Chicago Area Waterway System

Dredged Material Management Plan & Integrated Environmental Assessment

APPENDIX B: ECONOMIC ANALYSIS

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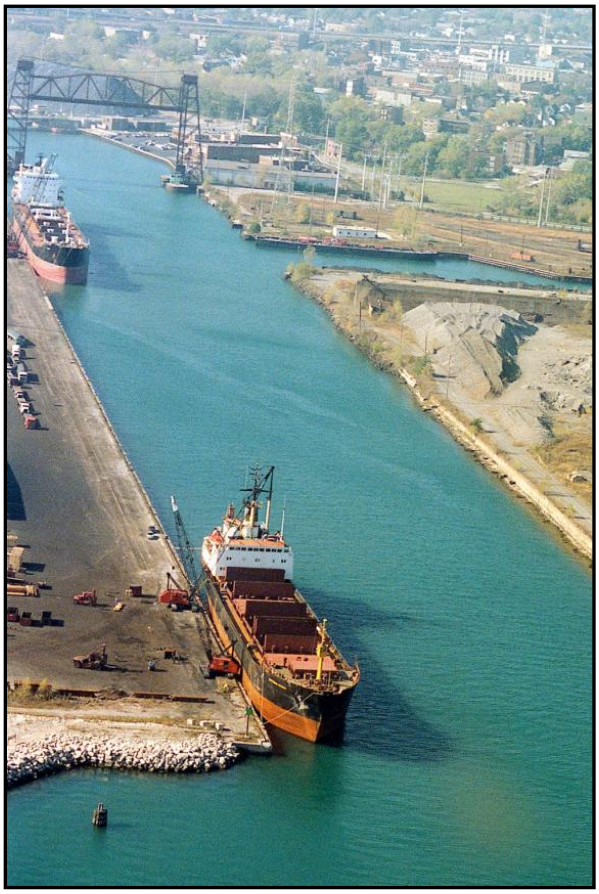

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June 2015

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CHICAGO AREA WATERWAY SYSTEM
DREDGED MATERIAL MANAGEMENT PLAN

Appendix B
Economic Analysis

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1 EXECUTIVE SUMMARY

The Chicago Area Waterway System (CAWS) Dredged Material Management Plan (DMMP) seeks to develop alternative plans that will allow for continued operation and maintenance dredging of Calumet Harbor and River and the Calumet Saganashkee Channel (Calumet-Sag) over a 25-year project evaluation period, beginning in year 2019. *This economic analysis seeks to determine the least cost, economically justified base plan.*

This economic appendix first presents the economic viability of Calumet Harbor and River, and the Calumet-Sag. Channel dimensions at Calumet Harbor and River (28 feet; 27 feet low water datum, respectively) allow for deep-draft (greater than 12 feet) and shallow draft (less than or equal to12 feet) vessels to move commodities at a specific transportation cost. Discontinued maintenance of the channels would allow shoaling to occur. Reduced channel dimensions could decrease the efficiency of moving goods on the waterway and increase the associated shipping costs. Shoaling during the 25-year period would occur at a rate that would affect the deep-draft traffic at Calumet Harbor and River, but not the shallow-draft traffic. The benefits associated with continued maintenance of the channels are the *avoided* increases in vessel transportation costs; average annual benefits are estimated at $5,147,000.

Channel dimensions at the Calumet-Sag (11 feet Chicago City datum) allow for shallow draft vessels to move commodities at a specific transportation cost. Discontinued channel maintenance would allow shoaling to occur. Reduced channel dimensions could decrease the efficiency of moving goods on the waterway and increase the associated shipping costs. Since almost all of the traffic utilizing the Calumet-Sag is through-traffic, all vessels would have to accommodate the reduced channel dimensions. The benefits associated with continued maintenance of the channels are the *avoided* increases in vessel transportation costs; average annual benefits are estimated at $3,920,000.

Three plans, including the Ridgeland, Republic, and LTV plans, were formulated to allow for continued channel maintenance at Calumet Harbor and River and the Calumet-Sag. Each plan addresses the need for a total of 1,330,000 cubic yards of sediment to be removed from the channels during the 25-year project evaluation period. The total cost for each plan includes construction of a dredged material management facility, and the dredging needed to maintain the channels. *The "Republic" plan currently presents the least cost alternative; average annual costs for this plan are estimated at $2,793,000.*

In order to establish that the Republic plan is economically justified, the average annual benefits for Calumet Harbor and River and the Calumet-Sag are compared to the average annual costs for the plan. Benefits of Calumet Harbor and River were added to the benefits for the Calumet-Sag ($9,067,000) and then compared to the total average annual costs of the Republic plan ($2,793,000). The Republic plan has positive net benefits ($6,274,000) and a benefit-to-cost ratio (BCR) greater than 1.0 (3.2), and is therefore economically justified.

2 ECONOMIC VIABILITY

Channel dimensions at Calumet Harbor and River (28 feet; 27 feet low water datum, respectively) allow for deep-draft (greater than 12 feet) and shallow draft (less than or equal to12 feet) vessels to move commodities at a specific transportation cost, while the Calumet-Sag is strictly a shallow-draft waterway. Therefore, the economic viability of Calumet Harbor and River's is assessed independently of the Calumet-Sag's.

Continued maintenance of a waterway allows vessels to move commodities through the given channel at a specific transportation cost. The benefits associated with continued maintenance of the channels (future with-project condition; FWP) are the *avoided* increases in vessel transportation costs.

Discontinued maintenance of a channel (future without-project condition; FWOP) would allow shoaling to occur. The reduction in channel dimensions could result in an increase of vessel trips to move the same amount of tonnage, and thus, increased transportation costs. The *avoided increase in transportation costs* is a proxy for the value of continued channel maintenance.

Dredging costs are calculated and subtracted from the transportation benefits, which yields the net benefits associated with a waterway. Net benefits are used to determine the amount of new investment the channels could support while maintaining a positive BCR. The economic viability assessments for Calumet Harbor and River, and the Calumet-Sag are presented sections 2.1 and 2.2.

This economic appendix presents an evaluation of the benefits and costs associated with the 25-year project evaluation period, the first project year (PY1) being Fiscal Year 2019 (FY19).

2.1 Economic Viability of Calumet Harbor and River

2.1.1 Tonnage Assessment

The first step in establishing vessel transportation costs is to identify the tonnage level anticipated to be moved at Calumet Harbor and River over a 25-year period of analysis (the first project year being 2019).

The USACE certified Great Lakes Systems Analysis of Navigation Depths (GL-SAND) model is used to estimate vessel transportation costs associated with tonnage levels for each deep draft waterway on the Great Lakes. The model utilizes annual tonnage levels (for each commodity) as reported by the USACE Waterborne Commerce Statistics Center (WCSC). Specifically, GL-SAND uses a single year's tonnage level to develop transportation costs; therefore, it is critical that the appropriate tonnage level is selected from the WCSC's annual estimates for Calumet Harbor and River.

Tonnage moved on Calumet Harbor and River's Federal channels has the potential to be affected by shoaling. The Federal channel for this project area includes the harbor channels and entire river channel until Lake Calumet. However, shipments with origins or destinations on Calumet River's Federal channel near Lake Calumet are categorized separately by the WCSC, and referred to as "Lake Calumet." *However, in accordance with the project area's Federal channel dimensions, the economic analysis will include all shipments on the Federal channel, and reference this sum as 'Calumet Harbor and River' for the remainder of this appendix – unless otherwise noted.*

The WCSC's estimate of historical annual tonnage levels for Calumet Harbor and River were used to identify trends for this project area, and to assist in the selection of an appropriate forecast. The WCSC's annual tonnage levels are the sum of shipments, receipts, and through-traffic in this project area. Table 1 displays the annual totals for the 10-year period between 2003 and 2012; the maximum tonnage occurs in year 2004, while the minimum occurs in 2009.

Table 1: Calumet Harbor & River Tonnage (Years 2003-2012)

Calendar Year	Calumet Harbor & River Tonnage
2003	12,176,000
2004	16,762,000
2005	16,463,000
2006	16,400,000
2007	16,082,000
2008	14,963,000
2009	11,557,000
2010	11,994,000
2011	14,814,000
2012	12,774,000
Maximum Tonnage: (2003-2012)	**16,762,000**
Associated Year	2004
Minimum Tonnage: (2003-2012)	**11,557,000**
Associated Year	2009
Average Tonnage: (2003-2012)	**14,399,000**

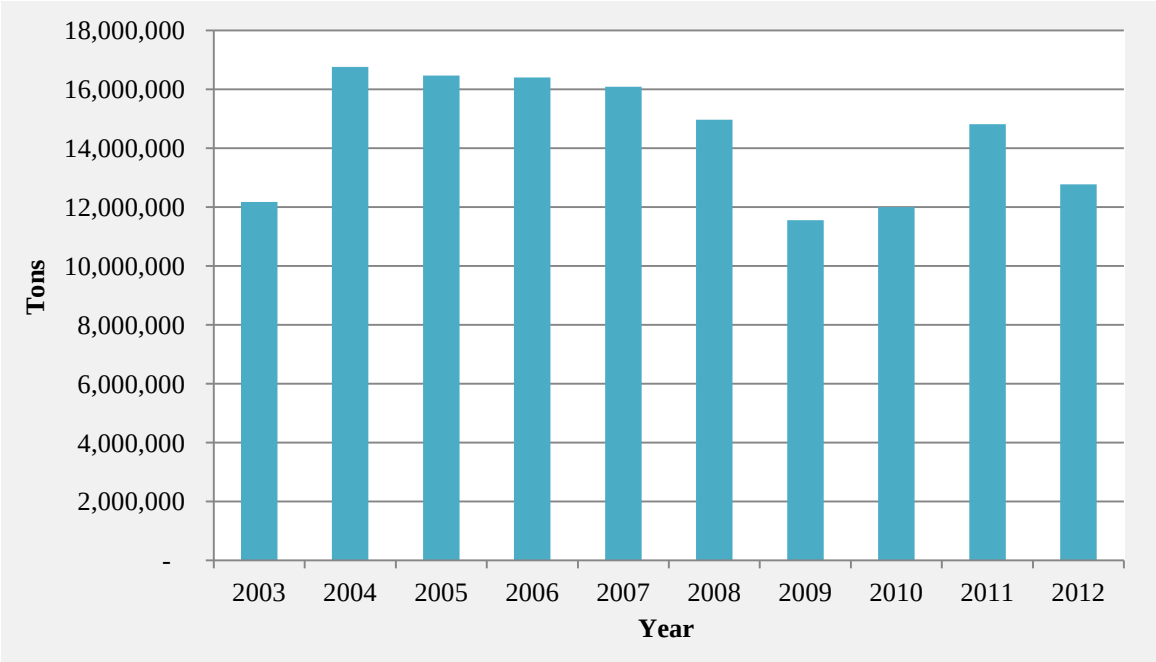
1. Annual tonnage levels were reported by the USACE Waterborne Commerce Statistics Center. Annual totals are the sum of shipments, receipts, and through-traffic in the project area. All values are rounded to the nearest thousand.

Figure 1 illustrates that tonnage levels over the 10-year period are relatively lower between years 2008 and 2012, which are reflective of the years during the most recent U.S. recession (December 2007 through June 2009) and also the years following this economic downturn (2010 through 2012). During this period, consumers' demand for various goods decrease and firms' current inventories build up, thus reducing their demand for newly produced goods. A reduction in demand for new goods implies that there is less need for producers to ship goods to consumers.

However, only minor volatility in tonnage levels occurred between years 2004 and 2007, which is reflective of a healthier economy. However, year 2011 tonnage closely

resembles tonnage levels prior to the onset of the recession in December of 2007. The 2011 total of approximately 14.8 million tons is not only indicative of more recent tonnage and a typical total for Calumet Harbor and River, but also accounts for changes in traffic patterns that may have occurred within the project area as a result of the recession, which are an essential component for GL-SAND's development of transportation cost estimates. *Therefore, year 2011's tonnage volume and associated traffic patterns suggest that this WCSC data set should be utilized within the GL-SAND model as a proxy for future tonnage and associated transportation costs.*

Figure 1: Calumet Harbor & River Tonnage (2003-2012)



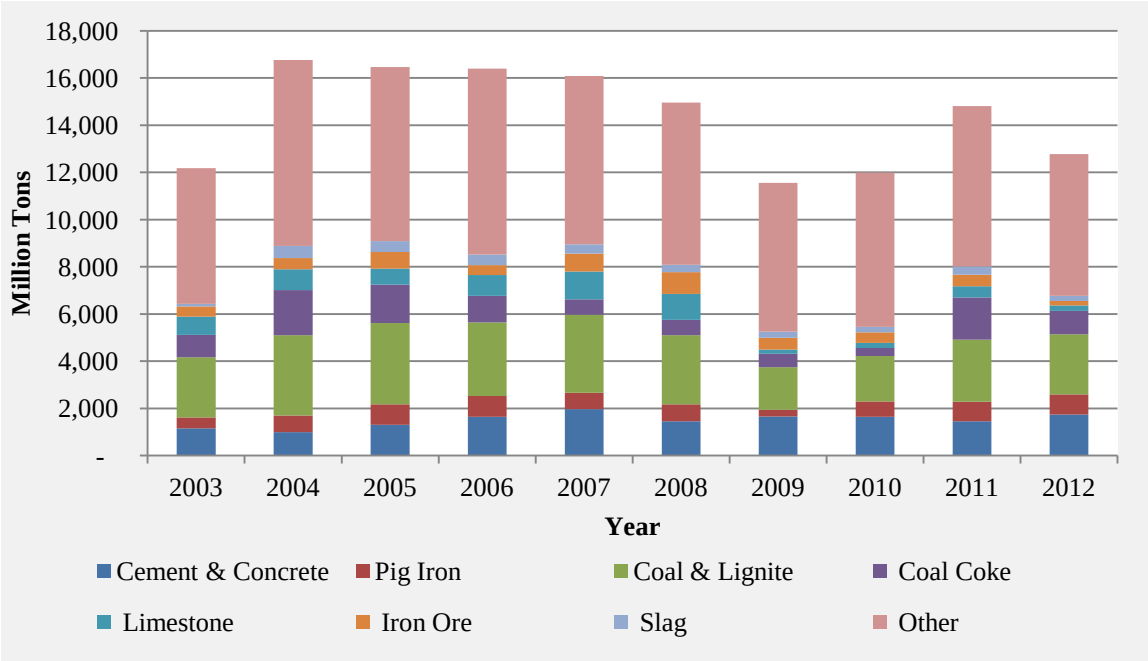
In order to confirm that year 2011's data is an appropriate approximation for use in the economic evaluation of Calumet Harbor and River, it is also important to address trends within the various commodity groups included in the total tonnage estimate. Table 2 identifies the annual tonnage for each commodity group that accounted for the greatest tonnage during the 10-year average (2003 through 2012), and the "other" category which includes the aggregate several commodities that each account for less tonnage on average than those individually listed.

Table 2: Calumet Harbor & River Tonnage by Commodity Type (2003-2012) – Thousand Tons

Year	Cement & Concrete	Pig Iron	Coal & Lignite	Coke Coal	Lime-stone	Iron Ore	Slag	Other	Total
2003	1,164	456	2,542	952	777	429	109	5,747	**12,176**
2004	992	709	3,397	1,910	883	482	512	7,877	**16,762**
2005	1,306	868	3,438	1,632	675	710	458	7,376	**16,463**
2006	1,648	877	3,115	1,127	888	415	456	7,874	**16,400**
2007	1,967	692	3,307	660	1,174	756	399	7,127	**16,082**
2008	1,452	723	2,928	652	1,100	919	310	6,879	**14,963**
2009	1,663	282	1,801	567	176	502	257	6,309	**11,557**
2010	1,649	651	1,916	340	219	446	230	6,543	**11,994**
2011	1,454	823	2,637	1,785	484	484	349	6,798	**14,814**
2012	1,747	851	2,540	999	225	192	210	6,010	**12,774**
10-Yr. Ave.	1,504	693	2,762	1,062	660	534	329	6,854	**14,399**

Table 2 shows that coal accounts for the greatest tonnage at Calumet Harbor and River, with 19 percent of the 10-year average being attributed to this commodity. Year 2011 tonnage closely mirrors this ratio; 18 percent of the 14.8 million tons is attributed to the "coal and lignite" group. Other commodity groups that significantly contribute to the total average tonnage include the cement and concrete (10 percent), and coal coke (7 percent). Again, 2011 tonnage ratios closely mirror this average, with 10 percent of the 14.8 million tons being attributed to cement and concrete, and 12 percent being attributed to coal coke. The "other" group accounted for 46 percent of the 2011 total tonnage, which is similar to its contribution to the 10-year average of 48 percent. Figure 2 displays the annual tonnage for Calumet Harbor and River for years 2003 through 2012 for each commodity group.

Figure 2: Calumet Harbor & River Tonnage by Commodity (2003-2012)



Since coal serves as the greatest single commodity that contributes to the harbor's tonnage, it is important to recognize past and future fluctuations in tonnage at the harbor. Figure 2 shows that there has been variation in coal tonnage at the harbor over the 10-year period between 2003 and 2012, with a general decline in the latter part of this period. In order to determine whether further declines are anticipated, past trends of coal production and consumption, along with future projections approximated by the U.S. Energy Information Administration (EIA), were examined.

Calumet Harbor and River is one of only two harbors on the Great Lakes' western coast (the other being Duluth-Superior Harbor in Minnesota and Wisconsin) that allow for coal to be transferred from rail to waterborne transportation. Calumet Harbor and River is equipped with docks that receive coal by rail from western states and then ship it via waterway vessels.

Intermodal availability is an important feature of this project area, since coal production over the past 30 years has transitioned from Eastern states to those in the West; Western states offer surface mines with low-sulfur coal. Low-sulfur coal is a more desirable commodity since policies regarding sulfur emissions have become stricter. Increases in production costs for high-sulfur coal have therefore resulted in a shift towards demand for less expensive low-sulfur coal. Table 3 shows that overall coal production has shifted from mines located east of the Mississippi River towards those located towards the West. While overall coal production has experienced a total decline of 7 percent between years 2002 and 2012, production from mines located in Western states have only experienced a total decline of 1 percent over this same period.

Table 3: U.S. Coal Production (Thousand Short Tons) by Location Relative to Mississippi River (2002-2012)

Year	Mines East of Mississippi River	% of Total	Mines West of Mississippi River	% of Total	U.S. Total[1]
2002	492,915	45%	601,368	55%	1,094,283
2003	469,247	44%	602,506	56%	1,071,753
2004	484,796	44%	627,303	56%	1,112,099
2005	493,801	44%	637,697	56%	1,131,498
2006	490,798	42%	671,952	58%	1,162,750
2007	478,161	42%	668,474	58%	1,146,635
2008	493,342	42%	678,467	58%	1,171,809
2009	449,594	42%	625,330	58%	1,074,923
2010	446,197	41%	638,171	59%	1,084,368
2011	455,795	42%	638,540	58%	1,094,336
2012	422,152	42%	592,983	58%	1,015,135

1. Annual values reflect those reported by U.S. Energy Information Administration.

The primary consumer of coal is the electric power sector, which consists of firms that provide the public with electricity or electricity and heat. Table 4 displays coal consumption by the United States' electric power sector for alternating years between

2002 and 2012. Coal consumption increased from 2002 through 2006, but then declined from 2008 through 2012. The Midwest region followed this trend, which is generally reflected in declines in coal tonnage at Calumet Harbor and River.

Table 4: United States Coal Consumption (2002-2012) – Electric Power Sector (Thousand Short Tons)

Census Region[1]	2002	2004	2006	2008	2010	2012
Northeast	70,942	74,145	78,763	75,454	56,994	46,794
Midwest	362,035	375,973	378,283	388,129	370,715	315,135
South	421,098	436,244	447,245	449,876	414,103	349,078
West	123,432	129,907	121,329	127,121	123,716	112,581
US Total	**977,507**	**1,016,268**	**1,025,621**	**1,040,580**	**965,528**	**823,587**

1. Values reflect those reported by U.S. Energy Information Administration (EIA). The "Northeast" region includes: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York and Pennsylvania. The "Midwest" region includes: Indiana, Illinois, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota. The "South" region includes: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma and Texas. The "West" region includes: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming, Alaska, California, Hawaii, Oregon and Washington.

Despite historical declines in coal consumption, the EIA's projects that future coal consumption by the electric power sector will not decline further, but rather, experience slight increases until year 2040, which is the final year of its forecast period. Table 5 shows the EIA's projection for coal consumption by the electric power sector for the years between 2015 and 2040; the net change between these years is approximately 6 percent – which indicates that slight increases in coal consumption are expected in the United States.

Table 5: Projections for United States Coal Consumption (Quadrillion BTUs) – Electric Power Sector (2015-2040)

2015	2020	2025	2030	2035	2040
16.55	17.59	17.75	17.63	17.54	17.52

1. Reported annual consumption levels (in quadrillion BTUs) from the Reference Case in the *Annual Energy Outlook 2015* by the U.S. Energy Information Administration (EIA). Note that various factors could alter these projections, including: high or low coal costs, high or low economic growth, or others.

Therefore, while coal tonnage has declined at Calumet Harbor and River in recent years, the 25 year project period will likely stabilize to reflect the steady coal consumption projected by the EIA.

As previously stated, the GL-SAND model, which is utilized to determine vessel transportation costs, requires the selection of a single year's WCSC data to be used to approximate transportation costs on a given Great Lakes waterway. Total tonnage levels at Calumet Harbor and River were relatively low in years 2008 through 2010. However, year 2011 tonnage rebounded to more closely mirror pre-recessionary volumes. Year 2011's volume of 14.8 million tons also reflects recent variations to commodity

composition and the associated vessel traffic. Further, an examination of past and future coal consumption reveals that this dominant commodity will likely continue to serve as a primary contributor to the overall tonnage level. *The WCSC's 2011 data for Calumet Harbor and River is selected for utilization within the GL-SAND model as a proxy for future tonnage and associated transportation costs at the project area.*

2.1.2 Vessel Movements at Calumet Harbor and River

This DMMP considers 25-year project evaluation period (2019 through 2043); given the discontinuation of maintenance dredging, several vessel movements would be adversely impacted by shoaling. Note that the transportation benefits for this analysis are determined by the difference between transportation costs in the FWOP and FWP conditions. This economic viability assessment considers only tonnages moved on deep-draft vessels (i.e., those that draft greater than 12 feet). Given shoaling rates within the Federal channel, only deep-draft movements would be expected to be adversely impacted by the resulting depth reductions. Therefore, all commodities that moved on shallow draft vessels (i.e., those drafting less than or equal to 12 feet), are not considered for this analysis. Shallow draft vessels would experience the same transportation costs in the FWOP and FWP conditions.

As established in Section 2.1.1, this economic analysis will utilize year 2011's reported tonnage levels for Calumet Harbor and River, as these tonnage levels and associated vessel movements are assumed to closely reflect those anticipated to occur annually during the 25-year project evaluation period.

Note that vessel movements at Calumet Harbor and River be generally categorized into the following three types: (1) shipments, (2) receipts, and (3) through-traffic. Through-traffic accounts for vessel movements with origins and destinations outside of the project area - indicating that these vessels are moving through Calumet Harbor and River as a connection point between the inland waterway system and the Great Lakes. Since the inland waterway system is a shallow-draft system, all through-traffic is also shallow draft. Shipments and receipts are either deep-draft or shallow-draft.

Summary statistics for shipments and receipts at Calumet Harbor and River are displayed in Table 6 in order to present the proportion of deep-draft movements; through traffic is not presented since none of the through traffic is moved on deep-draft vessels. Recall, shoaling during the 25-year project evaluation period is not anticipated to affect shallow-draft traffic, and therefore, is not included in the benefit evaluation.

Table 6: Calumet Harbor & River – Projected Deep-Draft Shipments & Receipts

Movement Type	Number of Vessel Movements (a)	Deep-Draft Vessels Movements (b)	Percent Deep Draft Movements (c = b/a)	Tons Shipped or Received (d)	Deep-Draft Tonnage (e)	Percent Deep Draft Tons (f = e/d)
Shipment (S)	982	282	29%	5,408,835	4,320,710	80%
Receipt (R)	2,386	434	18%	6,945,242	3,927,378	57%
Total (S+R)	**3,368**	**716**	21%	**12,354,077**	**8,248,088**	67%

1. Data is from the Waterborne Commerce Statistics Center. Deep-draft vessel movements include vessels drafting greater than or equal to 12 feet, while shallow-draft vessels draft less than 12 feet. This value does not account for through traffic, which is comprised of shallow-draft traffic only.

These vessel movements and corresponding tonnages at Calumet Harbor and River were used to generate vessel transportation costs associated with various harbor and river channel depths. In order to calculate increases in vessel transportation costs for each vessel movement given reductions in channel depth, the Great Lakes Systems Analysis of Navigation Depths (GL-SAND) model was utilized. GL-SAND was developed by the Buffalo District (LRB) in conjunction with the Planning Center of Expertise for Inland Navigation (PCX-IN).

It is a regional model which was developed to measure navigation project performance in the Great Lakes. The model generates transportation costs associated with a range of potential channel depths which are then used to generate a time stream of transportation costs under future without-project (FWOP) and future with-project (FWP) conditions. Information incorporated into the analysis includes harbor and river depths, variable lake levels, vessel characteristics, vessel costs, and the depths of harbors, whether vessels arrive empty and leave full or arrive full and leave empty, locks, and connecting channels. The GL-SAND model also takes into account alternative mode costs when providing transportation costs by channel depth[1].

The GL-SAND model was utilized to generate transportation cost data for vessels (drafting greater than 12 feet) which move the most dominant commodities to and from Calumet Harbor and River and Lake Calumet (since GL-SAND presents this as a

[1] The following description of how the GL-SAND model accounts for alternative mode costs was taken directly from the *Great Lakes-System Analysis of Navigation Depths Model Documentation for Certification*. "Alternative mode costs is comprised of the cost of loading at origin, charge to transfer point, transfer charge, line haul charge, handling at river destination, charge ex river, and cost of unloading at destination… As in the case of the barge-inclusive routings, some all-land routes require the use of more than one transport mode. The inclusion of a prior or subsequent truck at a railhead or the use of shuttle vessels to or from islands or captive shippers has been utilized. Therefore, when appropriate, calculations include all requisite transfer charges and/or storage charges…Alternative mode cost per ton is available for most ODC [Origin-Destination-Commodity] movements. After the water WC/T is obtained, the land-only portion is then added to obtain the final total cost per ton for the "water-land" movement. The All-Land cost per ton is then compared to this "water-land" cost per ton. The smaller of the two becomes the cost per ton for that ODC. The final Cost will either be from the "water-land" cost combination or the All-Land cost."

separate analysis)[2]. Several additional commodities were also shipped and received via these waterways on vessels that drafted greater than 12 feet, but were not modeled in GL-SAND[3]. These commodities include those such as: flat-rolled products of iron and steel, iron and steel bars, hollow profiles of iron and steel, petroleum coke, etc.

GL-SAND includes 41 commodities that are moved on the Great Lakes system, along with the associated vessel movements to the dock level, loading and unloading rates at these docks, along with a great deal of additional information. While GL-SAND identifies and analyzes about 90 percent of the tonnage for most harbors, some harbors have fewer tons modeled.

Approximately 1.9 million tons of commodities moved on deep-draft vessels to and from Calumet Harbor and River were not modeled in GL-SAND. In order to provide a more accurate estimation of the total transportation cost increases that vessels would incur if dredging were to cease, these non-modeled shipments and non-modeled receipts were also included in economic analysis[4].

It is important to note that all deep-draft vessels were included in this economic analysis. Shallow-draft vessels were not included in this economic analysis. This decision is based on the assumption that vessel transportation costs for vessels drafting 12 feet or less would be the same in the FWOP and FWP condition[5].

Transportation cost savings (the avoided increases in transportation costs) are determined by calculating shipping costs associated with the most recent yearly waterborne shipments and receipts at varying hypothetical constrained port channel depths. The economic analysis for Calumet Harbor and River required changes in transportation costs by 0.1 foot increments to a maximum decrease in channel depth of 10.0 feet. The GL-SAND model presents transportation costs for each movement and each incremental depth. This ensures that increases in transportation costs are captured for vessel movements that require the given draft. Deep draft vessels that do not require, 26 feet for example, do not see increases in transportation costs between 27 feet and 26 feet.

Transportation costs from GL-SAND's calendar year 2011 analysis were reported in FY2014 (October 2013) price levels. These values were updated to reflect FY2015 (October 2014) price levels using the Producer Price Index (PPI) for Ship Building and Repairing – Non-Military Self Propelled New (series ID: PCU336611336611A).

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[2] The GL-SAND model gives one foot of underkeel clearance for all vessel movements.

[3] All commodities shipped or received at Calumet Harbor and River in 2011 via vessels that drafted greater than 12 feet, but were not modeled in GL-SAND are, for the purposes of this document, referred to as "non-modeled shipments" and "non-modeled receipts."

[4]Modeled commodity movements' transportation costs were used as a proxy for non-modeled transportation costs. For instance, if a deep-draft movement of coal was not considered in GL-SAND, the average transportation cost per ton (at each depth) for modeled movements was used as an approximation for the missing commodity movement.

[4] All vessels that drafted 12 feet or greater are included in the economic analysis.

2.1.3 Average Annual Harbor and River Transportation Benefits

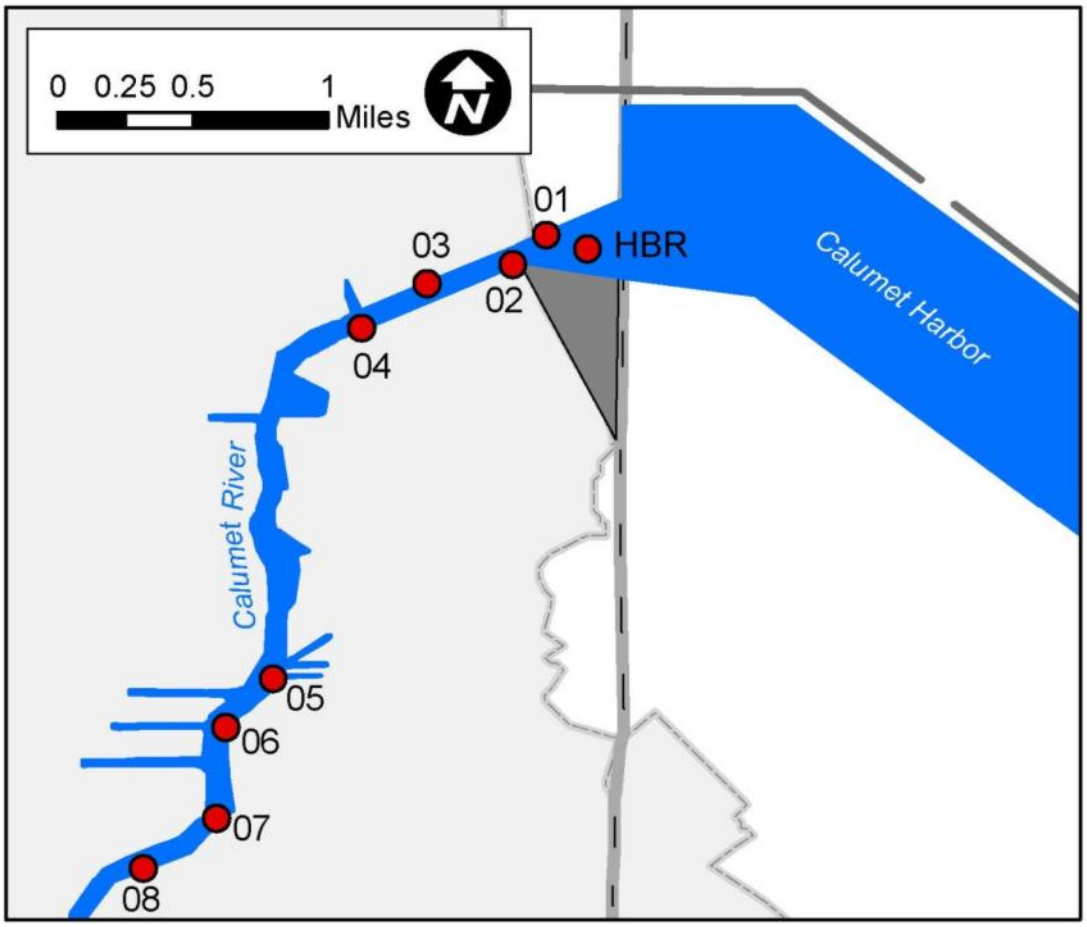
The avoided increases in transportation costs (due to the continuation of channel maintenance), over a 25 year project evaluation period, are the benefits for this evaluation. The difference in vessel transportation costs associated with maintaining current harbor depths (the FWP condition) and vessel transportation costs associated with the discontinuation of harbor dredging (the FWOP condition), are the benefits associated with continuing to maintain Calumet Harbor and River.

2.1.3.1 Future With-Project Condition Average Annual Transportation Costs

Calumet Harbor and River has three different authorized channel depths: 29 feet in the Approach Channel, 28 feet in the Outer Harbor Channel and 27 feet in the River Channel. *However, 27 feet was chosen as the maintained channel depth due to the fact that this is the limiting project depth adjacent to the docks where the vessels dock and transmit the cargo.*

Two locations along the river have been identified as places where the most shoaling occurs. These "critical shoals" represent locations that could substantially impact navigation if dredging were to cease. The first critical shoal is located near the mouth of Calumet River (at Shoal 04), while the second occurs downstream at Shoal 07. These locations are displayed in Figure 3. Commodities moving to and from docks located between Shoal 04 and Shoal 07 are assumed to be impacted by Shoal 04's shoaling rate. The remaining commodities with origins or destinations beyond Shoal 07 are assumed to be impacted by this shoaling rate.

Figure 3: Calumet Harbor & River Identified Shoal Locations



Dredging operations are assumed to target areas within the channel that experience the most shoaling in order to maintain authorized channel depths. Over-dredging of the channel up to 1 foot beyond authorized depth is permitted, which offsets any anticipated shoaling during the course of the year until the next dredging event. This is reflected in the FWP condition, where the authorized depth of 27 feet (river channel) and 28 feet (harbor channel) are maintained.

The FWP condition time stream (for the sum of all commodities for Reach 1 and Reach 2) was converted to an average annual value using a 25 year project life and the FY2015 (October 2014) Federal discount rate (FDR) of 3.375 percent and FY2015 price levels. Transportation costs remain constant during the 25-year period of analysis since the FWP condition assumes that the Federal channels at Calumet Harbor and River will be maintained. Therefore, shippers will not incur additional costs due to light-loading. Table 7 presents a summary of the total transportation costs for each reach during the 25-year period if dredging were continue. The total average annual transportation (shipping) costs associated with maintaining the harbor and river over the 25-year project evaluation period (FWP condition) is displayed in Table 7.

Table 7: Calumet Harbor & River – FWP Condition Average Annual Transportation Costs

Fiscal Year	Project Year	Transportation Cost	Present Value Factor	Present Value of Transportation Cost
2019	1	$159,651,057	0.967	$154,438,301
2020	2	$159,651,057	0.936	$149,395,746
2021	3	$159,651,057	0.905	$144,517,836
2022	4	$159,651,057	0.876	$139,799,193
2023	5	$159,651,057	0.847	$135,234,619
2024	6	$159,651,057	0.819	$130,819,083
2025	7	$159,651,057	0.793	$126,547,718
2026	8	$159,651,057	0.767	$122,415,817
2027	9	$159,651,057	0.742	$118,418,826
2028	10	$159,651,057	0.718	$114,552,341
2029	11	$159,651,057	0.694	$110,812,100
2030	12	$159,651,057	0.671	$107,193,982
2031	13	$159,651,057	0.650	$103,693,998
2032	14	$159,651,057	0.628	$100,308,292
2033	15	$159,651,057	0.608	$97,033,133
2034	16	$159,651,057	0.588	$93,864,911
2035	17	$159,651,057	0.569	$90,800,134
2036	18	$159,651,057	0.550	$87,835,425
2037	19	$159,651,057	0.532	$84,967,516
2038	20	$159,651,057	0.515	$82,193,247
2039	21	$159,651,057	0.498	$79,509,561
2040	22	$159,651,057	0.482	$76,913,500
2041	23	$159,651,057	0.466	$74,402,202
2042	24	$159,651,057	0.451	$71,972,901
2043	25	$159,651,057	0.436	$69,622,919
			Present Value – Transportation Costs	$2,667,263,297
			Annuity Factor	0.060
			Average Annual Transportation Costs	$159,651,057
			Rounded Average Annual Transportation Costs	$159,651,000

1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels. Transportation costs reflected in this table account for shipments and receipts of deep draft tonnage in Reach 1 and Reach 2 (approximately 8.2 million tons). Nominal transportation costs were estimated using the GL-SAND model.

2.1.3.2 Future Without-Project Condition Average Annual Transportation Costs

If dredging at Calumet Harbor and River was discontinued, due to a lack of a suitable dredged material disposal facility (DMDF), the harbor and river channels would gradually fill in. Thus, additional transportation costs would be incurred at various channel depths. Transportation costs associated with not maintaining the harbor and river is the transportation cost time stream that develops due to the discontinuation of dredging, and the annual shoaling rates at various parts of the channels. Since there is no

single shoaling rate that is representative of Calumet Harbor and River in its entirety, shoaling rates were developed for multiple areas along the harbor and river[6].

In order to forecast the transportation cost increases incurred by the vessels that ship goods to and from various locations along Calumet River, commodities were categorized by their origin or destination docks. Twenty docks accounted for the shipments and receipts of all commodities moved on deep-draft vessels. For each dock, the critical shoal[7] that all vessels must traverse in order to ship goods to or from its location was identified. The annual shoaling rate corresponding with the critical shoal for each dock was used to generate the various channel depths for years 2019 through 2043. Shoals for Reach 1 and Reach 2 are displayed in Table 8.

Table 8: Calumet Harbor & River Reach 1 and Reach 2 Shoals

Fiscal Year	Project Year	Reach 1 Depth LWD (ft)	Reach 1 Shoal (ft)	Reach 2 Depth LWD (ft)	Reach 2 Shoal (ft)
2019	1	-27.0	0.0	-27.0	0.0
2020	2	-26.5	0.5	-26.3	0.7
2021	3	-26.1	0.9	-25.7	1.3
2022	4	-25.6	1.4	-25.1	1.9
2023	5	-25.2	1.8	-24.5	2.5
2024	6	-24.9	2.1	-24.0	3.0
2025	7	-24.5	2.5	-23.5	3.5
2026	8	-24.1	2.9	-23.0	4.0
2027	9	-23.8	3.2	-22.5	4.5
2028	10	-23.5	3.5	-22.1	4.9
2029	11	-23.2	3.8	-21.7	5.3
2030	12	-22.9	4.1	-21.3	5.7
2031	13	-22.6	4.4	-20.9	6.1
2032	14	-22.4	4.6	-20.5	6.5
2033	15	-22.1	4.9	-20.2	6.8
2034	16	-21.9	5.1	-19.9	7.1
2035	17	-21.7	5.3	-19.6	7.4
2036	18	-21.5	5.5	-19.3	7.7
2037	19	-21.3	5.7	-19.0	8.0
2038	20	-21.1	5.9	-18.7	8.3
2039	21	-20.9	6.1	-18.5	8.5
2040	22	-20.7	6.3	-18.2	8.8
2041	23	-20.6	6.4	-18.0	9.0
2042	24	-20.4	6.6	-17.8	9.2
2043	25	-20.3	6.7	-17.6	9.4

Table 9 demonstrates how the vessel movements and associated commodity tonnages were allocated to each reach.

[6]Details regarding the processes used to generate the various shoaling rates along Calumet Harbor and River is included in the main report of the *DMMP*.

[7]For the purposes of this document, the critical shoal is defined as the location with the greatest shoaling rate that will adversely impact navigation to a particular dock.

Table 9: Calumet Harbor & River Tonnage – Reach 1 and Reach 2

Reach 1[1]	**Reach 2**
Calumet Harbor and River – *Shipments* with origins between Calumet Harbor and Shoal 07.	Calumet Harbor and River – *Shipments* with origins between Shoal 07 and Lake Calumet.
Calumet Harbor and River – *Receipts* with destinations between Calumet Harbor and Shoal 07.	Calumet Harbor and River –*Receipts* with destinations between Shoal 07 and Lake Calumet.
1. Shoal 07 indicates the location of the second critical shoal (the first being Shoal 04).	

The FWOP condition incorporates the transportation costs associated with moving commodities in the harbor and river at reduced -drafts resulting from projected shoaling in the channel. The available draft resulting from the shoals defined in Table 8 was used to assign an available draft for commodity movements at each dock. Using transportation cost increases resulting from this decreased available draft as calculated by the GL-SAND model, costs for each movement at the applicable reduced draft caused by projected shoaling rates were calculated and totaled for each dock.

Table 10 presents a summary of the total transportation costs for each reach during the 25 year period if dredging were to cease. The FWOP condition time stream was converted to an average annual value using a 25 year project life and the FY2015 3.375 percent Federal discount rate. The total average annual vessel transportation costs associated with not maintaining the harbor and river over the 25 year evaluation period is displayed in Table 10.

Table 10: Calumet Harbor & River FWOP Condition Average Annual Transportation Costs

Fiscal Year	Project Year	Transportation Cost	Present Value Factor	Present Value of Transportation Cost
2019	1	$159,651,057	0.967	$154,438,301
2020	2	$159,834,062	0.936	$149,566,996
2021	3	$160,071,103	0.905	$144,898,066
2022	4	$160,396,475	0.876	$140,451,923
2023	5	$160,770,395	0.847	$136,182,770
2024	6	$161,091,995	0.819	$131,999,797
2025	7	$161,610,467	0.793	$128,100,848
2026	8	$162,142,516	0.767	$124,326,195
2027	9	$162,687,087	0.742	$120,670,757
2028	10	$163,219,019	0.718	$117,112,414
2029	11	$163,788,858	0.694	$113,684,104
2030	12	$164,440,877	0.671	$110,409,995
2031	13	$165,152,802	0.650	$107,267,403
2032	14	$165,841,359	0.628	$104,197,641
2033	15	$166,603,449	0.608	$101,258,676
2034	16	$167,274,787	0.588	$98,347,191
2035	17	$168,037,629	0.569	$95,569,923
2036	18	$168,817,368	0.550	$92,878,466
2037	19	$169,664,294	0.532	$90,296,638
2038	20	$170,580,805	0.515	$87,820,216
2039	21	$171,373,159	0.498	$85,347,413
2040	22	$172,436,563	0.482	$83,073,046
2041	23	$173,107,694	0.466	$80,673,401
2042	24	$174,045,371	0.451	$78,462,056
2043	25	$174,791,222	0.436	$76,225,459
			Present Value – Transportation Costs	*$2,753,259,692*
			Annuity Factor	*0.060*
			Average Annual Transportation Costs	*$164,798,436*
			Rounded Average Annual Transportation Costs	*$164,798,000*

1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels. All transportations costs displayed in $1000s.

Total average annual transportation benefits is the difference between the average annual transportation costs associated with not maintaining the harbor and the average annual transportation costs associated with maintaining the current authorized river channel depth of 27 feet. The total average annual harbor transportation benefits are displayed in Table 11.

Table 11: Calumet Harbor & River Average Annual Benefits

Future Without-Project Condition Average Annual Transportation Costs	Future With-Project Condition Average Annual Transportation Costs	Total Average Annual Transportation Benefits (FWOP – FWP)
$164,798,000	$159,651,000	$5,147,000

2.1.4 Dredging Costs for Calumet Harbor and River

The average annual dredging costs for the harbor and river channels are subtracted from the channels' transportation benefits to yield the *net* benefits for Calumet Harbor and River. Average annual dredging costs were calculated using the assumption that 100,000 cubic yards of sediment will be removed during each dredging event (aside from the last two harbor dredging events in – PY 21; 50,000 cubic yards and PY24; 150,000 cubic yards – will be removed). This quantity of sediment will be removed from the Federal channel despite whether the dredging event is in the harbor or in the river.

Dredging at Calumet Harbor and River will occur on a biennial basis (alternative between the harbor and river). The estimated cost of each 100,000 cubic yard dredging event is $4,409,230 (see Table 12).

Dredging costs per cubic yard are anticipated to be the same whether the dredging event occurs in the Calumet Harbor or River – an estimated cost of $31.54 per cubic yard[8]. It is estimated that approximately 100,000 cubic yards of sediment would be removed from the harbor or river at each dredging event. Costs reflect the dredging needed to maintain the authorized depths of 27 feet LWD in the river channel and 28 feet LWD in the harbor. Dredging costs assume 100,000 cubic yards of sediment are removed on at each event. Dredging costs include the:

- contract cost (estimated at $3,154,000 per event)
- preconstruction, engineering, and design (PED) costs (estimated at $96,000 per event),
- construction management (CM) costs (estimated at $236,000 per event), and
- sediment management (SM) costs (estimated at $922,000 per event).

Dredging costs were placed into a 25 year time stream and converted to an average annual dollar value using the FY15 3.375 percent interest rate. The average annual harbor and river dredging costs are displayed in Table 12.

[8] Please refer to the cost appendix for the complete description of the derivation of dredging costs.

Table 12: Calumet Harbor & River Average Annual Dredging Costs

Fiscal Year	Project Year	Dredging Location	Cost ($)	Present Value Factor	Present Value of Dredging Costs ($)
2019	1	Harbor	$4,409,230	0.967	$4,265,264
2020	2		$0	0.936	$0
2021	3	River	$4,409,230	0.905	$3,991,282
2022	4		$0	0.876	$0
2023	5	Harbor	$4,409,230	0.847	$3,734,898
2024	6		$0	0.819	$0
2025	7	River	$4,409,230	0.793	$3,494,984
2026	8		$0	0.767	$0
2027	9	Harbor	$4,409,230	0.742	$3,270,481
2028	10		$0	0.718	$0
2029	11	River	$4,409,230	0.694	$3,060,399
2030	12		$0	0.671	$0
2031	13	Harbor	$4,409,230	0.650	$2,863,812
2032	14		$0	0.628	$0
2033	15	River	$4,409,230	0.608	$2,679,853
2034	16		$0	0.588	$0
2035	17	Harbor	$4,409,230	0.569	$2,507,711
2036	18		$0	0.550	$0
2037	19	River	$4,409,230	0.532	$2,346,626
2038	20		$0	0.515	$0
2039	21	Harbor	$2,252,641	0.498	$1,121,862
2040	22		$0	0.482	$0
2041	23	River	$4,409,230	0.466	$2,054,834
2042	24	Harbor	$6,565,818	0.451	$2,959,962
2043	25		$0	0.436	$0
				Present Worth of Harbor Dredging Costs Over 25 Years	$38,351,968
				Annuity Factor	0.060
				Average Annual Costs	$2,295,586
				Rounded Average Annual Costs	$2,296,000

1. Note that dredging costs reflect the dredging needed to maintain the authorized depths of 27 feet LWD in the river channel and 28 feet LWD in the harbor. Dredging costs assume 100,000 cubic yards of sediment are removed at each event (with the exception of PY21; 50,000 cubic yards, and PY24; 150,000 cubic yards).

2.1.5 Average Annual Benefits of Dredging Calumet Harbor and River

In order to calculate Calumet Harbor and River's average annual net benefits, average annual dredging costs were subtracted from the total average annual benefits for the harbor and river. The positive net average annual net benefits are displayed in Table 13, which establishes economic viability for the harbor and river channels.

Table 13: Calumet Harbor & River Economic Viability Overview

Authorized Channel Depth in River – LWD (ft)	Total Average Annual Benefits	Total Average Annual Dredging Costs	Net Average Annual Benefits	Benefit-to-Cost Ratio
27	$5,147,000	$2,296,000	$2,851,000	2.2

2.2 Economic Viability of the Calumet-Sag Channel

2.2.1 Tonnage Assessment

Similarly to the Calumet Harbor and River economic viability analysis, the first step in establishing vessel transportation costs for the Calumet-Sag is to identify the level of tonnage that is anticipated to be moved on the channel over the next 25 years (2019 through 2043). In order to generate this forecast, historical tonnage movements are identified. Since vessel transportation costs are calculated by the Commercial Cargo Tool (CCT), which utilizes any identified tonnage level to develop transportation costs at various depths, it is imperative that the appropriate tonnages by type and amount are selected.

The WCSC provides data regarding annual tonnage movements on U.S. waterways, and is utilized to establish tonnage trends along the Calumet-Sag. Table 14 displays the annual tonnage levels for traffic moving to, from, or through the channel for the years 2003 through 2012.

Table 14: Calumet-Sag Tonnage (2003-2012)

Calendar Year	Total
2003	6,575,000
2004	8,560,000
2005	8,483,000
2006	7,716,000
2007	6,255,000
2008	6,093,000
2009	4,304,000
2010	5,075,000
2011	5,992,000
2012	5,461,000
Maximum Tonnage: (2003-2012)	8,560,000
Associated Year	2004
Minimum Tonnage: (2003-2012)	4,304,000
Associated Year	2009
Average Tonnage: (2003-2012)	6,451,400
1. Annual tonnage levels were reported by the USACE Waterborne Commerce Statistics Center.	

Table 14 displays that the maximum tonnage occurs in year 2004, while the minimum tonnage occurs in 2009. Figure 4 displays the information presented in Table 1 in a graphical format. The lowest tonnage levels are apparent between years 2009 and 2010 – those years following the most recent U.S. recession (December of 2007 through June 2009). Years 2004 through 2006 are indicative of tonnage levels associated with a healthier economy than the tonnage levels of the following years (2007 through 2012).

Figure 4: Calumet-Sag Tonnage (2003-2012)

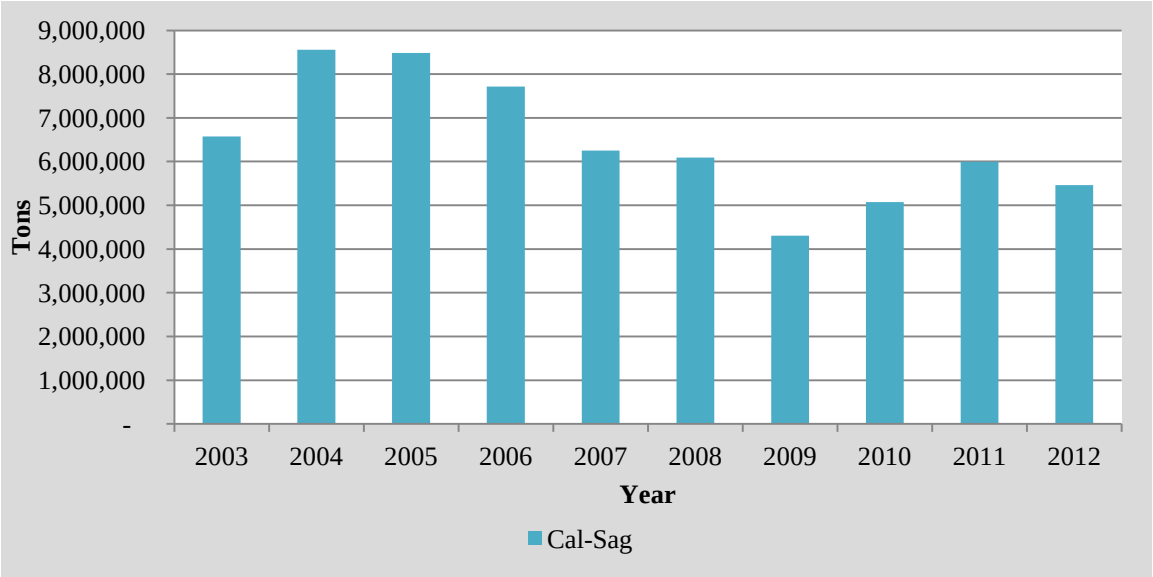


Table 15 shows that the main commodity types on the Calumet-Sag are within the iron and steel group with an average of 34 percent of total average annual tonnage (2.2 million tons) and petroleum group with an average of 23 percent of total average annual tonnage (1.45 million tons). While the iron and steel group includes iron ore, pig iron, iron and steel bars, and other related commodities, the petroleum group consists of gasoline, gas oils, fuel oils, kerosene, and other related commodities.

Table 15: Calumet-Sag Tonnage by Commodity Type – Thousand Tons

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**10-Year Ave.**
Coal	792	1,399	803	939	514	454	96	187	1,489	967	764
Petroleum	1,402	1,586	2,017	1,513	1,697	1,729	1,328	1,563	802	909	1,455
Aggregates	314	329	291	442	124	97	20	26	44	46	173
Grains	374	514	482	251	342	224	349	409	102	360	341
Chemicals	397	201	210	383	378	405	315	296	382	273	324
Non-Metallic Ores & Minerals	213	366	343	317	269	548	719	622	642	343	438
Iron & Steel Products	2,562	3,034	3,278	2,972	1,994	2,069	993	1,259	1,793	2,070	2,202
Others	521	1,131	1,059	899	937	567	484	713	738	493	754
Total	**6,575**	**8,560**	**8,483**	**7,716**	**6,255**	**6,093**	**4,304**	**5,075**	**5,992**	**5,461**	**6,451**

In order to determine vessel transportation costs on the Calumet-Sag over the 25-year evaluation period (2019 through 2043), a projection of future tonnage movements is required. This analysis utilized projections developed for the Great Lakes and Mississippi River Interbasin Study (GLMRIS) Report. The GLMRIS Report forecasted traffic

projections for each major bulk commodity group[9]. The forecasted traffic projections were based on news reports, industry newsletters, government forecasts, and interviews with shippers conducted by the University of Tennessee, Center for Transportation Research (UTK-CTR) for the USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED), and the results of interviews conducted with major users of the CAWS were reported in *Industry and Freight Profiles for Traffic Moving in the Chicago Area Waterway System* (Profiles)[10] which was completed in June 2012 (Dager, et al., UTK-CTR). These results formed much of the underlying rationale for the increased or decreased use of the Calumet-Sag for commercial cargo transportation.

The results of the projections for each commodity group moving on the Calumet-Sag are shown in Table 16. The major commodity movements expected to occur on the Calumet-Sag Channel between 2019 and 2038 are within the iron ore and iron and steel group as well as the coal groups. The total expected tonnage moving on the Calumet-Sag is approximately 6.5 million tons which is near the 10-year (2003-2012) average of tonnage moving on the Calumet-Sag (as displayed in Table 14). Note that due to high uncertainty surrounding future tonnage movements from years 2021 through 2043, year 2020 tonnages were used as a proxy for future levels. Thus, Table 16 displays that tonnage movements stay constant from 2020 through 2043.

Table 16: Projected Calumet-Sag Tonnage by Commodity Type – Thousand Tons

Commodity	2019	Annual Tonnage: 2020-2043
Coal	1,365	1,365
Petroleum Products	453	453
Aggregates	40	40
Grains	581	590
Chemicals	204	204
Non-Metallic Ores & Minerals	781	739
Iron Ore and Iron & Steel Products	2,374	2,472
Others	699	731
Total	**6,496**	**6,594**

1. Note that all tonnage forecasts for years 2019 through 2043 reflect the projections developed by the Great Lakes and Mississippi River Interbasin Study (GLMRIS) Report since these projections for the Calumet-Sag were also required for that study effort. The projections were based on news reports, industry newsletters, government forecasts, and interviews with shippers conducted by the University of Tennessee, Center for Transportation Research (UTK-CTR) for the USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED).

The following sections discuss the underlying factors and associated assumptions within each commodity group that were used to generate the projections identified in Table 16.

[9] A bulk commodity is defined as any cargo that is transported unpackaged in large quantities.
[10] This report is an internal USACE report because it contains proprietary information.

2.2.1.1 Iron and Steel

Tonnage in the iron and steel group consists of iron and steel scrap, pig iron, iron and steel plates, ferroalloys, iron ore, iron and steel bars and rods, primary iron and steel products, iron and steel pipe, and ingots. Iron and steel traffic on the Chicago Area Waterway System (CAWS) serves the raw material input needs of steel mills in the Chicago area (and other locations), as well as the intermediate iron and steel product needs of downstream steel manufacturers both in the Chicago area and other markets – especially along the Lower Mississippi River and Gulf Coast. Iron and steel traffic, including iron ore, scrap, and intermediate iron and steel products, originates along the Gulf Coast and Lower Mississippi, some of it at import terminals, along the Ohio and Tennessee rivers, along the Upper Mississippi, and at Chicago-area docks.

According to the GLMRIS Report, the iron and steel group – the second largest commodity group – accounted for 17 percent of total shallow draft tonnage moving on the CAWS between 2003 and 2011. On the Calumet-Sag, iron and steel group accounted for 34 percent of the total shallow draft tonnage moving during that same period. Though the iron and steel group accounts for a high percentage of tonnage moving on the CAWS, from 2003 to 2011 it declined by an annual rate of 5.2 percent on the CAWS and 3.75 percent on the Calumet-Sag. This decline in iron and steel moving on the CAWS and Calumet-Sag channel is partially due to the recession during 2007 and 2009 and the associated decline in steel demand and production. For example, large plate steel is an important input into automobile manufacturing and the reduced demand for automobiles impacted the steel mills in the Chicago area and elsewhere (GLMRIS Report).

The end of the recession led to an increase in the amount of iron and steel traveling on the Calumet-Sag, as tonnage increased from 900 thousand tons in 2009 to 2.0 million tons in 2012. This historical increase in iron and steel tonnage was considered, along with projections on automobile production and sales, to project a conservative annual growth rate of 4.13 percent for future iron and steel group tonnage (DiCianni, 2011).

2.2.1.2 Coal and Coke

The industry action that influenced the projections for this category was the recent closure of two coal burning steam plants (Fisk Generating Station, and Crawford Generating Station) in 2012. The two plants, combined, received nearly 2.7 million tons of coal annually by barge (GLMRIS Report).

2.2.2 Vessel Movements along the Calumet-Sag

This economic viability assessment considers tonnages moved on shallow-draft vessels, any movement with a draft below fifteen feet. Specifically, traffic moving on the Calumet-Sag has a maximum draft of 9 feet. These are the movements that would be expected to be adversely impacted by shoaling of Calumet-Sag.

Movements along the Calumet-Sag can be categorized by: shipments, receipts, and through-traffic. Table 17 displays that that the majority of movements (95 percent) along the Calumet-Sag are composed of through traffic. Most traffic transits the entire reach because there are fewer than 10 docks on the Calumet-Sag between the junction with Chicago Sanitary and Ship Canal (CSSC) and Thomas J. O'Brien (T.J. O'Brien) Lock and Dam.

Table 17: Calumet-Sag Vessel Through-Traffic Tonnage (2003 – 2012)

Through-Traffic	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	10-Year Ave.
% of Total Tonnage	90.1	95.8	96.3	94.3	96.8	94.9	95.7	96.6	98.1	98.8	95.7
1. Through-traffic indicates vessels with origins and destinations outside of the indicated study area (Calumet-Sag).											

Table 18 exhibits that between the years of 2003 and 2012 an average of about 65 percent of the commercial cargo traffic on the Calumet-Sag was moving towards the Great Lakes rather than the Mississippi River. This is important for this analysis because it demonstrates that the majority of the vessel movements along the Calumet-Sag will be coming from the confluence with the CSSC.

Table 18: Calumet-Sag Vessel Traffic Direction (2003 – 2012)

Direction of Movement	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	10-Year Ave.
% Towards GL	65.6	67.8	70.5	75.8	61.9	67.6	60.1	56.4	66.2	56.2	64.8
% Towards MR	34.4	32.2	29.5	24.2	38.1	32.4	39.9	43.6	33.8	43.8	35.2
1. GL indicates the Great Lakes; MR indicates the Mississippi River.											

2.2.3 Average Annual Transportation Benefits

The *avoided* increases in transportation costs (due to the continuation of channel maintenance), over a 25-year project evaluation period, are the benefits for this evaluation. The difference in vessel transportation costs associated with maintaining current channel dimensions (the FWP condition) and vessel transportation costs associated with the discontinuation of channel dredging (the FWOP condition), are the benefits associated with continued maintenance of the Calumet-Sag.

2.2.3.1 Future With-Project Condition Average Annual Transportation Costs

The Calumet-Sag has an authorized channel depth of 9 feet and an authorized channel width of 225 feet. Maintenance is authorized to a useable depth of 9 feet below the normal pool elevation, which normally maintained at -2 feet referenced to Chicago City Datum (CCD). Since the standard jumbo barge is 35 feet wide, this channel width allows for 2-barge wide tow configurations (70 feet wide) to pass each other (USACE 2002). The focus for this analysis was on the changing depth due to shoaling rather than changes

in width since the depth is the limiting channel dimension for vessel traffic at this location. Specifically, losses in depth could require vessels to light-load.

In calendar year 2014 however, the available draft in several areas of the Calumet-Sag was approximately 10-feet. Various channel depths and shoaling rates along the Calumet-Sag were identified; the greatest shoaling rate is expected to occur at River Mile (RM) 303 – a point along the Calumet-Sag near the confluence with the CSSC. Since there is a single shoaling rate that is representative of the most *limiting* channel dimensions along the Calumet-Sag (RM 303), this point was considered to be the restrictive location for navigation. It is important to note that 95 percent of traffic along the Calumet-Sag is through-traffic, which includes movements that have origins and destinations outside of the specific study area (in this case, the Calumet-Sag). Thus, the majority of shipments must pass RM 303, and would have to light-load to accommodate this reduced channel dimension.

The transportation costs for the FWP condition reflects a current draft of 10 feet at RM 303, and an associated initial shoaling rate of 0.17 feet per year, and an annual decay of 7 percent. The decayed shoaling rate is reflective of the reduced shoaling rate expected to occur in future years. Shoaling at RM 303 is expected to occur until PY07 when the first dredging event occurs. At this point, the channel is dredged to allow for a 9-foot vessel draft. Over-dredging of the channel up to 1 foot beyond authorized depth is permitted, which offsets any anticipated shoaling during the course of the year until the next dredging event in PY19. The FWP condition shoal for RM 303 is displayed in Table 19.

Table 19: Calumet Sag FWP Condition Shoal at River Mile 303

Fiscal Year	Project Year	River Mile 303[1] Available Draft Below Normal Pool Elevation (ft)	River Mile 303 Shoal (ft)[2]
2019	1	-9.3	-0.3
2020	2	-9.2	-0.2
2021	3	-9.1	-0.1
2022	4	-9.0	0.0
2023	5	-8.9	0.1
2024	6	-8.8	0.2
2025	7	-9.0	0.0
2026	8	-9.0	0.0
2027	9	-9.0	0.0
2028	10	-9.0	0.0
2029	11	-9.0	0.0
2030	12	-9.0	0.0
2031	13	-9.0	0.0
2032	14	-9.0	0.0
2033	15	-9.0	0.0
2034	16	-9.0	0.0
2035	17	-9.0	0.0
2036	18	-9.0	0.0
2037	19	-9.0	0.0
2038	20	-9.0	0.0
2039	21	-9.0	0.0
2040	22	-9.0	0.0
2041	23	-9.0	0.0
2042	24	-9.0	0.0
2043	25	-9.0	0.0

1. This column displays the depth feet below the normal pool elevation, which normally maintained at -2 feet referenced to Chicago City Datum (CCD).
2. The column displays the difference between a draft of 9 feet and the available draft. Negative values indicate that the available draft is greater than 9 feet, while positive values indicate that the available draft is less than 9 feet.

Table 20 displays the associated transportation costs for years 2019 through 2043.

Table 20: Calumet-Sag – FWP Condition Average Annual Transportation Costs

Year	PY	Transportation Costs ($)	Present Value Factor	Present Value of Transportation Costs ($)
2019	1	$165,432,421	0.967	$160,031,363
2020	2	$168,121,399	0.936	$157,322,903
2021	3	$168,121,399	0.905	$152,186,605
2022	4	$168,121,399	0.876	$147,217,997
2023	5	$168,121,399	0.847	$142,411,606
2024	6	$168,121,399	0.819	$137,762,134
2025	7	$168,121,399	0.793	$133,264,458
2026	8	$168,121,399	0.767	$128,913,623
2027	9	$168,121,399	0.742	$124,704,835
2028	10	$168,121,399	0.718	$120,633,456
2029	11	$168,121,399	0.694	$116,695,000
2030	12	$168,121,399	0.671	$112,885,127
2031	13	$168,121,399	0.650	$109,199,639
2032	14	$168,121,399	0.628	$105,634,475
2033	15	$168,121,399	0.608	$102,185,708
2034	16	$168,121,399	0.588	$98,849,536
2035	17	$168,121,399	0.569	$95,622,284
2036	18	$168,121,399	0.550	$92,500,395
2037	19	$168,121,399	0.532	$89,480,431
2038	20	$168,121,399	0.515	$86,559,063
2039	21	$168,121,399	0.498	$83,733,071
2040	22	$168,121,399	0.482	$80,999,344
2041	23	$168,121,399	0.466	$78,354,867
2042	24	$168,121,399	0.451	$75,796,727
2043	25	$168,121,399	0.436	$73,322,106
			Present Value – Transportation Costs	*$2,806,266,752*
			Annuity Factor[1]	*0.060*
			Average Annual Transportation Costs	*$167,965,708*
			Rounded Average Annual Transportation Costs	*$167,966,000*

1. The annuity factor is determined by utilizing the FY15 FDR of 3.375% and FY15 (October 2014) price levels.

2.2.3.2 Future Without-Project Condition Average Annual Transportation Costs

If dredging along the Calumet-Sag was discontinued, due to a lack of a suitable DMDF, shoaling would occur within the channel. Various shoaling rates along the Calumet-Sag were identified; the greatest shoaling rate would occur at River Mile (RM) 303 – a point along the Calumet-Sag near the confluence with the CSSC. In the FWOP condition, shoaling limits the draft availability throughout the project evaluation period. The shoaling rate begins at 0.17 feet per year, and decreases by 7 percent each consecutive year. The limiting channel depth would result in additional transportation costs due to shippers having to adjust to the changing depth by light-loading their vessels and increasing the number of barge trips to transport the same amount of tonnage. Transportation costs associated with not maintaining the channel is the "transportation cost time stream" that develops due to the discontinuation of dredging, and the annual shoaling rate at RM 303.

Since there is a single shoaling rate that is representative of the most *limiting* channel dimensions along the Calumet-Sag (RM 303), this point was considered to be the restrictive location for navigation. It is important to note that 95 percent of traffic along the Calumet-Sag is through-traffic, which includes movements that have origins and destinations outside of the specific study area (in this case, the Calumet-Sag). Thus, the majority of shipments must pass RM 303, and would have to light-load to accommodate this reduced channel dimension. Unlike the FWP condition, shoaling would occur throughout the project evaluation period, and not be offset by dredging procedures in project years 7 and 19.

The FWOP condition shoal for RM 303 is displayed in Table *21*.

Table 21: Calumet-Sag FWOP Condition Shoal at River Mile 303

Fiscal Year	Project Year	River Mile 303[1] Available Draft Below Normal Pool Elevation (ft)	River Mile 303 Shoal (ft)[2]
2019	1	-9.3	-0.3
2020	2	-9.2	-0.2
2021	3	-9.1	-0.1
2022	4	-9.0	0.0
2023	5	-8.9	0.1
2024	6	-8.8	0.2
2025	7	-8.8	0.2
2026	8	-8.7	0.3
2027	9	-8.6	0.4
2028	10	-8.6	0.4
2029	11	-8.5	0.5
2030	12	-8.4	0.6
2031	13	-8.4	0.6
2032	14	-8.4	0.6
2033	15	-8.3	0.7
2034	16	-8.3	0.7
2035	17	-8.2	0.8
2036	18	-8.2	0.8
2037	19	-8.2	0.8
2038	20	-8.1	0.9
2039	21	-8.1	0.9
2040	22	-8.1	0.9
2041	23	-8.1	0.9
2042	24	-8.0	1.0
2043	25	-8.0	1.0

1. This column displays the depth feet below the normal pool elevation, which normally maintained at -2 feet referenced to Chicago City Datum (CCD).
2. The column displays the difference between a draft of 9 feet and the available draft. Negative values indicate that the available draft is greater than 9 feet, while positive values indicate that the available draft is less than 9 feet.

Table 22 displays the FWOP condition increases in transportation costs associated with shoaling at RM 303 on the Calumet-Sag. Note that the first Project Year (PY) is FY2019 – the first year that the new DMDF would become operational.

Table 22: Calumet-Sag FWOP Condition Transportation Costs

Fiscal Year	Project Year	Transportation Cost	Present Value Factor	Present Value of Transportation Cost
2019	1	$165,432,421	0.967	$160,031,363
2020	2	$168,121,399	0.936	$157,322,903
2021	3	$168,121,399	0.905	$152,186,605
2022	4	$168,121,399	0.876	$147,217,997
2023	5	$168,692,554	0.847	$142,895,418
2024	6	$169,263,710	0.819	$138,698,166
2025	7	$169,263,710	0.793	$134,169,931
2026	8	$170,406,020	0.767	$130,665,445
2027	9	$171,548,331	0.742	$127,246,778
2028	10	$171,548,331	0.718	$123,092,409
2029	11	$172,119,486	0.694	$119,470,118
2030	12	$172,690,641	0.671	$115,953,145
2031	13	$172,690,641	0.650	$112,167,492
2032	14	$172,690,641	0.628	$108,505,434
2033	15	$173,832,952	0.608	$105,657,241
2034	16	$173,832,952	0.588	$102,207,730
2035	17	$176,062,215	0.569	$100,138,776
2036	18	$176,062,215	0.550	$96,869,433
2037	19	$176,062,215	0.532	$93,706,827
2038	20	$176,635,063	0.515	$90,942,411
2039	21	$176,635,063	0.498	$87,973,312
2040	22	$176,635,063	0.482	$85,101,148
2041	23	$176,635,063	0.466	$82,322,755
2042	24	$177,262,305	0.451	$79,917,861
2043	25	$177,262,305	0.436	$77,308,693
			Present Value – Transportation Costs	*$2,871,769,392*
			Annuity Factor	*0.060*
			Average Annual Transportation Costs	*$171,886,290*
			Rounded Average Annual Transportation Costs	*$171,886,000*

1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels.

Total average annual channel benefits is the difference between the average annual transportation costs associated with not maintaining the river (FWOP condition) and the average annual transportation costs associated with maintaining the current draft availability of 10 feet (FWP condition). The total average annual Calumet-Sag transportation benefits are displayed in Table 11.

Table 23: Calumet-Sag Average Annual Benefits

FWOP Condition Average Annual Transportation Costs	FWP Condition Average Annual Transportation Costs	Total Average Annual Transportation Benefits (FWOP – FWP)
$171,886,000	$167,966,000	$3,920,000

2.2.4 Dredging Costs for the Calumet-Sag

The average annual dredging costs for the Calumet-Sag are subtracted from the channel's total transportation benefits to yield *net* channel benefits. Average annual dredging costs were calculated using the assumption that approximately 15,000 cubic yards of sediment will be dredged at each event (PY07 and PY19). Note that this quantity accounts for 1 foot of over-dredging so that the channel remains at a 9-foot draft availability in the off-years where dredging does not occur.

In support of this DMMP's economic viability analysis, dredging costs for Calumet Harbor and River were developed through an analysis of available historical dredging costs for the harbor and river channels. Since the Calumet-Sag has not been dredged, dredging costs from Calumet Harbor and River were utilized to estimate the costs per cubic yard expected to be removed from the Calumet-Sag channel[11]. The estimated cost per cubic yard for Calumet-Sag sediment is $39.73. No PED costs were included, as it is assumed that dredging event costs for the Calumet-Sag (which occur the same years as Calumet River dredging) would be added to the total Calumet River dredging contract cost. Construction management costs for the Calumet-Sag are estimated at $44,697 per event, while sediment management costs are estimated at $138,324 per event.

These costs were placed into a 25 year time stream and converted to an average annual dollar value using the FY15 3.375 percent Federal discount rate. The average annual dredging costs for the Calumet-Sag are displayed in Table 12.

[11] See the Cost Appendix for the display of how dredging costs per cubic yard were calculated.

Table 24: Calumet-Sag Average Annual Dredging Costs

Fiscal Year	Project Year	Dredging Costs	Present Value Factor	Present Value of Dredging Costs
2019	1	$0	0.967	$0
2020	2	$0	0.936	$0
2021	3	$0	0.905	$0
2022	4	$0	0.876	$0
2023	5	$0	0.847	$0
2024	6	$0	0.819	$0
2025	7	$640,656	0.793	$507,817
2026	8	$0	0.767	$0
2027	9	$0	0.742	$0
2028	10	$0	0.718	$0
2029	11	$0	0.694	$0
2030	12	$0	0.671	$0
2031	13	$0	0.650	$0
2032	14	$0	0.628	$0
2033	15	$0	0.608	$0
2034	16	$0	0.588	$0
2035	17	$0	0.569	$0
2036	18	$0	0.550	$0
2037	19	$640,656	0.532	$340,962
2038	20	$0	0.515	$0
2039	21	$0	0.498	$0
2040	22	$0	0.482	$0
2041	23	$0	0.466	$0
2042	24	$0	0.451	$0
2043	25	$0	0.436	$0
			Present Value of Dredging Costs	$848,779
			Annuity Factor	0.060
			Average Annual Costs	$50,804
			Rounded	$51,000

2.2.5 Average Annual Benefits of the Calumet-Sag

In order to calculate the Calumet-Sag's average annual net benefits, average annual dredging costs were subtracted from the total average annual benefits for the harbor and river. The positive net average annual net benefits are displayed in Table 25, which establishes economic viability for the channel.

Table 25: Calumet-Sag Economic Viability Overview

Total Average Annual Benefits	Total Average Annual Dredging Costs	Net Average Annual Benefits
$3,920,000	$51,000	$3,869,000

3 ECONOMIC EVALUATION OF ALTERNATIVE PLANS

This DMMP seeks to develop various alternative plans that will allow for continued operation and maintenance of Calumet Harbor and River and the Calumet-Sag for the next 25 years – the first project year being 2019. This assessment evaluates the array of alternatives in order to indentify the base plan – otherwise known as the least-cost, environmentally acceptable plan. A total of 4 alternative plans are identified and analyzed, one of which is the "No-Action" Plan. The "No Action Plan" is identical to the future without-project (FWOP) condition. In the No Action Plan, maintenance of the Federal channels is discontinued.

3.1 Alternative Plan Descriptions

Three plans were formulated that would allow for continued channel maintenance at Calumet Harbor and River and the Calumet-Sag. Each plan addresses the need for a total of 1,330,000 cubic yards of sediment to be removed from Calumet Harbor and River, and the Calumet-Sag during the 25-year project evaluation period.

It is estimated that approximately 1,300,000 cubic yards of dredged material would be removed from Calumet Harbor and River, while the remaining 30,000 would be removed from the Calumet-Sag. Note that these quantities are reflective of the amount of dredged material needed to be removed in order to provide the targeted navigation depths (e.g., 28 feet in Calumet harbor, 27 feet in Calumet River, and 9 feet in the Calumet-Sag). In order to accommodate the 1,330,000 cubic yards of dredged material, at least one dredged material disposal facility (DMDF) is required. Three sites were identified that could be used to construct a DMDF, to include: the: Republic, Ridgeland, and LTV sites.

Each alternative plan includes the use of two disposal sites, the first being the current Chicago Area Confined Disposal Facility (CDF), and the second being the new DMDF. Each site's construction and dredging schedule is anticipated to be the same.

First, the real estate for the new DMDF is acquired.

Construction of the DMDF would occur in the following phases:

- **Phase I: Surface Preparation** - The initial surface preparation phase would include installation or rehabilitation of an impermeable bottom liner, construction of drainage structures, a dock, and a crane pad for offloading sediment at the site.
- **Phase II: Stage 1 Berm Construction** - Once the surface preparation is completed, material dredged from Calumet Harbor would be placed at the site and allowed to dewater. Once the volume of material needed for construction of the berms is accumulated, the second construction phase would begin. In the second phase, berms would be constructed around the perimeter of the facility with an impermeable liner on the inside face. Upon completion of the Stage 1 Berm construction, the facility could begin accepting contaminated sediment.

- **Phase III: Stage 2 Berm Construction -** When the facility is filled to the height of the Stage 1 Berms, the third construction phase would be initiated. Clean dredged material, dewatered and stockpiled while contaminated material is being placed in the facility, would be used to construct a second berm lift around the perimeter of the facility. The facility would then continue to accept contaminated sediment until the final capacity is reached.
- **Phase IV: Site Closure -**The facility would then be closed using a 3-foot cover layer consisting of 2.5 feet of clean dredged material covered with 0.5 foot of topsoil.

The schedule and cost assumptions are summarized in Table 26.

Table 26: Construction Schedule & Key Assumptions

Fiscal Year	Project Year	Construction Cost Item(s)
2017	-1	• Real Estate • PED for Surface Preparation
2018	0	• Surface Preparation • Construction Management
2019	1	
2020	2	
2021	3	
2022	4	
2023	5	
2024	6	• PED for Stage 1 Berm Construction
2025	7	• Stage 1 Berm Construction • Construction Management
2026	8	
2027	9	
2028	10	
2029	11	
2030	12	
2031	13	
2032	14	
2033	15	
2034	16	
2035	17	• PED for Stage 2 Berm Construction
2036	18	• Stage 2 Berm Construction • Construction Management
2037	19	
2038	20	
2039	21	
2040	22	
2041	23	
2042	24	• PED for Site Closure
2043	25	• Site Closure • Construction Management

*The key construction cost assumptions include:
●Real estate is acquired 1 year prior to the first construction event.
●There are 4 key construction events, to include: (1) surface preparation, (2) stage 1 of berm construction, (3) stage 2 of berm construction, and (4) site closure.
●Each construction event requires PED costs (one year prior), and CM costs (concurrent to construction).
●PED is estimated at 15 percent of the construction cost, while CM is estimated at 10 percent of the construction cost.

Dredging events will occur biennially and alternate between Calumet Harbor and Calumet River (e.g., PY1- harbor, PY3- river, PY5- harbor, etc.), with the exception of the final two dredging events, for which a river dredging event will occur in PY23 and a harbor dredging event in PY24. The Calumet-Sag will be dredged twice (PY07 and PY19).

The dredging schedule and cost assumptions are summarized in Table 27.

Table 27: Dredging Schedule & Key Assumptions

Fiscal Year	Project Year	Calumet Harbor (cubic yards)	Calumet River (cubic yards)	Calumet-Sag (cubic yards)
2017	-1	0	0	0
2018	0	0	0	0
2019	1	100,000	0	0
2020	2	0	0	0
2021	3	0	100,000	0
2022	4	0	0	0
2023	5	100,000	0	0
2024	6	0	0	0
2025	7	0	100,000	15,000
2026	8	0	0	0
2027	9	100,000	0	0
2028	10	0	0	0
2029	11	0	100,000	0
2030	12	0	0	0
2031	13	100,000	0	0
2032	14	0	0	0
2033	15	0	100,000	0
2034	16	0	0	0
2035	17	100,000	0	0
2036	18	0	0	0
2037	19	0	100,000	15,000
2038	20	0	0	0
2039	21	50,000	0	0
2040	22	0	0	0
2041	23	0	100,000	0
2042	24	150,000	0	0
2043	25	0	0	0

*The key dredging cost assumptions include:

- Dredging costs are estimated at $31.54 per cubic yard for Calumet Harbor and River, and $39.73 per cubic yard for the Calumet-Sag. Note that these dredging costs apply to the Republic and LTV plans. The Ridgeland plan assumes that these costs are the opposite (e.g., $31.54 per cubic yard for the Calumet-Sag).
- The trucking cost for dredged material is estimated at $3.46 per cubic yard.
- Additional barge costs are included for the Ridgeland site only ($7.50 per cubic yard).
- Sediment management costs are $9.22 per cubic yard (except Ridgeland which is $10 per cubic yard).
- PED for dredging is $96,052 per contract (note that the Calumet-Sag is assumed to be contracted in conjunction with Calumet River).
- Construction management for dredging is 15.27% of contract costs.
- Sediment management occurs the same year as dredging costs.

Sections 3.1.1 through 3.1.4 outline the descriptions of the alternative plans, as well as the associated costs. A combination of the dredging and cost schedule allowed for an economic evaluation of each plan. This economic analysis seeks to identify the base plan – otherwise known as the least-cost, environmentally acceptable plan.

3.1.1 No Action Plan – Economic Evaluation

The "No Action" plan is representative of the FWOP condition. It assumes that Federal navigation channels within Calumet Harbor, Calumet River, and the Calumet-Sag would not be maintained via dredging. Therefore, there are no dredging costs or DMDF costs associated with this alternative.

3.1.2 Republic Plan – Economic Evaluation

The Cost Appendix outlines the derivation of the costs for this plan. Each cost was correlated with the appropriate fiscal year (FY) during 25-year timestream (FY19 is project year 1) in order to determine the average annual cost of the plan. The total project costs and the associated average annual cost are outlined in Table 28.

Table 28: Republic – Derivation of Average Annual Costs

Cost Item[1]	Cost
Real Estate Cost	$[redacted]
Construction	$19,252,000
Total Construction Cost	**$[redacted]**
Dredging – Calumet Harbor & River	$45,331,905
Dredging – Calumet-Sag	$1,281,312
Sediment Management – Calumet Harbor and River	$11,988,080
Sediment Management – Calumet-Sag	$276,648
Total Operation and Maintenance Cost	**$58,877,945**
Total Project Cost	**$[redacted]**
Present Value	$46,656,571
Annuity Factor	0.060
Average Annual Cost (AAC)	$2,792,573
Rounded AAC	**$2,793,000**

1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels. Sediment maintenance estimates do not include the cost of infrequent maintenance related to the DMDF. The maintenance and related costs would be the same for each alternative plan considered, and therefore, would not affect the selection of the least-cost-plan. Interest during construction is accounted for in the cost for this plan.

3.1.3 Ridgeland Plan – Economic Evaluation

The Cost Appendix outlines the derivation of the costs for this plan. Each cost was correlated with the appropriate fiscal year (FY) during 25-year timestream (FY19 is project year 1) in order to determine the average annual cost of the plan. The total project costs and the associated average annual cost are outlined in Table 28.

Table 29: Ridgeland – Derivation of Average Annual Costs

Cost Item[1]	Cost
Real Estate Cost	$
Construction	$23,605,000
Total Construction Cost	**$**
Dredging – Calumet Harbor & River	$56,772,190
Dredging – Calumet-Sag	$1,017,305
Sediment Management – Calumet Harbor and River	$14,985,100
Sediment Management – Calumet-Sag	$345,810
Total Operation and Maintenance Cost	**$73,120,405**
Total Project Cost	**$**
Present Value	$57,009,865
Annuity Factor	0.060
Average Annual Cost (AAC)	$3,412,257
Rounded AAC	**$3,412,000**
1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels. Sediment maintenance estimates do not include the cost of infrequent maintenance related to the DMDF. The maintenance and related costs would be the same for each alternative plan considered, and therefore, would not affect the selection of the least-cost-plan. Interest during construction is accounted for in the cost for this plan.	

3.1.4 LTV Plan – Economic Evaluation

The Cost Appendix outlines the derivation of the costs for this plan. Each cost was correlated with the appropriate fiscal year (FY) during 25-year timestream (FY19 is project year 1) in order to determine the average annual cost of the plan. The total project costs and the associated average annual cost are outlined in Table 28.

Table 30: LTV– Derivation of Average Annual Costs

Cost Item[1]	Cost
Real Estate Cost	$
Construction	$19,833,000
Total Construction Cost	**$**
Dredging – Calumet Harbor & River	$45,331,905
Dredging – Calumet-Sag	$1,281,312
Sediment Management – Calumet Harbor and River	$11,988,080
Sediment Management – Calumet-Sag	$276,648
Total Operation and Maintenance Cost	**$58,877,945**
Total Project Cost	**$**
Present Value	$46,960,848
Annuity Factor	0.060
Average Annual Cost (AAC)	$2,810,785
Rounded AAC	**$2,811,000**
1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels. Sediment maintenance estimates do not include the cost of infrequent maintenance related to the DMDF. The maintenance and related costs would be the same for each alternative plan considered, and therefore, would not affect the selection of the least-cost-plan. Interest during construction is accounted for in the cost for this plan.	

3.2 Identification of the Least-Cost Plan

Three alternative plans were considered in this economic analysis, to include: (1) Republic, (2) Ridgeland, and (3) LTV plans.

Identification of the Base Plan involves the determination of the *least-cost* alternative plan. A summary of the costs associated with each plan are presented in Table 31. The "Republic" plan currently presents the least cost alternative.

Table 31: Plan Cost Summary

Cost Item	Plan		
	Republic	**Ridgeland**	**LTV**
Real Estate		$	
Construction	$19,252,000	$23,605,000	$19,833,000
Total Construction Costs	**$**	**$**	**$**
Dredging - Calumet H&R	$45,331,905	$56,772,190	$45,331,905
Dredging - Calumet-Sag	$1,281,312	$1,017,305	$1,281,312
Sediment Management - Calumet H&R	$11,988,080	$14,985,100	$11,988,080
Sediment Management - Calumet-Sag	$276,648	$345,810	$276,648
Total O&M Costs	**$58,877,945**	**$73,120,405**	**$58,877,945**
Total Cost (Construction + O&M)	**$**	**$**	**$**
Present Value	$46,656,571	$57,009,865	$46,960,848
Annuity Factor	0.060	0.060	0.060
Average Annual Cost (AAC)	$2,792,573	$3,412,257	$2,810,785
Rounded AAC	**$2,793,000**	**$3,412,000**	**$2,811,000**

1. The annuity factor is determined by utilizing the FY2015 Federal discount rate of 3.375 percent and FY2015 (October 2014) price levels.

In order to establish that the Republic plan is economically justified, the average annual benefits for Calumet Harbor and River, and the Calumet-Sag are compared to the average annual costs for the plan. Table 32 displays that the Republic plan is economically justified (i.e., the benefit-to-cost ratio is greater than 1.0; benefits exceed costs).

Table 32: Economic Justification for the Republic Plan

Site/Plan Name	Republic
Rounded Average Annual Benefits	$9,067,000
Rounded Average Annual Costs	$2,793,000
Rounded Average Annual Net Benefits	$6,274,000
Benefit-to-Cost Ratio	**3.2**

1. Benefits of Calumet Harbor and River were added to the benefits for the Calumet-Sag and then compared to the total average annual costs of the Republic plan. The Republic plan has positive net benefits and a benefit-to-cost ratio (BCR) greater than 1.0, and therefore, is economically justified.

Economic justification for the Calumet Harbor and River portion of the Republic plan is established by comparing Calumet Harbor and River benefits a portion of the Republic plan's costs. Specifically, 96 percent of the total dredged material is associated with Calumet Harbor and River; therefore, 96 percent of the Republic plan construction costs and 100 percent of operation and maintenance costs for Calumet Harbor and River are considered for this benefit-to-cost ratio (BCR) calculation. Table 33 displays that the Calumet Harbor and River portion of the Republic plan is economically justified (i.e., the benefit-to-cost ratio is greater than 1.0; benefits exceed costs).

Table 33: Economic Justification of the Republic Plan for Calumet Harbor & River

Site/Plan Name	Republic
Rounded Average Annual Benefits	$5,147,000
Rounded Average Annual Costs	$2,695,000
Rounded Average Annual Net Benefits	$2,452,000
Benefit-to-Cost Ratio	**1.9**
1. Benefits of Calumet Harbor and River compared to the average annual costs of the Calumet Harbor and River portion of the Republic plan. These costs were calculated at 100 percent of the real estate costs, 96 percent of the construction costs (since 96 percent of the dredged material is associated with Calumet Harbor and River), and 100 percent of the Calumet Harbor and River operation and maintenance costs. The Republic plan has positive net benefits and a benefit-to-cost ratio (BCR) greater than 1.0, and therefore, is economically justified.	

Economic justification for the Calumet-Sag portion of the Republic plan is established by comparing Calumet-Sag benefits a portion of the Republic plan's costs. Specifically, 4 percent of the total dredged material is associated with Calumet Harbor and River; therefore, 4 percent of the Republic plan construction costs and 100 percent of operation and maintenance costs for Calumet-Sag are considered for this benefit-to-cost ratio (BCR) calculation. Table 34 displays that the Calumet-Sag portion of the Republic plan is economically justified (i.e., the benefit-to-cost ratio is greater than 1.0; benefits exceed costs).

Table 34: Economic Justification of the Republic Plan for the Calumet-Sag

Site/Plan Name	Republic
Rounded Average Annual Benefits	$3,920,000
Rounded Average Annual Costs	$98,000
Rounded Average Annual Net Benefits	$3,822,000
Benefit-to-Cost Ratio	**40.0**
1. Benefits of Calumet-Sag compared to the average annual costs of the Calumet-Sag portion of the Republic plan. These costs were calculated at 4 percent of the construction costs (since 4 percent of the dredged material is associated with the Calumet-Sag), and 100 percent of the Calumet-Sag operation and maintenance costs; none of the real estate costs were allocated to the Calumet-Sag . The Republic plan has positive net benefits and a benefit-to-cost ratio (BCR) greater than 1.0, and therefore, is economically justified.	

4 REGIONAL ECONOMIC DEVELOPMENT

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) establishes four accounts to facilitate evaluation and display of the effects of alternative plans. These accounts are: national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE)." Consistent with the P&G, "the RED account registers changes in the distribution of regional economic activity that result from each alternative plan." Regional economic activity is measured in sales, jobs, and income.

The continued maintenance of Calumet Harbor and River, and the Calumet-Sag contributes to the regional economy in two key ways. First, the expenditures associated with maintaining the channels (e.g., DMDF construction, dredging, etc.) results in regional impacts such as increased sales and employment. Construction and dredging activities would be a new economic stimulus to the economy, and therefore, considered to be "regional economic development" (RED).

Further, the maintenance of these channels allows for shippers to continue moving goods on these waterways. The expenditures associated with shipping the commodities (e.g., transportation costs, port activities, etc.) also contribute to the regional economy in the way of sales and employment. The economic activity (shipping on the waterways that USACE maintains) is an existing economic stimulus to the economy that will continue given channel maintenance. This RED analysis is also referred to as "regional economic contribution." This term is used to differentiate the economic impacts associated with construction efforts from shipping activities associated with continued channel maintenance.

In order to estimate the regional economic development and contribution associated with the maintenance of Calumet Harbor and River, and the Calumet-Sag, the USACE Regional ECONomic System (RECONS) was utilized. RECONS is a certified regional economic impact modeling tool that was developed by USACE to provide accurate and defendable estimates of regional economic impacts and contribution associated with USACE spending and infrastructure. Sections 4.1 and 0 provide an overview of the regional economic development and contribution associated with the tentatively base plan – Republic.

4.1 Regional Economic Development Evaluation

This regional economic development (RED) evaluation measures the change in economic activity resulting from the implementation of the Republic plan (i.e., tentative base plan). For this evaluation, the work activities associated with this plan (e.g., DMDF construction, dredging, etc.) are simulated within RECONS. The work activities and the associated costs included in this analysis are outlined in Table 35.

Table 35: Regional Economic Development – Key Work Activities

Work Activity	Expenditure Amount
DMDF Construction (Placement Area Construction or Rehabilitation)	$
Dredging (Small Mechanical – Great Lakes)	$58,877,945
1. Work activities correlate with those identified within Regional ECONomic System (RECONS) .	

The work activities and associated expenditures are each simulated within RECONS, and allow for estimates of regional economic development. RECONS estimates the regional impacts associated with three regions, to include the: (1) local region – the Chicago, Naperville and Joliet, Illinois, Indiana and Wisconsin metropolitan statistical area (MSA), (2) state region – multi-state Illinois, Indiana, Wisconsin MSA, and the (3) national region – United States. The impacts of the local region are included in the state estimates. The impacts of the state region are included in the national estimates. Therefore, if the majority of the impacts are captured at the local level – the impacts captured in the remaining regions (state and national) do not show much variation.

The key findings from this RED evaluation for DMDF construction and dredging activities are displayed in Table 36 and Table 37. Each table shows the effects of these activities in terms of four economic indicators, including:

- ***Economic Output:*** the annual sales or revenues are equivalent to annual economic output or the value of production by industry.
- ***Employment:*** A job is the annual average of monthly jobs in that industry. A job can be full-time, part-time, or overtime, and includes proprietors (i.e., self-employed persons).
- ***Labor Income:*** Labor income represents all forms of annual employment earnings; it is the sum of employee compensation and proprietor (self-employed) income.
- ***Value Added or Gross Regional Product:*** Value-added is an estimate of the gross regional or state product.

The first set of columns in Table 36 and Table 37 identify the "direct" effects of either DMDF construction or dredging activities. In the impact area in which a project or economic activity is located, direct output (i.e., sales or revenues) effect represents that proportion of the spending or sales in each industry that flows to material and service providers in the impact area. For employment, labor income, and Gross Regional Product measures, the direct effect represents the jobs, labor income, and gross regional product associated with the directly affected industry.

The second set of columns in Table 36 and Table 37 identify the "total" effects of either DMDF construction or dredging activities; the total is the sum of the direct and secondary effects. Secondary effects consists of the: (1) indirect effects, which include the backward-linked industry suppliers for goods and services that support the directly affected industries, supporting indirect jobs, labor income, value added, and economic output. For example, if construction activity is the direct effect, indirect business supporting construction would include architectural and engineering, lumber suppliers,

trucking, steel manufacturers, among others; these are considered backward-linked industries supporting the construction activity, and (2) induced effects that occur from household expenditures or consumer spending associated with the direct and indirect workers spending their earnings within the impact area, supporting induced economic output, jobs, labor income, and gross regional product.

Table 36: Regional Economic Development Estimate – DMDF Construction

Region[1]	Direct Output (Sales) ($1,000s)	Direct Jobs	Direct Labor Income ($1,000s)	Direct GRP ($1,000s)	Total Output (Sales) ($1,000s)	Total Jobs	Total Labor Income ($1,000s)	Total GRP ($1,000s)
Local	$22,572	134	$9,363	$11,409	$49,588	295	$19,442	$27,804
State	$22,572	134	$9,363	$11,409	$49,684	305	$19,442	$27,804
National	$22,572	134	$9,363	$11,409	$65,486	382	$23,400	$35,026
1. All values are presented in FY15 price levels.								

Table 37: Regional Economic Development Estimate – Dredging Calumet Harbor & River, and the Calumet-Sag

Region[1]	Direct Output (Sales) ($1,000s)	Direct Jobs	Direct Labor Income ($1,000s)	Direct GRP ($1,000s)	Total Output (Sales) ($1,000s)	Total Jobs	Total Labor Income ($1,000s)	Total GRP ($1,000s)
Local	$34,096	258	$17,104	$21,189	$62,102	431	$27,007	$38,331
State	$42,372	412	$23,996	$28,486	$79,541	658	$36,873	$50,850
National	$55,981	655	$34,958	$40,009	$140,437	1,156	$62,207	$88,110
1. All values are presented in FY15 price levels.								

4.2 Regional Economic Contribution Evaluation

This regional economic contribution evaluation measures the economic activity resulting from the continued waterway shipments that would occur due to the implementation of the Republic plan (i.e., tentative base plan). For this evaluation, the work activities associated with shipping commodities on these waterways are simulated within RECONS. The annual tonnage levels for Calumet Harbor and River included in this evaluation are identified in Table 38, while those for the Calumet-Sag are outlined in Table 39. Consistent with the Great Lakes and Ohio River Division (LRD) reporting standard, the 5-year average (calendar year 2008 through 2012) of the commodity tonnage levels were used within RECONS.

Table 38: Regional Economic Contribution – Tonnage Level Assumptions for Calumet Harbor & River

2008	2009	2010	2011	2012	5-Year Ave.
14,963,000	11,557,000	11,994,000	14,814,000	12,774,000	**13,220,400**
1. Tonnage levels reported by the Waterborne Commerce Statistics Center (WCSC).					

Table 39: Regional Economic Contribution – Tonnage Level Assumptions for the Calumet-Sag

2008	2009	2010	2011	2012	5-Year Ave.
6,093,000	4,304,000	5,075,000	5,992,000	5,461,000	**5,385,000**
1. Tonnage levels reported by the Waterborne Commerce Statistics Center (WCSC).					

The work activities associated with shipping and the expenditures are simulated within RECONS, and allow for estimates of regional economic contribution. RECONS estimates the regional economic contribution associated with three regions, to include the: (1) local region – the Chicago, Naperville and Joliet, Illinois, Indiana and Wisconsin metropolitan statistical area (MSA), (2) state region – multi-state Illinois, Indiana, Wisconsin MSA, and the (3) national region – United States. The key findings from the Calumet Harbor and River, and the Calumet-Sag evaluations are displayed in Table 40 and Table 41.

Table 40: Regional Economic Contribution Estimate – Calumet Harbor & River

Region[1]	Direct Output (Sales) ($1,000s)	Direct Jobs	Direct Labor Income ($1,000s)	Direct GRP ($1,000s)	Total Output (Sales) ($1,000s)	Total Jobs	Total Labor Income ($1,000s)	Total GRP ($1,000s)
Local	$283,674	2,074	$132,708	$188,601	$546,692	3,562	$220,572	$339,724
State	$283,858	2,074	$132,741	$188,675	$584,515	4,121	$244,668	$376,471
National	$295,762	2,102	$192,824	$192,824	$776,155	5,124	$298,053	$470,600
1. All values are presented in FY15 (October 2014) price levels.								

Table 41: Regional Economic Contribution Estimate – Calumet-Sag

Region[1]	Direct Output (Sales) ($1,000s)	Direct Jobs	Direct Labor Income ($1,000s)	Direct GRP ($1,000s)	Total Output (Sales) ($1,000s)	Total Jobs	Total Labor Income ($1,000s)	Total GRP ($1,000s)
Local	$79,923	237	$19,028	$31,180	$155,758	708	$47,228	$77,315
State	$79,923	237	$19,028	$31,180	$155,758	708	$47,228	$77,315
National	$159,789	400	$35,997	$67,297	$388,764	1,824	$115,326	$199,549
1. All values are presented in FY15 (October 2014) price levels.								

5 ECONOMIC SENSITIVITY, RISK AND UNCERTAINTY

Uncertainties related to various aspects of this DMMP's economic analysis were identified. Areas of uncertainty related to the economic analysis presented in this analysis include:

1. Availability of funding to implement the base plan
2. Availability of funding to maintain channels at authorized depths
3. Vessel fleet composition at Calumet Harbor and River
4. Shoaling rates at critical shoals
5. Commodity movements at Calumet Harbor and River
6. Discount rate – effect on identification of the base plan.

In order to determine whether a sensitivity analysis should be completed to account for these uncertainties, risk ratings were developed for each of the parameters listed above, in the form of "low," "medium," or "high" risk ratings. Uncertainties with a medium or high risk rating will be accompanied by a sensitivity analysis, while those with a low risk rating will not. Descriptions of risk ratings and the sensitivity analysis *to be completed* are described in the following sections. An overview of risk the risk ratings are provided in Table 42, while Sections 5.1.1through 0 provide descriptions as to how each risk rating was determined.

Table 42: Potential Risks Associated with Assumptions Utilized in Economic Analysis

No.	Assumption	Risk Rating	Sensitivity Analysis?
1	Availability of funding to implement the base plan	Medium	Yes
2	Availability of funding to maintain channels at authorized depths	Low	No
3	Vessel fleet composition at Calumet Harbor and River	Low	No
4	Shoaling rates at critical shoals	Medium	Yes
5	Commodity movements at Calumet Harbor and River	Medium	Yes
6	Discount rate – affect on identification of the base plan	Medium	Yes

5.1.1 Availability of Funding to Implement the Base Plan

In order to address the *medium risk* related to the availability of funding to construct a new DMDF as outlined in the base plan and the subsequent dredging events, a sensitivity analysis was completed.

This analysis sought to demonstrate how the total average annual transportation benefits associated with: (1) Calumet Harbor and River, and (2) Calumet-Sag, would change given the assumptions that construction of the DMDF would be incomplete until project years 3 and 6. In these scenarios, dredging would cease in these waterways until construction of the DMDF is completed. Therefore, shoaling would be expected to occur in these project areas until dredging could commence again. This shoaling would induce transportation costs, as vessels (utilizing Calumet Harbor and River) or barges (utilizing the Calumet-Sag) would have to light-load in order to accommodate shallower depths.

The FWP condition would mimic the FWOP condition for the years that dredging could not occur.

For both Calumet Harbor and River and the Calumet-Sag, the FWP condition's transportation costs are the same as those in the FWOP condition until funding is available for construction of a DMDF and sediment removal in PY3 or PY6. The FWOP condition transportation cost savings remain the same.

Delays in funding availability results in fewer transportation benefits for Calumet Harbor and River since the FWP condition would require vessels to accommodate shoaling until PY3 or PY6. Conversely, these delays in funding availability would not alter the estimated transportation benefits for the Calumet-Sag since the FWP condition requires vessels to accommodate this shoaling until PY7, regardless of immediate funding availability.

For the 3-year and 6-year funding delay scenarios, the average annual benefits are compared to the average annual costs of each plan to derive the net benefits. In all scenarios, benefits are still greater than cost of the base plan. A summary of the results of this analysis are displayed in Table 43.

Table 43: Sensitivity of Plan Net Benefits to Delays in Funding Availability

Project Implementation	Calumet Harbor & River Benefits	Calumet-Sag Benefits	Total Benefits	Project Cost	Net Benefits
PY1 (FY2019)	$5,147,000	$3,920,000	$9,067,000	$2,793,000	$6,274,000
PY3 (FY2021)	$5,114,000	$3,920,000	$9,034,000	$2,768,000	$6,266,000
PY6 (FY2024)	$4,947,000	$3,920,000	$8,867,000	$2,658,000	$6,209,000

5.1.2 Availability of Funding to Maintain Channels at Authorized Depths

A *low risk* rating is assigned to assumption regarding the availability of funding to maintain: (1) Calumet Harbor and River, and (2) Calumet-Sag at authorized depths. Specifically, it is assumed that the authorized depths within these Federal channels will be maintained by dredging events in the future.

Calumet Harbor and River ranks as the third largest harbor in terms of annual tonnage. Given its relative importance to others on the Great Lakes, this harbor is not likely to be defunded.

The Calumet-Sag is provides the ability for vessels to transfer commodities between the Great Lakes and Mississippi River basins at a lower cost than would be required by alternate modes of transportation. Given this important navigable link between the basins, it is unlikely that funding would not be provided in order to maintain navigable channels. Further, given the Calumet-Sag's infrequent projected dredging events (15,000 cubic yards in PY7, and 15,000 cubic yards in PY19) that are needed in order to maintain

navigable channels in the Calumet-Sag, it is also unlikely that funding would not be provided to maintain this waterway.

5.1.3 Vessel Fleet Composition at Calumet Harbor and River

A *low risk* rating is assigned to assumption regarding the vessel fleet composition in Calumet Harbor and River. The size of vessels that utilize these channels is controlled by the available draft and dimensions of the harbor and river, as well as the connecting channels in the Great Lakes. No significant alterations the existing Great Lakes navigation system are planned.

5.1.4 Shoaling Rates at Critical Shoals

In order to address the *medium risk* related to the shoaling rates identified at the critical shoals in (1) Calumet Harbor and River, and (2) the Calumet-Sag, a sensitivity analysis *was completed.*

This assessment will demonstrate how the average annual transportation benefits associated with: (1) Calumet Harbor and River, and (2) Calumet-Sag, would change if shoaling rates were actually different (either greater or less) than projected shoaling rates identified in the economic viability analyses. In these scenarios, variations in the shoaling rate will be presented in order to determine the sensitivity of benefits to this parameter.

This analysis demonstrates the extent to which the FWOP condition transportation costs increases as the shoaling rate increases (resulting in greater benefits), and how transportation costs in the FWOP condition decrease as the shoaling rate is reduced (resulting in fewer benefits). Table 44 and Table 45 display the changes in transportation benefits associated with the shoaling rate variations for Calumet Harbor and River, and the Calumet-Sag. Note that Calumet Harbor and River transportation benefits are more sensitive to increases in the initial shoaling rate (reflected in relatively higher benefits) than decreases in the initial shoaling rate at Reaches 1 and 2.

Table 44: Sensitivity of Calumet Harbor and River's Transportation Benefits to Changes in the Shoaling Rate

Initial Shoaling Rate -	Reach 1 Shoaling Rate (ft/yr)	Reach 2 Shoaling Rate (ft/yr)	FWOP Condition Transportation Costs ($)	FWP Condition Transportation Costs ($)	Transportation Benefits (FWOP-FWP)
Base	0.50	0.70	$164,798,000	$159,651,000	$5,147,000
Variation: Increase	0.70	0.90	$169,062,000	$159,651,000	$9,411,000
Variation: Decrease	0.30	0.50	$164,383,000	$159,651,000	$4,732,000

1. The "base" shoaling rates represent those that were utilized for this economic evaluation. Initial shoaling rates indicate those associated with the beginning of the project evaluations period. A 95% decay rate is applied to each consecutive year.

Calumet-Sag transportation benefits are highly sensitive to both increases in the initial shoaling rate (reflected in relatively higher benefits) and decreases in the initial shoaling rate (resulting in no transportation benefits) as displayed in Table 45.

Table 45: Sensitivity of Calumet-Sag Transportation Benefits to Changes in the Shoaling Rate

Initial Shoaling	Shoaling Rate (ft/yr)	FWOP Condition Transportation Costs ($)	FWP Condition Transportation Costs ($)	Transportation Benefits (FWOP-FWP)
Base	0.17	$171,886,000	$167,966,000	$3,920,000
Variation: Increase	0.27	$183,005,000	$169,415,000	$13,590,000
Variation: Decrease	0.07	$168,924,000	$168,924,000	$0
1. The "base" shoaling rates represent those that were utilized for this economic evaluation. Initial shoaling rates indicate those associated with the beginning of the project evaluations period. A 7% decay is applied to each consecutive year.				

Note that a .10 foot decrease in the initial shoaling rate does not yield any transportation benefits since this minimal shoaling rate would yield available drafts of 9-feet or greater throughout the project evaluation period in both the FWP and FWOP conditions. Therefore, vessels are not forced to light load in either condition. While the DMDF cost estimate reflects the need to dredge the Calumet-Sag, a lack of required dredging would result in a minimally reduced total project cost. Recall, the Calumet-Sag only accounts for 4 percent of the total project cost estimate.

5.1.5 Commodity Movements at Calumet Harbor and River

In order to address the *medium risk* related to commodity movements at Calumet Harbor and River, a sensitivity analysis was completed.

This assessment demonstrates how the total average annual transportation benefits associated Calumet Harbor and River, would change given the assumption that the Waterborne Commerce Statistics Center's (WCSC) year 2007 (rather than year 2011) reported vessel movements and associated tonnage levels at Calumet Harbor and River would be utilized in the GL-SAND model to develop transportation costs associated with the FWOP and FWP conditions. Table 46 displays the transportation benefits associated with the vessel movements and tonnages for 2011 and 2007. The results suggest that the benefits are similar for pre-recessionary and post-recessionary conditions.

Table 46: Sensitivity of Calumet Harbor & River Transportation Benefits to Changes in the Tonnage Levels and Movements (2011 vs 2007 Tonnages)

Calendar Year	Total Tons	Total Deep-Draft Tons	% of Deep-Draft Tons	FWOP Condition Transportation Costs	FWP Condition Transportation Costs	Benefits (FWOP-FWP)
2011	12,354,077	8,248,088	67%	$164,798,000	$159,651,000	$5,147,000
2007	13,530,175	9,275,882	69%	$188,082,000	$182,606,000	$5,476,000
*The same assumptions and methods were used to derive the benefits.						

5.1.6 Discount Rate – Effect on Identification of Tentatively Selected Plan

In order to address the *medium risk* related to the discount rate's effect on the tentatively selected plan, a sensitivity analysis was completed.

An analysis was completed to determine the sensitivity of each plan's costs to the discount rate. The discount rate has implications for the DMMP – as this document seeks to identify the least-cost economically justified plan. Therefore, the applicable discount rate is critical to the identification of the base plan. Table 47 demonstrates that the Republic Plan is still the least-cost plan given varying discount rates.

Table 47: Sensitivity of the Base Plan to Changes in the Discount Rate

Discount Rate[1]	Republic	Ridgeland	LTV	Least-Cost Plan	Least-Cost
3.375%	$2,793,000	$3,412,000	$2,811,000	Republic	$2,793,000
2.500%	$2,707,000	$3,329,000	$2,716,000	Republic	$2,707,000
3.000%	$2,756,000	$3,377,000	$2,770,000	Republic	$2,756,000
3.500%	$2,805,000	$3,424,000	$2,824,000	Republic	$2,805,000
4.000%	$2,854,000	$3,470,000	$2,879,000	Republic	$2,854,000
4.500%	$2,902,000	$3,516,000	$2,934,000	Republic	$2,902,000
5.000%	$2,951,000	$3,561,000	$2,988,000	Republic	$2,951,000
5.500%	$2,999,000	$3,606,000	$3,043,000	Republic	$2,999,000
6.000%	$3,047,000	$3,650,000	$3,097,000	Republic	$3,047,000
6.500%	$3,095,000	$3,693,000	$3,152,000	Republic	$3,095,000
7.000%	$3,143,000	$3,736,000	$3,207,000	Republic	$3,143,000

1. Note that the 3.375% discount rate is the current rate for FY2015.

6 CONCLUSION

In support of the CAWS DMMP, this economic appendix presents the least cost, economically justified base plan, which allows for continued channel maintenance at Calumet Harbor and River and the Calumet-Sag for a 25-year project evaluation period. The benefits associated with continued maintenance of Calumet Harbor and River is the *avoided* increases in deep-draft vessel transportation costs, which is estimated at $5,147,000; the benefits associated with continued maintenance of the Calumet-Sag is the *avoided* increases in shallow-draft vessel transportation costs, which is approximately $3,920,000.

Three plans, including the Ridgeland, Republic, and LTV plans, were formulated to allow for continued channel maintenance at Calumet Harbor and River and the Calumet-Sag. The cost associated with each plan includes construction of a dredged material management facility, and the required dredging to maintain the channel dimensions; a total of 1,330,000 cubic yards of sediment is to be removed from the channels during the 25-year period. The Republic plan currently presents the least cost alternative; average annual costs for this plan are estimated at $2,793,000.

Economic justification of the Republic Plan is derived by comparing the sum of the average annual benefits for Calumet Harbor and River and the Calumet-Sag ($9,067,000) to the plan's average annual cost ($2,793,000). The Republic plan has positive net benefits ($6,274,000) and a benefit-to-cost ratio (BCR) greater than 1.0 (3.2), so it is economically justified. *Therefore, the Republic plan currently presents the least cost, economically justified plan.*

The continued maintenance of Calumet Harbor and River, and the Calumet-Sag also contributes to the regional economy. The expenditures associated with DMDF construction and dredging activities would result in increased sales and employment ($65,486,000 and 382 jobs; $140,473,000 and 1,156 jobs respectively). This continued maintenance of the channels allows for shippers to continue utilizing the waterways to ship their goods. The expenditures associated with shipping commodities(e.g., transportation costs, port activities, etc.) at Calumet Harbor and River, and the Calumet Sag also contribute to the regional economy ($776,155,000 and 5,142 jobs; $388,746,000 and 1,824 jobs respectively).

In order to address uncertainties associated with the economic analyses presented in this appendix, six potential risks areas were identified. While two risk areas received a rating of "low," four areas were assigned a "medium" risk rating and were accompanied by a sensitivity analysis. However, the results of each sensitivity analysis did not alter the conclusions of this report.

The Republic plan currently serves as the least cost, economically justified plan.

7 ACRONYMS AND ABBREVIATIONS

The following acronyms are used in the Economic Appendix:

ANS	Aquatic Nuisance Species
BCR	Benefit-to-Cost Ratio
CAWS	Chicago Area Waterway System
CCD	Chicago City Datum
CDF	Confined Disposal Facility
CELRB	Corps of Engineers, Buffalo District
CELRC	Corps of Engineers, Chicago District
CELRD	Corps of Engineers, Great Lakes and Ohio River Division
CEMVR	Corps of Engineers, Rock Island District
CSSC	Chicago Sanitary and Ship Canal
DMDF	Dredged Material Disposal Facility
DMMP	Dredged Material Management Plan
EIA	United States Energy Information Administration
FWOP	Future Without-Project
FWP	Future With-Project
FY	Fiscal Year
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GL-SAND	Great Lakes Systems Analysis of Navigation Depths
LWD	Low Water Datum
O&M	Operations and Maintenance
PCXIN-RED	Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division
PED	Preconstruction, Engineering, and Design
PPI	Producer Price Index
PY	Project Year
RECONS	Regional ECONomic System
RED	Regional Economic Development

RM	River Mile
S&A	Supervision and Administration
UTK-CTR	University of Tennessee, Center for Transportation Research
WCSC	Waterborne Commerce Statistics Center

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