ECONOMICS APPENDIX

Elizabeth River and Southern Navigation Improvements Draft Integrated General Reevaluation Report and Environmental Assessment

APPENDIX B

12 December 2017

U.S. Army Corps
of Engineers
Norfolk District

THE PORT OF VIRGINIA®

UNITED STATES ARMY CORPS OF ENGINEERS

Elizabeth River and Southern Branch Navigation Improvements, Virginia General Reevaluation Report

Economics Appendix

Norfolk District
North Atlantic Division
December 2017

Executive Summary

	Measure	Depth	Benefits	Cost	Net Benefits	BCR
Step-I: Planning Segment-1 Measures	Seg1-M1	41 + 41	$2,872,500	$758,400	$2,114,100	3.79
	Seg1-M2	42 + 42	$3,727,600	$1,081,000	$2,646,600	3.45
	Seg1-M3	43 + 42	$5,017,600	$1,364,800	$3,652,800	3.68
	Seg1-M4	**44 + 42**	**$6,442,500**	**$1,734,300**	**$4,708,200**	**3.71**
	Seg1-M5	**45 + 42**	**$6,966,400**	**$2,144,300**	**$4,822,100**	**3.25**

	Measure	Depth	Benefits	Cost	Net Benefits	BCR
Step-II: Planning Segment-2 Measures	Seg2-M1	36 + 35	$4,428,000	$1,627,000	$2,801,000	2.72
	Seg2-M2	37 + 35	$4,711,500	$2,409,200	$2,302,300	1.96
	Seg2-M3	**38 + 35**	**$7,055,000**	**$3,334,800**	**$3,720,200**	**2.12**
	Seg2-M4	**39 + 35**	**$8,476,700**	**$4,317,400**	**$4,159,300**	**1.96**
	Seg2-M5	**40 + 35**	**$9,615,400**	**$5,361,100**	**$4,254,300**	**1.79**

	Segment-1 Measures	Segment-2 Measures	Seg1a + Seg1b + Seg2 + Seg3 Depth	Benefits	Costs	BCR	Net Benefits
Step-III Final Array of Alternatives	Seg1-M4	Seg2-M3	44 + 42 + 38 + 35	$13,497,500	$5,069,100	$8,428,400	2.66
	Seg1-M4	**Seg2-M4**	**44 + 42 + 39 + 35**	**$14,919,200**	**$6,051,700**	**$8,867,500**	**2.47**
	Seg1-M4	Seg2-M5	44 + 42 + 40 + 35	$16,057,900	$7,095,400	$8,962,500	2.26
	Seg1-M5	Seg2-M3	45 + 42 + 38 + 35	$14,021,400	$5,479,100	$8,542,300	2.56
	Seg1-M5	**Seg2-M4**	**45 + 42 + 39 + 35**	**$15,443,100**	**$6,461,700**	**$8,981,400**	**2.39**
	Seg1-M5	Seg2-M5	45 + 42 + 40 + 35	$16,581,800	$7,505,400	$9,076,400	2.21

- **Economic Parameters**
  - Price Levels – FY 17
  - Discount Rate – 2.75%
  - Period of Analysis – 50yrs
  - Base Year – 2023
- **NED Plan:** Seg1-M4 + Seg2-M4
- **Plan Description:** 44’ + 42’ + 39’ + 35’ Where
  - 44’: Deepen Seg1a from 40’ to 44’. Seg1a extends from Lamberts Bend to just south of the Perdue Farms Terminal.
  - 42’: Deepen Seg1b from 40’ to 42’. Seg1b extends from Seg1a to the end of Planning Segment-1
  - 39’ : Deepen Planning Segment-3 from 35’ to 39’
  - 35’: Planning Segment-3 remains at 35’.
- **Economic Performance (AAEQ$)**
  - NED Benefits ~ $14.9 M
  - NED Costs ~ $6.052 M
  - BCR ~ 2.47
  - Net NED Benefits ~ $8.868 M

- **LPP Plan:** Seg1-M5 + Seg2-M4
- **Rationale:** Plan reasonably maximizes net NED benefits.
- **Plan Description:** 45’ + 42’ + 39’ + 35’ Where
  - 45’: Deepen Seg1a from 40’ to 44’. Seg1a extends from Lamberts Bend to just south of the Perdue Farms Terminal.
  - 42’: Deepen Seg1b from 40’ to 42’. Seg1b extends from Seg1a to the end of Planning Segment-1
  - 39’ : Deepen Planning Segment-3 from 35’ to 39’
  - 35’: Planning Segment-3 remains at 35’.
- **Economic Performance (AAEQ$)**
  - NED Benefits ~ $15.4 M
  - NED Costs ~ $6.462 M
  - BCR ~ 2.39
  - Net NED Benefits ~ $8.982 M

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1 Introduction

This document presents economic evaluations performed for the Southern Branch and Channels Deepening Study. The Elizabeth River 45 Foot and the Southern Branch of the Elizabeth River 40 Foot Channel Project is the Norfolk Harbor and Channels authorized project separable project element under consideration and is one of five port priorities identified at the Virginia Maritime Association's Annual Navigation Summit.

The Elizabeth River Channel, which is authorized to a depth of 45 feet, extends from Lambert's Point on the main branch of the Elizabeth River to the Norfolk and Southern Railroad Bridge on the Southern Branch of the Elizabeth River, a distance of 6 miles. This federal navigation channel is currently maintained at a depth of 40 feet over channel widths of 750, 450, and 375 feet.

The reach of the Southern Branch of the Elizabeth River Channel, which is authorized to a depth of 40 feet, extends from the Norfolk and Southern Railroad Bridge to the Gilmerton Bridge, a distance of 2.4 miles. This federal navigation channel is currently maintained at a depth of 35 feet over channel widths of 250 to 500 feet.

The reach of the Southern Branch of the Elizabeth River Channel extending from the Gilmerton Bridge to the Chesapeake Extension is authorized to a depth of 35 feet for a length of 2.1 miles. The current depth of this reach is 35 feet.

1.1 Authority

Section 201 of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662) authorized the construction of the 55-foot Norfolk Harbor and Channels, Virginia, Project, as described in House Document 99-85, dated July 18, 1985, entitled "Norfolk Harbor and Channels, Virginia." The authority states, as follows:

> *"The project for navigation, Norfolk Harbor and Channels, Virginia: Report of the Chief of Engineers, dated November 20, 1981, at a total cost of $551,000,000, with an estimated first Federal cost of $256,000,000 and an estimated first non-Federal cost of $295,000,000, including such modifications as the Secretary determines to be necessary and appropriate for mitigation of any damage to fish and wildlife resources resulting from construction, operation, and maintenance of each segment of the proposed project. The Secretary, in conjunction with appropriate Federal, State, and local agencies, shall study the effects that construction, operation, and maintenance of each segment of the proposed project will have on fish and wildlife resources and the need for mitigation of any damage to such resources resulting from such construction, operation, and maintenance."*

The major components of the authorized project include:
(1) Increasing the depth of the Elizabeth River and the Southern Branch of the Elizabeth River between Lamberts Point (river mile 9) and the Norfolk and Western Railway Bridge (river mile 15) from 40 feet to 45 feet over its existing 375 to 750 foot width.

(2) Increasing the depth of the Southern Branch of the Elizabeth River between the Norfolk and Western Railway Bridge (river mile 15) and the US Routes 460 and 13 highway crossing (river mile 17.5) from 35 feet to 40 feet over its existing 250 to 500 foot width, and providing a new 800 foot turning basin at the terminus of the channel improvement.

(3) Placing suitable dredged material resulting from project construction in a designated ocean placement site and unsuitable material in the Craney Island Dredged Material Management Area (CIDMMA) site.

The authorized project is being constructed in usable increments or elements in accordance with Section 207 of Public Law 99-662. Section 207, which is entitled "Construction in Usable Increments," states the following:

"Any navigation project for a harbor or inland harbor authorized by this title or any other provision of law enacted before, on, or after the date of enactment of this title may be constructed in usable increments."

1.2 Background

The Elizabeth River and Southern Branch of the Elizabeth River are authorized under the Norfolk Harbor and Channels, Virginia, Project, which is a single purpose deep draft navigation project located in Hampton Roads. The project area is made up of a 25 square mile natural harbor serving the port facilities in the cities of Norfolk, Newport News, Portsmouth, Chesapeake, and Hampton in southeastern Virginia. Since its authorization in 1986, the project has been constructed in separable elements based on the needs of the port community and the financial capability of the non-federal sponsor. The Elizabeth River and Southern branch of the Elizabeth River components of the Norfolk Harbor and Channels authorized project are authorized to depths ranging from 45 to 35 feet and maintained to depths ranging from 40 to 35 feet.

The purpose of this investigation is to identify whether the authorized plan is still in the federal interest and to evaluate measures which would improve the operational efficiency of commercial vessels currently using the federal navigation channel at the Elizabeth River and Southern Branch of the Elizabeth River and commercial vessels projected to use the federal navigation channel in the future.

The need for this investigation arises from inefficiencies currently experienced by commercial vessels in the Elizabeth River and Southern Branch of the Elizabeth River. These inefficiencies are projected to continue in the future.

1.3 Overview of the Economic Analysis

The Federal interest in navigable waterway improvements is derived from the commerce clause of the U.S. Constitution. Customs and court decisions that define Federal power to regulate commerce provide the linkage between the Federal interest and navigable waterway improvements. Economics is used to provide a rational and objective method for establishing the Federal Interest.
The role of the economic analysis on a navigable waterway improvement is to provide answers to the following two questions:

- Is an investment of Federal dollars in this project warranted?
- If an investment of Federal money is warranted, what is the appropriate level of investment?

An investment in a navigable waterway improvement is warranted if the project benefits exceed the costs expressed in monetary units. Project benefits are national economic development (NED) benefits and defined as a positive change in the value of the national output of goods and services. Conversely, NED costs are defined as a negative change in the value of the national output of goods and services. If it can be proven that the project causes a net positive change in NED, then the federal interest has been established subject to certain considerations.

The level of federal investment is determined based on the alternative that most reasonably maximizes net NED benefits.

1.3.1 Data

Existing condition data is integral to the study as it is the basis for the projections of both with- and without-project conditions. To ensure the highest level of precision and completeness of parameters, the study combines data from several sources to capture the existing conditions.

- **Waterborne Commerce Statistics Center Data (WCSC: 2009 - 2013)**
  - **Uses:** Useful in characterization of: commodity types & shipment sizes per vessel call by vessel class, cargo origin and destinations, sailing draft, domestic traffic, and docks.
  - **Limitations:** Data only available till available to 2013; some data were erroneous and or incomplete.
- **Virginia Pilots Association Data (2009 – 1st qtr. 2015)**
  - **Uses:** Primary source of data used in sailing draft distribution characterizations. Useful in characterization and verification of vessel class to terminal movements.
  - **Limitations:** No information on cargo movements.
- **PIERS Data (2009 – 1st qtr. 2015)**
  - **Uses:** Useful for verification of commodity types & tonnages, cargo movement dates, verification of vessel information.
  - **Limitations:** Numerous data gaps with respect to terminal used.
- **SEAWEB Data**
  - **Uses:** Primary use of SEAWEB data was to characterize the fleet with respect to vessel dimensions and capacities.

1.3.2 Information

Information was gathered to either make reasonable simplifying assumptions about vessel operational characteristics and details, trade flows, and to project future traffic levels. Information was used to inform characterizations of vessel operating costs, speed at sea, commodity density, deadweight utilization assumptions, route group distances, and commodity projections. The information sources were as follows:

- Economic Guidance Memorandum for FY 13 (EGM, 15-04, 28 September 2015) and FY 16 (EGM, 17-04, 24 April 2017): Used to assign vessel operating cost and speeds.
- Route Distances: Distances were assigned to numerous ports in the data using websites such as sea-distances.org, and others.
- NED Planning Manual was used for general reference and to assign deadweight utilization rates.
- IHS Global Insight was used to develop growth rates in order to project future traffic.

1.3.3 Model

HarborSym was used to calculated transportation benefits for the Southern Branch and Channels Deepening Study. HarborSym is a planning-level model developed and approved by the U.S. Army Corps of Engineers to assist in economic analyses of proposed deep draft channel improvements. The model creates an event-driven simulation based on current operating procedures input by the users within the simulation environment. Based on information obtained by centralized databases, Virginia harbor pilots, and the Virginia Port Authority, the model is driven by user-specified transit rules to calculate delays within the system and inefficiencies. For the ERSB, alternative sets are defined to determine the

potential cost savings resulting from reduced delays and efficiency in vessel calls as a result of a channel deepening.[1]

1.3.4 Appendix Layout

Appendix layout is as follows:

- Introduction – Description of the authority, purpose, and context for the conduct of the economic analysis. In addition, sources and uses of data, information, and models are also provided.
- Inventory of Existing Conditions – Identification of the relevant factors in the ERSB harbor system and how they are used in the economic analysis. The end result is a characterization of the system.
- Forecast of Future Conditions – Explanation of the process and results of developing the future without project condition (FWOP) for the Economic Analysis.
- Alternative Analysis – Explanation of the process of estimating life cycle NED benefits and cost pursuant to the evaluation and comparison of alternatives.
- Plan Selection – Description of the recommended plan economic performance.
- Risk & Uncertainty – Description of the uncertainties in the economic analysis.

2 Inventory of Existing Conditions

2.1 Elements of the Existing Condition Inventory

To obtain the existing condition inventory, a historical vessel call list is required. The vessel call list is a series of data references required in HarborSym that confirm vessel movement and vessel traffic in the harbor. Vessel call lists use existing current and historical data to help configure the model. For this study, historical vessel call lists were generated for 2009 through 2013. The existing condition inventory, along with vessel and fleet forecasts, are then used to help inform the future without project condition.

Vessel call lists consist of data from several data sources and linked to form complete lists for years 2009, 2010, 2011, 2012, and 2013. Data used from Waterborne Commerce Data Statistics (WCDS) contained vessel data for the arrival date, movement direction, commodity name, Vessel IMO number, Vessel Name, and Foreign Port name. This data was then linked by the arrival date and vessel IMO number from pilot logs data provided by the Virginia Pilot's Association to obtain the dock visits for each vessel in the harbor. This data linked movement dates and IMO numbers to dock visits. The pilot log data also provided some helpful information used in designing the harbor model for anchorage and turning basin use. This data was then linked with the Virginia Port Authority terminal data to obtain service information, including the service code and service names.

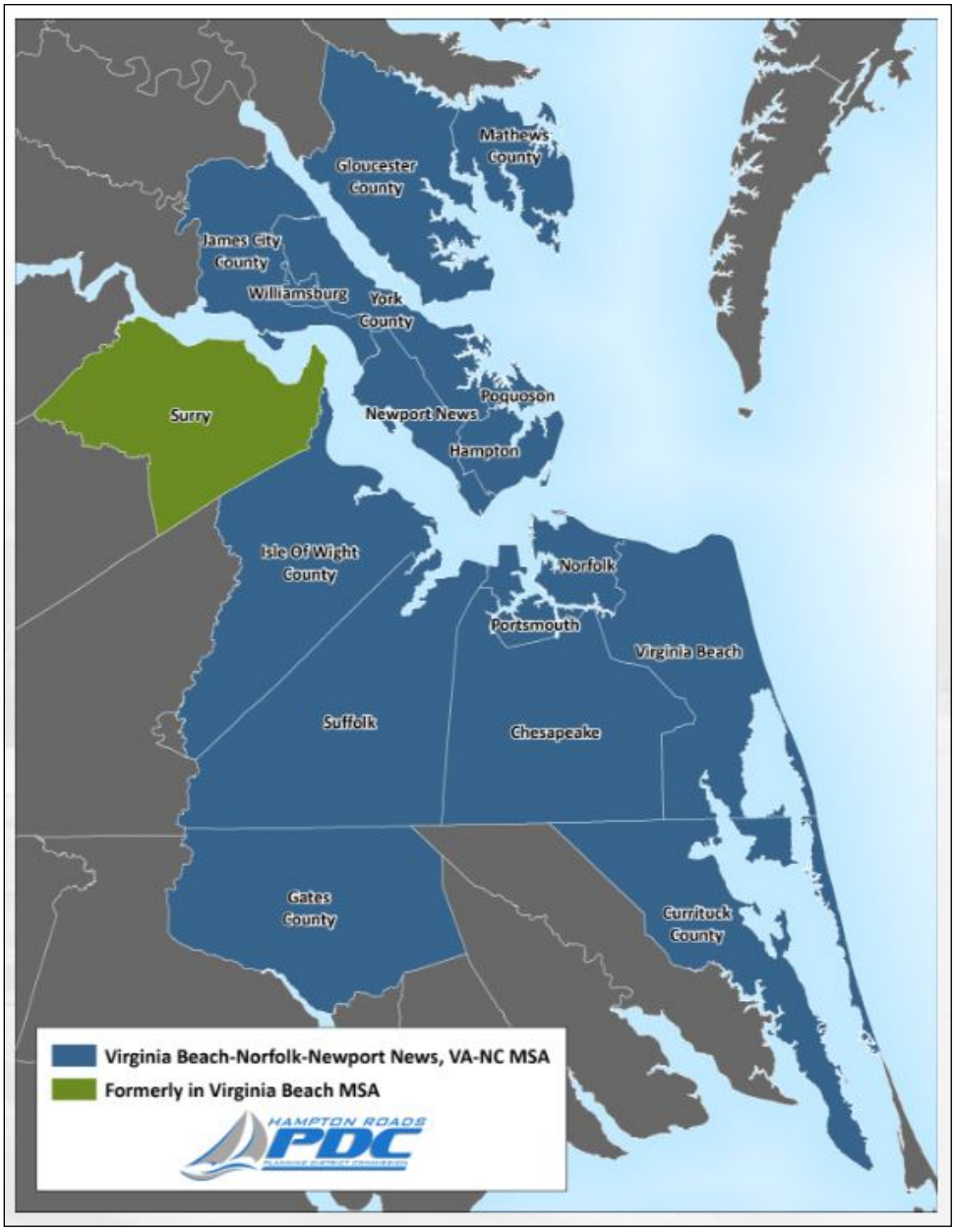
2.2 Economic Study Area

The immediate area surrounding the ERSB and Norfolk Harbor includes the U.S. Census Bureau's Virginia Beach-Norfolk-Newport News, VA-NC Metropolitan Statistical Area (MSA) (Figure 1). The MSA is made up of the cities of Chesapeake, Franklin, Hampton, Newport News, Norfolk, Poquoson, Portsmouth,

[1] Moser, et al. "HarborSym: A Data-Driven Monte Carlo Simulation Model of Vessel Movement In Harbors". IWR Report 04-NETS-P-02. 4 July 2014.

Suffolk, Virginia Beach and Williamsburg; the Virginia Counties of Gloucester, Isle of Wight, James City, Southampton, and York; and the North Carolina Counties of Currituck and Gates[2]. The U.S. Census Bureau's 2010 Census reported that the population of the Virginia Beach-Norfolk-Newport News, VA-NC MSA was 1,671,683[3]. Table 1 compares the population data from the 2000 and 2010 census and calculates the percent change for each of the municipal boundaries that were within the Hampton Roads MSA at the time the respective census was taken.

Figure 1: Virginia Beach-Norfolk-Newport News, VA-NC MSA



[2] Hampton Roads Planning District Commission (HRPDC). 2013. Hampton Roads MSA: Analysis of Recent Delineation. Retrieved from: http://www.hrpdcva.gov/news/article/march/25/2013/hampton-roads-msa-:-analysis-of-recent-delineation/.

[3] U.S. Census Bureau. 2010. 2010 Census Data. Retrieved from: http://www.census.gov/2010census/data/

Table 1: Virginia Beach-Norfolk-Newport News, VA-NC MSA Population

MSA Component	2000 Census	2010 Census	Percent Change
Virginia Cities			
Chesapeake	199,184	222,209	11.6
Hampton	138,437	137,436	-0.7
Newport News	180,150	180,719	0.3
Norfolk	234,403	242,803	3.6
Poquoson	11,566	12,150	5.1
Portsmouth	100,565	95,535	-5.0
Suffolk	63,677	84,585	32.8
Virginia Beach	425,257	437,994	3
Williamsburg	11,998	14,068	17.3
Counties			
Currituck Co., NC	18,190	23,547	29.5
Gates Co., NC	10,516	12,197	16
Gloucester Co., VA	34,780	36,858	6
Isle of Wight Co., VA	29,728	35,270	18.6
James City Co., VA	48,102	67,009	39.3
Surry Co., VA	6,829	7,058	3.4
York Co., VA	56,297	65,464	16.3
Total MSA Population	**1,569,679**	**1,674,902**	**6.7**

2.2.1 Hinterland

The Norfolk Harbor Channels Project supports transport of goods to/from the Mid-Atlantic, Appalachian, and Midwest regions of the United States. For example, grains, a major export from the ERSB, come primarily from the Midwest.

2.2.2 Infrastructure

The marine terminals at Norfolk Harbor are well served by a network of highways and rail that connect the terminals to their hinterland. The infrastructure available for transporting goods to and from the harbor are outlined in the following subsections.

2.2.2.1 Roads

Interstate Highway 64 and U.S. Highway 58 are the main highways in the harbor area, with branch routes in all directions via Interstate Highways 264, 464, 564, and 664. State Highway 58 connects directly with Interstate Highways 95 and 85 providing north-south corridor access.

2.2.2.2 Rail

The Norfolk and Portsmouth Belt Line Rail Road (NPBLRR) services terminals along the ERSB, including Kinder Morgan's Elizabeth River, VA terminal.[4] NPBLRR has connections to Norfolk Southern and CSX rail lines for broader access geographically. Norfolk Southern and CSX service extends from the Norfolk area to the southeastern, Midwestern, and northeastern U.S.

2.3 Port Facilities

The Elizabeth River 45 Foot and the Southern Branch of the Elizabeth River 40 Foot Channel Project is the Norfolk Harbor and Channels authorized project separable project element under consideration and is one of five port priorities identified at the Virginia Maritime Association's Annual Navigation Summit.

[4] Kinder Morgan Terminals, Elizabeth River, VA Terminal. Retrieved from: https://www.kindermorgan.com/content/docs/terminalbrochures/ma_elizabethriver.pdf; http://www.npblrr.com/wp-content/uploads/2013/11/map.jpg.

The Elizabeth River Channel, which is authorized to a depth of 45 feet, extends from Lambert's Point on the main branch of the Elizabeth River to the Norfolk and Southern Railroad Bridge on the Southern Branch of the Elizabeth River, a distance of 6 miles. This federal navigation channel is currently maintained at a depth of 40 feet over channel widths of 750, 450, and 375 feet. The reach of the Southern Branch of the Elizabeth River Channel, which is authorized to a depth of 40 feet, extends from the Norfolk and Southern Railroad Bridge to the Gilmerton Bridge, a distance of 2.4 miles. This federal navigation channel is currently maintained at a depth of 35 feet over channel widths of 250 to 500 feet. The reach of the Southern Branch of the Elizabeth River Channel extending from the Gilmerton Bridge to the Chesapeake Extension is authorized to a depth of 35 feet for a length of 2.1 miles. The current depth of this reach is 35 feet.

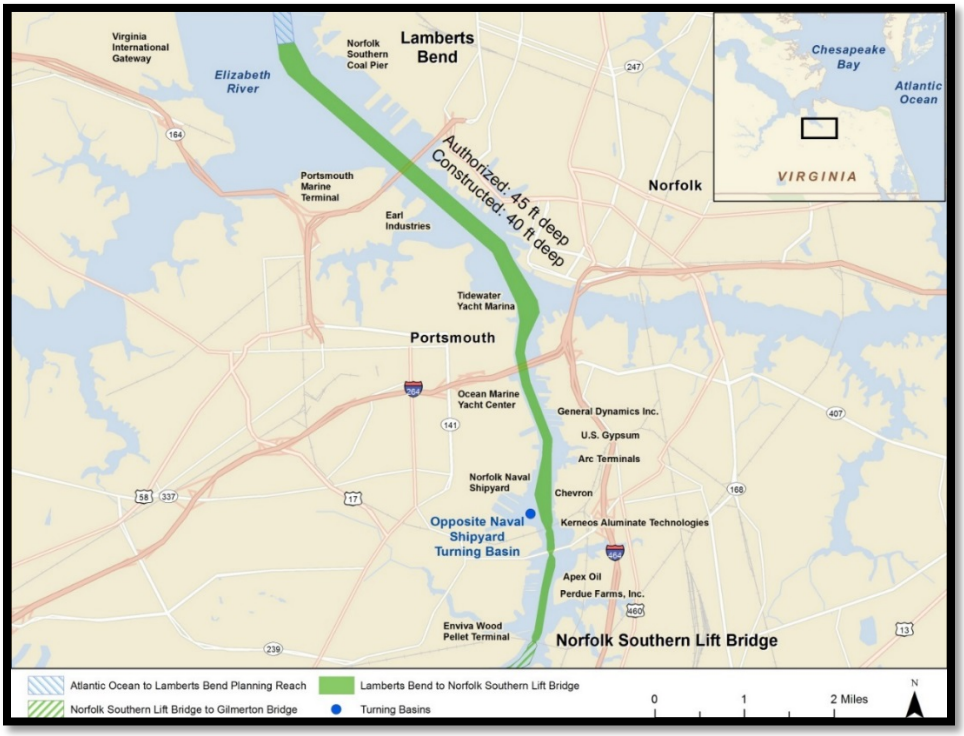


Figure 2: Planning Segment-1

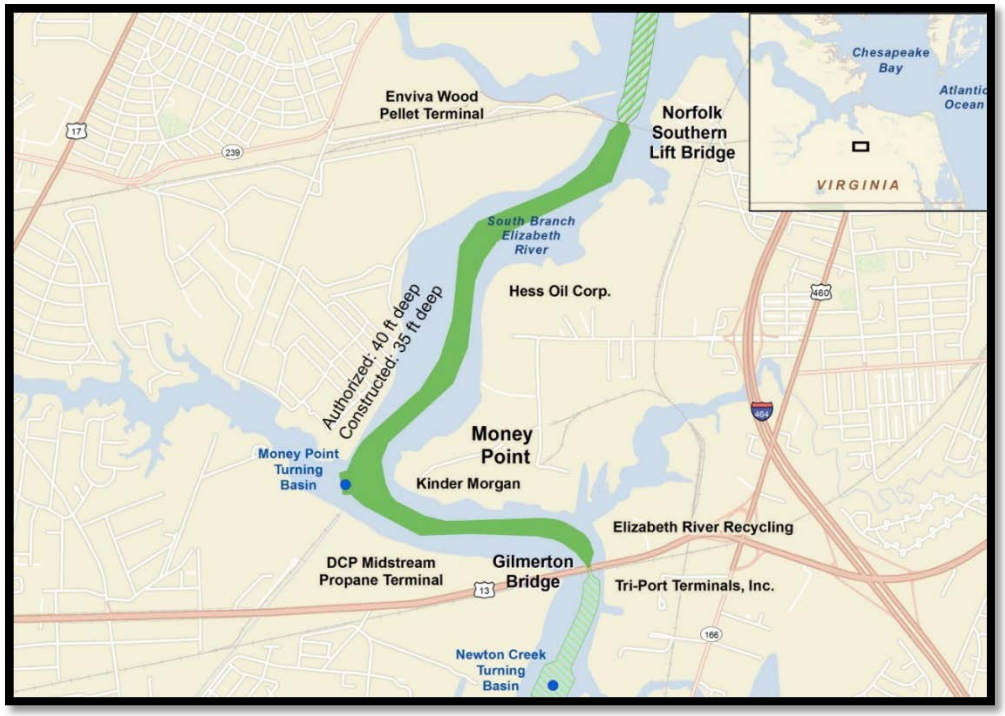


Figure 3: Planning Segment-2

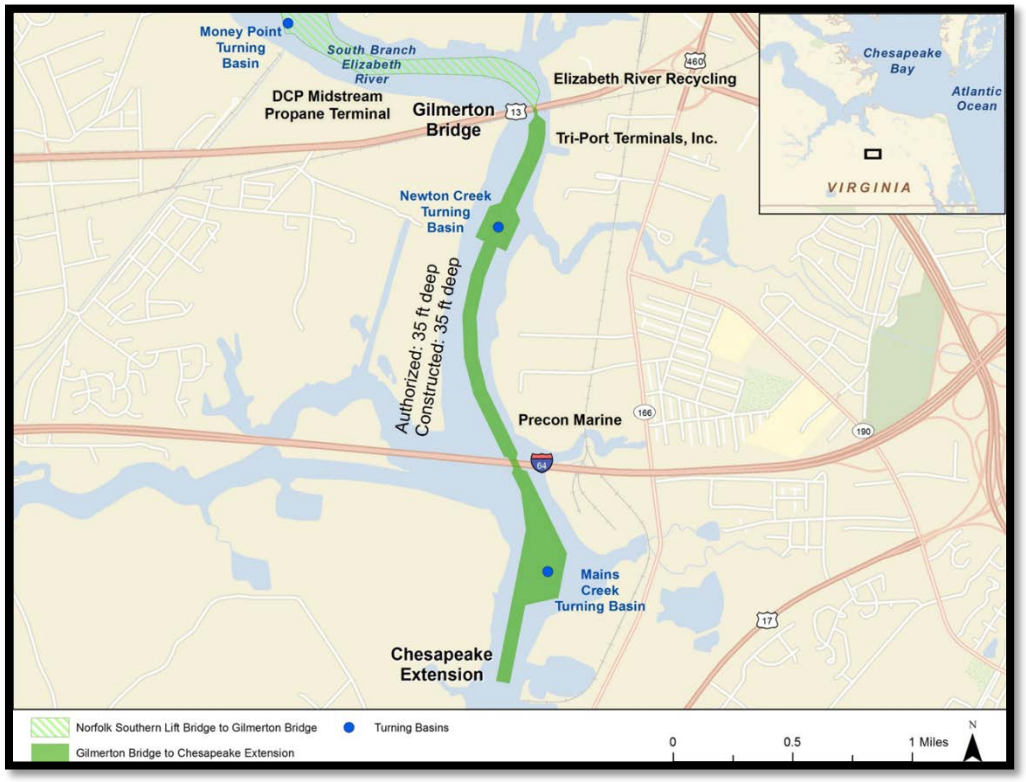


Figure 4: Planning Segment-3

2.3.1.1 Terminal Facilities

The Elizabeth River and Southern Branch of the Elizabeth River channel reaches are heavily industrialized, providing marine access to numerous industrial facilities and Norfolk Naval Shipyard (NNSY). The following lists the active terminals and maritime facilities located on the channel reaches. Note that there are no currently active terminals along Upper Channel Reaches B, although the reach does include the site of a former coal fired Dominion Generation Corporation power generation facility. Port Facilities/Terminal Operators adjacent to the Southern Branch of the Elizabeth River Lower Reach include:

- Tidewater yacht marine: marina and boatyard.
- Ocean Marine Yacht Center: Marina and boatyard;
- BAE Systems – Norfolk Ship Repair: Naval shipyard
- General Dynamics: Naval shipyard;
- U.S. Gypsum: Aggregates, sand, stone;
- Arc Terminal: Petroleum products;
- Kerneos Aluminate Technologies: high alumina cement production; and
- Norfolk Naval Shipyard: Naval shipyard and Navy Base.
- Apex Oil Terminal: Petroleum products; and
- Perdue Farms: Grains, Liquid bulk food products
- Enviva Wood Pellet Terminal: Wood pellets;
- Hess Oil: Petroleum products;
- Kinder Morgan Money Point Terminal: Aggregates, sand, stone;
- DCP Midstream Propane Terminal: Propane and other natural gas liquids; and
- Elizabeth River Recycling: Scrap metal
- Precon Marine: Heavy marine construction and waterfront construction contractor; and Tri-port Fuel Pier

Analysis of the data returned over 80 different terminal locations (some active, some inactive). These were aggregated into the 27 terminals shown in Table 2.

Table 2: Dock Aggregation

Dock	Channel	Planning Segment	Commodities
LAMBERT POINT DOCKS	Lambert Bend to Pinner Point	ERSB-Segment-1	Dry-Bulk Grains, Barge Aggregates, Dry-Bulk Fertilizers, Ores & Minerals, Wood Pellets, Lards Fats & Oils, Liquid Bulk Chemicals, Petroleum, General Cargo, Passenger Cruises
PINNERS POINT DOCKS	Pinners Point to Town Point Reach		
CRUISE TERMINAL TOWN POINT REACH DOCKS EAST BRANCH DOCKS	Town Point Reach		
US GYPSUM BERKLEY DOCKS ELMSLEY DOCKS TRANSMONTAIGNE ARC TERMINALS	Southern Branch - Lower Reach		
JORDAN BRIDGE DOCKS PERDUE FARMS TERMINAL	Southern Branch - Middle Reach		

APEX TERMINAL PARADISE POINT DOCKS ENVIVA TERMINAL			
KINDER MORGAN SOUTH HILL TERMINAL BUCKEYE-HESS TERMINAL KINDER MORGAN SOUTHEAST TERMINAL MONEY POINT DOCKS SOUTHERN AGGREGATES MILLDAM CREEK DOCKS KINDER MORGAN ELIZABETH RIVER TERMINAL SOUTHERN STATES RECYCLING TERMINAL	N&W Railway Lift Bridge Reach Gilmerton Bridge Reach	ERSB-Segment-2	Liquid Bulk Petroleum Products, Dry & Liquid Bulk Chemicals, Ores & Minerals, Liquid Bulk Fertilizers, LPG, Aggregates, General Cargo, Scrap Iron
TRIPORT TERMINAL NEWTON CREEK DOCKS TERMINUS DOCKS	Gilmerton Bridge Reach to End of Newton Creek Turning Basin End of Newton Creek Turning Basin to Upstream Limit	ERSB-Segment-3	Petroleum, Fertilizers, Chemicals, Aggregates

2.3.1.2 Channel Reaches

This section provides information on the channel reaches. Reaches are important for returning time and cost the vessel spends steaming from one point to another within the harbor. Channel conditions and constraints determine whether a vessel will be able to transit the channel, and/or meet other vessels within the channel or accrue wait times on arrival or at the dock.

2.3.1.2.1 Channel Reach Dimensions

The channel lengths and widths shown in Table 3 are in nautical miles but within the model are recorded in feet. Reach lengths were obtained by measuring shape-files using GIS.

Table 3: Reach Dimensions

Reach Dimensions			
Channel Reach	**Depth(feet)**	**Width (feet)**	**Length (miles)**
Lambert Bend to Pinner Point	40	750	.93
Pinner Point to Town Point Reach	40	750	1.0
Town Point Reach	40	750	.63
Southern Branch Lower Reach	40	450	1.6
Southern Branch Middle Reach	40	375	.88
Southern Branch N&W Railway Lift Bridge Reach	35	50	.17
Southern Branch Gilmerton Bridge	35	400	2.0
Gilmerton Bridge Reach to End of Newton Creek Turning Basin	35	300	.42
End of Newton Creek Turning Basin to Upstream Limit	30	250	1.36

2.3.1.2.2 Channel Reach Operations

Table 4 provides detail on the vessel speeds by vessel type when vessels are operating within the channel reaches. Speeds are represented as a uniform distribution between light and loaded speeds. Transit speeds were obtained through conversation with the Virginia Pilots Association.

Table 4: Reach Transit Speeds

Vessel Speeds in Reach (knots)						
Channel Reach	**Bulkers**	**Tankers**	**Gas Carriers**	**Cruise Ship**	**Navy Vessels**	**Barges**
Lambert Bend to Pinner Point	7 - 6	7 - 6	7 - 6	7 - 6	7 - 6	7 - 6
Pinner Point to Town Point Reach	6	6	6	6	6	6
Town Point Reach	8 - 6	8 - 6	8 - 6	8 - 6	8 - 6	8 - 6
Southern Branch Lower Reach	6 - 3	6 - 3	6 - 3	6 - 3	6 - 3	6 - 3
Southern Branch Middle Reach	6 - 3	6 - 3	6 - 3	6 - 3	6 - 3	6 - 3
Southern Branch N&W Railway Lift Bridge Reach	4 - 2	4 - 2	4 - 2	4 - 2	4 - 2	4 - 2
Southern Branch Gilmerton Bridge Reach	4 - 2	4 - 2	4 - 2	4 - 2	4 - 2	4 - 2
Gilmerton Bridge Reach to End of Newton Creek Turning Basin	3 - 1	3 - 1	3 - 1	3 - 1	3 - 1	3 - 1
End of Newton Creek Turning Basin to Upstream Limit	3 - 1	3 - 1	3 - 1	3 - 1	3 - 1	3 - 1

Table 5 and Table 6 provide detail on operational practices as indicated by the Virginia Pilots Association.

Table 5: Vessel Meeting Rules

	Largest vessels that can meet in the channel	
Channel Reach	Vessel-1	Vessel-2
Lambert Bend to Pinner Point	700 x 105	700 x 105
Pinner Point to Town Point Reach	965 x 106	965 x 106
Town Point Reach	751 x 106	Small tug and barge traffic
Southern Branch Lower Reach	No meeting	No meeting
Southern Branch Middle Reach	No meeting	No meeting
Southern Branch N&W Railway Lift Bridge Reach	No meeting	No meeting
Southern Branch Gilmerton Bridge Reach	No meeting	No meeting
Gilmerton Bridge Reach to End of Newton Creek Turning Basin	No meeting	No meeting
End of Newton Creek Turning Basin to Upstream Limit	No meeting	No meeting

Table 6: Reach Operational Practices

Channel Reaches	Description of Operational Practice
Lambert Bend to Pinner Point	Constructed depth of 40 feet and a constructed width of 750 feet allows for two-way traffic for smaller vessels.
Pinner Point to Town Point Reach	The width allows for two-way traffic and contains one of the four containership terminals in the area, the Portsmouth Marine Terminal.
Town Point Reach	Constructed depth of 40 feet and a constructed width of 750 feet allows for two-way traffic for smaller vessels.
Southern Branch Lower Reach	Constructed depth of 40 feet and a constructed width of 450 feet, the Southern Branch Lower Reach extends through the Cities of Portsmouth and Chesapeake, VA. With military presence, there are speed and passing restrictions in parts of the reach.
Southern Branch Middle Reach	Constructed 40 feet deep and 375 feet wide. One-way traffic is practiced.
Southern Branch N&W Railway Lift Bridge Reach	Constructed 35 feet deep and 500 feet wide. One-way traffic is practiced.
Gilmerton Bridge Reach	Constructed 35 feet deep and 400 feet wide. One-way traffic is practiced.
Gilmerton Bridge Reach to End of Newton Creek Turning Basin	Constructed 35 feet deep and 300 feet wide. One-way traffic is practiced. Tide, current and daylight restrictions to pass through the Gilmerton Bridge. Vessel size restricted to 625' LOA and 80' Beam. There are also minimum tug requirements based on the length of the ship and draft.
End of Newton Creek Turning Basin to Upstream Limit	Constructed 30 feet deep and 250 feet wide. One-way traffic is practiced. Tide, current and daylight restrictions to pass through the Gilmerton Bridge. Vessel size restricted to 625' LOA and 80' Beam. There are also minimum tug requirements based on the length of the ship and draft.

It is expected that operational procedures for the FWOP and FWP conditions will not be changed since the channel design will not be altered.

2.3.2 Cargo Volume by Planning Segments

Table 7 provides details on the distribution of cargo volume of cargo by planning segment. Analysis of the data suggests that most of the cargo tonnage and vessel calls occur in the 1st two planning segments. Because of this, Planning Segment-3 was screened out of the plan formulation.

Table 7: Cargo Volume & Calls by Planning Segment

Planning Segment	# Calls	# Units
ERSB-Segment-1	2,374	5,338,593
ERSB-Segment-2	1,448	2,721,457
ERSB-Segment-3	6	28,670
Total	**3,828**	**8,088,720**

2.4 Vessels

Vessel Types were defined by the type of cargo moved and the overall vessel structure. Vessel Type and Class were identified for each unique vessel calling ERSB over the period from 2009 through 2013. Vessel Types defined in the study include those displayed in Table 8. The "Classification" column states the vessel characteristic used to classify ships of a given type into different Vessel Classes in HarborSym.

Table 8: Vessel Types

Vessel Type	Classification
10K-30K DWT Bulker	Capacity
40K-70K DWT Bulker	Capacity
Capesize Bulker	Capacity
Tanker	Capacity
Gas Carrier	Capacity
General Cargo Ship	Capacity
Cruise Ship	Capacity
Tanker Barge	Capacity
Dry Cargo Barge	Capacity
Navy Vessel	Beam

The model incorporates those vessels that are currently calling at the ERSB. It is not anticipated that a fleet transition will occur for the Elizabeth River Southern Branch. Instead, as the channel gets deeper, the utilization of the channel will increase with the transfer of cargo from smaller to larger vessels in the existing fleet. In this way, calls by smaller vessels are eliminated and larger vessels are able to utilize capacity that cannot currently be used given the existing channel depth. The FWOP and FWP conditions incorporate those vessels currently calling the ERSB channel.

2.4.1 Bulkers, General Cargo Vessels, & Dry Cargo Barges

Table 9 outlines the physical characteristics of bulkers, general cargo vessels, and dry cargo barges calling the ERSB in the existing condition. Based on the minimum to maximum draft ranges shown below, the largest bulkers in the existing ERSB fleet have the ability to draft as deep as 58 feet (100K DWT Bulker) and thus, depending on actual loading practices and commodity densities discussed in subsequent sections of this appendix, could potentially use channel depth beyond 40 feet (Segment-1) and beyond 35 feet (Segment-2 and Segment-3). Note that most bulker classes (30K-100K DWT) calling the ERSB have maximum drafts of greater than 35 feet. Large general cargo vessels have the ability to draft up to 41 feet, meaning these vessels also have the potential to benefit from additional channel depth, mainly in Segment-2 and Segment-3 where the current channel depth is 35 feet. Note that due to the relatively shallow maximum drafts of dry barges, these vessels are able to fully load at the channel's current depths. Thus, barges add to the total harbor traffic but do not stand to benefit from the implementation of any channel deepening measures. Fleet composition in the existing condition is expected to remain similar in the future conditions.

Table 9: Bulker, General Cargo, & Dry Cargo Barge Vessel Dimensions

Class	Minimum LOA	Maximum LOA	Minimum Beam	Maximum Beam	Minimum Draft	Maximum Draft	Minimum Capacity	Maximum Capacity

10K DWT Bulker	370	480	55	74	20	29	7,000	13,700
20K DWT Bulker	449	643	75	92	19	35	14,000	24,299
30K DWT Bulker	515	666	73	98	24	36	24,300	34,100
40K DWT Bulker	559	738	75	106	29	48	33,000	42,256
50K DWT Bulker	553	752	82	121	27	47	42,700	51,999
60K DWT Bulker	616	755	105	106	23	45	52,000	60,800
70K DWT Bulker	689	804	76	120	40	48	62,000	74,900
80K DWT Bulker	731	1005	92	122	39	49	71,250	79,800
90K DWT Bulker	623	846	105	142	41	49	81,947	89,011
100K DWT Bulker	623	1001	105	154	35	58	90,250	145,022
10K DWT Gen Cargo	65	674	20	106	1	34	-	14,128
20K DWT Gen Cargo	459	822	68	110	19	39	14,500	24,400
30K DWT Gen Cargo	557	760	85	106	29	39	25,500	32,700
40K DWT Gen Cargo	597	870	90	107	32	40	34,600	44,000
50K DWT Gen Cargo	600	959	101	146	34	41	48,100	50,000
10K DWT Dry Barge	61	420	10	108	14	31	-	13,400
20K DWT Dry Barge	419	463	80	82	21	28	15,400	24,100

2.4.2 Tankers, Gas Carriers, & Tank Barges

Table 10 outlines the physical characteristics of tankers, gas carriers, and tank barges calling the ERSB in the existing condition. The largest tankers calling the ERSB in the existing condition are 200K DWT Tankers with capacities up to 158K DWT tonnes. Gas carriers (LPG) and tank barges also call docks along the ERSB. Tanker, gas carrier, and tank barge fleet composition in the existing condition is expected to remain similar in the future conditions.

Table 10: Tanker, Gas Carrier, & Tank Barge Dimensions

Class	Minimum LOA	Maximum LOA	Minimum Beam	Maximum Beam	Minimum Draft	Maximum Draft	Minimum Capacity	Maximum Capacity
10K DWT Tanker	327	553	13	101	18	36	-	13,900
20K DWT Tanker	423	600	64	92	27	36	14,500	24,100
30K DWT Tanker	515	689	75	106	31	44	24,400	32,800
40K DWT Tanker	560	716	85	106	23	44	34,000	43,400
50K DWT Tanker	580	736	93	106	28	45	43,700	51,200
60K DWT Tanker	600	791	104	132	40	44	59,400	63,100
70K DWT Tanker	600	849	104	132	41	48	63,200	73,000
80K DWT Tanker	690	791	104	158	45	53	73,300	74,000
100K DWT Tanker	747	994	124	165	44	58	90,649	144,185
200K DWT Tanker	876	987	144	174	55	65	152,726	158,846
10K DWT Gas Carrier	98	517	17	92	5	40	-	5,700
20K DWT Gas Carrier	475	655	69	96	26	40	20,000	23,000
40K DWT Gas Carrier	591	815	89	115	30	42	39,000	43,000
50K DWT Gas Carrier	720	844	105	132	34	42	45,000	49,000
60K DWT Gas Carrier	721	755	106	121	38	45	50,000	64,999
80K DWT Gas Carrier	900	957	135	161	36	44	77,000	83,000
10K DWT Tank Barge	58	670	15	151	6	36	1,100	14,970
20K DWT Tank Barge	326	558	72	86	22	39	15,000	23,400
30K DWT Tank Barge	469	615	76	91	30	36	23,500	30,000
40K DWT Tank Barge	580	692	93	96	30	46	36,000	45,700

2.4.3 Cruise Ships, Navy & Other Vessels

Table 11 outlines the physical characteristics of vessel classes currently calling the ERSB but not described in previous sections of this appendix. Cruise and Navy vessels are given distinct vessel classes while all other vessels (e.g., yachts, tugs, Coast Guard vessels, etc.) are captured by the "Misc." vessel class. Again, the existing fleet composition here is assumed to remain constant in future conditions.

Table 11: Other Vessel Dimensions

Class	Minimum LOA	Maximum LOA	Minimum Beam	Maximum Beam	Minimum Draft	Maximum Draft	Minimum Capacity	Maximum Capacity
1K Passenger	223	1082	39	106	8	26	-	1,499
2K Passenger	915	990	105	106	25	26	1,500	2,499
3K Passenger	826	1132	105	106	23	28	2,500	3,499
4K Passenger	895	1115	116	119	27	28	3,500	4,499
Aircraft Carrier Other Navy Misc.	Navy vessel dimensions are withheld due to sensitivity of information. Misc. vessel dimensions vary widely because this class captures a variety of vessels. These dimensions are not included as they do no impact the analysis.							

In addition to serving as the basis for identifying vessel dimensions and for dividing vessels into classes based on these dimensions, historical call data (2009-2014) was used to identify the number of calls by vessel class to ERSB docks (Table 12). Data on the number of calls for 2009-2014 for each vessel class was used to come up with a representative number of existing condition calls for 2015. The 2015 number of calls serves as the base condition for calibration of the economic model and thus as the baseline for the economic analysis. Note that nearly 90% of the 2015 calls are by just three vessels classes, 10K DWT Tank Barges, 10K DWT Dry Barges, and Misc. vessels. This is important because it means that the large majority of vessel calls to ERSB contribute to harbor traffic but do not stand to benefit from any potential future channel deepening.

Table 12: Existing Condition Vessel Calls

Vessel Class Name	2009	2010	2011	2012	2013	2014	2015*
10K DWT Bulker	8	6	14	10	6	2	8
20K DWT Bulker	20	36	21	9	10	13	18
30K DWT Bulker	48	43	47	51	51	50	49
40K DWT Bulker	21	15	36	10	11	23	19
50K DWT Bulker	10	12	9	12	9	10	10
60K DWT Bulker	4	6	11	18	25	26	15
70K DWT Bulker	7	3	7	5	5	2	5
80K DWT Bulker	1	1	3	5		5	3
90K DWT Bulker			1			1	1
10K DWT Tanker	14	21	17	9	16	12	15
20K DWT Tanker	7	12	15	15	14	25	15
30K DWT Tanker	3	6	11	6	7	2	6
40K DWT Tanker	12	13	9	9	12	7	11
50K DWT Tanker	6	11	15	8	6	11	10
60K DWT Tanker	1		5	8	1	1	2
70K DWT Tanker	16	9	8	4	3	3	7

80K DWT Tanker		1		1			1
100K DWT Tanker		1					1
200K DWT Tanker					1		1
10K DWT Gas Carrier						3	3
20K DWT Gas Carrier				1	1		1
40K DWT Gas Carrier	5	3	5	2			4
60K DWT Gas Carrier		1					1
80K DWT Gas Carrier						1	1
10K DWT Tank Barge	1013	994	956	968	953	977	975
20K DWT Tank Barge	17	16	14	6	17	14	15
30K DWT Tank Barge			3	1	1	2	2
40K DWT Tank Barge	16	7	9	2	1	7	7
10K DWT Dry Barge	1101	1204	1055	968	1303	1101	1112
20K DWT Dry Barge	34	38	37	42	27	37	37
10K DWT Gen Cargo	84	75	89	80	47	50	75
20K DWT Gen Cargo	7	15	12	14	13	8	13
30K DWT Gen Cargo		6	2	11	13	8	8
40K DWT Gen Cargo	3	1	7	1	2	1	3
50K DWT Gen Cargo	1				1		1
1K Passenger	4	6	5	3	7	5	5
2K Passenger	8	9		3	1		6
3K Passenger	1	1	2	3	1	4	2
4K Passenger	7	7	7	8	12		8
Navy Ships	12	5	10	7	6	1	7
Misc.	1342	1213	1391	1470	1246	1342	1338
Total	**3833**	**3797**	**3833**	**3770**	**3829**	**3754**	**3821**

2.5 Commodities

Table 13 lists the commodities and associated tonnages passing through the ERSB on an annual basis from 2009 through 2013. The historical data was then used to derive representative 2015 tonnages by commodity type. Table 14 shows the breakdown of commodities by percentage export versus percentage import tonnage. The commodity category with the most estimated throughput in 2015 is Dry-Bulk Grains, which makes up around 34% of the total baseline (2015) tonnage passing through the ERSB docks. The majority of the Dry-Bulk Grains tonnage is attributable to exports.

Table 13: Existing Condition Commodity Throughput

Commodity Name	2009	2010	2011	2012	2013	2015*
Dry-Bulk Grains	2,546,536	2,563,175	3,096,279	3,005,957	2,710,364	2,788,735
Dry-Bulk Fertilizers	855,154	674,613	621,192	553,571	611,137	642,163
Dry-Bulk Aggregates	161,202	223,382	180,086	128,401	180,101	177,360
Barge Aggregates	1,325,588	1,086,394	1,018,500	1,081,005	1,288,525	1,123,198
Dry-Bulk Chemicals	58,967	317,080	216,441	265,239	186,886	212,682
Ores & Minerals	102,634	106,255	77,167	111,286	54,606	96,512
Lards Fats & Oils	159,002	177,896	172,901	160,005	72,344	154,217
Liquid-Bulk Petroleum	240,263	181,542	509,113	160,889	139,321	213,884
Barge Petroleum	1,267,037	1,251,226	1,013,621	724,401	755,108	1,007,950
Liquid-Bulk Fertilizers	218,714	397,538	412,912	412,015	297,682	372,655
Liquid-Bulk Chemicals	159,840	115,734	136,677	202,052	192,256	160,576
LPG/LNG	102,780	106,171	114,130	34,978		137,534
Scrap Iron	214,379	417,211	472,451	435,323	262,896	388,832

Wood Pellets			28,080	231,300	409,934	409,934
General Cargo	199,142	125,718	128,645	268,473	137,596	154,755
Passengers	49,618	51,924	32,702	44,866	50,142	47,734
Coal	1,364,454	1,054,933	1,114,334	32,528		-
Total Units	9,025,310	8,850,792	9,345,231	7,852,289	7,348,898	8,088,720

Coal transits were excluded from the FWOP condition. Based on the data available, coal transits to the Chesapeake Energy Center were discontinued.

Table 14: Commodity Imports vs. Exports

Commodity Name	Exports	Imports
Dry-Bulk Grains	69%	31%
Barge Aggregates	4%	96%
Barge Petroleum	50%	50%
Coal	3%	97%
Dry-Bulk Fertilizers	55%	45%
Scrap Iron	99%	1%
Liquid-Bulk Fertilizers	0%	100%
Liquid-Bulk Petroleum	13%	87%
Dry-Bulk Chemicals	4%	96%
Dry-Bulk Aggregates	3%	97%
General Cargo	53%	47%
Liquid-Bulk Chemicals	34%	66%
Lards, Fats, & Oils	100%	0%
Wood Pellets	100%	0%
Ores & Minerals	7%	93%
LPG/LNG	0%	100%

2.6 Trade Units

A trade unit is a consolidation of the existing condition inventory. Historical data shows a wide variety of vessels transporting various quantities of many diverse commodities to/from distinct docks in the port of study. Each vessel call is also associated with an origin and/or destination port that could be located anywhere around the world or country. Trade units are used to boil this large and varied data set down to a manageable catalog of distinct and representative vessel call possibilities occurring in the existing condition and likely to occur in the future.

A trade unit is made up of a combination of commodity, vessel class, and dock associated with a vessel call. This allows the economist to group vessel calls with common characteristics. A route group is then added to each trade unit to allow for a distance to and/or from the destination and/or origin port to be established. For each trade unit summary statistics for tonnage per call and for other key call characteristics is calculated and used in the economic analysis. In this way summarized historical information creates a representative picture of the existing condition.
For the ERSB study, the characterization of historical data to build trade units resulted in the following trade unit components:

- 18 commodity types,
- 27 docks,

- 44 vessel classes,
- 13 route groups, and
- roughly 462 commodity + dock + vessel class + route group combinations that were further simplified to 149 based on factors including the frequency with which each combination appeared historically.

The remainder of the current section outlines how route groups were established and describes the trade units that are most important to the ERSB analysis.

2.6.1 Route Groups

Once a trade unit is identified, a route group and a route distance associated with that specific trade unit is assigned. The following methodology was used to create ERSB route groups and calculate route distances:

1. Identify the origin/destination associated with a call based on historical data.
2. Associate each origin/destination with a geographic region.
3. Find a port in that region to represent calls to/from the region.
4. Identify the distance in nautical miles from the region's representative port to ERSB.
5. Assign the distance from #4 to each call to/from that region.
6. Estimate average distance for each trade unit using the distances assigned to calls in steps #1-5.
7. Set up route groups based on distance in 1000-nautical mile (1K NM) increments.
8. Assign a route group to each trade unit based on the average distances calculated in step #6 and the route groups set up in step #7. For example, if the estimated average distance for a trade unit were 4,087 NM, then the 4K NM route group would be assigned to the trade unit.
9. Apply the same route group category for the round trip.

The following summarizes the route groups and distances associated with some of the most important commodity types passing through the ERSB docks:

- **Grain Routes** → Dry-Bulk Grains were assigned route groups and distances from 2-5 NM and from 7-8K NM. Route distance varied by vessel size/capacity, with larger bulkers generally tending to be on longer routes than smaller bulkers.
- **Dry-Bulk Routes** → Route groups and distances vary from 1-12K NM. Again, larger vessels generally tend to be on longer routes than smaller vessels.
  - Fertilizers, Aggregates, Chemicals, Ores & Minerals, Wood Pellets, Scrap Irons
- **Liquid-Bulk Routes** → Route groups and distances are 1-6K NM, 8K NM, and 10K NM.
  - Lards Fats & Oils, Fertilizers, Gaseous Liquids, Chemicals, Petroleum Products

2.6.2 Planning Segment-1 Trade Units

Table 15 shows the trade units associated with Segment-1 and the route distance (in nautical miles) assigned to each trade unit. For presentation purposes, the dock component of the trade unit is not shown in this table. Rather, Table 15 aggregates all docks that make up Segment-1 and displays only the commodity and vessel class components of each trade unit. See Table 2 for information on which specific docks are included in Segment-1.

For Segment-1, Dry-Bulk Grains are the main export cargo. The trade units associated with the Dry-Bulk Grains commodity are important because these trade units have the greatest potential to benefit from channel deepening.

Table 15: Planning Segment-1 Trade Units

Commodity Name	Vessel Class Name	Route Distance	Significance
Dry-Bulk Grains	10K DWT Bulker	3K NM	Dry-Bulk Grains are the primary export cargo for planning segment-1. This trade could benefit from additional depth.
Dry-Bulk Grains	20K DWT Bulker	5K NM	
Dry-Bulk Grains	30K DWT Bulker	5K NM	
Dry-Bulk Grains	40K DWT Bulker	5K NM	
Dry-Bulk Grains	50K DWT Bulker	5K NM	
Dry-Bulk Grains	60K DWT Bulker	8K NM	
Dry-Bulk Grains	70K DWT Bulker	7K NM	
Dry-Bulk Grains	80K DWT Bulker	8K NM	
Dry-Bulk Grains	10K DWT Gen Cargo	2K NM	
Dry-Bulk Grains	20K DWT Gen Cargo	4K NM	
Dry-Bulk Grains	30K DWT Gen Cargo	5K NM	
Dry-Bulk Grains	40K DWT Gen Cargo	3K NM	
Dry-Bulk Grains	50K DWT Gen Cargo	5K NM	
Dry-Bulk Fertilizers	10K DWT Bulker	2K NM	Dry-Bulk Fertilizer imports and exports on foreign flag vessels. This trade could conceivably benefit from additional depth.
Dry-Bulk Fertilizers	20K DWT Bulker	3K NM	
Dry-Bulk Fertilizers	30K DWT Bulker	5K NM	
Dry-Bulk Fertilizers	40K DWT Bulker	7K NM	
Dry-Bulk Fertilizers	50K DWT Bulker	9K NM	
Dry-Bulk Fertilizers	60K DWT Bulker	12K NM	
Dry-Bulk Fertilizers	10K DWT Gen Cargo	4K NM	
Dry-Bulk Fertilizers	20K DWT Gen Cargo	5K NM	
Dry-Bulk Fertilizers	30K DWT Gen Cargo	3K NM	
Dry-Bulk Aggregates	50K DWT Bulker	3K NM	Aggregates on foreign flag vessels with design drafts > 40’
Dry-Bulk Aggregates	70K DWT Bulker	1K NM	
Wood Pellets	30K DWT Bulker	4K NM	Wood pellet exports on vessels bound for Europe.
Wood Pellets	40K DWT Bulker	4K NM	
Wood Pellets	50K DWT Bulker	4K NM	
Wood Pellets	60K DWT Bulker	4K NM	
Lards Fats & Oils	10K DWT Tanker	4K NM	Liquid Bulk food & farm product cargoes.
Lards Fats & Oils	20K DWT Tanker	4K NM	
Lards Fats & Oils	30K DWT Tanker	4K NM	
Lards Fats & Oils	50K DWT Tanker	8K NM	
Liquid-Bulk Chemicals	10K DWT Tanker	4K NM	These trade units were anticipated to have relatively low significance due to the small number of vessel calls and cargo movements.
Liquid-Bulk Petroleum	50K DWT Tanker	3K NM	
General Cargo	10K DWT Gen Cargo	4K NM	
General Cargo	20K DWT Gen Cargo	5K NM	
General Cargo	30K DWT Gen Cargo	8K NM	
Dry-Bulk Grains	10K DWT Dry Barge	These trade units are only relevant to measure congestion. Transits are either domestic coastwise traffic, intra-harbor movements, cruise traffic, or Naval vessels going into dry-dock.	
Dry-Bulk Fertilizers	20K DWT Dry Barge		
Barge Aggregates	10K DWT Dry Barge		
Barge Petroleum	10K-20K DWT Tank Barge(s)		
Liquid-Bulk Chemicals	10K-30K DWT Tank Barge(s)		
General Cargo	10K DWT Tank Barge		
General Cargo	30K DWT Tank Barge		
No Freight	10K -20K DWT Tank Barge(s)		
No Freight, General Cargo	Misc.		
Passengers	1K – 4K Passenger		
No Freight	Navy Ships, Aircraft Carriers		

Table 16 displays the annual number of calls; the total tonnage across all calls; and the mean, minimum, maximum, and standard deviation tonnage per call in the existing condition (2015 calibration call list) for Segment-1 docks by trade unit for benefitting trades. Benefitting trades are those that stand to benefit

from proposed channel deepening measures and include calls by vessels that may be able to load deeper with additional channel depth and calls that have the potential to be reduced as their tonnage is moved to larger ships that are able to load deeper. The "Remaining Trades" represent additional vessel calls that contribute to harbor congestion but that do not stand to benefit from increased channel depth. Tonnage, sailing drafts, and other specific data associated with these remaining trades does not impact the outcome of the current analysis. Thus, going forward, discussion of Segment-1 in this appendix will focus on details of benefitting vessels only.

Table 16: Segment-1 Shipment Size Distribution by Trade Unit

Commodity Name	Vessel Class Name	Calls	Tonnes	Mean	SD	Minimum	Maximum
Dry-Bulk Grains	10K DWT Bulker	5	47,640	7,594	4,331	200	12,351
Dry-Bulk Grains	20K DWT Bulker	11	175,124	11,239	5,907	998	23,002
Dry-Bulk Grains	30K DWT Bulker	18	514,361	20,334	10,740	1,199	32,215
Dry-Bulk Grains	40K DWT Bulker	3	93,364	23,068	9,299	5,036	33,002
Dry-Bulk Grains	50K DWT Bulker	3	143,454	29,536	16,832	1,500	50,037
Dry-Bulk Grains	60K DWT Bulker	4	195,146	45,919	13,867	9,618	53,175
Dry-Bulk Grains	70K DWT Bulker	4	234,107	55,087	10,052	14,414	60,482
Dry-Bulk Grains	80K DWT Bulker	2	104,082	57,146	1,680	53,334	59,257
Dry-Bulk Grains	10K DWT Gen Cargo	33	221,870	4,185	2,552	570	16,791
Dry-Bulk Grains	20K DWT Gen Cargo	5	78,933	10,835	5,284	3,163	21,995
Dry-Bulk Grains	30K DWT Gen Cargo	1	25,277	20,818	5,912	11,181	27,499
Dry-Bulk Grains	40K DWT Gen Cargo	1	29,147	23,317	12,441	6,597	37,431
Dry-Bulk Grains	50K DWT Gen Cargo	1	45,096	46,091	-	46,091	46,091
Dry-Bulk Fertilizers	10K DWT Bulker	2	15,153	8,158	4,182	2,877	11,747
Dry-Bulk Fertilizers	20K DWT Bulker	4	55,421	12,972	6,699	3,109	22,500
Dry-Bulk Fertilizers	30K DWT Bulker	9	185,105	19,164	9,159	2,291	31,000
Dry-Bulk Fertilizers	40K DWT Bulker	1	15,110	16,593	13,483	5,251	31,500
Dry-Bulk Fertilizers	50K DWT Bulker	1	11,212	12,313	6,680	5,099	21,260
Dry-Bulk Fertilizers	60K DWT Bulker	1	32,354	35,529	33,264	12,008	59,050
Dry-Bulk Fertilizers	10K DWT Gen Cargo	1	4,778	5,247	2,700	2,199	7,339
Dry-Bulk Fertilizers	20K DWT Gen Cargo	1	12,297	13,503	8,540	3,869	20,142
Dry-Bulk Fertilizers	30K DWT Gen Cargo	1	12,353	13,565	10,062	3,226	27,372
Dry-Bulk Aggregates	50K DWT Bulker	1	42,563	45,015	26	45,000	45,045
Dry-Bulk Aggregates	70K DWT Bulker	1	57,505	52,623	2,420	49,028	54,280
Wood Pellets	30K DWT Bulker	3	66,340	27,079	3,327	24,051	31,000
Wood Pellets	40K DWT Bulker	2	73,923	30,174	1,673	28,080	31,804
Wood Pellets	50K DWT Bulker	2	51,357	41,927	3,474	39,470	44,383
Wood Pellets	60K DWT Bulker	5	218,313	44,556	2,545	39,442	47,264
Lards Fats & Oils	10K DWT Tanker	12	55,122	4,679	4,199	996	25,887
Lards Fats & Oils	20K DWT Tanker	5	60,877	11,576	7,554	948	28,991
Lards Fats & Oils	30K DWT Tanker	1	17,051	17,329	5,057	11,022	22,555
Lards Fats & Oils	50K DWT Tanker	1	21,167	20,125	1,703	17,921	22,712
Liquid-Bulk Chemicals	10K DWT Tanker	1	4,781	4,811	3,167	1,217	7,193
Liquid-Bulk Petroleum	50K DWT Tanker	1	33,345	7,046	-	7,046	7,046
General Cargo	10K DWT Gen Cargo	27	124,029	1,318	2,273	2	12,200
General Cargo	20K DWT Gen Cargo	13	26,150	397	379	9	1,578

General Cargo	30K DWT Gen Cargo	7	4,577	278	-	278	278
Remaining Trades		2,180	2,230,109				
Total		2,374	5,338,593				

Historical vessel sailing drafts both entering (inbound) and exiting (outbound) the ERSB are used to help determine the need for additional channel depth. If actual sailing drafts on either or both legs indicate that vessels are using all available existing channel depth considering tide and UKC and if the vessels have the physical capacity to load deeper (see Table 10, Table 11, and Table 12 for vessel dimensions), then the vessels can be considered depth constrained and have the potential to benefit from deepening. Table 17 gives a summary of inbound and outbound sailing drafts by vessels class for calls to Segment-1 docks over the period from 2009 to 2015 based on pilots' log data.

Table 17: Planning Segment-1 Sailing Draft Distribution

Arrival/Departure	Vessel Class Name	Frequency	Mean	SD	Min	Max
Planning Segment-1 Vessels Inbound	10K DWT Bulker	5	18.13	2.47	15.25	20.33
	20K DWT Bulker	3	17.25	1.15	16.25	18.50
	30K DWT Bulker	23	23.62	6.16	17.08	33.50
	40K DWT Bulker	11	26.26	5.89	20.33	35.00
	50K DWT Bulker	10	24.73	6.97	20.50	38.00
	60K DWT Bulker	35	23.71	3.55	19.67	36.42
	70K DWT Bulker	4	29.88	5.79	24.75	38.08
	80K DWT Bulker	3	27.67	4.69	22.58	31.83
	10K DWT Gen Cargo	43	16.20	2.86	11.17	23.00
	20K DWT Gen Cargo	9	19.10	2.80	15.75	24.25
	30K DWT Gen Cargo	2	27.54	9.25	21.00	34.08
	40K DWT Gen Cargo	1	38.00	-	38.00	38.00
	10K DWT Tanker	32	21.34	2.43	17.75	26.92
	20K DWT Tanker	30	22.27	1.71	19.67	25.92
	30K DWT Tanker	3	25.08	1.59	23.42	26.58
	40K DWT Tanker	2	26.42	2.59	24.58	28.25
	50K DWT Tanker	12	28.24	2.03	25.25	31.50
Planning Segment-1 Vessels Outbound	10K DWT Bulker	37	27.26	1.79	22.92	30.42
	20K DWT Bulker	79	28.94	2.35	21.67	35.00
	30K DWT Bulker	199	31.66	2.52	19.33	36.08
	40K DWT Bulker	45	31.91	3.73	18.92	36.58
	50K DWT Bulker	30	33.11	7.11	20.00	40.00
	60K DWT Bulker	55	37.71	2.62	26.33	40.67
	70K DWT Bulker	18	37.06	5.22	23.00	40.00
	80K DWT Bulker	13	39.21	0.57	38.42	40.67
	10K DWT Gen Cargo	164	23.39	2.61	11.50	32.75
	20K DWT Gen Cargo	25	30.44	2.00	25.58	33.00
	30K DWT Gen Cargo	11	32.16	1.79	28.25	34.00
	40K DWT Gen Cargo	5	31.68	4.36	25.08	37.33
	50K DWT Gen Cargo	1	40.08	-	40.08	40.08
	10K DWT Tanker	26	25.52	3.35	18.67	29.83
	20K DWT Tanker	26	25.97	4.69	18.08	32.50
	30K DWT Tanker	5	28.10	5.12	23.00	35.58
	40K DWT Tanker	1	32.42	-	32.42	32.42
	50K DWT Tanker	17	29.71	4.20	25.58	38.08

2.6.3 Planning Segment-2 Trade Units

The trade units and associated route distances identified for Segment-2 of the ERSB are outlined in Table 18.

Table 18: Planning Segment-2 Trade Units

Commodity Name	Vessel Class Name	Route Distance	Significance
Dry-Bulk Grains	30K DWT Bulker	5K NM	Very limited traffic, no benefits anticipated.
Dry-Bulk Fertilizers	10K DWT Bulker	2K NM	Multiple terminals moving dry-bulk fertilizers could stand to benefit from deepening. Vessels have design drafts that exceed current channel depth.
Dry-Bulk Fertilizers	20K DWT Bulker	3K NM	
Dry-Bulk Fertilizers	30K DWT Bulker	5K NM	
Dry-Bulk Fertilizers	40K DWT Bulker	7K NM	
Dry-Bulk Fertilizers	10K DWT Gen Cargo	4K NM	
Dry-Bulk Fertilizers	20K DWT Gen Cargo	5K NM	
Dry-Bulk Fertilizers	40K DWT Gen Cargo	6K NM	
Dry-Bulk Aggregates	10K DWT Gen Cargo	4K NM	Aggregates moving to Kinder Morgan & ERT terminals. Slight potential for benefits
Dry-Bulk Aggregates	20K DWT Bulker	2K NM	
Dry-Bulk Aggregates	60K DWT Bulker	10K NM	
Dry-Bulk Chemicals	30K DWT Bulker	5K NM	Dry –Bulk Chemicals moving on vessels
Dry-Bulk Chemicals	40K DWT Bulker	4K NM	
Dry-Bulk Chemicals	50K DWT Bulker	4K NM	
Dry-Bulk Chemicals	60K DWT Bulker	4K NM	
Ores & Minerals	10K DWT Gen Cargo	8K NM	Benefits unlikely due to extremely light intermittent traffic.
Ores & Minerals	10K DWT Bulker	2K NM	
Ores & Minerals	30K DWT Bulker	7K NM	
Ores & Minerals	40K DWT Bulker	12K NM	
Liquid-Bulk Fertilizers	10K DWT Tanker	4K NM	Benefits are possible; Some vessel drafts exceed current channel depths
Liquid-Bulk Fertilizers	20K DWT Tanker	4K NM	
Liquid-Bulk Fertilizers	30K DWT Tanker	5K NM	
Liquid-Bulk Fertilizers	40K DWT Tanker	4K NM	
Liquid-Bulk Fertilizers	50K DWT Tanker	4K NM	
Liquid-Bulk Chemicals	10K DWT Tanker	4K NM	No benefits; intermittent traffic and vessel drafts do not exceed channel depth
Liquid-Bulk Chemicals	20K DWT Tanker	4K NM	
LPG	10K DWT Gas Carrier	5K NM	Benefits are possible, but anticipated to be uncertain.
LPG	20K DWT Gas Carrier	5K NM	
LPG	40K DWT Gas Carrier	5K NM	
LPG	50K DWT Gas Carrier	5K NM	
LPG	60K DWT Gas Carrier	6K NM	
LPG	80K DWT Gas Carrier	6K NM	
Liquid-Bulk Petroleum	50K DWT Tanker	3K NM	Benefits are possible. Vessel drafts exceed existing channel depth.
Liquid-Bulk Petroleum	60K DWT Tanker	1K NM	
Liquid-Bulk Petroleum	70K DWT Tanker	1K NM	
Liquid-Bulk Petroleum	80K DWT Tanker	1K NM	
Scrap Iron	30K DWT Bulker	6K NM	Benefits are possible. Scrap iron throughput is picking up. Larger vessels have drafts that can benefit.
Scrap Iron	40K DWT Bulker	6K NM	
Scrap Iron	50K DWT Bulker	8K NM	
Scrap Iron	60K DWT Bulker	6K NM	
Barge Aggregates	10K DWT Dry Barge	No deepening benefits: Vessels are primarily domestic jones act traffic. Primary role is to represent harbor congestion. Route distance is not represented in the modeling effort.	
Barge Aggregates	20K DWT Dry Barge		
Barge Petroleum	10K DWT Tank Barge		
Barge Petroleum	20K DWT Tank Barge		
Barge Petroleum	40K DWT Tank Barge		

Liquid-Bulk Chemicals	10K DWT Tank Barge	
General Cargo	10K DWT Tank Barge	
General Cargo	Misc.	
No Freight	10K-20K DWT Tank Barge	
	20K Dry Barge	

Table 19 displays the annual number of calls; the total tonnage across all calls; and the mean, minimum, maximum, and standard deviation tonnage per call in the existing condition (2015 calibration call list) for Segment-2 docks by trade unit for potentially benefitting trades. Note that these potentially benefitting trades accounts for less than 10% of the total annual vessel calls estimated to Segment-2 docks but for around 58% of the total commodity throughput at these same docks in 2015. Thus, capturing the calls associated with the remaining (non-benefitting) trade units is very important for reasonably representing and capturing channel congestion. However, including details of the specific loading patterns associated with these calls is not necessary since these calls do not contribute to the need for channel deepening.

Table 19: Segment-2 Shipment Size Distribution by Trade Unit

Commodity Name	Vessel Class Name	Estimated Annual Calls	Tonnes Per Annum	Mean	SD	Minimum	Maximum
Dry-Bulk Grains	30K DWT Bulker	4	37,693	10,348	3,334	3,000	15,590
Dry-Bulk Fertilizers	10K DWT Bulker	1	7,869	8,642	2,459	6,428	10,901
Dry-Bulk Fertilizers	20K DWT Bulker	1	6,223	6,833	764	6,000	7,500
Dry-Bulk Fertilizers	30K DWT Bulker	1	31,199	9,880	7,127	3,000	26,151
Dry-Bulk Fertilizers	40K DWT Bulker	1	6,420	7,050	778	6,500	7,600
Dry-Bulk Fertilizers	10K DWT Gen Cargo	3	14,846	5,328	1,474	3,150	8,252
Dry-Bulk Fertilizers	20K DWT Gen Cargo	1	4,553	5,000	1,131	4,200	6,600
Dry-Bulk Fertilizers	40K DWT Gen Cargo	1	16,206	17,796	-	17,796	17,796
Dry-Bulk Aggregates	10K DWT Gen Cargo	7	54,314	7,952	1,877	5,887	12,001
Dry-Bulk Aggregates	20K DWT Bulker	1	13,524	12,376	4,270	6,000	15,002
Dry-Bulk Aggregates	60K DWT Bulker	1	9,454	9,999	1,416	8,998	11,000
Dry-Bulk Chemicals	30K DWT Bulker	7	101,519	8,437	9,060	108	32,600
Dry-Bulk Chemicals	40K DWT Bulker	1	26,816	19,313	13,415	2,004	33,000
Dry-Bulk Chemicals	50K DWT Bulker	1	30,473	21,948	10,664	4,999	37,706
Dry-Bulk Chemicals	60K DWT Bulker	2	53,874	33,259	13,913	6,060	43,386
Ores & Minerals	10K DWT Gen Cargo	2	13,219	6,221	1,245	4,010	7,567
Ores & Minerals	10K DWT Bulker	1	5,424	5,792	1,953	3,999	7,873
Ores & Minerals	30K DWT Bulker	6	61,314	10,492	7,951	1,924	27,500
Ores & Minerals	40K DWT Bulker	2	16,554	7,040	2,731	3,258	10,006
Liquid-Bulk Fertilizers	10K DWT Tanker	1	10,434	11,342	1,174	10,000	12,176
Liquid-Bulk Fertilizers	20K DWT Tanker	5	61,769	11,609	6,401	1	27,000
Liquid-Bulk Fertilizers	30K DWT Tanker	5	65,239	12,531	5,826	2,722	27,381
Liquid-Bulk Fertilizers	40K DWT Tanker	9	133,509	14,946	8,140	3,249	37,286
Liquid-Bulk Fertilizers	50K DWT Tanker	5	73,033	15,753	10,528	4,000	36,791
Liquid-Bulk Chemicals	10K DWT Tanker	1	5,291	5,061	3,483	1,500	9,840
Liquid-Bulk Chemicals	20K DWT Tanker	2	12,886	7,043	4,117	2,806	14,050
LPG/LNG	10K DWT GasCarrier	3	5,696	-	-	-	-
LPG/LNG	20K DWT GasCarrier	1	11,393	-	-	-	-
LPG/LNG	40K DWT GasCarrier	2	29,621	23,141	9,826	5,000	32,967

LPG/LNG	50K DWT GasCarrier	2	34,178	10,938	-	10,938	10,938
LPG/LNG	60K DWT GasCarrier	1	28,482	-	-	-	-
LPG/LNG	80K DWT GasCarrier	1	28,164	1,357	1,188	10	3,000
Liquid-Bulk Petroleum	50K DWT Tanker	2	32,046	37,892	19,385	21,268	79,572
Liquid-Bulk Petroleum	60K DWT Tanker	2	36,050	22,587	9,007	10,247	48,374
Liquid-Bulk Petroleum	70K DWT Tanker	4	91,481	41,212	-	41,212	41,212
Liquid-Bulk Petroleum	80K DWT Tanker	1	20,962	7,186	-	7,186	7,186
Scrap Iron	30K DWT Bulker	3	54,252	29,530	8,286	15,463	37,504
Scrap Iron	40K DWT Bulker	4	99,942	25,024	9,070	12,718	38,270
Scrap Iron	50K DWT Bulker	5	123,159	33,571	13,225	9,400	43,700
Scrap Iron	60K DWT Bulker	4	111,479	15,243	4,761	9,411	24,339
Remaining Trade Units		1,341	1,140,897				
Total		1,448	2,721,457				

Table 20 pulls from 2009-2015 pilots' log data to display summary statistics for inbound and outbound sailing drafts associated with calls to Segment-2 docks. Only potentially benefitting vessel classes are shown. Given the assumptions of 1.75 feet of UKC and 1 foot of usable tide, some of the larger bulker, tanker, and gas carrier classes are utilizing all available channel depth on the inbound and/or outbound leg of the call. This indicates that these vessel classes may be able to load deeper, and thus benefit, with channel deepening beyond the existing 35 foot depth.

Table 20: Planning Segment-2 Sailing Draft Distribution

Arrival/Departure	Vessel Class Name	Frequency	Mean	SD	Min	Max
Planning Segment-2 Vessels Inbound	10K DWT Bulker	4	26.04	3.07	23.58	30.50
	20K DWT Bulker	13	27.25	2.88	21.67	32.17
	30K DWT Bulker	47	29.61	4.07	20.42	34.42
	40K DWT Bulker	12	29.92	4.24	20.33	35.00
	50K DWT Bulker	9	22.81	3.29	20.25	31.33
	60K DWT Bulker	13	27.03	4.45	21.00	34.75
	10K DWT Tanker	1	24.67	-	24.67	24.67
	20K DWT Tanker	9	26.94	4.10	22.67	34.00
	30K DWT Tanker	4	30.52	3.35	25.58	33.00
	40K DWT Tanker	7	32.69	1.79	29.83	34.75
	50K DWT Tanker	7	30.27	3.39	24.58	32.50
	60K DWT Tanker	-	-	-	-	-
	70K DWT Tanker	6	31.46	1.99	28.58	33.67
	80K DWT Tanker	-	-	-	-	-
	10K DWT GasCarrier	3	17.53	0.99	16.83	18.67
	20K DWT GasCarrier	1	23.58	-	23.58	23.58
	40K DWT GasCarrier	15	34.07	1.29	31.00	35.00
	60K DWT GasCarrier	1	30.83	-	30.83	30.83
	80K DWT GasCarrier	1	34.75	-	34.75	34.75
	10K DWT Gen Cargo	53	22.73	3.32	14.08	28.92
	20K DWT Gen Cargo	9	24.69	3.57	20.83	31.50
	40K DWT Gen Cargo	2	27.58	5.07	24.00	31.17
Planning Segment-2 Vessels Outbound	10K DWT Bulker	7	17.45	2.80	15.00	22.00
	20K DWT Bulker	17	20.37	4.42	16.08	27.75
	30K DWT Bulker	65	23.97	5.25	17.00	35.00

	40K DWT Bulker	21	27.16	5.24	19.17	35.08
	50K DWT Bulker	18	28.63	4.82	20.00	35.00
	60K DWT Bulker	23	30.38	3.94	22.25	35.08
	10K DWT Tanker	2	18.88	3.48	16.42	21.33
	20K DWT Tanker	6	23.04	1.77	20.33	25.58
	30K DWT Tanker	1	23.75	-	23.75	23.75
	40K DWT Tanker	9	27.40	1.97	23.33	29.50
	50K DWT Tanker	15	27.27	2.08	23.92	32.00
	60K DWT Tanker	14	27.18	2.39	23.92	30.17
	70K DWT Tanker	31	28.12	2.59	19.67	32.83
	80K DWT Tanker	2	27.88	2.30	26.25	29.50
	10K DWT GasCarrier	3	20.14	2.97	16.83	22.58
	20K DWT GasCarrier	1	30.17	-	30.17	30.17
	40K DWT GasCarrier	15	28.54	2.09	25.00	33.17
	60K DWT GasCarrier	1	29.83	-	29.83	29.83
	80K DWT GasCarrier	1	34.75	-	34.75	34.75
	10K DWT Gen Cargo	56	17.85	4.26	12.50	28.58
	20K DWT Gen Cargo	10	24.58	5.80	18.58	32.67
	30K DWT Gen Cargo	1	19.42	-	19.42	19.42
	40K DWT Gen Cargo	2	27.00	6.84	22.17	31.83

2.6.4 Planning Segment-3 Trade Units

The trade units and estimated annual number of calls for 2015 associated with Planning Segment-3 are outlined in Table 21. As the data shows, only two calls to docks located in this planning segment had the potential to either load deeper or be reduced based on historical call data. The other four calls shown in the table add to traffic for this segment but do not stand to benefit from any proposed channel improvements. Segment-3 was screened from further consideration for channel deepening due to the small number of vessel calls visiting docks in this segment. Note that the calls to Segment-3 docks were included in the HarborSym model runs conducted for Segment-2 since these calls add to the overall traffic and congestion in Segment-2 of the ERSB.

Table 21: Planning Segment-3 Trade Unit Data

Commodity Name	Vessel Class Name	Estimated Typical Distance	Tonnes	Calls
Liquid-Bulk Fertilizers	20K DWT Tanker	4K NM	12,787	1
Liquid-Bulk Fertilizers	40K DWT Tanker	4K NM	15,883	1
General Cargo	Misc.	DEFAULT	-	4

3 Forecast of Future Conditions

This section of appendix builds upon the existing condition established in Section 2 to describe the future without-project condition. It includes the methods used to go from the existing condition to the future condition as well as the future condition that results when the outlined methods are applied.

3.1 Commodity Forecast

The import and export commodity forecast and report completed by IHS were used to help inform trends for analysis of the future conditions. The trends taken from the IHS forecast were applied to the ERSB existing condition assessment to estimate future throughput over time by commodity, the results of which are shown in Table 22. Beyond the year 2045 commodity throughput was held constant through the end of the 50-year period of analysis (period of analysis is 2023 through 2072).

Table 22: Commodity Projections

Commodity Name	Assumption	2015	2023	2030	2035	2040	2045
Dry-Bulk Grains	Change over Time	2,788,735	3,322,894	3,974,839	4,356,438	4,710,435	5,029,599
Dry-Bulk Fertilizers	Change over Time	642,163	717,154	799,737	856,052	909,661	959,305
Dry-Bulk Aggregates	Change over Time	177,360	191,311	212,604	228,091	242,938	256,911
Barge Aggregates	Constant	1,123,198	1,123,198	1,123,198	1,123,198	1,123,198	1,123,198
Dry-Bulk Chemicals	Change over Time	212,682	306,957	429,304	528,280	639,003	760,959
Ores & Minerals	Change over Time	96,512	98,901	98,587	94,497	88,852	81,954
Lards Fats & Oils	Change over Time	154,217	154,217	154,217	154,217	154,217	154,217
Liquid-Bulk Petroleum	Change over Time	213,884	193,433	194,560	195,409	198,618	204,303
Barge Petroleum	Constant	1,007,950	1,007,950	1,007,950	1,007,950	1,007,950	1,007,950
Liquid-Bulk Fertilizers	Changes over time	372,655	416,725	465,347	499,789	534,675	569,550
Liquid-Bulk Chemicals	Changes over time	160,576	229,019	317,349	388,550	468,366	555,788
LPG/LNG	Changes over time	137,534	200,833	200,833	200,833	200,833	200,833
Scrap Iron	Changes over time	388,832	550,171	730,791	864,070	1,004,660	1,150,210
Wood Pellets	Changes over time	409,934	491,228	587,551	656,817	725,970	793,137
General Cargo	Changes over time	154,755	182,327	217,418	241,949	267,155	292,728
Passengers	Constant	47,734	47,734	47,734	47,734	47,734	47,734

Dry-Bulk Grains tonnage is expected to grow significantly (nearly double) from the 2015 starting tonnage to the 2045 projected tonnage (Table 22). This is important because Dry-Bulk Grains is the commodity component associated with many of the potentially benefitting Segment-1 trade units established in Table 15. Scrap Iron and Dry-Bulk Chemicals are two other examples of benefitting commodities that are projected to experience significant growth over the forecast period.

3.2 Cargo Movements & Vessel Calls

Combining projected commodity throughput with the trade units established using historical data and the existing condition annualized call list results in estimates of the tonnage by commodity type that will need to be moved by each vessel class in each future year to accommodate the total projected tonnage for that year (Table 23 and Table 24). This was accomplished by using the annualized call list to calculate the proportion of a given commodity allocated to each vessel class. The increase in tonnage over the forecasted period was then added to each vessel class consistent with this historical proportion.

Table 23: Segment-1 Cargo Forecast by Trade Unit & Model Year (FWOP)

Commodity Name	Vessel Class Name	2023	2030	2035	2040	2045
Dry-Bulk Grains	10K DWT Bulker	56,765	67,902	74,421	80,468	85,920
Dry-Bulk Grains	20K DWT Bulker	208,668	249,608	273,571	295,801	315,843
Dry-Bulk Grains	30K DWT Bulker	612,883	733,129	803,512	868,804	927,671

Dry-Bulk Grains	40K DWT Bulker	111,247	133,073	145,849	157,700	168,386
Dry-Bulk Grains	50K DWT Bulker	170,932	204,468	224,098	242,307	258,725
Dry-Bulk Grains	60K DWT Bulker	232,524	278,145	304,848	329,620	351,954
Dry-Bulk Grains	70K DWT Bulker	278,948	333,677	365,711	395,428	422,221
Dry-Bulk Grains	80K DWT Bulker	124,018	148,350	162,592	175,804	187,716
Dry-Bulk Grains	10K DWT Gen Cargo	264,367	316,236	346,595	374,759	400,152
Dry-Bulk Grains	20K DWT Gen Cargo	94,052	112,505	123,306	133,326	142,359
Dry-Bulk Grains	30K DWT Gen Cargo	30,119	36,028	39,487	42,695	45,588
Dry-Bulk Grains	40K DWT Gen Cargo	34,730	41,543	45,532	49,232	52,567
Dry-Bulk Grains	50K DWT Gen Cargo	53,734	64,276	70,447	76,171	81,333
Dry-Bulk Fertilizers	10K DWT Bulker	16,923	18,871	20,200	21,465	22,637
Dry-Bulk Fertilizers	20K DWT Bulker	61,893	69,020	73,880	78,507	82,791
Dry-Bulk Fertilizers	30K DWT Bulker	206,722	230,527	246,760	262,213	276,523
Dry-Bulk Fertilizers	40K DWT Bulker	16,875	18,818	20,143	21,405	22,573
Dry-Bulk Fertilizers	50K DWT Bulker	12,522	13,964	14,947	15,883	16,750
Dry-Bulk Fertilizers	60K DWT Bulker	36,132	40,293	43,130	45,831	48,332
Dry-Bulk Fertilizers	10K DWT Gen Cargo	5,336	5,951	6,370	6,768	7,138
Dry-Bulk Fertilizers	20K DWT Gen Cargo	13,733	15,314	16,392	17,419	18,369
Dry-Bulk Fertilizers	30K DWT Gen Cargo	13,795	15,384	16,467	17,498	18,453
Dry-Bulk Aggregates	50K DWT Bulker	45,911	51,021	54,737	58,300	61,654
Dry-Bulk Aggregates	70K DWT Bulker	62,028	68,932	73,953	78,767	83,298
Wood Pellets	30K DWT Bulker	79,496	95,084	106,294	117,485	128,354
Wood Pellets	40K DWT Bulker	88,583	105,953	118,443	130,914	143,026
Wood Pellets	50K DWT Bulker	61,542	73,610	82,287	90,951	99,366
Wood Pellets	60K DWT Bulker	261,607	312,905	349,793	386,620	422,391
Lards Fats & Oils	10K DWT Tanker	55,122	55,122	55,122	55,122	55,122
Lards Fats & Oils	20K DWT Tanker	60,877	60,877	60,877	60,877	60,877
Lards Fats & Oils	30K DWT Tanker	17,051	17,051	17,051	17,051	17,051
Lards Fats & Oils	50K DWT Tanker	21,167	21,167	21,167	21,167	21,167
Liquid-Bulk Chemicals	10K DWT Tanker	6,819	9,448	11,568	13,945	16,547
Liquid-Bulk Petroleum	50K DWT Tanker	30,157	30,333	30,465	30,965	31,852
General Cargo	10K DWT Gen Cargo	146,126	174,250	193,909	214,111	234,607
General Cargo	20K DWT Gen Cargo	30,809	36,739	40,884	45,143	49,464
General Cargo	30K DWT Gen Cargo	5,392	6,430	7,155	7,901	8,657
Remaining Trades		2,419,122	2,708,673	2,895,177	3,078,805	3,256,211
Total		6,048,723	6,974,675	7,557,141	8,117,229	8,643,645

Table 24 and Table 26 outline the number of projected calls by trade unit and year for benefitting trade units associated with Segment-1 and Segment-2, respectively. The number of calls needed for each trade unit to move the projected tonnage was calculated by dividing the tonnage allocated to that trade unit (from Table 23 above and Table 25) by the average historical tonnage for that same trade unit[5]. These numbers of calls represent the with future without-project condition for Segment-1 and Segment-2. Note that in the future without-project condition, as commodity throughput increases, the number of calls needed to move that throughput also increases.

Table 24: Planning Segment-1 Vessel Call Projections by Trade Unit & Model Year (FWOP)

Commodity Name	Vessel Class Name	2023	2030	2035	2040	2045

[5] See Table 15 and Table 18 for ship size by trade unit for Segment-1 and Segment-2, respectively.

Dry-Bulk Grains	10K DWT Bulker	6	7	8	9	9
Dry-Bulk Grains	20K DWT Bulker	13	15	16	18	19
Dry-Bulk Grains	30K DWT Bulker	22	26	28	31	33
Dry-Bulk Grains	40K DWT Bulker	4	4	5	5	5
Dry-Bulk Grains	50K DWT Bulker	4	5	5	6	6
Dry-Bulk Grains	60K DWT Bulker	5	6	6	7	8
Dry-Bulk Grains	70K DWT Bulker	5	6	7	8	8
Dry-Bulk Grains	80K DWT Bulker	3	3	3	4	4
Dry-Bulk Grains	10K DWT Gen Cargo	39	46	51	55	59
Dry-Bulk Grains	20K DWT Gen Cargo	6	7	8	9	9
Dry-Bulk Grains	30K DWT Gen Cargo	2	2	2	2	2
Dry-Bulk Grains	40K DWT Gen Cargo	1	2	2	2	2
Dry-Bulk Grains	50K DWT Gen Cargo	2	2	2	2	2
Dry-Bulk Fertilizers	10K DWT Bulker	2	2	2	3	3
Dry-Bulk Fertilizers	20K DWT Bulker	5	5	6	6	6
Dry-Bulk Fertilizers	30K DWT Bulker	11	12	13	13	14
Dry-Bulk Fertilizers	40K DWT Bulker	1	1	1	1	1
Dry-Bulk Fertilizers	50K DWT Bulker	1	1	1	1	1
Dry-Bulk Fertilizers	60K DWT Bulker	1	1	1	1	2
Dry-Bulk Fertilizers	10K DWT Gen Cargo	1	1	1	1	1
Dry-Bulk Fertilizers	20K DWT Gen Cargo	1	1	1	1	2
Dry-Bulk Fertilizers	30K DWT Gen Cargo	1	1	1	1	1
Dry-Bulk Aggregates	50K DWT Bulker	1	1	2	2	2
Dry-Bulk Aggregates	70K DWT Bulker	2	2	2	2	2
Wood Pellets	30K DWT Bulker	3	4	4	5	5
Wood Pellets	40K DWT Bulker	3	4	4	4	5
Wood Pellets	50K DWT Bulker	2	2	2	3	3
Wood Pellets	60K DWT Bulker	6	7	8	9	9
Lards Fats & Oils	10K DWT Tanker	12	12	12	12	12
Lards Fats & Oils	20K DWT Tanker	5	5	5	5	5
Lards Fats & Oils	30K DWT Tanker	1	1	1	1	1
Lards Fats & Oils	50K DWT Tanker	1	1	1	1	1
Liquid-Bulk Chemicals	10K DWT Tanker	1	2	2	3	3
Liquid-Bulk Petroleum	50K DWT Tanker	1	1	1	1	1
General Cargo	10K DWT Gen Cargo	32	38	42	47	51
General Cargo	20K DWT Gen Cargo	15	18	20	22	24
General Cargo	30K DWT Gen Cargo	8	10	11	12	13
Remaining Trades		**2,333**	**2,518**	**2,638**	**2,755**	**2,869**
Total		**2,562**	**2,782**	**2,925**	**3,070**	**3,203**

Table 25: Planning Segment-2 Cargo Forecast by Trade Unit & Model Year (FWOP)

Commodity Name	Vessel Class Name	2023	2030	2035	2040	2045
Dry-Bulk Grains	30K DWT Bulker	44,913	53,725	58,883	63,668	67,982
Dry-Bulk Fertilizers	10K DWT Bulker	8,788	9,800	10,490	11,147	11,756
Dry-Bulk Fertilizers	20K DWT Bulker	6,949	7,750	8,295	8,815	9,296
Dry-Bulk Fertilizers	30K DWT Bulker	34,842	38,855	41,591	44,195	46,607

Dry-Bulk Fertilizers	40K DWT Bulker	7,170	7,995	8,558	9,094	9,591
Dry-Bulk Fertilizers	10K DWT Gen Cargo	16,579	18,488	19,790	21,030	22,177
Dry-Bulk Fertilizers	20K DWT Gen Cargo	5,085	5,670	6,070	6,450	6,802
Dry-Bulk Fertilizers	40K DWT Gen Cargo	18,098	20,182	21,603	22,956	24,209
Dry-Bulk Aggregates	10K DWT Gen Cargo	58,586	65,106	69,849	74,396	78,675
Dry-Bulk Aggregates	20K DWT Bulker	14,588	16,212	17,392	18,525	19,590
Dry-Bulk Aggregates	60K DWT Bulker	10,198	11,333	12,159	12,950	13,695
Dry-Bulk Chemicals	30K DWT Bulker	146,519	204,918	252,162	305,013	363,226
Dry-Bulk Chemicals	40K DWT Bulker	38,702	54,128	66,607	80,568	95,944
Dry-Bulk Chemicals	50K DWT Bulker	43,981	61,511	75,692	91,556	109,030
Dry-Bulk Chemicals	60K DWT Bulker	77,755	108,747	133,818	161,866	192,758
Ores & Minerals	10K DWT Gen Cargo	13,547	13,503	12,943	12,170	11,225
Ores & Minerals	10K DWT Bulker	5,558	5,540	5,310	4,993	4,606
Ores & Minerals	30K DWT Bulker	62,833	62,633	60,034	56,448	52,066
Ores & Minerals	40K DWT Bulker	16,964	16,910	16,209	15,241	14,057
Liquid-Bulk Fertilizers	10K DWT Tanker	11,668	13,029	13,993	14,970	15,946
Liquid-Bulk Fertilizers	20K DWT Tanker	69,074	77,134	82,843	88,625	94,406
Liquid-Bulk Fertilizers	30K DWT Tanker	72,954	81,466	87,496	93,603	99,709
Liquid-Bulk Fertilizers	40K DWT Tanker	149,298	166,718	179,057	191,555	204,050
Liquid-Bulk Fertilizers	50K DWT Tanker	81,670	91,199	97,949	104,786	111,621
Liquid-Bulk Chemicals	10K DWT Tanker	7,546	10,456	12,802	15,432	18,312
Liquid-Bulk Chemicals	20K DWT Tanker	18,378	25,467	31,180	37,585	44,601
LPG/LNG	10K DWT GasCarrier	8,318	8,318	8,318	8,318	8,318
LPG/LNG	20K DWT GasCarrier	16,636	16,636	16,636	16,636	16,636
LPG/LNG	40K DWT GasCarrier	43,254	43,254	43,254	43,254	43,254
LPG/LNG	50K DWT GasCarrier	49,908	49,908	49,908	49,908	49,908
LPG/LNG	60K DWT GasCarrier	41,590	41,590	41,590	41,590	41,590
LPG/LNG	80K DWT GasCarrier	41,127	41,127	41,127	41,127	41,127
Liquid-Bulk Petroleum	50K DWT Tanker	28,982	29,151	29,278	29,759	30,611
Liquid-Bulk Petroleum	60K DWT Tanker	32,603	32,793	32,936	33,477	34,435
Liquid-Bulk Petroleum	70K DWT Tanker	82,734	83,216	83,579	84,952	87,383
Liquid-Bulk Petroleum	80K DWT Tanker	18,957	19,068	19,151	19,465	20,023
Scrap Iron	30K DWT Bulker	76,763	101,964	120,559	140,175	160,483
Scrap Iron	40K DWT Bulker	141,411	187,836	222,093	258,229	295,640
Scrap Iron	50K DWT Bulker	174,262	231,472	273,687	318,218	364,320
Scrap Iron	60K DWT Bulker	157,735	209,519	247,731	288,038	329,767
Remaining Trade Units		**1,149,011**	**1,159,482**	**1,167,922**	**1,177,384**	**1,187,747**
Total		**3,105,535**	**3,503,810**	**3,800,549**	**4,118,168**	**4,453,180**

Table 26: Planning Segment-2 Vessel Call Projections by Trade Unit & Model Year (FWOP)

Commodity Name	Vessel Class Name	2023	2030	2035	2040	2045
Dry-Bulk Grains	30K DWT Bulker	4	5	6	6	7
Dry-Bulk Fertilizers	10K DWT Bulker	1	1	2	2	2
Dry-Bulk Fertilizers	20K DWT Bulker	1	1	1	1	1
Dry-Bulk Fertilizers	30K DWT Bulker	2	2	2	2	2
Dry-Bulk Fertilizers	40K DWT Bulker	1	1	1	1	1
Dry-Bulk Fertilizers	10K DWT Gen Cargo	3	3	4	4	4
Dry-Bulk Fertilizers	20K DWT Gen Cargo	1	1	1	1	1
Dry-Bulk Fertilizers	40K DWT Gen Cargo	1	1	1	1	1

Dry-Bulk Aggregates	10K DWT Gen Cargo	7	8	9	9	10
Dry-Bulk Aggregates	20K DWT Bulker	1	1	1	1	2
Dry-Bulk Aggregates	60K DWT Bulker	1	1	1	1	1
Dry-Bulk Chemicals	30K DWT Bulker	10	14	17	20	24
Dry-Bulk Chemicals	40K DWT Bulker	2	2	3	3	4
Dry-Bulk Chemicals	50K DWT Bulker	2	2	2	3	3
Dry-Bulk Chemicals	60K DWT Bulker	2	3	4	5	6
Ores & Minerals	10K DWT Gen Cargo	2	2	2	2	2
Ores & Minerals	10K DWT Bulker	1	1	1	1	1
Ores & Minerals	30K DWT Bulker	6	6	6	5	4
Ores & Minerals	40K DWT Bulker	2	2	2	2	2
Liquid-Bulk Fertilizers	10K DWT Tanker	2	2	2	2	2
Liquid-Bulk Fertilizers	20K DWT Tanker	6	6	8	8	9
Liquid-Bulk Fertilizers	30K DWT Tanker	6	6	7	7	8
Liquid-Bulk Fertilizers	40K DWT Tanker	10	11	12	13	14
Liquid-Bulk Fertilizers	50K DWT Tanker	5	6	6	6	7
Liquid-Bulk Chemicals	10K DWT Tanker	1	2	3	3	4
Liquid-Bulk Chemicals	20K DWT Tanker	2	3	4	5	5
LPG/LNG	10K DWT GasCarrier	4	4	4	4	4
LPG/LNG	20K DWT GasCarrier	2	2	2	2	2
LPG/LNG	40K DWT GasCarrier	2	2	2	2	2
LPG/LNG	50K DWT GasCarrier	2	2	2	2	2
LPG/LNG	60K DWT GasCarrier	2	2	2	2	2
LPG/LNG	80K DWT GasCarrier	1	1	1	1	1
Liquid-Bulk Petroleum	50K DWT Tanker	2	2	2	2	2
Liquid-Bulk Petroleum	60K DWT Tanker	2	2	2	2	2
Liquid-Bulk Petroleum	70K DWT Tanker	4	4	4	4	4
Liquid-Bulk Petroleum	80K DWT Tanker	1	1	1	1	1
Scrap Iron	30K DWT Bulker	5	6	8	9	10
Scrap Iron	40K DWT Bulker	6	7	8	10	11
Scrap Iron	50K DWT Bulker	7	9	11	12	15
Scrap Iron	60K DWT Bulker	5	7	8	9	12
Remaining Trade Units		**1,338**	**1,339**	**1,341**	**1,342**	**1,344**
Total		**1,465**	**1,483**	**1,506**	**1,518**	**1,541**

Table 27 displays the tonnage and number of calls by model year for Segment-3. Even with projected commodity growth, the number of calls to docks along this segment is expected to be too low to produce any deepening benefits. It should be noted that the Segment-3 vessel calls are included with the Segment-2 traffic.

Table 27: Planning Segment-3 Trade Unit Cargo & Vessel Call Projections

Cargo Tonnes Per Model Year	**Commodity Name**	**Vessel Class Name**	**2023**	**2030**	**2035**	**2040**	**2045**
	Liquid-Bulk Fertilizers	20K DWT Tanker	14,299	15,967	17,149	18,346	19,543
	Liquid-Bulk Fertilizers	40K DWT Tanker	17,762	19,834	21,302	22,789	24,275
	General Cargo	Misc.	-	-	-	-	-
	Total		32,061	35,801	38,451	41,135	43,818
# Calls Per Model Year	**Commodity Name**	**Vessel Class Name**	**2023**	**2030**	**2035**	**2040**	**2045**
	Liquid-Bulk Fertilizers	20K DWT Tanker	1	2	2	2	2
	Liquid-Bulk Fertilizers	40K DWT Tanker	1	2	2	2	2

	General Cargo	Misc.	4	4	4	4	4
	Total		6	8	8	8	8

4 Alternative Analysis

4.1 Methods & Assumptions

Increase in channel depth allows a portion of the ERSB fleet to sail deeper and use more of their cargo capacity. Since carrying more cargo per vessel call is more efficient, the anticipated fleet response is that more cargo will be moved on this portion of the fleet. As a result, less cargo is anticipated to be moved on smaller vessels. The result is a reduction in the number of voyages moving cargo between the FWOP and the FWP condition. This causes a reduction in the cost of commodity movement between the FWOP and FWP condition.

The assumptions made for the alternative analysis are as follows:

- ***Representative Annualized Call List***
  - All existing condition cargo movement data for all years compiled into 1 annualized representative call list for use in Harbor Sym.
  - This call list was used for calibration and is the basis for commodity and fleet projections.
  - Loading and sailing practices from existing condition data are assumed to apply to future conditions.
- ***Commodities***
  - There is no difference between the amount of commodity forecasted between the FWOP and the FWP condition.
  - IHS Global Insight commodity growth rates were applied to annualized call list to project future commodity growth and fleet levels.
- ***Fleet***
  - Fleet composition assumed to be similar to existing conditions. There is no transition to larger vessels anticipated. The fleet is only anticipated to be loaded more efficiently in response to the depth measures.
- ***Planning Segments***
  - Vessel call reductions will only take place on a terminal by terminal basis. It is assumed that each terminal maintains the same proportion of commodity throughput in the FWOP and FWP conditions.
  - Vessel call reductions are assumed to be evenly distributed between the non-benefiting trade units of a trade grouping. This is meant to reflect the uncertainty surrounding which vessel classes will actually be reduced.
  - Useable tide assumptions are as follows:
    - Planning Segment-1 ~1.25 ft
    - Planning Segment-2 ~ 1.00 ft
    - Planning Segment-3 ~ 0.50 ft

4.2 Load Factor Analysis

A load factor analysis (LFA) was done to determine the maximum practicable draft and the maximum practicable cargo capacity for each trade unit. A load factor analysis is used to account for the physical components that determine the vessel draft. Combining these factors allows the analyst to determine whether the vessel will reach its volumetric capacity before it reaches its deadweight capacity. Once the vessel reaches its volumetric cargo capacity the vessel is said to have “cubed out”, meaning it can carry no more cargo no matter how much additional channel depth is available. Table 28, Table 29, and Table 30 shows the MXSLLD and MXSLLD capacity for the trade units in question.

Table 28: LFA - Grains, Fertilizer, & Aggregate Trade Units

Trade Unit			MXSLLD (ft.)			MXSLLD Capacity (tonnes)		
Commodity	Vessel Class Name	Cargo Density	35	40	45	35	40	45
Dry-Bulk Grains	10K DWT Bulker	0.71	28.74	28.74	28.74	11,746	11,746	11,746
Dry-Bulk Grains	20K DWT Bulker	0.66	31.40	31.40	31.40	21,214	21,214	21,214
Dry-Bulk Grains	30K DWT Bulker	0.65	33.30	33.30	33.30	26,989	26,989	26,989
Dry-Bulk Grains	40K DWT Bulker	0.71	34.25	38.09	38.09	30,149	34,255	34,255
Dry-Bulk Grains	50K DWT Bulker	0.72	34.25	39.25	40.98	37,037	46,094	46,094
Dry-Bulk Grains	60K DWT Bulker	0.72	34.25	39.25	42.00	36,685	47,318	48,708
Dry-Bulk Grains	70K DWT Bulker	0.75	34.25	39.25	44.25	41,280	53,245	64,213
Dry-Bulk Grains	80K DWT Bulker	0.74	34.25	39.25	44.25	41,123	53,776	66,429
Dry-Bulk Grains	10K DWT Gen Cargo	0.68	24.08	24.08	24.08	9,869	9,869	9,869
Dry-Bulk Grains	20K DWT Gen Cargo	0.67	31.17	31.17	31.17	16,642	16,642	16,642
Dry-Bulk Grains	30K DWT Gen Cargo	0.65	32.88	32.88	32.88	25,986	25,986	25,986
Dry-Bulk Grains	40K DWT Gen Cargo	0.71	34.25	38.52	38.52	28,212	33,633	33,633
Dry-Bulk Grains	50K DWT Gen Cargo	0.74	34.25	39.25	40.36	35,979	44,826	44,826
Dry-Bulk Fertilizers	10K DWT Bulker	1.01	27.61	27.61	27.61	10,625	10,625	10,625
Dry-Bulk Fertilizers	20K DWT Bulker	0.94	30.57	30.57	30.57	19,922	19,922	19,922
Dry-Bulk Fertilizers	30K DWT Bulker	0.98	33.30	33.30	33.30	31,044	31,044	31,044
Dry-Bulk Fertilizers	40K DWT Bulker	0.89	34.13	38.09	38.09	29,954	34,245	34,245
Dry-Bulk Fertilizers	50K DWT Bulker	1.11	34.25	39.25	41.14	36,687	46,216	49,818
Dry-Bulk Fertilizers	60K DWT Bulker	1.11	34.25	39.25	42.72	35,869	46,266	53,481
Dry-Bulk Fertilizers	10K DWT Gen Cargo	1.07	28.42	28.42	28.42	8,560	8,560	8,560
Dry-Bulk Fertilizers	20K DWT Gen Cargo	1.07	32.14	32.14	32.14	17,008	17,008	17,008
Dry-Bulk Fertilizers	30K DWT Gen Cargo	1.11	32.88	32.88	32.88	30,583	30,583	30,583
Dry-Bulk Fertilizers	40K DWT Gen Cargo	0.67	34.00	38.52	38.52	27,750	31,738	31,738
Dry-Bulk Aggregates	20K DWT Bulker	1.36	31.40	31.40	31.40	22,406	22,406	22,406
Dry-Bulk Aggregates	50K DWT Bulker	0.96	34.25	39.25	41.14	36,687	46,216	49,818
Dry-Bulk Aggregates	60K DWT Bulker	1.15	34.00	39.00	39.00	35,349	45,746	45,746
Dry-Bulk Aggregates	70K DWT Bulker	0.96	34.25	39.25	41.25	41,280	53,245	58,031
Dry-Bulk Aggregates	10K DWT Gen Cargo	1.41	24.08	24.08	24.08	9,869	9,869	9,869

Table 29: LFA-Dry Bulk Chemical, Mineral, Wood Pellets, Scrap, & Breakbulk Trade Units

Trade Unit			MXSLLD (ft.)			MXSLLD Capacity (tonnes)		
Commodity	Vessel Class Name	Cargo Density	35	40	45	35	40	45
Dry-Bulk Chemicals	30K DWT Bulker	0.85	31.17	31.17	31.17	28,837	28,837	28,837
Dry-Bulk Chemicals	40K DWT Bulker	0.91	34.00	38.02	38.02	29,741	36,033	36,033
Dry-Bulk Chemicals	50K DWT Bulker	0.86	34.00	39.00	39.00	37,855	47,817	47,817
Dry-Bulk Chemicals	60K DWT Bulker	0.93	34.00	39.00	39.00	35,349	45,746	45,746
Ores & Minerals	10K DWT Bulker	1.06	26.47	26.47	26.47	9,503	9,503	9,503
Ores & Minerals	30K DWT Bulker	1.93	32.67	32.67	32.67	29,153	29,153	29,153
Ores & Minerals	40K DWT Bulker	2.10	33.09	35.13	35.13	32,618	35,820	35,820
Ores & Minerals	10K DWT Gen Cargo	1.20	32.75	32.75	32.75	7,252	7,252	7,252
Wood Pellets	30K DWT Bulker	0.65	33.47	33.47	33.47	28,621	28,621	28,621
Wood Pellets	40K DWT Bulker	0.65	34.25	38.38	38.38	34,110	35,265	35,265
Wood Pellets	50K DWT Bulker	0.65	34.25	39.25	40.84	38,165	42,536	42,536
Wood Pellets	60K DWT Bulker	0.65	34.25	39.25	41.25	35,869	44,206	44,206
Scrap Iron	30K DWT Bulker	1.20	32.59	32.89	32.89	29,013	29,417	29,417
Scrap Iron	40K DWT Bulker	1.20	34.00	38.02	38.02	29,741	36,033	36,033
Scrap Iron	50K DWT Bulker	1.20	34.00	39.00	39.00	36,211	45,740	45,740
Scrap Iron	60K DWT Bulker	1.20	34.00	39.00	39.00	35,349	45,746	45,746
General Cargo	10K DWT Gen Cargo	0.71	25.43	25.43	25.43	7,477	7,477	7,477
General Cargo	20K DWT Gen Cargo	0.56	31.83	31.83	31.83	12,752	12,752	12,752
General Cargo	30K DWT Gen Cargo	0.52	34.25	36.75	36.75	19,484	19,484	19,484

Table 30: LFA - Liquid Bulk Trade Units

Trade Unit			MXSLLD (ft.)			MXSLLD Capacity (Tonnes)		
Commodity	Vessel Class Name	Cargo Density	35	40	45	35	40	45
Lards Fats & Oils	10K DWT Tanker	0.92	28.65	28.65	28.65	11,502	11,502	11,502
Lards Fats & Oils	20K DWT Tanker	0.92	30.93	30.93	30.93	17,510	17,510	17,510
Lards Fats & Oils	30K DWT Tanker	0.92	32.89	32.89	32.89	28,764	28,764	28,764
Lards Fats & Oils	50K DWT Tanker	0.92	34.25	39.25	42.65	28,853	39,740	47,144
Liquid-Bulk Fertilizers	10K DWT Tanker	0.75	28.75	28.75	28.75	9,544	9,544	9,544
Liquid-Bulk Fertilizers	20K DWT Tanker	0.75	29.68	29.68	29.68	15,224	15,224	15,224
Liquid-Bulk Fertilizers	30K DWT Tanker	0.75	32.61	34.33	34.33	23,228	23,801	23,801
Liquid-Bulk Fertilizers	40K DWT Tanker	0.75	33.83	36.14	36.14	29,590	31,095	31,095
Liquid-Bulk Fertilizers	50K DWT Tanker	0.75	34.00	39.00	39.00	27,803	38,496	38,496
LPG/LNG	10K DWT GasCarrier	0.58	23.79	23.79	23.79	2,337	2,337	2,337
LPG/LNG	20K DWT GasCarrier	0.58	30.00	30.00	30.00	12,888	12,888	12,888
LPG/LNG	40K DWT GasCarrier	0.58	34.00	39.00	39.00	25,686	25,686	25,686
LPG/LNG	50K DWT GasCarrier	0.58	34.00	37.21	37.21	30,229	30,229	30,229
LPG/LNG	60K DWT GasCarrier	0.58	34.00	38.15	38.15	32,125	32,125	32,125
LPG/LNG	80K DWT GasCarrier	0.58	34.00	39.00	39.00	48,902	51,887	51,887
Liquid-Bulk Petroleum	50K DWT Tanker	0.93	34.08	39.08	39.85	27,981	38,674	40,321
Liquid-Bulk Petroleum	60K DWT Tanker	0.95	34.00	39.00	39.00	37,464	53,075	53,075
Liquid-Bulk Petroleum	70K DWT Tanker	0.96	34.00	39.00	39.00	37,202	48,828	48,828
Liquid-Bulk Petroleum	80K DWT Tanker	0.96	34.00	39.00	39.00	27,724	43,126	43,126

4.3 Alternative Evaluation

4.3.1 Planning Segment-1 Measure Evaluation

Planning Segment-1 measures were analyzed using HarborSym. Only the vessel calls within this planning segment were imported into the model to better isolate the benefits of deepening in this segment. The measures analyzed for Planning Segment-1 are as follows:

- M0 – (FWOP) channel depth of 40'
- M1 – 41' channel depth
- M2 – 42' channel depth
- M3 – 43' channel depth
- M4 – 44' channel depth
- M5 – 45' channel depth

Table 31 illustrates the number of vessel calls by vessel class for Planning Segment-1 for each depth measure for model year 2040. Vessel call reductions are attributable to capacity gains in 60K-80K DWT Bulker vessel classes.

Table 32 provides detail on all vessel calls for in Segment-1 for each model year and depth measure, while Figure 5 illustrates how vessel call reductions occur for each model year. Figure 6 illustrates the distribution of benefits by model year.

Table 31: Planning Segment-1 # Calls by Vessel Class (2040)

Class	40	41	42	43	44	45
10K DWT Bulker	12	9	9	9	9	9
20K DWT Bulker	24	23	23	23	22	22
30K DWT Bulker	49	48	48	48	48	48
40K DWT Bulker	10	10	10	9	9	9
50K DWT Bulker	12	12	11	11	11	11
60K DWT Bulker	17	17	17	17	17	17
70K DWT Bulker	10	10	10	10	10	10
80K DWT Bulker	4	4	4	4	4	4
10K DWT Gen Cargo	103	101	101	100	100	99
20K DWT Gen Cargo	32	31	31	31	30	30
30K DWT Gen Cargo	15	15	14	14	14	14
40K DWT Gen Cargo	2	1	1	1	1	1
50K DWT Gen Cargo	2	2	2	2	2	2
10K DWT Tanker	15	15	15	15	15	15
20K DWT Tanker	5	5	5	5	5	5
30K DWT Tanker	1	1	1	1	1	1
50K DWT Tanker	2	2	2	2	2	2
Tank Barges	694	694	694	694	694	694
Dry Barges	1429	1429	1429	1429	1429	1429
Cruise Ships	22	22	22	22	22	22
Navy & Other	639	639	639	639	639	639
Total Calls	**3099**	**3090**	**3088**	**3086**	**3084**	**3083**

Table 32: Planning Segment-1 # Vessel Calls by Model Year & Depth Measure

Model Year	40	41	42	43	44	45
2023	2591	2585	2585	2583	2582	2582
2030	2811	2811	2810	2805	2805	2805
2035	2951	2951	2950	2948	2946	2945
2040	3099	3090	3088	3086	3084	3083
2045	3232	3225	3224	3219	3219	3219

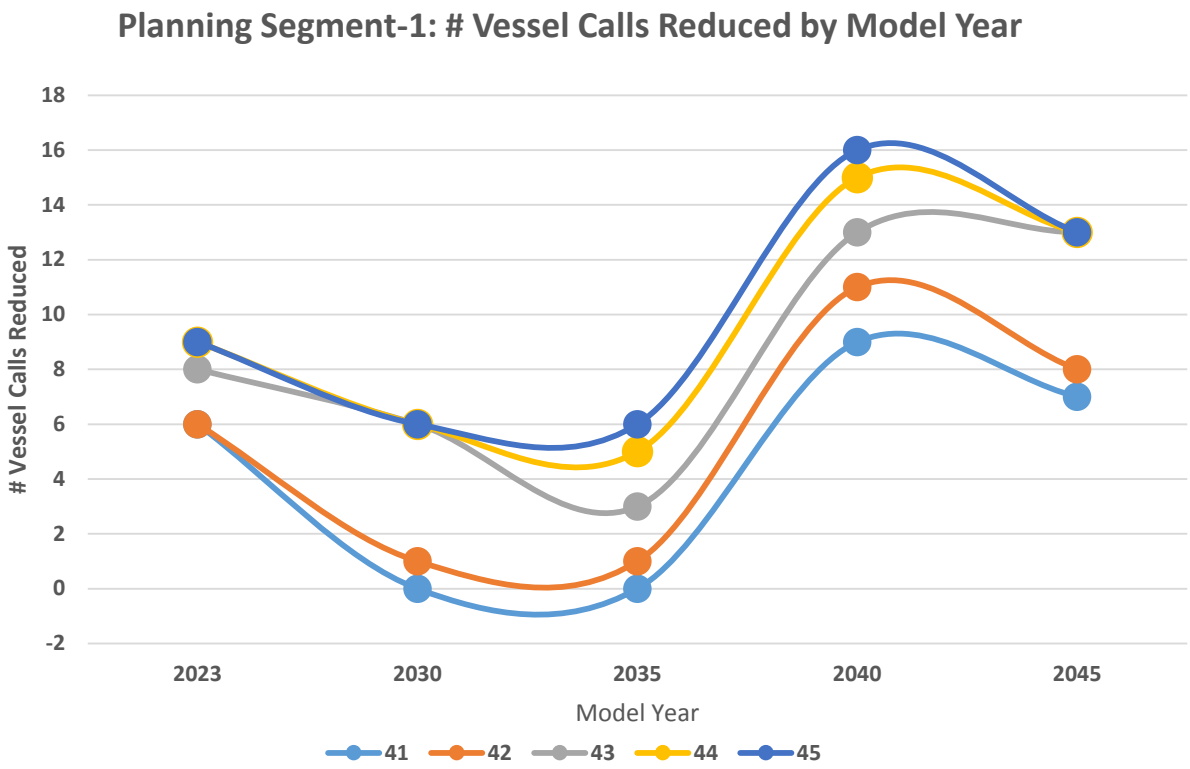


Figure 5: Planning Segment-1: Vessel Calls Reduced by Model Year & Depth Measure

Figure 5 and Figure 6 illustrates the following:

1. Annual cargo throughput increases over time
2. As annual commodity throughput increases, so do the number of vessel calls
3. This causes the average amount of cargo moved per vessel call in FWOP (shipment size) to fluctuate over time.
4. Because the shipment size fluctuates over time, the ability of an alternative to reduce vessel calls fluctuates over time as well.
5. When FWOP shipment size goes down, alternatives tended to reduce more calls and vice versa…..

- Pattern is cyclical
- Ability to distinguish between alternatives tends to increase with more cargo traffic
- Ability to reduce calls tends to increase with more cargo traffic

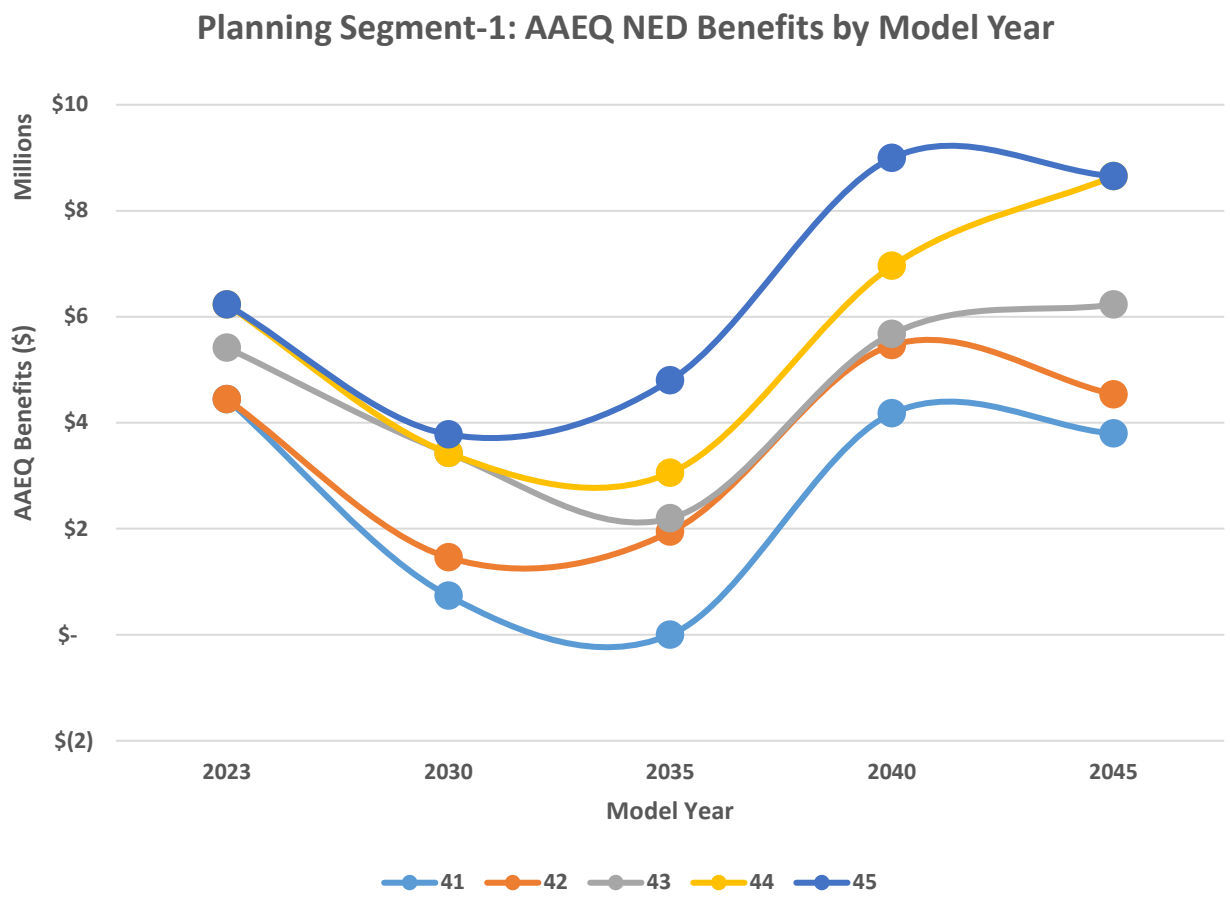


Figure 6: AAEQ Benefits by Model Year in Planning Segment-1

Grain exports are primary driver of growth in traffic for segment-1. Wood pellet exports and other dry bulk commodity throughput provide some benefits up to 42'. Benefitting terminals include TransMontaigne (42') and Enviva (42').

Table 33 and Figure 7 both provide tabular and graphical illustrations of life cycle NED benefits, costs, net NED benefits and BCRs expressed in AAEQ dollars. While M-5, or the 45' plan has the highest net benefits, they are only 2% higher than M-4, or the 44' plan.

Table 33: Planning Segment-1 Economic Summary

Measures	Depth	Benefits	Cost	Net Benefits	BCR
Seg1-M1	41	$2,872,500	$758,400	$2,114,100	3.79
Seg1-M2	42	$3,727,600	$1,081,000	$2,646,600	3.45
Seg1-M3	43	$5,017,600	$1,364,800	$3,652,800	3.68
Seg1-M4	44	$6,442,500	$1,734,300	$4,708,200	3.71
Seg1-M5	45	$6,966,400	$2,144,300	$4,822,100	3.25

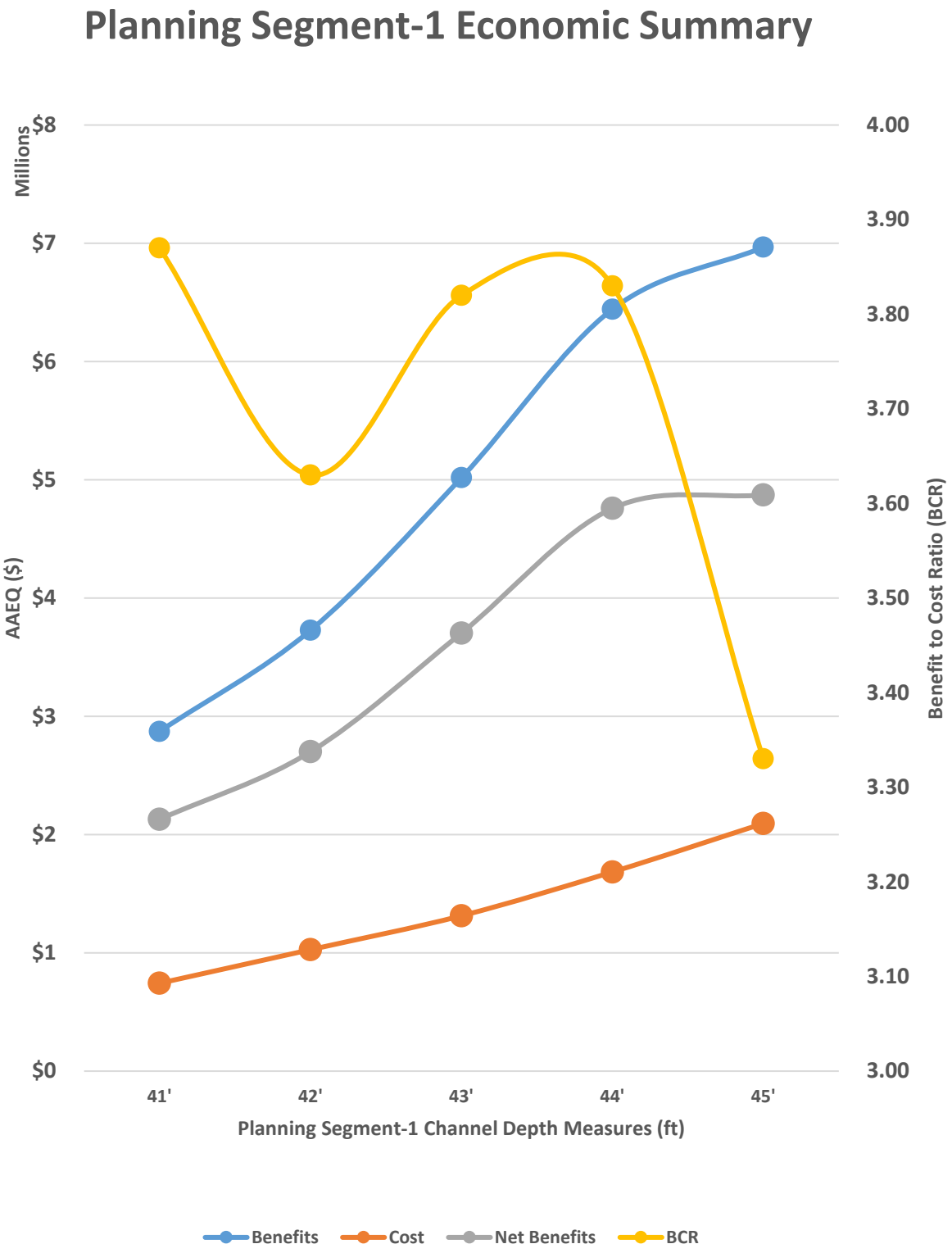


Figure 7: Planning Segment-1 Economic Summary (AAEQ$)

4.3.2 Planning Segment-2: Measure Evaluation

Planning Segment-2 measures were analyzed using HarborSym. Only the vessel calls within Planning Segment-2 and Planning Segment-3 were imported into the model to better isolate the benefits of deepening in this Segment-2. The measures analyzed for Planning Segment-2 are as follows:

- M0 – (FWOP) channel depth of 35'
- M1 – 36' channel depth
- M2 –37' channel depth
- M3 – 38' channel depth
- M4 – 39' channel depth
- M5 – 40' channel depth

Table 34 illustrates the number of vessel calls by vessel class for Planning Segment-2 for each depth measure for model year 2040. Vessel call reductions are attributable to capacity gains in 40K-60K DWT Bulkers, 40K-70K DWT Tankers, 50-80K DWT Gas Carriers, and 40K DWT Gen Cargo vessel classes. Table 35 provides detail on all vessel calls for in Segment-2 for each model year and depth measure, while Figure 8 illustrates how vessel call reductions occur for each model year. Figure 9 illustrates the distribution of benefits by model year.

Table 34: Planning Segment-2 # Calls by Vessel Class (2040)

Vessel Class Name	35	36	37	38	39	40
10K DWT Bulker	3	2	2	2	2	2
20K DWT Bulker	2	2	2	2	2	2
30K DWT Bulker	42	39	38	37	36	35
40K DWT Bulker	20	18	18	18	17	17
50K DWT Bulker	15	15	14	14	13	13
60K DWT Bulker	15	15	15	14	14	14
10K DWT Tanker	5	5	5	5	5	5
20K DWT Tanker	15	13	12	13	13	13
30K DWT Tanker	7	6	5	5	5	5
40K DWT Tanker	15	15	15	15	15	15
50K DWT Tanker	8	8	8	8	8	8
60K DWT Tanker	2	1	1	1	1	1
70K DWT Tanker	4	4	4	4	4	3
80K DWT Tanker	1	1	1	1	1	1
10K DWT GasCarrier	4	3	3	3	3	3
20K DWT GasCarrier	2	2	2	2	2	2
40K DWT GasCarrier	2	2	2	2	2	2
50K DWT GasCarrier	2	2	2	2	2	2
60K DWT GasCarrier	2	2	2	2	2	2
80K DWT GasCarrier	1	1	1	1	1	1
Tank Barges	531	531	531	531	531	531
Dry Barges	106	106	106	106	106	106
General Cargo	17	17	17	17	17	17
Misc., Other	705	706	707	708	709	710
Total Calls	**1526**	**1516**	**1513**	**1513**	**1511**	**1510**

Table 35:# Vessel Calls by Model Year & Depth Measure

Model Year	35	36	37	38	39	40
2023	1471	1461	1460	1460	1457	1454
2030	1491	1486	1486	1484	1476	1475
2035	1514	1505	1502	1499	1496	1496
2040	1526	1515	1511	1510	1507	1505
2045	1549	1538	1538	1528	1526	1526

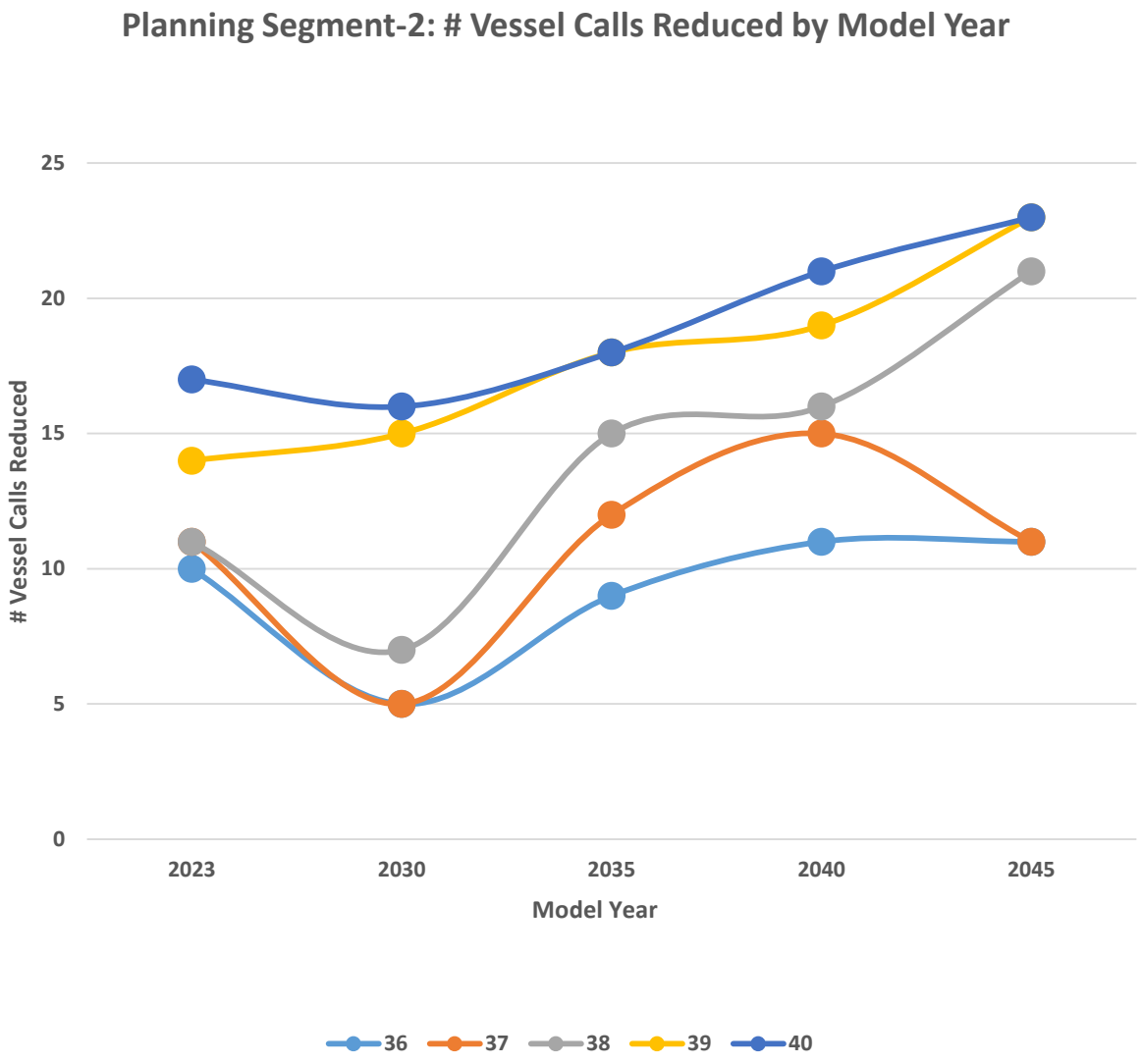


Figure 8: Planning Segment-2: Vessel Calls Reduced by Depth Measure & Model Year

FWOP Cargo moved per call shows a cyclical pattern somewhat similar to Segment-1. However, vessel calls are more easily reduced because there are a greater number of smaller vessel classes that can use more DWT capacity between 35' & 40'. Because vessels tend to be smaller, FWOP shipment sizes are also smaller, which contributes to the ability to reduce calls relative to the FWOP condition. Vessel call reduction and the ability to distinguish between alternatives becomes more pronounced with more cargo traffic.

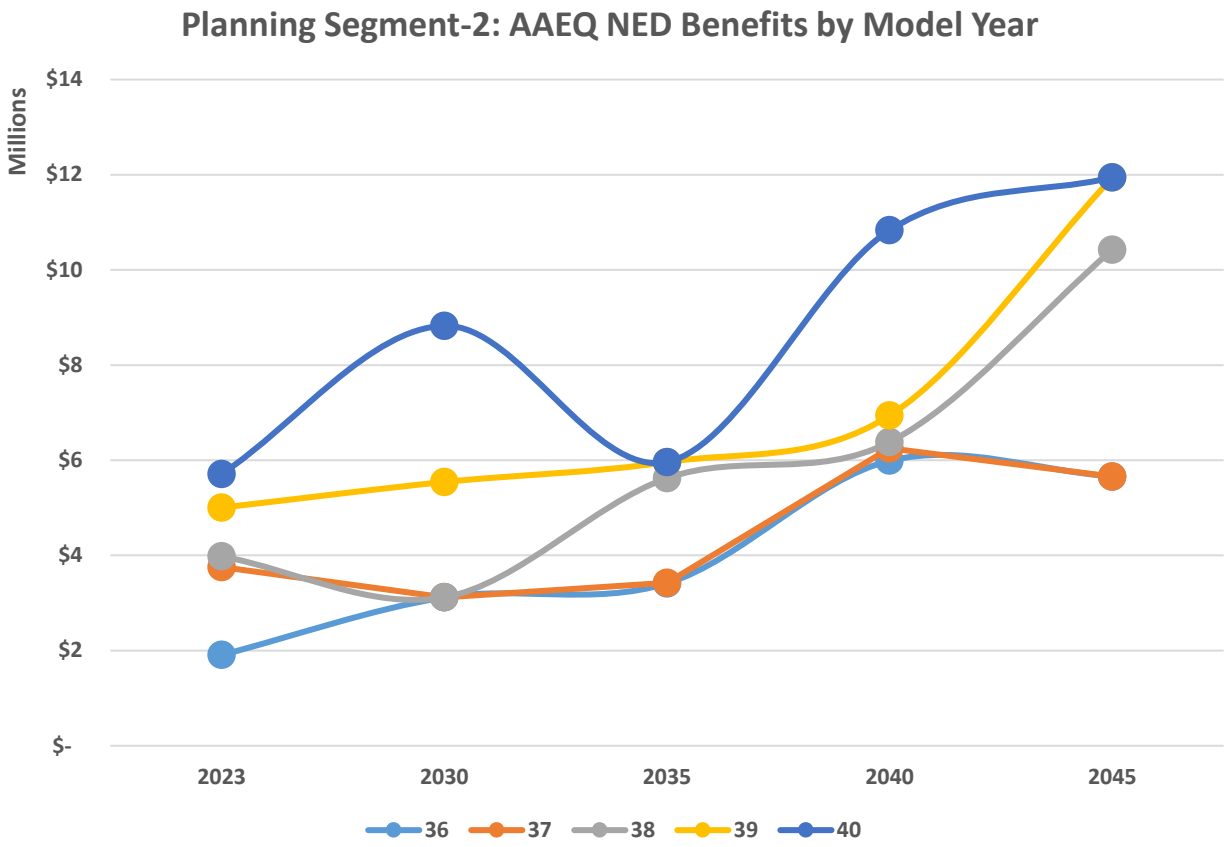


Figure 9: AAEQ Benefits by Model Year & Depth Measure

Table 36 and Figure 10 provide tabular and graphical illustrations of life cycle NED benefits, costs, net NED benefits and BCRs expressed in AAEQ dollars for Planning Segment-2. While M-5, or the 40' plan has the highest net benefits, they are ~ 3% higher than M-4, or the 39' plan.

Table 36: Planning Segment-2 Economic Summary

Measures	Depth	Benefits	Cost	Net Benefits	BCR
Seg2-M1	36	$4,428,000	$1,627,000	$2,801,000	2.72
Seg2-M2	37	$4,711,500	$2,409,200	$2,302,300	1.96
Seg2-M3	38	$7,055,000	$3,334,800	$3,720,200	2.12
Seg2-M4	39	$8,476,700	$4,317,400	$4,159,300	1.96
Seg2-M5	40	$9,615,400	$5,361,100	$4,254,300	1.79

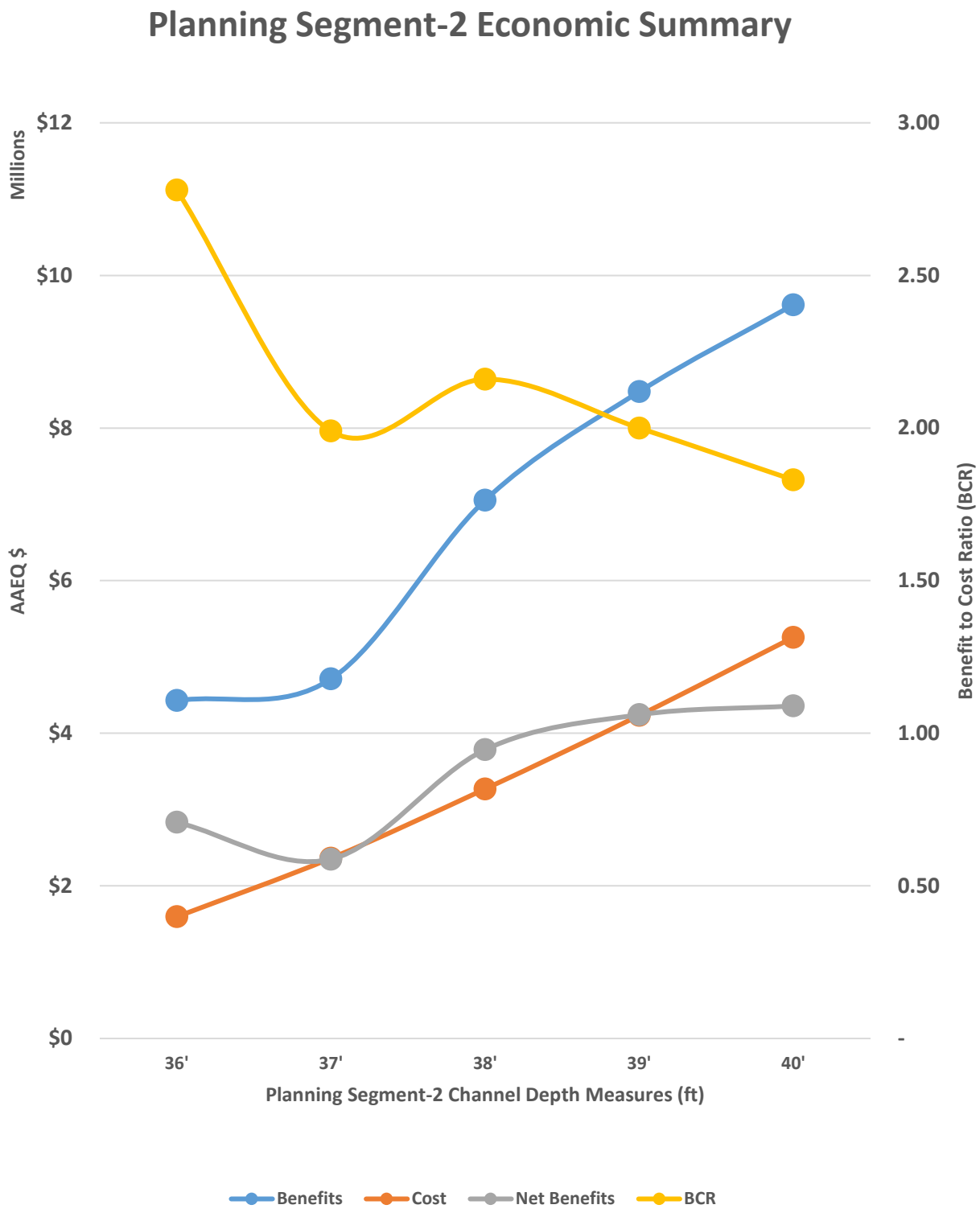


Figure 10: Planning Segment-2 Economic Summary (AAEQ$)

5 The NED Plan

Information gained from the Segment-1 and Segment-2 alternative analyses discussed in the previous section is combined in this section in order to select a comprehensive plan that includes all planning segments studied. The plan that reasonably maximizes net benefits is the NED plan.
Based on the results of the Planning Segment-1 and -2 analyses, the 44-foot and 45-foot depths for Segment-1a and the 38-, 39-, and 40-foot depths for Segment-2 were carried forward and combined to form the final array of alternatives shown in Table 37.

Table 37: Final Array of Alternatives

Segment-1 Measures	Segment-2 Measures	Seg1a + Seg1b + Seg2 + Seg3 Depth	Benefits	Costs	Net Benefits	BCR
Seg1-M4	Seg2-M3	44 + 42 + 38 + 35	$13,497,500	$5,069,100	$8,428,400	2.66
Seg1-M4	**Seg2-M4**	**44 + 42 + 39 + 35**	**$14,919,200**	**$6,051,700**	**$8,867,500**	**2.47**
Seg1-M4	Seg2-M5	44 + 42 + 40 + 35	$16,057,900	$7,095,400	$8,962,500	2.26
Seg1-M5	Seg2-M3	45 + 42 + 38 + 35	$14,021,400	$5,479,100	$8,542,300	2.56
Seg1-M5	**Seg2-M4**	**45 + 42 + 39 + 35**	**$15,443,100**	**$6,461,700**	**$8,981,400**	**2.39**
Seg1-M5	Seg2-M5	45 + 42 + 40 + 35	$16,581,800	$7,505,400	$9,076,400	2.21

Considering the difference in costs and net benefits between the alternatives, the combination of Seg1-M4 and Seg2-M4 was selected as the alternative that reasonably maximizes net benefits and is the NED plan. The plan is made up of the following components:

- Deepen Seg1a from 40’ to 44’. Seg1a extends from Lamberts Bend to just south of the Perdue Farms Terminal.
- Deepen Seg1b from 40’ to 42’. Seg1b extends from Seg1a to the end of Planning Segment-1.
- Deepen Planning Segment-3 from 35’ to 39’.
- Planning Segment-3 remains at 35’.

Transportation costs savings associated with the TSP are produced by carrying the same total commodity tonnage in the FWP as is carried in the FWOP but by doing so using fewer annual vessel calls in the FWP than are needed in the FWOP, which reduces total annual voyage costs associated with that level of throughput. Table 38 displays a comparison of the FWOP and FWP number of vessel calls per model year by vessel class. Note that bulkers are expected see the greatest reduction in vessel calls due to the implementation of the TSP across all model years. This is due to several factors including grain exports being the primary driver of growth in traffic for Segment-1 and the ability of the large bulker vessels to load deeper and therefore take advantage of increased channel depth.

Table 38: FWOP & FWP Calls by Vessel Class & Model Year

Vessel Class Name	2023		2030		2035		2040		2045	
	FWOP	FWP	FWOP	FWP	FWOP	FWP	FWOP	FWP	FWOP	FWP
10K DWT Bulker	10	9	11	10	13	11	15	11	15	12
20K DWT Bulker	20	19	22	21	24	24	26	24	28	27
30K DWT Bulker	63	57	75	70	84	79	91	84	99	92
40K DWT Bulker	23	20	25	24	28	26	30	26	33	30
50K DWT Bulker	17	16	20	18	23	20	27	24	30	27
60K DWT Bulker	20	20	25	23	28	27	32	31	38	35
70K DWT Bulker	7	6	8	8	9	9	10	10	10	10
80K DWT Bulker	3	3	3	3	3	3	4	4	4	4
10K DWT Tanker	16	16	18	18	19	19	20	20	21	21
20K DWT Tanker	14	12	16	14	19	16	20	18	21	17
30K DWT Tanker	7	6	7	6	8	6	8	6	9	7
40K DWT Tanker	11	11	13	13	14	14	15	15	16	16
50K DWT Tanker	9	9	10	10	10	10	10	10	11	11
60K DWT Tanker	2	1	2	1	2	1	2	1	2	1
70K DWT Tanker	4	3	4	3	4	3	4	4	4	4
80K DWT Tanker	1	1	1	1	1	1	1	1	1	1
10K DWT GasCarrier	4	3	4	3	4	3	4	3	4	3
20K DWT GasCarrier	2	2	2	2	2	2	2	2	2	2
40K DWT GasCarrier	2	2	2	2	2	2	2	2	2	2
50K DWT GasCarrier	2	2	2	2	2	2	2	2	2	2
60K DWT GasCarrier	2	2	2	2	2	2	2	2	2	2
80K DWT GasCarrier	1	1	1	1	1	1	1	1	1	1
10K DWT Gen Cargo	84	82	98	97	109	107	118	115	127	123
20K DWT Gen Cargo	23	22	27	27	30	29	33	31	36	34
30K DWT Gen Cargo	11	10	13	12	14	13	15	14	16	15
40K DWT Gen Cargo	2	2	3	2	3	2	3	2	3	2
50K DWT Gen Cargo	2	2	2	2	2	2	2	2	2	2
Tank Barges	1082	1082	1135	1135	1179	1179	1225	1225	1277	1277
Dry Barges	1252	1252	1385	1385	1463	1463	1535	1535	1599	1599
Cruise Ships	22	22	22	22	22	22	22	22	22	22
Navy & Other	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344
Total Calls	**4062**	**4039**	**4302**	**4281**	**4468**	**4442**	**4625**	**4591**	**4781**	**4745**

The overall economic performance of the NED Plan can be summarized as follows:

- NED Benefits of ~ $14.9 M,
- NED Costs of ~ $6.052 M,
- BCR of ~ 2.47, and
- Net NED Benefits of ~ $8.868 M.

6 Assumptions, Risks & Uncertainty

- Vessel Operating Costs – Benefit calculations were made in HarborSym using FY 2013 VOCs. However, a 14.26% reduction was applied to the benefit calculations based on guidance from the DDN-PCX in order to be in compliance with EGM 17-04. The more precise method would involve entering the new VOCs into the HarborSym model at additional time and cost and would likely yield different figures. However, it is not anticipated that the result would be significantly different. Economic justification and plan formulation are unlikely to be impacted.
- Data – Data gaps and inconsistencies created uncertainty in the ability to characterize some elements of the existing condition. Those are as follows:
  - *Data was light on DCP Midstream (Milldam Creek*) operations in terms of loading practices and vessel class sizes. However, it is unlikely that this uncertainty had a significant effect on the analysis.
  - *Dock Aggregation* was made more difficult due to the number of docks identified using various datasets. Over 88 different terminals in WCSC data and approximately 69 terminals from the pilot's data. All these had to be aggregated into no more than 30 aggregated terminals for modeling purposes. However, this difficulty was dealt with by observing commonalities in the number of calls and commodity tonnages going to specific locations within the harbor.
- Call Reduction Methods – The Southern Branch is characterized by relatively small cargo tonnage being distributed to a relatively large number of terminals. This coupled with the assumption that vessel call reductions only take place on a terminal by terminal basis limited the ability of the method to reduce calls.