Port of Redwood City

Deep Draft Navigation Project

Appendix J

Economics

Redwood City, California

June 2015

U.S. Army Corps of Engineers
San Francisco District
South Pacific Division

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List of Acronyms

AAEQ – Average Annual Equivalent

BLT – Bulk Loading Tool

CY – Calendar Year

DWT – Deadweight Tonne

ETTC – Estimate Total Trip Cargo

FY – Fiscal Year

GDP – Gross Domestic Product

GI – Global Insight

GRP – Gross Regional Product

HMST – HarborSym Modeling Suite of Tools

IMO – International Maritime Organization

IWR – Institute for Water Resources

LAUS – Local Area Unemployment Statistics

LFA – Loading Factor Analysis

LOA – Lengths Overall

MSA – Metropolitan Statistical Area

MXSLLD – Maximum Summer Loadline Draught

NED – National Economic Development

OD – Origin-to-Destination

OECD - Organization for Economic Co-operation and Development

PDT – Project Delivery Team

PX - Panamax

QCEW – Quarterly Census of Employment and Wages

RECONS – Regional Economic System

RED – Regional Economic Development

TPI – Tons Per Inch Immersion

TSP – Tentatively Selected Plan

UKC – Underkeel Clearance

USACE – United States Army Corps of Engineers

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Port of Redwood City
Deep Draft Navigation Project
Economic Evaluation

1.0 Introduction

This document presents the economic evaluations performed for the proposed Port of Redwood City channel improvement project. The current federally authorized channel depth for the Redwood City channel and harbor is 30 feet. The U.S. Army Corps of Engineers (USACE) San Francisco District was approved by the Office of Management and Budget to begin a multi-year feasibility study to determine if deepening Redwood City channel and harbor is both economically beneficial and environmentally acceptable to the nation. The Deep Draft Navigation Planning Center of Expertise together with the San Francisco District USACE District performed the economic analyses contained within this document to evaluate the proposed channel modification.

1.1 Study Purpose and Scope

The purpose of this study is to evaluate problems and opportunities for improved navigation for the Port of Redwood City and identify the plan that best satisfies the environmental, economic, and engineering criteria. The scope of this feasibility study involves analysis of existing conditions and requirements, identifying opportunities for improvement, preparing economic analyses of alternatives, identifying environmental impacts, and analyzing the National Economic Development (NED) plan.

Potential navigation improvements include deepening and widening (for O&M savings) of navigational channels, turning basin expansion, and other operational changes. The purpose of these potential improvements is to increase the efficiency of cargo vessel operations on Panamax vessels, which are already calling on the Port and are projected to call on the port with increased frequency in the future. This study identifies and evaluates alternatives that will:

- Accommodate recent and anticipated future growth in bulk and general cargo traffic;
- Improve the efficiency of operations for bulk and general cargo vessels within the Port of Redwood City Harbor Navigation Project; and
- Allow more efficient (i.e., increased load factors) bulk and general cargo ships to call on the Port.

1.2 Document Layout

Section 2 details the existing conditions at the Port of Redwood City. Section 3 examines future without and with project conditions and includes an evaluation and description of forecast trade, the vessel fleet, and operations at the harbor. Section 4 presents the transportation cost savings benefit analysis. In Section 5, sensitivities to the forecast are explored. Section 6 examines the multi-port analysis while Section 7 describes the socioeconomics of Redwood City and the surrounding region.

2.0 Historical & Existing Conditions

The existing conditions are defined in this report as the project conditions that exist (empirical data from 2013) The last significant improvement to the federal project was in 1964, when the channel was widened to 400 feet and deepened to its current authorized depth of 30 feet. This improvement was designed to serve bulk vessels primarily for the salt industry that served California and the Pacific Northwest, as well as exports to Japan. The following year, cement, lumber, and sand & gravel firms became major tenants of the Port. In 1975, the company now known as Sims Metal Management (still a primary Port customer) set up at the Port to establish a major recycling center that exports scrap metal to Asian markets.

Since the late 1980s, the Port has marketed itself as a "niche" focusing upon bulk products catering to the construction industry that serves the greater south San Francisco Bay area. Over the past three decades, the Port has received imports of bauxite (for Northern California cement plants) and gypsum rock (used in the manufacturing of wallboard). In fact, the Port has become key to supplying the building trades industry, due in large part to the closures of rock quarries in the early 2000s, with no new domestic facilities planned to replace them. While cement is not currently being imported due to the still recovering post Great Recession economy, during the late 90s and early "Oughts" the cement that crossed the Port's wharves was used to build the San Francisco Giants' stadium and to expand the San Francisco Airport, as well as many others.

Today, the Port continues primarily to support the construction industry throughout the San Francisco Bay/San Jose region. For the state fiscal year ending June 30, 2015, the Port has processed nearly 1.3 million metric tonnes of sand and aggregates. And it has exported nearly a quarter million metric tonnes of scrap metal. Additionally, modest amounts of ground slag (cement component), gypsum (drywall/sheetrock component), and bauxite (world's main sorce of aluminum)are imported through the port for use in the construction industry.

2.1 Economic Study Areas (Hinterlands)

2.1.1 Inland Distribution Areas

In 2011, San Francisco District Economics Section contracted with IHS Global Insight to complete the report "Commodity Forecasts and Competitive Market Analysis for the Ports of West Sacramento, Stockton, and Redwood City". The following documents their analyses of the hinterlands for the commodities of cement and scrap metal. While the Port isn't currently importing cement, their main commodities of Canadian sand and aggregates is primarily used for domestic cement production throughout the area.

According to the IHS report, the use of import projections of stone, clay, and other crude minerals for the South Pacific region of the United States from IHS Global Insight's World Trade Service (WTS) is likely too broad a measure to adequately address the uniqueness of the ports in this study. First, the category of stone, clay, and other crude minerals contains 78 commodities ranging from table salt to asbestos. Second, the regional grouping includes not only the ports in this study area but also 31 of the larger ports in California plus four ports in Hawaii.

Therefore, IHS decided that a better proxy for cement demand could be found in IHS Global Insight's U.S. Construction Service. The Construction Service maintains historical and forecast data for real and nominal spending on construction at the national, state, and metropolitan levels of geography. The forecasts produced by the Construction Service are directly linked to the well-regarded forecasts produced by our U.S. Macroeconomic Service and our U.S. Regional Service. As such, the Construction Service forecasts embody IHS' forward view of the nation as a whole and at the specific levels of Metropolitan Statistical Areas (MSAs). Thus, though the report talks about cement specifically, the data and forecasts are actually based upon their Construction Service tied to commodities closely related to the sand and aggregates that constitute much of the Port's annual throughput

CEMENT (Sand and Aggregate proxy)

The cement hinterland for the Port of Redwood City was determined to be a 25-county area that surrounds the port. According to the HIS report cited above, the hinterland has a population base of approximately 12 million people, with 4.3 million employed in 2010. Per capita personal income was just over $48 thousand in 2010 and is expected to grow by 2.2% annually through 2036. Gross product was $595 billion in gross product, growing to $1.3 billion in 2036, an annualized growth rate of 3.2%. Population and employment are expected to grow by an annual average rate of 1.1% and 1.4%, respectively, between 2010 and 2036.

Table 1. Redwood City Cement Hinterland Indicators

Hinterland Statistics	Cement - Port of Redwood City 2007	2008	2009	2010	2016	2036	Compound Average Annual Growth 2010 / 2007	2016 / 2010	2036 / 2016
Indicators									
Real Gross Product *(Billions)*	$597.0	$595.3	$579.8	$594.5	$718.0	$1,331.7	-0.1%	3.2%	3.1%
Real Per Capita Personal Income *(Thousands)*	$44.9	$43.9	$42.2	$42.1	$48.1	$73.4	-2.1%	2.2%	2.1%
Population *(Millions)*	11.6	11.8	11.9	12.1	12.9	15.9	1.2%	1.2%	1.0%
Employment *(Millions)*	4.8	4.7	4.4	4.3	4.9	6.2	-3.2%	1.9%	1.2%
Related Industry (Inflation Adjusted, Billions)									
Construction Spending	$27.7	$21.2	$16.8	$15.6	$35.2	$59.7	-17.4%	14.5%	2.7%

Figure 1. Port of Redwood City Cement Hinterland

SCRAP METAL

Using Transearch to trace scrap metal freight flows destined for the Port of Redwood City, the scrap metal hinterland, or inland supply area, was determined to be a 14-county area that surrounds the port .

According tho the IHS report previously cited, the hinterland has a population base of a little over 9 million people, and 3.8 million were employed in 2010. The hinterland generates a little over $42 thousand in real per capita personal income and nearly $540 billion in gross product. Population and employment are expected to grow by an annual average rate of 1.0% and 1.3%, respectively, between 2010 and 2036. Income and GDP are foreseen to grow by 2.2% and 3.0% respectively through 2036.

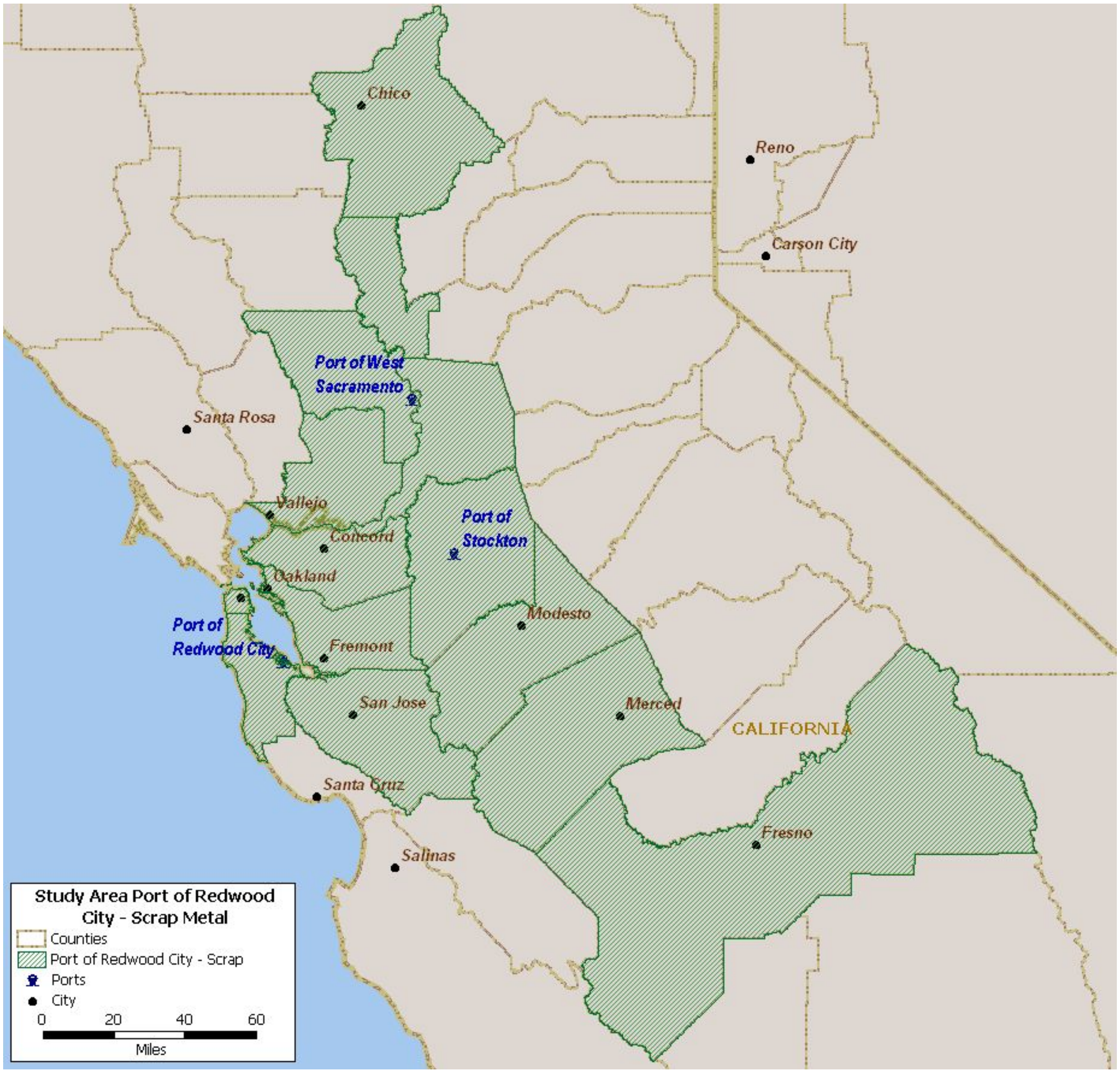
Table 2. Redwood City Scrap Metal Hinterlands Indicators

	Scrap Metal - Port of Redwood City						Compound Average Annual Growth		
Hinterland Statistics	**2007**	**2008**	**2009**	**2010**	**2016**	**2036**	**2010 / 2007**	**2016 / 2010**	**2036 / 2016**
Indicators									
Real Gross Product *(Billions)*	$539.7	$539.7	$526.0	$538.6	$647.1	$1,174.9	-0.1%	3.1%	3.0%
Real Per Capita Personal Income *(Thousands)*	$45.5	$44.4	$42.5	$42.2	$47.9	$73.7	-2.5%	2.1%	2.2%
Population (Millions)	9.1	9.2	9.3	9.4	10.0	12.1	1.2%	1.1%	1.0%
Employment (Millions)	4.2	4.1	3.9	3.8	4.2	5.3	-3.1%	1.8%	1.1%
Related Industries *(Inflation Adjusted Sales, Millions)*									
Fabricated Metal Products Mfg.	$6,952	$6,518	$5,840	$6,403	$7,583	$9,922	-2.7%	2.9%	1.4%
Primary Metal Manufacturing	$1,023	$935	$764	$926	$1,099	$1,824	-3.3%	2.9%	2.6%

In this hinterland's counties, the fabricated metal products industry generated nearly $7 billion in sales in 2010. From 2007 to 2010, this industry's sales shrank by 2.7% per year, in line with the global economic downtown. This industry is expected to expand at a slightly slower rate than in the Sacramento hinterlands, with average annual growth of 1.7% from 2010 through 2036.

The primary metal manufacturing industry in this hinterland generated nearly $1 billion in sales in 2010. From 2007 to 2010, this industry's sales dropped by 3.3% per year, once again due to the decline in overall U.S. metals-intensive manufacturing and the global recession. Average annual growth for this industry is projected to be 2.6%.

Figure 2. Port of Redwood City Scrap Metal Hinterland



2.1.2 Maritime Businesses

The Port has a number of businesses that currently use its facilities. There are four firms operating related to the cement business (Cemex, Central Concrete, International Materials, Inc.—imports bauxite from Australia for use in cement kilns, and Lehigh Southwest Cement Company). Cemex Aggregates and Pabco Gypsum imports commodities used in the Building and construction business. Sims Metals recycles junked vehicles to export shredded scrap to Asia.

2.1.3 Cargo Profile

In Fiscal Year (FY) 2013, the Port served 53 deep draft vessels at its wharfs. The Port of Redwood City, handled 1.5 million metric tonnes, up 13.6 percent from the previous fiscal year. Top commodities across Redwood City wharfs include aggregates, sand, and scrap metal. Other commodities consisted of gypsum and bauxite.

2.2 Facilities and Infrastructure

There are three terminal (comprising 5 wharves) at the Port of Redwood City. Two of the three existing terminals handle dry bulk and general cargo. The third terminal is for petroleum and liquid bulk products. The Port plans, designs, constructs, and operates its marine terminal facilities. The three facilities are shown within Figure 6 and described below.

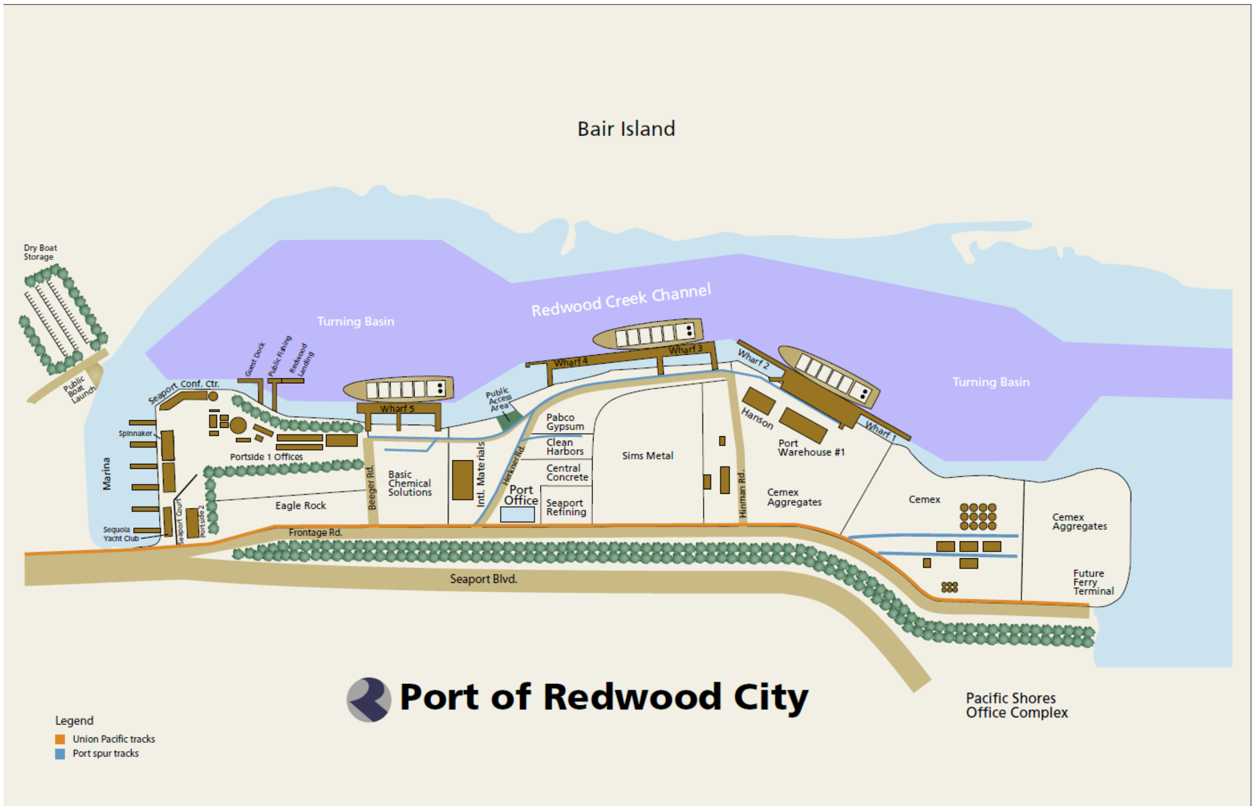


Figure 3. Port of Redwood City Terminal Facilities

The Port's three berthing facilities are:

- Wharves No. 1 & 2—overall length 855'; 34' alongside depth (MLLW); unload conveyor 800/1000 tons per hour; bulk cement pipeline and hoppers; adjacent to 30,000sq ft transit shed; bulk cement and general cargo
- Wharves No. 3 & 4—overall length 450' long plus additional berthing of 280' with dolphins, 34' alongside depth (MLLW), reinforced concrete pile and deck, load conveyor 300 tons per hour, open upland area for marshaling/storage, scrap metal and dry bulk cargo
- Wharf No. 5—overall length 500'; 34' alongside depth (MLLW); reinforced concrete deck; petroleum pipeline; adjacent to paved area and storage tanks; petroleum and liquid bulk products
- All wharves lighted for 24 hour operation; electric, telephone and water hookups; US Coast Guard certified oil waste reception facility; handling equipment: 25-ton mobile crane, tractors, and forklifts
- Union Pacific tracks run adjacent to the entire Port.

2.4 Historical Commerce

Figure 8 shows the historical total commerce at the Port of Redwood City as reported by the Port. The top line depicts total commodity shipments for each year from 1995 through 2014. As illustrated, total commerce has varied over time with substantial growth from 1990 to 2006. There was a precipitous 56 percent decline from 2005 to 2010. Since 2010, commodity tonnage has rebounded by nearly 112 percent.

Figure 4. Historical Trends in Commerce in Metric Tons

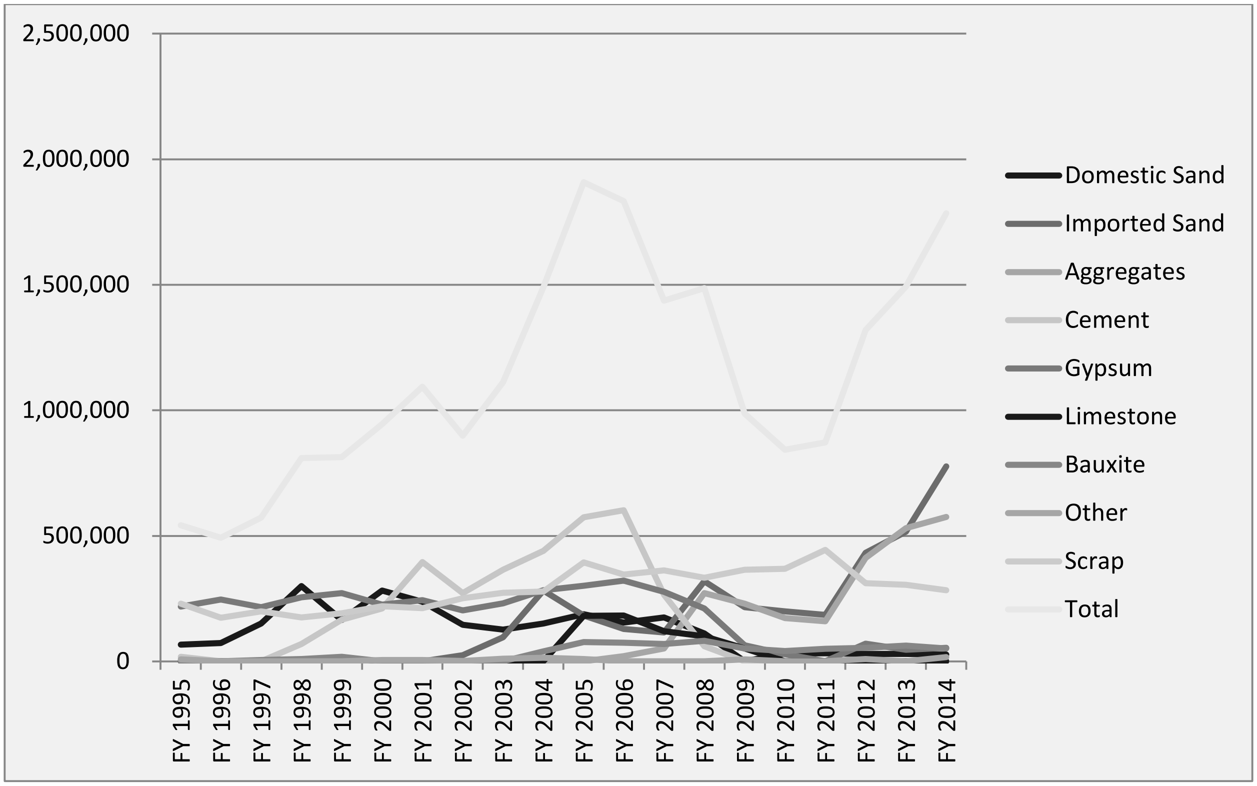


Table 3. Port of Redwood City Historical Commerce – All Commerce (Metric Tons)

Commodity	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Domestic Sand	67,225	72,561	151,233	300,521	164,409	282,339	237,792	145,800	127,079	151,505
Imported Sand	0	0	0	0	0	0	0	24,977	95,676	281,989
Aggregates	0	0	0	0	0	0	0	0	7,158	0
Cement	18,321	0	0	69,946	165,901	211,070	395,375	272,223	365,079	440,483
Gypsum	218,061	246,135	216,290	255,201	271,444	226,574	244,021	202,935	231,553	282,863
Limestone	0	0	0	0	0	0	0	0	0	0
Bauxite	0	0	5,591	10,050	18,597	0	0	0	0	40,000
Other	8,288	0	0	0	1,000	5,354	5,364	2,347	11,043	15,005
Scrap	229,869	174,311	199,564	174,642	192,279	219,966	212,030	251,371	273,814	278,780
Total	541,764	493,007	572,678	810,360	813,630	945,303	1,094,582	899,653	1,111,402	1,490,625

Commodity	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	**FY 2013**	FY 2014
Domestic Sand	187,690	154,578	174,949	110,997	0	30,967	31,775	30,482	**30,049**	27,734
Imported Sand	182,763	129,878	115,049	318,532	216,503	199,489	185,566	432,166	**517,297**	776,360
Aggregates	0	20,735	52,020	272,112	230,091	172,409	160,378	412,204	**530,508**	575,455
Cement	573,542	602,469	265,685	59,800	0	0	0	0	**0**	0
Gypsum	301,413	321,778	277,100	211,128	64,734	28,972	0	70,266	**46,825**	53,469
Limestone	181,729	182,927	120,101	100,010	51,373	0	0	0	**0**	0
Bauxite	76,761	74,489	69,432	81,888	50,909	41,754	49,629	53,517	**63,554**	51,764
Other	10,000	0	0	0	8,471	0	0	8,857	**0**	16,952
Scrap	394,274	346,169	362,290	332,596	364,646	369,136	444,591	311,705	**304,956**	282,925
Total	1,908,172	1,833,023	1,436,626	1,487,063	986,727	842,727	871,939	1,319,197	**1,493,190**	1,784,659

2.5 Existing Fleet

Data for vessel fleet was obtained from the Port of Redwood City and then cross-referenced using vesseltracker.com to obtain the International Maritime Organization (IMO), a unique vessel identification number. In 2013 a variety of different vessel classes called on the Port of Redwood City. These ships are classified as Handy, Handymax, Supramax, and Panamax, depending on their capacity. The vessels are distinguished based on physical and operation characteristics, including lengths overall (LOA), design draft, beam, speed, and DWT capacity.

Table 4. Vessel Class Definitions

Vessel Class	Beam	LOA	Capacity (DWT)	Draft	2013 Calls
Handy	85 –93	550 – 607	22000 - 40000	17 – 36	12
Handymax	93 –99	607 – 643	40000 – 50000	27 – 39	5
Supramax	99 – 104	643 – 678	50000 – 60000	22 – 41	6
Panamax	104 – 114	678 – 742	60000 - 80000	26 – 45	30

There were 23 unique vessels that called on the Port in 2013. The design drafts ranged from 32.9 to 45.7 feet, all of which are greater than the current depth of 30 feet for the Redwood City federal channel.

Table 5. Characteristics of Vessels Calling on the Port of Redwood City

Vessel Name	Vessel Identifier	Vessel Class	LOA	Beam	Capacity	Flag	TPI Factor	Design Draft
CSL TRAILBLAZ	7708857	Bulker small	584	85	24478	Z_Fore	103.1	32.9
IVS ORCHARD	9528029	Bulker small	591	92	29932	Z_Fore	103.1	33.5
HANJIN MIMITSU	9527958	Bulker med A	607	102	35399	Z_Fore	111.7	34.1
BONNIE VENTU	9612155	Bulker small	582	93	29900	Z_Fore	103.1	34.1
NEW FRONTIER	9561796	Bulker small	577	92	32212	Z_Fore	103.1	35.7
CSL CABO	9288904	Bulker small	596	84	28856	Z_Fore	103.1	35.8
GIOVANNI TOPI	9251315	Bulker med B	623	105	48116	Z_Fore	129	36.1
PIONEER	7925613	Bulker small	731	76	34452	Z_Fore	103.1	36.4
EMERALD	9595967	Bulker small	623	92	34057	Z_Fore	103.1	36.4
MAINE DREAM	9520601	Bulker med C	623	105	53457	Z_Fore	146.6	36.7
NEMTAS-2	9299915	Bulker med B	623	105	44948	Z_Fore	129	38.1
CONDOR	9224659	Bulker med B	620	105	46272	Z_Fore	129	38.4
SOPHIE OLDEN	9138109	Bulker large	738	105	64431	Z_Fore	182.7	39
JUERGEN SCHU	9146003	Bulker med B	623	102	44366	Z_Fore	129	39
SPAR URSA	9490856	Bulker med C	623	106	53360	Z_Fore	146.6	39.7
GREAT SCENER	9264049	Bulker med B	617	102	43939	Z_Fore	129	39.7
BALTIC PEARL	7930137	Bulker med A	597	98	35684	Z_Fore	111.7	40.4
UNITED MADER	9632600	Bulker med C	620	105	53360	Z_Fore	146.6	42.3
LUSITANIA G.	9500091	Bulker med C	643	66	54280	Z_Fore	146.6	42.7
BALTO	9600982	Bulker large	721	98	65780	Z_Fore	182.7	44.3
CSL TECUMSEH	9600994	Bulker large	751	105	65780	Z_Fore	182.7	45
RT.HON.PAUL E.	9600970	Bulker large	748	105	65780	Z_Fore	182.7	45.3
NELVANA	8105492	Bulker large	797	106	68977	Z_Fore	182.7	45.67

2.6 Shipping Operations

2.6.1 Underkeel Clearance

The measure of underkeel clearance (UKC) for economic studies is applied according to planning guidance. According to this guidance, UKC is evaluated based on actual vessel operator and pilot practice within a harbor and subject to present conditions, with adjustment as appropriate or practical for with-project conditions. Generally, practices for UKC are determined through review of written pilotage rules and guidelines, interviews with pilots and vessel operators, and analysis of actual past and present practices based on relevant data for vessel movements. Typically, UKC is measured relative to immersed vessel draft in the static condition (i.e., motionless at dockside). When clearance is measured in the static condition, explicit allowances for squat, trim, and sinkage are unnecessary. Evaluation of when the vessel is moved or initiates transit relative to immersed draft, tide stage, and commensurate water depth allows reasonable evaluation of clearance throughout the time of vessel transit.

Evaluation of all movements renders a distribution of UKC requirements. Evaluation of minimal clearance (i.e., some level of clearance below which operators or pilots will not move a vessel due to concerns for insufficient safety) helps to quantify the period of time each day a given vessel with a specified immersed draft can be moved relative to tide.

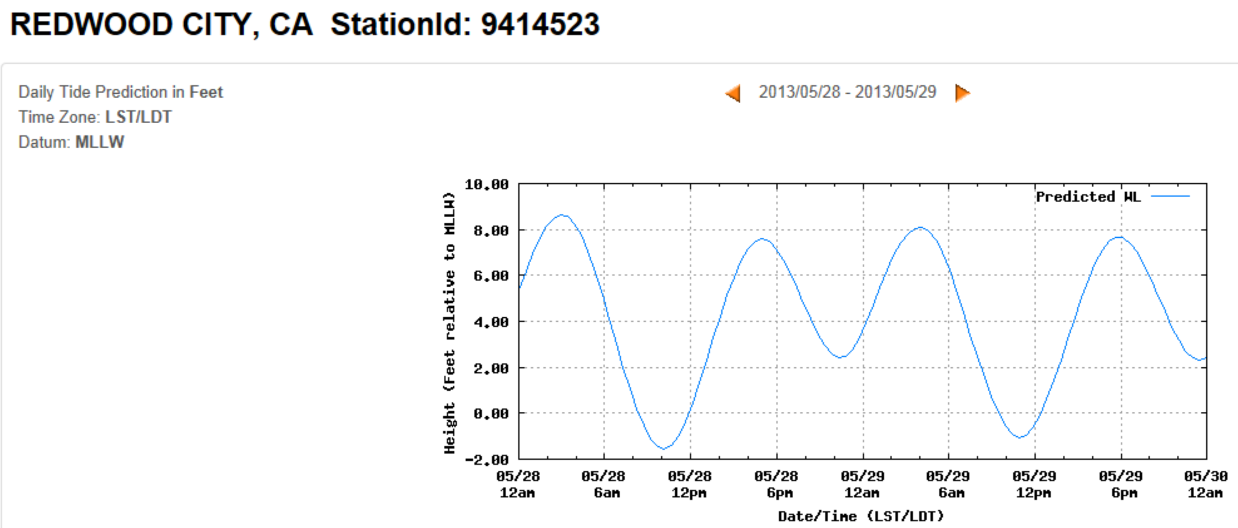
According to the San Francisco Bar Pilots Operations Guidelines for the Movement of Vessels on San Francisco Bay and Tributaries published 18 September 2014, the minimum UKC for non-tank vessels is two feet. Meetings with San Francisco Bay Bar Pilots over the course of this study confirm that while tidal ranges are frequently used to navigate loaded ships to the Port with drafts greater than 30 feet, the two-foot safety UKC is maintained.

2.6.2 Tidal Range

Tides are used often in order to transport cargo to the wharfs of the Port of Redwood City. High tides average approximately 7 to 8.5 feet above MLLW while load tides typically fall from -0.8 feet to 2.9 feet below MLLW. The Tide Tool included in the HarborSym model was incorporated for the analysis described later in this report. The IWR Tide Tool makes use of standard astronomical tidal prediction techniques and databases of tidal stations. The Tide Tool generates tidal height and current information for primary and secondary tidal stations as well as statistics on tidal availability, for example the cumulative distribution function of tidal availability at a location. A geographical interface making use of Google Earth™ allows for simple identification of tidal stations, and supports creation of secondary tidal stations for use in HarborSym.

Here is a random, typical tide scenario from 2013, taken from the NOAA website.

Figure 5. Random, Typical Tide Scenario from NOAA Website



2.7 Design Vessel

The selection of vessel specifications for fleet service forecasts sometimes poses unique concerns given requirements to evaluate design and improvements for waterway systems over time. Generally, waterway improvements should be designed to be optimized across the entire forecasted fleet. In this case, it would include service by several forms or types of vessels (i.e., tankers and dry cargo carriers, etc.). Where vessel designs are relatively mature (tankers and dry bulk carriers), the task is straightforward.

Such is the case with the Port of Redwood City. The design vessel class of Panamax ships already calls on the Port, albeit light-loaded. The Port has indicated that the new CSL Trillium Class Self-Unloaders will be the largest vessels that will regularly call on the Port throughout the foreseeable future. There is currently a fleet of five of these vessels (Rt. Honorable Paul E. Martin, Balto, Balchen, Tacoma, and Tecumseh) that regularly bring sand and aggregates to the Port from Vancouver Canada. Four of the five were built in 2013 (the fifth in 2012) and are classified as Panamax ships. Their DWT capacity is approximately 71,500 tonnes with design drafts of roughly 44 feet. In 2013, design vessel ships comprised 57% of Port calls and carried nearly 64% of total tonnage to the Port.

3.0 Future Conditions

3.1 Terminal Expansions

Currently the Port has indicated that they have no plans to expand annual throughput capacity, which is estimated to be up to about 3.5 million tonnes per year. The Port has recently upgraded its Wharf 1 facilities and continues to seek out new customers, particularly in light of the continued absence of cement imports.

3.2 Commodity Forecast

3.3.2 Trade Forecast

3.3.2.2 IHS Global Insight

In 2011, bulk trade forecasts were obtained from GI, which operates as a research firm to provide economic and financial coverage of countries, regions, and industries. It offers data collection of macro, regional and global economics; financial markets and securities; survey; U.S. economic; energy; industry; and international trade.

When making global trade forecasts, GI employs sophisticated macroeconomic models which contain all commodities that have physical volume. The commodities are then grouped into 88 categories derived from the International Standard Industrial Classification. GI tracks 66 major countries then groups the remaining world trade partners into 12 regions according to their geographic location. Accordingly, they forecast 88 commodities among 78 countries or regions and include 582,528 potential trade flows.

When performing the Redwood City Harbor commodity forecast, GI considered four areas of concern that may threaten to slow the trajectory of global trade, among them the uncertainty over how the sovereign debt of the Eurozone will be resolved; concerns about China "hard-landing" and whether the government can prevent a recession; jitters about potential impact of sharply higher oil prices on the global economy; and political transitions in countries like Russia, China and Venezuela.

3.3.2.2.1 GI Trade Data Sources

GI obtains trade data from a wide variety of public and proprietary resources. IHS Global Insight resources included the data and expertise of the U.S. Macroeconomic Service, U.S. Regional Service, World Trade Service, Agriculture Service, U.S. Construction Service, Pricing and Purchasing Service, Trade and Transportation Service, and Energy Service, plus the resources of IHS CERA. Additional information was provided by government agencies, such as the U.S. Department of Agriculture's Economic Research Service, and the Bureau of Labor Statistics; industry associations and publications; academic publications; interest group publications, and the general press.

GI world trade forecast models use its comprehensive macroeconomic history and forecast databases and in particular, data on population, GDP, GDP deflators, industrial output, foreign exchange rates, and export prices by country. The data are used as exogenous variables in the trade forecast models. In this case, for cement (proxy for aggregates and sand) the forecasting process began with the historical data available on the imports of those commodities. IHS reviewed the forecasts in the draft report for each commodity and made changes as appropriate in the assumptions, methodology, or data sources to develop our baseline forecasts. The chapters for each commodity contain more detailed information on the forecasting methodology and assumptions used for that particular commodity.

For scrap metal, the methodologies for generating forecasts primarily focused on the potential demand for each commodity. The hinterland is the most likely area from which raw material would be supplied, and it is assumed that the demand for raw material would be met without constraint. Therefore, the overseas demand for these commodities was the principal driver of their forecasts.

Based upon the 2011 analysis by GI and using historical data from 1995 through 2014 and the TREND function in Microsoft Excel, the following commodities forecast has been developed for the channel improvement study. Multiple trend lines were examined, after making adjustments to reflect that several historical commodities have disappeared and not expected to return for at least several years (and thus not included in the benefits, as based upon most likely scenario). The trendline chosen for forecasts that follow is approximately 2.8% per year.

Figure 6. Projected Trendlines for Growth in Commerce at Port of Redwood City

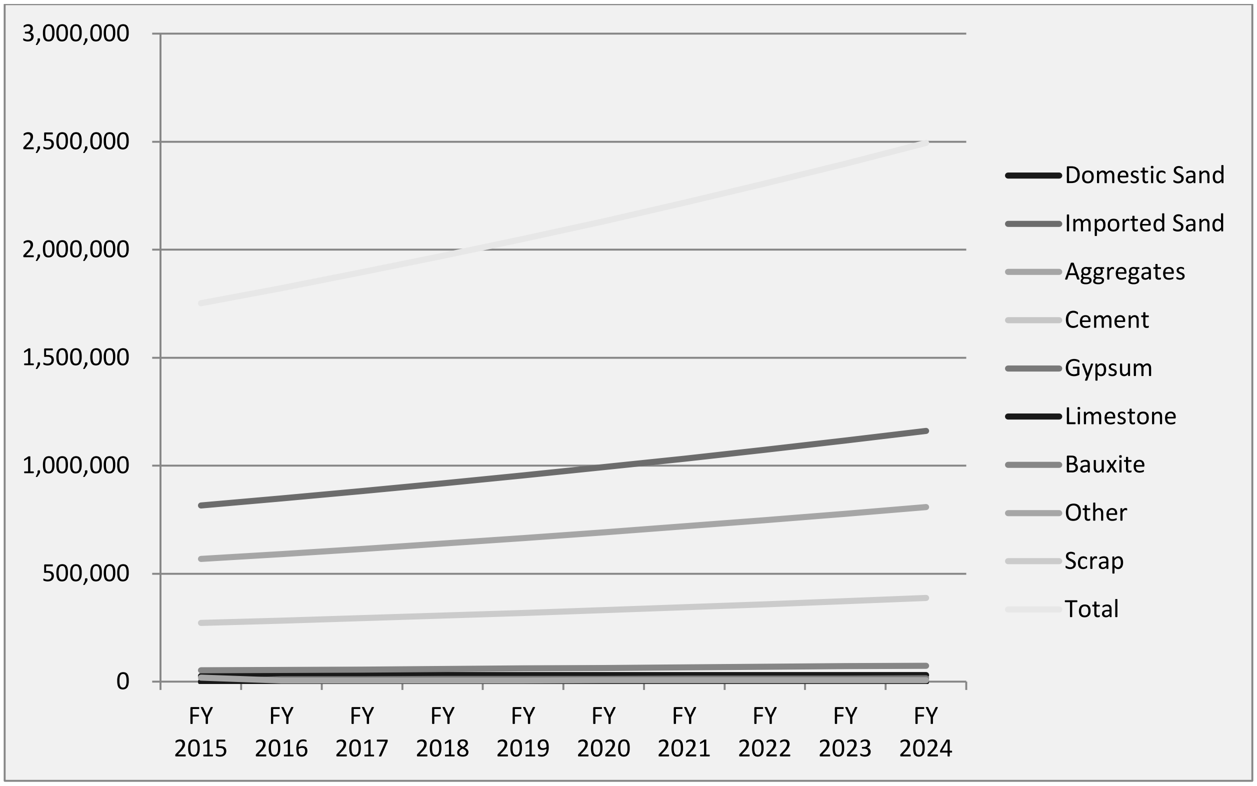


Table 6. Projected Growth in Commerce at the Port of Redwood City

Commodity	FY 2015	FY 2016	FY 2017	**FY 2018**	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	**FY 2024**
Domestic Sand	26,000	30,000	30,000	**30,000**	30,000	30,000	30,000	30,000	30,000	**30,000**
Imported Sand	816,000	848,640	882,586	**917,889**	954,605	992,789	1,032,500	1,073,800	1,116,752	**1,161,422**
Aggregates	568,000	590,720	614,349	**638,923**	664,480	691,059	718,701	747,449	777,347	**808,441**
Cement	0	0	0	**0**	0	0	0	0	0	**0**
Gypsum	0	11,000	11,440	**11,898**	12,374	12,868	13,383	13,919	14,475	**15,054**
Limestone	0	0	0	**0**	0	0	0	0	0	**0**
Bauxite	52,000	54,080	56,243	**58,493**	60,833	63,266	65,797	68,428	71,166	**74,012**
Other	18,000	5,200	5,408	**5,624**	5,849	6,083	6,327	6,580	6,843	**7,117**
Scrap	272,000	282,880	294,195	**305,963**	318,202	330,930	344,167	357,933	372,251	**387,141**
Total	1,752,000	1,822,080	1,894,963	**1,970,762**	2,049,592	2,131,576	2,216,839	2,305,512	2,397,733	**2,493,642**

SAND AND AGGREGATES IMPORT FORECASTS (IHS Global Insight)

As previously noted, IHS prepared a report for San Francisco District in 2011 incorporating forecasts for the Port of Redwood City. While cement was being considered, they concluded that an index tied to the construction industry was the appropriate one to use. Therefore, the following IHS forecast analysis is being used as a reasonable proxy for sand and aggregates that are imported through the Port. The table below depicts the MSAs that were used as a proxy for construction demand for cement for all three study areas.

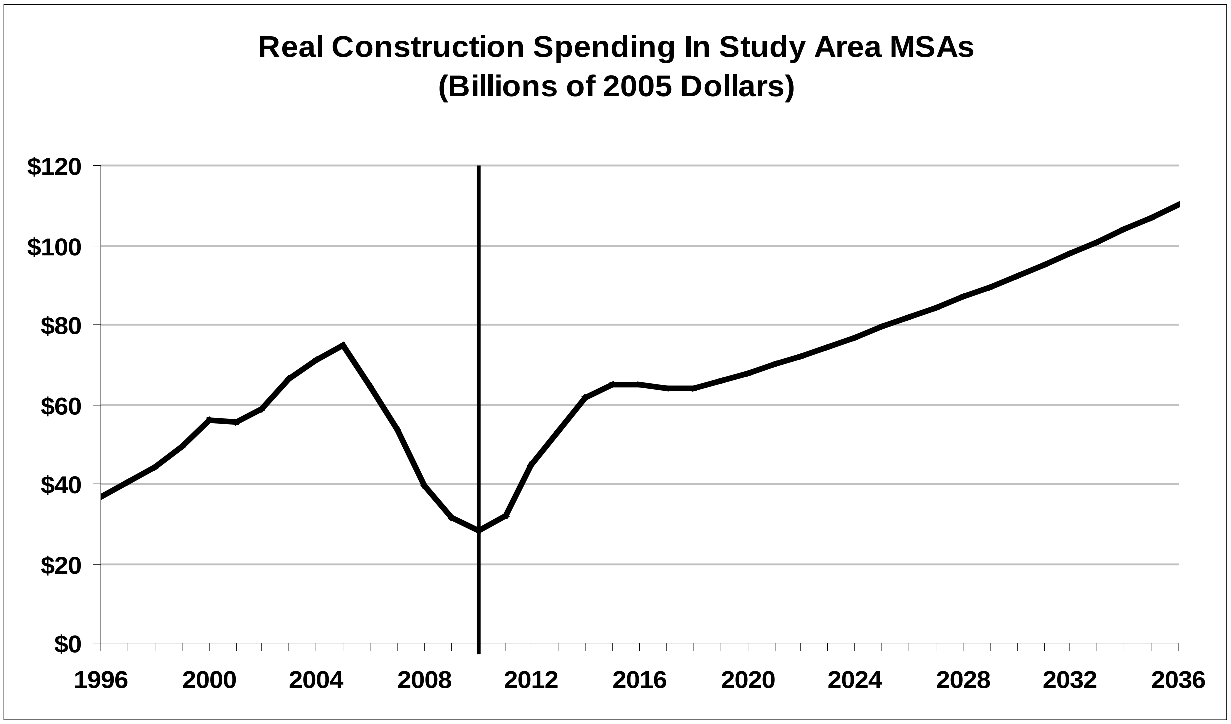
Table 7. Metropolitan Areas for Cement Hinterland Demand

Metropolitan Statistical Areas Used to Represent Hinterland's Cement Demand		
Sacramento	**Redwood**	**Stockton**
Chico	San Francisco-Oakland-Fremont	Fresno
Napa	San Jose-Sunnyvale-Santa Clara	Hanford-Corcoran
Redding	Salinas	Madera-Chowcilla
Sacramento--Arden-Arcade--Roseville		Merced
San Francisco-Oakland-Fremont		Modesto
Santa Rosa-Petaluma		Sacramento--Arden-Arcade--Roseville
Vallejo-Fairfield		Stockton
Yuba City		Visalia-Porterville

Upon examination of the data, the pattern of construction spending over the period from 1996 to 2010 exhibits the same trends as seen in the ports' cement import data. According to the Construction Service's latest forecast for the California Metropolitan Statistical Areas (MSAs) that lie within this report's study area, real (adjusted for inflation) construction spending is expected to increase by an average of 15% per year from 2011 to 2016. This strong growth is the result of fulfilling the pent-up demand that has been accruing while the construction industry wallowed during the recent recession, particularly in the housing segment. And according to California Financial & Economic Data—Construction: Housing Permits & Starts, the annual rate of change was 23% in 2010, almost 6% in 2011, 25% in 2012, and just over 44% in 2013.

Strong growth is also expected in the infrastructure segment as a result of Federal stimulus spending. Growth then is projected to be flat for four years, but spending will remain above $60 billion per year, which is 150% higher than the 2006 level of spending. For the remainder of the forecast period, the industry will settle into long-term trend growth of 3.1% per year, in line with the area's growth in gross domestic product. Despite the strong growth expected over the next five years, spending equivalent to the 2005 peak will not be achieved again until 2023.

Figure 7. Construction Spending



3.2 Forecast Assumptions

Construction spending was used as the driver for forecasting the demand sand and aggregates imported primarily for cement production. Several key concepts were considered prior to forecasting:

- Wet cement can only be moved locally a short distance, with the maximum range typically 50 miles. As such, the three ports do not compete for market shares of wet cement. However, the demand for dry cement extends well beyond a 50-mile radius around each port, as indicated in the hinterland maps. It is also understood from interviews and research that the majority of the cement moved through the hinterlands is dry, and it is moved by truck. Because the hinterlands for each of the ports overlap, the ports compete, to varying degrees, for dry cement market share.

- Delivered costs certainly will influence market penetration. However, existing facilities could mitigate some marine-related cost differentials. For instance, CEMEX has facilities at Redwood City and Sacramento. Depending on geographic demand, CEMEX will likely use those facilities rather than diverting shipments to Stockton. Similarly, the cement companies at Stockton would use their facilities for imports. This also indicates that import volumes would be influenced by intra-industry competition.

- All three ports have imported and distributed cement in the past. Therefore, connectivity to hinterland markets is not a constraint, but it is a factor in delivered cost.

- Capacity is not a constraint on the cement forecasts. Capacity at Sacramento is over 2 million metric tons per year, as is capacity at Stockton. Redwood City has capacity of roughly 850,000 metric tons. All three ports have demonstrated the ability to dramatically ramp up import volumes when demand nears or supersedes domestic production.

- In 2010, Polaris Materials Corporation entered into an amended and restated 20-year shipping agreement with CSL International Inc. for the bulk transportation of sand and gravel from the Orca Quarry (Orca), primarily to locations in California. Through this action, Polaris secured the long-term ability to supply existing and future terminals using rapid self-discharging Panamax vessels. Through its US subsidiary company, Eagle Rock Aggregates, Inc. (ERA) Polaris supplies Orca sand and gravel to a combination of owned and third-party terminals. In northern California, supplies are made to the Company's own Richmond Terminal within the Port of Richmond, which commenced the storage and distribution of Orca aggregate in 2008. Three additional locations are supplied directly: Redwood City, Pier 92 in the Port of San Francisco and Petaluma through a terminal operated by Landing Way Depot, Inc. In February, 2013 the Company commenced sales on an ex-quarry, or Free-on-Board, basis to a company with its own shipping capacity, these materials being delivered into Pier 94 in the Port of San Francisco. In respect of Pier 92 and Landing Way Depot deliveries, sand and gravel is loaded into customers' barges while the Panamax vessel is at anchor in San Francisco Bay. In this way the residual cargo can be discharged directly into the Richmond or Redwood City terminals, where shallow water prevents access to a fully loaded Panamax vessel.
- The Orca Quarry is located on the north east coast of Vancouver Island west of Port McNeill, British Columbia. Polaris Materials Corporation owns 88% of Orca Sand & Gravel Ltd. with the remaining 12% participating interest held by the 'Namgis First Nation. Trading commenced in April 2007, when the first shipment of sand and gravel departed for San Francisco. The Orca Quarry is permitted to produce 6.6 million tons of sand and gravel per year and has a dedicated ship loading facility capable of rapidly loading ships and barges, including 'Panamax' vessels with a capacity of up to 80,000 tons. The sand and gravel produced is of very high quality and exceeds all specification requirements for use in the United States, particularly in California, as well as in Canada. It has become well accepted in markets through its use in several major infrastructure projects such as the new San Francisco-Oakland Bay Bridge. The Orca Quarry has a long life with remaining permitted reserves at December 31, 2009 of 128.8 million tons. In 2008, the Company drilled and sampled two adjacent sites and confirmed the presence of suitable sand and gravel deposits which can be expected to add significantly to the life of the quarry, subject to obtaining final tenure and permitting.
- Polaris Minerals has a conveyor system over 1 kilometer long that brings the material directly from the quarry to a ship loader which can load Panamax ships at a rate of 5,000 tons/hour. CSL International has brought 4 newly built state-of-the-art Panamax ships into this aggregate materials trade. They have self unloading conveyors which can unload 35,000 - 40,000 tons in Redwood City in 18 - 24 hours. The high quality material from the Orca quarry, and the highly efficient transportation system that brings it to the Port of Redwood City, makes this material competitive with locally available material for the production of redi-mix concrete.
- According to the Port's internal analysis, Northern California has a deficit in construction aggregates supply to meet the growing demand. This is due to a gradual production slow down and/or closing of quarries from the Russian River valley in the north to

Gilroy/Watsonville in the south. Trucking material into this traffic congested area is difficult and expensive. There is a steady increase in demand based on population growth in the SF Bay area. Each person in a growing economy "consumes" an average of 7 tons of construction aggregates per year. Add to this construction cycles when demand increases (spikes) above the normal growth. In the last 15 years there have been 2 major spikes in demand for construction material - the housing boom roughly from early 2000 to 2007, which was wide spread in Northern California, and the Silicon Valley building boom starting in 2011 and which is still going strong. Canadian sand started to be shipped to Redwood City in 2003. Aggregates (two sizes of gravel) from Canada followed several years later. The sand and aggregates are used almost exclusively for making redi-mix concrete. Total tonnage grew gradually from 96,000 tons in 2003 to over 400,000 in 2010 as the material became more widely accepted and, in terms of quality, exceeded building specifications. Redwood City was the first port in the SF Bay Area to receive these shipments be followed by Richmond and later San Francisco. In 2011 the tonnage of construction aggregate material shipped to Redwood City doubled in one year to 850,000 tons and has grown steady every year since then to reach 1.3 million tons in 2014. This is due to the growth of the Silicon Valley economy and the building boom occurring from San Francisco to San Jose. According to experts in the construction industry, this is the hottest construction market in the US. They don't see the market slowing appreciably in this cycle; it may moderate briefly once these companies build their buildings and new campuses, but the long term outlook is this is the tech hub of the world and these companies will continue to grow and change and expand for the foreseeable future.

On the supply side, the Canadian company, Polaris Minerals, opened the Orca quarry on the northeast coast of Vancouver Island in 2007. It is the largest construction materials quarry in Canada and is currently permitted to produce 6.6 million tons per year. It has a conveyor system over 1 kilometer long that brings the material directly from the quarry to a ship loader which can load Panamax ships at a rate of 5,000 tons/hour. CSL International has brought 4 newly built state-of-the-art Panamax ships into this aggregate materials trade. They have self unloading conveyors which can unload 35,000 - 40,000 tons in Redwood City in 18 - 24 hours. The high quality material from the Orca quarry, and the highly efficient transportation system that brings it to the Port of Redwood City, makes this material competitive with locally available material for the production of redi-mix concrete.

sThe first pass at forecasting produced reasonable growth rates for imports at all three ports. However, the tonnage levels did not appear to be reasonable, as none of the ports approached the volumes seen in the prior construction boom. This was due to the fact that the volume for the beginning of the forecast jump-off period, 2010, was so low that despite the growth in construction spending, significant volumes were not attained.

To adjust for this, IHS looked at the historical relationship of construction spending within each port's hinterland versus their cement imports to determine a year-by-year factor representative of this relationship. The significance of this factor is to replicate the potential for these ports to "bounce back" when demand warrants a sharp increase in imports. IHS then took an average of these factors over history to create a single "bounce back" factor for use in an appropriate future year. An average was used to avoid bias of either a high- or low-import year.

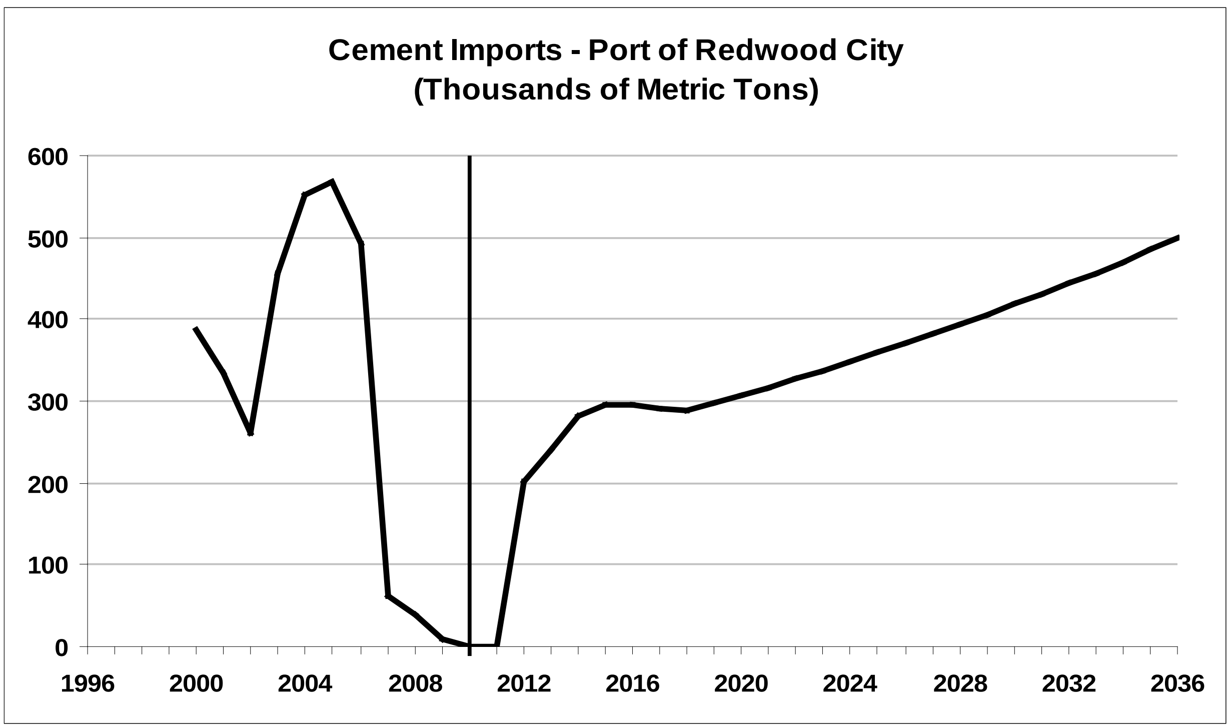
IHS applied the factor in the year 2013 by multiplying the estimate of construction spending by each port's "bounce back" factor. This resulted in an import "bounce back" in 2013, the consequence of two consecutive years of strong growth in construction spending. .

Using this methodology, a second round of import forecasts was developed. These forecasts were deemed to be a more reasonable prediction of imports in a recovering market, given historical patterns seen in a rising market.

Table 8. Sand & Aggregate proxy Import Forecasts

	Metric Tons						Compound Average Annual Growth		
							2010 /	2016 /	2036 /
	2007	2008	2009	2010	2016	2036	2007	2010	2016
Redwood City	61,012	38,799	8,471	0	294,380	499,472	N/A	N/A	2.7%
Stockton	1,150,997	233,764	183,980	243,947	826,378	1,417,073	-40.4%	22.6%	2.7%
West Sacramento	207,025	156,893	176,571	32,833	264,871	448,692	-45.9%	41.6%	2.7%

Figure 8. Redwood City Cement Imports Forecast



3.3 Steel Scrap

3.3.1 National Overview

As of 2011, the metal recycling industry is an $86 billion global industry that in the United States employs about 85,000 people and processes 150 million tons of recyclable material each year, including 85 million tons of iron and steel.[1] Export demand is the largest driver for the steel scrap market in the United States, which is the world's largest steel scrap exporter.

Although the global demand for scrap was affected sharply by the global economic downtown, demand is on the rebound. One factor behind the growth in demand is the worldwide increase in the use of electric arc furnace technology, which uses steel scrap as its primary production input. This is particularly true in Europe, where companies using EAF technology account for over 40% of all steel production – that proportion will increase as new plants come online.[2] In addition, steel scrap demand will grow to support the rapidly expanding economies of the emerging markets where steel consumption per capita is well below that of developed markets.[3]

Nearly 40% of U.S. scrap exports went to China in 2009; continued strong demand in China leads IHS Global Insight to project that as of 2010, China will pass the United States in scrap consumption and will continue as the world's largest consumer for the foreseeable future. South Korea and Taiwan are other major importers of U.S. scrap; demand in these countries is expected to continue to be strong. Another support for scrap demand is the fact that scrap recycling reduces the need for raw ore mining, thereby reducing mining's impact on the environment. Continued foreign demand plus the expectation that the U.S. dollar will remain weak versus other currencies suggests that the demand for U.S. scrap exports should be sustainable into the future.

In the United States, steel use remains well below historical averages, even with a bounce back in 2010 from the depressed levels of 2009.[4] As the U.S. economy picks up speed, domestic demand for scrap by U.S. companies is expected to rise.[5] For example, even though significant sectors of the American economy have yet to fully recover from the recession, some sectors – such as energy, aerospace, defense and automotive –are gaining strength and are consuming more scrap. Eventually, the rise in activity will result in the generation of more domestic scrap.

Domestic supply conditions have recently tightened in the United States for several reasons. First, there has been a decline in overall metals-intensive manufacturing in the United States, which has led to a significant drop off in the generation of industrial or "prompt" scrap, which traditionally accounts for 50

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[1] West Coast Recycling Group LLC's Proposed Metal Recycling Facility for the Port of West Sacramento, Project Overview.
http://westcoastrecyclinggroup.com/
[2] "Scrap Outlook Points to Steel Recovery," Breakbulk Online, August 13, 2010.
http://www.breakbulk.com/steel-metals/scrap-outlook-points-steel-recovery
[3] Steel & Input Cost Economics 2010," McCoy Bolt Works, January 2010.
http://mccoybolt.com/assets/files/Steel-and-Input-Cost-Economics-2010.pdf
[4] MetalsOutlook January 2011", All Metals & Forge Group, January 2011.
http://www.steelforge.com/metalswatch/2011/January.htm
[5] "Scrap Metal's Lament: Few Scraps," *Wall Street Journal*, March 18, 2010.

percent of the country's scrap supply. Second, steel manufacturing efficiency has improved, resulting in less "home" scrap being produced.[6] Third, supply dried up during the recession as people were more likely to repair potential sources of scrap, such as an old appliance, than to discard it. This is known as obsolete scrap.

Figure 9. U.S. Shredded Scrap Exports, 2006-2012

However, the potential reservoir of scrap material is not in question. Studies commissioned by Institute of Scrap Recycling Industries (ISRI) estimate U.S. scrap reserves (obsolete scrap) are in excess of one billion tons. Following the dynamics of the supply-demand equation, high scrap prices will provide the incentive to bring more obsolete scrap to the market. Because of the enormous amount of obsolete scrap supply, its introduction to the market as scrap prices increase tends to result in moderating prices.

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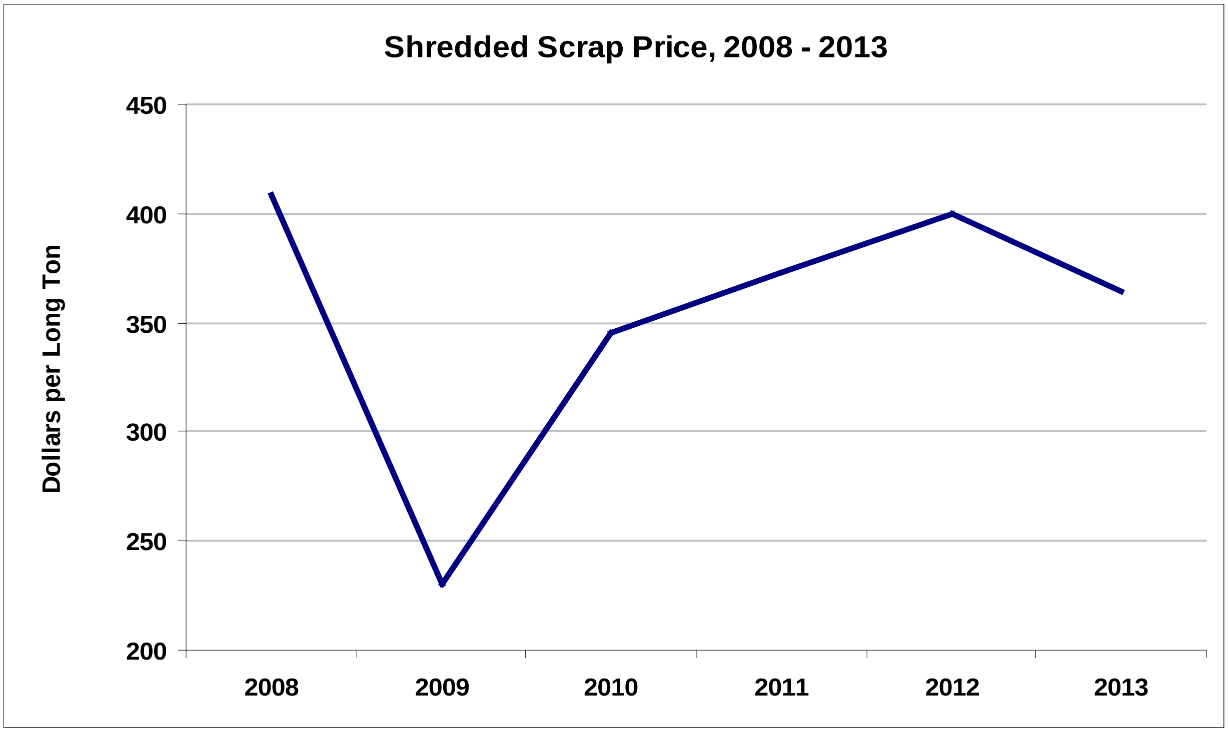
[6] What's Up with the Price of Scrap? Economic Recovery and Global Demand Setting the Pace, ISRI, Institute of Scrap Recycling Industries, Inc, February 2011.
http://www.isri.org

Figure 10. Price of Shredded Steel Scrap, 2008-2013



Although the global recession put the brakes on commodity price appreciation for a time, prices have heated up again as the world's economies begin to recover.[7] Prices for a metric ton of shredded steel scrap, the type that would be produced by the new Sacramento facility, fluctuated between $305 and $397 in 2010[8] and are predicted to remain in the $300-$400 range through 2012. IHS Global Insight does not predict a crash and even the bottom of our forecast represents levels 15% higher than the average in 2007. The rising tide of demand from steel mills around the world means the floor for scrap prices (both in the United States and around the world) is edging higher as well.

3.3.2 Scrap Metal Exports Background

Port of Redwood City: Scrap metal exports from Redwood City began in 2000, with 200,524 metric tons exported in that calendar year. Tonnage increased steadily until a slight drop in 2007 and 2008, but rebounded strongly in 2009 to nearly 400,000 tons in 2009 and peaked at 406,025 tons in 2010.

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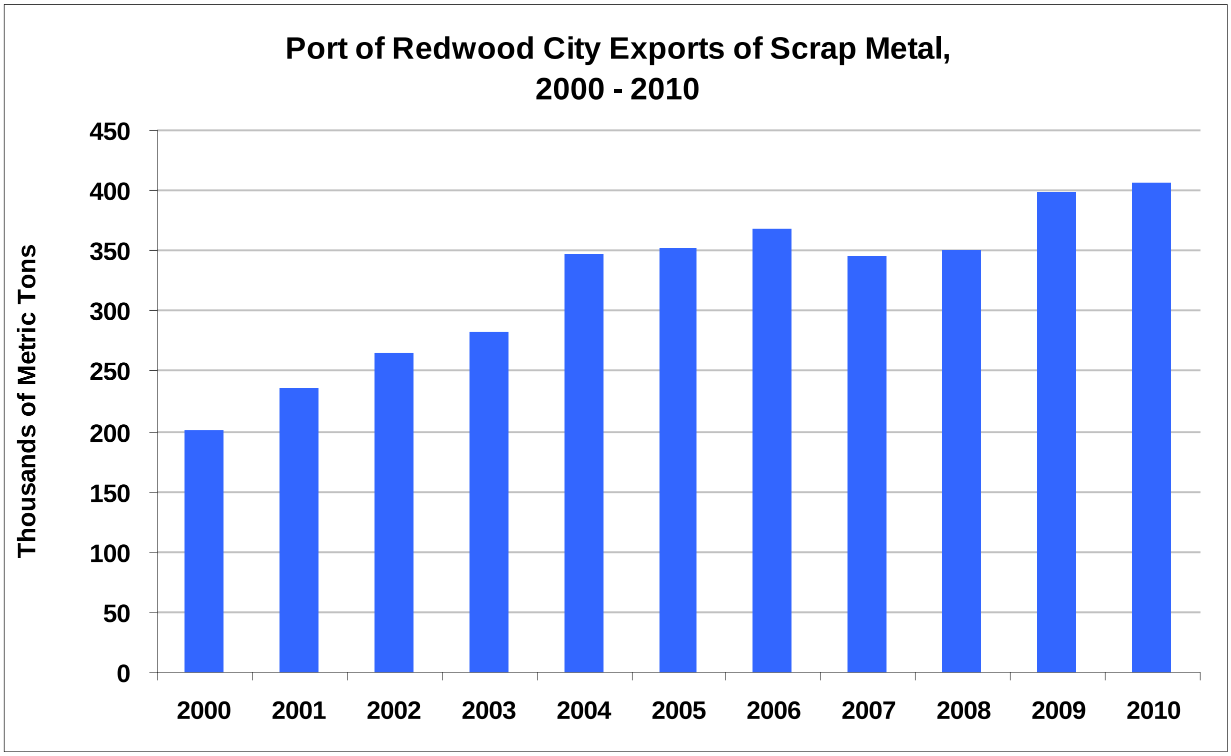
[7] Ibid.
[8] "The Buyers' Perspective, November 2010", IHS Pricing and Purchasing Service.

Figure 11. Exports of Scrap Metal at Redwood City, 2000-2010



3.4 Scrap Metal Export Forecasts

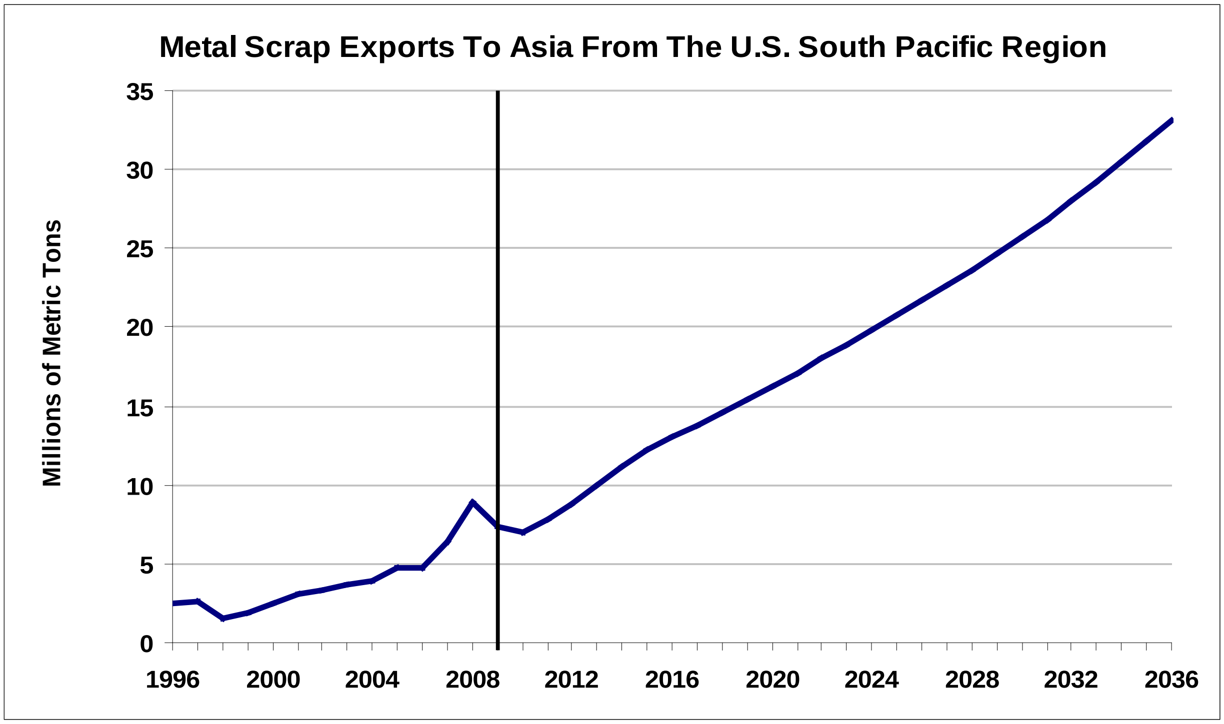
To produce a forecast of import tonnage for the two ports, we reviewed the work that the Corps had done for Sacramento and their sources of information. The Corps approach was similar to the approach that we applied, namely, that there is ample supply in the hinterland and that demand would ultimately drive the potential for scrap exports. However, we had the benefit of additional data sources from which to build and validate a forecast.

First, because Redwood City was not a part of the Corps' study, the history of Redwood City's exports was not part of their review. As depicted in Figure IVI-X, over the last decade, Redwood City's annual scrap metal exports have doubled from 200,000 tons to 400,000 tons, exhibiting growth despite the recession. This demonstrates the continuing strength of demand for scrap metal.

The Corps used information from IHS Global Insight's World Trade Service (WTS), which was the forecast of scrap exports from the North Pacific region. As opposed to the commodity used by the Corps in producing a cement forecast, the scrap category in WTS is narrowly defined, with only five sub-categories (mainly centered on whether the scrap is ferrous or non-ferrous). The Corps used a December 2009 forecast; we were able to incorporate the December 2010 version into our analysis. Another minor point is that the Corps used the North Pacific region data for their forecast, whereas these two ports actually are part of the South Pacific region.

From the WTS data, it is apparent that Asia is the leading destination for scrap exports from the U.S. South Pacific region – in 2009, exports to Asia were 7.3 million metric tons, while exports to Europe totaled fewer than 6,000 tons. Exports to Asia are expected to grow considerably over the forecast interval. The WTS forecast expects average annual growth to be 6.3% from 2009 through 2036, when scrap exports are forecast to reach 33 million tons.

Figure 12. Metal Scrap Exports to Asia from the U.S. South Pacific Region



Our third source was IHS Global Insight's World Industry Service (WIS). Information from WIS was reviewed to cross-check the WTS data because exports and imports serve as inputs into the WIS forecast process, and we did not want to "double-count" the expectations for exports from the South Pacific region or imports into Asia. Note that there are many other inputs into the WIS forecast process, so if these forecasts did not complement each other, it would be a signal that additional research would be necessary to understand the differences.

The Asian industries that would be most likely to generate the primary demand for scrap metal are construction, steel making, and automobile manufacturing. From WIS, we looked at the production indices for each of these industries as a representative sample of Asian countries: India, Japan, South Korea, Thailand, and Vietnam. (Industrial production index data is not yet available for China.) With the exception of Japan, which is not an economic growth engine for the region, these industries are expected to grow by an average of 6.0% over the forecast interval in these countries. Therefore, the cross-check of the expectations for scrap metal exports lends credence to the predicted export growth.

Land-side delivery costs then were reviewed to determine whether or not they would favor one port over the other. The analysis revealed that the hinterlands were distinct enough to ensure supply to both ports (please see Table 4 in Appendix II), but Sacramento does have the advantage of being closer to a larger number of supplying counties. The introduction of Sacramento as a user of scrap metal would likely shift some supply away from Redwood City, thus slowing the growth of Redwood City's exports. As can be seen in the table, dredging of the channel would reduce the total delivered costs of scrap exports from Sacramento by approximately $4/ton.

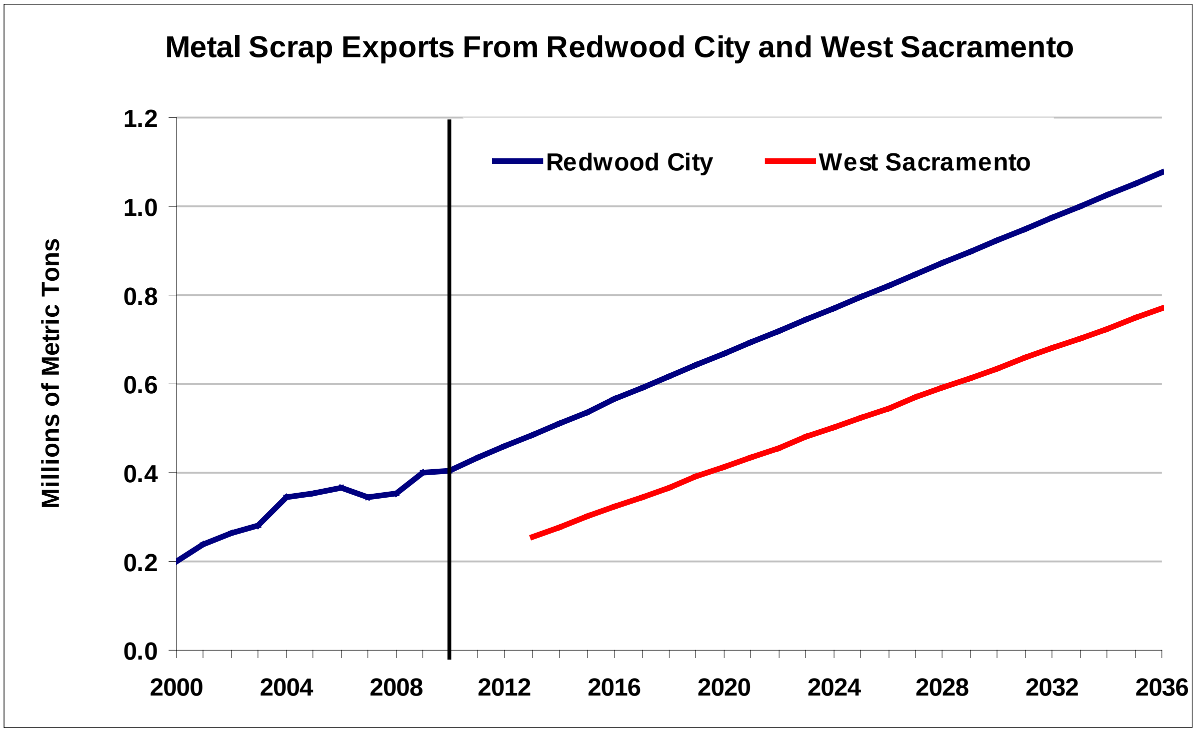
The final piece of analysis was to assume that the Sacramento scrap facility will become operational and to determine exports from Sacramento would commence. Clearly, the current appetite for scrap metal in Asia and the expected near-quintupling of demand is sufficient to support multiple suppliers. It is unlikely that meaningful volumes of scrap will begin to be exported from Sacramento in 2011. To be conservative, 2013 was picked as the starting year for Sacramento scrap exports, allowing ample time for permitting and for demand to build as a result of global economic recovery. Under this scenario, exports from Sacramento begin at 256,000 tons (eight 32,000 MT shipments) and grow at an average annual rate of 4.9%. Exports from Redwood City grow at a slightly slower pace of 3.5% annually, reflecting the competition for supply from Sacramento. Combined, their scrap exports grow at 6.0% per year from 2010 to 2036, consistent with the forecast of export growth from the IHS World Trade Service.

The question of whether or not exports actually will start cannot be answered within the confines of this analysis. If the scrap processing plant is not built, the forecast is obviously zero for Sacramento, and Redwood City would experience stronger growth over the forecast interval.

Table 9. Scrap Metal Exports Forecasts

	Metric Tons						Compound Average Annual Growth		
	2007	**2008**	**2009**	**2010**	**2016**	**2036**	**2010 / 2007**	**2016 / 2010**	**2036 / 2016**
Redwood City	344,928	351,077	351,077	351,077	563,893	1,077,634	0.6%	8.2%	3.3%
		2013	**2014**	**2015**	**2016**	**2036**			
West Sacramento		256,000	278,316	300,632	322,948	769,265	N/A	N/A	4.4%

Figure 13. Metal Scrap Export Forecasts for Redwood City and West Sacramento



4.0 Transportation Cost Savings Benefit Analysis

The purpose of this analysis is to describe the benefits associated with the deepening at the Port of Redwood City channel. NED benefits were estimated by calculating the reduction in transportation cost for each project depth using the HarborSym Modeling Suite of Tools (HMST) developed by IWR. The HMST reflects USACE guidance on transportation cost savings analysis[9].

4.1 Methodology

Channel improvement modifications result in reduced transportation cost by allowing a more efficient future fleet mix and higher load factors when traversing the port. The HMST was designed to allow users to model these benefits. With a deepened channel, carriers will be able to load Panamax vessels more efficiently and thereby reduce transiting costs. In the future, these carriers are anticipated to replace smaller less efficient vessels with modern Panamax that will continue to call on Port of Redwood City. The primary effect from channel deepening that could induce changes in the future fleet at Redwood City an increase in a vessel's maximum practicable loading capacity, if the vessel is depth constrained in the current channel. Channel restrictions can limit a vessels capacity by limiting its ability to load to its design draft. Deepening the channel can reduce this constraint and the vessel's maximum practicable capacity can increase towards its design capacity if commodities are available to transit, vessel loading practices allow, and the weight of all commodities on a vessel can "push" deeper into the water. This increase in vessel capacity utilization can result in fewer vessel trips being required to transport the forecasted cargo.

To begin, HarborSym was setup with the basic required variables. To estimate cost saving benefits, the Bulk Loading Tool (BLT), a module within the HMST, was used to generate a vessel call list based on the commodity forecast at the Port of Redwood City and available channel depth under the various alternatives. The resulting vessel traffic was simulated using HarborSym, producing average annual vessel transportation costs. The transportation costs saving benefits were then calculated from the existing 30-foot depth for each additional project depth. The Tentatively Selected Plan (TSP) was identified by considering the highest net benefit based on the transportation cost saving benefits.

4.1.1 HarborSym Model

IWR developed HarborSym as a planning level, general-purpose model to analyze the transportation costs of various waterway modifications within a harbor. HarborSym is a Monte Carlo simulation model of vessel movements at a port for use in economic analyses. While many harbor simulation models focus on landside operations, such as detailed terminal management, HarborSym instead concentrates on specific vessel movements and transit rules on the waterway, fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with the ocean voyage.

HarborSym represents a port as a tree-structured network of reaches, docks, anchorages, and turning areas. Vessel movements are simulated along the reaches, moving from the bar to one or more docks, and then exiting the port. Features of the model include intra-harbor vessel movements, tidal influence, the ability to model complex shipments, incorporation of turning areas and anchorages, and within-simulation visualization. The driving parameter for the HarborSym model is a vessel call at the port. A HarborSym analysis revolves around the factors that characterize or affect a vessel movement within the harbor.

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[9] HarborSym and the Bulk Loading Tool (BLT) are USACE certified planning models.

4.1.1.1 Model Behavior

HarborSym is an event driven model. Vessel calls are processed individually and the interactions with other vessels are taken into account. For each simulation, the vessel calls for an iteration that fall within the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all of the docks in the vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route. Potential conflicts with other vessels that have previously entered the system are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If rule activation occurs, such as no passing allowed in a given reach, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. Vessels move from reach to reach, eventually arriving at the dock that is the terminus of the leg.

After the cargo exchange calculations are completed and the time the vessel spends at the dock has been determined, the vessel attempts to exit the dock, starting a new leg of the vessel call; rules for moving to the next destination (another dock or an exit of the harbor) are checked in a similar manner to the rule checking on arrival, before it is determined that the vessel can proceed on the next leg. As with the entry into the system, the vessel may need to delay departure and re-try at a later time to avoid rule violations and, similarly, the waiting time at the dock is recorded.

A vessel encountering rule conflicts that would prevent it from completely traversing a leg may be able to move partially along the leg, to an anchorage or mooring. If so, and if the vessel can use the anchorage (which may be impossible due to size constraints or the fact that the anchorage is filled by other vessels), then HarborSym will direct the vessel to proceed along the leg to the anchorage, where it will stay and attempt to depart periodically, until it can do so without causing rule conflicts in the remainder of the leg. The determination of the total time a vessel spends within the system is the summation of time waiting at entry, time transiting the reaches, time turning, time transferring cargo, and time waiting at docks or anchorages. HarborSym collects and reports statistics on individual vessel movements, including time in system, as well as overall summations for all movements in an iteration.

HarborSym was initially developed as a tool for analyzing channel widening projects, which were oriented toward determining time savings for vessels transiting within a harbor. It did not allow for assessing changes in vessel loading or in shipping patterns. The most recent release of HarborSym was designed to assist analysts in evaluating channel-deepening projects, in addition to the original model capabilities. The deepening features consider fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with ocean voyage.

Each vessel call has a known (calculated) associated cost, based on time spent in the harbor and ocean voyage and cost per hour. Also for each vessel call, the total quantity of commodity transferred to the port (both import and export) is known, in terms of commodity category, quantity, and tonnage. The basic problem is to allocate the total cost of the call to the various commodity transfers that are made. Each vessel call may have multiple dock visits and multiple commodity transfers at each visit, but each commodity transfer record refers to a single commodity and specifies the import and export tonnage. Also, at the commodity level, the "tons per unit" for the commodity is known, so that each commodity transfer can be associated with an export and import tonnage. As noted above, the process is greatly simplified if all commodity transfers within a call are for categories that are measured in the same unit, but that need not be the case.

When a vessel leaves the system, the total tonnage, export tonnage, and import tonnage transferred by the call are available, as is the total cost of the call. The cost per ton can be calculated at the call level (divide total cost by respective total of tonnage). Once these values are available, it is possible to cycle through all of the commodity transfers for the vessel call. Each commodity transfer for a call is associated with a single vessel class and unit of measure. Multiplying the tons or value in the transfer by the appropriate per ton cost, the cost totals by class and unit for the iteration can be incremented. In this fashion, the total cost of each vessel call is allocated proportionately to the units of measure that are carried by the call, both on a tonnage and a value basis. Note that this approach does not require that each class or call carry only a commensurate unit of measure.

The model calculates import and export tons and import and export allocated cost. This information allows for the calculation of total tons and total cost, allowing for the derivation of the desired metrics at the class and total level. The model can thus deliver a high level of detail on individual vessel, class, and commodity level totals and costs.

Either all or a portion of the at-sea costs are associated with the subject port, depending on whether the vessel call is a partial or full load. The at-sea cost allocation procedure is implemented within the HarborSym Monte-Carlo processing kernel and utilizes the estimate total trip cargo (ETTC) field from the vessel call information along with import tonnage and export tonnage. In all cases the ETTC is the user's best estimate of total trip cargo. Within the BLT, the ETTC field is estimated as cargo on board the vessel at arrival plus cargo on board the vessel at departure, in tons. ETTC can also be expressed as:

$$\text{ETTC} = 2^{*}\text{Cargo on Board at Arrival} - \text{Import tons} + \text{Export tons}$$

There is a basic algorithm implemented to determine the fraction of at-sea costs to be allocated to the subject port. First, if ETTC for a vessel call is equal to zero or null, then none of the at-sea costs are associated with the port. The algorithm then checks if import or export tons are zero for a vessel call. If either are zero, then the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\text{At-Sea Cost Allocation Fraction} = (\text{Import tons} + \text{Export tons})/\text{ETTC}$$

Finally, when both import and export tons are greater than zero, the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\text{At-Sea Cost Allocation Fraction} = 0.5 * (\text{Import tons}/\text{Tonnage on board at arrival}) + 0.5 * (\text{Export tons}/\text{Tonnage on board at departure})$$

Where:

$$\text{Tonnage on board at arrival} = (\text{ETTC} + \text{Imports} - \text{Exports})/2$$

$$\text{Tonnage on board at departure} = \text{Tonnage on board at arrival} - \text{Imports} + \text{Exports}$$

4.1.1.2 Data Requirements

The data required to run HarborSym are separated into six categories, as described below. Key data for the Redwood City Channel Improvement study are provided. These data imputs were developed with assistance from the Port, the San Francisco Bay Bar Pilots Asoociation, and the Institute for Water Resources.

Simulation Parameters: Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay. These inputs were included in the model runs for the Redwood City study. The base year for the model was 2018. A model run was performed for the following years: 2013 (empirical data), 2018 (year in which benefits are expected to accrue), and 2025 (the year that the Port will meet its forecasted maximum of 2.5M tonnes. After 2025 the forecast number of tonnes was held constant until the end of the period of analysis. Each model run consisted of 100 iterations.

Physical and Descriptive Harbor Characteristics: These data inputs include the specific network of Redwood City Harbor such as the node location and type, reach length, width, and depth, in addition to tide and current stations. This also includes information about the docks in the harbor such as length and the maximum number of vessels the dock can accommodate at any given time.

Figure 14. Redwood City Channel Nodes, Turning Basin, and Wharves

Table 10. Redwood City Channel Dimensions and Docking Facilities

Reach

	Length (ft)	Width (ft)	Depth (ft)	Description	Reach Safety Zone Active	ID(#)
▶	1000	200	30	Reach - 1	☐	6
	1500	200	30	Reach - 2	☐	7
	2000	200	30	Reach - 3	☐	8
	750	200	30	Reach - 4	☐	9
	500	200	30	Reach - 5	☐	10
	1750	200	30	Reach - 6	☐	11

Docks

	Dock Description	Length (ft)	Limiting Depth (ft)	Max Vessels	Default Turning Basin	Default Usage	ID(#)	VSU Capacity
▶	Wharves 1 & 2	855	34	2	Main TB	Before	3	250
	Wharves 3 & 4	730	34	2	Main TB	Before	4	250
	Wharf 5	500	34	2	Main TB	Before	5	250

General Information. General information used as inputs to the model include: specific vessel and commodity classes, route groups (Table 11), commodity transfer rates at each dock (Table 12), specifications of turning area usage at each dock, and specifications of anchorage use within the harbor. Distances between the route groups were developed by evaluating the trade routes calling on Redwood City Harbor in 2013.

Table 11. HarborSym Route Groups

Route Group Name	Description	Distance to Prior Port (nautical miles)	Distance to Next Port (nautical miles)
Aus-Vanc	Australia - Vancouver	6,600	820
Can-Can	Canada – Canada	900	900
Can-Mex	Canada - Mexico	900	1,800
China-China	China – China	5,650	5,650
Chi-May	China – Malaysia	5,650	7,550
Chi-SK	China – South Korea	5,650	4,550
Mal-Can	Malaysia – China	7,550	5,650
Mex-Mex	Mexico – Mexico	1,800	1,800
Pusan SK	Pusan, South Korea	4,514	4,514
SD-Chi	San Diego – China	1,000	5,650
CentAm-Chi	Central America – China	2,500	5,650

Table 12. HarborSym Commodity Transfer Rates

Dock Name	Loading/Unloading Rate for Commodities (tonnes/hour)		
	Min	Most Likely	Max
Wharves 1 & 2	600	800	1000
Wharves 3, 4, & 5 (load)	200	250	300
Wharves 3, 4, & 5 (unload)	650	700	750

Vessel Speeds. The speed at which vessels operate in the harbor, by vessel class both loaded and light loaded, were determined for each channel segment by evaluating pilot logs and port records and verifying the data with the pilots. Vessel speed inputs are provided in Table 14 for each reach of the node network for vessels.

Table 13. HarborSym Vessel Speed in Reach for Vessels (knots)

Reach		Handy		Handymax		Supramax		Panamax	
		Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded
All		10	7	10	7	10	7	10	7

Vessel Operations. Hourly operating costs while in-port and at-sea were determined by IWR for both domestic and foreign flagged vessels in accordance with Economic Guidance Memorandum 11-05. Sailing speeds at-sea were also taken from IWR tables based upon vessel class. These values are entered as a triangular distribution.

Table 14. Vessel Speeds

Description	Handy	Handymax	Supramax	Panamax
Vessel Speed at Sea, Min (knots)	11	11.3	11.3	11.3
Vessel Speed at Sea, Most Likely (knots)	12.6	12.7	12.7	12.8
Vessel Speed at Sea, Max (knots)	14.3	14.3	14.4	14.4

Reach Transit Rules.

Only one transit rule was identified and used in HarborSym: Draft Exceeds Depth Using Tide/Underkeel, and was applied to all reaches.

Vessels Calls. The vessel call lists are made up of forecasted vessel calls for a given year as generated by the BLT (see Section 4.1.3). Each vessel call list contains the following information: arrival date, arrival time, vessel name, entry point, exit point, entry draft, import/export, dock name, dock order, commodity, units, origin/destination, vessel type, dead weight tons, capacity, length overall, beam, draft, flag, tons per inch immersion factor, ETTC, and the route group for which it belongs.

4.1.3 Vessel Call List

The vessel call list for future years was developed using the BLT, a tool within the HarborSym Modeling Suite of Tools. Users must provide data to specify the framework for generating the synthetic vessel call list. The BLT relies on much of the information and data from HarborSym, but has data additional specific requirements. Within the BLT, the input requirements include:

- Commodity forecasts (annual import/export) at each dock;
- Description of the available fleet by vessel class, including:
  - Statistical data describing the cumulative distribution function for deadweight tons of vessels within the class,
  - Regression information for deriving length overall (LOA), beam and design draft from capacity,
  - Regression information for calculating TPI based on beam, design draft, capacity and LOA;
  - The number of potential calls that can be made annually by each vessel class;
- Logical constraints describing:
  - Commodities that can be carried by each vessel class,
  - Vessel classes that can be serviced at each dock,
  - Parameters, defined at the vessel class/commodity level for determination of how individual calls and commodity transfers are generated, such as commodity loading factors, allocation priorities, and commodity flow direction (import or export calls).

Procedures exist, using the Extreme Optimization package and some Access routines, to populate much of the required forecast information based on an examination of an existing vessel call list created from historical data. Statistical measures, commodity transfer amounts, and logical constraints can all be derived from an examination of a set of historical calls that have been stored in a HarborSym database. The system populator function facilitates data entry by providing a basis for the forecasts, which the user can edit as necessary.

4.1.3.1 BLT Loading Algorithm

With the user provided input requirements, the BLT creates and loads a synthetic fleet according to the following steps.

1. Generation of a fleet of specific vessels based upon a known number of vessel calls by class and a statistical description of the characteristics of the vessel class. This process begins by generating one specific vessel for each call in the class. The capacity of the vessel is set by a random draw from the cumulative density function that is stored for the class. Based on the regression coefficients that are stored for the class, each of which is of the form:

   - log (parameter) = a + b* log (Capacity)
   - LOA, Beam and Design Draft are determined for the vessel using a linear regression of the form:

   TPI = a + b*Beam + c*Design Draft + d*Capacity + e*LOA

   - The TPI is calculated based on the previously generated physical characteristics and coefficients stored, at the class level, for this regression model. This process is repeated until a unique vessel is created for each available call in the forecast. If no TPI is generated, the default TPI specified by the user for the vessel class is assigned.

2. Attempt to assign a portion of the commodity forecast at a dock to a vessel. Each commodity forecast at a dock is processed in turn. If a vessel is available that can serve the commodity at the dock, it is loaded for either export only, import only, or both export and import. Potential vessels that can carry the forecast are assigned in a user-specified (at the class level) allocation order, so that the most economical vessel classes will always be used first. Under the current assumptions, a vessel call handles a single commodity at a single dock, i.e., each call consists of a single dock visit and a single commodity transfer (which may contain both an export quantity and an import quantity). The specification of the actual call assignment and commodity loading is dependent upon the maximum that a vessel can draft and still reach and leave the dock.

   - The amount of the commodity forecast that is actually carried on the vessel is used to decrement the remaining quantity to be allocated for that particular commodity forecast. After a single vessel call is assigned to a particular forecast, the total number of remaining available vessels for the class is decremented and the next commodity forecast in turn is processed. That is, each forecast attempts to have a portion of its demand satisfied by a single vessel call and then the next forecast is processed. This is to prevent all of the most efficient vessels from being assigned to a single commodity forecast.
   - This process proceeds, in a loop, continually attempting to assign commodity to a vessel from the remaining available fleet. Whenever a successful assignment is made, this generates a vessel call, dock visit, and the associated commodity transfer. This effort continues until no more assignments to a vessel call can be made, either because all commodity forecasts have been satisfied or there is no available vessel that can service the remaining quantities (because there is no vessel of the required class that can handle the particular commodity/dock combination of the forecast or because no vessel can be loaded to satisfy the dock controlling depth constraint).

3. At the end of the process, when no more assignments are possible, arrival times are assigned for each vessel. The algorithm used to assign arrival times assumes a uniform inter-arrival time for all calls within a class. After the allocation process is complete, the number of calls made by each class of vessel is known. This is used to calculate the inter-arrival time of vessels for that class. The arrival of the first vessel in the class is set randomly at a time between the start of the year and the calculated inter-arrival time, but all subsequent vessel arrivals for the class will have the identical inter-arrival time.

4. The generated vessel calls are written to a HarborSym vessel call database and the user is presented with output information on which commodity forecasts were satisfied, any remaining unsatisfied forecasts and detailed information on each vessel loading and the vessels that were used to satisfy each commodity forecast.

The intended approach is for the user to work iteratively within the BLT, making runs, examining the forecast satisfaction that is achieved and varying the fleet character and composition for subsequent runs, so that the final result is a balanced, reasonable projection of vessel calls to satisfy the input forecast demand. The BLT provides extensive output to assist the user in this regard.

Once a vessel is determined to be available for loading for a particular forecast, the BLT must determine the type of loading, the quantity loaded, and the arrival draft of the vessel. The user can control certain aspects of the process through data specification, in particular the type of call (import, export or both) and the percent of capacity that is loaded for import and export, as described below.

Any given vessel call can attempt to satisfy an import demand (arrive with cargo for the port, leave empty), an export demand (arrive empty, leave with cargo loaded at the port) or simultaneously an import and export demand (that is, arriving with cargo to unload at the port [import], and then departing with cargo bound for another port [export]), based on the user defined directional movement assigned to the vessel class. Four possibilities are defined for this behavior, with specification at the Vessel Class/Commodity Category level:

- Export Only
- Import Only
- Random
- Both Export and Import

Certain combinations of class and commodity categories might be exclusively import only or export only. A "Random" assignment designates that calls from the class/commodity combination can be either import or export at a dock, but not both simultaneously. If a "Random" type is assigned, then the ratio of calls that will be randomly generated as import is specified.

The quantity of a vessel's capacity that is to be loaded for satisfaction of the import and export demands is described, again at the Vessel Class/Commodity Category level, by a triangular distribution that specifies a loading factor. A minimum, most likely, and maximum, in percent of total available capacity, is defined for both export and import.

When a vessel is available for satisfying a demand, first the type of satisfaction (import only, export only, random or both) is determined, as noted above. If "random" is associated with the current class/commodity, then a random draw is made from a uniform distribution and compared with the user-specified import ratio, to determine if the call is import only or export only. For example, if the user has entered a value of 70 percent for imports, indicating that 30 percent of the calls are exports, then a random draw is made from a uniform (0.1) distribution. If the random number is less than or equal to 0.7, then the call is assigned as an import, otherwise it is assigned as export.

Once the type of call is determined, the BLT must next ascertain how much capacity can be loaded on the vessel while satisfying the draft constraints. The process is similar for both export and import. First, a draw is made from the respective triangular distribution to get a percentage loading factor. This is then applied to the vessel DWT, adjusted to reduce the available tonnage based on allowance for operations, to get a tentative quantity to be loaded. The import/export capacity to be loaded is adjusted only if the available loading capacity is less than the initial calculation.

The tonnage associated with allowance for operations is based on IWR-developed data given fractional allowance for operations as a function of vessel tonnage (DWT), see Figure 31. The additional draft implied by the tentative quantity to be loaded is calculated based on the vessel TPI. A value of empty vessel draft for each vessel has previously been calculated, based on an assumption that the vessel DWT is associated with the vessel design draft. The empty vessel draft from which loading can start is then calculated as:

$$\text{Empty Vessel Draft} = \text{Design Draft} - (\text{DWT}/\text{TPI})/12.0$$

Figure 15. Allowance for Operations by Vessel DWT – Non-containerized Vessels

The total draft associated with the tentative loading is then calculated as the sum of four drafts:

Total Draft (tentative loading) = Empty Vessel Draft + Additional Draft Associated with Tentative Loading + Additional Draft associated with Allowance for Operations + Underkeel Clearance

In order to test the ability of the vessel to arrive at or leave the dock, to this total draft associated with tentative loading must be added the required underkeel clearance (a function of the vessel class). This gives the "test draft" that is checked against the limiting depth to the dock. Note that this is not the same as the eventually calculated arrival draft of the vessel at the bar, which is written to the vessel call data base. If this test draft is greater than the limiting depth to the dock (as defined by user input), the quantity loaded must be reduced, so that the calculated draft is less than the limiting depth to the dock. This calculation is executed to determine if the tentative loading can be reduced sufficiently to meet the dock limiting depth. If so, then the vessel is loaded with the amount of commodity to reach the target draft. If it is not possible to assign a commodity quantity that, when loaded on the vessel, does not exceed the dock limiting depth, then the vessel cannot service the allocation.

Once the commodity allocation has been completed, the vessel loading is known and the arrival draft (at the bar) must be determined. A class level "minimum sailing draft" has been specified by the user at the vessel class level. This minimum sailing draft, or empty vessel draft, reflects the ballasted draft at which a light vessel will sail. If a vessel is handling an export only, then it is assumed to arrive light, at the empty vessel sailing draft. If a vessel is handling an import to the port, then it arrives at the draft associated with the import loading (which may have been reduced to the limiting depth at the dock). It is important to note that underkeel clearance is not included in the arrival draft that is stored in the vessel call database because it does not factor into the actual sailing draft, but, as noted above it is used in checking the constraint associated with the limiting depth to the dock. In practice, underkeel clearance is used in the BLT to handle the depth constraint, but is not incorporated in the actual sailing draft. Underkeel clearance is then added back in as an additional constraint that is applied in HarborSym itself based on sailing rules. In this manner, the arrival draft is consistently calculated based on the sum of empty vessel draft, draft associated with loading, and draft associated with allowance for operations.

The BLT module writes all the needed fields to the vessel call database. Of note is how the ETTC field is handled. Within the BLT, ETTC is populated by simply adding together import tons and export tons, which assumes that all at-sea costs for a vessel call generated by the BLT are allocated to the subject port.

4.1.3.2 BLT Data Inputs

The bulk fleet was developed using historical calls from July 1, 2012 to June 30, 2013. The table below provides the resulting bulk vessel fleet.

Table 15. Vessel Fleet Forecasts

Existing Condition 30 Foot

	2018	2025-2067
Handy	15	16
Handymax	7	8
Supramax	10	15
Panamax	50	65
Total	82	104

32 Foot

	2018	2025-2067
Handy	10	15
Handymax	8	8
Supramax	10	12
Panamax	47	60
Total	75	95

34 Foot

	2018	2025-2067
Handy	8	14
Handymax	7	0
Supramax	10	19
Panamax	44	55
Total	69	87

37 Foot

	2018	2025-2067
Handy	8	6
Handymax	5	7
Supramax	10	15
Panamax	40	50
Total	63	78

Table 16. Vessel Load Factors

Vessel Class	30 FOOT CHANNEL		
	Minimum	Average	Maximum
Handy (<40k DWT)	50%	66%	80%
Handymax (40k - 50k DWT)	32%	41%	46%
Supramax (50k - 60k DWT)	29%	37%	43%
Panamax (70k - 75k DWT)	21%	44%	58%

Vessel Class	32 FOOT CHANNEL		
	Minimum	Average	Maximum
Handy (<40k DWT)	56%	72%	86%
Handymax (40k - 50k DWT)	38%	47%	52%
Supramax (50k - 60k DWT)	35%	43%	49%
Panamax (70k - 75k DWT)	27%	50%	64%

Vessel Class	34 FOOT CHANNEL		
	Minimum	Average	Maximum
Handy (<40k DWT)	62%	78%	92%
Handymax (40k - 50k DWT)	44%	53%	58%
Supramax (50k - 60k DWT)	41%	49%	55%
Panamax (70k - 75k DWT)	33%	56%	70%

Vessel Class	37 FOOT CHANNEL		
	Minimum	Average	Maximum
Handy (<40k DWT)	71%	87%	92%
Handymax (40k - 50k DWT)	53%	62%	67%

Supramax (50k - 60k DWT)	50%	58%	64%
Panamax (70k - 75k DWT)	39%	65%	79%

Note: per the Immersion Factors by class from the IWR Vessel Characteristics spreadsheet, load factors were increased 3% per foot of deepening. Except when a cap of 92% was reached for the Handy vessels

4.2 Origin-Destination Transportation Cost Savings Benefits by Project Depth

Transportation cost benefits were estimated using the HarborSym Economic Reporter, a tool that summarizes and annualizes HarborSym results from multiple simulations. This tool collects the transportation costs from various model run output files and generates the transportation cost reduction for all project years, and then produces an Average Annual Equivalent (AAEQ). Results and calculations were verified using spreadsheet models as well.

Transportation costs were estimated for a 50-year period of analysis for the years 2018 through 2067. Transportation costs were estimated using HarborSym for the years 2018 and 2025. Since forecasted capacity is expected to be reached in 2025, the transportation costs were held constant beyond 2025. The present value was estimated by interpolating between the modeled years and discounting at the current FY 2015 Federal Discount rate of 3.375 percent. Estimates were determined for each alternative project depth.

The table below provides the annual transportation costs in total and for the at-sea and in-port portions. The transportation cost saving benefit is provided in Table 18. The AAEQ transportation costs and cost saving benefits are provided in Table 19. AAEQ cost statistics are also provided (Table 20).

Table 17. Origin-Destination Annual Transportation Cost (in Million $)

Year	30	32	34	37
2018	**$31.4**	**$28.1**	**$25.9**	**$23.5**
2019	$32.3	$28.9	$26.5	$24.4
2020	$33.2	$29.7	$27.1	$25.3
2021	$34.1	$30.6	$27.7	$26.1
2022	$35.1	$31.4	$28.2	$27.0
2023	$36.0	$32.2	$28.8	$27.9
2024	$36.9	$33.0	$29.4	$28.8
2025	**$37.9**	**$33.8**	**$30.0**	**$29.7**
2026-2067	$37.9	$33.8	$30.0	$29.7

Table 18. O-D Annual Transportation Cost Saving Benefits by Channel Depth (in Million $)

Year	32	34	27
2018	$3.2	$5.4	$7.9
2019	$3.4	5.8	$7.9
2020	$3.5	$6.1	$8.0
2021	$3.6	$6.5	$8.0
2022	$3.7	$6.8	$8.0
2023	$3.8	$7.2	$8.1
2024	$4.0	$7.6	$8.1
2025	$4.1	$7.9	$8.1
2026-2067	$4.1	$7.9	$8.1

Table 19. Origin-Destination AAEQ Transportation Cost and Cost Saving Benefits by Project Depth (Million $)

Project Depth	OD AAEQ Transportation Cost (Million $)	OD AAEQ Transportation Cost Savings (Million $)
30	$36.9	-
32	$32.9	$4.0
34	$29.3	$7.5
37	$28.8	$8.1

Table 20. Origin-Destination AAEQ Cost Statistics by Project Depth (Million $)

Statistic	30	32	34	37
Mean	$36.9	$32.9	$29.3	$28.8
Standard Deviation	$0.6	$0.7	$0.5	$0.8
Median	$36.9	$32.9	$29.3	$28.8
Min	$34.2	$30.9	$27.9	$26.6
Max	$38.6	$35.2	$31.1	$30.8
Range	$4.4	$4.4	$3.2	$4.2
Confidence for Mean +/-	$0.04	$0.05	$0.03	$0.06

Note: Confidence calculation assumes a normal distribution and 95 percent confidence level

Table 21 provides the OD cost saving benefits for the benefiting trade routes for each alternative depth.

Table 21. Origin-Destination AAEQ Transportation Cost Saving Benefits by Route Group and Project Depth (Million $)

	32		34		37		
Route Group	$	% TOT	$	% TOT	$	% TOT	
Aus-Van	-0.5	-13.7%	0.0	0%	0.5	5.7%	
Can-Can	0.7	18.9%	1.8	23.7%	3.0	36.9%	
Can-Mex	0.0	0%	0.0	0%	0.0	0%	
CentAm-Chi	0.7	16.5%	0.2	2.1%	1.2	14.4%	
Chi-Chi	0.9	22.2%	1.7	3%	1.6	19.1%	
Chi-May	0.8	21.1%	3.8	49.9%	1.4	16.6%	
Chi-SK	0.0	0.0%	2.1	28.1%	0.5	6.2%	
Mex-SK	0.5	12.1%	-1.3	-17.5%	-0.2	-1.8%	
Pusan SK	0.0	0.0%	1.6	20.8%	0.4	4.3%	
SD-Chi	1.0	24.9%	-0.7	-8.9%	0.0	0%	

Note: Totals affected by rounding.

4.4 Transportation Cost Saving Benefit Analysis

The benefit cost analysis presented in this section is for the project depths determined to be the most likely selected plans based on the OD benefits and the rough order cost analysis. Tables 22 through 24 below provide the Origin-Destination benefit cost analysis for the 32, 34, and 37 at three different disposal sites. As shown, the 32 depth provides the greatest total net benefits in the OD analysis between either the Deep Ocean Disposal Site or the Cullinan disposal area.

Table 22. Origin-Destination Benefit Cost Analysis (Million $) SF-DODS

Project Depth	Total AAEQ Costs	O-D AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
32	$3.5	$4.0	$0.5	-	1.2
34	$7.2	$7.5	$0.3	-$0.2	1.1
37	$13.8	$8.1	-$5.7	-$6.0	0.6

Table 23. Origin-Destination Benefit Cost Analysis (Million $) Cullinan

Project Depth	Total AAEQ Costs	O-D AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
32	$3.5	$4.0	$0.5	-	1.2
34	$7.1	$7.5	$0.4	-$0.1	1.1
37	$14.2	$8.1	-$6.1	-$6.5	0.6

Table 24. Origin-Destination Benefit Cost Analysis (Million $) Montezuma

Project Depth	Total AAEQ Costs	O-D AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
32	$3.6	$4.0	$0.4	-	1.1
34	$7.7	$7.5	-$0.2	-$0.6	0.9
37	$14.8	$8.1	-$6.7	-$6.5	0.6

The AAEQ costs estimates include increases in annual costs for O&M dredging due to increased shoaling and increased maintenance.

5.0 Sensitivity Analysis

5.1 Discussion

In the interest of further testing the sensitivity of project justification to uncertainty in parameters, future scenarios must be assessed. The analysis of these scenarios is intended to illustrate the effect of changes in different assumptions on project benefits and project justification. There are both microeconomic and macroeconomic risks that add to the uncertainty of the commodity forecasts. The microeconomic risk is the company-specific risk that stems from issues such as permitting, project financing, commodity prices, etc.

The broader macroeconomic risk is associated with factors such as overall economic growth in the U.S. and its major trading partners, and the unemployment rate. For example, the domestic demand for sand and aggregates is closely tied to growth in the residential and non-residential construction industries. As the overall U.S. economic growth recovers, the construction industry is expected to follow suit, which will increase demand

While all of the shippers are exposed to both microeconomic and macroeconomic risks, sand and aggregate is primarily associated with macroeconomic risk and is estimated to have the lowest level of overall risk. The facilities are already constructed, there is a history of shipping this commodity through the Port, and there are no foreseeable regulatory or permitting challenges that would delay or prevent imports from moving through the Port. Alternatively, the greater risk to scrap metal is connected primarily to the overall health of Asian economies, China's being the most important.

At this time not enough information is known to be able to assign probabilities to any of the alternative scenarios. They are simply intended to provide information to help decision-makers understand the economic risk associated with the Tentatively Selected Plan. In all likelihood based upon the HarborSym model runs and the modest positive economic benefits reported above, without sustained growth in the tonnage of benefiting commodities moving through the channel, no deepening project is economically justified.

6.0 Multiport Analysis

This multiport analysis presents the results of a systematic assessment of potential effects the deepening of the Port of Redwood City could have on other ports. The analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput and sea, port and land-based transportation options and costs. Since the purpose of a multiport analysis is to estimate potential changes in the with-project condition traffic forecasts, only the commodities affecting benefits and handled by alternative ports were analyzed.

The intent of the multi-port analysis introduced above is to understand the potential for regional shifts in commodity flows between the region's ports. An important component of this analysis is an estimate of the total delivered cost (also known as delivered price) of each of the relevant, overlapping commodities at each of the regional ports. The estimates were also developed by IHS Global Insight as part of the broader contract that included commodity forecasts. The total delivered cost is defined here as the cost per metric ton to deliver the commodity to the appropriate hinterland counties, and it is comprised of both landside and waterside costs – including port-specific charges such as dockage fees. This is an important component of the analysis because it provides an indication of the relative competitiveness of two or more ports that share a commodity (or have substituting products) and also have some product market or hinterland overlap. Large differences between ports for a particular commodity could signal a future shift to the lower cost port. In general, the IHS Global Insight analysis finds that the consideration of the delivered cost of commodities that are shipped (or anticipated to ship) through both the Port of Redwood City and other regional ports—specifically West Sacramento and Stockton should not alter the commodity forecasts; either the cost differential is too small to make a material difference, or there are good reasons why regional competition is limited into the foreseeable future.

The Port of Redwood City deepening project alone will not cause traffic to be diverted from or to other ports. Other factors involved in port developments such as new facilities, location of distribution centers, and landside transportation improvements appear to have a greater influence on cargo diversions.

7.0 Regional Economic Development Analysis

The regional economic development (RED) account measures changes in the distribution of regional economic activity that would result from each alternative plan. Evaluations of regional effects are measured using nationally consistent projection of income, employment, output and population.

7.2 Regional Analysis

The USACE Online Regional Economic System (RECONS) is a system designed to provide estimates of regional, state, and national contributions of federal spending associated with Civil Works and American Recovery and Reinvestment Act (ARRA) Projects. It also provides a means for estimating the forward linked benefits (stemming from effects) associated with non-federal expenditures sustained, enabled, or generated by USACE Recreation, Navigation, and Formally Utilized Sites Remedial Action Program (FUSRAP). Contributions are measured in terms of economic output, jobs, earnings, and/or value added. The system was used to perform the regional analysis for the Port of Redwood City Channel Improvement Project.

This report provides estimates of the economic impacts of Civil Works Budget Analysis for New Analysis Project. The Corps' IWR, the Louis Berger Group, and Michigan State University developed RECONS to provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Work program spending, and stem-from effects for Ports, Inland Water Way, FUSRAP, and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE project locations. These multipliers were then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates.

Table 25 provides the project information while Table 26 provides the economic impact regions for the Port of Redwood City analysis.

Table 25. Project Information

Project Name:	Port of Redwood City
Project ID:	
Division:	SWD
District:	San Francisco District
Type of Analysis:	Civil Works Budget Analysis
Business Line:	Navigation
Work Activity:	CWB - Navigation Construction

Table 26. Economic Impact Regions

Regional Impact Area:	Metropolitan Area Generic Model
Regional Impact Area ID:	METRO
Counties included	
State Impact Area:	California

National Impact:	Yes

7.2 Results of the Economic Impact Analysis

The RED impact analysis was evaluated at three geographical levels: Local, State, and National. The Local analysis represents the Redwood City impact area which encompasses the area included in about a 50-mile radius around the project area. The State level analysis includes the State of California. The National level includes the 48 contiguous U.S.

Table 27 displays the overall spending profile that makes up the dispersion of the total project construction cost among the major industry sectors. The spending profile also identifies the geographical capture rate, also called Local Purchase Coefficient (LPC) in RECONS, of the cost components. The geographic capture rate is the portion of USACE spending on industries (sales) captured by industries located within the impact area. In many cases, IMPLAN's trade flows Regional Purchase Coefficients (RPCs) are utilized as a proxy to estimate where the money flows for each of the receiving industry sectors of the cost components within each of the impact areas.

Table 27. Input Assumptions (Spending and LPCs)

Category	Spending (%)	Spending Amount	Local LPC (%)	State LPC (%)	National LPC (%)
Dredging Fuel	6%	$4,401,150	52%	84%	90%
Metals and Steel Materials	4%	$3,102,450	29%	56%	90%
Textiles, Lubricants, and Metal Valves and Parts (Dredging)	2%	$1,515,150	17%	43%	65%
Pipeline Dredge Equipment and Repairs	5%	$3,751,800	32%	51%	100%
Aggregate Materials	3%	$2,092,350	75%	79%	97%
Switchgear and Switchboard Apparatus Equipment	0%	$216,450	25%	42%	80%
Hopper Equipment and Repairs	2%	$1,370,850	3%	10%	97%
Construction of Other New Nonresidential Structures	14%	$9,812,400	84%	100%	100%
Industrial and Machinery Equipment Rental and Leasing	7%	$5,266,950	71%	99%	100%
Planning, Environmental, Engineering and Design Studies and Services	5%	$3,318,900	60%	100%	100%
USACE Overhead	7%	$4,761,900	85%	85%	100%
Repair and Maintenance Construction Activities	4%	$2,958,150	85%	100%	100%
Industrial Machinery and Equipment Repair and Maintenance	11%	$7,575,750	89%	100%	100%
USACE Wages and Benefits	13%	$9,595,950	75%	100%	100%
Private Sector Labor or Staff Augmentation	15%	$11,038,950	100%	100%	100%
All Other Food Manufacturing	2%	$1,370,850	28%	75%	90%
Total	**100%**	**$72,150,000**	**-**	**-**	**-**

The USACE is planning on expending $72,150,000 on the project. Of this total project expenditure $52,150,000 will be captured within the regional impact area. The rest will be leaked out to the state or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity in that can be measured in jobs, income, sales and gross regional product as summarized in the following table and includes impacts to the region, the State impact area, and the Nation. Table 28 is the overall economic impacts for this analysis.

The labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income. The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues The GRP, which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. An interesting note is that in the local geography, one job averages an annual wage of $55,227, the State equivalent is $57,877 and the National equivalent is $58,044 (labor income/job). The total impact, direct and secondary, yields a local average wage of $51,975, State average wage of $56,710, and $56,081 average wage at the national level.

Table 28. Overall Summary of Economic Impacts

Impacts	Impact Areas	Regional	State	National
Total Spending		$72,150,000	$72,150,000	$72,150,000
Direct Impact				
	Output	$52,149,509	$64,456,952	$70,559,556
	Job	590.11	659.76	690.49
	Labor Income	$32,590,295	$38,185,201	$40,079,145
	GRP	$37,123,891	$44,267,690	$46,857,149
Total Impact				
	Output	$96,025,942	$133,853,729	$187,820,008
	Job	920.86	1,091.24	1,397.00
	Labor Income	$47,861,879	$61,884,605	$78,346,445
	GRP	$63,327,501	$85,616,390	$113,138,201

Tables 29, 30, and 31 present the economic impacts by industry sector both for each geographical region. Note that Labor -5001- is the largest impact area at the regional, state and national levels, implying that all the labor demand can be met at the regional level. Impacts at the National level show a tremendous expansion most certainly due to the many multiple turnover of money that ripples throughout the National economy.

Table 29. Economic Impact at Regional Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$1,745,533	0.21	$57,238	$268,199
171	Steel product manufacturing from purchased steel	$419,285	0.85	$71,481	$86,816
198	Valve and fittings other than plumbing manufacturing	$72,684	0.23	$17,472	$33,748
201	Fabricated pipe and pipe fitting manufacturing	$526,377	1.87	$123,909	$214,617
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$674,008	3.97	$314,232	$378,945
268	Switchgear and switchboard apparatus manufacturing	$22,442	0.06	$5,220	$10,807
290	Ship building and repairing	$29,832	0.12	$9,522	$11,497
319	Wholesale trade businesses	$1,395,556	7.93	$620,421	$1,090,026
322	Retail Stores - Electronics and appliances	$5,754	0.06	$2,505	$3,278
323	Retail Stores - Building material and garden supply	$377,621	4.54	$180,025	$258,992
324	Retail Stores - Food and beverage	$8,241	0.14	$4,242	$6,071
326	Retail Stores - Gasoline stations	$110,711	1.57	$45,591	$77,501
332	Transport by air	$1,969	0.01	$472	$860
333	Transport by rail	$63,724	0.18	$20,276	$34,322
334	Transport by water	$13,083	0.03	$2,775	$5,804
335	Transport by truck	$959,212	7.37	$433,975	$521,260
337	Transport by pipeline	$18,887	0.03	$6,293	$6,019
36	Construction of other new nonresidential structures	$8,194,773	57.29	$3,018,880	$3,606,379
365	Commercial and industrial machinery and equipment rental and leasing	$3,755,189	12.77	$987,620	$2,064,421
375	Environmental and other technical consulting services	$1,976,650	16.98	$1,377,438	$1,382,365
386	Business support services	$4,063,840	71.05	$2,510,454	$2,485,502
39	Maintenance and repair construction of nonresidential structures	$2,528,814	19.85	$1,053,417	$1,268,340
417	Commercial and industrial machinery and equipment repair and maintenance	$6,731,829	61.53	$4,118,800	$5,018,155
439	* Employment and payroll only (federal govt, non-military)	$7,196,963	61.07	$6,538,148	$7,196,962
5001	Labor	$11,038,950	259.81	$11,038,950	$11,038,950
69	All other food manufacturing	$217,581	0.60	$30,941	$54,053
	Total Direct Effects	$52,149,509	590.11	$32,590,295	$37,123,891
	Secondary Effects	$43,876,433	330.75	$15,271,585	$26,203,609
	Total Effects	**$96,025,942**	**920.86**	**$47,861,879**	**$63,327,501**

Table 30. Economic Impact at State Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$3,076,305	0.36	$102,770	$477,893
171	Steel product manufacturing from purchased steel	$1,216,324	2.47	$219,018	$266,531
198	Valve and fittings other than plumbing manufacturing	$447,520	1.45	$114,210	$221,517
201	Fabricated pipe and pipe fitting manufacturing	$1,145,657	4.11	$269,687	$467,114
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$714,759	4.23	$333,230	$401,856
268	Switchgear and switchboard apparatus manufacturing	$54,711	0.15	$12,726	$26,345
290	Ship building and repairing	$114,798	0.47	$38,949	$46,837
319	Wholesale trade businesses	$1,654,798	9.41	$735,672	$1,292,512
322	Retail Stores - Electronics and appliances	$6,909	0.07	$3,089	$4,043
323	Retail Stores - Building material and garden supply	$377,621	4.54	$180,025	$258,992
324	Retail Stores - Food and beverage	$9,571	0.17	$4,927	$7,051
326	Retail Stores - Gasoline stations	$118,176	1.67	$48,693	$82,726
332	Transport by air	$3,146	0.01	$804	$1,440
333	Transport by rail	$65,794	0.19	$20,935	$35,437
334	Transport by water	$16,636	0.03	$3,529	$7,380
335	Transport by truck	$1,019,310	7.84	$461,220	$554,022
337	Transport by pipeline	$22,887	0.04	$8,399	$8,046
36	Construction of other new nonresidential structures	$9,812,400	68.60	$3,680,438	$4,437,630
365	Commercial and industrial machinery and equipment rental and leasing	$5,209,759	17.71	$1,370,174	$2,872,987
375	Environmental and other technical consulting services	$3,317,155	29.29	$2,311,575	$2,319,843
386	Business support services	$4,063,840	71.05	$2,510,454	$2,485,502
39	Maintenance and repair construction of nonresidential structures	$2,953,806	23.18	$1,242,394	$1,507,749
417	Commercial and industrial machinery and equipment repair and maintenance	$7,575,750	69.24	$4,639,390	$5,647,245
439	* Employment and payroll only (federal govt, non-military)	$9,592,333	81.40	$8,716,196	$9,592,333
5001	Labor	$11,038,950	259.81	$11,038,950	$11,038,950
69	All other food manufacturing	$828,038	2.29	$117,750	$205,708
	Total Direct Effects	$64,456,952	659.76	$38,185,201	$44,267,690
	Secondary Effects	$69,396,777	431.47	$23,699,404	$41,348,700
	Total Effects	**$133,853,729**	**1,091.24**	**$61,884,605**	**$85,616,390**

Table 31. Economic Impact at National Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$3,295,347	0.39	$119,814	$551,902
171	Steel product manufacturing from purchased steel	$2,247,333	4.57	$409,863	$499,001
198	Valve and fittings other than plumbing manufacturing	$776,960	2.51	$199,232	$386,546
201	Fabricated pipe and pipe fitting manufacturing	$2,962,983	10.69	$711,768	$1,237,973
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$1,033,539	6.23	$481,850	$581,083
268	Switchgear and switchboard apparatus manufacturing	$135,333	0.38	$31,955	$65,936
290	Ship building and repairing	$1,311,444	5.37	$453,390	$544,549
319	Wholesale trade businesses	$1,677,235	9.53	$745,647	$1,310,037
322	Retail Stores - Electronics and appliances	$6,926	0.07	$3,098	$4,055
323	Retail Stores - Building material and garden supply	$387,360	4.65	$184,701	$265,753
324	Retail Stores - Food and beverage	$9,596	0.17	$4,939	$7,069
326	Retail Stores - Gasoline stations	$118,828	1.68	$48,964	$83,183
332	Transport by air	$4,194	0.02	$1,100	$1,959
333	Transport by rail	$85,578	0.24	$27,253	$46,129
334	Transport by water	$24,094	0.05	$5,110	$10,739
335	Transport by truck	$1,081,135	8.31	$489,248	$587,727
337	Transport by pipeline	$48,396	0.08	$21,831	$20,970
36	Construction of other new nonresidential structures	$9,812,400	68.60	$3,680,438	$4,437,630
365	Commercial and industrial machinery and equipment rental and leasing	$5,259,256	17.88	$1,383,191	$2,900,501
375	Environmental and other technical consulting services	$3,318,460	29.30	$2,312,484	$2,320,756
386	Business support services	$4,760,397	83.22	$2,974,050	$2,944,291
39	Maintenance and repair construction of nonresidential structures	$2,957,307	23.21	$1,243,951	$1,509,721
417	Commercial and industrial machinery and equipment repair and maintenance	$7,575,750	69.24	$4,639,390	$5,647,245
439	* Employment and payroll only (federal govt, non-military)	$9,595,949	81.43	$8,719,484	$9,595,949
5001	Labor	$11,038,950	259.81	$11,038,950	$11,038,950
69	All other food manufacturing	$1,034,807	2.86	$147,443	$257,497
	Total Direct Effects	$70,559,556	690.49	$40,079,145	$46,857,149
	Secondary Effects	$117,260,453	706.51	$38,267,300	$66,281,052
	Total Effects	**$187,820,008**	**1,397.00**	**$78,346,445**	**$113,138,201**

Table 32. Top Ten Industries Affected by Work Activity (2008)

Project:	New Analysis
Business Line:	Navigation
Work Acitiy:	CWB - Navigation

The following table shows the top ten industries that typically benefit from the types of expenditures made for this project by the USACE. This analysis was conducted at the national level and thus it cannot be guaranteed that these industries would be present in the regional impact area as analyzed.

Table 33. Top Ten Industries that Benefit from Project Expenditures

Rank	Industry (millions)	IMPLAN No.	% of Total Employment
1	* Employment and payroll only (federal govt, non-military)	439	8 %
2	Business support services	386	7 %
3	Construction of other new nonresidential structures	36	6 %
4	Food services and drinking places	413	5 %
5	Commercial and industrial machinery and equipment repair and maintenance	417	4 %
6	Real estate establishments	360	3 %
7	Wholesale trade businesses	319	3 %
8	Employment services	382	3 %
9	Maintenance and repair construction of nonresidential structures	39	3 %
10	Offices of physicians, dentists, and other health practitioners	394	2 %
			43 %