan)	$42,791	12,111	22.13	$947,077
Savannah(Suez)	$42,791	10,664	19.49	$833,922
Jacksonville(Pan)	$42,791	12,064	22.05	$943,402
Jacksonville(Suez)	$42,791	10,710	19.57	$837,519

Source: Booz·Allen analysis

Vessel operating cost and cargo loading assumptions are the same as in the Rotterdam route example, so that information is not repeated here. The calculation of maneuvering time was done using the same methodology as for the Rotterdam route, and included New York and Los Angeles.

Exhibit 5-8
Calculation of Total Marine Costs per Container, Singapore to U.S. Ports
(1997 Dollars)

U.S. Port	Total Voyage Cost	Canal Transit Cost	Maneuvering Cost	Total Marine Cost	Marine Cost per Container
Los Angeles	$615,197	$0	$5,349	$620,546	$1,418
New York (Panama)	$979,295	$179,128	$4,457	$1,162,881	$2,658
New York (Suez)	$794,822	$163,384	$4,457	$962,664	$2,200
Norfolk (Panama)	$963,968	$179,128	$4,457	$1,147,554	$2,623
Norfolk (Suez)	$806,318	$163,384	$4,457	$974,159	$2,227
Charleston(Panama)	$947,155	$179,128	$3,566	$1,129,849	$2,583
Charleston(Suez)	$826,102	$163,384	$3,566	$993,052	$2,270
Savannah (Panama)	$947,077	$179,128	$5,349	$1,131,554	$2,586
Savannah (Suez)	$833,922	$163,384	$5,349	$1,002,655	$2,292
Jacksonville (Panama)	$943,402	$179,128	$2,229	$1,124,758	$2,571
Jacksonville (Suez)	$837,519	$163,384	$2,229	$1,003,132	$2,293

Source: Booz·Allen analysis

In addition to marine transportation costs, port cost must be considered when evaluating total transportation cost. Port costs include: pilotage, tug, dockage, wharfage, stevedoring, terminal operations, and crane rental (equipment) costs. The costs for our example vessel at each of several U.S. ports are summarized in Exhibit 5-9. Panama and Suez Canal tolls reflect the net tolls paid by vessels on these respective routes. The port costs per container are calculated by dividing the total port costs by the average number of containers handled per call.

Exhibit 5-9
Port Cost Components per Container for Selected U.S. Ports
(1997 Dollars, Based on 4000 TEU Vessel)

Port Cost Item	Los Angeles	New York	Norfolk	Charleston	Savannah	Jacksonville
Pilotage	$1,894	$4,197	$2,975	$2,551	$2,831	$2,757
Tug Assist	$1,200	$5,116	$6,435	$3,817	$3,950	$3,939
Docking Pilot	$0	$531	$627	$291	$311	$228
Dockage (24 hours)	$5,336	$6,886	$6,459	$5,889	$9,450	$6,544
Wharfage Cost	$33,250	$12,877	$12,726	$12,877	$12,877	$12,777
Stevedoring	$49,466	$87,236	$38,916	$33,143	$32,476	$35,254
Terminal Operations	$15,979	$30,876	$23,616	$19,603	$21,601	$19,603
Crane Rental	$10,223	$13,452	$11,838	$9,741	$9,596	$9,352
Total Port Cost	$117,348	$161,172	$103,592	$87,913	$93,092	$90,454
Cost per Container	$268	$368	$237	$201	$213	$207

Source: Booz·Allen analysis of example 4000 TEU vessel; Per container costs calculated for average capacity utilization of the vessel

Lastly, landside intermodal costs were calculated in order to determine total transportation costs. Containers are transported either by truck or intermodal rail service between ports and their hinterland markets. Both Cost and service time are considered by shippers in selecting overland mode choice, but length of haul is a critical factor which typically drives rates, service, and shipper decisions. For purposes of our analysis, containers traveling greater than 500 miles are assumed to move via intermodal rail. All shorter trips are assumed to move by truck. To illustrate mode choice and cost differences between different modes of transport, two sample hinterland markets were chosen for presentation. Atlanta, Georgia was chosen as the regional representative market, and Memphis, Tennessee as a longer distance, Midwest hinterland market commonly served by several U.S. ports. Rail and truck distances were taken from truck and rail industry mileage guides reflecting actual distances used in industry to set truck and rail rates. Truck and rail rates were developed from a sample of actual rate quotes provided by industry. In the following two exhibits, relative landside transportation costs for containers routing from

Savannah and its competitor ports to the two inland markets are presented. The landside costs include port drayage, landside transportation, and local delivery charges.

Exhibit 5-10 displays the comparative landside costs for containers routed to or from Atlanta via Savannah and its competitor ports. This market is close to many South Atlantic ports and favors landside transportation by a truck from Savannah, Charleston, and Jacksonville. Though rail rates per mile are usually less expensive than truck rates, in cases where truck rates are observed to be less, the lower rate was chosen as a better representation of long run average landside costs for this route. In Exhibit 5-10, this applies to the landside cost per container between Norfolk and Atlanta.

Exhibit 5-10
Landside Intermodal Costs per Container,
Selected U.S. Ports to Atlanta, GA
(1997 Dollars)

U.S. Port	Truck Distance	Truck $/Mile	Truck Cost	Rail Distance	Rail $/Mile	Rail Cost	Mode Choice	Rate $/Cont.
Los Angeles	2,154	$1.01	$2,176	2,285	$0.47	$1,070	Rail	$1,070
New York	852	$1.02	$869	862	$0.78	$670	Rail	$670
Norfolk	535	$1.03	$551	658	$0.87	$572	Rail	$551
Charleston	285	$1.03	$294	383	$0.94	$360	Truck	$294
Savannah	243	$1.03	$250	258	*	*	Truck	$250
Jacksonville	307	$1.03	$316	350	*	*	Truck	$316

Source: Booz·Allen analysis
Note(*): Not available or not applicable

In comparison to the above, rail is the preferred mode of landside transport in all port-city pairs. Exhibit 5-11 presents the results of the landside transportation cost analysis between various U.S. ports and Memphis.

Exhibit 5-11
Landside Intermodal Costs per Container
Selected U.S. Ports to Memphis, TN
(1997 Dollars)

U.S. Port	Truck Distance	Truck $/Mile	Truck Cost	Rail Distance	Rail $/Mile	Rail Cost	Mode Choice	Rate $/Cont.
Los Angeles	1,797	$1.01	$1,815	1,942	$0.59	$1,150	Rail	$1,150
New York	1,100	$1.02	$1,122	1,153	$0.75	$870	Rail	$870
Norfolk	867	$1.03	$893	1,061	$0.49	$520	Rail	$520
Charleston	650	$1.03	$670	802	$0.66	$530	Rail	$530
Savannah	608	$1.03	$626	678	$0.75	$509	Rail	$509
Jacksonville	668	$1.03	$688	691	$0.75	$518	Rail	$518

Source: Booz·Allen analysis

Total transportation cost was then developed by combining marine, port, and landside transportation costs for each hinterland city, port, trade region combination. For the Rotterdam trade, Exhibit 5-12 and Exhibit 5-13 presents a summary of total transportation cost to serve the Atlanta and Rotterdam markets.

Exhibit 5-12
Total Transportation Costs per Container,
Rotterdam to Atlanta, via Selected U.S. Ports
(1997 Dollars)

South Atlantic Port	Marine	Port	Landside	Total
Norfolk	$656	$237	$551	$1,444
Charleston	$700	$201	$294	$1,194
Savannah	$722	$213	$250	$1,185
Jacksonville	$723	$207	$316	$1,246

Source: Booz·Allen analysis

Exhibit 5-13
Total Transportation Costs per Container,
Rotterdam to Memphis, via Selected U.S. Ports
(1997 Dollars)

South Atlantic Port	Marine	Port	Landside	Total
Norfolk	$656	$237	$520	$1,413
Charleston	$700	$201	$530	$1,431
Savannah	$722	$213	$509	$1,443
Jacksonville	$723	$207	$518	$1,448

Source: Booz·Allen analysis

The exhibits highlight that for the Atlanta market, Charleston and Savannah are significantly advantaged to Norfolk and Jacksonville. On the other hand, all ports are found to be cost competitive in serving Memphis, with Norfolk having the lowest total transportation cost.

Similar calculations were completed for other trade routes, including Asia which requires vessels calling directly to East Coast ports to transit either the Panama Canal or Suez Canal. Additionally, transportation costs were developed for the mini-landbridge option which routes containers through Los Angeles. Exhibit 5-14 and Exhibit 5-15 presents total transportation cost for an Asian trade route between Singapore and the Atlanta and Memphis markets.

Exhibit 5-14
Total Transportation Costs per Container
Singapore to Atlanta, via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost
Los Angeles	$1,418	$268	$1,070	$2,757
New York (Panama)	$2,658	$368	$670	$3,696
New York (Suez)	$2,200	$368	$670	$3,239
Norfolk (Panama)	$2,623	$237	$551	$3,411
Norfolk (Suez)	$2,227	$237	$551	$3,014
Charleston (Panama)	$2,583	$201	$294	$3,077
Charleston (Suez)	$2,270	$201	$294	$2,764
Savannah (Panama)	$2,586	$213	$250	$3,049
Savannah (Suez)	$2,292	$213	$250	$2,755
Jacksonville (Panama)	$2,571	$207	$316	$3,094
Jacksonville (Suez)	$2,293	$207	$316	$2,816

Source: Booz·Allen analysis

Exhibit 5-15
Total Transportation Costs per Container,
Singapore to Memphis, via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost
Los Angeles	$1,418	$268	$1,150	$2,837
New York (Panama)	$2,658	$368	$870	$3,896
New York (Suez)	$2,200	$368	$870	$3,439
Norfolk (Panama)	$2,623	$237	$520	$3,380
Norfolk (Suez)	$2,227	$237	$520	$2,983
Charleston (Panama)	$2,583	$201	$530	$3,313
Charleston (Suez)	$2,270	$201	$530	$3,001
Savannah (Panama)	$2,586	$213	$509	$3,308
Savannah (Suez)	$2,292	$213	$509	$3,013
Jacksonville (Panama)	$2,571	$207	$518	$3,296
Jacksonville (Suez)	$2,293	$207	$518	$3,018

Source: Booz·Allen analysis

These transportation costs are compared in the following section.

5.3.2 Savannah and Competitor Port Comparison

In recent years, each container port in the South Atlantic has engaged in major container handling capacity development to service growing trade volumes. The Ports of Hampton Roads, Charleston, and Savannah have each added significant new facilities. In each port, additional capacity expansion is planned to meet projected growth in container traffic in the future.

South Atlantic ports are well positioned to increase their share of the wider U.S. market. While South Atlantic ports already dominate the Southeastern region of the U.S., these ports are also cost competitive in serving many segments of the important Midwestern market. The hinterland region served by Savannah extends throughout the Southeastern U.S. and inland to the Midwest. The hinterland markets for which Savannah competes with other ports includes distant hinterland markets in addition to relatively close markets such as Atlanta. Within Georgia, Savannah competes directly with Charleston for containerized cargo imports and exports. South Atlantic ports have enjoyed stronger growth than North Atlantic ports in recent years partly because they are better positioned to serve this wide and growing geographic market.

Exhibits 5-16 through 5-18 present the rankings of total transportation costs for competitive ports to service the sample inland markets. For selected competitor ports, including Savannah, transportation costs are compared for a container cargo shipment to Atlanta and Memphis from the Asian port of Singapore and the European port of Rotterdam. For the Singapore shipments, cargo transportation costs were calculated for both Suez and Panama Canal routed transits and the lower cost option then selected for further comparison. For the Asian cargo, the cost of the mini-landbridge option through Los Angeles is shown as is a routing through New York. For Savannah, Exhibits 5-16 and 5-18 show that total transportation through the Panama Canal are higher.

In the future as larger vessels serve each trade, maritime costs per container as a percent of total transportation costs, will tend to decrease. The exception would include situations where Post-Panamax vessels via the Suez Canal replace Panamax vessels on shorter routes through the Panama Canal. Over time, total transportation cost will favor those routings with lower overland costs, if the competing ports are served by equivalent sized vessels.

For Southeastern regional markets such as Atlanta, Savannah is cost competitive on any overseas route. In Exhibit 5-16, where Asian cargo from Singapore is carried on a Pendulum service through the Suez Canal, Savannah is $2 less in total cost than the next lowest cost routing through Los Angeles. Since Savannah's cost is within 0.1 percent of the cost through Los Angeles, they are essentially equivalent with no cost advantage or disadvantage to either port.

Exhibit 5-16
Comparison of Total Transportation Costs per Container,
Singapore to Atlanta via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost	Rank
Los Angeles	$1,418	$268	$1,070	$2,757	2
New York	$2,200	$368	$670	$3,238	7
Norfolk	$2,227	$237	$551	$3,014	5
Charleston	$2,270	$201	$294	$2,764	3
Savannah(Panama)	$2,586	$213	$250	$3,049	6
Savannah(Suez)	$2,292	$213	$250	$2,755	1
Jacksonville	$2,293	$207	$316	$2,816	4

Source: Booz·Allen analysis; numbers may not add due to rounding.

For shorter trade routes, such as a North-Atlantic trade connecting Rotterdam with Atlanta, Exhibit 5-17 illustrates port's cost advantaged to its competition. This is primarily due to its significant landside cost advantage to the Atlanta market. The magnitude of the cost advantage is small, however, so the advantage is not likely to divert cargo from Savannah's competitor ports. For such local markets, Savannah can be characterized as cost competitive with most of the Southeast.

Exhibit 5-17
Comparison of Total Transportation Costs per Container,
Rotterdam to Atlanta, via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost	Rank
Norfolk	$656	$237	$551	$1,444	4
Charleston	$700	$201	$294	$1,195	2
Savannah	$722	$213	$250	$1,185	1
Jacksonville	$723	$207	$316	$1,246	3

Source: Booz·Allen analysis

Savannah's cost competitiveness to serve Midwest hinterland regions depends on the inland distance and availability of rail intermodal service connecting Savannah an competitor ports. For Asian cargo destined to or originating from the Memphis hinterland market, Savannah's is not cost advantaged as found in its ability to serve markets in closer proximity to the Port. Transportation cost figures in Exhibit 5-18 show that despite having the highest landside costs, the significantly cheaper ocean cost of the mini-land bridge service through California contributes to the continuation of the west coast's competitive cost position – which is 6 percent below that of Savannah's.

Exhibit 5-18
Comparison of Total Transportation Costs per Container,
Singapore to Memphis, via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost	Rank
Los Angeles	$1,418	$268	$1,150	$2,837	1
New York	$2,200	$368	$870	$3,438	7
Norfolk	$2,227	$237	$520	$2,983	2
Charleston	$2,270	$201	$530	$3,001	3
Savannah(Panama)	$2,586	$213	$509	$3,308	6
Savannah(Suez)	$2,292	$213	$509	$3,014	4
Jacksonville	$2,293	$207	$518	$3,018	5

Source: Booz·Allen analysis

For the North-Atlantic trade route between Rotterdam and the Memphis hinterland, Savannah is competitive with most of its competitors. As shown in Exhibit 5-19, Savannah has the lowest landside costs and has the third lowest cost routing. Total transportation cost through Norfolk is $30 less than Savannah, but is within 2 percent of total cost and thus, is considered equivalent for purposes of comparison given expected elasticities of demand for container transportation.

Exhibit 5-19
Comparison of Total Transportation Costs per Container,
Rotterdam to Memphis, via Selected U.S. Ports
(1997 Dollars)

U.S. Port	Marine Cost	Port Cost	Landside Cost	Total Cost	Rank
Norfolk	$656	$237	$520	$1,413	1
Charleston	$700	$201	$530	$1,431	2
Savannah	$722	$213	$509	$1,443	3
Jacksonville	$723	$207	$518	$1,448	4

Source: Booz·Allen analysis

Each of these examples demonstrates the competitiveness of the transportation market and the inability of one transportation cost component to positively or negatively impact total transportation cost and a ports competitive position. in serving various hinterland markets. Importantly, the analysis found that under different without and with project alternatives, maritime transportation cost as a percent of total transportation cost will likely not be impacted such that the ports competitive position to serve various hinterland markets will not be impacted.

5.4 Summary and Conclusions

The examination of competitive infrastructure and cost factors shows that today, Savannah is a competitive port in the context of both maritime infrastructure and the total transportation costs, and that it does not incur any significant disadvantage or advantage over its port competitors. More important, with current facilities and costs, Savannah is not in a position to gain significant advantages versus its competitor ports by providing either superior infrastructure or significantly lower maritime transportation costs under various with project deepening scenarios.

6. NATIONAL ECONOMIC DEVELOPMENT BENEFIT-COST ANALYSIS

6.1 Overview

This chapter presents benefit-cost analysis and results for determining the National Economic Development (NED) plan for the Savannah Harbor Expansion Project. The benefit-cost analysis is the final step in the economic analysis of the feasibility study, following commodity forecasting and fleet forecasting. Those forecasts were presented in Chapters 3 and 4 respectively.

6.2 Methodology and Assumptions

In the benefit-cost analysis, a relatively simple comparison is made between the aggregate of annual benefits from each channel deepening alternative to the aggregate of annual project costs. The benefits and costs are determined for the baseline without project condition, and several with project condition channel deepening scenarios. The difference between the benefits and costs equals the net benefits.

Economic benefits of harbor deepening on a national level are accrued through lower transportation costs and hence lower prices for the goods transported. The total cost of transporting the projected traffic over the study period was computed for the without project condition (42-foot channel depth), and for 44-, 45-, 46-, 47-, 48-, and 50-foot with project condition channel deepening alternatives.[11] Benefits were determined for both containerships and liquid and dry bulk cargo vessels[12]. Total net transportation costs includes vessel operating costs (benefit), tidal delays (cost), and ship beam-channel width delay costs due to one-way traffic in the channel (cost). Each of these are discussed in turn.

6.2.1 Vessel Transportation Costs

Total vessel operating costs for projected traffic over the study period were computed for the 42-foot without project condition channel, and the alternative with project conditions. As shown in the fleet forecasts in Chapter 4, the distribution of the deep draft vessels is expected to vary with the alternative projects. Consequently, the transportation costs will vary and are reduced with an higher distribution of deep draft vessels. The reduction in transportation costs produces benefits for the alternative projects over the without project condition.

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11 *Initial analysis included determination of benefits for alternative projects at 2-foot increments between 44 and 50 feet.*

12 *Following preliminary NED analysis, the benefits attributed to bulk vessels were included in the benefit-cost analysis. Subsequent discussion with the USACOE prompted removal of those benefits since non-containership berths at the Port of Savannah will not be deepened to accommodate vessels sailing at deeper drafts.*

Vessel transportation costs were calculated for containerships, in addition to liquid and dry bulk vessels. The methodology for calculating the transportation costs of containerships, and liquid and dry bulk vessels is essentially identical. Vessel operating costs were developed for each ship type's draft category using the *National Economic Development Procedures Manual for Deep Draft Navigation* ("NED guidelines"), the IWRs (Institute for Water Resources) FY97/98 memorandum on Vessel Operating Costs, and average vessel deadweights. Hourly operating costs were developed on a per ton-mile basis for each of three trade lanes[13] considered for containerized tonnage and six trade lanes[14] considered for non-containerized (i.e., bulk) tonnage. The methodology utilized to calculate annual transportation costs is as follows:

Total annual transportation costs for each draft increment

= trade route cargo tons

x trade route distance

x vessel operating costs per ton-mile

x fleet distribution by draft increment

x light loading distribution by draft increment

Each of the above components utilized to calculate annual transportation costs is addressed in turn.

6.2.1.1 Trade Route Cargo Tonnage

Trade route cargo tonnage was taken from the trade forecast as described in Chapter 3 of this Appendix. The reader is referred to that chapter for further details.

6.2.1.2 Trade Route Distances

Sample trade routes, including multiple ports of call, for containership operations were developed, to act as representative service patterns for containership operators. These routes are based on actual carrier services currently provided and expected future services of carriers over the study period. Distances between ports for each trade route were calculated and summed to determine total trade distances. Trade routes distances for bulk cargo operations were determined by the type of commodity being moved and the origin or destination of the commodity. Instead of using actual ports, route distances from Table IV-6 of the NED Guidelines were used. Exhibit 6-1 presents trade route distances of services including the Port of Savannah.

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13 *Three trade lanes include: Asia-USEC, Europe-USEC, and South America-USEC.*

14 *Six trade lanes include Africa-USEC, Asia-USEC, Caribbean-USEC, Europe-USEC, Canada-USEC, and South America-USEC.*

Exhibit 6-1
One Way Route Distances for Containerized and Non-Containerized Cargoes (Nautical Miles)

Liner Routes	Route Distances	Bulk Routes	Route Distances
Far East	11,353	Africa	5,000
Europe	5,271	Asia	9,500
South America	7,633	Caribbean	1,750
		Europe	3,500
		North America	1,210
		South America	3,875

Source: U.S. Government Publication H.O. 151, USACE IWR Report 91-R-13, Booz·Allen analysis

These distances are used in calculating the costs per ton-mile ($/ton-mile) values used in the benefit-cost analysis. Actual services to and from the U.S. to the overseas destinations have longer or shorter trade route distances. However, sensitivity analysis results show insignificant effects on the final benefit results. Exhibit 6-2 presents several itineraries of major liner operators serving the Port of Savannah.

Exhibit 6-2
Itineraries of Major Container Shipping Lines Serving Savannah

Shipping Line	Trade Area	Ports	Frequency
Hanjin/Cho Yang/DSR Senator	Asia-Mediterranean-USEC (AMA Service)	New York, Norfolk, (Wilmington), Savannah, Valencia, La Spezia, Gioia Tauro, Jeddah, Khor Fakkan, Singapore, Pusan, Kaoshiung, Hong Kong, Singapore, Jeddah, Gioia Tauro, La Spezia, Fos, Valencia, New York	Weekly
	Asia - USWC - USEC - N. Europe (AWE all water pendulum)	Hong Kong, Kaoshiung, Pusan, Oakland, Manzanillo (Mex.), Manzanillo (Pan.), Savannah, Norfolk, New York, Felixstowe, Bremerhaven, Rotterdam, Le Havre, New York, Norfolk, Wilmington, Savannah, Manzanillo (Pan.), Manzanillo (Mex.), Long Beach, Yokohama, Kove, Pusan, Hong Kong	Weekly
	USEC - ECSA (NSA)	Norfolk, New York, Savannah, Miami, Fortaleza, Rio de Janeiro, Santos, Buenos Aires, Rio Grande, Itajai, Santos, Rio de Janeiro, Fortaleza, Norfolk	Every 10 days
Zim	USEC - ECSA	New York, Norfolk, Savannah, Miami, Kingston, Buenos Aires, Montevideo, Rio Grande, Itajai, Santos, Rio de Janeiro, Ilheus, Kingston	Weekly
	Westbound Round-the-World	Haifa, Piraeus, Livorno, Barcelona, Halifax, New York, Savannah, Kingston, Long Beach, Shekou, Hong Kong	Weekly
	Eastbound Round-the-World	Shekou, Hong Kong, Keelung, Pusan, Osaka, Yokohama, Long Beach, Kingston, Savannah, New York, Halifax, Barcelona, Haifa	Weekly
Hapag-Lloyd	N. Europe - N. America	Thamesport, Bremerhaven, Rotterdam, Halifax, New York, Norfolk, Savannah, Los Angeles, Oakland	Weekly
	North America - Far East	Oakland, Yokohama, Kobe, Kaoshiung, Hong Kong, Kobe, Yokohama, Seattle, Oakland	Weekly
Empresa de Navagacao Alianca/ Columbus	USEC - ECSA	Rio de Janeiro, Santos, Buenos Aires, Itajai, Fortaleza, New York, Baltimore, Norfolk, Savannah, Miami	Weekly
P&O Nedlloyd	N. Europe - North America - Asia	Antwerpen, Thamesport, Bremerhaven, Rotterdam, Halifax, New York, Norfolk, Savannah, Cristobal, Los Angeles, Oakland, Yokohama, Kobe, Kaoshiung, Hong Kong, Kobe, Nagoya	Weekly
CGM	Round the-World	Marseilles, Valencia, Antwerpen, Dunkirk, Le Havre, Savannah, Cristobal, Papeete, Noumea, Brisbane, Port Botany, Melbourne, Tanjung Priok, Singapore, Colombo, Genoa, Marseilles	Every 16 days
Croatia Line	Europe/Med - USEC	Port Said, Trieste, Koper, Rijeka, Naples, Livorno, Genoa, Barcelona, Lisbon, New York, Baltimore, Norfolk, Savannah, Barcelona, Livorno, Port Said	Every 20 days
	Europe/Med - USEC	New York, Norfolk, Savannah, Valencia, La Spezia, Fos, Port Said, Naples	Weekly

Source: Carrier schedule information, Containerization International Yearbook, 1998

6.2.1.3 Vessel Operating Costs per Ton-Mile

Vessel operating costs per ton-mile ($/ton-mile) and vessel operating costs per hour at-sea and in-port ($/hour), were calculated for containerships, tankers, and dry bulk vessels, based on information detailed in the USACE FY97/98 Vessel Operating Costs Memorandum, provided by the IWR. The memorandum contains operating costs for a range of vessel sizes for tankers, dry bulkers, containerships, and general cargo vessels, both for foreign and US flag vessels. Foreign flag vessel operating costs were regressed by draft to determine the At-Sea and In-Port hourly operating costs.

In addition, the IWR memorandum includes regression equations for vessel length, beam, draft, tons per inch immersion (TPI), horsepower, speed, and fuel consumption. The speed and TPI equations were used to determine voyage duration and potential cargo carrying capacity of vessels when operating in a light loaded condition.

6.2.1.4 Fleet Distribution

The distribution of the fleet by draft was developed using a fleet forecast model, integrating cargo tonnage forecasts for the world and the Port of Savannah, and forecasts of past and current containership fleet usage in the world and Savannah. The forecast provides a fleet distribution for the without project condition and for each with project condition alternatives. Details on the methodology and results are presented in Chapter 4 of this Appendix.

6.2.1.5 Light Loading Distribution

Vessel light loading occurs when ships are loaded to drafts that are less than the vessel's maximum design draft. Light loading occurs due to several factors including cargo planning strategies, vessel schedule, and the mixture of cargoes on board. Most tanker and bulker operations involve dedicated services between a handful of ports, where their cargo are of fixed density or type. Port constraints, such as water depth, and the amount of cargo carried by the vessels are the main cause of light loading of liquid and dry bulk vessels.

Containership operations involves the transportation of a variety of cargoes, both in tonnage, density, cargo mixture, and also the repositioning of empty TEUs to a number of ports. This results in containerships experiencing a significant range of operating drafts above or below their design drafts during the course of their service life. In addition, liner operators load vessels not only to the draft limit of the current port, but also must consider draft limits of subsequent ports of call or the Panama Canal. Inclusion of light loading in the analysis also compensates for any restrictions caused by other ports on vessel rotations.

Light loading decreases the cargo carrying capacity of vessels. To account for light loading, cargo deadweight for each vessel size was adjusted, and a cargo deadweight matrix for each vessel size was developed. These cargo adjustments were calculated using the deadweight tonnage per vessel draft and TPI values determined from the IWR Vessel Operating Costs memorandum. In turn, cargo deadweights for each foot of light loading were used to develop a matrix of transportation costs per ton-mile ($/ton-mile) for each trade lane and vessel size and loading characteristic.

Curves representing the light loading distribution of containerships, tankers, and bulkers, by design draft, were developed from vessel call statistics for the Port of Savannah. The number of vessel arrival and departures, by design draft and calling draft, is presented in Chapter 4 of this Appendix. The distributions of these vessel calls are presented in Exhibit 6-3 through 6-5.

Exhibit 6-3
Light Loading Distribution of Containerships
Calling the Port of Savannah, 1996

Design Draft (ft)	Number of Feet Light Loaded								
	0	1	2	3	4	5	6	7	8+
<=30	48.6%	11.1%	7.6%	18.8%	9.7%	2.1%	1.4%	0.0%	0.7%
31	35.0	8.3	8.3	19.4	13.1	6.3	4.9	2.4	2.4
32	3.2	1.6	9.7	21.0	21.0	16.1	12.9	8.1	6.5
33	3.4	2.5	7.6	14.4	16.1	17.8	10.2	6.8	21.2
34	5.4	1.5	13.8	21.5	16.9	13.8	13.1	6.9	6.9
35	12.5	20.0	22.5	15.0	5.0	15.0	2.5	2.5	5.0
36	30.3	17.1	21.1	11.8	5.3	5.3	3.9	2.6	2.6
37	0.0	2.9	0.0	8.8	5.9	26.5	22.1	23.5	10.3
38	15.0	14.2	13.3	10.0	15.8	14.2	6.7	6.7	4.2
39	3.3	7.5	10.0	5.0	14.2	20.8	10.8	17.5	10.8
40	0.9	0.9	3.4	7.3	11.2	12.5	14.7	13.8	35.3
41	0.5	0.5	2.4	5.9	8.3	9.0	14.6	13.4	45.5
42	0.0	0.0	1.0	4.2	4.7	4.7	14.6	13.0	57.8
43	0.0	0.0	0.0	0.0	4.0	12.0	8.0	12.0	64.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

Exhibit 6-3 illustrates two aspects of the containership fleet using the Port. First, no containerships with design drafts greater than 43 feet called the Port in 1996, indicating the constraints imposed on ship operations by the current channel depth. Second, the deeper the design draft of a vessel, the higher the probability that the vessel is light loaded upwards of four feet or more.

Exhibit 6-4
Light Loading Distribution of Liquid Bulk Vessels
Calling the Port of Savannah, 1996

Design Draft (ft)	Number of Feet Light Loaded								
	0	1	2	3	4	5	6	7	8+
<30	39.3	13.1	13.1	8.2	3.3	3.3	8.2	6.6	4.9
30	9.5	14.3	28.6	9.5	9.5	19.0	4.8	4.8	0.0
31	9.5	14.3	28.6	9.5	9.5	19.0	4.8	4.8	0.0
32	9.5	14.3	28.6	9.5	9.5	19.0	4.8	4.8	0.0
33	64.3	0.0	0.0	0.0	0.0	0.0	7.1	0.0	28.6
34	0.0	0.0	0.0	0.0	25.0	50.0	25.0	0.0	0.0
35	22.2	0.0	0.0	11.1	11.1	11.1	0.0	0.0	44.4
36	0.0	14.3	0.0	0.0	14.3	14.3	0.0	0.0	57.1
37	6.1	8.2	6.1	8.2	10.2	6.1	8.2	0.0	46.9
38	0.0	14.3	7.1	0.0	10.7	14.3	10.7	3.6	39.3
39	0.0	0.0	10.0	14.3	14.3	0.0	28.6	0.0	42.9
40	0.0	0.0	4.2	8.3	0.0	0.0	0.0	25.0	62.5
41	0.0	0.0	0.0	0.0	18.2	0.0	27.3	9.1	45.5
42	0.0	0.0	0.0	0.0	0.0	14.3	14.3	14.3	57.1
43	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0
44	0.0	0.0	0.0	0.0	0.0	0.0	25.0	25.0	50.0
>44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

Exhibit 6-5
Light Loading Distribution of Dry Bulk Vessels
Calling the Port of Savannah, 1996

Design Draft (ft)	Number of Feet Light Loaded								
	0	1	2	3	4	5	6	7	8+
<30	38.2%	8.8%	0.0%	14.7%	2.9%	17.6%	2.9%	2.9%	11.8%
30	33.3	50.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
31	62.5	12.5	12.5	0.0	0.0	0.0	0.0	0.0	12.5
32	34.3	45.7	0.0	2.9	0.0	0.0	0.0	5.7	11.4
33	18.8	9.4	3.1	9.4	9.4	3.1	12.5	9.4	25.0
34	25.0	4.2	0.0	8.3	8.3	4.2	4.2	0.0	45.8
35	21.1	5.3	2.6	10.5	18.4	0.0	7.9	10.5	23.7
36	7.5	11.3	11.3	3.8	1.9	1.9	0.0	3.8	58.5
37	10.0	5.0	10.0	5.0	0.0	0.0	10.0	5.0	55.0
38	5.3	36.8	10.5	5.3	5.3	5.3	0.0	0.0	31.6
39	0.0	0.0	10.0	0.0	10.0	20.0	0.0	0.0	60.0
40	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	83.3
41	0.0	0.0	8.3	8.3	58.3	0.0	8.3	8.3	8.3
42	0.0	0.0	0.0	0.0	22.2	0.0	11.1	0.0	66.7
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
>44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Source: Georgia Ports Authority, Savannah Pilots Association, Booz·Allen analysis

These last two exhibits show that the current Savannah Harbor navigation channel does not provide sufficient depth for liquid and dry bulk vessel managers to operate their vessels at optimum/maximum drafts or cargo loads.

The distributions presented above are used with the average of the At-Sea and In-Port vessel operating costs to determine a "weighted" cost per ton-mile for each vessel draft class.

6.2.1.5.1 Without Project

For without project conditions, vessels are expected to maintain their current light loading condition, that is, the vessel light loading distribution will remain constant through the study period.

6.2.1.5.2 With Project

For with project conditions, Post-Panamax containerships and deep draft tankers and dry bulk vessels with design drafts greater than 42 feet, are expected to call Savannah more frequently due to the availability of deeper water and the corresponding reduction in operating restrictions.

For each with project condition scenario, it was assumed that a number of deep draft vessels would transition from constrained status to unconstrained status. Unconstrained operations for a vessel occurs when available water depth exceeds a vessel's operating draft plus four feet for under keel clearance. For each alternative project condition, it was assumed that constrained vessels transitioning to unconstrained status would take on the operating characteristics of unconstrained 38 foot draft vessels under without project conditions.

As in the without project condition, light loading distributions within each vessel class were combined with the cost per ton-mile values to determine a weighted cost per ton-mile for each vessel draft class.

6.2.1.6 Vessel Operating Cost Results

Using the equation it component variables presented above, the vessel operating costs for containerships and bulk cargo vessels was calculated, for each alternative deepening project and for the 42-foot without project condition. The results of these calculations for containerships are presented Exhibit 6-6.

Exhibit 6-6
Annual Transportation Costs for Containerships
Calling the Port of Savannah, 2000 - 2050
(1998 Dollars in Thousands)

Project	Forecast Period					
	2000	2010	2020	2030	2040	2050
42′	$113,304	$198,204	$350,309	$566,887	$878,276	$1,315,807
45′	$101,516	$177,385	$314,145	$509,590	$790,919	$1,186,145
46′	$98,268	$171,850	$303,996	$492,879	$764,458	$1,145,782
47′	$97,118	$169,718	$299,757	$485,203	$751,491	$1,125,334
48′	$96,992	$165,285	$286,227	$463,554	$719,105	$1,078,908
50′	$96,761	$164,367	$283,450	$458,540	$710,599	$1,065,380

Source: Booz·Allen analysis

6.2.2 Tide Delay Costs

The methodology for calculation of tidal delay costs utilizes a similar methodology as used in calculating transportation savings, and integrates data on the natural tide cycle at Savannah. Costs were determined for vessels with operating drafts subject to tidal delays, how long they would be delayed, using the average of At-sea and In-port operating costs, for both with and without project conditions.

To quantify tidal delay costs, traffic was first categorized by vessel draft. Next, the percentage of vessels operating fully loaded or light loaded was determined from the light loading analysis. Finally, the time of availability of each foot of tide was determined in order to develop a probability distribution of vessels which will use tidal assistance to transit the channel. Third, channel depth was compared with the operating draft of vessels serving Savannah (less underkeel clearance required), and a required tide depth was determined, along with the time such a tidal advantage was expected to prevail during a 24 hour window (adjusted for the average channel transit time of 2.5 hours).

Because arrivals and departures occur in a random fashion, compared to the cyclical nature of ocean and river tide, the probability of arrival or departure during the period is simply the number of hours of tidal availability divided by 24. The probability of the vessels experiencing tidal delay are one minus this probability.

From these analysis, the annual tidal delay costs for the without project condition and each with project condition alternative was determined using the following equation:

Total annual tidal delay costs for each draft increment

= average of vessel operating costs per hour at-sea and in-port

x probability of delay

x length of delay, in hours

x fleet distribution to the draft increment

x light loading distribution to the draft increment

Annual tidal delay costs were calculated, by draft, and summed to determine total costs for each project alternative.

6.2.2.1 Tidal Delay Cost Results

Using the equation presented above, the expected tide delay costs incurred by containership and bulk cargo vessel operators serving the Port of Savannah were calculated, for each alternative deepening project and for the 42-foot without project condition. The results of these calculations are presented Exhibit 6-7.

Exhibit 6-7
Annual Tidal Delay Costs for Containerships Calling the Port of Savannah, 2000 - 2050
(1998 Dollars in Thousands)

Project	Forecast Period					
	2000	2010	2020	2030	2040	2050
42′	$45	$65	$90	$124	$184	$268
45′	$16	$25	$43	$70	$114	$176
46′	$5	$11	$26	$53	$94	$153
47′	$0	$3	$11	$26	$49	$82
48′	$0	$2	$8	$18	$33	$55
50′	$0	$0	$1	$1	$3	$4

Source: Booz·Allen analysis

The exhibit shows that tidal delay costs are relatively minor compared to the vessel operating costs presented above.

6.2.3 Ship Beam/Channel Width Delay Costs

Channel designs for without and with projects conditions in the feasibility study maintain existing channel side slope angles, resulting in narrower effective channel width at the bottom of the channel. This in turn results in a potential situation where two or more vessels operating laden may no longer have sufficient clearance to meet or pass in some sections of the channel. Discussions with the Savannah Pilots concluded that one-way traffic is already occurring to some extent in the channel. The pilots have worked out a system to minimize the frequency of delay by planning for meeting at both safe and relatively open places in the channel, and not at the bends in the river. The frequency of incidence of the beam conflict and delays occurring was estimated through the use of a vessel traffic simulation model. Subsequently, all costs of delay were calculated from the results for each project condition. The approach used is described in Chapter 12 of this Appendix.

6.2.3.1 Without Project

For without project conditions, the channel is maintained at its current authorized width. The width of the current channel is sufficient to allow Savannah's current fleet mix and level of vessel activity to transit the Savannah River with few operating restrictions regarding two way operation. However, while two way traffic is possible in the Savannah River along its entire length, there are a number of bends and turns where good maneuvering practice dictates that one way traffic is a safer course of action and is part of standard pilot practices when taking vessels into or out of the Port. Simulations identified little cost to vessel operators as a result of this operating environment.

6.2.3.2 With Project

Under with project conditions, it was expected that situations will occur where vessel beam width conflicts will occur more frequently. The incidence and duration of beam width conflict resulting in delays for vessels in the Savannah fleet were evaluated and estimated using a vessel traffic simulation model developed by Dr. Michael Racer, a Professor of Civil Engineering at Memphis State University. For this study, Dr. Racer adapted a vessel traffic simulation model used in previous USACE deep draft navigation studies adjusting for the dimensions of the Savannah Harbor under the with project conditions.[15] Future vessel activity from the vessel fleet forecasts was classified by vessel beam width for each project alternative to develop a distribution of the Savannah fleet. Using this data, the simulation model produced estimates of

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15 *Earlier studies using Dr. Racer's vessel traffic simulation model include the Baltimore Harbor Turning Basin Analysis and the Delaware Channel Deepening Study.*

the incidence of beam width conflicts and the resulting delays for each project alternative over the study period. Vessel delay costs were then calculated using the vessel daily in-port costs, described in Section 6.2.1.3 of this Chapter, for each vessel draft class incurring delay.

6.2.3.3 Channel Width Delay Cost Results

Using the equation presented above, the expected tide delay costs incurred by containership and bulk cargo vessel operators serving the Port of Savannah were calculated, for each alternative deepening project and for the 42-foot without project condition. The results of these calculations are presented Exhibit 6-8.

Exhibit 6-8
Annual Delay Costs due to Channel Width for Containerships Calling the Port of Savannah, 2000 - 2050
(1998 Dollars in Thousands)

Project	Forecast Period					
	2000	2010	2020	2030	2040	2050
42′	$83	$125	$189	$267	$379	$520
45′	$83	$125	$190	$269	$384	$529
46′	$83	$125	$190	$269	$385	$530
47′	$83	$125	$190	$269	$385	$530
48′	$83	$125	$190	$269	$385	$530
50′	$83	$125	$190	$269	$385	$530

Source: Booz·Allen analysis
Note: Numbers appear equal but are not due to rounding.

The results show that the delays incurred on vessels transiting the channel due to the design of the channel are relatively minor compared to the vessel operating costs presented above. In addition, the differences in costs between the alternative projects is relatively minor.

6.2.4 Total Transportation Costs

The summation of the vessel operating, tidal delay, and channel width delay costs determines the total transportation costs for each alternative deepening project. Exhibit 6-9 presents the total transportation cost stream for the forecast study period.

Exhibit 6-9
Total Transportation Costs for Alternative Deepening Projects
(1998 Dollars in Thousands)

Project	Forecast Period					
	2000	2010	2020	2030	2040	2050
42′	$113,432	$198,393	$350,588	$567,278	$878,838	$1,316,594
45′	$101,615	$177,535	$314,378	$509,929	$791,417	$1,186,850
46′	$98,356	$171,986	$304,212	$493,201	$764,937	$1,146,465
47′	$97,201	$169,845	$299,959	$485,498	$751,925	$1,125,946
48′	$97,075	$165,412	$286,425	$463,841	$719,522	$1,079,493
50′	$96,844	$164,493	$283,641	$458,811	$710,986	$1,065,915

Source: Booz·Allen analysis
Note (1): Total transportation costs are sum of vessel operating costs, tidal delay costs, and channel width delay costs.
Note(2): Numbers may not add due to rounding.

The exhibit shows that benefits will accrue in the form of lower transportation costs for channel depths greater than the current 42-foot depth. Annual benefits for each project were determined by calculating the difference in transportation costs stream for the 42-foot channel and each alternative project. Exhibit 6-10 presents the benefits for each alternative project.

Exhibit 6-10
Transportation Cost Savings for Alternative Deepening Projects
(1998 Dollars in Thousands)

Project	Forecast Period					
	2000	2010	2020	2030	2040	2050
42′	$0	$0	$0	$0	$0	$0
45′	$11,817	$20,858	$36,210	$57,349	$87,422	$129,745
46′	$15,076	$26,408	$46,376	$74,077	$113,902	$170,130
47′	$16,231	$28,548	$50,630	$81,780	$126,913	$190,648
48′	$16,357	$29,897	$53,056	$85,839	$132,368	$197,145
50′	$16,588	$30,897	$56,137	$91,342	$141,626	$211,794

Source: Booz·Allen analysis
Note: Numbers may not add due to rounding.

The exhibit shows that benefits could accrue in the first year of the forecast study period. Under the without project condition, it is assumed that no benefits will accrue. For the alternative projects, transportation costs reductions range from over $12 million in the first year of the forecast study period to over $211 million in 2050 years. To complete the benefit-cost analysis these benefits are converted into an average annual equivalent.

6.2.5 Average Annual Benefits

Following USACE guidelines, the economic benefits associated with reduced transportation costs for each project have been annualized back to the first year of each project's operation. Annual benefits were derived using the following methodology:

- Present worth factors based on the federal discount rate and 50 year period were calculated for the 50 years following the base year of operation for each alternative project
- The benefits for each alternative was converted to present worth values using the calculated present worth factors
- The present worth values for each project were summed to determine the total present worth of each alternative project's benefits
- The total present worth of each alternative were converted to annualized benefits, using the partial payment factor based on the federal discount rate.

Benefit calculations were completed for each year of the study period. The results of these calculations are presented in Exhibits 6-11 and 6-12 below.

Exhibit 6-11
Alternative Project Benefits and Present Worth Calculations
(1998 Dollars in Thousands)

	Forecast Period					
	2000*	2010	2020	2030	2040	2050
Benefits:						
- 45′ Project	$0	$20,858	$36,210	$57,349	$87,422	$129,745
- 46′ Project	$0	$26,408	$46,376	$74,077	$113,902	$170,130
- 47′ Project	$0	$28,548	$50,630	$81,780	$126,913	$190,648
- 48′ Project	$0	$29,897	$53,056	$85,839	$132,368	$197,145
- 50′ Project	$0	$30,897	$56,137	$91,342	$141,626	$211,794
Present Worth Factor:**						
- 45′ - 47′ Projects		0.6177	0.3104	0.1559	0.0784	0.0394
- 48′ - 50′ Projects		0.6617	0.3325	0.1670	0.0839	0.0422
Present Worth Stream:						
- 45′ Project	$0	$12,883	$11,238	$8,943	$6,850	$5,108
- 46′ Project	$0	$16,311	$14,393	$11,551	$8,924	$6,697
- 47′ Project	$0	$17,633	$15,713	$12,752	$9,943	$7,505
- 48′ Project	$0	$19,783	$17,639	$14,339	$11,110	$8,314
- 50′ Project	$0	$20,445	$18,664	$15,258	$11,887	$8,932

Source: Booz·Allen analysis
Note(*): Using USACE methodology, accounting for calculation of annualized benefits begin in year after completion of construction. Channel dredging completion is estimated for 2003 and 2004 depending on the project.

Note(**): Based on 7.125 percent interest rate. 45-47 foot projects are completed in 2003, first year of benefits accounted for in 2004. 48- and 50 foot projects are completed in 2004, first year of benefits accounted for in 2005.

Exhibit 6-12
Alternative Project Total Present Worth and Annualized Benefits
(Dollars in Thousands)

	Alternative Project				
	45′*	**46′***	**47′***	**48′****	**50′****
Total Present Worth	$463,895	$595,001	$653,510	$716,542	$755,574
Annual Benefits	$34,146	$43,869	$48,103	$52,743	$55,616

Source: Booz·Allen analysis
Note: Based on an annual interest rate of 7.125 percent, partial payment factor of 0.073607.
Note(*): Channel construction completed in 2003; accounting of accrued benefits from 2004 - 2053
Note (**) Channel construction completed in 2004, accounting of accrued benefits from 2005 - 2054.

These annual benefits are compared to annual costs for each alternative project to determine the benefit-cost ratio and net benefits. The next step in the benefit-cost analysis is computation of the total and annual costs of each project alternative.

6.3 Alternative Project Costs

This section presents the costs that are used in the benefit-cost analysis for determining the NED Plan. The costs to deepen the Savannah river navigation channel, for the 45-, 46-, 47-, 48-, and 50-foot deepening projects, were estimated by the USACE, and Booz·Allen & Hamilton. The estimates include costs for:

- Construction
- Lands and Damages
- Environmental Mitigation
- Cultural Resources Mitigation
- Interest During Construction
- Other NED Costs.

Following USACE guidelines, cultural resource mitigation costs are not included in the benefit-cost analysis. Other NED Costs are the public or private non-federal expenditures on general navigation features, such as a annual maintenance costs.. These cost items are described in detail in the Engineering Appendix and Main Report of the Feasibility Study.

6.3.1 Project Costs

Project costs consist of construction, lands & damages, and environmental costs incurred to construct the deepening projects. Construction costs of each project alternative are inclusive of both Federal and non-Federal costs and incorporate all associated costs for project implementation. These include cost items for: Dredging and Mobilization, Debris Removal, Disposal Area Improvements, Continuing Engineering and Design, and Supervision and Administration.

Under the without project condition alternative, there are no incremental project construction costs associated with maintaining the current authorized channel dimensions. Therefore, the project costs for the without project condition are zero. Cost estimates were developed by the USACE Savannah District. Contingencies accounting for between 15 and 25 percent of the construction costs accounts. Details of the cost estimates provided in the Main Report and the Engineering Appendix of the Feasibility Study, are summarized in Exhibit 6-13.

Exhibit 6-13
Estimates of Alternative Project Total Costs
(1998 Dollars in Thousands)

ITEM	Contingency (%)	ALTERNATIVE 45 ft.	46 ft.	47 ft.	48 ft.	50 ft.
Dredging	25	$66,004,600	$77,915,400	$85,160,300	$96,722,100	$136,058,700
Mobilization	25	$2,956,500	$3,120,800	$3,367,100	$3,367,100	$5,017,500
Debris Removal	25	$2,278,805	$2,278,805	$2,278,805	$2,278,805	$2,278,805
Disposal Area Improvements	25	$10,927,500	$10,975,000	$11,431,300	$11,863,800	$13,784,900
Aids to Navigtion		$694,625	$772,125	$810,875	$810,875	$849,625
Dredging non-Federal Berth	25	$277,000	$334,000	$389,000	$454,000	$530,000
Continuing Engineering & Design	15	$8,400,000	$8,400,000	$8,400,000	$8,400,000	$8,400,000
Supervision & Administration	15	$3,844,000	$3,844,000	$3,844,000	$3,844,000	$3,844,000
Lands, Easements, Relocations & Rights of Way	25	$2,185,300	$2,185,300	$2,185,300	$2,185,300	$2,185,300
Environmental Mitigation		$9,612,480	$9,612,480	$9,612,480	$9,612,480	$9,612,480
Chloride Mitigation (if reqd)		$46,000,000	$46,000,000	$46,000,000	$46,000,000	$46,000,000
Dissolved Oxygen Mitigation		$24,000,000	$24,000,000	$24,000,000	$24,000,000	$24,000,000
Subtotal		**$177,180,810**	**$189,437,910**	**$197,479,160**	**$209,538,460**	**$252,561,310**
Project Costs Including Historic Preservation Mitigation & Data Recovery						
Old Fort Jackson Mitigation	25	$1,264,800	$1,264,800	$1,264,800	$1,264,800	$1,264,800
CSS Georgia Mitigation	35	$13,083,525	$13,083,525	$13,083,525	$13,083,525	$13,083,525
Total Project Costs		**$191,529,135**	**$203,786,235**	**$211,827,485**	**$223,886,785**	**$266,909,635**

Source: *USACE, Savannah District, Engineering Appendix*
Note(*): *Includes 25 percent contingency*
Note(**): *Includes 15 percent contingency*

6.3.2 Interest During Construction

Interest during construction (IDC) costs were calculated by Booz·Allen & Hamilton. These costs are the cost of capital expended during the construction of the selected alternative deepening project, based on the Total Project Costs presented in Exhibit 6-10 above. The calculations were completed in accordance with USACE methodology and guidelines. The federal discount rate of 7.125 percent was converted to a monthly rate of 0.5752 percent. The following formula is used for computing the IDC for each project:

$$IDC = \Sigma P_m[(1+i)^{n-1} -1]$$

where:

P_m = the mth monthly payment
n = number of periods in months
i = monthly interest rate

Exhibit 6-14 presents the results of the calculations to determine the IDC for each alternative deepening project.

Exhibit 6-14
Interest During Construction Costs for Alternative Deepening Projects
(1998 Dollars where indicated)

ANNUAL BENEFITS AND COSTS	45 ft.	46 ft.	47 ft.	48 ft.	50 ft.
Construction:					
Start	Oct-01	Oct-01	Oct-01	Oct-01	Oct-01
Duration	23 months	23 months	25 months	30 months	30 months
Total Project Costs*	$177,180,810	$189,437,910	$197,479,160	$209,538,460	$252,561,310
Interest During Construction	$11,697,352	$12,506,557	$14,274,060	$18,472,156	$22,264,896
Total Economic Cost including IDC	$188,878,162	$201,944,467	$211,753,220	$228,010,616	$274,826,206
Annual Project Cost	**$13,902,774**	**$14,864,547**	**$15,586,540**	**$16,783,200**	**$20,229,160**

Source: USACE Savannah District, Booz·Allen analysis

6.3.3 Other NED Costs

Other NED costs for the Savannah Harbor Expansion Project consist of annual Differential Operations and Maintenance (O&M) costs and annual Dissolved Oxygen Mitigation costs. These costs were estimated by the USACE Savannah District. Differential O&M costs are incurred annually over the life of the project. The costs are necessary in order to maintain a navigation channel at its authorized depth and maintain safe passage of vessels. These O&M costs, over those O&M costs already incurred to maintain the 42-foot project, were estimated by the USACE Savannah District for each alternative with project condition. Exhibit 6-15 presents the annual Other NED Costs for each project.

Exhibit 6-15
Other NED Costs For Alternative Deepening Projects
(1998 Dollars)

Other NED Costs	Alternative Deepening Project				
	45 ft	46 ft	47 ft	48 ft	50 ft
Differential O&M	$27,000	$102,000	$141,000	$149,000	$171,000
Dissolved Oxygen Mitigation	$650,000	$650,000	$650,000	$650,000	$650,000
Total Other Costs	**$677,000**	**$752,000**	**$791,000**	**$799,000**	**$821,000**

Source: USACE, Savannah District

6.3.4 Total Project Costs

The total summation of project construction costs, interest during construction costs, and other costs determines the total economic costs used in the benefit-cost analysis. To complete this calculation, the Project Costs for each alternative are annualized using the series present worth factor, based on the federal discount rate and the 50 year life of the projects. Exhibit 6-16 presents the results of the calculation and the total costs used in the benefit-cost analysis.

Exhibit 6-16
Annual Costs for Alternative Deepening Projects
(1998 Dollars where indicated)

Other NED Costs	Alternative Deepening Project				
	45 ft	46 ft	47 ft	48 ft	50 ft
Total Project Costs	$13,902,774	$14,864,547	$15,586,540	$16,783,200	$20,229,160
Interest During Construction	$11,697,352	$12,506,557	$14,274,060	$18,472,156	$22,264,896
Total Economic Cost (w/IDC)	$188,878,162	$201,944,467	$211,753,220	$228,010,616	$274,826,206
Series Present Worth Factor*	0.073607	0.073607	0.073607	0.073607	0.073607
Annual Project Costs	**$13,902,774**	**$14,864,547**	**$15,586,540**	**$16,783,200**	**$20,229,160**

Source: Booz·Allen analysis

Note(*): Based on 7.125 percent interest rate and 50 year period.

6.4 Benefit-Cost Calculations by Project Alternative

The benefits and costs for developing 45-, 46-, 47-, 48-, and 50-foot deepening projects for the Savannah Harbor have been presented. In this section we bring together the benefits and costs to determine the benefit-cost ratio of each project over the current without project condition. Exhibit 6-17 presents the benefit-cost analysis.

Exhibit 6-17
Benefit-Cost Analysis of Alternative Deepening Projects
(1998 Dollars in Thousands)

Benefit-Cost Analysis	Alternative Projects				
	45 ft	46 ft	47 ft	48 ft	50 ft
Annual Benefits	$34,145,990	$43,869,133	$48,102,967	$52,742,579	$55,615,616
Project Costs:					
- Annual Project Costs	$13,902,774	$14,864,547	$15,586,540	$16,783,200	$20,229,160
- Other NED Costs	$677	$752	$791	$799	$821
Adjusted Annual Project Costs	$14,579,774	$15,616,547	$16,377,540	$17,582,200	$21,050,160
Benefit/Cost Ratios	2.34	2.81	2.94	**3.00**	2.64
Net Annual Benefits	$19,566,216	$28,252,586	$31,725,427	$35,160,379	$34,565,456

Source: Booz·Allen analysis

In order to determine the economic viability of alternative projects, the project benefits were compared with project costs. Those projects that have average annual equivalent benefits exceeding average annual costs are deemed economically justified. When more than one project is economically justifiable, benefit-cost analysis is used to determine which project is superior. The ratio of benefits to costs is called the Benefit/Cost Ratio (BCR). If a project's BCR is less than 1.0, then the project is not economically feasible. The plan with the highest net benefits and has a benefit-cost ratio greater than 1.0 is the recommended plan.

6.4.1 Benefit-Cost Ratios and Net Benefits

The benefit cost ratios calculated for each of the project alternatives is greater than 1.0 (i.e., benefits exceed costs), therefore all projects are economically justifiable. The ratios range from 2.39. for the 45-foot project to 3.45 for the 48-foot project. The net benefits range from almost $20 million for the 45-foot project to nearly $44 million dollars for the 48-foot project

6.4.2 NED Preferred Plan

Study of the benefit-cost analysis shows the highest net benefits and benefit-cost ratio are found in the 48-foot project. Based on this information the economically justifiable NED plan for the Savannah Harbor Expansion Study is the 48-foot alternative project.

6.5 Summary and Conclusions

The benefit cost analysis of with project conditions show that all projects are economically feasible with average annual equivalent NED benefits exceeding project costs. Primary benefits occur from transportation cost savings derived by the use of larger more economical vessels and reductions in tidal delay time. The incidence of one-way traffic delays from beam width conflicts reduces net benefits under with project conditions, but not significantly. The project benefits and costs are such that the maximum net benefits support 48-foot project alternative as the NED Plan.

7. SENSITIVITY AND RISK ANALYSIS

This chapter presents the risk and sensitivity analysis performed on the assumptions and methodology for determining the NED Plan.

7.1 Overview

As part of the analysis to determine the NED benefits of a harbor deepening project, an assessment of the risks and uncertainty of the assumptions and cost estimates utilized in the analysis is required. This section presents risk and sensitivity analysis of the assumptions and methodology used in the NED analyses. Specifically, this section will present analysis on the:

- commodity forecast
- fleet forecast
- transportation costs
- net benefits and project costs.

Each of these will be discussed in turn.

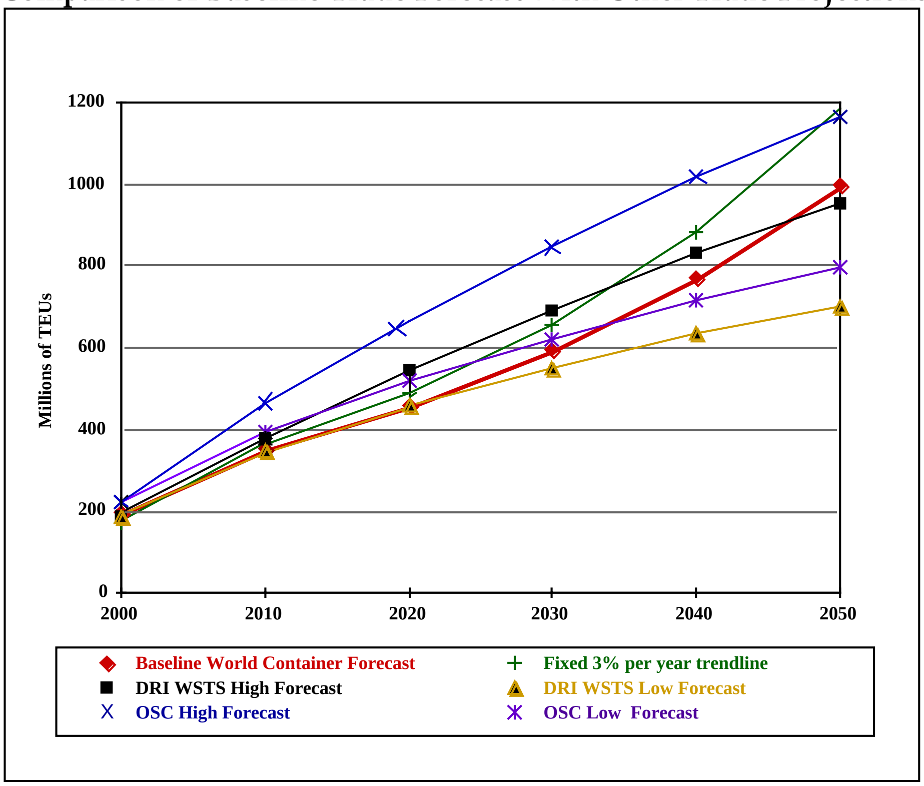
7.2 Commodity Forecast

Changes in business investments and business strategies can impact the pattern of international commerce and business that drive the demand for trade Over the long-term, many trade flows will be "new", representing a changing mix of inter-regional and inter-company sales. There are typically non-economic factors that drive these new relationships. While the models used in this study can anticipate some of these, they are not capable of predicting a new trade flow or anticipating the development of completely new industries where old industries did not previously exist. It is around such trade issues as these which creates uncertainty and risks in the trade forecasts. To the extent, however, that the trade forecasts used in this deepening study take into account the emerging development and consumption pattern (as represented by each exporting country's production of traded commodities), they can project the direction and degree that future trade growth will take.

7.2.1 Comparison With Other Trade Forecasts

Compared to other trade forecasts, the trade forecast used in the economic analysis is relatively conservative. For perspective, the baseline world commodity trade forecast was compared with other commercial long-term trade forecasts and also against a fixed annual growth trend of 3 percent. The results of the comparison show the other forecasts to be higher in the early years of the period and to be both higher and lower in the out years. This supports the view that the baseline world container forecast is reasonable and conservative over the long-term. Exhibit 7-1, below, presents this comparison over the study period for the Deepening Study forecast and high and low long-term forecast developed by DRI/McGraw-Hill and Ocean Shipping Consultants.

Exhibit 7-1
Comparison of Baseline Trade Forecast With Other Trade Projections



Sources: Ocean Shipping Consultants, DRI/Mercer World Sea Trade Service, Booz·Allen analysis

7.2.2 Savannah Harbor Commodity Forecast Alternative Share Scenarios

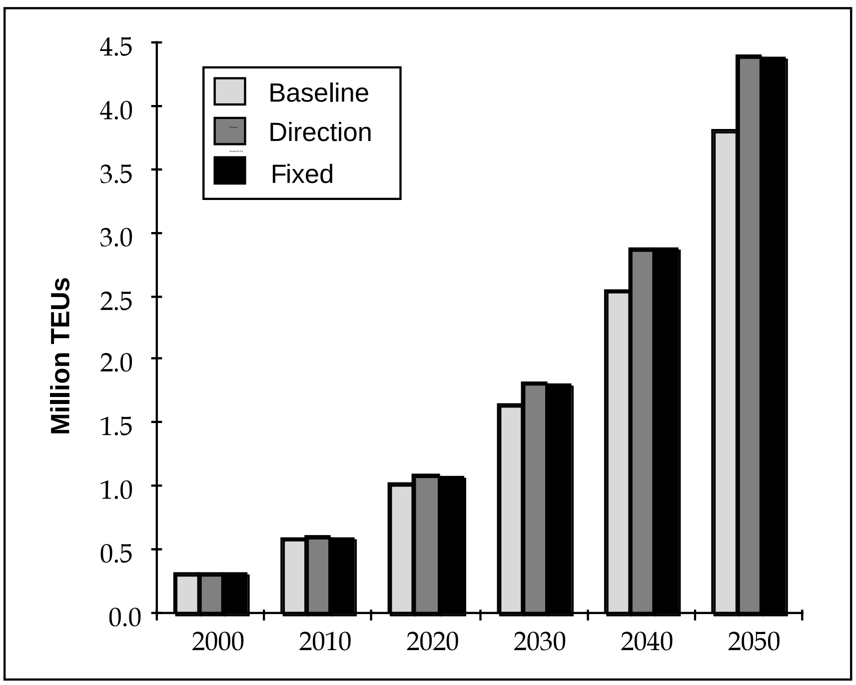
To measure the sensitivity of the Savannah Harbor commodity forecasts, alternative forecasts were prepared applying different trade share assumptions than those utilized in the Deepening Study. As detailed in the methodology section of Chapter 3, the baseline Savannah trade forecasts reasonably assume that the Port of Savannah maintains its share of container trade handled by South Atlantic port range ports. Specifically, the shares were fixed at on a trade route and direction (e.g., import or export) level so that the overall port trade share of Savannah as a percent of the South Atlantic total trade, in aggregate, may vary.

Two alternative Savannah forecasts were prepared using less detailed share assumptions than described above to evaluate the sensitivity of, including:

- The Savannah Harbor share of commodity trade would be fixed for total for imports and exports (i.e., Direction scenario).
- The Savannah Harbor trade forecast as a percent of the South Atlantic trade will remain fixed regardless of direction or trade route (i.e., Fixed scenario)

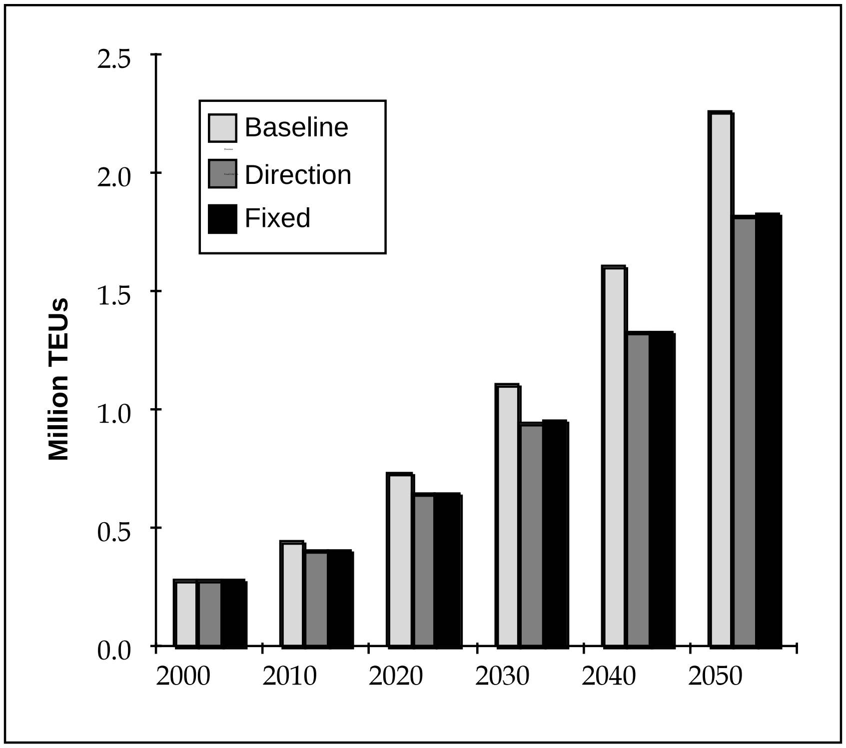
This last, more uncomplicated approach, mirrors the approach used in some earlier USACE deep draft navigation feasibility studies. The baseline route and direction forecast is compared to the two alternatives, one for imports and one for exports, in Exhibits 7-2 and 7-3.

Exhibit 7-2
Comparison of Alternative Trade Projections on Container Exports Through the Port of Savannah, 2000 - 2050
(TEUs)



Source: Booz·Allen analysis

Exhibit 7-3
Comparison of Alternative Trade Forecast on Container Imports Through the Port of Savannah, 2000 - 2050
(TEUs)



Source: Booz·Allen analysis

7.2.3 Savannah Harbor Non-Containerized Commodity Trade

The regional approach port-specific forecast was validated with a separate Booz·Allen forecasting exercise. This forecast used historical U.S. Army Corps of Engineers Waterborne Commerce Statistics, in conjunction with selected regional macroeconomic explanatory variables, to produce a traditional econometric bottom-up forecast for Port of Savannah total and containerized tonnage. There are no plans to increase the depths of the liquid or dry bulk cargo berthing facilities at the Port of Savannah to meet the NED Plan depth of the channel. Lack of berth depth prevents liquid and dry bulk vessels from achieving any benefits since the operators will have to light load the vessels will in order to dock. Inclusion of the benefits would require inclusion of cost estimates for the additional dredging in the costs of the alternative projects. However, because benefits from bulk cargoes are relatively small (2-3% of container cargo benefits), there is most likely an even trade off between the costs and the benefits accrued from bulk cargoes.

7.2.4 Uncertainty in Trade Growth Factors

There remains uncertainty around several factors influencing global trade conditions including the rate of technological advancement, expansion of port landside and waterside capacity, changes in government maritime funding, success of port marketing efforts, and increased environmental regulations. Among those factors with unknown impacts on the path of long-term trade growth are technological, financial, political, and environmental risks.

Except for unforeseen technological advances, it is not clear that the direction or impact of any one of these factors, especially at the individual port level will have any substantive impact. There are possible developments in each area that could act to increase or decrease trade, depending on market reactions. For example, there is a long-term federal trend towards increased local cost sharing for improvements to infrastructure. This could indirectly affect the future location of containerized cargo moving in and out of the United States. The ability of U.S. port authorities and their local and state supporters to finance and develop improvements becomes proportionally more important in an increased local cost share environment, but is not easily predictable. Similarly, the invalidation of the current application of the harbor maintenance fee adds further uncertainty to the plans of carriers and the U.S. ports at which they call. There is likely to be little direct impact on South Atlantic range U.S. ports, yet the indirect impacts from changes to carrier's port rotations to shift cargo to viable Canadian or Mexican ports could change the share of trade loaded or off-loaded across North American ports.

7.3 Fleet Forecast

The objective of risk and uncertainty analysis for the fleet forecast is to identify assumptions and calculations that are critical to the overall benefits and costs of competing projects, and their impact to the NED plan. Major assumptions driving the results of the fleet forecast include forecasts of containerization, utilization, and fleet growth over the study period. For this study, sensitivity testing was performed around critical variables instead of general uncertainty in the fleet forecast.

Past experience and guidelines hold that deepening study fleet forecasts are driven by vessel draft. However, the largest Post-Panamax containerships currently operating, being built, or on order can impact the actual results via other vessel dimensions (e.g., ships length and beam) – influencing channel width and bend design. In traditional USACE fleet forecast methodology, operating draft has been the critical dimension used. Previous analysis shows that the trends in Post-Panamax containership dimensional growth is occurring in vessel beam and length; while the vessels' drafts are increasing significantly less. Consequently, fleet forecasting methodologies that use only draft as the primary independent variable driving cargo capacity of vessels contain some level of uncertainty. However, including length and/or beam into a fleet forecast model increases the level of complexity – and adds additional uncertainty. Therefore, for purposes of this Deepening Study, applying fleet forecasting methodologies as presented in the NED guidelines for deep draft navigation projects is acceptable.

7.3.1 Containerization and Utilization

A key assumption utilized in developing the world and Savannah fleet forecasts was the level of containerization penetration into the general cargo and bulk cargo transportation markets. There is uncertainty as to the level of container penetration (the amount of the world trade that will be moved in containers) over the study period. A review of historical containerization levels shows that the level of containerization of the general cargo market is continuing to grow. However, it is unlikely that containerization will achieve 100 percent market penetration due to various factors regarding: lot sizes, suitability of bulk and general cargoes for containers, inadequacy of some markets and ports to support containers (especially in developing markets)[16], etc. The study assumes a moderate increase in container penetration over the next 10 years and then leveling over the remainder of the study period. Container penetration increases above those detailed in the Deepening Study will increase the trade forecast and subsequently, size of the fully cellular fleet and project benefits. However, no impact to the NED plan was identified.

There is also some uncertainty as to the level of containership utilization. These utilization levels vary according to trade lane and economic conditions in world or trade regions. Continuing consolidation in the liner shipping industry will continue, resulting in the reduction of over capacity in the fleet and increasing the utilization rate of the fully cellular container fleet. Sensitivity analysis on the utilization factor applied in the fleet forecast showed that a decrease in the factor resulted in a corresponding increase in the number of units in the world fleet at the end of the study period. An analysis of the carriers serving the Port of Savannah showed that approximately 80 percent of the vessel calls to the Port are either first in or last out. Although uncertainty as to the future of this ratio exists, trade patterns do not change rapidly, unless a catastrophic incidence occurs (such as the closing of one of the canals). Ignoring natural or political incidents, this ratio should continue for some time. In addition, Savannah is geographically positioned in the South Atlantic. No other port further south on the East Coast currently has the capability to increase channel depth greater than 41 to 42 feet. Consequently, as trade volumes and vessel sizes increase over the long-term on trade lanes to the southern hemisphere,

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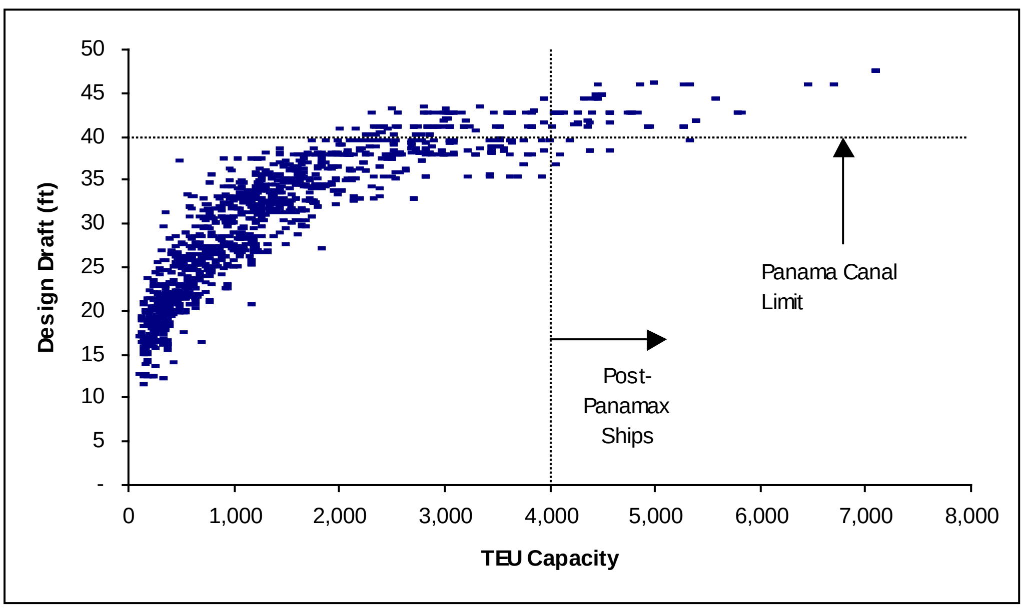
16 *Due to the high level of capital costs required to implement fully cellular containerized cargo handling operations, expectations of investments in such facilities in several third world market areas are low. Correspondingly, low labor costs for handling general cargo precludes the cost benefit of containerized handling.*

Savannah, with a deep draft port and proximity to markets has significant potential of capturing the trade. Over the long-term it is expected that the ports in the new and developing markets will be improved, eliminating current constraints imposed by ports.

7.3.2 Ship Size and Fleet Mix

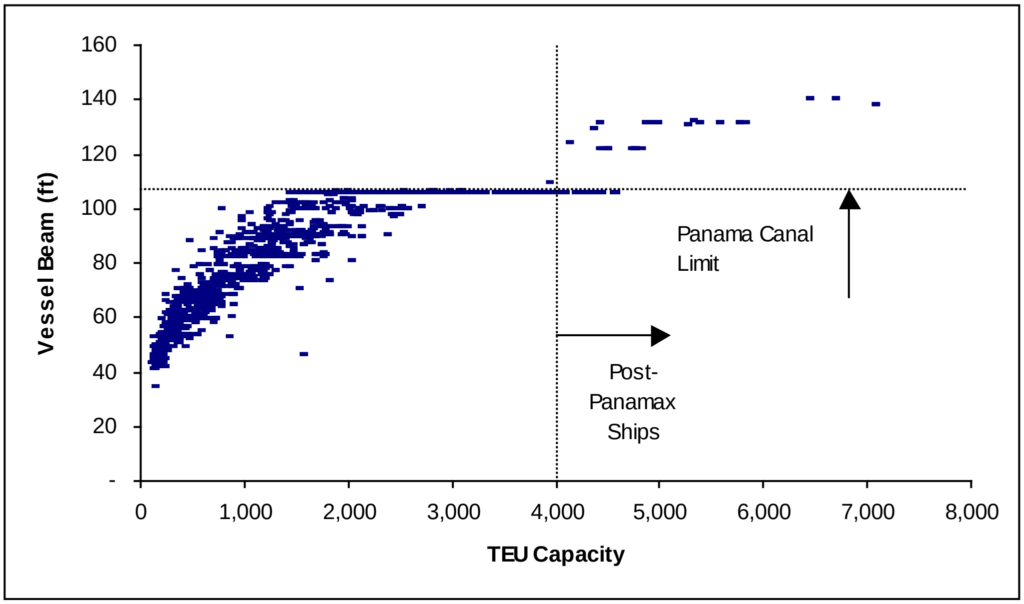
There is uncertainty regarding the pace of containership fleet capacity increases. The uncertainty concerns what is the largest capacity containership which will be built and when will this occur. In 1997, Ocean Shipping Consultants predicted the first 8,000 TEU vessel would be in service by 2000. Analysis shows that the *Sovereign Maersk* (a sister ship of the 6,400 TEU *Regina Maersk*) launched in September 1997, has a capacity of between 7,600 and 8,400 TEU. Exhibits 7-4 and 7-5 illustrates the relationship of vessel design draft and vessel beam versus TEU capacity of the 1997 world containership fleet and orderbook.

Exhibit 7-4
Relationship in 1997 World Containership Fleet
Between Design Draft and TEU Capacity



Source: Clarkson Research Studies Containership Registry Database, Booz·Allen analysis

Exhibit 7-5
Relationship in 1997 World Containership Fleet
Between Vessel Beam and TEU Capacity



Source: Clarkson Research Studies Containership Registry Database, Booz·Allen analysis

The exhibit illustrates how the world container fleet has been impacted by the constraints imposed by the Panama Canal. With expectations of wider and deeper locks at the Canal during the study period, these constraints in vessel operations will decrease. Mean while, growth in Asian trade is expected to move via the Suez Canal, which does not have these operational constraints.

As indicated previously, the growth in vessel size and capacity impacts the fleet forecast. In the fleet forecast, the average capacity of vessels within each draft category was determined assuming an annual growth rate of average capacity and an assumption regarding maximum capacity. Preliminary analysis which assumed a standard growth rate across all vessel sizes (including mature and evolving categories) resulted in unrealistic vessel sizes for the deeper draft categories. To address this, capacity growth for each draft category was bifurcated across the fleet as follows: Panamax (38 to 41 foot draft) and Post-Panamax (42+ foot draft). Average capacity increases were determined for these two classes of vessels and used to project the average vessel size (in TEUs) over the study period. Increasing these percentages accelerates the use of larger sized (8,000 TEU or greater) vessels into the world and Savannah fleet forecast, and consequently impacts the fleet mix (i.e., portion of deep draft and other vessels in the fleet).

As described in Chapter 4, the World and Savannah fleet is composed of three categories of vessels. The 'current tonnage' comprises the first category. Each year, some portion of the current fleet is retired or scrapped due to excess age and must be replaced. Thus, the 'replacement tonnage' accounts for the second category of vessels where new tonnage is constructed to replace retired/scrapped containerships. Combined, these first two categories support a static level of container trade. For incremental growth in trade volumes above these static levels, 'incremental tonnage' resulting from new vessel construction accounts for the third, and last, category of vessels.

The last area of uncertainty to highlight in this section is that of replacement tonnage and the assumption of what size of vessel replaces a retired or scrapped vessel. For purposes of the Deepening Study, is was assumed that all replacement vessels (i.e., tonnage) were 15 percent larger than that of the vessel replaced. This growth rate was taken from the USACE *Deep Draft Navigation Project Guidelines*. Sensitivity analysis which varied this growth rate by 5 percent resulted in no consequential impact to total project benefits or the NED project.

7.4 Transportation Costs

The objective of risk and uncertainty analysis which addresses vessel operations is to identify assumptions and calculations that are critical to the benefit and cost results, and the impact to the NED project. In completing this analysis, the major assumption identified which impacts total transportation costs and benefits is the level of light loading assumed under without and with project conditions.

7.4.1 Operating Costs

Some uncertainty exists around the calculations of vessel operating costs, mostly due to the initial data used to determine these costs. Vessel operating costs are determined using data from a USACE memorandum produced semi-annually describing results of deep draft vessel costs analysis. These costs segmented by type of vessel and for capacity ranges of 600 to 6000 TEUs. Because there are very few vessels of the 6000 TEU capacity segment, the accuracy of the regressed data is subsequently open to some error. The At-Sea and In-Port costs for containerships were derived by the USACE IWR using capacity (deadweight) as the independent variable. However, the fleet forecasts used in this analysis were developed based on the vessel drafts that are expected to exist in the world fleet and call the Port of Savannah. To integrate the two data sets for this study, the USACE equations for draft given deadweight capacity was rearranged to a deadweight capacity given draft equation.

7.4.2 Light Loading

Due to the dynamic nature of containership operations, there is a level of uncertainty as to how container vessels will be operated over the study period. Interviews with carriers found that they do not have, or were not willing to share, long-term strategic plans for their operations. However, carriers typically maintain near term – two to four year – operating plans. In developing these near term plans, carriers consider competition (including relative cost position and pricing to serve each market), port and vessel lease commitments, current and planned fleet capacity, alliances with other carriers, trade volumes on each trade route and their interrelation across all trades, and operating restrictions. Combined, each of these are considered as carriers determine how to deploy their fleet, maximize cargoes and revenues, and manage costs. Hub ports, feeder services, dedicated trade services, slot chartering, and alliances are a few operating alternatives utilized by ocean carriers to maximize efficiency and minimize cost.

The ability of a carrier to serve a port without operating restrictions impacts if and how it serves the port and where is falls in a vessels service schedule (e.g., first port in, last port out, intermediate port, etc.). Of specific importance to carriers is a ports loading restrictions and how this influences light loading practices. Light loading is when a vessel's operating draft is less than that of its design draft after fully loading (e.g., 36 feet operating draft versus 40 feet design draft is termed "4 feet light loaded"). Light loading may be coincidental and reflect a vessels mix of cargo and commodities[17] which even when fully loaded to volumetric capacity, does not result in a vessel being fully loaded to design draft marks. The analysis identified that this occurs frequency in industry and varies to some degree by trade and vessel size. Additionally, light loading may be intentional under circumstances where ocean carriers find that it is more advantageous or necessary to load below capacity to maintain voyage schedule or navigate to or from a port of call. Carriers often plan the port rotation and selection of vessels deployed on a trade to enable a more predictable operating drafts and light loading.

The Deepening Study assumes that carriers will improve the operating efficiencies of their vessels as channel constraints (e.g., channel depth) are eliminated. In 1991, the constrained fleet at Savannah consisted of vessels with design drafts of 34 feet or more. After the recent deepening project to 42 feet, the constrained fleet shifted to vessels with design drafts of 38 feet or more. Exhibit 7-6 highlights the light loading practice of vessels in the 38 feet draft category pre and post deepening to 42 feet.

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17 *Major factors that influence light loading are cargo mix (or densities), type of commodities moving through the port, and total volume of cargo available for trade.*

Exhibit 7-6
1988 and 1996 Light Loading Distribution of 38-foot Design Draft Containership Calling the Port of Savannah

	Feet of Light Loading						
	0′	1′	2′	3′	4′	5′	6′+
1988	5.7%	4.1%	4.6%	4.4%	15.3%	21.3%	44.5%
1996	15.0%	14.2%	13.3%	10.0%	15.8%	14.2%	17.5%

Source: USACE Savannah District, Georgia Ports Authority, Booz·Allen analysis

The exhibit highlights the dramatic change in vessel light loading between 1988 and 1996. While light loading is not eliminated, the degree of light loading decreases significantly. The Deepening Study assumes that all vessels which become unconstrained as a result of harbor deepening, will take on the light loading characteristics of the 38 feet design draft vessel as experienced in 1996. In discussions with carriers, this assumption was found to be reasonable.

7.5 Benefits and Net Benefits

Sensitivity of the calculated benefits of alternative deepening projects was analyzed by varying the trade forecasts. These variances from the baseline forecast included two alternative trade forecasts:

- A conservative growth forecast, below the baseline forecast, identified by the USACE Washington Level Review: 4 percent growth per annum from 1996 to 2000; 3 percent growth pa from 2001 through 2010; and 2 percent growth pa after 2010
- A medium growth forecast, above the baseline forecast, gradually increasing trade volumes by 5 percent in 2020, and constant thereafter.

Exhibit 7-7 presents the results of benefits, benefits-cost ratio, and net benefits calculations, based on these alternative trade forecasts.

Exhibit 7-7
Sensitivity of Trade Forecasts on Annual Benefits, Benefit-Cost Ratio, and Net Benefits
(1998 Dollars in Millions where indicated)

	Alternative Deepening Depths				
	45′	**46′**	**47′**	**48′**	**50′**
Benefits:					
- Baseline	$34.15	$43.87	$48.10	$52.74	$55.62
- WLR Trade Forecast	$18.97	$24.28	$26.28	$29.60	$30.88
- 5% Gradual Increase	$35.48	$45.59	$50.01	$54.76	$57.77
Project Costs:	$14.26	$15.36	$16.57	$17.93	$20.96
Benefit-Cost Ratio					
- Baseline	2.39	2.86	2.90	**2.94**	2.65
- WLR Trade Forecast	1.33	1.58	1.59	**1.65**	1.47
- 5% Gradual Increase	2.51	2.97	3.02	**3.06**	2.76
Net Benefits:					
- Baseline	$19.88	$28.51	$31.53	**$34.82**	$34.66
- WLR Trade Forecast	$4.71	$8.91	$9.71	**$11.67**	$9.93
- 5% Gradual Increase	$21.22	$30.22	$33.44	**$36.84**	$36.82

Source: *Booz·Allen analysis*
Note: *Numbers may not add due to rounding.*

The exhibit shows that by varying the trade forecast does not change the results of the NED plan. Even with a relatively conservative trade forecast provided by the USACE, there are still sufficient benefits to warrant a 48-foot NED Plan. A higher growth rate would push the benefits even higher and could make a 50-foot NED plan achievable.

In addition to trade forecasts sensitivity, other tests of the reliability of the benefit-cost analysis have been completed. The following assumptions and constants in the transportation costs have been varied to test the sensitivity of the benefit-cost analysis:

- Usage of the average of In-Port and At-Sea vessel costs per hour versus In-Port costs per hour for calculation of tidal delay costs.
- Increase of underkeel clearance requirement by 1 foot to compensate for vessel squat[18] when transiting the channel.[19]

[18] *Squat is the dynamic trim experience by motor vessels as they are propelled through the water. As a ships' propeller turns, hydrodynamic forces trim the hull in such a way that the stern of the vessel is lower in the water than the bow.*

- Impact of vessel capacity utilization
- Impact of fleet forecast remaining constant for channel depths greater than 46 feet.

The impact to the NED Plan of changing these assumptions is presented in Exhibit 7-8. These assumptions do not change the final results of the NED Plan. It should be noted that in the baseline result and the test for the assumptions for each of the sensitivity, the difference in net benefits between the 48- and 50-foot project ranges from $20 thousand to $400 thousand. A gain in the benefits stream of this small a magnitude could make the 50-foot project more attainable.

[19] *Savannah Pilots Association uses a two feet of underkeel clearance plus two feet additional clearance for vessel squat rule, regardless of vessel speed or size. Other ports use 5 feet of underkeel clearance. This sensitivity provides the ability to understand the impact of additional underkeel clearance requirements.*

Exhibit 7-8
Sensitivity of Transport Cost Assumptions on Annual Benefits, Benefit-Cost Ratio, and Net Benefits
(1998 Dollars in Millions where indicated)

	Alternative Deepening Depths				
	45′	46′	47′	48′	50′
Benefits:					
- Baseline	$34.15	$43.87	$48.10	$52.74	$55.62
- Vessel Operating Costs	$34.14	$43.86	$48.10	$52.73	$55.60
- Vessel Squat	$34.31	$43.99	$48.30	$52.99	$55.88
- 46-ft forecast	$34.15	$43.87	$48.10	$51.51	$54.14
- 70% Vessel Utilization	$34.15	$43.87	$48.10	$52.74	$55.62
- 90% Vessel Utilization	$34.15	$43.87	$48.10	$52.74	$55.62
Project Costs:	$14.26	$15.36	$16.57	$17.93	$20.96
Benefit-Cost Ratio					
- Baseline	2.39	2.86	2.90	**2.94**	2.65
- Vessel Operating Costs	2.39	2.85	2.90	**2.94**	2.65
- Vessel Squat	2.41	2.86	2.91	**2.96**	2.67
- 46-ft forecast	2.39	2.86	**2.90**	2.87	2.58
- 70% Vessel Utilization	2.39	2.86	2.90	**2.94**	2.65
- 90% Vessel Utilization	2.39	2.86	2.90	**2.94**	2.65
Net Benefits:					
- Baseline	$19.88	$28.51	$31.53	**$34.82**	$34.66
- Vessel Operating Costs	$19.87	$28.50	$31.52	**$34.80**	$34.64
- Vessel Squat	$20.05	$28.63	$31.73	**$35.07**	#34.92
- 46-ft forecast	$19.88	$28.51	$31.53	**$33.58**	$33.19
- 70% Vessel Utilization	$19.88	$28.41	$31.53	**$34.82**	$34.66
- 90% Vessel Utilization	$19.88	$28.41	$31.53	**$34.82**	$34.66

Source: *Booz·Allen analysis*
Note: *Numbers may not add due to rounding.*

7.6 Conclusions

Analysis conducted during the study included an examination of year-by-year benefits and found that benefits could accrue in the first year. However, due to construction, benefits will not be accounted for until completion of construction; accounting of benefits begins in the first completed year following construction. Additionally, the sensitivity of the NED plan to a growth forecast which maintained lower annual growth rates than that identified in Chapter 2 of this appendix has been calculated and presented. The sensitivity analysis resulted in no change to the NED plan determined using the baseline forecasts.

The key variables from the commodity, fleet, and vessel operations analysis in this economic feasibility study have been tested for risk and uncertainty, and their impact on the NED plan have been presented. Sensitivity analysis was used with the models to measure the change in outcome under alternative conditions. The analysis presented and completed in conjunction with this chapter has demonstrated that the Deepening Study conclusions are reasonable and accurate.

8. SUMMARY AND CONCLUSIONS

The economic feasibility of the proposed with project alternatives was presented in the benefit cost analysis of Chapter 6. The comparison of the alternative project depths is summarized in Exhibit 8-1 below.

Exhibit 8-1
Summary Project Alternative Benefits And Costs
(1998 Dollars)

Project Depth (feet)	Project Costs*	Annual Project Costs**	Annual Benefits	Net Benefits	Benefit-Cost Ratio
45′	$173,157,000	$14,264,039	$34,145,990	$19,881,951	2.39
46′	$186,194,000	$15,362,008	$43,869,133	$28,507,125	2.86
47′	$199,923,000	$16,570,427	$48,102,967	$31,532,541	2.90
48′	$213,825,000	$17,925,535	$52,742,579	**$34,817,044**	**2.94**
50′	$251,381,000	$20,955,622	$55,615,616	$34,659,994	2.65

Source: Booz·Allen analysis
Note(*): Includes General Navigation Features (mobilization and dredging, disposal area improvements, continuing engineering and design, and supervision and administration), Lands and Damages, Aids to Navigation, Environmental mitigation, and Interest During Construction.
Note(**): Includes annualized total project costs and other NED costs (Annual Differential Operations and Maintenance to maintain channel depth and Annual Dissolved Oxygen Mitigation Maintenance).

The project benefit cost estimates incorporate commodity and fleet forecasts as detailed in this economic appendix combined with project cost estimates provided by the USACE Savannah District. At the project cost levels identified, all projects under consideration have benefit-cost ratios greater than one. Benefits and costs for each alternative are calculated using the Federal discount rate of 7.125 percent. The analysis assumes benefits from the project are derived from containerships, tankers, and dry bulk vessels. The Savannah Harbor commodity forecast assumes growth in demand without shifts in share to or from competing ports. The vessel operations forecast for Savannah Harbor assumes vessel operators will load large containerships similar to how they have been loaded in the past.

To identify risk and uncertainty factors around these estimates, sensitivity analysis was performed around methodology assumptions and results. Sensitivity analysis was performed on the following assumptions:

- Light loading - how light loading will change in the future, under alternatives
- Traffic mix - how soon deeper cellular vessels are introduced into the fleet

- Costs - how vessel cost changes affect benefits from larger vessels (e.g. 8000 TEU ships)
- Contingency costs as a portion of the total project costs
- Volume of trade - Trade tonnage related to traffic levels and ship calls.

The sensitivity analysis of these variables reveals the project cost estimates and the shift in the light loading of vessels are the critical determinants of benefits levels.

8.1 Economically Justifiable NED Plan

The economic analysis demonstrates that the 48-foot project alternative maximizes net project benefits of $34,817,000 given the assumptions documented above. Therefore the 48-foot project is the tentative National Economic Development plan, in accordance with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

9. HISTORIC AND FORECAST COMMODITY TRAFFIC

9.1 Historic Commodity Traffic in Savannah Harbor

The growth in waterborne freight commerce through Savannah Harbor is summarized in Exhibit 9-1. The international trade share of total Savannah Harbor tonnage has increased from 61 percent in 1970 to 82 percent in 1996.

Exhibit 9-1
Historic Freight Traffic Through Savannah Harbor, 1970 - 1996
(Short Tons)

Year	Total*	Imports	Exports	Coastwise	
				Receipts	Shipments
1970	6,810,770	2,736,471	1,398,183	1,808,780	140,155
1971	7,231,944	3,157,786	1,301,613	1,843,866	288,313
1972	8,037,171	3,650,220	1,376,680	2,059,680	174,147
1973	8,980,201	4,052,364	1,766,444	2,144,013	223,277
1974	9,698,679	4,251,970	1,981,240	1,962,471	441,362
1975	7,593,297	3,120,987	1,781,919	1,780,276	319,580
1976	9,187,805	3,989,164	1,962,552	2,265,357	319,758
1977	9,875,678	4,129,709	2,074,475	2,630,733	402,742
1978	11,425,936	5,138,030	2,585,059	2,619,509	290,802
1979	13,527,771	6,350,101	3,948,857	2,178,533	335,339
1980	12,293,179	4,202,760	4,863,722	2,218,595	450,850
1981	12,707,864	4,111,007	5,957,146	1,674,503	284,597
1982	10,975,740	3,771,761	4,712,847	1,307,498	595,656
1983	10,610,367	4,124,399	4,135,698	1,400,951	389,113
1984	11,245,804	5,451,071	3,486,077	1,568,261	334,645
1985	11,326,551	5,283,891	4,036,996	1,285,471	415,254
1986	12,041,148	5,839,312	4,038,936	1,348,278	465,160
1987	13,201,806	6,153,495	4,238,914	1,677,947	633,820
1988	13,980,978	5,696,536	5,382,644	1,614,515	589,412
1989	12,830,333	4,992,710	5,399,510	1,413,817	361,355
1990	13,569,000	4,777,000	5,372,000	1,801,000	395,000
1991	13,337,000	4,444,000	5,845,000	1,731,000	342,000
1992	13,989,000	4,412,000	6,583,000	1,727,000	307,000
1993	14,963,000	4,938,000	6,168,000	2,108,000	586,000
1994	15,905,000	5,593,000	6,383,000	2,012,000	539,000
1995	17,380,000	6,438,000	7,375,000	2,512,000	635,000
1996	17,598,000	7,296,000	7,101,000	2,227,000	625,000

Source: Waterborne Commerce of the United States
Note (*): Includes traffic on the Atlantic Intracoastal Waterway and shipments within the Savannah Harbor.

The Savannah Harbor foreign and domestic waterborne commerce, by commodity group in 1996, is summarized in Exhibit 9-2 below.

Exhibit 9-2
1996 Foreign and Domestic Freight Traffic
Through the Port of Savannah, by Commodity Group
(Thousand of Short Tons)

Commodity	Foreign*		Domestic	
	Imports	Exports	Receipts	Shipments
Coal	102	0	0	0
Petroleum Products:				
- Crude Petroleum	916	0	0	0
- Other Petroleum Products	497	28	1,402	652
Chemicals & Related Products:				
- Fertilizers	23	3	14	0
- Other Chemicals	948	485	441	0
Crude Materials:				
- Forest Products	133	522	3	0
- Pulp, Waste Paper	105	939	0	0
- Soil, Sand, Gravel, etc.	939	91	0	0
- Iron Ore & Scrap	10	4	0	0
- Marine Shells	0	0	0	0
- Non-Ferrous Ores & Scrap	117	36	0	0
- Sulfur, Clay & Salt	8	2,802	0	0
- Slag	146	0	0	0
- Other Non-Metallic Minerals	368	17	0	0
Primary Manufactured Goods:				
- Paper Products	35	967	0	0
- Lime, Cement & Glass	432	41	99	0
- Iron & Steel Products	559	16	0	0
- Non-Ferrous Metal Products	130	40	33	5
- Wood Products	174	16	0	60
Food & Farm Products:				
- Fish	5	5	0	0
- Grain	2	36	0	0
- Oilseeds	9	79	0	0
- Vegetable Products	60	30	0	0
- Processed Grain & Animal Feed	8	25	0	0
- Other Agricultural Products	791	330	259	0
Manufactured Equipment	767	576	4	51
Other Commodities	11	8	0	0
TOTAL	**7,296**	**7,101**	**2,254**	**768**

Source: Booz·Allen analysis of Waterborne Commerce of the United States data.
Note (*): Includes Canadian imports and exports.

9.2 Forecast Commodity Traffic through the South Atlantic Port Range

Details on the containerized commodity forecast for the South Atlantic port range are presented in Exhibits 9-3 for detailed trade partner regions for 2000 to 2050.

Exhibit 9-3
Forecast Container Cargo Traffic Through South Atlantic Ports, By Trade Partner Region, 1995 - 2050
(Thousands of TEUs)

Region	1995	2000	2010	2020	2030	2040	2050
Canada	8.7	15.6	22.0	39.0	66.9	108.5	167.7
North Europe	933.3	1,150.4	1,693.6	2,554.1	3,612.7	4,817.9	6,328.5
Mediterranean	280.1	332.0	507.8	785.4	1,092.0	1,426,2	1,810.3
Japan/South Korea/ Taiwan	355.0	394.0	579.2	872.3	1,217.3	1,685.6	2,263.5
Hong Kong	79.2	109.7	207.3	361.1	599.2	999.2	1,642.6
China	162.1	269.0	562.8	1,019.3	1,665.4	2,559.5	3,785.1
Southeast Asia	160.7	247.0	462.3	806.5	1,295.3	1,921.9	2,680.8
Australia/New Zealand	56.7	71.1	121.1	199.4	296.8	407.7	539.0
Indian Subcontinent	53.9	77.6	135.4	229.7	363.3	541.2	760.4
East Coast of South America	398.0	525.9	941.2	1,663.8	2,745.7	4,319.3	6,539.7
Colombia	77.9	96.7	179.8	326,2	526.5	788.6	1,113.4
West Coast of South America	82.4	101.4	200.9	382.9	643.2	994.2	1,446.3
Central America	243.1	352.2	657.0	1,214.3	2,119.7	3,462.5	5,341.2
Caribbean	255.7	340.9	670.4	1,237.0	2,067.3	3,238.9	4,829.8
Eastern Europe	72.2	138.7	294.5	659.4	1,413.0	2,829.6	5,410.9
Africa	75.7	109.0	209.1	371.3	573.8	824.7	1,122.3
Persian Gulf and Others	71.4	107.4	235.5	447.3	733.0	1,125.2	1,646.6
Total	**3,356.7**	**4,438.7**	**7,679.9**	**13,169.0**	**21,030.9**	**32,050.5**	**47,428.3**

Source: Market shares and trade regions based on 1996 PIERS data, ICF Kaiser trade forecast 1997-2050
Note: Numbers may not add due to rounding.

9.3 Forecast Commodity Traffic in Savannah Harbor

The containerized trade forecast for Savannah is shown in Exhibit 9-4 below. The forecast is by trade partner region in TEUs from 2000 to 2050.

Exhibit 9-4
Forecast TEU Volumes Through the Port of Savannah, by Trade Partner Region, 1995 - 2050
Containerized Commodities in TEUs

Region	1995	2000	2010	2020	2030	2040	2050
Europe/Med.	112,401	148,062	227,950	365,223	558,737	828,717	1,237,526
Latin America	49,842	66,825	124,924	227,474	382,043	603,709	908,639
North East Asia	204,662	269,282	470,227	785,075	1,213,459	1,827,639	2,680,386
South East Asia	21,114	32,447	60,740	105,961	170,171	252,491	352,193
Subcontinent	12,697	18,284	31,901	54,130	85,610	127,532	179,206
Other	40,268	57,462	111,410	200,373	316,679	467,521	658,925
Total	**445,984**	**592,362**	**1,027,152**	**1,738,237**	**2,726,699**	**4,107,609**	**6,016,874**
Growth Rate		6.1%	5.4%	4.9%	4.4%	3.9%	3.8%

Source: Market shares and trade regions based on 1996 PIERS data, ICF Kaiser trade forecast 1997-2050

The forecast for containerized metric tons by trade route for Savannah Harbor are shown in Exhibit 9-5 below.

Exhibit 9-5
Forecast Container Traffic Through the Port of Savannah, by Trade Partner Region, 1995 - 2050
(Metric Tons)

Region	1995	2000	2010	2020	2030	2040	2050
Europe	1,066,003	1,360,273	2,133,777	3,483,321	5,429,631	8,205,317	12,484,477
Far East	2,165,334	2,940,015	5,268,841	9,014,550	14,277,601	21,858,577	32,401,311
Latin America	452,567	613,936	1,169,379	2,169,537	3,712,567	5,977,466	9,166,588
Other	365,632	527,914	1,042,880	1,911,065	3,077,388	4,629,038	6,647,401
Total	**4,049,536**	**5,442,138**	**9,614,878**	**16,578,474**	**26,497,187**	**40,670,398**	**60,699,777**

Source: Market shares and trade regions based on 1996 PIERS data, ICF Kaiser trade forecast 1997-2050; Booz·Allen analysis.

The estimated Savannah Harbor TEU traffic forecast that matches the GPA's definition of TEU volumes handled, including lifts of empty containers, is presented in Exhibit 9-6. The forecast growth rate is identical to the loaded container forecasts presented previously but uses GPA's Fiscal Year 1997 TEU Savannah Harbor counts as a base.

Exhibit 9-6
Forecast of Container Volumes Through GPA Facilities at the Port of Savannah, 1995 - 2050
(TEUs, Including Estimates of Empties, Transshipments and Multiple Handling)

	1995	2000	2010	2020	2030	2040	2050
Total GPA TEUs	626,151	828,213	1,436,115	2,430,319	3,812,340	5,743,062	8,412,505

Source: Booz·Allen analysis of GPA data and ICF Kaiser trade forecast for 1997 - 2050.

10. COMMODITY FORECAST METHODOLOGIES

10.1 Methodology For Commodity Trade Forecasts

10.1.1 Introduction

As the future of commodity trade passing through Savannah exists mainly in the context of what will happen to international trade, the future of US trade and trade through the US South Atlantic port region is critical to this study. To ensure comprehensiveness of trade analysis, Booz·Allen has used commodity trade forecasts from ICF Kaiser's Trade and Transportation Group. ICF Kaiser is one of the commercial providers of detailed ocean borne trade forecasts with previous experience forecasting very long-term commodity flows for deep draft port feasibility studies. The ICF Kaiser modeling system forecasts trade through a system of global commodity models that capture individual country demands for imports, linked to economic growth and domestic production, by industry, within each country. The short and medium-term macroeconomic forecasts used in the trade models come from the country and regional models produced by the economic forecasting firm, the WEFA Group. The very long-term forecasts are driven by a special stages-of-development world regional growth model. Outputs of the trade models include individual commodity movements in value and volume terms measured in US dollars and metric tons. For liner trades, containerized metric tons and container volume measured in TEUs are also generated by the models. For the United States, trade is further disaggregated by port range. The US and South Atlantic port range forecasts used in this study come from this modeling system. The forecast for trade through Savannah is derived from the South Atlantic port range forecast. A detailed discussion of the trade model methodology follows.

10.2 Background To Commodity Modeling Approach

As trade demand for specific vessel types is ultimately required in the analysis for this study, trade must be forecast at a level detailed enough to distinguish between the type of trade, on a commodity-by-commodity basis. A global trade model system that covers a sufficient number of commodity and industrial flows provides the needed planning tool for this analysis. Developing this type of model system and related data bases, however, requires the analyst to cross a number of different thresholds, not the least of which is the insurance of a quality of data that can support this form of economic analysis. In reality developing a global trade model system requires the economist to make a number of difficult design choices and compromises to insure that the results meets tests of reliability and sensibility.

What are these forecast design choices? At the start of the process of model development, model structure must be determined. Trade data is normally organized in terms of reporter and partner country data. Given that this information is collected by statistical organizations in each country there can be a significant degree of dissimilarity between data sources. A recent study by Alexander Yates at the World Bank suggests that bilateral trade data is a poor measure of true trade or at least finds that there is such a significant difference in reported trade of an exporter to an importer compared to an importer from an exporter to cast doubt on the validity of either direction of trade. Despite this, researchers have little choice but to rely upon statistical organizations to extract the truth from the flow of goods throughout the world. With the increasing volume of this trade and the importance of it to countries, it is likely that the statistical reliability of the data collection and reporting will improve over time.

The question of trade model structure thus needs to be assessed in light of the problems associated with trade statistics. How many countries and regions should be included? Should the model reflect the share of total imports and exports of each country or region or reflect the bottom up, commodity-by-commodity approach? Should one assess trade in terms of a commodity flow and the resulting balance in worldwide demand and supply or at the individual country level with the total for the commodity determined by the apportioning of the import demand among many competing products? If one follows the former course then trade growth will be uncontrolled because each flow is independent of each other. If the later approach is taken, exports are assumed to be a reflection of choice within a budget constraint. And while the concept of a budget constraint for poor countries is a reasonable one, such a constraint for the countries with convertible currencies (and free floating exchange rates) is inappropriate.

The trade model employed here uses a bottom-up approach with a set of controls imposed. The bottom up approach assumes that trade in each commodity represents a universe of individual decisions by companies and consumers. It is a model that reflects the imperfectly competitive nature and the limited amount of information that may be available to consumers regarding potential suppliers worldwide. Trade moves along pre-defined routes with only a modest ability to shift suppliers in the short run. In the model, competition is introduced between export sources by forcing forecast trade for each exporter to be equal to a separately estimated import demand from a group of exporters as a whole. For example, if exports are estimated separately for each of the OECD countries to the United States and the import demand of the United States from the OECD is also estimated separately, one approach to this problem would be to scale the model-developed forecasts to the "topline" or OECD-wide estimate of imports. Using this approach, differential price and production factors would be taken into account as a result of the scaling process since the market shares would be determined by the relative competitiveness of each exporting country.

In building such a model the analyst needs to first determine the characteristics of the desired outputs. Though it is possible that a set of broad trade aggregates may be ideal for some types of macroeconomic studies, deep draft navigation benefits studies need more detail in commodity coverage and in the inter-regional relationships assessed. This is the detail that allows the classification of trade by vessel type and trade route. For comprehensiveness, the model employed covers the full world trade including the intra-LDC trade between countries and regions. Using this approach, the significant commodity trade detail is maintained while the total of trades for all trade partners and data reporting countries adds up to world trade without double counting. This means that by definition, exports of all countries/regions to the world are exactly equal to imports of all countries/regions from the world.

The challenge for the analyst is to choose the best economic model structure that allows for the full range of possible country sizes and strengths. Because of the very nature of goods exchange between countries, one assumes that trade is not solely a reflection of specific country experience in isolation. Trade can be represented by a system of models sharing the same general structure that take into account patterns of investment and consumption. Previous research has shown that the common or framework model is superior to standard time series models in forecasting international trade. This is because the framework models capture the predictive information in a cross-country data set as well as the time dimension in the historical observations. The resulting forecasts better reflect the long-term relationship between trade and economic growth by allowing countries to adapt and change over the long-term.

Trade has become more volatile in the last few decades, with many examples of trade flows growing by 25-50% and then falling by the same amount the next period. This volatility makes a time series model less efficient in deciphering the underlying factors that are at work. A pooled data set combining country specific information over time and multi-country information offers a better model for assessing the factors that are at work. With this approach, a poor country can, over time, become richer. As a country moves through various stages of economic growth it experiences different needs and trades commodities in different absolute and relative volumes.

In the trade model methodology employed here, each commodity model of world trade is first estimated by itself, defining the interrelationship between exporters and importers trading in a single commodity category. For each commodity, the model attempts to measure the global competitive balance between exporters and importers. Unlike other attempts at world trade model development these models do not begin with a top down estimate of total trade demand but rather are built up, in logical steps, from demand and supply to each partner region. Econometric models define import demand and export supply potential wherever possible. If separate econometric models are inappropriate due to the sparseness of the data available or due to a failure to find a statistically significant model structure using the best econometric techniques, parameter models are substituted in relationship with the econometric model forecasts. With this approach, the best estimates are made for each commodity category traded. The trade model industry and commodity categories are detailed in Exhibit 10-9 at the end of this attachment.

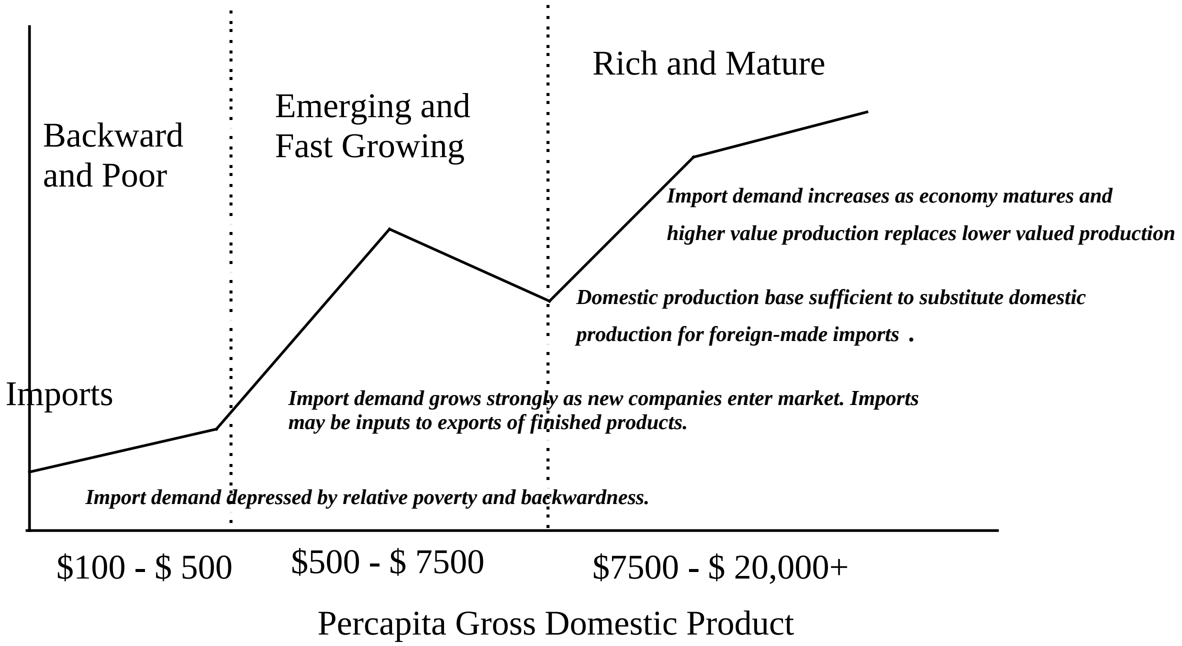
US merchandise trade statistics from the Bureau of the Census serve as the foundation for international trade to and from the United States. World trade data is drawn primarily from detailed, commodity specific, trade data covering 160 countries worldwide developed from United Nations trade information sources by Statistics Canada. This data reflects Statistics Canada's estimates of bilateral flows. The data base covers a single direction of trade, i.e. Mexican imports from Japan are identical to Japanese exports to Mexico. All trade models are specified as import demand models. Export supply is derived from import demand from a specific region or country. A 60 country/region matrix of trading partners has been selected. There are approximately 48 countries plus 12 additional regions comprising the world under this organization of the data. (see trade country / region exhibit below.) These countries and regions aggregate to the world (as defined by the initial 160 country set of trade data available in the Statistics Canada data set); and trade data is arranged in a symmetrical data set where there are an equal number of partner regions as reporter countries. Import demand equations are estimated based on the WEFA Group's international macroeconomic data, price data, and exporter performance measures – relative wages and relative rates of productivity growth.

10.3 Theoretical Framework: International Trade Life Cycle

The strong growth experienced in the world economy over the period starting in the early 1980's and continuing through 1997 reflects the increasing internationalization of production. Increasingly international trade is less a function of national development than a function of international development. Trade flows are then a direct result of foreign investments and the increasing diffusion of technological information from the core or more advanced nations to the less advanced ones. As a result, understanding the factors that are driving this shift and forecasting future patterns of growth must rely upon economic models that are not linear in orientation, i.e. that do not reflect a growth along a single production path, but rather reflect the multiplicity of production paths that are apparent. Countries continually leap frog as new investments are made and new enterprises develop.

Trade reflects economic maturity. Countries move through various phases from relatively poor and undeveloped, with imports constrained by capability and financial capital availability; to emerging growth, when imports may increase as they fill in gaps in domestic production that are often oriented towards exports; and through more mature emerging markets, when domestic producers substitute for foreign (import demand may then fall as more local production substitutes for foreign production). At some point countries reach a mature stage in which imports increase as foreign producers replace domestic producers. This later stage reflects the maturity of the production base as it shifts from lower valued to higher valued production and from manufacturing to services.

Exhibit 10-1
Idealized Stage of Economic Development
Model for Import Demand



Source: Booz·Allen & Hamilton Inc. from ICF Kaiser, Inc.

Countries and markets tend to reach point of maturity when consumer markets become saturated. During this later stage there is a replacement of old with new, but little real growth. These more mature economies also tend to be slower growing ones in terms of population growth, but their absolute volume of demand is such that they buy "more" than others that are faster growing but are currently less well developed. Development stages also dictate the kinds of products that are consumed and the trade relationships established. Economies thus move through phases and these phases are predictable using models that relate these differing patterns of growth.

10.4 The Underlying Quantitative Model

Cross-country models reflect stages of economic development by utilizing information from more than one country in a joint estimation procedure. The advantages of the approach are many, not the least of which is the ability to model the longer term trends. Short term patterns, however, may require inputs of more country specific data. As a compromise between the short-term benefits of a time series model and the long-term power of a cross-country one, a hybrid specification framework that mixes time series data with cross-country data has been selected. Thus all of the component trade models were estimated using a pooled cross-sectional data set with 60 countries/regions and fifteen years of international commodity trade data.[20]

The underlying theoretical model is based on a very traditional international trade model form in which import demand is a function of aggregate demand and relative prices for imported products. Trade models are "import-oriented" models with export supply assumed to be rationalized across major regional groupings. Exporter success in selling depends critically upon their relative prices, productivity trends, and exchange rates. Import demand is determined by personal consumption expenditures, business investment, and consumption structure.

From the perspective of demand for traded products, nearly all import demand can be defined by domestic economic activity. A very simple form of this type of model is:

$$M_{ijk} = (Y_i) = APM_{ijk} * Y_i = \frac{\hat{M}_{ijk}}{\hat{Y}_i} * Y_i ,$$

where: M is the mean imports over the period for country I from region j for product k

Y is the mean income over that same period for country i. Y is either income or GDP.

APM is an average propensity to import and it assumes that each additional dollar of income leads to a fixed share of additional imports. A more complex form would be to examine the marginal import demand relative to the marginal dollar of income. To compute this, one takes the first difference in imports relative to the first difference in income, or:

$$M_{ijk}t = M_{ijkt-1} + MPM_{ijk} * \Delta Y_i ,$$

where: $MPM_{ijk} = \frac{M_{ijkt} - M_{ijkt-1}}{Y_{it} - Y_{it-1}}$ and

$$\Delta Y_i = Y_{it} - Y_{it-1} .$$

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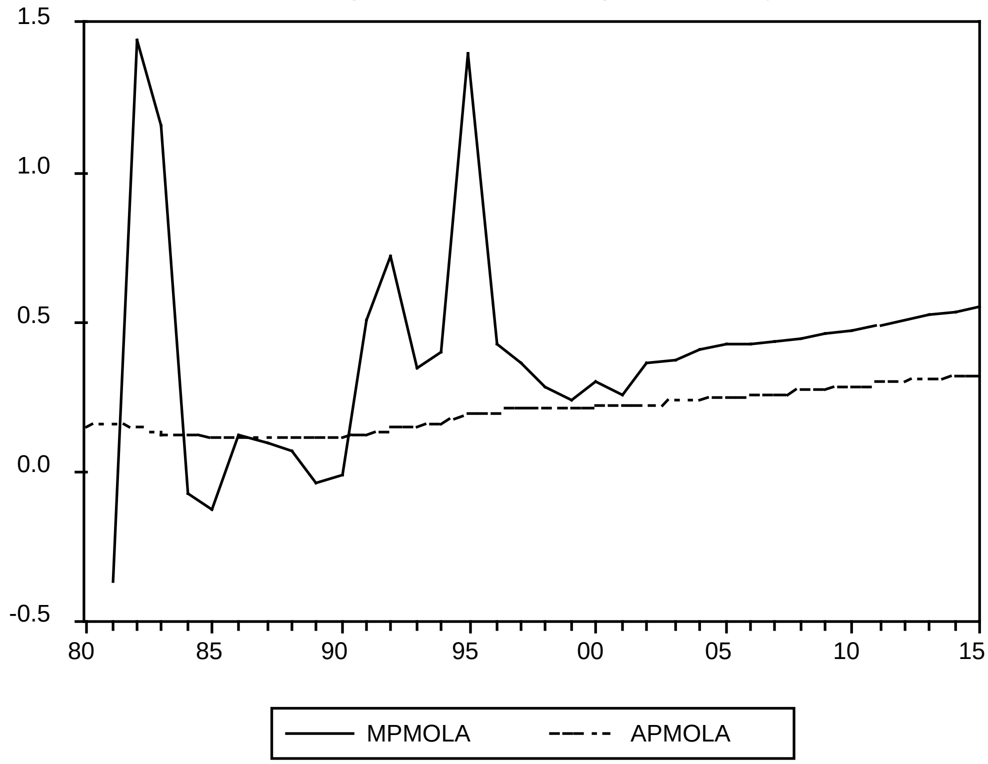
[20] *This is therefore a 60 x 15 sample of data, potentially 900 observations and, even with individual country intercepts, more than 800 observations. Few time series models come close in terms of total number of observations. Since the statistical reliability increases as the number of observations increases, in most cases the coefficients are statistically valid even if the t-statistic is less than 2 (greater than 1.5 is generally acceptable).*

Neither **APM** or **MPM** are entirely satisfactory. To demonstrate this, one can examine the example below drawn from trade of countries in Latin America. One can see that there is an extreme volatility in the marginal propensity to import relative to income. At the same time there is a slow growth in the **APM** showing that it is not a constant but changes over time. As shown in Exhibit 10-2 below, the marginal propensity to import is extremely variable while the average propensity to import is relatively flat and rising. This variability makes using the "marginal" indicator difficult. It suggests that small changes in imports may not be fully explained by small changes in GDP.

Exhibit 10-2
Comparison of Marginal versus Average Propensity to Import



What then is a more robust theoretical model for determining international trade performance and forecasting it into the future? Over the years economists have used a variety of time series estimations to predict import demand. Some have been specific to commodities, some even have modeled groups of countries and cross-country or bilateral trade, but in general there have been few econometric models developed that have used a pooled-cross-sectional-time-series-model framework and are commodity specific and route specific. In developing a more sophisticated model we need to take into account structural parameters that impact trade propensities.

Over the period starting in the 1960's and continuing through the 1990's there was a steady increase in the average propensity to import. If we can understand what is behind this trend then we can understand why international trade has increased dramatically since the early 1980's.

One way to understand what has happened is to divide **APM** into its component parts or:

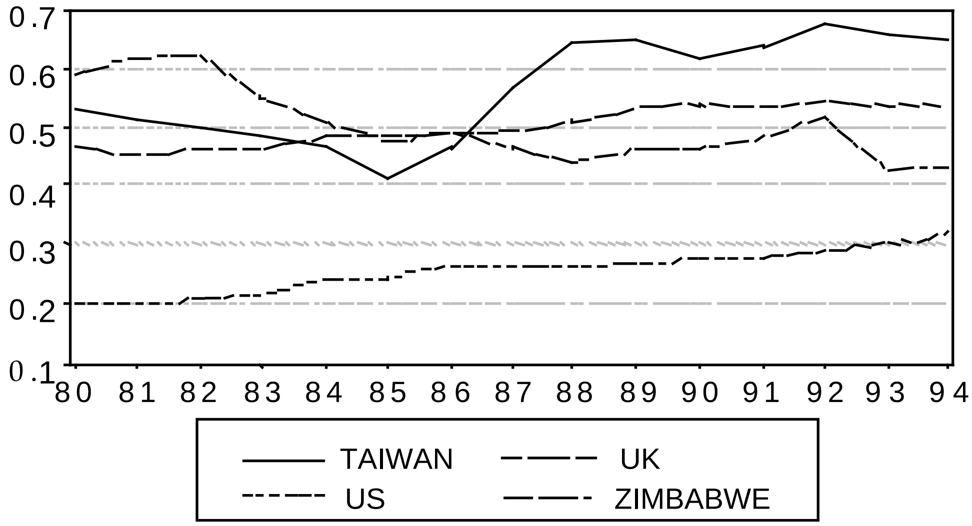
$$APM = \frac{CG}{Y} \times \frac{M}{CG},$$

where: CG = PG - E + M.

PG is the production of traded goods, **E** is exports of traded goods (possibly reduced by a factor to take into account the make-up of exports by the non-manufacturing sectors of the economy), and **M** for imports of traded goods.

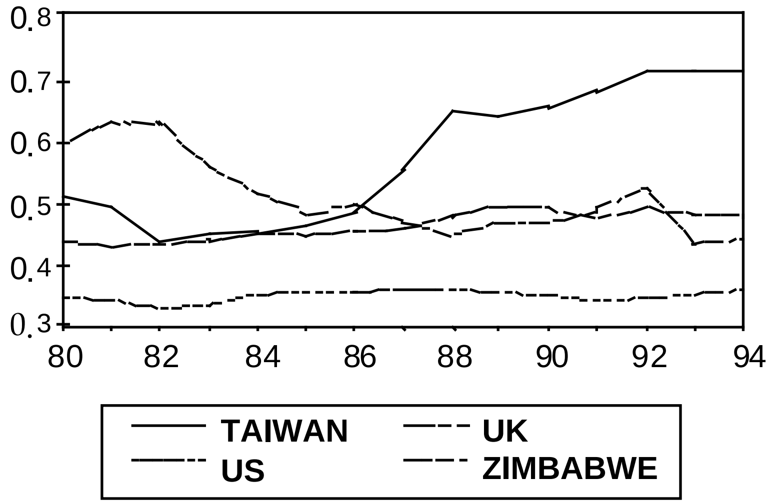
Trade intensity thus is now defined in terms of share of consumption of traded goods rather than share of total income. The ratio of consumed goods to income, **CG/Y**, is slowly adjusting as consumption patterns adjust and change. We know that the ratio of imported goods to consumed goods, **M/CG**, cannot, by definition, exceed 1.0 (although for some countries with significant inflows of transit and re-export trade the share may be quite high.) In general small countries tend to have higher import shares than larger ones. This suggests that there is greater specialization. The example countries of the US, the UK, Taiwan and Zimbabwe are shown in Exhibit 10-3 below. There has been a gradual increase in the share of imports to consumption of traded goods. The increase is significant for the US, the UK and Taiwan. Zimbabwe's share has fallen over time due in part to the embargo that limited its ability to buy from the world (when it was known as Rhodesia) and in part due to its poverty and lack of hard currency to buy foreign imports.

Exhibit 10-3
Import Share of Consumption of Internationally Traded Goods



For the more advanced nations, such as the US and the UK, the consumption share of GDP has been flat, as shown in Exhibit 10-4 below. Most of the advanced economies now have a significant share of total gross output concentrated in services. These economies have a relatively smaller share of output that can be affected by rapid increases in imports. Improvements in the quality of life in these economies parallel the increase in consumption of goods that can be traded internationally.

Exhibit 10-4
Consumption Share of GDP
for the US, the UK, Taiwan and Zimbabwe



The two ratios thus represent limits. Over time, the **CG/GDP** ratio will be flat or decline as service trade takes a larger share of total **GDP**. It is assumed that the imports to consumption ratio, **MG/CG**, will reach an asymptotic limit less than 1.0. No country can be truly 100% specialized in production. Marginal adjustments in **APM** that changes in these two elements induce tend to slow as a country approaches its asymptotic limits. Evidence for this is found in Western Europe, where for most smaller countries, European Union integration has already led to trade intensity measures that are approaching unity (1.0). Over the past thirty years, nearly all trade growth is reflected in the imports to total consumption ratio, as the general trend in consumption to income, for most countries, has been negative.

Income can next be divided into two components -- market size and wealth per capita. The shift in demand can be related to market size since larger markets tend to demand more of some products, and, they also tend to be more competitive as foreign sellers find it less expensive to penetrate larger markets (the market potential is greater and thus the cost of entry per probable unit of sales is less). The wealth effect on trade is usually positive since wealthier markets attract more foreign suppliers. It may, however, sometimes be negative. Wealthier nations may find it too expensive to produce lower valued products and thus will turn to imports. Even high technology products can be "low value" in terms of profitability. An increasingly global production base assures that each trading nation will export products that it has a comparative advantage in (either in terms of land, technology, knowledge, or the skills of its work force) and import those products for which it has only a limited advantage. Increasingly products are made in one country for export to second with parts produced in a third.

Using these relationships the import demand model can be revised as follows:

$$M_{ikt} = A_i \times \left[\frac{CG}{Y}_{it}\right]^{b1} \times \left[\frac{MG}{CG}_{it}\right]^{b2} \times \left[\frac{GDP}{N}_{it}\right]^{b3} \times N^{b4},$$

where A is the constant intercept, **CG/Y** is the average consumption of traded goods to income, **MG/CG** is the trade intensity measure, **N** is market size (population), and **GDP/N** is per capita income or wealth.

This model is non-linear. Each of these "factors" has an impact on the others. One can estimate this equation using a log-log specification. The betas then become point elasticities measuring the rate of change in imports relative to the rate of change in each of the independent variables. The original constant **APM** occurs when the beta's estimated are approximately equal to 1.0. The approximate size of the beta measures the importance of the effect. If trade intensity is of greater importance in explaining import demand then the beta will be greater than 1.0. When the beta is close to zero the net impact of this factor is insignificant and the entire change can be explained by the elements that are non-zero. If **b1** and **b2** each were equal to 1.0 [21]then the average propensity to import would be exactly equal to:

$$APM_{ikt} = \left[\frac{CG}{Y}_{it}\right] \times \left[\frac{MG}{CG}_{it}\right].$$

Export supply factors that influence trade can be summarized by the relative rate of expansion or contraction of production within the exporting region. In the development of these models, a number of structural forms were tested to account for the influence of changing export supply factors on the size and direction of growth in regional trade. In the current modeling system, it was decided to reflect the relative rate of production growth in exporting regions alone. This version of the commodity

21 *Similarly if b3 and b4 were equal to 1.0 each, then the product of Y/N and N would be identical to Y. As it turns out, in few cases are these relationships homogeneous of a degree 1.0 which this condition implies. In nearly all cases the impact of economic structure, wealth and market size on trade in a specific, kth, commodity varies.*

trade models embody structural relationships for production in the exporting region.[22]

The import model, however, has been formulated to mirror correctly the short-term patterns in market demand as reflected by the demand for consumer products (personal consumption expenditures) and investment goods (business fixed investment spending). The relative price term adjusts import demand to reflect cross-price relationships between exporter and importers. Import price changes alone, however, are assumed sufficient to adjust import demand. Efforts to compare import prices to domestic prices tend to yield unsatisfactory results primarily because of the difficulty in finding comparable price measures for both the exporter and the importer. Moreover, trade tends to "fill-in" at the margin, so that small changes in prices of traded goods can lead to larger adjustments in trade volumes. In general, however, price elasticities calculated using this approach are consistent with a priori expectations and fall within a range of -2 to 0.

10.5 Nominal U.S. Dollar Trade And Real Volume Trade

One of the most vexing problems in international trade forecasting involves finding a useful common measurement for comparing real growth across countries and between regions. Econometric models are typically estimated in terms of real volume measures with prices assumed to be external or exogenously given. Given that nominal dollar amounts tend to reflect exchange rate changes that may, or may not, impact real demand for the products, there can be an extreme volatility in the nominal values where there is only a limited volatility in the real volumes. This differential becomes even more apparent when we compare Country A to Country B especially if exchange rates have changed dramatically over time.

The volatility of currency exchange rates makes use of nominal value trade data problematic for forecasting. This volatility is clear in Exhibit 10-5 below for German, Japan and Singapore. Even if there was no change in the real volume of trade, use of nominal values over this period would lead to large swings in reported nominal dollar trade.

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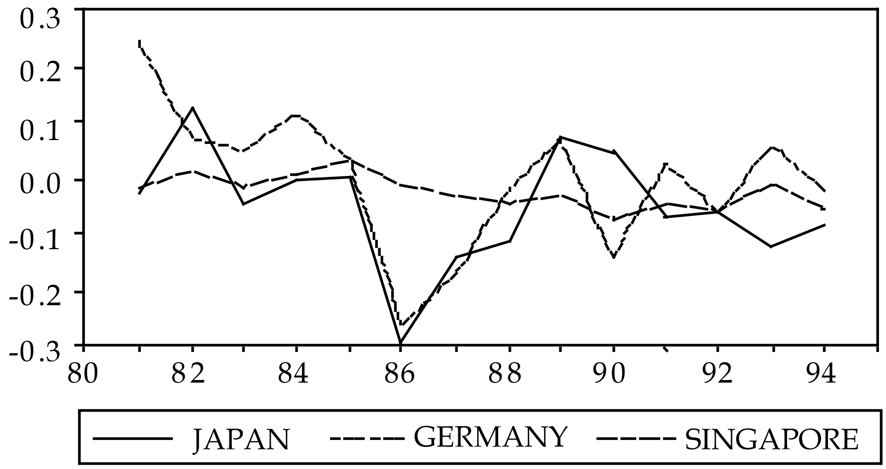
22 *Relative wage and relative productivity measures are not included in the supply potential portion of the analysis. These proved to be too difficult to interpret with any precision. By scaling export supply for all regions j to import demand from the world, a control is imposed that allows for export market shares among suppliers to shift over time.*

Exhibit 10-5
Volatility in US Dollar Foreign Currency Exchange Rates
Japan, Germany and Singapore



Prices are both descriptive of the current value and also structurally important, describing the behavior of consumers as they change. To find a common denominator for all countries in order to do a proper comparison then two elements need be considered: commodity price changes and exchange rates.

The United States dollar is typically used as a measure of trade and economic performance. Assuming that prices are in US dollars, one has to insure that the dollar/local currency rate is held constant over time so that the volatile nature of the dollar's rise and fall is avoided. A measure was developed that reflects dollars converted as of a certain point in time. This was done by taking out of the nominal dollar value of country trade the changes that have occurred since the conversion point in both commodity prices and exchange rates.

A standardized approach to adjustment of trade value to volume has been developed that takes into account both commodity prices and cross-exchange rates. Commodity prices are in terms of US dollars, measured using SITC commodity-based export and import price indices. Individual country differences in price inflation relative to US prices are taken into account using export price indices. Two principals have guided this approach:

1. Real changes in commodity prices should be captured in any price index applied;
2. Exchange rate changes should not be introduced mechanically, in order to avoid assuming the full effect of the change in international prices are passed onto buyers by sellers.

The lack of fully consistent, trade specific prices for commodities included in this study has led to the development of a hybrid methodology using United States price statistics, exchange rates, and general export price indices for exporting countries and regions. These representative measures are specific to OECD and selected emerging markets (with generally convertible currencies) but are not used to convert exports of other less developed countries, as these countries are assumed to be price takers. This approach also assumes that the less developed country trade volumes reflect US dollar price adjustments only (not exchange rates).

Import demand price indices are based on United States Bureau of Labor Statistics trade price indices. These indices are developed using survey data from US importers and exporters; indices are commodity specific. They are not, however, specific to any one trade partner country or region. Price index forecasts are based on forecasts derived from United States input-output industry models and reflect the macroeconomic developments and factors specific to related industries. An illustrative example may help explain this. To understand the impact of US dollar changes on Japan's exports to the world, exchange rates and Japanese export price adjustments need to be taken into account. In Japan, export price trends have often been counter to exchange rate trends. Export prices in yen-denominated terms have fallen as the yen/dollar rate has appreciated. When the rate of adjustments are of equal amounts (in opposite directions) then the net impact of the yen's appreciation in terms of export volume is zero. Thus the reported volume exported from Japan may be greater than it would have been, if only the exchange rate adjustment and commodity price changes had been applied to the nominal dollar value of trade.

While the approach used to making international trade flow data consistent in real volume measures may appear to be somewhat abstract, it offers the significant advantage of being consistent across countries and regions. It also allows for differential impacts associated with domestic price inflation (or deflation). Given the importance of the American market or competition against US dollar denominated exports, US commodity price trends appear to offer a consistent set of price indices for deflating nominal value data.

$$IX_{jk} = \frac{ICUS_k \bullet \frac{ITX_j}{IUS}}{IEXR_j},$$

where: IX is the export price index for country y for commodity k;
ICUS is the commodity price index from US data for commodity k with a base 1978 = 1.0
ITX is the country specific export price index (local currency) for country j with a base 1987 = 1.0
IUS is the general price inflation index for the United States with a base 1978 = 1.0
IEXR is the index of exchange rate for country j in local currency/US $ terms with a base 1987 = 1.0.

The export price index IX is used to deflate the nominal dollar trade of the importing country. The nominal dollar trade reflects exchange rate adjustments in each importing country. Thus the resulting real imports reflect a real, 1987 base, volume of trade removing both exchange rate adjustment and commodity price trends.

$$M_{ijk} = \frac{NM_{ijk}}{IX_{jk}},$$

where: M is the real imports of country i from region/country j of product k
NM is the nominal imports in US dollars of country i from region/country j of product k
IX is the export price index for the jth exporter to all countries for product k.

When a currency appreciates relative to the dollar the export price index increases. If the importer's currency is also appreciating, so that the nominal dollar imports of that country are greater, then the impact of the appreciation on the exporter and the resulting rise in the price index is reduced. The higher dollar value of the reported imports and the greater value in the price index cancel out. The adjustment of the commodity price for product k is designed to relate the export price of the exporter to the US general price level. For example, when the Japanese yen appreciated against the dollar during the mid-1980's, the Japanese export price declined (in yen terms). The reduction in the export price countered the appreciation in the yen/dollar exchange rate (fewer yen per dollar).

For less developed country (LDC) exporters it is assumed that each importing country's own dollar (nominal dollar) volume may be properly deflated with the general price inflation in US dollars. This assumes that LDC exporters are price takers and that they regulate their exchange rates to insure that their exports remain competitive in terms of the general inflation rate in the American market. Thus when a local economy is inflating rapidly it is assumed that the export price in dollars adjusts as the country's own exchange rate devalues in line with the internal inflation rate. To the extent that this does not occur, the exporters would find themselves priced out of the market unless they are able to subsidize the exports. In either case they cannot sell their products at prices above the rate of US price inflation for the commodity in question.

10.6 The Structure Of The Global Trade Model System

Each trade represents a single commodity trade flow. These are not top down models but rather are built up from the sum of their pieces. Total world trade is the result of the interaction of 3600 individual trade routes for each of the 82 commodity groups that make up the full sample. Each commodity's trade model is independently developed and, whenever possible, importer-exporter relationships are independently forecast. At the commodity level, however, there are controls imposed to insure consistency with past periods and reasonable forecasts for future period growth.

Each model includes a fully described set of historical and trade data for the 60 countries and regions (43 countries and 17 regions). There are 60 trade reporting regions and countries and 60 trade partner regions and countries, thus the resulting model reflects a bilateral matrix of world trade. Unlike earlier efforts, this model covers all reported trade flows and is based on data derived from a 160 country collection of commodity trade data (collected annually by the United Nations) . These reports represent a universe of information drawn from sometimes conflicting sources. To insure consistency, the historical data base uses as its core, United Nations world trade data supplied by Statistics Canada and reported as a unidirectional matrix of trade, i.e. only one direction of trade information is reported for each country pair (160 x 160).

The advantages of this are several. In developing models for international trade, consistency is important and trade data often is inconsistent. This is especially true with respect to bilateral trade where Japanese imports from China may not be fully consistent with Chinese exports to Japan. It makes the development of a trade model less complex in that each flow is independent of each other. Exhibit 10-6 below lists the reporting and partner country trade regions used in the model. Detailed region definitions are contained in Exhibit 10-8 at the end of this attachment.

Exhibit 10-6
Countries and Regions Used in
Commodity Trade Forecasting Models

Exporting Country
Historical & Forecast
International Trade Data

North America	Indian Subcontinent
United States	Pakistan
Canada	India
Europe	Other Subcontinent
Western Europe	Developed Asia
Austria	Japan
Belgium	Australia
Denmark	New Zealand
Finland	Central America
France	Mexico
Germany	costa Rica
Greece	Panama
Ireland	Other Central America
Italy	Caribbean Basin
Netherlands	Latin America
Norway	Argentina
Spain	Brazil
Portugal	Venezuela
Sweden	Other East Coast South America
Switzerland	Chile
Turkey	Colombia
United Kingdom	Peru
Other Western Europe	Other West Coast South America
Eastern Europe	Africa/Mediterranean Region
Former CIS	Persian Gulf
Emerging Asia	Israel
China	Mediterranean
Hong Kong	Northern Africa
Indonesia	Eastern Africa
Malaysia	Western Africa
Philippines	South Africa
Singapore	Other Southern Africa
South Korea	
Taiwan	
Thailand	
Vietnam	
Other Region	

Exports To →

← **Imports From**

Importing Country
Historical & Forecast
International Trade Data

North America	Indian Subcontinent
United States	Pakistan
Canada	India
Europe	Other Subcontinent
Western Europe	Developed Asia
Austria	Japan
Belgium	Australia
Denmark	New Zealand
Finland	Central America
France	Mexico
Germany	costa Rica
Greece	Panama
Ireland	Other Central America
Italy	Caribbean Basin
Netherlands	Latin America
Norway	Argentina
Spain	Brazil
Portugal	Venezuela
Sweden	Other East Coast South America
Switzerland	Chile
Turkey	Colombia
United Kingdom	Peru
Other Western Europe	Other West Coast South America
Eastern Europe	Africa/Mediterranean Region
Former CIS	Persian Gulf
Emerging Asia	Israel
China	Mediterranean
Hong Kong	Northern Africa
Indonesia	Eastern Africa
Malaysia	Western Africa
Philippines	South Africa
Singapore	Other Southern Africa
South Korea	
Taiwan	
Thailand	
Vietnam	
Other Region	

10.7 The Forecast Process: The Multistage Approach To Global Trade Forecasting

A pooled time series cross sectional data base is used for the econometric model development. Estimations depend upon a weighted Generalized Least Squares estimation using weights derived from the co-variance matrix estimated in the initial pass.[23] Pooled cross-sectional time series models combine information on many countries while allowing for generally consistent estimators to be developed across a

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23 *The generalized least squares approach allows for individual series to be estimated efficiently in a pooled estimation. Individual country differences are somewhat problematic so these are accounted for using a set of individual country intercepts and employment of a weighted least squares approach. The weights for the second iteration are drawn from the initial errors. This correction for the implied heteroscedasticity insures that the estimators in the equation are generally unbiased by differences in individual country sample data.*

shortened time period. At the present time, however, the models use the full sample of data starting in 1982 through 1995/96[24]. There are 13 to 14 observations available for each country pair included in the trade model. In most cases there are a minimum of over 700 observations in the data sample for each pooled cross-sectional time series model estimated.[25]

In the cross-sectional model, the focus is the long-term trends in a country's demand for imports. Future trade of a poor country should roughly follow the path identified by the richer countries. Cross-country models tend to reflect the stage of economic development of the countries in the sample set and thus allow for a shift in demand to occur as countries pass from one stage to another.

Separate country intercepts reduce the degree of heteroelasticity within the sample thus allowing each country to reflect its average size as a starting point.

There are three different types of variables:

1. Coefficients specific each country or group of countries;
2. Coefficients common to the set of all countries; and
3. Specific intercepts.

In general the equation has the following form:

$$M_{jk} = \Phi_{ik} + \mathrm{B}X + \mathrm{A}_i X_i .$$

where: i is the importing country for which there is a single intercept term for each (A),
k is the product type
j is the partner region..

The B (beta) represents the generalized coefficients jointly estimated, while the Φ (phi) is the coefficient for importer and region specific variables. In general, region specific variables are used for differential price effects. In earlier research, it has been found that there are sometimes quite different reactions to changes in import prices among countries and regions.

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24 *At the present time Statistics Canada data is available through 1995 for all countries (with some exceptions). The Statistics Canada 1995 data were made consistent by completing individual series to insure consistency. The 1996 commodity trade data from US Department of Commerce data base has been applied for US trade routes.*

25 *There are some flows which are sparse. For each flow a test of available data is applied and if the size of the data sample is insufficient parameter model alternatives to econometric estimation are used to forecast trade flows.*

10.8 Econometric Specification For Import Demand Models

The econometric model specified uses the key variables in Exhibit 10-7 on the following page. These can be divided between structural variables that apply across all importers in a general way, macroeconomic variables that reflect short-term factors, relative price variables, and partner region production factors.

Exhibit 10-7
Key Variables in the Commodity Import Demand Models

Independent Variable	Description of Variable	Type of Effect
CGSH	Apparent consumption share of traded products relative to total apparent consumption. Total apparent consumption reflects gross output for goods and services less exports plus imports of traded goods.	**Structural Parameter**
MGCG	Import share of apparent consumption of traded goods. Reflects trade concentration of overall economy.	**Structural Parameter**
PCONPOP87	Personal Consumption Per Capita of Goods and Services in 1987 $.	**Demand Variable**
INV87	Investment in 1987 $.	**Demand Variable**
Import Price	Import price index reflecting cross-exchange rates and commodity price.	**Price Variable**
POP	Population	**Market Size**
Consumption / Production	Consumption of Commodity relative to growth in Domestic Production	**Demand-Supply Relationship in Importing Market**
Production of Commodity	Exporter's production of commodity. This reflects the supply potential of the partner or export region.	**Supply Variable**

The model specification selected allows for separation of regional impacts. This has been approached in two ways. The first assumes that there is a significant, but gradually adjusting, factor that serves as a linkage between two estimated coefficients. For example, included is a variable that gradually adjusts in relationship to the rate of growth in per capita income. When per capita income is less than $ 20,000 (1987 $) per year, this variable takes on a value between zero and 1.0. When per capita income is greater than $20,000 the variable is equal to 1.0. This variable can be called an income adjustment factor. By estimating coefficients that apply across all countries and also a separate coefficient that is pre-multiplied by this factor (from just greater than zero to 1.0 maximum) one can differentiate the elasticity impact between poor and rich nations over time. This is shown in the (somewhat complex) equation below.

$$\mathbf{M}_{\mathbf{ijk}} = \mathbf{A}_{\mathbf{ijk}} + \mathbf{b}_1 \ln(\mathbf{I}_i) + \mathbf{b}_2 \ln(\mathbf{I}_i) * \mathbf{IA}_i + \mathbf{b}_3 \ln(\mathbf{CGSH}_i) + \mathbf{b}_4 \ln(\mathbf{CGSH}_i) * \mathbf{IA}_i + \mathbf{b}_5 \ln(\mathbf{MGCG}_i)$$
$$+ \mathbf{b}_6 \ln(\mathbf{MGCG}_i) * \mathbf{IA}_i + \mathbf{b}_7 \ln(\mathbf{PCONPOP}87) + \mathbf{b}_8 \ln(\mathbf{PCONPOP}87)^2 + \mathbf{b}_9 \ln(\mathbf{PCONPOP}87) * \mathbf{IAi} + \mathbf{c} \ln(\mathbf{Pij}) +$$
$$\sum_{\mathbf{m}=1}^{\mathbf{M}} \mathbf{c}_{\mathbf{m}} \ln(\mathbf{P}_{\mathbf{ij}}) * \mathbf{D}_{\mathbf{m}} + \mathbf{e}_1 \ln(\mathbf{POP}_i) + \mathbf{e}_1 \ln(\mathbf{POP}_i)^2 + \mathbf{f}_1 \ln(\mathbf{CONSUMP} / \mathbf{PROD})_{\mathbf{ik}} + \mathbf{f}_2 \ln(\mathbf{CONSUMP} / \mathbf{PROD})_{\mathbf{ik}} * \mathbf{IA}_i$$
$$+ \mathbf{g}_1 \ln(\mathbf{PROD}_{\mathbf{jk}}), \textbf{ where}$$

M is imports of the ***i***th country from the ***j***th partner region of the ***k***th commodity/industry category;

I is the investment by business, government, and individuals in new capital equipment, buildings, and infrastructure;

IA is the dynamic adjustment factor based on the ratio of per capita GDP (Y/N). The variable is always greater than zero but may be equal to 1.0 when the per capita income of the country or region exceeds $ 20,000. A moving average is used to insure a smooth transition as income grows.

CGSH is the consumption of traded goods share of total apparent consumption. Total apparent consumption is the sum of gross output for goods and services less exports plus imports of traded products.

MGCG is the imports of traded goods as a share of the consumption of traded goods, i.e. the trade intensity of the importer *i*.

P is the price of the exported commodity in the importing region or country, i.e. price of exports of commodity *k* from region *j* in importer *i*. It represents the combination of the US dollar commodity price of *k*, the exchange rate of the *j*th region, an adjustment to the commodity price to represent the differential inflation between the *jth* market and the US market, and the importer's exchange rate.

PCONPOP87 is the per capita consumption expenditure for the *i*th region.

PCONPOP87^2 The joint elasticity reflects the combination of $\mathbf{b}_7 + 2\mathbf{b}_8 * \ln(\mathbf{PCONPOP}_i) + \mathbf{b}_9 * \mathbf{IA}_i$, where IA takes on a value of between just greater than zero and 1.0 depending upon the relative wealth.

Dm is a set of instrumental variables for the following price setting regions: US, Japan, Western Europe, Newly Industrialized Economies (Hong Kong, Korea, and Taiwan), and Other Developed Economies. Each variable takes on a value of either zero or 1.0. This allows for a differentiation in the price effect between these markets with a general price impact assumed for the all other markets. The price elasticity is the sum of the coefficient $c+c_m$, where *m* represents one of the five regions.

CONSUM/PROD is the consumption of commodity *k* for country i (production less exports plus imports) over the production of commodity *k* for country *i*. When this ratio is increasing import demand should increase, when it declines domestic production may be impacting imports and reducing the relative rate of import growth.

PROD is the production of the jth country of commodity *k*. It measures the general strength of the domestic economy as an exporter.

The joint elasticity for personal consumption expenditures varies across countries and regions. For example the elasticity for radio, TV and communications equipment (mostly dominated by trade in telecommunications equipment) for the United States varies between 1.6 and 1.5. The elasticity for China for this same type of imports is between 2.6 and 2.4. Zimbabwe, in Africa, has an import demand elasticity of between 2.35 and 2.2, while Costa Rica an elasticity of between 3.5 and 3.3. (The second number represents the elasticity as of 2015 based on the forecast for total personal consumption expenditure.) What is clear is that there is a wide range between countries and regions and that (in this case) the marginal rate of growth in import demand declines, thus for each additional 1% in personal consumption the resulting import demand growth will moderate as time passes and the size of the personal consumption expenditure pool becomes larger.

10.9 Propensity Model For Forecasting Import Demand

For many trades there is no structural model that fairly measures trade performance. This problem may affect all countries in the data reporter-trade partner (importer-exporter) pair or it may be specific to a set of countries within that pair for which there is insufficient data or where the econometric specification inaccurately portrays the pattern of actual trade.[26] For trade routes that do not meet the test of accuracy expected an alternative model specification is applied.

10.9.1 A Parametric Market Share Model

The trade models cover more than 3600 potential routes. It is thus not unexpected to find that there are routes for which observed trade is relatively sparse. For trade routes where the econometric fit of the equation is weak, alternative methods are used that relate the market share of each individual partner region or country with the import demand apparent from the world as a single region. A straight forward econometric approach is used to develop these alternative estimates of import demand for each specific region. This approach utilizes information drawn from the

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[26] *In many cases trade has been erratic swinging up and down by often more than 50%. In such cases it is preferable to introduce an alternative, less dynamic, approach that relies upon the relationship between the reporter-partner country trade and the reporter-world trade. The later is estimated in all cases by an econometric model, and thus it reflects the "general" pattern of growth in the economy as a whole and from the world in general. Specific regional detail is taken into account in the trend variables, i.e. the changing share of the partner in terms of the whole region.*

pure econometric model. To do this effectively, for each partner country in the sample of trade data, a ratio was calculated showing the share for each reporter country of its imports from each partner region relative to its imports from the world region. By definition this set of market shares sums to 1.0. These equations take the form:

$$MS_{ijk} = \frac{M_{ijk}}{M_{iwk}}, \sum_{j=1}^{J} MS_{ijk} = 1.0$$

where: I is the importer,
j is the partner region,
k is the commodity, and
w is the world market

If the rate of growth in import market share, MS, over time can be forecast, then one can forecast M_P, the propensity model forecast for imports M from region *j* of product *k*, by multiplying MS_{ijk} by M_{iwk}. The approach taken is to transform MS into a logit function so that the share approaches the asymptotic limit of unity or zero gradually:

$$Log\left(\frac{MS_{ijkt}}{1-MS_{ijkt}}\right) = A_{ijk} + a1 \times Log\left(\frac{MS_{ijkt}-1}{1-MS_{ijkt}-1}\right) + bi \times (Time),$$

where: A is the constant term for ith importer,
logit(MS) is lagged one time period, and
bi is the individual time trend for each logit function for each importing country/region.

The import demand forecast using the propensity model is then the forecast for MS and the forecast for M_w. Limits are placed on the projected rate of growth (from the logit model) in the MS variable at plus or minus 4% per year as a further check.

$$M_{Pijk} = MS_{ijk} \times M_{ikw}, where - 4\% \le MS_{ijkt} \le 4\%,$$

10.9.2 Integration Of Econometric And Propensity Projections: A Self Adjusting Forecasting Approach

Because of the large number of trade flows forecast and their interdependence, it is critical that the world trade models incorporate internal tests and limits to insure that valid, reasonable forecasts are developed. Since logarithmic forms used in the econometric models can be sometimes explosive, limits are imposed in the models assuring the quality of the forecasts developed.

The testing is done through a self contained expert system. A number of rules continuously check results against past trends in trade. Whenever a preliminary flow is assumed to be moving erratically, an alternative, more stable, method is substituted.

Generally, the expert system employs a hierarchy of choices. If there are sufficient observations, then econometric models are estimated. If, however, there are insufficient degrees of freedom for accurate statistical models to be developed, then alternative, non-econometric approaches can be used. Or if the volume of trade is particularly small or erratic, then non-econometric approaches may again be favored.

If an econometric model is sufficiently accurate -- judged by the Standard Error of the base equation (an initial test for statistical accuracy), then the equation's forecasting accuracy is tested against the actual experience within the historical period (1982 through 1996) in order to determine for which countries and regions the forecasts based on the cross-country model should be utilized and for which countries and regions alternative, parametric, specifications need to be applied.

Model accuracy is checked by estimation of an average error over this period (the cumulative average percentage deviation of the forecast from the actual) for each reporter country or region. The pooled cross-sectional model technique allows the easy separation of each of the 60 country/region reporters once the multi-country model is estimated.

$$\varepsilon_{ijk} = \frac{\dfrac{\sum_{1982-1994} (\mathbf{M}_{ijk} - \hat{\mathbf{M}}_{ijk})}{\mathbf{n}}}{\dfrac{\sum_{1982-94} \mathbf{M}_{ijk}}{\mathbf{n}}}, \text{ where n = number of observations for the period 1982-94.}$$

If the error for country i from region j for product k calculated over the forecast interval (1982-96) is over a pre-determined limit (MaxError,) then the propensity model forecast is used in place of the econometric forecast. When the standard error for the country is less than MaxError, but greater than MinError, then the non-econometrically determined estimate of trade is used. The forecast models here used a MinError of 2% and a MaxError of 4%. A formula is used to fix the weights:

ADJUST = (Standard Error - MinError)/(MaxError-MinError)

From this formula we can see that if the Standard Error for the equation is close to low error, then the majority of the influence will be derived from the econometric specification. If, on the other hand, the Standard Error is closer to the Maxerror then the opposite is the case.

If the standard error of the equation is less than the MinError, then only the forecast is utilized. In this case the forecast then depends solely on the econometric results.

10.9.3 Final Adjustment And Testing

There is a final step to the forecasts to assure that the models produce consistent results. This step requires external expert judgment on the part of the economists crafting the forecasts. There are a number of reasons why the forecasts produced are not uniformly precise. International commodity trade data is usually quite volatile at the very detailed level, with swings of sometimes more than 50% in either direction. Trade has also been growing strongly for the last fifteen years with worldwide growth in the 6% range – more than twice the rate of growth in GDP. This trade pattern is a departure from the experience of earlier decades in this century. Differences in trade flows between partners can also be dramatic from period to period. This is especially true given the large number of trade partners that are included in the model procedures.

To insure that the forecasts reflect reality, the model system imposes limits to smooth out the peaks and troughs experienced in the forecast interval. When growth exceeds 20% (+ or -), an adjustment factor is applied to reduce the implied growth. A smaller adjustment factor is applied when the forecast trade is greater than 12% but less than 20% (+ or -).

10.10 Summary

The global commodity trade models employed in this study are based on a robust statistical model specification that provides a sound methodology for projecting past and future trends in ocean borne commodity trade. Due to imbedded limitations in historical reported trade data, the models employ a design that represents a compromise between commodity detail and regional detail. The forecast outputs of the models, have been used in conjunction with a careful analysis of the factors that are at work affecting patterns of trade. Like other good statistical modeling techniques, this forecast approach relies upon outside information to provide factual support and validation.

The forecasts developed using this model approach reflect the existing conditions—the current period's trade, the impact of past trends in trade and the WEFA Group's latest forecasts for macroeconomic factors that influence trade, and thus enable the trade models to project future growth. Unlike more traditional trade models that rely upon time series estimates, these models are based on a more generalized approach to trade forecasting. Thus they allow for greater flexibility for individual countries and partner regions. The potential to "grow" is there so long as the general factors that have historically described that growth across the full sample of countries and over the full time period support this type of trade growth or expansion. For long-term forecasts, these models produce forecasts that are better grounded in the theories of economic development and macroeconomic growth.

10.11 Commodity Trade Forecasting Model Trade Partner Countries And Regions

Exhibit 10-8
Trade Model Region Classifications
(60 Exporting Regions to 60 Importing Regions)

Region Name	Country/Region Name	Code
Developed Countries		
North America	U.S.	US
	Canada	CA
Asia	Japan	JP
Europe	Germany	DE
	France	FR
	United Kingdom	UK
	Italy	IT
	Austria	AT
	Belgium	BE
	Denmark	DK
	Finland	FI
	Greece	GR
	Ireland	IE
	Netherlands	NL
	Norway	NW
	Portugal	PT
	Spain	ES
	Sweden	SE
	Switzerland	SZ
	Turkey	TR
	Other Western Europe	OWE
Oceania	Australia	AU
	New Zealand	NZ
Emerging Markets and Developing Countries		
Asia	Hong Kong	HK
	South Korea	KR
	Taiwan	TW
	China	CN
	Indonesia	ID
	Malaysia	MY
	Philippines	PH
	Singapore	SG
	Thailand	TH
	Vietnam	VN

Region Name	Country/Region Name	Code
Emerging Markets and Developing Countries (cont.)		
Indian Subcontinent	India	IA
	Pakistan	PK
	Other Subcontinent	OINS
Latin America	Argentina	ARAR
	Brazil	BR
	Venezuela	VE
	Other East Coast S.A.	OELA
	Chile	CL
	Colombia	CO
	Peru	PE
	Other West Coast S.A.	OWLA
	Mexico	MX
	Caribbean Basin	CB
	Costa Rica	CR
	Panama	PA
	Other Central America	OCLA
CIS/E. Europe	Former Soviet Union	CIS
	Eastern Europe	EE
Middle East	Israel	IL
	Mediterranean	MED
	Persian Gulf	PG
Africa	North Africa	NAF
	Eastern Africa	EAF
	Western Africa	WAF
	South Africa	ZA
	Other Southern Africa	OSAF
Other	Other Region	OREG

Exhibit 10-9
Trade Model Industry/Commodity Categories

ISIC	Description
Primary	
C1	Agriculture, Hunting, Forestry, Fishing
C1A	Grain
C1B	Oil Seeds
C1C	Vegetables, Fruits and Eggs - Refrigerated
C1D	Vegetables and Fruits - non-Refrigerated
C1E	Cork and Wood
C1F	Natural Rubber
C1G	Cotton
C1H	Other Raw Textile Materials
C1I	Other Agriculture
C2	Mining and Quarrying
C2A	Stone, Clay and Other Crude Minerals
C2B	Crude Fertilizers
C2C	Ores and Scrap
C2D	Coal and Coke
C2E	Crude Petroleum
C2F	Natural Gas
Manufacturing	
C311	Food
C311A	Meat/Dairy/Fish - Refrigerated
C311B	Other Meat/Dairy/Fish/Fruit/Vegetables
C311C	Sugar
C311D	Animal Feed
C311E	Animal and Vegetable Oils
C311F	Other Food
C313	Beverages
C314	Tobacco
C321	Textiles
C322	Wearing Apparel
C323	Leather Products
C324	Footwear
C331	Wood Products
C332	Furniture and Fixtures
C341	Paper Products
C341A	Waste Paper
C341B	Pulp
C341C	Paper and Paperboard Products
C342	Printing and Publishing
C3511	Basic Industrial Chemicals
C3511A	Organic Chemicals
C3511B	Inorganic Chemicals
C3512	Fertilizers and Pesticides
Manufacturing (cont.)	
C3513	Synthetic Resins
C3521	Paints, Varnishes and Lacquers
C3522	Drugs and Medicines
C3523	Soap and Cleaning Preparations
C3529	Chemical Products, nec.
C353	Petroleum Refineries
C354	Petroleum and Coal Products
C354A	Briquettes, Lignite, Peat and Coke
C354B	Residual Petroleum Products
C355	Rubber Products
C356	Plastic Products
C361	Pottery, China etc.
C362	Glass and Products
C369	Non-Metallic Products.
C371	Iron and Steel
C372	Non-Ferrous Metals
C381	Metal Products
C3821	Engines and Turbines
C3822	Agricultural Machinery
C3823	Metal and Wood Working Machinery
C3824	Special Industrial Machinery
C3825	Office and Computing Machinery
C3829	Machinery and Equipment
C3831	Electrical Industrial Machinery
C3832	Radio, TV and Communications Equipment
C3832A	Radio and TV
C3832B	Semi-conductors, Electronic Tubes, etc
C3832C	Other Communications Equipment
C3833	Electrical Appliances and Houseware
C3839	Electrical Apparatus
C3841	Shipbuilding and Repairing
C3842	Railroad Equipment
C3843	Motor Vehicles and Parts
C3843A	Motor Vehicles
C3843B	Parts of Motor Vehicles
C3844	Motorcycles and Bicycles
C3845	Aircraft
C3849	Transport Equipment.
C3851	Professional Equipment
C3852	Photographic and Optical Goods
C3853	Watches and Clocks
C390	Other Manufacturing

11. FLEET FORECAST METHODOLOGIES

11.1 Overview

This attachment presents a detailed discussion of the methodology and calculations used for developing the world and Savannah containership fleet forecasts. Although the USACE provides guidance in the Institute for Water Resources (IWR) Deep Draft NED Procedures Manual, there is considerable flexibility in applying the methodologies to particular studies. Three methods for developing fleet forecasts are outlined in the NED guidelines: expert opinion, trend analysis, and demand-supply analysis. To ensure comprehensiveness of the analysis, Booz·Allen has used a combination of the three methods in producing a forecast of the world and Savannah cellular containership fleets over the study period.

As a segment of the overall analysis leading to NED benefits for a deep draft navigation deepening study, fleet forecasting is the second step in the process, following commodity forecasting and prior to transportation cost and project analysis. In combination with commodity forecasts, transportation costs for each with project condition are determined, then compared to the without project condition to determine transport costs savings. In turn, these savings are combined with the engineering estimates to determine the NED benefits for competing channel deepening projects.

11.2 Background To Forecast Modeling Approach

The USACE's methodology for determining transportation costs requires calculating the distribution of the cargo capacity of the fleet. This distribution is determined through the use of fleet forecasting. A key assumption in the development of the Savannah fleet forecast over the study period, is that the distribution of the Savannah fleet will approach the distribution of the world containership fleet. Therefore, development of the world fleet forecast precedes that of the Savannah forecast.

The general approach to developing the fleet forecast is analytical in nature, applying historical statistics and trend analysis to calculate fleet capacities, average vessel capacities, and capacity distribution, by draft categories. For trend analysis, the fleet forecast base year for data is 1980.

The next section will discuss the methodology for determining the demand in TEU capacity in the world containership fleet. Subsequent sections will cover supply in world capacity and Savannah capacity.

11.3 World Fleet Capacity Demand Forecast

The world fleet forecast methodology uses a market equilibrium process, where the supply of TEU transportation capacity of the fleet in the world economy adjusts to equal the world demand for TEU movements.

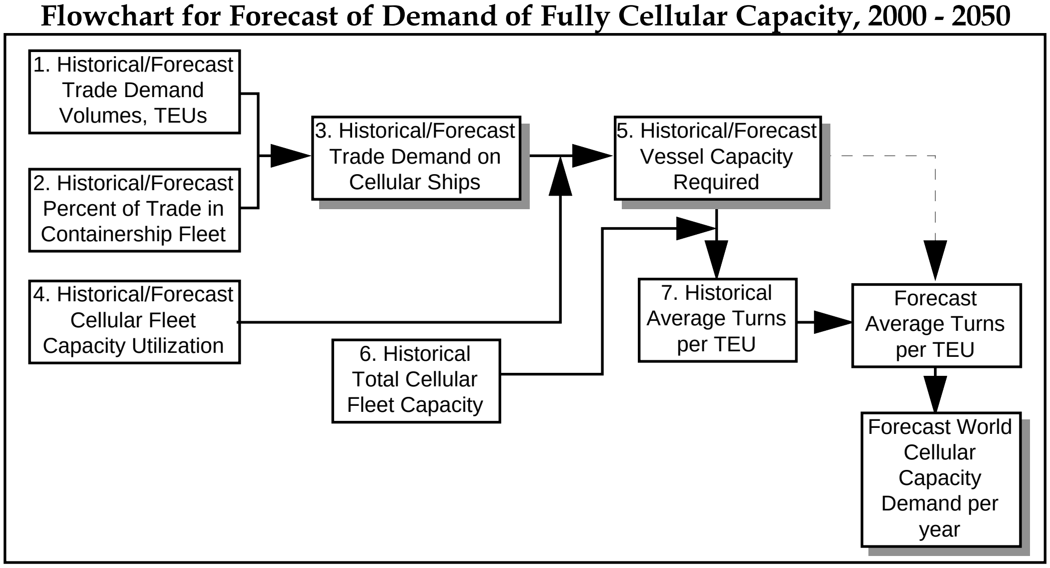
As stated in Section C.2 above, trend analysis is used in the forecast methodology. Historical statistics are analyzed and trends are developed to determine the future direction of the statistics. The forecast in demand for TEU transportation capacity in the world fleet is determined using the following inputs:

- historical and forecast trade data
- historical percent of the world trade served by cellular ships
- historical vessel utilization levels
- a ratio of the slot capacity to port lifts
- historical and current fleet capacity data
- historical average yearly turns per slot (how many times per year an individual slot on a fully cellular containership is used to move a TEU-equivalent box).

Each of these is discussed in turn.

Exhibit 11-1 illustrates the flow process utilized in the methodology to determine the level of TEU transportation capacity due to world ocean borne trade. The numbers in the exhibit correspond to the numbers in parentheses in the discussed below.

Exhibit 11-1
Flowchart for Forecast of Demand of Fully Cellular Capacity, 2000 - 2050



Source: Booz·Allen & Hamilton

Annual historical and forecast world trade demand (1), for the period 1980 œ 2050 is developed in the commodity forecast discussed in Chapter 3, and Attachments A and

B of this Appendix. The historical percentage of trade moved on fully cellular vessels (2) is taken from data provided by professional analysis and opinion.[27] An annual forecast, over the study period, of the future percentage of cargo moved by fully cellular vessels was developed from the historical data.

The importance of these two forecasts is straightforward; with these annual statistics, historical and future annual demand for TEUs transported by fully cellular vessels can be determined (3). However, the resulting figure is only the annual level of TEU slots necessary to move all containerized cargo on fully cellular vessels. Because the slots are used several times a year to move boxes, it is unnecessary to have as many slots in the fleet as there is TEU trade demand. A second utilization factor must be incorporated into the process in order to determine the actual number of TEU slots in the fleet.

The utilization factor used are annual historical capacity utilization (4) figures for several major trade lanes in the world market, determined from professional opinion and prior studies.[28]. Incorporating this factor reduces the annual historical number of TEU moves in the world fleet down to the number of moves actually made by the total capacity of the world fleet in a particular year (5). To bring the historical data to the future, made by the vessels, total capacity (6) of the actual world fleet is necessary. Using professionally produced databases[29] the following statistics are developed:

- Number of fully cellular containerships in the world fleet
- Capacity of containership fleet, by vessel design draft class and total
- Orderbook capacity by draft class and total
- Average capacity of vessels, by design draft
- Distribution of TEU capacity, by design draft.

These statistics were determined for each year 1980 to 1997, from the containership databases.[30]

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27 *Drewry's Global Container Markets, July 1996*

28 *Prior Booz·Allen analysis of four major trade lanes: Europe/North America, Europe/Asia, South America/North America, North America/Asia.*

29 *Clarkson Research Studies Containership Registry, 2nd Quarter, 1997.*

30 *The fleet forecast was updated during the winter and spring of 1998 to reflect the latest orderbook information from the containership databases, using 3rd Quarter, 1997 through 1st Quarter 1998 databases.*

Working backwards, the methodology process determines the annual historical level of TEU capacity in the world fleet for 1980 through 1997. With this data, the average number of times a container slot (TEU slot) is used in a given historical year from 1980 to 1997 is determined by dividing the number of moves by the total TEU capacity of the fleet (7), and equals (5)/(6). Trend analysis was completed on the historical values of (7) and forecasted out over the study period.

The forecast calculations thus far have only determined the TEU capacity of the fleet required to meet the future trade levels discussed in Chapter 3 of this Appendix. The next step in the process requires a calculation of the supply of TEU capacity available to meet the demand over the forecast period.

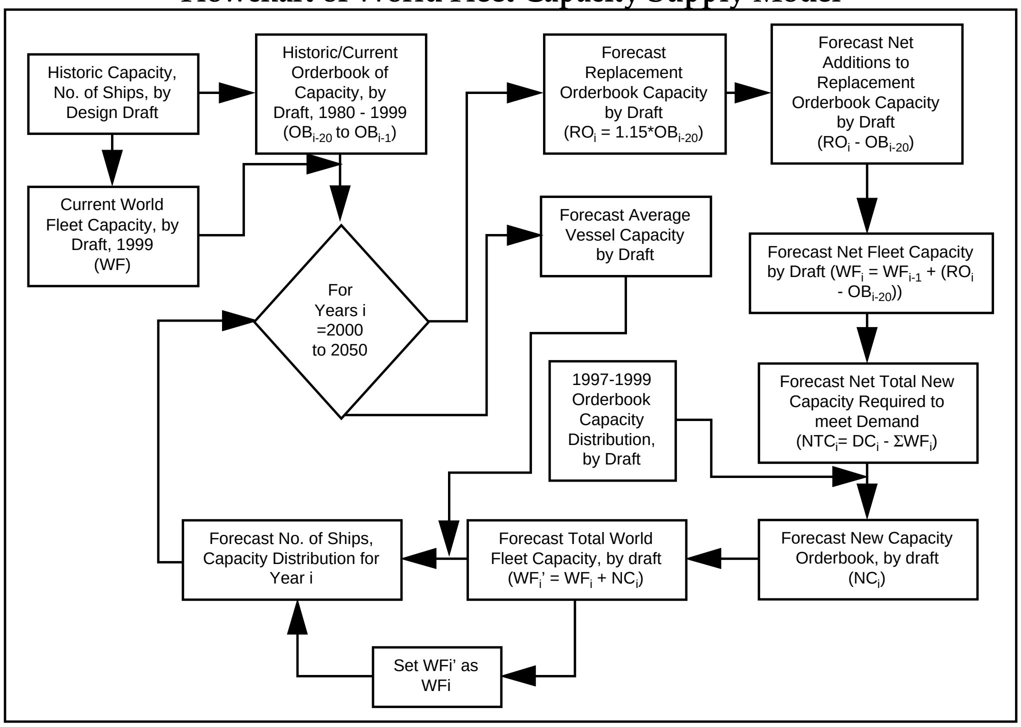
11.4 World Fleet Capacity Supply Forecast

This section describes the calculations used to forecast the supply of TEU capacity in the fully cellular world fleet. This forecast was developed using a combination of historical fleet statistics and assumptions on the growth in vessel size. In addition, the forecast compensates for future building of new capacity, replacement capacity, and scrapping of retired vessels.

Recalling from above, several historical fleet statistics were calculated using the containership database. In addition, a historical distribution of orderbook capacity, by draft category, by year and the distribution of the 1997-1999 orderbook are calculated. These statistics are used in the supply forecast to develop a new containership fleet throughout the study period.

Exhibit 11-2 below presents a flowchart describing the process used in the world fleet forecast model for determining the supply of TEU capacity available in the fully cellular fleet to handle the TEU cargo demanded by the world economy, by draft.

Exhibit 11-2
Flowchart of World Fleet Capacity Supply Model



Source: Booz·Allen & Hamilton

The exhibit illustrates that the methodology applies an iterative process to calculate fleet statistics for each year of the study period. The methodology includes steps to compensate for the scraping or retirement of aged or future capacity, replacement capacity for the scrapped vessels, and additional capacity to meet demand. In addition, the methodology forecasts an average vessel capacity (in TEUs) by design draft.

For the forecast period, vessels in the current fleet are retired and/or scrapped based on a 20-year service life. Capacity is scrapped from the fleet by deleting all vessels and their capacity from the database that were ordered 20 years prior to the current year. For example, if the current year is 2000 and if in 1981 the total capacity of the fleet was 150,000 TEU, and the capacity in the year 2000 is 1,000,000 TEUs, then the net capacity supplied due to scrapping equals 850,000 TEUs.

To take advantage of economies of scale while replacing scrapped capacity, owners typically replace vessels with slightly larger capacity vessels. To compensate for the increased capacity, a multiplier is placed on the orderbook representing the replacement capacity[31]. The additional capacity created by the multiplier is added to the previous year fleet capacity less the scrapped capacity, resulting in the current year capacity.

The current year capacity is compared to the capacity demanded (calculated in the Section C.3) to determine if the current fleet capacity is sufficient to meet demand. If the supply capacity is higher than the demand capacity, there is an over supply of capacity in the world fleet. If the demand capacity still exceeds the supply capacity after scraping and replacement occurs, then additional new building capacity is necessary. The additional capacity is distributed to draft categories in accordance with the 1997-1999 orderbook capacity distribution. The sum of the additional capacity and current year capacity determines the total year capacity, by draft.

These calculations all lead to the primary purpose of the fleet forecast, forecasting the distribution of the fleet capacity across the draft classes. This forecast is used to project the Savannah fleet forecast. The next section of this Attachment provides a description of methodology applied to develop that forecast.

11.5 The Savannah Fleet Forecast Methodology

As stated above, a key assumption in the fleet forecast methodology is that the Savannah fleet capacity distribution will evolve and reflect the capacity of the world fleet over the course of the study period. This assumption is based on the tenet that as trade volumes increase at the Port of Savannah, the Port's significance will rise. Therefore, with the world fleet forecast as a backdrop, a model was developed for determining fleet forecasts for Savannah.

The Savannah fleet forecast methodology is similar to the world fleet forecast methodology, in that it uses trade forecast data to determine the demand for TEU capacity in Savannah, then calculates the required fleet supply needed to support that demand. In addition, it applies an iteration process, by which calculations of the statistics leading to fleet distribution are completed for each year of the study period, based on the values calculated for the previous year. The calculations were completed for each of three major trade lanes intersecting at Savannah: Europe/North America, North America/Latin America, and the Asia/North America lanes.

The forecast methodology process involves the following steps:

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31 *This methodology is described in the NED Guidelines.*

- The historical (1987 - 1995) number of vessels and total capacity distribution, by design draft category (38 to 46 feet), are determined, from Georgia Ports Authority and Savannah Pilots Association vessel logs. Using historical Georgia Ports Authority data from 1987 to 1995 of vessel calls by name, the historical number of vessels and total capacity of these vessels was calculated[32] and segregated by design draft category.
- From the data determined above, the trend in the average available capacity, per draft category over the study period (using the historical values as a basis) was calculated; by dividing total available capacity draft by total vessel calls. As was the case in the world fleet forecast, the figures are used to determine the distribution of the fleet capacity.
- A series of calculations are performed to determine the number of vessel calls per draft category over the study period using the 1996 GPA data as a baseline. Incorporated in the calculations are near term service plans determined through interviews with carrier operators. The number of vessel calls per year is determined using average TEU lifts per draft category, carrier service plans. The total capacity available from these vessel calls over the study period is compared to the trade volumes forecasted. If shortfalls occur, additional ships calls are required.
- The number of additional vessels required, is determined by dividing the shortfall by the average vessel capacity. The additional vessels are distributed through the fleet at the three deepest draft categories available to operate in the channel. The distribution of the TEU capacity is determined by dividing the capacity of each draft category by total capacity, for each trade lane and with project alternative. These distributions are used in the calculations for transportation costs.

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32 *CRS Containership Registry and Lloyd's Registry of Ships.*

12. VESSEL TRAFFIC SIMULATION MODEL

12.1 Vessel Traffic Simulation Overview

A system that is suitable for simulation usually consists of at least one of the following two characteristics. First, the system might contain a significant amount of activity that is probabilistic in nature. Uncertainty of an activity may influence whether the activity occurs, when the activity occurs, and to what level the activity occurs. For instance, in modeling a ship arriving to Savannah Harbor in the future, there are a number of uncertain elements:

- time of arrival to the system
- time to complete service at the dock
- whether the vessel is involved in an encounter (e.g., meeting, passing, collision) with a second vessel
- what type of vessel is calling
- the cargo loaded on the vessel (which affects its operating draft).

Note that at some point in time, these elements may in fact gain certainty. For instance, we might know with accuracy within minutes the arrival times of all vessels calling on the Port tomorrow. However, the feasibility study analysis addresses the issue as an uncertain one, given the 2000 to 2050 study period.

The second key system characteristic that lends itself to a simulation analysis is pure complexity. That is, a system may consist of a number of interacting activities, each of which alone might be amenable to an analytical solution, but not true in the aggregate. Again, with respect to the harbor system, it might be a very straightforward analysis to define the equipment needs of a particular dock in the system. Even if each of these elements alone could be evaluated simply, interaction effects make a global analysis much more difficult.

For example, let us again consider the channel system. There are a number of functions, which together define vessel movements:

- vessel transit
- pilotage
- docking pilot service
- bunkering
- off-load/on-load.

The simulation is a "What if...?" type of tool. Each element in the system is defined by what are deemed to be its key characteristics. For instance, in this simulation model, the key concept is physical vessel interactions. We must be aware of the impacts of vessels approaching each other - either meeting or passing. Because of the nature of pilot responses in such situations, it becomes necessary to capture in-depth the width and draft of the encountering vessels. For the current model, the various vessel classes are distinguished in this regard. (We should note that, for a scenario such as an anchorage development, another characteristic - vessel operating costs - becomes important.) One common element in all simulation models is the employment of various probability distributions. The concept of a probability distribution is that some characteristic might differ over elements in the system, and the distribution indicates how that variation arises. For instance, a number of different vessel classes call on Savannah. We define a distribution, which ensures that the proportion and numbers of each class are consistent with current observations and future expectations.

It is important to note that the level of detail to which an element is modeled should depend on the questions to be investigated with the simulation model. It is not possible to completely mimic that activity of the system. At the same time, important characteristics should not be omitted.

The final element that is inherent in most simulation models is the definition of policies. Many systems rely on some sort of decision making, either explicitly or implicitly. Vessel traffic moves at a certain rate, a vessel in an encounter with another vessel acts in some manner, incoming vessels are assigned to berths or wait at anchor. To be useful, the simulation must imitate actual behavior, or provide a reasonable agreed-upon surrogate.

Note that the vessel traffic simulation is used as a tool that does not provide a solution to the problem. It cannot suggest the optimal project alternative. It will provide an understanding of how different particular project alternative will impact the vessel operations through the navigation channel.

12.2 The Vessel Traffic Simulation Model

The simulation model created is essentially an imitation of vessel movements within the Savannah Harbor system. The original vessel traffic simulation model was originally developed for the Galveston District of the US Army Corps of Engineers, and was used to identify the impact of deepening and widening the main Houston/Galveston navigation channel. The simulation model was adapted for the Savannah Harbor channel using the physical channel characteristics provided by the US Army Corps of Engineers and vessel operating practice information from the Savannah Pilots Association.

The Savannah model reflects the system characteristics required for the beam width conflict delay estimation, and is also similar to that required for a previous US Army Corps of Engineers Baltimore Harbor improvements feasibility study. The simplest analogy is to liken the model to a tube (the channel), into which items (vessels) are shot from both ends. The model captures the speed at which vessels move through the channel, and the release of a vessel is delayed for the case in which the vessels can not safely meet each other in the Channel. It is this delay impact that was critical in the previous studies, and is also important for the current analysis.

It is important to note that the improvement in a channel does not necessarily generate the entire benefits in reduced delays that might accompany, say, a channel deepening. While such a expansion means freer movement for the existing calling fleet, it should be expected that improved conditions might also result in the operating dimensions of the calling fleet also changing. A larger calling fleet might result in offsetting some of the inherent advantages of the channel improvement. The changes in fleet operations might result in efficiencies of delivery and receipt of goods. Such improvements are generally recognized in terms of the following:

- a reduction in the number of vessels delayed or sailing light through the channel
- an increase in the use of more efficient vessel size classes.

12.3 Model Inputs and Outputs

Model inputs consisted of the annual number of vessels forecasted to call the Port of Savannah during the study period and the average transit time of 2.5 hours per vessel.[33] The model output shows that the average vessel will require 2:36:14, or approximately 6.25 additional minutes to transit the canal.

Criteria from USACE engineering manuals was applied to the channel design to determine the beams of vessels that would be impacted by uni-directional traffic flow. Analysis of vessel beam was conducted by USACE Savannah District engineers, based on three scenarios:

- Maximum of 3 knot current
- Passing existing channel design vessel
- Ideal conditions.

Exhibit 12-1 presents the results of the analysis.

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[33] *2.5 hours according to USACOE Savannah District and discussions with Savannah Pilots Association.*

Exhibit 12-1
Calculation of Constrained Vessel Beams in Uni-Directional Channel

Basis	Station		Design Vessel Beam		Existing	Deepening	Multipliers	Deepened Channel Vessel Beams
	Start	End	Existing Channel	Deepened Channel	Channel Width	Channel Width		
Max 3 kt. Current	85000B	14000B	106	140.6	600	552	6.5	84.9 ft
	14000B	10200B			500	452		69.5 ft
Pass Existing Design Vessel	85000B	14000B			600	552	5.660377358	97.5 ft
	14000B	10200B			500	452	4.716961132	95.8 ft
Ideal Conditions	85000B	14000B			600	552	4.5	122.7 ft
	14000B	10200B			500	452		100.4 ft

Source: USACE Savannah District

12.4 Summary

The essential value of the simulation lies in the determination of the impacts of a series of complex interactions. In the Savannah Harbor system, under with and without-project conditions, there are projected to be a significant number of vessel movements over the study period . Because the future vessel arrivals and departures cannot be timed precisely, the impacts of increased traffic levels in the future cannot be physically pre-determined. The value of the delay simulation analysis lies in its ability to quantify the anticipated impacts of the traffic patterns, for each project alternative.