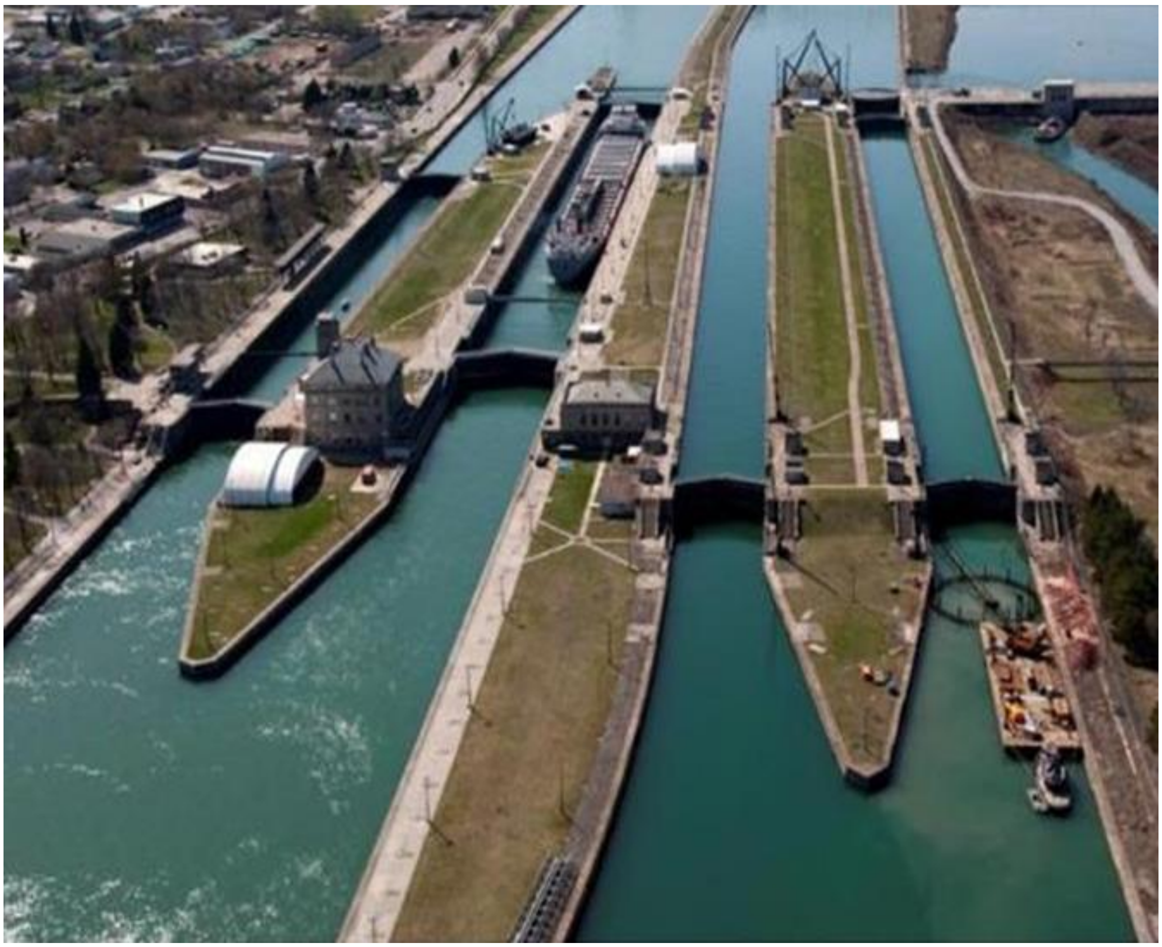
SOO LOCKS
ST. MARYS RIVER
SAULT STE. MARIE, MICHIGAN

New Soo Lock Economic Validation Study



June 2018

U.S. Army Corps
Of Engineers®
Detroit District

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ST. MARYS RIVER
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NEW SOO LOCK ECONOMIC VALIDATION STUDY REPORT

EXECUTIVE SUMMARY

The Soo Locks complex is considered the lynch pin of the Great Lakes Navigation System and are National Critical Infrastructure due to their national economic importance and impact on national security. Ten out of eleven integrated steel mills in the Great Lakes region depend primarily on taconite that must transit the Soo Locks. The largest lock at the complex, the Poe Lock, is vital to the U.S. iron ore (shipped in the form of taconite pellets), steel, and automobile manufacturing supply chain. U.S. integrated steel mills produce high strength steel critical to the U.S. automobile manufacturing sector. In 2017, the Poe Lock handled 89% of the total tonnage that transited the Soo Locks complex.

The need for an additional, Poe-sized lock was first identified in the 1986 U.S. Army Corps of Engineers (USACE) Feasibility Study, *Great Lakes and Connecting Channels and Harbors* and authorized by Congress in Water Resources Development Act (WRDA) of 1986. The most recent authorizing language in WRDA 2007 calls for the construction, at full federal expense, of “a second lock….adjacent to the existing lock…” The Detroit District seeks an updated authorization to construct a new lock at the Soo Locks complex. This Validation Study is an economic update of the construction of a new Poe-sized lock.

The conceptual basis for the economic benefit of a navigation project is the reduction in the value of resources required to transport commodities. To measure the benefit, the current cost of lake transportation is compared to the least-cost alternative mode of transportation (typically rail or truck). A challenge in updating the economics of a new lock at Soo is the lack of overland alternative modes to the delivery of taconite through Poe Lock to the steel mills. When overland transportation markets for existing water transportation do not exist, alternative transportation market costs need to be approximated. In the case of taconite shipped through the Poe Lock, alternative proxy costs were developed to estimate transportation cost savings or benefits.

Three alternative taconite delivery markets were developed: stockpiling at the mill, conveyance at the Soo Locks, and expanding the Port of Escanaba, MI. These alternative modes/costs were developed to accommodate expected unmet taconite demand due to Poe Lock closures. They are utilized according to least-cost first – stockpiling, conveyance, Escanaba until capacity is reached. The capital investment costs and operations and maintenance costs are used to develop the “proxy” market cost to move the diverted taconite.

The economic model used in the analysis, the Soo-REM, identifies and costs tonnage affected by service disruptions at the locks. Given a lock closure, Soo-REM calculates tonnage that can be accommodated and diverts the remaining tonnage to alternative modes either existing or constructed.

This economic update analyzed a number of scenarios through different sensitivities. The benefit-to-cost ratios (BCR) for the sensitivity analyses range from 0.97 to 6.89. A USACE

decision was made to calibrate to a minimum Escanaba floor cost. The Escanaba floor scenario includes a minimum floor cost of $2.8 billion to provide a throughput capacity of 8.7 million tons of taconite. USACE believes the floor sensitivity is appropriate for recommendation. All three proxy transportation modes (stockpiling, conveyance, and expanded Escanaba) have a minimum capital expenditure. The table below displays the economic results of the Escanaba floor analysis. Annual project cost is based on a current $922.4 million cost estimate. The fully funded cost estimate which considers inflation through the mid-point of construction is approximately $1 billion. The new lock is expected to provide annual benefits of $77.4 million and a BCR of 2.42 at the current Federal discount rate (2.75%). At the OMB 7.0% discount rate, the BCR is 2.32.

Benefit-to-Cost (BCR) Evaluation, 2020-2076 (Oct '18 (FY19) Dollars)

	New Poe-Size Lock (fixed Escanaba floor cost)	
Cash Flow Category	2.75% Discount Rate	7.0% Discount Rate
Total Average Annual Project Costs	$32,708,888	$69,480,408
Total Average Annual Project Benefits	$77,437,864	$157,962,038
BASE NET BENEFITS	$44,728,975	$88,481,630
BENEFIT-TO-COST RATIO (BCR)	**2.37**	**2.27**
Base Net Benefits	$44,728,975	$88,481,630
Allowable Labor Resource Benefits	$1,607,854	$3,145,301
NET BENEFITS	$46,336,829	$91,626,931
BENEFIT-TO-COST RATIO (BCR)	**2.42**	**2.32**

The current cost estimate exceeds the Section 902 of WRDA 1986 limit and triggers the need for a post authorization change report (PACR) and change control board review. The PACR report is submitted in conjunction with this Validation Study. The change control board at USACE headquarters approved the project in April 2018.

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New Soo Locks Economic Validation Study Report

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New Soo Locks Economic Validation Study Report

1. PURPOSE OF VALIDATION STUDY

The purpose of the U.S. Army Corps of Engineers (USACE) Detroit District Validation Study is to provide an economic update of the cost and benefits of constructing a new lock to provide redundancy at the Soo Locks complex on the St. Marys River at Sault Ste. Marie, Michigan. The complex consists of four navigation locks (MacArthur, Poe, Davis, and Sabin Locks), two hydropower facilities, and a compensating works structure. The proposed new lock would replace the two existing locks in the North Canal, the Davis and Sabin Locks, which were constructed during World War I and are no longer capable of accommodating the largest Great Lakes vessels. The Poe Lock is the only lock at Sault Ste. Marie capable of handling the Great Lakes' largest vessels, both national and international flagged. In 2017, the Poe Lock handled 89% of the total tonnage that transited the Soo Locks Complex. Due to the need for redundancy at this vital point in the Great Lakes Navigation System (GLNS) and the significant national economic consequences of a service disruption at the Poe Lock, the proposed new lock would have dimensions identical to the Poe Lock as directed in the most recent authorizing legislations (Section 3091 of WRDA 2007).

The Poe Lock is the critical single point of failure on the GLNS. There is currently no redundancy for the Poe Lock, and a scheduled or unscheduled lock closure, exceeding 14 days, results in undelivered tonnage. Existing rail and truck infrastructure is insufficient to support the vast quantities of tonnage that would have to bypass the lock.

In 1985, the Detroit District completed a feasibility study for the construction of a redundant lock at the site of the Davis and Sabin locks. The feasibility report (19 May 1986) recommended replacement of the Davis and Sabin locks with a single large (Poe-sized) lock to provide redundancy. Congress first authorized the construction of the project in the Water Resource Development Act (WRDA) 1986 and subsequently reauthorized in WRDA 1990. The District submitted a draft limited revaluation report (LRR) containing an economic update to USACE Headquarters in 1999. Revisions were submitted in 2000, 2002, and 2003. In 2005, a new LRR was completed along with a Section 902 maximum project cost analysis.

The 2005 LRR evaluated an updated project design for the new lock. This report incorporated re-evaluated costs and benefits to reflect changes in economic assumptions around the Great Lakes, specifically in the taconite pellet industry. The 2005 LRR identified a benefit-to-cost (BCR) ratio of less than 1.0, making the project not economically justifiable. Since 2005, however, several key assumptions in the LRR were updated, mostly related to the hypothetical alternative transportation modes identified for the analysis.

The following Validation Study provides an economic update of the 2005 LRR includes an updated certified, risk-informed, cost estimate, an updated benefits analysis, and a Section 902 maximum project cost analysis. Most importantly, this economic update takes into consideration the value of taconite pellet tonnage that is unable to transit the Soo Locks in the event of a scheduled or unscheduled closure. Previous studies assumed the long run availability of overland delivery of taconite pellets. Given the supply logistics of the Great Lakes integrated steel mills, this assumption has been adjusted. This study recognizes that some tonnage would be stranded in the event of a closure in excess of 14 days and is considered "*unmet demand*".

2. INTRODUCTION

2.1. Soo Locks Background

Official federal involvement in the development of the Soo Locks complex as a waterway began early in the Nation's history. The first federal lock, the Weitzel Lock, constructed parallel to the existing State Lock, was initiated in 1872 and opened for traffic in 1881. The United States accepted the State of Michigan locks in 1880. In 1896, the State Lock was replaced by the first Poe Lock. As the traffic demand increased and the size of the cargo ships increased, Congress authorized the construction of the Davis and Sabin Locks in 1914 and 1919, respectively. During World War II, shipping demands increased for wartime manufacturing which led to the construction of the MacArthur Lock in 1943. It was constructed on the site of, and consequently replaced, the shallow Weitzel Lock. A new Poe Lock was constructed in 1969 over the footprint of the original Poe Lock. The Poe Lock is the only lock at the site currently capable of handling vessels Larger than 75' in width and 780' in length.

The Soo Locks provide an efficient, reliable, environmentally acceptable, and economical way for vessels to transport bulk commodities, such as taconite pellets, coal, limestone (aggregates), chemicals, petroleum fuels, grains, and minerals, between Lake Superior and the lower Great Lakes. USACE is responsible for the planning, design, construction, and operation and maintenance (O&M) of the Soo Locks.

The project purpose and federal interest in the Soo Locks is to provide continued, efficient operation of the locks as a component of the GLNS. Cargo shipped through the Soo Locks originates or terminates in numerous states and foreign countries. The Soo Locks provide direct benefits to a wide spectrum of public, commercial, industrial, and agricultural users and indirect benefits to consumers. The complex is used for a number of purposes other than navigation, including hydroelectric power generation, recreational boating, fishing, and as a tourist destination that boasts a visitor center that averages over 500,000 visitors per year and is one of the most visited USACE visitor centers in the Nation.

The GLNS is a complex deep water navigation system stretching 1,600 miles through all five Great Lakes and connecting channels from Duluth, MN to Ogdensburg, NY. The GLNS is a vital component of America's transportation system. It contains nearly a quarter (22) of the nation's top 100 harbors by tonnage. Commodities transported on the GLNS represent 10% of all U.S. waterborne domestic traffic. The 60 large and smaller federal commercial ports on the Great Lakes are linked in trade with each other, with Canadian ports, and with ports throughout the rest of the world. Unlike ports along the eastern and western U.S. coasts that compete against each other for trade business, the GLNS is unique in that its ports do not compete with each other for commercial shipping traffic. Great Lakes ports are part of an overall system that competes against other modes of transportation that are less economically viable and far less environmentally sustainable.

The Soo Locks are the lynch pin of the GLNS. From 2007 – 2017, an average of 72.5 million tons of commercial commodities passed through the Soo Locks annually. In 2017, 89% of commodities transited through the Poe Lock. Currently, there is no redundancy for the Poe Lock. Unscheduled closures of the Poe Lock can have significant economic impacts which are discussed in the economic section of this report. On the Great Lakes, it is important to note that iron ore is shipped in the form of taconite pellets which are specialized pellets made of iron ore fines. These pellets are fed into a blast furnace as part of the process to make steel and specially formed for the specific blast furnace.

The economic impact of unscheduled closures occurs primarily because no alternate form of transportation exists to move the primary bulk commodities, taconite pellets and coal, through the Poe Lock. Full overland transportation accommodation does not exist for all Poe commercial traffic. It would take seven 100 car trains with 100 ton capacity cars or 3,000 semi-trucks to transport 70,000 tons of taconite pellets, as compared to one 1,000 ft. vessel that regularly transits the locks (Figure 1). However, not only does the infrastructure and equipment not exist for alternate forms of transportation, infrastructure on the receiving end does not exist either for rail deliveries, making the uninterrupted reliable operation of the Soo Locks vital to the Nation's economy.

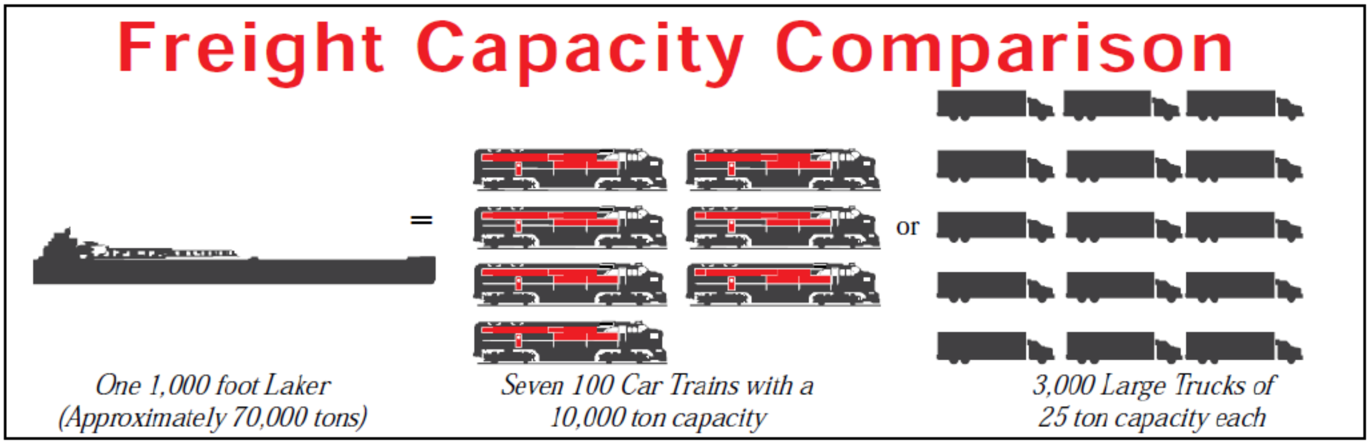

Figure 1. Freight Capacity Comparison Between a 1,000 ft. Freighter, Rail Cars, and Trucks.

2.2. Purpose and Scope

The Validation Study is a reexamination of an economic project justification required in EC 11-2-214, Appendix C (Corps of Engineers Civil Works Direct Program Development Policy Guidance Fiscal Year 2019) but does not include a reformulation of alternatives. The Validation Study is consistent with the 8 March 2012 Director of Civil Works' Policy Memorandum CWPM 12-001 ("Methodology for Updating Benefit-to-Cost Ratios (BCR) for Budget Development"). The Validation Study uses reliability data from the recently completed Soo Locks Major Rehabilitation Evaluation Report (USACE, 2017) which provides updated traffic forecasts, outlines hypothetical alternative transportation modes for unmet demand, includes an updated certified project cost estimate, and recalculates the BCR and the remaining benefits remaining costs ratio (RBRCR). Cost ratios for both the Federal fiscal year 2018 discount rate of 2.75% (used within USACE for project policy compliance) and the 7% discount rate used by the Office of Management and Budget (OMB) for budgeting purposes are covered. The Validation Study includes a Section 902 analysis due to the current certified costs exceeding the current authorized cost by 66%. These cost changes trigger the need for a post authorization change report which the Detroit District is pursuing as a separate effort outside of this study.

2.3. Project Authorization

Congress first appropriated funds to design and construct the first federal lock at the site, the Weitzel Lock, in 1872 (RHA 1872). Congress authorized the Secretary of the Army to accept control of the original lock on the St. Marys River from the State of Michigan on June 14, 1880 (Rivers & Harbors Act (RHA) 1880). The original Poe Lock, which replaced the State Lock, was authorized in 1886 (RHA 1886, 24 Stat. 310) and completed in 1896. In subsequent years, additional larger locks were constructed: Davis Lock completed in 1914; Sabin Lock completed in 1919; MacArthur Lock in 1943; and the Poe Lock replacement completed in 1969.

In 1985, the Detroit District completed a feasibility study for the construction of a new lock at the site of the Davis and Sabin Locks. The feasibility report recommended replacement of the Davis and Sabin Locks with a single large (Poe-size) lock. Congress first authorized construction of the new lock in Section 1149 of the WRDA of 1986, which states:

"Subject to section 903(b) of this Act, the Secretary is authorized and directed to construct a second lock 1,294 feet in length, 115 feet in width, and 32 feet in depth, adjacent to the existing lock at Sault Sainte Marie, Michigan, in accordance with the report of the Board of Engineers for Rivers and Harbors, dated May 19, 1986, at a total cost of $227,428,000. The Federal and non-Federal shares of such project shall be determined in accordance with section 101, with the method of payment to be determined in accordance with the report of the Chief of Engineers." (PL 99-662, 100 Stat 4254, 17 Nov 1986).

Section 107 of WRDA 1990 continued the authorization for the second lock and directed USACE to develop a cost share formula for the eight Great Lakes states as the cost-sharing non-Federal sponsors. (PL 101-640, 100 Stat 4620, 28 Nov 1990). This analysis was completed in May 1991.

Section 330 of WRDA 1996 required the eight Great Lakes States to provide the non-Federal share which could be paid over 50 years or the life of the project, whichever is shorter (PL 104-303, 110 Stat. 3717, 12 Oct 1996) and Section 330 of WRDA 1999 further modified the non-Federal share by not requiring interest payments. (PL 106-53, 17 Aug 1999, 113 Stat. 305).

However, Section 3091 of WRDA 2007, the most recent authorization, authorized the second lock be constructed at Federal expense and repealed the cost share requirements in Section 107 (1990), Section 330 (1996) and Section 330 (1999). It also modified the dimensions of the new lock, and increased the total cost. It specifically states:

"(a) IN GENERAL.—The text of section 1149 of the Water Resources Development Act of 1986 (100 Stat. 4254) is amended to read as follows:
''The Secretary shall construct, at Federal expense, a second lock, of a width not less than 110 feet and a length not less than 1,200 feet, adjacent to the existing lock at Sault Sainte Marie, Michigan, generally in accordance with the report of the Board of Engineers for Rivers and Harbors, dated May 19, 1986, and the limited reevaluation report dated February 2004 at a total cost of $341,714,000.''.
(b) CONFORMING REPEALS.—The following provisions are repealed:
(1) Section 107(a)(8) of the Water Resources Development Act of 1990 (104 Stat. 4620).
(2) Section 330 of the Water Resources Development Act of 1996 (110 Stat. 3717).
(3) Section 330 of the Water Resources Development Act of 1999 (113 Stat. 305).
(PL 110-114, 121 Stat 1043, 8 Nov 2007)

2.4. Location and Description

2.4.1. Location

The Soo Locks are located on the St. Marys River at Sault Ste. Marie, Chippewa County, Michigan on Michigan's Upper Peninsula (Figure 2). The St. Marys River is the natural outlet of Lake Superior into Lake Huron. The cities of Sault Ste. Marie Michigan and Sault Ste. Marie Ontario, Canada flank the Soo Locks complex on both sides of the river.

Figure 2. Project Study Area

2.4.2. Significant Project Features

The Soo Locks consist of two canals and four locks (Table 1). The North Canal includes the Davis and Sabin Locks and the South Canal, the MacArthur and Poe Locks (Figure 3). The Sabin Lock was removed from service in 1989 and the Davis Lock was removed from service for handling commercial traffic in 2011. Both the Davis and Sabin Locks are obsolete due to insufficient functional depth. All cargo vessels moving through the St. Marys River transit either the Poe or the MacArthur lock, with 71% of cargo aboard vessels that can only transit the Poe Lock.

Table 1. Features of the St. Marys Canal Locks

Soo Locks - Physical Characteristics								
Lock	Lift	Depth (ft.)	Width (ft.)		Length (ft.)		Year Open	Status
			Actual	Usable	Actual	Usable		
Poe	22	32.0	110	105	1,200	1100	1969	Operational
MacArthur[1]	22	31.0	80	75	800	730	1943	Operational
Davis	22	23.1	80	75	1,350	1271	1914	Closed
Sabin	22	23.1	80	75	1,350	1271	1919	Closed

[1]Per 33 CFR 207.440, if the Poe Lock is out of service more than 24 hours, the USACE Detroit District Engineer may allow vessels up to 767 ft. in length and 75 ft. in width with special handling procedures.

Figure 3. St Marys River and the St. Marys Falls Canal

2.4.3. Project Area Characteristics

The Soo Locks are located at the St. Marys Falls Canal Multi-Purpose Project adjacent to the cities of Sault Ste. Marie, Michigan and Sault Ste. Marie, Ontario. The northern property line is the Canadian border and the southern property line is the city of Sault Ste. Marie, Michigan. The St. Marys Falls Canal, also known as the Soo Locks, encompasses approximately 600 acres of land and water. The project site includes four parallel locks, two hydroelectric power plants and a 16-gate dam with the 8 northern gates owned by Canada and the 8 southern gates owned by the United States. In addition, there are two public parks on the site and a Visitor Center which is among the top three in the U.S. Army Corps of Engineers for visitors. Two of the four locks are currently in service, the MacArthur Lock and the Poe Lock. The entire site is listed on the National Historic Register, all changes to the site must be coordinated with the National Park Service and the State Historic Preservation Office.

The Soo Locks navigation season is limited from 25 March through 15 January, when the locks are closed to vessels for winter maintenance as directed in 33 CFR § 207.441. Depending on maintenance and vessel traffic needs, the MacArthur Lock closes from about 15 December and opens in late March or early April. This often depends on the ice condition of the St. Marys River.

2.5. Relevant Studies and Reports

After reviewing existing reports and studies, the Validation Study uses relevant data and information from the following reports:

Soo Locks Major Rehabilitation Evaluation Report (MRER), U.S. Army Corps of Engineers, Detroit District 2017.
The Major Rehabilitation Evaluation Report (MRER) examined components of the Poe Lock and MacArthur Lock [redacted] This plan has an estimated total cost of $57,581,000 with a benefit-to-cost ratio of 2.92. The report was approved in December 2017.

2017 Traffic Statement, St. Marys Falls Canal, Michigan, U.S. Army Corps of Engineers. The purpose of this statement is to provide an annual summary of lock statistics including information on delays, vessel passages, lockages, and net tons of cargo passed through the MacArthur and Poe Locks.

The Perils of Efficiency: An Analysis of an Unexpected Closure of the Poe Lock and its Impact, U.S. Department of Homeland Security, October 2015.
The report discusses the impact of an unexpected six-month closure of the Poe Lock on the iron mining, integrated steel production, and steel manufacturing supply chain. The report addresses the challenges facing alternative modes of transportation to support the supply chain and found there is no single strategy which can compensate for the negative effect to the North American economy from a Poe Lock closure. The DHS report, estimated that a six-month closure of the Poe Lock would likely temporarily reduce gross domestic product by $1.1 trillion and would result in a loss of an estimated 11 million jobs within the first year in the United States and up to 16 million jobs across North America. One of the mitigation strategies from the report is to construct a second Poe-sized lock at the Soo Locks to reduce the risk and the consequences of an extended unscheduled outage of the existing Poe Lock.

Partial Benefits Evaluation – Soo Locks, Michigan. U.S. Army Corps of Engineers, 2014.
This study addresses concerns voiced by the Great Lakes maritime community about the inadequate accounting of benefits in the 2005 Soo Locks Limited Reevaluation Report (LRR).

This report addresses these concerns through a “sensitivity analysis” to determine if a re-examination of potential lock closure impacts might result in a significantly different BCR for the construction of a second Poe-sized lock if a new benefits evaluation study occurs. Three interrelated components of the study include 1) a Stakeholder Response Analysis entailing a series of interviews with Great Lakes shippers and operators involved primarily in taconite and coal movements; 2) an expert elicitation workshop involving a range of industry representatives (e.g., mining, manufacturing, utilities, railroads) focused on lock closure scenarios and the ability/feasibility of alternatives to move coal and taconite around the locks; and 3) a feasibility test that involved constructing and running economic models to quantify the impacts of a lock closure. Each of these study components examined five alternatives for moving taconite and coal in the event of a lock closure: re-route through Escanaba, MI; re-route to rail/rail to vessel trans-loading; lightering; foreign sourcing; and re-route to trucking.

Semi-Quantitative Risk Assessment (SQRA), U.S. Army Corps of Engineers, Detroit District 2014
This report gathers issues from preceding reports and inspections. It also sets the stage for the issues suitable for MRER consideration. Appendix A-2 of the SQRA identifies potential failure modes that were non-risk-drivers for the SQRA but had potential performance issues over time that warranted evaluation under the Major Rehabilitation Evaluation Program. The complete SQRA report is provided as a reference to the MRER.

The Economic Value of Iron Ore Transiting the Soo Locks, Peter Kakela, June 2013.
This report highlights the importance of iron ore moving through the Soo Locks and quantified its direct, indirect, and induced economic value. The report found that the total dollar value of iron ore shipped through the Soo Locks in 2012 amounts to $500.4 billion, or 3.2% of the U.S. Gross Domestic Product (GDP). Additionally, this report estimates over 650,000 jobs depend on these iron ore shipments. Further, the report highlights a history of the significance of iron ore to National security.

2008 Great Lakes Navigation System Transportation Rate Update for Great Lakes Water Movement, University of Toledo, 2008
The University of Toledo conducted this study on behalf of USACE. It was used to update the information estimating transportation rate savings in the Great Lakes and St. Lawrence Seaway. Using 2006 commodity tonnage data for 51 origin-destination-commodity combinations on the Great Lakes St. Lawrence Seaway (GLSLS), this study developed detailed transportation rate estimates for the existing water routing and the lowest cost alternative land routing. These combinations were selected from the 2006 Waterborne Commerce Statistics Center (WCSC) data. For estimating cost, the study depended on data collected in the Tennessee Valley Authority study referenced below. These cost data were adjusted using 2006 Waybill data and published cost and inflation information. The study found that the water route was the cheapest route in all but one case. Finally, this study estimated that the 51 combinations resulted in $904.5 million in transportation rate savings through use of the waterway system.

Transportation Rate Analysis: Great Lakes & St. Lawrence Seaway, The Tennessee Valley Authority 2005.
The Tennessee Valley Authority (TVA) conducted this study on behalf of USACE to facilitate the calculation of the National Economic Development (NED) benefits attributable to the Great Lakes and St. Lawrence Seaway navigation. The study also measured the transportation cost effect of alternative short-term unplanned navigation structure closures. It provides a full range of transportation rates and supplemental costs for 857 waterborne commodity movements in 2002. Freight rates for each movement were calculated based on the actual water-inclusive

routing for a competing all-land alternative, and for a set of closure durations (15, 30, 90, or 180 days) of the Soo Locks, Welland Canal, or St. Lawrence Seaway. This report estimated that the users of this navigation system saved more than $2.66 billion in transportation and handling charges when available vessel costs were compared to the next-best, all-land transportation alternatives. This and other rate studies are used to estimate the transportation rates and associated savings for this 2018 Validation Study.

Soo Replacement Lock Limited Reevaluation Report, U.S. Army Corps of Engineers, Detroit District, August 2005.
This report addressed an updated design and the associated increase in costs for a replacement lock. The report reevaluated the recommendations from previous studies and documented changes in the taconite pellets industry and general economic conditions around the Great Lakes. Under assumptions about alternative transportation modes of commodities which have since proven to be inaccurate, the report concluded that the replacement lock alternative was not economically justified. In addition, no outages due to reliability concerns were projected for the study.

Sault Ste. Marie Lock Traffic Study, U.S. Army Corps of Engineers, Detroit District, May 1991.
This report documented revisions to the 1985 Soo Locks traffic forecast from the feasibility report. The revisions are based on actual tonnage recorded between 1985 and 1990, general market conditions, and the opinions of industry experts on future market conditions.

Final Interim Feasibility Report and Environmental Impact Statement Great Lakes Connecting Channels and Harbors, U.S. Army Corps of Engineers, Detroit District, March 1985, revised March 1986.
This report documented the engineering and economic feasibility of constructing a replacement lock on the site of the Davis and Sabin Locks, as well as rehabilitating the Sabin and Davis Locks. The report concluded that both alternatives are economically justified. As the replacement lock alternative had greater net benefits, the report recommended its construction.

Periodic Inspection Reports, U.S. Army Corps of Engineers, Detroit District, 1968–2017
Periodic inspections occur regularly at the Soo Locks and includes assessing risk of potential failure modes judged to be risk-drivers. Periodic inspection reports are available from 1968 to 2017 and describe the current condition of a feature, identify deficiencies, and provides recommendations for improvement. These include separate periodic inspection reports for the Poe Lock, MacArthur Lock, compensating works and hydropower facilities

Operational Condition Assessments (OCAs), U.S. Army Corps of Engineers, Detroit District, 2015
Operational Condition Assessments (OCA) are periodic reviews by independent teams of all major components and subcomponents at a project site. In an OCA, letter grades (A through F) are assigned to components through referencing past inspections and assessments, and applying professional judgment which allows for components to be ranked. The December 2015 OCA report was used to support and help to inform the analysis in the recent Soo Locks MRER. Major features assessed in this OCA included the Poe Lock, MacArthur Lock, and the compensating works.

2.6. History and Components of Major Soo Locks Features

Past evaluation and inspection reports are written on the separable major features. These major features are labeled in Figure 4. For detailed descriptions, see Chapter 2 of the SQRA report.

Figure 4. General Map of Soo Locks, Major Features

2.7. Historical Levels of Service

Table 2 provides a 2007-2017 Lock Performance Monitoring System (LPMS) data summary for the Soo Locks. From 2007–2017, the Soo Locks complex accommodated more than 72.5 million tons on an average annual basis, including taconite pellets (57%), coal (21%), grain (11%), aggregates (limestone) (6%), and other commodities (5%). In 2017, 89% of the total tonnage transiting the Soo Locks Complex passed through the Poe Lock.

Table 2. Tonnage through the Soo Locks, 2007–2017

Soo Locks Tonnage			
Year	Total Poe Lock Tonnage	Total MacArthur Lock Tonnage	Grand Total Tonnage
2007	63,505,000	17,589,000	81,094,000
2008	62,573,000	18,059,000	80,632,000
2009	42,696,000	10,071,000	52,767,000
2010	58,882,000	14,501,000	73,383,000
2011	60,478,000	14,352,000	74,830,000
2012	60,911,000	14,334,000	75,245,000
2013	60,858,000	10,959,000	71,817,000
2014	63,837,000	12,241,000	76,078,000
2015	61,386,000	8,207,000	69,593,000
2016	61,136,000	6,111,000	67,247,000
2017	67,378,421	7,953,447	75,331,868
Average:	**60,330,900**	**12,216,100**	**72,547,100**

Eleven integrated steel mills in the Great Lakes region are dependent upon domestic taconite (taconite pellets) production from mines in northern Minnesota and the Upper Peninsula of Michigan. Eight facilities are located in the United States, and three are in Canada. Ten of these mills rely on taconite shipments that transit the Soo Lock Complex, the exception being Essar Steel's Algoma facility which it is located on Lake Superior in Sault Ste. Marie, Ontario. The eight U.S. steel mills account for 40% of domestic steel production, and all of the advanced high strength steel used for the manufacture of products like automobiles and appliances. An unscheduled Poe Lock closure of any duration during the navigation season, could result in significant regional and National economic impacts due to the idling of steel plant.

Multiple coal-fired power plants are reliant on coal shipments which transit the Soo Locks; however, they are less dependent than steel mills because many power plants have the required infrastructure to receive shipments via rail.

2.8. Historic Ship Traffic and Commodity Forecasts

2.8.1. Historic Traffic

There are five primary commodity groups used for the Validation Study analysis; taconite pellets, coal, grain, limestone (aggregate) and "others". Commodities were grouped with consideration to the transportation equipment used plus industry characteristics that drive the projects tonnage demand into the future. Commodities that transit the Soo Locks serve select major industries that process significant tonnage volumes, such as the iron and steel industry, the coal-fired electric generating industry, and the export grain market.

Figure 5 provides a summary of total tonnage through the Soo Locks by commodity type from years 2007 – 2017.

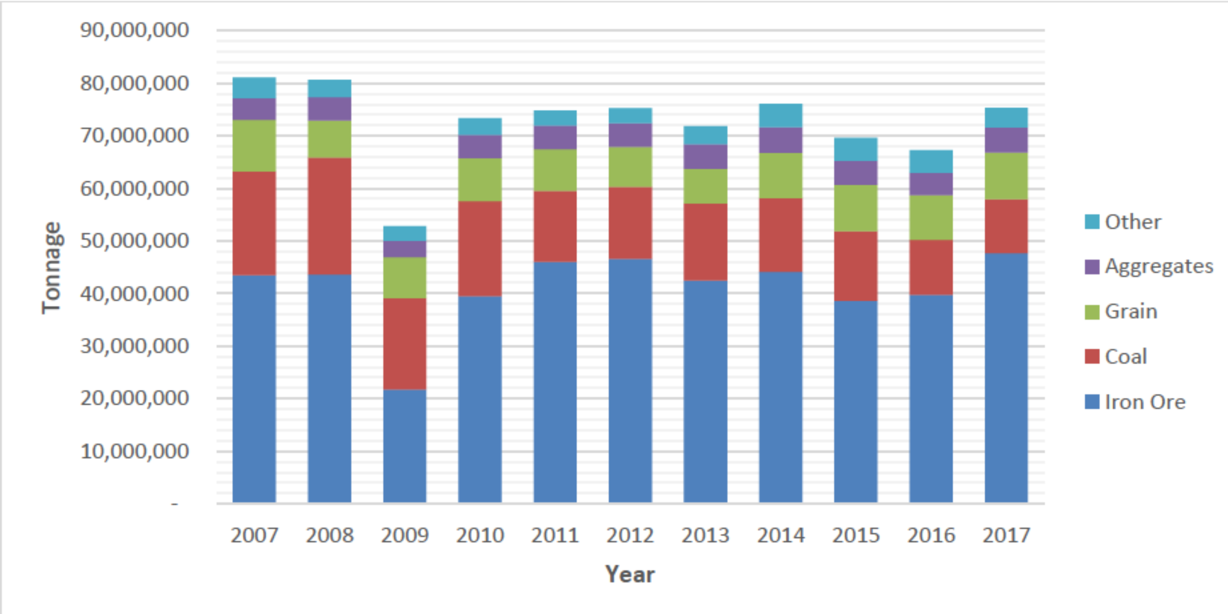

Figure 5. Commodity Summary through the Soo Locks

2.8.2. Traffic Forecasts

Commodity forecasts were developed as part of this study and are available in the Economics Appendix. Figure 6 illustrates the outcome of the commodity forecasts in terms of total tonnage. These forecasts are necessary for estimating vessel and cargo movement through the Soo Locks. Four primary commodities—taconite pellets, coal, grain and limestone —were analyzed and forecasted over the 60-year period of analysis. Three future scenarios (low, medium, and high tonnages) were developed for each of the four primary commodities and a fifth "other" tonnage category. These future scenarios were developed by using tonnage reports from the Soo Locks, data from other government agencies, and qualitative input from stakeholders and industry experts.

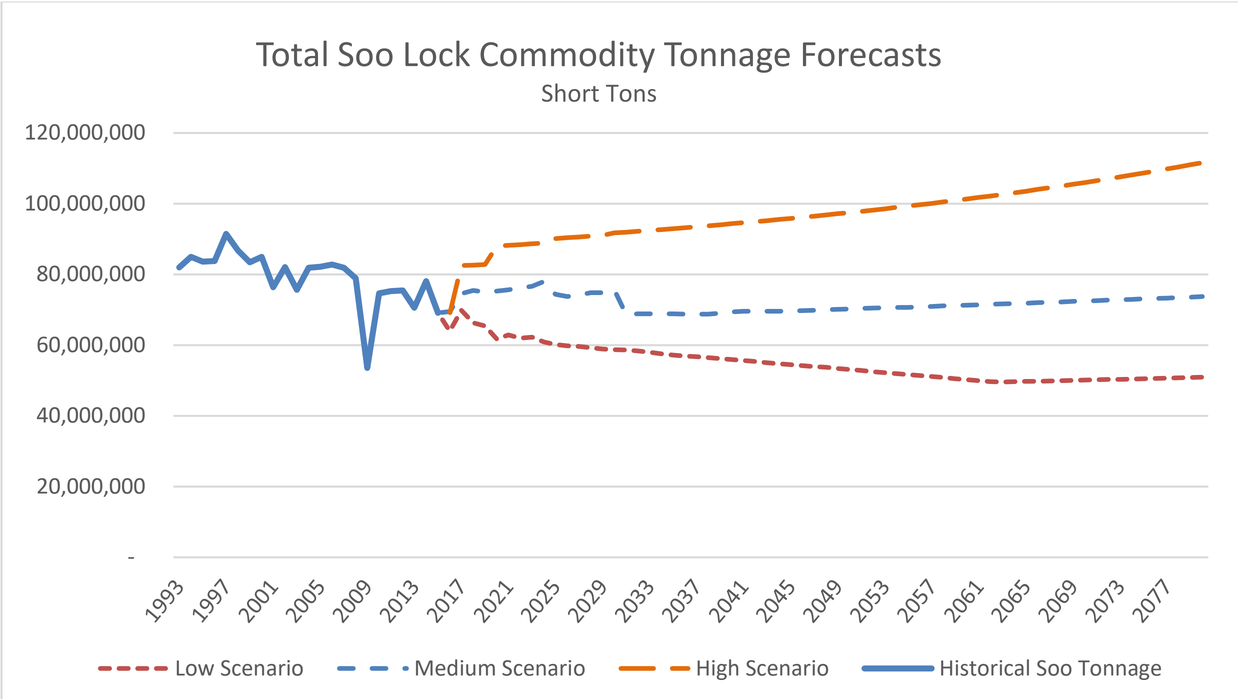

Figure 6. Traffic Forecast by Commodity

Future projections vary between commodities, given their end uses and the factors that affect their demand. The high and low scenarios were developed based on reasonable assumptions of the upper and lower bounds of tonnage expectations, respectively. The medium scenario was developed around the best available information to attempt to identify realistic future tonnage expectations.

Taconite pellets represents over half of the total tonnage transported through the Soo Locks. This commodity is sensitive to economic shocks since it is used as an intermediate input for durable products like automobiles and appliances. Taconite pellets tonnage fluctuates from year to year depending on the business cycle.

Over the last 15 years, between 38 and 46 million tons of taconite pellets transited the Soo Locks annually, (when restricting for the economic recession in 2009). Specifically, the demand for steel produced in integrated steel mills drives the demand for taconite pellets. Steel imports and steel manufactured in electric arc furnaces are factors that impact historical and projected tonnage levels.

In terms of tonnage, coal is the second largest commodity group. Two types of coal transit the Soo Locks, Powder River Basin (PRB) and Appalachian, which have different end uses. Tonnage trends differ depending on the PRB destination. Over the last decade, tonnage for Canadian-bound PRB has declined significantly as a result of Ontario’s power initiative to eliminate coal-fired power generation. This same downward trend has been underway in the United States with utilities phasing out old, coal-fired power generation plants. In contrast, most of Appalachian coal shipped through the Soo Locks is used at a steel facility upstream of Sault Ste. Marie. Given the different trends for coal, separate sub-forecasts were developed for PRB coal and Appalachian coal.

Grain, grown in the U.S. heartland and on the Canadian prairies, is transported by train to Lake Superior ports for export to European and Middle Eastern markets. Most grain is loaded onto vessels in Thunder Bay, Ontario and Duluth, Minnesota before transferring to larger ocean-going vessels at Canadian ports at the mouth of the St. Lawrence River. It should be noted grain exports vary significantly from year to year as a result of currency fluctuations, freight rates, and the global supply of grain.

Limestone is one of the few commodities that moves through the Soo Locks in a westerly (or up-bound) direction. Nearly two-thirds of aggregate (limestone) tonnage is used for manufacturing taconite pellets; 15% of this tonnage is attributed to flue gas desulfurization at coal-fired facilities; the remaining 20% of tonnage is employed for a variety of uses.

The remaining commodities such as salt, animal feeds, and fertilizers were aggregated into one commodity group for simplicity, which represent 5% of commodities transiting the Soo Locks.

Three future tonnage projections range from the low of 50 million short tons long term, to a high of 105–110 million short tons long term. The medium scenario ends up on the lower end of the overall commodity projection range at 70–75 million short tons. The stabilization is due to flat expectations for taconite pellets and declining coal tonnage offset primarily by higher grain tonnage forecasts.

2.8.3. Great Lakes Fleet Information

Cargo vessels on the Great Lakes and St. Lawrence Seaway are classified by size into ten classes and fall into two distinct fleets (Table 3). These fleets include:

An intra-laker fleet—These ships travel throughout the Great Lakes moving mostly taconite pellets and coal. This fleet comprises the Class X "1,000-footers" and smaller Class Vs and VIIs. The below pictures provide vessel examples (Figure 7 and Figure 8)

Figure 7. Paul R. Tregurtha (Class X) – Unloading Coal (Marquette, Michigan)

Figure 8. American Mariner (Class VII) – Unloading Coal (River Rouge, Michigan)

A combined laker/seaway fleet—This fleet moves commodities around the Great Lakes and transits the Welland Canal and in the St. Lawrence Seaway. The Welland Canal is in Ontario and connects Lake Erie to Lake Ontario. This fleet is comprised of thelargest vessels that can go through the Welland Canal (78-foot beam, 740-foot length). This fleet mostly ships grain from Lake Superior ports to grain elevators on the lower St. Lawrence. It also moves taconite pellets from the lower St. Lawrence to steel mills on Lake Ontario. Upgrades and replacements of ships within the Canadian Fleet has resulted in additional vessels restricted to the Poe Lock due to the increase in width of the new or rehabbed vessels.

For detailed information about daily vessel operating costs, please see the Economics Appendix, Section 2.1.1.

Table 3. Major Bulk and Self-Unloading Vessels in the Great Lakes Fleet (2012)

	Length (feet)	United States	Canada	Total	Fleet %
Vessel Class I	Less than 400	8	9	17	12%
Vessel Class II	Between 400 and 499	5	3	8	6%
Vessel Class III	Between 500 and 549	3	0	3	2%
Vessel Class IV	Between 550 and 599	1	1	2	1%
Vessel Class V	Between 600 and 649	17	5	22	16%
Vessel Class VI	Between 650 and 699	7	4	11	8%
Vessel Class VII	Between 700 and 730	6	37	43	31%
Vessel Class VIII	Between 731 and 849	12	7	19	14%
Vessel Class IX	Between 850 and 949	1	0	1	1%
Vessel Class X	Greater than 950	13	0	13	9%
Total		**73**	**66**	**139**	**100%**

Source: Greenwoods Guide To Great Lakes Shipping 2012

2.9. Soo Locks Major Maintenance/Component Replacement Planning

The Detroit District periodically produces and updates a list of assets at the Soo Locks. This list is developed by evaluating the project components to understand and document when components will require major maintenance or be replaced. It is informed by the component conditions identified through operational condition assessments, periodic inspection reports, or other engineering reports. It also prioritizes components based on their potential for interrupting traffic in order to minimize vessel delays. The list serves as a guideline for prioritizing operations and maintenance (O&M) budgeting decisions. Although it is updated periodically, it can be considered in a nearly constant state of change as priorities change, budgets change, new reliability issues arise, and scopes of work increase or decrease. The list was used in development of the Without Project Condition for the Validation Study. It helped inform the team on the likely timing of component repair and replacement. [redacted]

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3. NATIONAL ECONOMIC IMPORTANCE

3.1. Introduction

The Soo Locks are a well-established and integral part of the regional as well as the national economy. Many corporations utilizing the Soo Locks developed with the Soo Locks as an integral part of their business operations. While the degree of reliance on the Soo Locks for transporting commodities differs across firms and commodities, the taconite pellets and smelting industries place a significant level of reliance on the single point of failure for the critically important infrastructure in the GLNS – the Poe Lock. The primary bottleneck is in transporting taconite pellets from mines located in the Iron Range of Lake Superior to integrated steel mills located in the lower Great Lakes region. In the event of scheduled or unscheduled closure of greater than six months of the Soo Locks, some manufacturers may have no choice but to shut down because their whole supply chain relies on passage through the locks.

3.2. Evolution of the Taconite Pellet Industry

All of the iron ore mined in the U.S. originates from northeastern Minnesota and the upper peninsula of Michigan and the majority of taconite pellets must transit the Soo Locks to reach steel mills in the lower Great Lakes. Due to its location and cost advantage over other modes of transportation, the GLNS is used to transport 100% of the taconite pellets mined in the U.S. Taconite pellets represents the largest sector of commerce moved on the Great Lakes, making up 60% of total commodities.

The U.S. steel industry has developed over time to take full advantage of the efficiencies provided by the GLNS. Since the first iron ore shipments 160 years ago, the movement of iron ore by lake carrier rapidly increased as waterborne transportation was recognized as the most economical and practical mode of transportation for these bulk commodities. The difference in cost was so pronounced that a rail system was never developed. Accordingly, integrated steel mills on the lakes are set up to receive taconite pellets by vessel only; they do not have the infrastructure to receive taconite pellets by rail.

The taconite pellets commodity route has remained largely unchanged since the late 1800s. The flow of taconite pellets from the mines of the upper Great Lakes basin to the steel mills in the manufacturing heartland of the lower lakes has been consistent for over 160 years (Figure 9 and Figure 10).

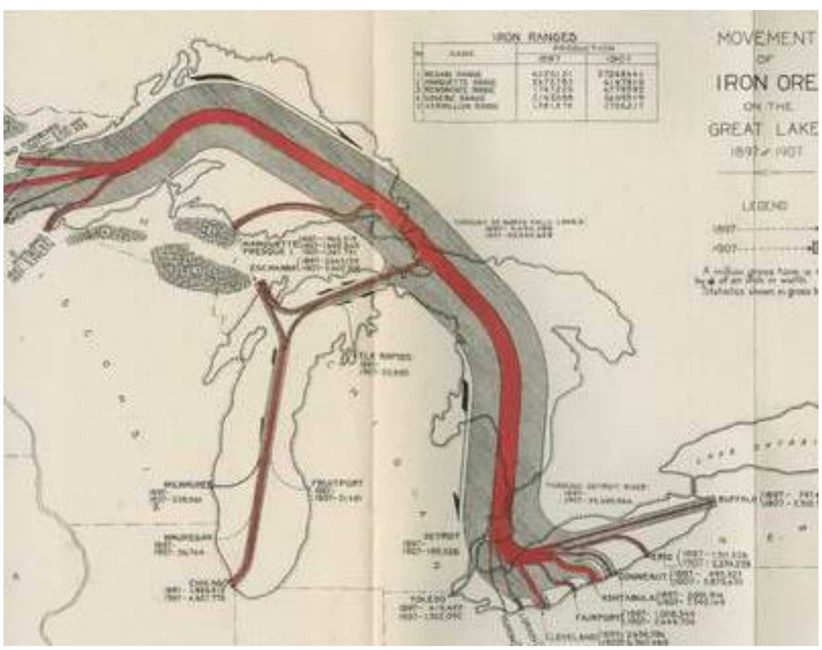

Figure 9. 1897–1907 Iron Ore Routes

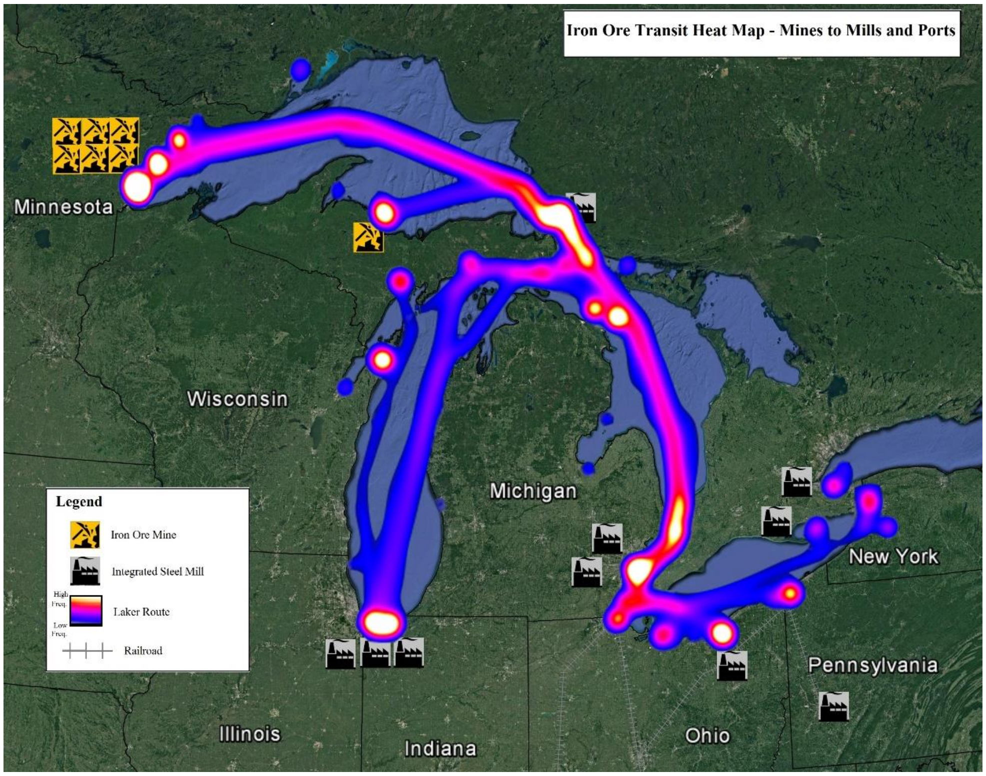

Figure 10. Taconite pellets Transit Heat Map From Great Lakes Mines to Mills and Ports (2017).

3.3. Mining to Manufacturing

In the United States, there are two common approaches to making steel. The first is via an integrated steel mill interspersed around the Great Lake states, which use taconite pellets pellets for conversion into steel. Integrated steel mills use large batch sizes to reach significant economies of scale. Because their primary input is raw iron and energy, the iron can be mixed into exacting formulas required by specialty steel buyers. There are eleven integrated steel mills in North America that provide the advanced high-strength lightweight steel for the Nation. The second approach to making steel is via electric arc furnaces in mini-mills that operate on a much smaller scale and are scattered throughout the country. Electric arc furnaces can take raw taconite pellets as a primary input, but mostly reduce scrap metals into steel products. When scrap metals are the primary input, the final products cannot be tailor-formulated for specialty uses. Electric arc furnaces often produce structural steel products, rebar, rods, wire and fasteners. Currently, mini-mills are not capable of making advanced high-strength lightweight steel.

Integrated steel must be used for certain auto parts and is relied upon for the predictability of specified steel properties. Currently, approximately 40-50% of a vehicle requires advanced high-strength lightweight steel from an integrated mill, made from taconite. Each individual auto part requires an exact grade of steel from a specific mill. Components originate from more than one mill, which reveals there is not a simple linear relationship from mill to manufacturer. The majority of the steel used in the auto industry is sourced and produced in the United States; at least one industry stakeholder reported using over 90% U.S.-made steel. According to industry experts, it takes at least one year to certify a certain grade of steel for use in automobile production. Industry experts do not see the percentage of integrated steel usage shifting much in the future due to the continued demand for lightweight steel as a continued requirement in meeting automobile emission and safety standards.

The vehicle and vehicle parts manufacturing sectors are highly dependent on the iron supplied to U.S. integrated steel mills. The auto industry is the largest integrated steel mill consumer, and thus serves as a key U.S. economic driver. Auto manufacturers, suppliers, and dealers support over 7 million private sector jobs, and every vehicle manufacturing job creates an estimated seven additional jobs in industries across the economy (Economics Appendix, Attachment 5). Competition and efficiency in the industry has spurred "Just-In-Time" delivery methods (minimal inventories) at every stage of the supply chain. Interruptions at any stage of the supply chain quickly ripple down to the final product. Delays such as these have an immediate effect on the economy. Furthermore, the Nation has demonstrated that it is essential to maintain the U.S. automobile industry and has recently demonstrated a commitment to the American steel industry through the use of tariffs on foreign-produced steel.

3.3.1. Soo Locks: Regional and GDP Impacts

During stakeholder engagement meetings held at the Detroit District office in December 2016, Great Lakes shipping industry executives indicated any event over a 30-day Poe Lock unplanned outage would be difficult to manage and a six-month unplanned or planned outage would not be "survivable."

As part of the Validation Study, USACE contracted with the Center for Economic Analysis at Michigan State University to conduct an economic assessment at the Soo Locks using the USACE-Institute for Water Resources Regional Economic System (RECONS) model. The RECONS model is a USACE-certified model for undertaking economic impact estimates. The assessment specifically examined two things: the economic contribution of the operations of the Soo Locks and how the Soo Locks impact the specific taconite pellets commodity flow from raw material to finished product (in this case automobile manufacturing). Since a single commodity flow is examined, the RECONS user interface needed to be bypassed to analyze the input data. This input data (developed in Microsoft Excel) and outside of RECONs, triggered the USACE model certification process with approval for one time use granted on March, 23, 2018. The full report can be found in the Economics Appendix, Attachment 5. In short, the analysis describes how shipping taconite pellets through the Soo Locks contributes to gross regional products (GRP) and gross domestic products (GDP).

The GDP evaluation determined that the Soo Locks is directly or indirectly tied to $46.4 billion in output for the eight-state Great Lakes region and $58.2 billion for the Nation. This is associated with 142,000 full- and part-time jobs in the Great Lakes region and 237,000 across the Nation, with wage and salary disbursements of $10.1 and $15.1 billion, respectively. From a social accounting framework, the Soo Locks is associated with just over $17 billion in gross regional product (GRP) in the Great Lakes region and about $25.5 billion for the Nation. To put these numbers into perspective, the estimated gross regional product contributions of the Soo Locks amounts to about 0.52 percent of the eight-state GRP and just over 0.14 percent of the National counterpart of GDP. Both measures are relatively small compared to the total value of economic activities in the Great Lakes region and the Nation, but significant enough to have real contributions.

The economic impact assessment was further refined to examine the impact of a medium-term Poe Lock closure on the U.S. vehicle and vehicle parts sectors because it represents a unique level of co-dependence between the taconite pellets mined in Minnesota and Michigan and the steel producers in the lower Great Lakes. The expected economic impact of an unanticipated 12 disruption in the Soo Locks would result in a temporary reduction of employment of about 8.5 million U.S. jobs with total labor income declining by $451.1 billion. Gross domestic product would likely see a temporary decline of about $666.5 billion while economic activity, measured by output (gross sales) would decline by about $1.1 trillion. Many of these results depend on how firms respond to a temporary disruption; firms may choose to under-employ their workforce, lest they risk losing long-term employees.

These findings are comparable to a recent report by the Department of Homeland Security (DHS), which sought to highlight the potential impact of an unexpected closure of the Poe Lock. The DHS report also concluded that the automobile industry would likely be most impacted by such a disruption. The DHS report, estimated that a six-month closure of the Poe Lock would likely temporarily reduce gross domestic product by $1.1 trillion and would result in a loss of an estimated 11 million jobs. That study also focused on the auto sector, but the estimated impacts exceed those of the USACE RECONS economic impact assessment which estimated the change in gross domestic product as $666.5 billion. The USACE report and the DHS report have several differences most notably in the duration of the assessed closure (6 months vs 12 months). Nonetheless, both assessments highlight the importance of the Soo Locks to both the Great Lakes regional and National economy.

The use of GDP is not a USACE policy-compliant measure to determine a project's final National Economic Development (NED) plan. However, the GDP metric can provide useful information to decision-makers. The Corps of Engineers economists recognized that a limit of using GDP as a metric is the assumption that there is no substitution for the good measured (in this case taconite pellets from Northern Minnesota/Michigan). As a sensitivity to the economic analysis, the GDP information (eight categories of impact costs such as employment impacts, labor impacts etc) from the Michigan State University report was used to value taconite pellets tonnage that could not be delivered during a Poe Lock closure and assess the impact on the automobile industry. For this sensitivity test, researchers assumed an unplanned 296-day Poe Lock closure. In short, from 0–2 weeks, substitution likely exists for steel production such as through the use of stockpiled taconite pellets at the end user. From 2–6 weeks steel production starts to shut down and end users slow down production. Between 6 weeks and 6 months there is a complete loss of end user (automobile) production due to the unavailability of steel. From 6 months to 296 days, the global market would likely have enough time to adjust and start producing the required steel for the automobile sector. It would take foreign steel mills about six months to retool their systems to begin creating the specialty steel blends required for the U.S. automobile industry. Using GDP impact costs avoided as a benefit in the economic analysis in conjunction with the timeframes described above results in average annual benefits of $224 million and a BCR ratio of 6.89 at a discount rate of 2.75%. For a full description of how this sensitivity analysis was performed please see Section 9 of the Economics Appendix.

3.4. National Security

World War II (WWII) highlighted the importance of the Soo Locks to national defense and security. During WWII, the Soo Locks was the only facility in the Central Defense Command that involved the use of Army Combat Units for security. Attacks to the locks would cripple waterborne commerce and therefore halt the crucial steel manufacturing process, which was essential for national defense during wartime. Over 10,000 soldiers were stationed at Sault Ste. Marie to protect the locks from land, air, and water attacks. This included a military police battalion, a barrage balloon battalion, a coastal artillery regiment, an anti-aircraft regiment, and an infantry regiment.

In addition, six early warning radar stations were constructed across northern Ontario and the Upper Peninsula of Michigan and staffed with 2,000 Soldiers. During the war, the MacArthur Lock was built, torpedo nets were installed across all lock approaches, and the Sault Ste. Marie Military District was established under the command of an Army general officer.

The Defense Production Act was passed after WWII due to concern about the availability of iron ore. This legislation led the way for industry to develop the taconite pelletizing process which concentrated the iron ore and produced pellets with higher iron ore content than the waste rock. The pelletizing process revolutionized U.S. steel production since it enabled the development of new, specialized grades of steel. It was widely recognized at the time that having a reliable source of raw iron ore was essential to national defense.

DHS lists the Soo Locks as National Critical Infrastructure. In fact, a goal of the 2013 DHS National Infrastructure Protection Plan report was to develop critical National infrastructure resilience by minimizing adverse consequences of incidents. A 2013 presidential policy directive (PD-21) stated that all critical infrastructure must be secure and be able to rapidly recover from potential hazards. Additionally, the White House highlighted the importance of the National supply chain to protect the American people and protect the Nation's economic interests with the secure movement of goods, in a 2012 National Strategy for Global Supply Security Chain report.

4. RISK AND UNCERTAINTY

Risk and Uncertainty

In accordance with the USACE Planning Guidance Notebook and the Planning Manual, Part II (IWR 2017), this report addresses many assumptions and uncertainties – known and unknown – surrounding them. Planners fully acknowledge that elements of risk and uncertainty could affect the ultimate costs and benefits of a project. Efforts to address risk and uncertainty have been made throughout the study process. Key risks, uncertainties, and their potential effects are described in detail below:

Economic Analysis of Cost and Benefits
The Validation Study includes a robust and complex economic analysis. Due to the unique nature of the Soo Locks, especially in terms of types of commodities transported and specialized vessels that transit the locks, numerous assumptions were required. For the Soo Locks, there is no single best plan or method to calculate the value of the unmet demand in the event of a lock closure. The validation study calculates the national economic development benefits in a reasonable and policy-compliant way. The methods used in this report have been fully vetted within the USACE vertical team and represent the best information available at this point in time.

<u>Proxy modes of transportation –</u> There is no existing infrastructure or means to move all the iron that must transit the Soo Locks in the event of a Poe Lock closure. To estimate the economic impact of unmet demand surrounding a lock closure, proxy alternative transportation costs were developed. These proxy methods of transportation are not actual proposed alternatives, but rather serve as hypothetical surrogates to value the existing methods of transportation against a next-best, least cost-alternative. The proxy modes include stockpiling at end user location, building a conveyor system at the Soo Locks to bypass a closed Poe Lock, and expanding the Port of Escanaba. It is recognized that other possible proxy modes could have been analyzed including the expanded use of Class 7 ships (which can transit the MacArthur Lock), expanded

ports in other cities such as Green Bay WI, or lightering of ships. Assumptions about capital costs, timing of use, and cost of operations were required for the transportation modes.

Accident probabilities and durations – Accident risk is a key component of the economic modeling effort and has a significant impact on benefit calculations. Accident risk data was derived from "Poe Lock System Risk Analysis" (Institute of Water Resources, 1994). This report examined four types of accident risks relating to vessel grounding, vessel fires, vessel gate impacts, and chemical spills. For this report, the PCXIN supplemented the original dataset with current information and extrapolated the accident probabilities. It is acknowledged there is significant uncertainty pertaining to both accident probabilities and accident durations. The probabilities of accidents relating to human error (i.e. lock operation error causing a lock gate miss-miter), terrorism attack post 2001, and criminal activity were not considered in the analysis. Such low probability incidents could likely have significant duration impacts. However, USACE does not have reliable data that can be used in an economic analysis for these three types of accidents.

Expanded Port of Escanaba, MI – An uncertainty in the economic analysis is how the expanded Port of Escanaba is used to calculate benefits. In the economic analysis, once the need for the expanded Port of Escanaba is required capital costs are weighted based on the tonnage required. The estimated minimum investment to get an expanded port "up and running" is $2.8 billion dollars. In reality, this would not be spent to move one ton of stranded taconite pellets, therefore in the analysis, the cost of expanding Escanaba is weighted (i.e. reduced) in an attempt to capture what might realistically be spent. In the analysis, a USACE decision was made to calibrate to a minimum Escanaba floor cost. The Escanaba floor scenario includes a minimum floor cost of $2.8 billion to provide a throughput capacity of 8.7 million tons of taconite. All three proxy transportation modes (stockpiling, conveyance, and expanded Escanaba) have a minimum capital expenditure.

Efficient Funding and Use of the Continuing Contract Clause

The FY19 certified cost estimate assumes efficient and continuous funding over the seven-year implementation period. The use of the continuing contract clause (which requires approval from the Assistant Secretary of the Army for Civil Works) would need to occur in order to utilize this most efficient contracting method. There is a high risk that inefficient funding, or funding that is received piecemeal, would result in construction cost increases and schedule delays.

GDP Impacts and role of the Soo Locks in National Security

There is uncertainty in the extent of the impacts to GDP that could be caused by an extended Poe Lock shutdown. The Validation Study attempts to quantify the impact to GDP through a sensitivity analysis. Information from the Department of Homeland Security Report "*The Perils of Efficiency: An Analysis of an Unexpected Closure of the Poe Lock and Its Impact*" (DHS, was used to inform this analysis. There is uncertainty whether economic impacts of a Poe Lock closure are regional impacts or national impacts, and therefore whether they qualify for inclusion in the calculation of net annual benefits and the BCR. Regardless, the Validation Study and the Department of Homeland Security report both identified a large economic impact to the Nation based on an extended Poe Lock closure. In fact, the Soo Locks is identified as National Critical Infrastructure due to the economic severe impacts that could occur during a six-month or longer unscheduled closure. It is extremely difficult to determine the likelihood of a long term closure at the Poe Lock. The uncertainty surrounding the duration of a closure creates uncertainty for assessing regional and national economic impacts.

Additional areas of uncertainty
Other key assumptions into the analysis where uncertainty exists, but was minimized to the greatest extent practicable, including the commodity traffic forecasts, timing of capital costs within the proxy modes, component reliability of the existing Poe Lock, and expected future OMRR&R expenditures. Changes in any of these assumptions would change the benefit calculation, however, these risks are viewed as tolerable.

5. UPDATED ENGINEERING AND COSTS FOR THE RECOMMENDED PLAN

5.1. Engineering Reliability and Evaluation

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5.2. Engineering Update

The 2005 Limited Reevaluation Report (LRR) included an engineering cost appendix that updated the design from the 1985 feasibility report. Currently, two Decision Documentation Reports (DDRs) based on the 2005 LRR engineering appendix are in various states of completion with most recent efforts occurring in 2009. The DDRs are titled:

- Soo Lock Replacement Lock Approach Walls and Channel Deepening Design Documentation Report, 80%, March 2009
- Soo Lock Replacement Lock Design Documentation Report, 35%, July 2009 (updated with Value Engineering Markups in January 2018)

Design efforts to date have been piecemeal due to the inconsistent funding the project has received. The FY19 certified cost estimate is based on the most current design within the DDRs. However, once a new authorization is received and the project receives construction funds one of the first tasks will be to inventory the current state of the design and finalize the DDRs. The 2009 DDR was not updated for the Validation Study since the focus of the Validation Study is on the economic justification of the project. A risk-informed decision was made to postpone updating the design documents since there was concern that the project would not be economically justified (similar to the results in the 2005 LRR). Design criteria and regulations were considered in the 2009 DDR development to ensure design criteria met current design standards. The Detroit District acknowledges the risk associated with the current state of the design and captures this discussion in the Cost Schedule Risk Analysis (CSRA) to quantify risks associated with potential impacts. These design risks are one reason the project cost estimate has a contingency of 37%. The Walla Walla Cost Center of Expertise determined that the current design was suitable to develop a certified cost estimate.

The following paragraphs briefly describe the major features of the proposed design in its current state. The proposed project is to build a new lock in the footprint of the current Davis and Sabin locks (the smallest and oldest locks at the complex). In general, the scope of the New Soo Lock provides for a redundant lock of 1,200-foot length by 110-foot width adjacent to the existing Poe Lock. The new lock will be constructed in an expanded footprint of the existing Sabin Lock. The existing North Sabin Lock wall will remain with rehabilitation of the chamber face and installation of anchors to improve reliability and stability. Approach walls will be constructed both upstream and downstream of the lock chamber and steel sheet pile (SSP) cells will be constructed around existing bridges to protect the established infrastructure. The bedrock approach channels will be deepened to 29-feet below Low Water Datum (LWD). The south Sabin Lock wall will be demolished, rock excavation will be performed to widen the existing chamber, and new concrete monoliths will be constructed on the south wall. The new lock will be filled and emptied through an In-Chamber Longitudinal Culvert System (ILCS). The upper and lower lock gates will be of miter design and have a height of 38.2 and 59.9-feet, respectively, above the sill. Installation of two cofferdams and downstream deepening is the only completed construction work to date. Figure 11 provides a view of the Soo Locks while Figure 12 provides a conceptual rendition of the proposed new "Poe-sized" lock.

Figure 11. View of the Soo Locks at Sault Ste. Marie, MI.

Figure 12. Conceptual rendition of the Proposed "Poe-sized" lock in the Davis and Sabin Lock Footprint

5.3. Value Engineering

A value engineering (VE) study following the six phase VE methodology was conducted in October 2017. Fifteen features of work were identified for the project. Function analysis was performed on each feature of work. During the creative phase of the study 43 ideas were generated. Ultimately, the outcome of the VE was the inclusion of 7 proposals in the FY19 certified cost estimate (Table 4). In addition, three proposals representing approximately $71 million in cost savings will be considered during the design documentation phase of the project (Table 5).

Table 4. Value Engineering Proposals incorporated into FY19 certified costs

Description	PDT Recommendation	Potential Cost Savings
Eliminate Vertical Lift Gate	Accepted	$25,000,000
Eliminate Large Operations Building and Replace with Two Smaller Control Shelters	Accepted	$5,000,000
Remove Sluiceway and Replace it with SSP Cell Structure	Accepted	$1,000,000
Reduce the Size of the Bridgeway on top of Miter Gate	Accepted	$500,000
Reduce Fill Material in Davis Lock Chamber	Accepted	$2,392,000
Reduce Length of Approach Wall Upstream of the Bascule Railroad Bridge	Accepted	$19,939,000
Reduce the Number of SSP Cells for the Upstream and Downstream Nose Piers	Accepted	$12,960,000
Total		**$66,791,000**

Table 5. Future Potential Savings to Consider During Planning, Engineering, and Design.

Description	PDT Recommendation	Potential Cost Savings
Change to a Bottom Lateral Filling System is the existing Davis Lock Chamber as a Flume way.	Accepted	$34,509,900
Rubberize Davis Lock Floor Instead of Placing Flowable Fill in Davis Lock Culverts	Accepted	$1,500,000
Eliminate pump well and provide dewatering via the Davis Lock	Not Accepted (revisit at 35% Design VE Study)	$35,000,000
Total		**$71,009,900**

The Value Engineering Report is available as an Appendix to the Validation Study.

5.4. Updated Cost Estimate for New Lock Construction

The primary objective of the construction effort is to build a 1,200-foot long by 110-foot wide redundant Poe-sized new lock within the footprint of the existing Sabin Lock. This effort includes construction of new approach walls and partially filling the Davis Lock chamber. The new lock will be completed by way of new cofferdams upstream and downstream, while approach walls will be completed in place through construction on the water. The contracting strategy assumes three distinct contracts: a contract for canal deepening, a contract for approach walls, and a contract for a new lock. A brief scope of work for the proposed contracts include:

Contract #1—Upstream Channel Deepening
This contract includes loosening overburden and blasting rock material from the upstream channel that will be removed in wet conditions via barge-mounted hydraulic excavator. Rock demolition for approach channel deepening is anticipated to be performed in the wet via floating plant. Rock will be broken loose by explosive blasting or mechanical means with a hydraulic excavator. Excavated material will be loaded onto barges cycling to be offloaded at the spoil area. The material will be offloaded to trucks, cycled to the dump area where it will be spread and compacted.

Contract #2—Upstream/Downstream Approach Walls
This contract includes the construction of the upstream and downstream approach walls made of a combination of steel sheet pile (SSP) wall connected to existing walls, and new SSP cells. This includes all work associated with SSP wall and new SSP cells construction.

Contract #3—New Lock Construction
This contract includes all work to construct the new lock between cofferdams including mobilization, demobilization, demolition, excavation, spoil, backfill Davis Lock, foundation work,

concrete, anchors, miter gates, electrical, culvert valves, hydraulic system, electrical work, ice control, miscellaneous metals, fender booms and all other features listed herein. The cofferdam will be placed prior to the lock construction so work can occur in dry conditions. The backfilling of the Davis Lock will be performed initially in the wet until the material provides sufficient stability to the existing Davis walls to allow the chamber to be dewatered. Remaining backfill will be placed in the dry.

Standard USACE cost estimating software was used to develop the cost estimate for the new Soo Lock. The estimate considers all previous and remaining project costs. These include construction, engineering, design, and contract supervision and administration. Table 6 shows the total project cost summary (TPCS) with a fully funded project cost of $1,030,670,000 at the FY19 price level, which escalates the project first cost to the mid-point of construction. This cost estimate is at an 80% confidence level based on the receipt of efficient funding and use of the Continuing Contracts Clause. While this cost estimate includes contingency representing project risks, the cost estimate does not include funding risks. It is standard practice by the Cost Center of Expertise (MCX) in Walla Walla, WA to assume efficient funding during construction. This assumption is used for all certified cost estimates from the MCX.

Table 6. Total Project Cost Summary for the New Soo Lock.

[redacted]

5.5. Previous Expenditures

In 2002, funding was received through the Construction General Account. Funding amount and associated tasks are illustrated in Table 7. Total sunk costs for the project are $32,153,151. This includes construction of two cofferdams in the Sabin Lock at approximately $4M and downstream channel deepening at approximately $7.1M. The remaining funds were utilized for feasibility, PED activities including geotechnical exploration and testing, stability analyses, construction sequencing analysis, physical modelling of the filling and emptying system, a ship simulation study to refine the lock alignment for safe transits, coordination with historic preservation agencies, and S&A activities.

Table 7. Construction General Account Funding History (Sunk Costs)

Year	Amount	Tasks/Actions
2002	$2,283,219.05	1. Continue limited reevaluation effort (LRR) 2. Identified lock alignment alternatives 3. Initiated filling system design 4. Develop project cost estimate
2003	$1,802,957.89	
2004	$1,861,811.18	1. Complete subsurface investigations and hydrologic surveys 2. LRR developed and submitted (2005) 3. Continued coordination on the Project Cooperation Agreement 4. Design refinements made (e.g. alignment changes, cofferdam, lock foundation, approach walls, fill management, deepening) 5. Designs initiated (e.g. operations buildings & vertical lift gate) 6. Modeled filling system 7. Emergency Closure Study completed 8. Drafted Design Document Report & Plans for lock chamber, guide walls, and deepening approach channel.
2005	$1,942,964.50	
2006	$93,446.80	
2007	$608,303.70	
2008	$1,474,518.71	
2009	$4,099,793.71	
2010	$12,779,640.36	Construction of two cofferdams and downstream deepening
2011	$2,443,311.14	
2012	$259,457.38	1. Continue work on DDR for guide walls and lock chamber 2. Finalize model simulations and ship simulation study 3. Completed Partial Benefits Sensitivity Analysis Report
2013	$263,706.70	
2014	$97,128.10	
2015	$64,638.45	
2016	$503,840.22	Economic Validation Study/Post Authorization Change Report
2017	$1,574,413.14	
TOTAL	**$32,153,151.03**	

6. ECONOMIC EVALUATION OF FEDERAL INTEREST IN THE NEW SOO LOCK PROJECT

Section 5 presents the economic update for the proposed new Poe-sized lock at the Soo Locks complex. This section identifies the main problems at the site, describes the with and without project condition, describes various inputs required for the modeling effort, and provides the results of the modeling effort including a series of sensitivity analyses to test various inputs. In summary this report finds, in the base analysis, construction of new lock justified with an average annual benefit of $58.2 million at an average annual cost of $32.8 million, producing an average annual net benefit of $25.5 million and a benefit to cost ratio (BCR) of 1.78 at the FY18 federal discount rate (2.75 percent). The BCR is 1.54 at a 7% discount rate typically used for federal budgeting.

Additional information provided in this section includes the results of the regional and GDP impacts of the Soo Locks analysis, a comparison between the benefits of this report with past efforts, and a Section 902 analysis.

6.1. Problem Identification

The majority of vessel traffic at the Soo Locks is only able to transit the existing Poe Lock, the largest lock at the complex. Intermittent Poe Lock closures can cause severe traffic disruptions. Benefits for the proposed new Soo Lock (also often referred to as the second Poe-sized lock) come from avoiding service disruption impacts if/when the existing Poe Lock is closed. In short, with a new, redundant lock vessels would still be able to transit the Soo Locks in the event of a scheduled or unscheduled Poe Lock closure or closure of the south canal to navigation due to vessel accident or highway/railway bridge failure. In addition, a redundant lock would allow for long duration major maintenance of the Poe Lock without impact to navigation. To estimate the benefits of the new lock, risk exposure for the existing project and the recommended project are quantified and compared. The risk exposure estimation involves a Monte Carlo simulation of Soo Locks performance over a 57-year planning horizon given engineering reliability data, vessel accident probabilities, transportation costs, and traffic demand forecasts. The Soo-REM model (a USACE model created for this project) simulates random structural, electrical/mechanical, and vessel accident lock service disruption events and estimates consequent transportation delay and diversion costs. The transportation benefits of a new lock are the transportation cost savings from reduced delay and transit times and the avoidance of more costly traffic diversions. The analysis also takes into account reduced repair, maintenance, and rehabilitation costs with a new lock. Additional benefits include recreation and area redevelopment.

The main problem at the Soo Locks is the lack of redundancy, which means the majority of commodities can only transit the existing Poe Lock. This makes the Poe Lock the single point of failure of critical infrastructure on the Great Lakes, especially for taconite pellets which cannot be transported via other means (such as truck or rail). In addition:

- Eleven integrated steel mills in the Great Lakes region are dependent upon domestic taconite production from mines in northern Minnesota and the Upper Peninsula of Michigan. Eight facilities are located in the United States, and three are in Canada. Ten of these mills rely on taconite shipments that transit the Soo Lock Complex.

- The likelihood of unscheduled Poe Lock closures increases with the aging of the infrastructure. The primary risk drivers are accidents and component failures. Vessel congestion does not drive service disruptions at the Poe Lock.

- The consequences of an unplanned Poe Lock closure can be severe especially in terms of regional and national economic impacts. The risk of severe consequences warrants the Poe Lock’s National Critical Infrastructure designation.

There is an opportunity to meet the Congressional intent for redundancy at the Soo Locks by constructing a second Poe-sized lock adjacent to the existing Poe Lock in the adjacent North Canal. This is important to Great Lakes navigation since accidents and reliability issues result in costly service disruptions since commodities must be transported via water.

6.2. With and Without Project Conditions

[redacted] Only a second Poe-sized lock can reduce (buy down) accident risk exposure. A new lock would provide *resiliency* and *redundancy* that will help mitigate the damage from lock components failure and reduce the risk that a vessel accident could close the Poe Lock. See Section 4.1 and 4.2 of the Economics Appendix for a more detailed discussion about accident and lock component risk.

Since this report is a Validation Study, a reformulation of alternatives is not required. Therefore, the analysis compares the without project condition (continued operation and maintenance of the Poe Lock and MacArthur Lock) to the with project condition (construction of a new Poe-sized lock and continued maintenance of the existing Poe lock).

The most likely future funding scenario reflects the historical trend in Operation & Maintenance (O&M) funding for the project. O&M funding for coastal projects throughout USACE, including the Soo Locks and St. Marys River, is provided via receipts from the Harbor Maintenance Trust Fund. Language included in WRRDA 2014 resulted in increased O&M funding, so that a certain level of proactive maintenance has been and will likely continue to be possible. This scenario does not assume completely unconstrained future O&M and Construction (CG) funding streams. Several factors impact the ultimate funding levels, such as inadequate funding for approved major rehabilitation projects USACE-wide. They also take into consideration that additional O&M funding being received as a result of WRRDA 2014 language will come via work plan additions versus the President's budget. Various tools, including engineering reliability and operational condition assessments, are used to prioritize the funding and timing of major maintenance to address the most critical components analyzed, while also recognizing that the level of funding in any given year cannot reach an unreasonable level. On average, the Soo Locks receives approximately $20 million dollars per year in routine O&M funding. This funding "above and beyond" the normal O&M funding is expected to increase when full HMTF utilization is achieved and is the likely funding source for the WOPC. Table 8 provides the recently provided assets renewal funding at the Soo Locks (above normal O&M funding). It is anticipated that this funding climate will continue and potentially improve further as the WRRDA 2014 guidance is fully implemented.

Table 8. Soo Locks O&M Funding for Asset Renewal funding from FY08 – FY17

O&M allocations for asset renewal at St. Marys River – Soo Locks ($M)	
FY08	3.3
FY09	16.3
FY10	5.5
FY11	2.4
FY12	5.2
FY13	3.1
FY14	11.4
FY15	8.65
FY16	14.6
FY17	9.6

Without Project Condition (WOPC)—The without project condition entails the continued operation and maintenance of both the Poe and MacArthur Locks and associated support features. Engineering and economic analyses focused on the potential impacts to navigation associated with the continued aging and degradation of critical lock components. This includes several facility features (such as the facility steam plant) that support lock operations. Nineteen major components have general plans for repairs/replacement based on information related to component reliability and risk of failure due to age, fatigue, etc. It is critical that prioritized major maintenance occurs so the Soo Locks meet their primary navigation mission.

It should be noted that the recently approved MRER for the Soo Locks used a slightly different WOPC. The same list of major components was considered for both studies; however, EP 1130-2-500 requires the MRER baseline condition to be the "the most efficient manner possible". This was interpreted to be a "fix-as-fails" maintenance strategy. In contrast, the Validation Study WOPC is determined to be the "most likely" as specified in the Planning Guidance Notebook (ER 1105-2-500)[1]. In addition, the Validation Study WOPC provides additional detail for components without direct service impacts. Therefore, the WOPC conditions for the MRER and Validation Study vary slightly in that the MRER focused on *efficiency*, while the Validation Study focuses on the *most likely* scenario. The same components are examined for both, but variations exist in the timing and strategies for major maintenance. Additionally, the prospect of a new lock can allow for different decisions for repairing and/or replacing components.

With Project Condition (New Lock)—The future with project condition is the most likely scenario associated with construction of a redundant, Poe-sized, lock. It involves construction of a new lock and prioritized major maintenance on only the existing Poe Lock. However, this will still include several facility features (such as the facility steam plant) that support lock operations. In this scenario, a new lock would be built by 2027, and the O&M program would continue routine and prioritized major maintenance on the Poe Lock; this would be to maintain the navigation mission and meet the Congressional intent of redundancy. This also reflects the importance of maintaining a lock chamber capable of accommodating vessel traffic in either the North or South canals. This would reduce the risk of navigation outages [redacted] There are also operational benefits to maintaining an operational lock in both canals. They include dealing with ice and wind conditions. The MacArthur Lock would be placed in a standby but ready status once the new lock is completed. However, it would be briefly placed back into service as needed to allow for major maintenance and/or replacement of certain Poe Lock components to reduce impacts to navigation. In anticipation of the idle status of the MacArthur lock, O&M expenditures for major maintenance on the MacArthur Lock would be held to a minimum. It is anticipated that by 2041, the MacArthur Lock would be placed into permanent "caretaker" status with minimal usage and minimal O&M to keep it from decaying.

[redacted]

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[1]The Planning Guidance Notebook (ER 1105-2-100) defines the WOPC as *"… the most likely condition expected to exist in the future in the absence of a proposed water resources project. … Forecasts of future without project conditions shall consider all other actions, programs that would be implemented in the future to address the problems and opportunities in the study area in the absence of a Corps project."* EP 1130-2-500 (27-DEC-1996) Chapter 3 Major Rehabilitation Program describes the base, or WOPC, for an MRER as a "*base condition"* that *"… assumes that the project will be operated in the most efficient manner possible without the proposed rehabilitation.*" The EP also notes that *"Considerable risk and uncertainty is inherent in the base condition."*

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

[redacted]

- [redacted]

- [redacted]

[redacted]

6.3. Service Disruptions and Affected Tonnage

Accidents and reliability issues can cause service disruptions that (depending on the outage duration) can prevent tonnage delivery via the waterway. The risk of vessel accidents coupled with the reliability of lock components determines the events that impact lock performance that ultimately lead to service disruptions. Service disruptions can include lock closures or vessel "slowdowns". Traditionally, the conceptual basis for the economic benefit of a USACE navigation project is the reduced value of resources required to transport commodities. In the case of the Soo Locks, benefits are derived from the avoiding unscheduled service disruptions and the risk of unmet demands to the Nation's steel industry. For this Validation Study, benefits are considered disruption costs avoided which include lock delay costs, idle vessel costs, and unmet demand transportation costs. The Great Lakes fleet is assumed to be 100% fully utilized for this analysis. For a full description of how benefit categories have evolved over the lifetime of the project please see Economics Appendix, Section 7.1.

Calculating the cost of moving commodities through the Soo Locks complex is a challenging task. However, USACE and other agencies have completed several rate studies. They have provided key data points that analysts relied on for the current analysis (See Economics Appendix, Section 1.4 for list of available rate studies). The Soo Locks are unique in that alternative transportation modes are extremely limited, especially for taconite pellets. In fact, in the event of a 14-day or greater Poe Lock closure, the majority of taconite pellets would not be able to move through the Soo Locks and would be considered stranded tonnage. This stranded tonnage is referred to as "unmet demand" and is discussed in detail in Section 5.3.2 of this report.

6.3.1. Diversion Costs Avoided (NED Benefit)

For diversion costs, the Validation Study analysis builds upon the Detroit District Partial Benefits Analysis Report (PBA) (USACE, 2014). The PBA included three interrelated study components: 1) a stakeholder response analysis entailing a series of interviews with Great Lakes shippers and operators involving primarily taconite pellets and coal movements; 2) an Expert Elicitation Workshop involving a range of industry representatives (e.g. mining, manufacturing, utilities, railroads); and 3) a feasibility test that involved constructing and running economic models to quantify, under various scenarios, the impacts of lock closure. Additional information was obtained from the University of Toledo and Tennessee Valley Authority rate studies. Table 9 shows the results of alternative delivery routes by commodity and direction used for the Validation Study.

Table 9. Alternative Transportation Mode Summary, by Commodity and Direction

Commodity	Direction	Alternative transportation mode	Maximum annual capacity[4/]	Incremental cost per ton	Incremental cost per ton including expanded capital costs
Coal	upbound	Mac Vessel Backhaul	Dynamic[1/]	$0.44	$0.44
		Vessel to Truck	1,100,000	$132.11	$132.11
		Least Cost All-Overland Route[3/]	Not Limited	$16.16	$16.16
	downbound	Direct Rail to Coal Plants[3/]	3,900,000	$11.00	$11.00
		Rail to Toledo, OH	4,300,000	$22.58	$22.58
Iron Ore	downbound	Current Port at Escanaba	5,000,000	$5.94	$86.22[2/]
		Canadian Sourcing	50,000	$18.81	$18.82
Iron Ore (unmet demand)	downbound	Conveyance	4,468,800	$0.62	$77.07[2/]
		Stockpiling	2,565,000	$4.41	$145.72[2/]
		New Port at Escanaba	Not Limited	$26.00	$590.89[2/]
Limestone	upbound	Mac Vessel Backhaul	Dynamic[1/]	$0.29	$0.29
		Least Cost All-Overland Route[3/]	Not Limited	$34.67	$34.67
Grain	downbound	Least Cost All-Overland Route[3/]	Not Limited	$28.97	$28.97
Others	both	Least Cost All-Overland Route[3/]	Not Limited	$62.55	$62.55

[1/] The amount of upbound Mac-sized vessel capacity depends upon the forecast year, since the amount of empty return trips is driven by the amount of downbound tonnage and vessel trips.

[2/] Includes the additional capital invesment and maintenance costs based on expected (average) Soo-REM results made over 10,000 simulation iterations. Values reflect the cost per ton using the medium traffic forecast scenario under the most-likely planning scenario. Capital investments are made upfront, in 2020, and are calculated by using the highest observed diverted tonnage need throughout the 57-year period of each Soo-REM simluation iteration. The expected investment and maintenance costs are then converted to average annual values, by capitalizing them over 57-years using the current federal discount rate of 2.75%. The average annual invesment and maintenance costs were then divded by the average tonnage moved by each mode throughout the 57-year period to derive the rate per ton for the capital expenditures. The additional capital investment rate per ton was then added to the current rate per ton to derive the total rate per ton that includes the expanded modal capacity.

[3/] Rates are derived from transportation rate data sets developed by rate experts at the Tennessee Valley Authority and the University of Toledo.

[4/] Total capacity (throughput) is annualized for this summary table. But the total throughput for some modes is limited to a daily capacity based on the length of lock closure. For example, the conveyor has a daily throughput restriction. See the individual diversion write-ups for additional detail.

Rates for six commodity groups were developed for the Validation Study. These include: coal, limestone, grain, “other”, taconite pellets, and taconite pellets that cannot be delivered in the event of a Poe Lock closure. A unique situation at the Soo Locks is the taconite pellets delivery route’s dependence on the Poe Lock. This is why the Poe Lock is considered National Critical Infrastructure and is the single point of failure for the Great Lakes Navigation System. In the case of taconite pellets, hypothetical delivery modes were developed in order to value stranded taconite pellets with a USACE policy-compliant method. Table 9 provides an overview of the alternative delivery modes and the final transportations rates used in the analysis. Below is a general description of the alternative delivery routes identified. For more information about the development of alternative delivery modes please see the Economics Appendix, Section 6.3.

Coal—Downbound (traveling south to lower Great Lakes)
Most of the coal that transits the Soo Locks is headed from Duluth-Superior, MN-WI to the power-plants on the lower Great Lakes. Two alternative transportation modes were identified for downbound coal that could be affected by a service disruption at the Soo Locks. These include direct rail-to-power plants and rail-to-vessel via Toledo, Ohio.

The direct rail alternative is exclusive to coal, and more specifically, coal-fired power plants with rail access. This route has historical precedence, since coal is frequently shipped via direct rail to select power plants. This was validated as part of the PBA Expert Elicitation Workshop, and was a major point of consensus for the group. To develop an estimate of the incremental cost differences between the waterway-routed movements compared to the direct rail alternative (i.e. rate savings), the USACE study team used Tennessee Valley Authority (TVA) and the University of Toledo transportation rates.

The PBA team developed the rail-to-vessel alternative for down bound coal. It consists of diverting coal from Lake Superior ports to a terminal in Toledo, Ohio, via rail, and then trans-loading the coal onto vessels for delivery. In terms of total capacity, this transportation mode is limited both physically and contractually.

Coal—Upbound (traveling north to Lake Superior)
Upbound coal tonnage is less constrained than downbound coal flows, primarily due to the smaller tonnage volumes. One end user (Essar Steel’s Algoma operation) uses the majority of upbound coal. Smaller power plants along Lake Superior also use coal.

Three transportation modes are identified for upbound coal flows. The first is a vessel-to-truck movement from Thesselon, Ontario to Sault Ste. Marie, Ontario to supply Essar Steel’s Algoma operation in Sault Ste. Marie. Historically, this movement has occurred to meet any production shortfalls that have occurred during the non-navigation season because the locks were not operational. The second mode consists of using vessels that can travel through the MacArthur Lock on their return trip upbound. It is common for empty MacArthur-sized vessels to travel upbound through the Soo Locks after delivering their commodities to end users on the lower Great Lakes. Since empty backhauls are driven by the frequency of the loaded down-bound vessel movements, total capacity fluctuates from year-to-year. In a forecast year, it is estimated that total capacity of this delivery route is approximately 5% of the total annual projected tonnage. This percentage was derived by comparing the historical percentage of empty up-bound MacArthur-sized vessel transits to the loaded down-bound transits.

The third method is the overland routes identified during previous TVA and University of Toledo studies. For a full description of the overland transportation methods used for coal movements, please see Economics Appendix, Section 7.4.1.4.

Limestone Diversions

Limestone moving through the Soo Locks typically travels up-bound, and is primarily used at taconite pellets production facilities; there it is melded with iron ore to create various blends of taconite pellets. Additionally, it is used at coal-fired power plants and agricultural processing plants. Two alternative transportation modes were identified for limestone movement: backhaul on empty vessels that can travel through the MacArthur Lock and overland routes as identified by TVA and the University of Toledo.

Grain Diversions

Wheat and oilseeds are the most common grains shipped through the Soo Locks. These grains are typically loaded onto vessels in either Thunder Bay, Ontario or Duluth, Minnesota and are destined for the export market overseas. Export tonnage volumes fluctuate primarily when local consumption exceeds local production. Rail is the alternative transportation mode as identified in the TVA study, which assumed sufficient overland capacity for the current grain forecast.

"Others" Diversions

The others commodity group contains a mixture of commodities including: animal feeds, salt, slag, cement and concrete, and more refined iron and steel products (e.g. plates and sheets). These commodities together represent a small percentage of total Soo Locks complex tonnage, and serve a variety of industries. For this analysis, sufficient overland capacity is assumed for these commodities, and the rates and individual routings determined by TVA and Toledo are used to estimate alternative modal impacts.

Taconite pellets Diversions

There are very limited transportation options for taconite pellets to circumvent the Soo Locks. As part of a fully-integrated supply chain, the use of water transportation creates an efficient, low-cost delivery mode for a significant amount of tonnage. However, this mode also creates a substantial risk at the Soo Locks since the Poe Lock is the single point of failure for taconite pellets. For the Validation Study, the risk is quantified in terms of transportation costs avoided, by comparing the current water routed deliveries to a next best, least cost alternative. In the case of taconite pellets, the broader study team was unable to identify sufficient existing overland capacity to re-route taconite pellets tonnage that might be affected by lock service disruptions. To remain policy compliant, the USACE study team developed proxy transportation costs to re-route and value all remaining tonnage. Current alternative transportation modes for taconite pellets include utilizing the current Port at Escanaba, Michigan or sourcing Canadian taconite pellets.

Current Port at Escanaba – Since 1852, large volumes of taconite pellets have shipped from the Port of Escanaba, MI. Historically, this facility has sourced taconite pellets from the Empire (primary) and Tilden (secondary) mines, thereby allowing a portion of the movement flows to avoid the Soo Locks complex completely. As part of the Partial Benefits Analysis, many interviewees and Expert Elicitation Workshop panelists recommended Escanaba as a viable solution to move displaced taconite pellets during a lock outage. However, in 2016, Cliffs Natural Resources closed the Empire Mine, and in early 2017, Canadian National announced it would be closing its dock at Escanaba. Taconite pellets that once went through the Port of Escanaba will now have to transit the Soo Locks. Further investigations revealed that end users will continue to receive taconite pellets from northern Minnesota and Michigan mines which means additional tonnage must travel through the Soo Locks complex. The dock at Escanaba could become functional, but long-term transport of taconite pellets would require substantial investment.

Capacity is a limiting factor at Escanaba, with the closure of the Empire mine. In addition, due to fleet utilization restrictions, it is assumed that Escanaba would only have ships available to process taconite pellets deliveries during a lock outage. Once the locks were to become fully operational, vessels would again become fully employed and begin operating under business-as-usual shipping patterns. The exception to this assumption is the winter season, when the Soo Locks complex is closed. According to vessel users due to the severe winters and ice-building the Escanaba dock cannot be used year-round.

Canadian Sourcing
This alternative entails shipping Canadian taconite pellets from the Labrador mines via the St Lawrence Seaway. Very limited additional capacity was identified for this mode, totaling 50,000 tons per year.

6.3.2. Unmet Taconite Pellet Demand and Hypothetical (Proxy) Diversions
It is an efficient process to move taconite pellets in massive Great Lakes freighters from Lake Superior to end users on the lower Great Lakes. There are very limited overland transportation options for most of the taconite pellets shipped on the Great Lakes. If there is a closure, some taconite pellets will not be able to be delivered to the end user and would become stranded tonnage which is referred to as unmet demand. The challenge of the economic update is to develop transportation costs for the unmet demand. In essence, this means to develop costs for a market that does not exist. An existing market price cannot be used since the existing alternative transportation routes are at their capacity. Since the existing market is not available, a hypothetical market price can be developed to value the unmet demand. This hypothetical market price is developed by costing out the hypothetical delivery routes. The cost associated with using these delivery routes is a *proxy* for what the market price could be if the routes could be used to move the stranded tonnage. The Economics Appendix refers to these hypothetical delivery routes as proxy alternative transportation modes and provides detailed descriptions in Section 7.4.3 and Attachment 2, 3, and 4.

For the purpose of the Validation Study, analysts developed three proxy routes to determine the value of the taconite pellets unmet demand. They include stockpiling at end-user location, a conveyor system at the Soo Locks, and full development of the Escanaba, Michigan port. This means that not all three routes would be needed for every simulated outage because of differing outage durations. The three hypothetical delivery modes include:

Stockpiling at end-user location—A Geographic Information System (GIS) analysis was conducted for the eight steel mills and two ore docks that receive taconite pellet shipments that must transit the Soo Locks. The theory is that end users could stockpile additional taconite pellets on-site in case of a Poe Lock closure. Utilizing GIS, potential storage areas were identified at each site and verified with their representatives. Cost estimates for developing and maintaining the stockpiles were then developed.

Key assumptions for the stockpiling option include:

- One acre of land can hold up to 22,000 tons of taconite pellets.
- Up to 2.6 million tons of taconite pellets could be stockpiled across 10 end-user sites.

Conveyor System—One potential delivery route is a conveyor system that would move commodities from ships upstream of the Soo Locks, place the commodity on a conveyor belt system, deliver it across the locks, and place it into a vessel docked downstream of the Soo Locks. A conveyor system placed on the land between the Davis and Sabin Locks, and a pair of barge mounted conveyors would move the commodities over the Davis Lock channel. The conveyor would be approximately 5,000 ft in length and capable of transferring 2,000 tons of taconite pellets per hour. Assumptions with the conveyor system include:

- Three Class VIII vessels are available above the Soo Locks to ship taconite pellets from Lake Superior ports in Minnesota to the Soo Locks. Three Class VIII vessels are located below the Soo Locks and are available to transport taconite pellets from the conveyor system to users in the lower Great Lakes.
- The conveyor system has a daily output of up to 19,600 tons and a yearly output of up to 4,468,800 tons.

Escanaba Port--Constructing a fully operational port at the city of Escanaba, Michigan was carried forward as a potential delivery method for stranded taconite pellets. This hypothetical mode came out of the “Alternative Rail Lake Vessel Routing Analysis” report which examined the costs required for improving the railroad to deliver taconite pellets from northern Minnesota to a port on the lower Great Lakes. The report selected Escanaba as the most likely location for taconite pellets to bypass the Soo Locks. The cost estimate included developing the rail infrastructure costs needed from Duluth, Minnesota to Escanaba, Michigan, the port related infrastructure costs required, and all rail rolling stock costs. Assumptions include:

- Up to 18 million tons of taconite pellets could move through the Escanaba Port per year. Only taconite pellets would be transported through the Escanaba facility.

For the three hypothetical delivery routes, transportation rates are a function of the cost of the capital infrastructure, the cost of maintaining that capital, and the cost to operate the mode to transport commodities. Therefore, assessing NED benefits by itemizing the alternative transportation costs into the capital, maintenance, and operating components is simply a more granular accounting of traditional NED costs avoided where a transportation rate is used. Itemizing the transportation costs was necessary for the Validation Study, since the expansion of alternative modal capacity (the capital investment) is a significant contributor to the overall project benefits. Additionally, the total impact cost of these hypothetical delivery route expansions is predicated on lock performance since users of these routes are moving from the waterway system after a service disruption. Itemizing the transportation costs allows the study team to determine an appropriate cost estimate tailored to the total amount of unmet demands for each planning scenario. Please see the Economics Appendix, Section 7.4 for a full cost itemization for the hypothetical delivery routes.

6.4. Economic Model Descriptions

The purpose of this planning analysis, *“… is to estimate changes in National economic development that occur as a result of differences in project outputs with a plan, as opposed to National economic development without a plan*[2]”. This is accomplished through a federally mandated National Economic Development (NED) analysis which is *“… generally defined as an economic cost-benefit analysis for plan formulation, evaluation, and selection that is used to evaluate the federal interest in pursuing a prospective project plan*.[3]” NED benefits are defined

[2] Planning Manual, IWR Report 96-R-21, U.S. Army Corps of Engineers, November 1996, page 56.
[3] NED Procedures Manual Overview, IWR Report 09-R-2, U.S. Army Corps of Engineers, June 2009, page 1.

as *"… increases in the net value of the National output of goods and services, expressed in monetary units …."*

For a navigation project investment, NED benefits are composed primarily of the reductions in transportation costs attributable to the improved waterway system. The reduction in transportation costs are achieved through increased efficiency of existing waterway movements, shifts of waterway and overland traffic to more efficient modes and/ or routes, and/ or shifts to more efficient origin-destination combinations. Further benefits can accrue from induced (new output/production) traffic that is transported because of the lower transportation cost deriving from an improved project and from creating or enhancing uses of the waterway, such as hydropower generation. National defense benefits can also be realized from regional and National growth, and from diversity in transportation modes. In many situations, lower emissions can be achieved by transportation of goods on the waterway.

In the case of the Validation Study, the NED benefits were derived from avoiding transportation cost increases from unscheduled service disruptions to the Soo Locks complex (more so than from either project reliability issues or vessel accidents.)

However, the Soo Locks are unique in that the main issue is the complete lack of an alternative transportation mode for taconite pellets if the Poe Lock closes. For the Validation Study to be policy-compliant, hypothetical transportation modes (described in the previous section) for taconite pellets were created to provide a basis for the analysis. A series of sensitivities analyses were also conducted to provide decision makers with additional information on how benefits changed with varying inputs.

6.4.1. Soo-REM and ARENA

The estimated project reliability and the expected consequences of unsatisfactory performance are the conceptual basis of a computer model (named Soo-REM) that was developed to simulate the project performance over the next 50 years; i.e., it performs a life-cycle analysis. The model's core logic is based on the possible event sequences as shown in the component level event-trees produced as part of the engineering reliability analysis (event-trees available in Appendix B). Microsoft EXCEL software with the @Risk add-on feature is used for the programming. EXCEL and @Risk are both commercial off-the-shelf software applications with wide use by academic, corporate, and government entities. The Soo-REM model went through the USACE model certification process and the Detroit District received approval to use it for the Validation Study in a Headquarters memo dated November 21, 2017.

The Soo-REM model uses a Monte Carlo simulation to determine how much tonnage would be impacted by unexpected service disruptions at the Soo Locks. It also determines the expected increase in transportation costs due to unexpected closures. Soo-REM uses a baseline condition and then compares the outputs from alternative conditions. Outputs, such as the incremental transportation costs and other impacts, under a baseline condition as well as each alternative condition, are essentially a function of component reliability and associated service disruption impacts, traffic levels at the project, tonnage that cannot be delivered via waterways due to service disruptions, and the incremental cost and capacity of hypothetical alternative transportation modes. The ARENA model utilized traffic forecasts and service disruption categories to develop estimates on how traffic would react in different scenarios. These were done through a contract with the company, Baird/JV, to estimate the impacts of disruption events (lock closures and processing time increases) on vessel traffic. It used a discrete event simulation model representing the lock system. Use of the ARENA model also went through the

USACE model certification process, and the Detroit District received approval to use it for the Validation Study in a USACE Headquarters memo dated November 21, 2017.

Benefits result from reductions in these incremental transportation costs and other impacts through reduction in either the incidence or duration of service disruptions. This reduction in transportation costs are benefits to the Nation.

6.4.2. Soo-REM Model within the Study Process

The model comprises a series of linked EXCEL workbooks which handle separate components of the analysis. The workbooks are categorized into the 1) input, 2) calculations/model, and 3) outputs/summary workbooks. Figure 13. Soo-REM Study Process and Inputs provides a conceptual framework for the study process and illustrates the data Soo-REM uses.

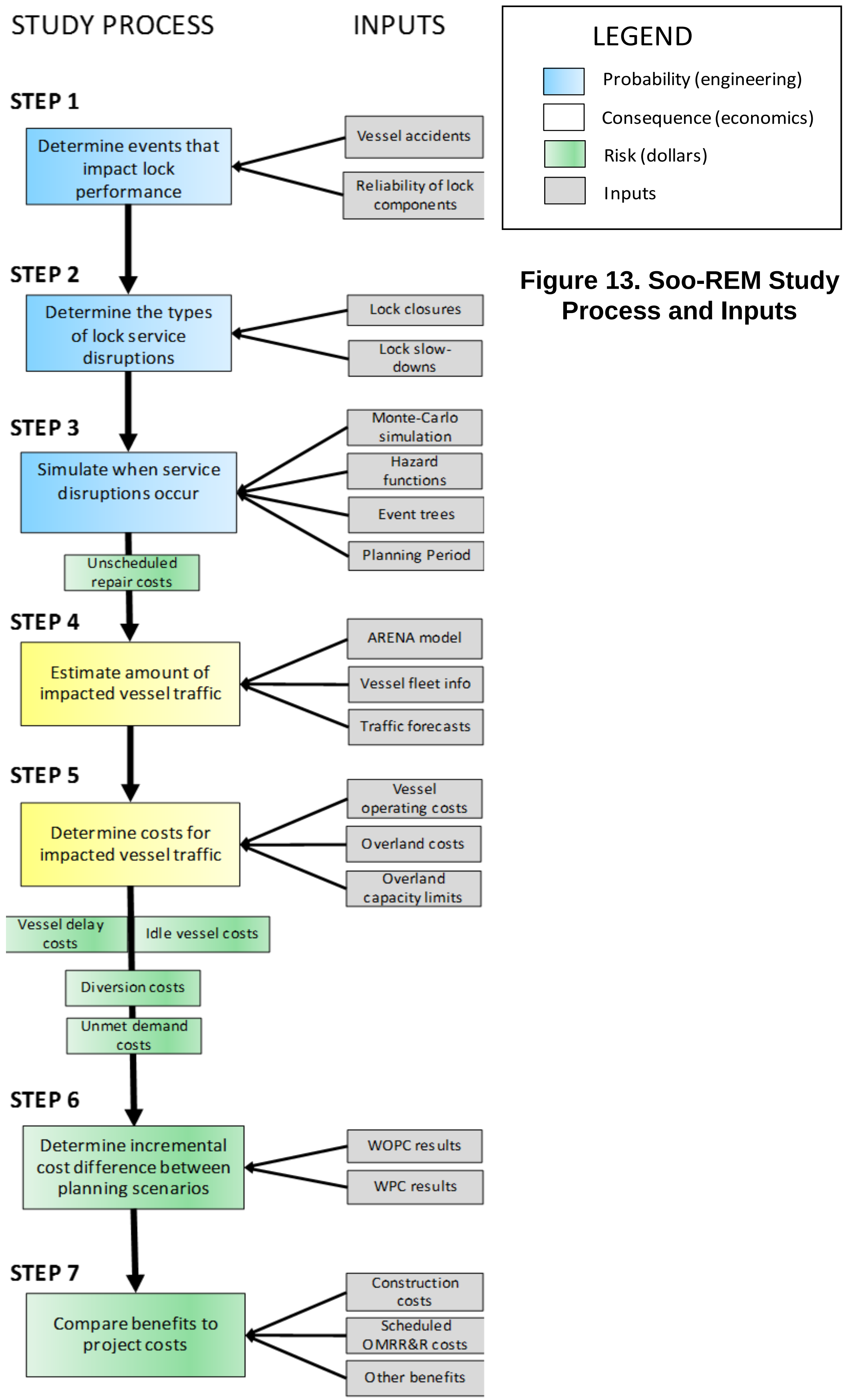

Figure 13. Soo-REM Study Process and Inputs

Figure 13 presents a series of steps and how they interrelate to the required inputs for the analysis. A brief explanation of each step is provided below.

Step 1—At this point, potential problems are initially identified and opportunities to solve the problems are defined. Since this is a validation study, alternatives were not developed, but the with and without project conditions were updated due to the new engineering reliability data. Problems and opportunities are presented in Section 5.1, and the WPC and WOPC definitions are available in Section 5.2. A discussion of vessel accident risk can be found in the Economics Appendix, Section 4.1 and detailed information about component reliability is available in the Engineering Reliability Appendix.

Step 2—The ARENA model (a lock capacity model) is used to determine vessel queuing and operation under different lock performance scenarios and is synced with the types of events and durations that are expected to occur in the future. Lock performance scenarios come from the probability of vessel accidents and component reliability in step 1.

Step 3—This is the first step in the Soo-REM modeling process. Engineering data is used across the planning period to determine when lock closures and slowdowns occur. Since this engineering data is probabilistic, a Monte Carlo simulation is used to determine expected values. At this point, unscheduled component repair and replacement costs can be determined.

Step 4—This is the second step of the Soo-REM model. Since the outputs of the ARENA® model are synced with the types of service disruptions that can occur, it can now be determined how much traffic is forced to divert off the waterway, queue up at the lock, or go into idle status until the project comes back into full service. Forecasts are used to determine the amount of traffic that is affected in each year of the planning period.

Step 5—This is the third and final step of the Soo-REM model. Traffic delayed, idled, or diverted off the waterway is now assigned an impact cost. Traffic forced off the waterway (traffic diversions) is also compared against the capacity restrictions identified for the available overland modes for each commodity. Diverted traffic that does not have sufficient overland capacity is treated as unmet demand.

Step 6—Steps 3, 4, and 5 (the Soo-REM model cycle) are performed 10,000 times and expected values are determined. The expected impact cost results are saved for each planning scenario analyzed. Then, the WOPC is compared to the WPC to determine the incremental transportation costs avoided between the various scenarios.

Step 7—Transportation costs avoided, unscheduled repair and replacement costs avoided, and scheduled operations, maintenance, repair, rehabilitation and replacement (OMRR&R) costs avoided are added to other WPC benefits categories, such as labor resource benefits. Then, benefits are compared to the WPC construction cost.

In summary, The Soo-REM model identifies and provides a cost for tonnage affected by service disruptions at the Soo Locks. Given a lock closure duration, the model calculates how many tons of commodity can move through one lock. It then diverts remaining tonnage to various delivery routes. Excess capacity on existing delivery routes is used first. Once this tonnage throughput is calculated, the remaining tons that would have moved through both locks during the outage period is allocated to various delivery modes. Once all excess delivery capacity for existing delivery modes is used, the amount of stranded tonnage (tonnage not able to be moved via existing transportation infrastructure) is calculated. This stranded tonnage is then allocated to various proxy transportation routes. The three hypothetical delivery routes (stockpiling, conveyor system, and full Escanaba port build-out) are described in the previous section. The model uses the lowest cost system first (the conveyor system) until its throughput capacity is reached. Then the next lowest cost delivery method is used (stockpiling). Once stockpiling reaches capacity, the last delivery route is used – the full build-out at the port of Escanaba. The capital investment costs are used to develop the hypothetical proxy market price to move the stranded taconite pellets tonnage.

It is important to note that the current approach for estimating capital investment costs is to place the costs in the first year of the planning period. Regular maintenance cost streams are also assessed from that time period forward, and each time the mode is used, operational costs are incurred. These capital investment costs are assessed by using the largest closure duration that is experienced in each modeled simulation of lock performance over the planning period. This method ensures all unmet tonnages are assessed an appropriate capital cost that is weighted by the probability and magnitude of each closure event that results in unmet demand. Placing these costs in the first year means the investment is not discounted and would need to occur up front. Capital investments costs used to assess future closure risks need to occur up front, since the timing of unscheduled closure events are unpredictable. This same assumption is used for both the WOPC and WPC to ensure a fair incremental risk comparison. In addition, capital investment costs are weighted against the event duration within the Soo-REM simulation.

6.4.3. Commodity Driven GDP Impact Model and Automotive Based GDP Impact Model

Two separate GDP spreadsheet models were developed in support of this study. A*nnual Operational Contributions to Economy* is an assessment of the economic contribution of the operations of the Soo Locks complex based on a standard multiplier analysis. This entails all the activities and associated economics of those activities that can be directly attributed to the Soo Locks complex as it relates to shipping commodities through the Great Lakes Navigation System.

The second framework, *Detailed Assessment of Industry Dependence of the Soo Locks: A View from the Vehicle Manufacturing Sector*, recognizes that the Soo Locks complex is a means to an economic-related end. By this, the operations of the Soo Locks complex facilitates production value chains that would likely be hindered should the Soo Locks complex experience an unanticipated shut-down. Because of the wide-breadth of commodities and goods flowing through the Soo Locks and the even wider breadth of value chains for which these flows contribute, the frame of assessment is limited to a single commodity value chain, from taconite pellets raw materials to final goods for consumption.

The Economics Appendix, Attachment 5 provides detailed information on the two spreadsheet models.

6.5. Project Costs

For the economic update, costs include the implementation (construction) costs for the new lock, and OMRR&R costs for the WPC and WOPC. For the WPC, decommission cost of the Sabin and Davis lock were estimated at $21,551,000 (FY 2018 price level) over four years, from 2025 through 2028.

6.5.1. Operations, Repair, Replacement, and Rehabilitation (OMRR&R) Costs

Future OMRR&R costs were itemized for four future maintenance scenarios as follows:

- *WOPC with most likely maintenance*—The project (Poe & MacArthur Locks) will continue to operate with major component repair and replacement scheduled. This will be in accordance with operations and engineering best professional judgment (based on previous experience, component age, LRD guidance, operational condition assessments, etc.) and funding availability.
- *WPC with most likely maintenance*—The new lock is anticipated to be 100% reliable throughout the planning analysis period. However, the existing Poe Lock will continue to operate with major component repair and replacement scheduled. This will also be in accordance with operations and engineering best professional judgment (based on previous experience, component age, LRD guidance, operational condition assessments, etc.) and funding availability.

As a sensitivity test, the following two maintenance scenarios were analyzed:

- *WOPC with reactive maintenance*—Reactive maintenance (commonly referred to as fix-as-fails) is a scenario where repairs occur once a component fails. The long-run cost effectiveness of maintenance and repairs is not considered.
- *WPC with reactive maintenance*—This scenario consists of building the new lock and relying on just normal O&M maintenance for the existing Poe. The new lock is anticipated to be 100% reliable throughout the planning analysis period. Also, minimal repairs are performed as needed to maintain the current level of service. The long-run cost effectiveness of maintenance and repairs is not considered.

Attachment 6 of the Economics Appendix provides a full breakdown of the OMRR&R costs for the economic update. Table 10 provides a summary of the OMRR&R cost breakdown.

Table 10. Average Annual Project OMRR&R Costs
(FY2018 dollars at 2.75%, 2020 through 2076 with 2027 base year)

OMRR&R Cost Category	Average Annual Project Costs by Maintenance Scenario			
	Without project condition		With project condition	
	Fix as Fails	Most Likely	Fix as Fails	Most Likely
Normal O&M *	$17,943,596	$17,943,596	$17,943,596	$17,943,596
Replacements				
Project Level	$0	$4,962,663	$0	$4,283,890
New Lock	$0	$0	$0	$0
Existing Poe	$0	$3,939,239	$0	$2,373,038
MacArthur	$0	$1,890,659	$0	$0
Major Maintenance				
Project Level	$2,253,264	$564,715	$2,203,507	$504,675
New Lock	$0	$0	$90,397	$270,535
Existing Poe	$2,170,914	$1,857,029	$2,170,914	$768,363
MacArthur	$2,112,220	$1,913,442	$28,173	$28,173
TOTAL	$24,479,993	$33,071,343	$22,436,587	$26,172,269

** Normal O&M costs are $14M annually for the Poe and MacArthur Lock; however, 2.75% amortization over 50-years of the 57-year planning period results in an average annual normal O&M of $17.9M.*

6.5.2. Project First Costs

The Cost Engineering Mandatory Center of Expertise (MCX) Fiscal Year (FY) 2018 project first cost is $903,158,151 ($871,005,000 remaining and $32,153,000 sunk through FY2017). The MCX FY 2019 project first cost is $922,432,000 ($890,279,000 remaining and $32,153,000 sunk through FY2017). These Cost and Schedule Risk Analysis (CSRA) construction costs contains contingencies for an 80 percent confidence of successful execution and completion.

For the cost-benefit analysis the project first cost (construction cost) is converted to an average annual equivalent value at the various discount/amortization rates and displayed in FY18 dollars (the year of the economic update). The certified costs (included within Appendix C) are presented in FY19 dollars since this will be when construction dollars are first received. Economic updates must present information in the fiscal year the update is completed, therefore, the certified costs from the MCX were converted into FY18 dollars. Table 11 illustrates the amortization of the sunk and remaining construction cost laydown used in this economic update.

[redacted]

6.6. Project Benefits

This economic update provides a benefit cost analyses based on anticipated cost savings (benefits) and the estimated implementation costs of constructing a second Poe-sized lock at the Soo Locks complex. Benefits include the annualized value of net reductions in service disruption impact costs and in scheduled project costs, as well as recreation and labor resource benefits.

Benefit-cost analyses were based on anticipated cost savings (benefits) and the estimated implementation investment costs of constructing a second Poe-sized lock at the Soo Locks complex.

Benefits resulting from net costs (service disruption and scheduled project costs) were evaluated by comparing annualized costs in the without-project condition and with-project condition for the respective subcategories of each. When the with-project condition results in a net reduction in costs of one these subcategories, the reduction is a benefit of the with-project condition. In addition to the diversion costs avoided benefit described in Section 5.3.1, several additional benefits were calculated for the Validation Study. These include:

6.6.1. Vessel Delay and Layup Costs Avoided

Vessel costs from service disruption events show themselves in queuing and increased transit time (delay costs). They also show up as Poe-restricted vessels are laid up or idled during Poe Lock closure events. In the Soo-REM simulation model, given a service disruption, the resulting project throughput, average transit time, and hours of Poe-restricted vessel layup are estimated off the Baird ARENA vessel-level simulation results (Attachment 8).

6.6.2. Repair Costs Avoided

With simulated component unscheduled engineering reliability failure event, a repair cost is used plus the service disruption specification (type and duration) from the engineering reliability event-tree

6.6.3. Major Maintenance Costs Avoided

In addition to unscheduled repair costs, each analyzed alternative can have different maintenance cost needs. Maintenance costs are itemized into two categories: normal operations and maintenance (O&M) and major maintenance. Normal O&M is defined as a fixed annual expense for base operations, while major maintenance costs are periodic work packages that often increase in frequency and cost through time as the project (e.g., component) ages.

6.6.4. Decommissioning Costs Avoided

The Davis and Sabin Locks are no longer used because of their age and condition. In the without project condition, expenditures will be necessary to close and decommission the locks. Detroit District Operations estimated that it would cost $21.55 million to decommission the Davis and Sabin Locks, and it would occur from 2025–2028. In the with project condition, the new Poe-sized lock will be constructed in the North Canal using the footprint of the existing Davis and Sabin locks. Thus, decommissioning expenditures will not be necessary.

6.6.5. Recreation Benefits

Recreation benefits are based on the increase in the recreational experience due to construction of the new Poe sized lock. The value of the recreation experience was calculated using the unit day value (UDV) Method for general recreation. Recreation was evaluated for three categories of recreational experiences for users of:

- The visitor center and those visiting the locks by automobile.
- Owners and passengers of small recreational craft that transit the locks.
- Passengers of the tour boats that transit the locks.

Benefits are calculated as the difference in total recreational experience under the without project condition and total recreational experience under the with project condition (Table 12). For a complete description of how recreation benefits were calculated see Economics Appendix, Section 7.5.5.

Table 12. Soo Locks Complex Expected Annual Benefit Summary

Category	Expected Annual Benefit (2.75%)
Visitor Center:	**$2,902,500**
Recreational Craft:	**$800**
Tour Boats:	**$66,400**
Total Recreation Benefits:	**$2,969,700**

6.6.6. Labor Resources Benefit

Due to the substantial and persistent unemployment in Sault Ste. Marie and Chippewa County, the Validation Study analysis can include labor resource benefits. Chippewa County, Michigan has experienced an unemployment rate of greater than 6% over the most recent 12 months of published data. In addition the annual average rate of unemployment was 50% above the National average for three of the preceding four calendar years (2017, 2016 and 2014).

New Soo Lock construction would likely use unemployed labor directly from Chippewa County. The initial investment would create new jobs, thereby directly reducing unemployment. There would be demands for both labor and construction materials for the project, and incomes of individuals in associated industries would increase indirectly due to the interrelationship and interdependence of these industries. These conditions would stimulate the economy and raise the general level of income. Table 13 displays the labor resource benefits for the construction of a new Soo Lock. See Economics Appendix, Section 7.5.6 for a full description of the labor resource benefit category.

Table 13. Labor Resource Benefit–New Soo Lock

UNEMPLOYED OR UNDEREMPLOYED LABOR RESOURCES BENEFIT

(FY 2018 dollars at 2.75%)

1. Estimate On-Site Labor Cost			
Total Project Cost (remaining)*:			$793,648,170
Percent Allocated to Labor:			40.8%
On Site Labor Cost:			$323,810,000
2. Allocation of On-Site Labor Cost			
Labor Classification	On Site Labor Cost	Percent Allocation	Wages
Skilled	$323,810,000	40%	$129,524,000
Semiskilled and Unskilled	$323,810,000	50%	$161,905,000
Administrative and Supervisory	$323,810,000	10%	$32,381,000
		TOTAL:	$323,810,000
3. Allocation of Wages to Locally Unemployed or Underemployed Labor			
Labor Classification	Wages	Percent of Locally Hired Labor	Wages Paid to Local Hired Unemployed or Underemployed Labor
Skilled	$129,524,000	25%	$32,381,000
Semiskilled and Unskilled	$161,905,000	25%	$40,476,250
Administrative and Supervisory	$32,381,000	25%	$8,095,250
		TOTAL:	$80,952,500
4. Average Annual Labor Resource Benefits			
		Average Annual Labor Resource Benefits:	$2,998,555
		Less WOPC O&M Asset Renewal Labor Resource Benefits Foregone:	$1,390,701
		TOTAL:	$1,607,854

** Only remaining costs are applicable. Does not include E&D, S&A, or land costs.*

6.7. Regional and GDP Impacts

Analysts developed two separate GDP spreadsheet models for the Validation Study (available in the Economics Appendix, Attachment 5). The first model, *Annual Operational Contributions to Economy*, is an assessment of the economic contribution of the operations of the Soo Locks complex based on a standard multiplier analysis. The second model, *Detailed Assessment of Industry Dependence of the Soo Locks: A View from the Vehicle Manufacturing Sector* recognizes that the Soo Locks complex is a means to an economic-related end. This means the operations of the Soo Locks complex facilitates production value chains would likely be hindered should the Soo Locks complex experience an unanticipated shut-down. Because of the wide breadth of commodities and goods flowing through the Soo Locks and the even wider breadth of value chains to which these flows contribute, the frame of assessment is limited to a single commodity value chain, from taconite pellets raw materials to final goods for consumption.

The first GDP/RED evaluation provides an estimate of the economic contributions of the Soo Locks to the Great Lakes regional economy, which is made up of eight states bordering the Great Lakes.[4] More specifically, this analysis provides estimates of the level of economic activities facilitated by the Soo Locks that include: 1) shipping activities of Great Lakes port regions that ship commodities through the Soo Locks; 2) operation and maintenance (O&M) of the existing lock system; and 3) production of commodities shipped through the Soo Locks. It is important to recognize that this is an economic contribution analysis, which estimates the *existing* economic activity (output, labor income, value added, and employment) associated with an *already occurring* economic stimulus. As such, the estimates differ from those that would underlie a regional economic impact analysis, where impact estimates are based on the expected *change in* economic activity associated with a *new* economic stimulus to an economy.

This analysis shows that the Soo Locks is directly or indirectly tied to $46.4 billion in output for the eight-state Great Lakes region and $58.2 billion for the Nation (Table 14).

Table 14. Regional and National Total Economic Contribution of the Soo Locks

	Contribution Region	
Contribution	**8 Great Lakes States**	**Nation**
Output	$46,355.9M	$58,189.1M
Jobs	142,366	237,080
Labor Income	$10,103.9M	$15,082.2M
GRP	$17,026.4M	$25,544.3M

This second evaluation provides an estimate of the economic contributions of the Soo Locks to the National economy, as measured by the contribution of taconite pellets shipped through the Soo Locks for use in the vehicle and vehicle parts manufacturing and distribution sectors.

Table 15 displays net economic impact estimates for this analysis. The total impact of an unscheduled 12- to 18-month disruption in the Soo Locks would result in a temporary reduction of employment of about 8.5 million U.S. jobs with total labor income declining by $451.1 billion. Gross domestic product would likely see a temporary decline of about $666.5 billion while economic activity, measured by output (gross sales) would decline by about $1.1 trillion. Much of these results depend on how firms respond to an expected temporary disruption: firms may choose to under employ their workforce, lest risk losing long-term employees. They may also make temporary transitions to other markets, further mitigating the overall economic effects of an unexpected lock closure.

[4] States include: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin

Table 15. Net Economic Impacts by Value Chain Leg

Value Chain Leg	Employment		Labor Income ($2016 Million)	
	Direct	Total	Direct	Total
Mining	-15,000	-67,000	-1,791	-4,869
Iron and Steel Production	-24,000	-217,000	-2,261	-13,870
Motor Vehicle Production	-573,000	-3,750,000	-51,656	-244,918
Motor Vehicle Sales	-3,246,000	-4,436,000	-157,556	-187,439
Aggregate Impact	**-3,858,000**	**-8,470,000**	**-213,264**	**-451,095**
Value Chain Leg	**Gross Domestic Product ($2016 Million)**		**Output (Sales) ($2016 Million)**	
	Direct	**Total**	**Direct**	**Total**
Mining	-4,113	-9,596	-7,264	-17,329
Iron and Steel Production	-1,807	-21,872	-21,009	-58,560
Motor Vehicle Production	-74,746	-391,740	-365,144	-1,023,678
Motor Vehicle Sales	-156,531	-243,248	-11,890	-29,404
Aggregate Impact	**-237,197**	**-666,456**	**-405,307**	**-1,128,971**

6.8. Economic Evaluation

Benefits of the analyzed plan include the annualized value of net reductions, relative to the baseline, in service disruption impact costs and in scheduled project costs. Other benefits include, gross benefits such as recreation and labor resource benefits.

Unscheduled service disruptions at the project [redacted] result in service disruption impact costs. These include costs of tonnage diverted over existing alternate modes, vessel costs, unscheduled repair costs, and unmet demand costs.

Scheduled project costs are costs generally associated with scheduled events, and include project investment costs, maintenance costs, and both the investment and maintenance costs for alternative transportation modes, including unmet demand proxy modes. There is some degree of overlap between these categories however; scheduled major maintenance actions such as the [redacted], that result in service disruption events will be tallied under both the project scheduled costs and service disruption impact costs.

Analysts evaluated benefits resulting from these net costs (service disruption and scheduled project costs) by comparing annualized costs in the baseline to the with project conditions for the respective subcategories of each. In cases in which the with project condition results in a net reduction in costs of one these subcategories, the reduction is a benefit of the with project condition. Likewise, in cases where the with project condition results in a net increase in a cost category, that increase is a cost of the project. Table 16 itemizes the scheduled project cost categories, with costs for both the without project and with project conditions shown, as well as net reductions (benefits) and net increases (costs).

Table 16. Average Annual Scenario Costs, 2020–2076
Q1 FY18 Dollars, 2.75% Discount Rate

Cost Category	WOPC	WPC	Benefit	Cost
Project Investment				
Construction (new Poe Lock)	$421,776	$32,860,129	$0	$32,438,353
Davis / Sabin decommissioning	$781,433	$0	$781,433	$0
Asset Renewal Plan				
Project Level Components	$4,962,663	$4,283,890	$678,772	$0
Poe Lock Components	$3,939,239	$2,373,038	$1,566,202	$0
Mac Lock Components	$1,890,659	$0	$1,890,659	$0
Sub-Total Investment Costs	**$11,995,770**	**$39,517,057**	**$4,917,066**	**$32,438,353**
Project Maintenance				
Normal O&M				
Pre-2027 (pre-online)	$3,943,596	$3,943,596	$0	$0
Post-2027 (post-online)	$14,000,000	$14,000,000	$0	$0
Scheduled Maintenance				
Project Level Components	$564,715	$504,675	$60,039	$0
Old Poe Lock Components	$1,857,029	$768,363	$1,088,667	$0
New Poe Lock Components	$0	$270,535	$0	$270,535
Mac Lock Components	$1,913,442	$28,173	$1,885,269	$0
Sub-Total Maintenance Costs	**$22,278,782**	**$19,515,341**	**$3,033,975**	**$270,535**
TOTALS	**$34,274,552**	**$59,032,398**	**$7,951,041**	**$32,708,888**

Itemized service disruption impact costs are shown in Table 17 and Table 18. Diverted tonnage costs use existing delivery routes and hypothetical delivery routes, which are itemized by commodity type.

Table 17. Average Annual Service Disruption Impacts, 2020–2076
Q1 FY18 Dollars, 2.75% Discount

Impact Cost Category	WOPC	WPC	Benefit	Cost
Service Disruption Diverted Tonnage Costs				
Taconite pellets				
Escanaba (existing)	$632,452	$102,842	$529,610	$0
Canadian ore	$137,472	$52,745	$84,726	$0
Coal				
empty upbound mac vessels	$2,658	$849	$1,809	$0
vessel to truck	$0	$0	$0	$0
all overland route	$403	$107	$296	$0
direct rail to coal plants	$336,020	$180,398	$155,622	$0
rail to Toledo	$11,557	$8,285	$3,272	$0
Aggregates				
empty upbound mac vessels	$3,526	$1,164	$2,362	$0
all overland route	$920	$298	$622	$0
Grains (all overland route)	$729,997	$206,200	$523,797	$0
Others (all overland route)	$429,645	$138,918	$290,727	$0
Sub-Total Diverted Tons Costs	**$2,284,650**	**$691,807**	**$1,592,843**	**$0**
Service Disruption Vessel Costs				
Vessel Transit Time Costs	$19,567,206	$17,617,904	$1,949,303	$0
Poe-restricted Vessel Layup (wait at port)	$2,003,976	$672,392	$1,331,584	$0
Sub-Total Vessel Costs	**$21,571,182**	**$18,290,296**	**$3,280,887**	**$0**
Service Disruption Repair Costs				
Engineering Reliability Components	$60,719	$55,210	$5,508	$0
Accidents	$0	$0	$0	$0
Sub-Total Repair Costs	**$60,719**	**$55,210**	**$5,508**	**$0**
TOTALS	**$23,916,551**	**$19,037,313**	**$4,879,238**	**$0**

Figure 14 illustrates the severity of service disruption impacts between the WOPC and WPC. In the WPC, component risk from the existing Poe Lock is greatly reduced. The service disruption impacts avoided category accounts for vessel capacity issues. These include diverted traffic costs, vessel transit time costs, and Poe-restricted vessel layup (wait at port) delay costs. This category accounts for approximately $12.6 million per year, or 13 percent of the total project benefits.

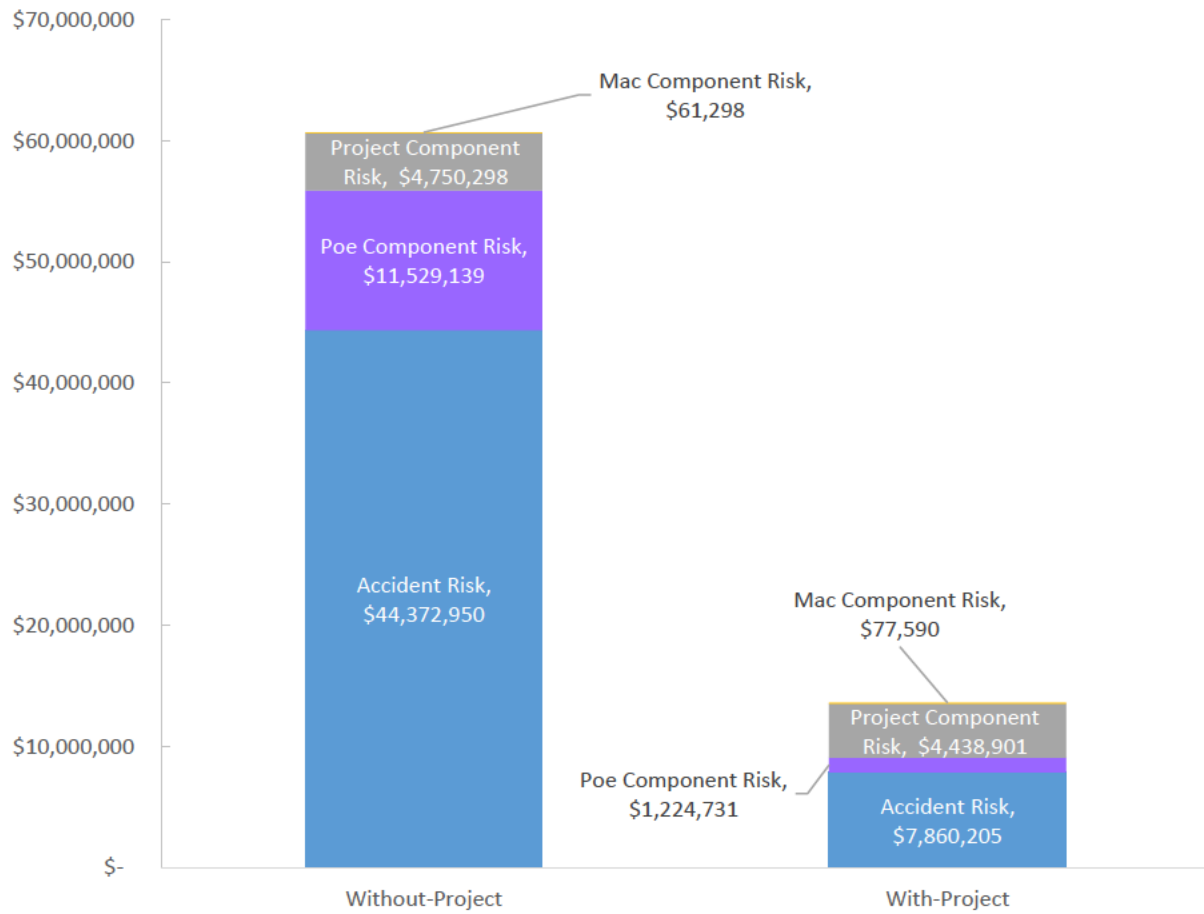

Figure 14. Average Annual Service Disruption Impacts by Risk Category
2020—2076, Q1 FY18 Dollars, 2.75% Discount Rate

Table 18.Average Annual Unmet Demand Impacts, 2020–2076
Q1 FY18 Dollars, 2.75% Discount Rate

Impact Cost Category	WOPC	WPC	Benefit	Cost
Unmet Demand Proxy Impact Costs				
Service Disruption Tonnage Cost (Taconite pellets)				
Conveyor	$35,673	$12,204	$23,470	$0
Stockpile	$1,206,879	$101,512	$1,105,367	$0
Escanaba (expansion)	$4,244,304	$331,135	$3,913,169	$0
Alt. Route Investments *				
Escanaba (existing)				
Investment	$1,983,498	$1,460,915	$522,584	$0
Maintenance	$1,873,654	$1,380,010	$493,643	$0
Conveyor System				
Investment	$1,804,813	$790,390	$1,014,423	$0
Maintenance	$151,887	$66,517	$85,371	$0
Stockpile Expansion				
Investment	$3,475,607	$1,113,265	$2,362,342	$0
Maintenance	$5,839,849	$1,870,551	$3,969,297	$0
Escanaba (expansion)				
Investment	$30,724,042	$4,212,713	$26,511,329	$0
Maintenance	$884,086	$119,497	$764,589	$0
TOTALS	**$52,224,293**	**$11,458,710**	**$40,765,584**	**$0**

** Proxy costs for Unmet Demands were estimated through costing of alternative routing or stockpiling capital investment. Values shown are expected values. Investments made were specific to individual simulation iteration need. Investment was then timed in year 2020 regardless of the year or years needed.*

The unmet demand impacts avoided category accounts for material conveyance issues in the event of a Poe lock closure (Table 18). This category includes three alternative modes that would be required to accommodate the unmet transportation demand for materials: via a conveyor system, via expanded stockpiling options, and through an expansion at Escanaba. This category accounts for approximately $39,749,357 million per year, or 68 percent of the total project benefits.

Table 19 provides greater detail on the calculated benefits and displays the breakdown of service disruption costs avoided, unmet demand impacts avoided, total WOPC costs avoided, recreation benefits, and labor resources benefits. Total average annual benefits are $58,173,417. The WOPC costs avoided category accounts for costs associated with the existing transportation components. These include normal O&M, scheduled maintenance, existing costs at Escanaba, Davis and Sabin lock decommissioning, service disruption repair costs, and the asset renewal plan implementation. This category accounts for approximately $9 million per year, or 15 percent of the total project benefits. The recreation benefits category accounts for enhanced recreation activities resulting from the construction of a new lock. These include opportunities related to the visitor center, recreational craft lockages, and tour boats. This category accounts for approximately $2.9 million per year, or 5 percent of the total project benefits. The final benefit category is the effect on labor resources, which is the economic effects of the direct use of unemployed or underemployed labor resources during project construction or installation. This category accounts for approximately $1.6 million per year, or 3 percent of the total project benefits.

Table 19. Average Annual Benefits by Category, 2020–2076
Q1 FY18 Dollars, 2.75% Discount Rate

Benefit Category	
Service Disruption Impact Costs Avoided	
Diverted Traffic Costs	$1,592,843
Vessel Transit Time Costs	$1,949,303
Poe-restricted Vessel Layup (wait at port)	$1,331,584
Sub-Total Service Disruption Costs Avoided	**$4,873,730**
Unmet Demand Proxy Transportation Impacts Avoided	
Taconite pellets - via conveyor system	$1,123,263
Taconite pellets - via expanded stockpile	$7,437,006
Taconite pellets - via expanded Escanaba	$31,189,087
Sub-Total Unmet Demand Impacts Avoided	**$39,749,357**
Without-project Costs (WOPC) Costs Avoided (benefits)	
Normal Operations & Maintenance	$0
Scheduled Maintenance	$3,033,975
Escanaba (existing)	$1,016,227
Davis / Sabin decommissioning	$781,433
Service Disruption Repair Costs	
Engineering Reliability Components	$5,508
Accidents	$0
Major Maintenance/Component Replacement	
Project Level Components	$678,772
Poe Lock Components	$1,566,202
MacArthur Lock Components	$1,890,659
Sub-Total WOPC Costs Avoided	**$8,972,776**
Recreation Benefits	
Visitor Center	$2,902,500
Recreational Craft	$800
Tour Boats	$66,400
Sub-Total Recreation Benefits	**$2,969,700**
Labor Resource Benefits	
Labor Resource Benefits	$1,607,854
TOTAL PROJECT BENEFITS without Labor Resource Benefits:	**$56,565,563**
TOTAL PROJECT BENEFITS with Labor Resource Benefits:	**$58,173,417**

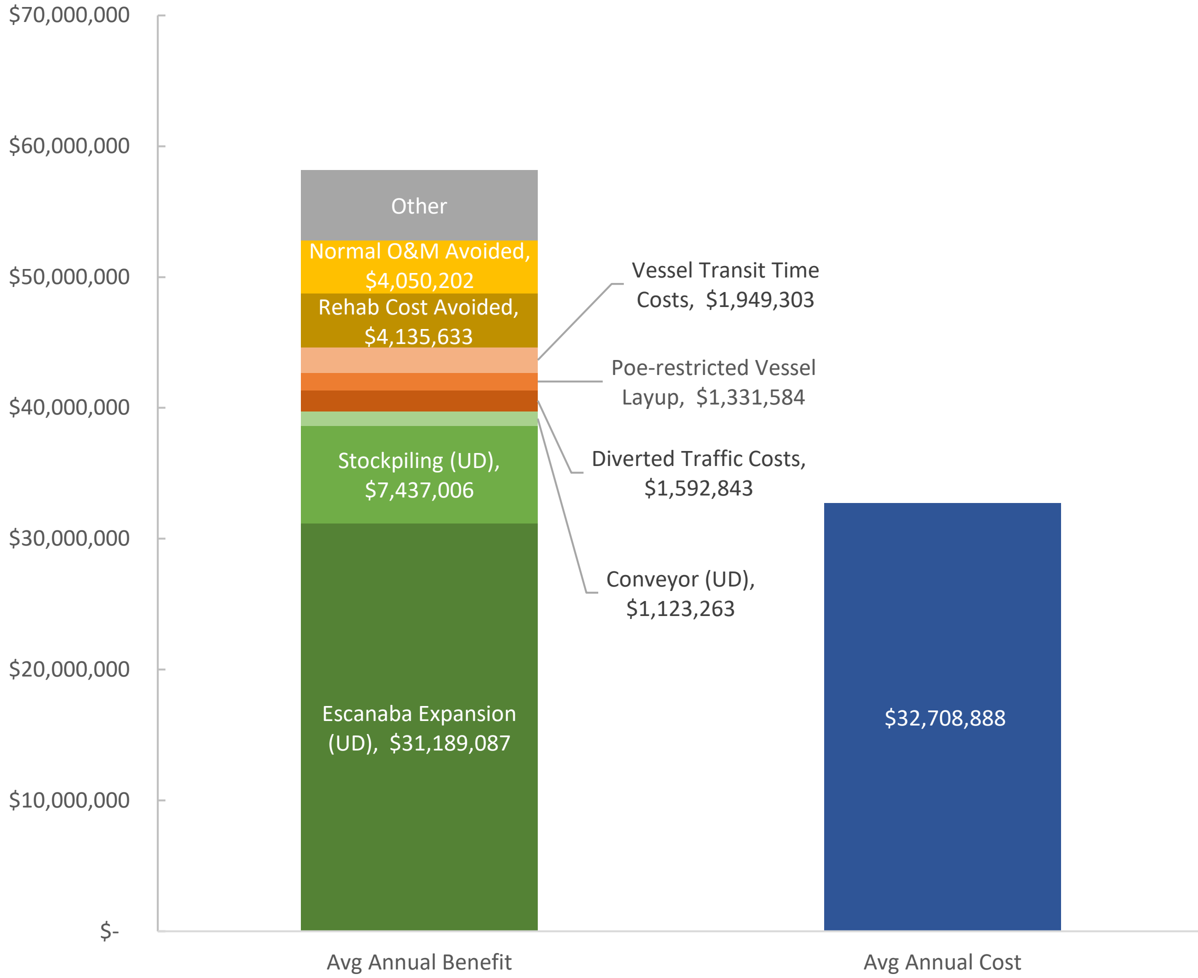

Figure 15. The Factors Contributing to the Average Annual Benefits

The net benefit and BCR ratio calculations are shown at the current FY18 discount rate of 2.75% and at the 7.0% rate (Table 20). New lock construction, for the base condition, would result in an average annual benefit of $96.6 million at an average annual cost of $32.8 million, producing an average annual net benefit of $63.8 million and a benefit to cost ratio of 2.94 at the current discount rate.

Table 20. Benefit-to-Cost Evaluation, 2020–2076

Q1 FY18 Dollars

Scaled Escanaba Capital Costs and Fixed Capital Costs

Cash Flow Category	New Poe-Size Lock (Escanaba Scaled Capital Cost) 2.75% Discount Rate	New Poe-Size Lock (Escanaba Scaled Capital Cost) 7.0% Discount Rate
Total Average Annual Project Costs	$32,708,888	$69,480,408
Total Average Annual Project Benefits	$56,565,563	$103,795,851
BASE NET BENEFITS	$23,856,675	$34,315,443
BENEFIT-TO-COST RATIO (BCR)	**1.73**	**1.49**
Base Net Benefits	$23,856,675	$34,315,443
Allowable Labor Resource Benefits	$1,607,854	$3,145,301
NET BENEFITS	$25,464,528	$37,460,744
BENEFIT-TO-COST RATIO (BCR)	**1.78**	**1.54**

Cash Flow Category	New Poe-Size Lock (fixed Escanaba floor cost) 2.75% Discount Rate	New Poe-Size Lock (fixed Escanaba floor cost) 7.0% Discount Rate
Total Average Annual Project Costs	$32,708,888	$69,480,408
Total Average Annual Project Benefits	$77,437,864	$157,962,038
BASE NET BENEFITS	$44,728,975	$88,481,630
BENEFIT-TO-COST RATIO (BCR)	**2.37**	**2.27**
Base Net Benefits	$44,728,975	$88,481,630
Allowable Labor Resource Benefits	$1,607,854	$3,145,301
NET BENEFITS	$46,336,829	$91,626,931
BENEFIT-TO-COST RATIO (BCR)	**2.42**	**2.32**

6.9. Sensitivity Analysis

The study team conducted a series of sensitivity analyses to better understand how key assumptions and inputs affect the BCR. The Economics Appendix, Section 9.2 provides greater detail and rationale about the sensitivity analyses.

The “base” WPC scenario is the construction of a new lock and includes the following assumptions:

- Medium traffic forecast
- Most likely prioritized maintenance of the existing Poe Lock as defined in Section 5.2
- Planning horizon from 2020—2076

- Hypothetical delivery routes (proxy modes) used to deliver unmet demand. Escanaba port expansion capital costs are scaled depending on the required tonnage throughput.
- Accident risk (likelihood and duration) based on recent historical data, *Poe Lock System Risk Analysis* report (USACE, 1994), and extrapolated by the USACE Planning Center of Expertise for Inland Navigation (PCXIN).

Recognizing that the input data and assumptions have uncertainties, the following sensitivity analyses were performed with results presented in Table 21.

Traffic forecast
The mid-level traffic forecast scenario is considered the most probable future condition and was used as an input for the base condition. In light of uncertainty surrounding this traffic level and the future of key industrial markets, analysts developed alternate traffic forecast scenarios to help measure the sensitivity of project benefits against different tonnage levels. These include a high and low traffic scenario. Two additional sensitivities were also modelled: a traffic forecast scenario that assumes no traffic growth occurs and traffic remains at historically observed levels, and a scenario that assumes the most probable traffic growth occurs, but growth is held flat after 20 years from the first forecasted year. This latter point has the effect of weighting the initial years of the project economic life and de-emphasizing the latter years, which, by their nature, involve greater uncertainty.

Maintenance costs
The WPC and WOPC includes prioritized major maintenance and does not assume a fix-as-fails approach. This is due to available reliability data, engineering judgment at the site, and historical and projected O&M funding. The most likely WOPC includes rehabilitation work totaling $160.2M of investment in Poe Lock components, $68.5M in MacArthur Lock components, and $139.4M in project level components. Every component with identified reliability issues (12 total) would be replaced at some point over the planning period along with six non-reliability components.

[redacted]

To better understand the benefits of a most likely maintenance approach versus a fix-as-fails approach a sensitivity was modelled for the fix-as-failed maintenance approach (See Economics Appendix, Section 9.2.4 for a full description of the fixed-as-fails and most likely maintenance approach.

Risk Period
The base condition assumes a planning period from 2020 – 2076. In the WPC, the new lock is not available for traffic until 2027. This means that in both the WPC and WOPC, there is a service disruption risk in the first seven years of the project that could cause unmet demand. The risk is greatly reduced in the WPC because once the new lock is built vessels will be able to transit either lock. Although the accident risk is a constant value, weighing in the seven year risk during construction produces a different result than an analysis that only evaluates that risk during the 50-year analysis period.

The broader stakeholder community has asked the Army Corps of Engineers whether the risk in the construction period should be discounted and considered an acceptable level of risk. This assumes that no alternative capital investment costs should be considered in the time period before the new Poe-sized chamber is able to come online. In other words, this sensitivity test isolates the question “Is the project economically viable?” To account for this, a sensitivity test was modelled that eliminates all failures (both accident and lock component) before project implementation. Since the intent of this update is not to compare the timing of possible solutions to mitigating the risk at the project but to estimate the economic viable of the recommended plan, this sensitivity test is an important result to decision-makers. This sensitivity analysis is for information purposes only. The 1983 Principles and Guidelines (P&G) explicitly requires that the implementation period be included in the period of analysis. Paragraph 1.4.12 defines the Period of Analysis: "The period of analysis is to be the same for each alternative plan. The period of analysis is to be the time required for implementation plus the lesser of—(1) The period of time over which any alternative plan would have significant beneficial or adverse effects; or (2) A period not to exceed 100 years." Because this sensitivity does not include the implementation period, it is not compatible with the P&G and cannot be supported by USACE in an official capacity.

GDP Impacts

This sensitivity analysis is for information purposes only as it groups National Economic Development (NED) and Regional Economic Development (RED) benefit accounts which are not additive. Because of this, there is a potential of double counting benefits and cannot be supported within USACE policy For the analysis, analysts valued unmet demand through the use of hypothetical delivery routes. As a sensitivity to the analysis, value for each stranded ton was estimated as a GDP impact per ton.

Several complications exist when determining a GDP impact for each ton of undelivered taconite. These complications are fully described in the Economics Appendix. Section 9.2.3. In short, the regional and GDP impact assessment, produced as part of this study, shows that there is fairly limited flexibility in the U.S. market to adapt to a short-run disruption of taconite pellets. For this sensitivity analysis, data was derived from the Validation Study Economics Appendix Attachment 5 and recent reports from the DHS. For this sensitivity test an unplanned 296-day Poe Lock closure was assumed. In short, from 0-2 weeks, substitution likely exists for steel production such as through the use of stockpiled taconite pellets at the end user. From 2 – 6 weeks steel production starts to shut down and end users slow down production. Between 6 weeks and 6 months there is a complete loss of end user (automobile) production due to the unavailability of steel. From 6 months to 296 days, the global market would likely have enough time to adjust and start producing the required steel for the automobile sector. It would take foreign steel mills about six months to retool their systems to begin to create the specialty steel blends required for the automobile industry. These various timeframes were modelled in Soo-REM to calculate the year, closure duration, affected taconite pellets tonnage, and undelivered ore tonnage. From this the affected taconite pellets tonnage per day is estimated. Additional minor adjustments were required and are fully described in the Economics Appendix.

Accident Risk

[redacted] accident probabilities are based on historic data and the Poe *Lock System Risk Analysis* report (USACE, 1994). This sensitivity focused on the assumed durations of severe accidents. This component of accident risk was chosen as sensitivity analysis because it directly drives service disruption impact cost, as well as drives total service disruption risk in a nonlinear fashion. This is because it is the largest contributor to extended service disruptions that result is higher volumes of affected tonnage than can be accommodated by existing alternate modes.

To test the sensitivity of the analysis to changes in assumed accident closure durations, beta distributions defined by the minimum and maximum elicited parameters, rather than the average, were used to characterize possible closure durations for a “Low” and “High” case, respectively. The Economics Appendix, Section 9.2.5 provides greater detail on the accident risk sensitivity.

Only four types of accidents were analyzed for the Validation Report. They include vessel grounding, vessel fires, vessel gate impacts, and chemical spills. Accidents relating to human error (i.e. lock operation error causing a gate miss-miter), terrorism attack, and criminal activity were not considered in the analysis due to the lack of available data. These low probability items could likely have significant duration impacts.

Escanaba Cost Scaling - Fixed Floor
This sensitivity analysis compares the base analysis which scaled the Escanaba capital costs to the throughput needed to a “floor” method which assumes there is a minimum (floor) cost incurred for transporting any tonnage amount though the Escanaba port. Therefore, anytime the need for the Escanaba Port is triggered in the model run, a minimum of $2.8 billion for capital costs is required. See Economics Appendix Section 9 for a full discussion about the floor sensitivity.

Table 21 provides a summary of the different sensitivities and how the final BCR is impacted. All sensitivities resulted in a BCR greater than 1. Figure 16 provides a visual representation of the average annual benefit comparison for the sensitivity analysis. The red line in Figure 16 indicates the average annual equivalent cost, which remained constant across all sensitivity scenarios. For a full breakdown of benefits for the varying sensitivities see the Economics Appendix, Section 9.2.

Table 21. A Comparison of the Various Sensitivity Tests Conducted
(FY18 @ 2.75%)

Cash Flow Category	Base	Traffic Forecast Scenario				OMRR&R	Risk Period	Unmet Demand	Accident Duration		Escanaba Cost Scaling
		Low	High	No Growth	No Growth After 20 Yrs	Fix-as-Fails	2027-2078	GDP Impacts	Low	High	Fixed Floor
Total Average Annual Project Costs	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888	$32,708,888
Total Average Annual Project Benefits	$56,565,563	$39,790,021	$89,742,299	$54,450,202	$54,600,800	$67,894,451	$60,677,043	$223,719,095	$31,742,220	$99,788,375	$77,437,864
BASE NET BENEFITS	$23,856,675	$7,081,133	$57,033,411	$21,741,314	$21,891,912	$35,185,563	$27,968,155	$191,010,207	($966,668)	$67,079,487	$44,728,975
BENEFIT-TO-COST RATIO (BCR)	**1.73**	**1.22**	**2.74**	**1.66**	**1.67**	**2.08**	**1.86**	**6.84**	**0.97**	**3.05**	**2.37**
Base Net Benefits	$23,856,675	$7,081,133	$57,033,411	$21,741,314	$21,891,912	$35,185,563	$27,968,155	$191,010,207	($966,668)	$67,079,487	$44,728,975
Allowable Labor Resource Benefits	$1,607,854	$1,607,854	$1,607,854	$1,607,854	$1,607,854	$1,607,854	$1,607,854	$1,607,854	$0	$1,607,854	$1,607,854
NET BENEFITS	$25,464,528	$8,688,986	$58,641,265	$23,349,168	$23,499,766	$36,793,417	$29,576,009	$192,618,060	($966,668)	$68,687,340	$46,336,829
BENEFIT-TO-COST RATIO (BCR)	**1.78**	**1.27**	**2.79**	**1.71**	**1.72**	**2.12**	**1.90**	**6.89**	**0.97**	**3.10**	**2.42**

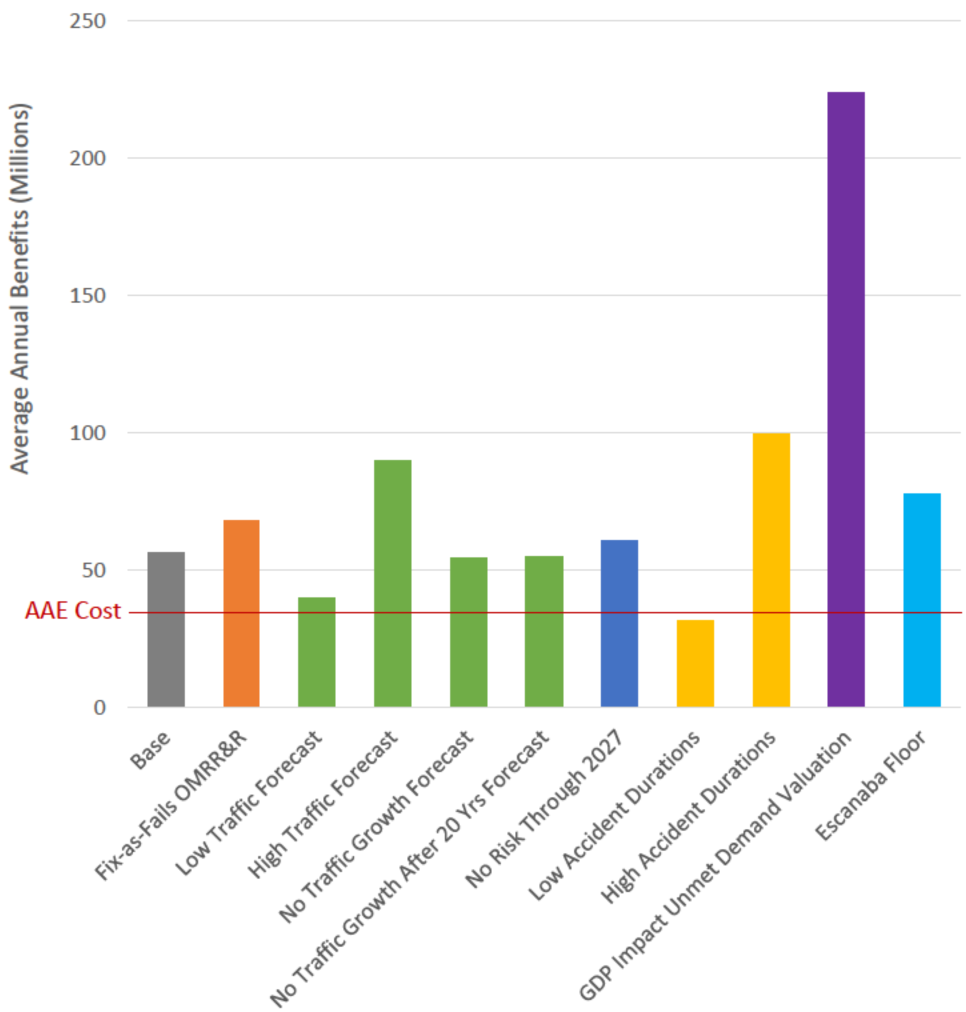

Figure 16. Sensitivity Scenario Average Annual Benefit Comparison
2.75% Discount Rate

6.10. Historical Comparison of Benefits from Past Reports

Table 22 illustrates how benefit categories have changed since the 1986 feasibility report and 2005 LRR. A complete description can be found in the Economics Appendix, Section 7.1. Benefits greatly increased from the 2005 report to the 2018 report due to changes in the federal discount rate, assumptions about taconite pellets unmet demand, and the inclusion of engineering reliability data. Specifically the primary drivers for the benefits increase include:

- The discount rate in 2005 was 5.63% which is much higher than the current discount rate of 2.75%.

- The current analysis recognizes and quantifies impacts due to the lack of overland capacity and the capability restrictions to move taconite from Duluth, MN to steel mills on the Lower Great Lakes. There have been substantial overland developments, including the continued degradation of rail lines, many of which are now not suitable to move a fully loaded taconite pellets rail car, and also the closure of a large trans-modal port at Escanaba, MI. Currently, taconite pellets move exclusively through the Poe Lock in Class 10s during the navigation season. The potential for large quantities of unmet demand exists in the event of lock failures. The 2005 report assumed that taconite pellets could move via overland routes in the event of an unscheduled Poe Lock closure. This means, in 2005, there was no unmet demand to value. This difference represents the greatest change in benefits between the 2005 and 2018 reports and is captured in the “unmet demand transportation costs”. To estimate the economic impact of this unmet demand, proxy alternative transportation costs were developed. These proxy methods of transportation are not actual proposed alternatives, but rather serve as a surrogate to value the existing methods of transportation against a next-best, least-cost alternative.

- In 2018, the analysis considers risk due to lock component failures [redacted] Previous studies only analyzed the likelihood that vessel accidents could occur.

- In 2018, the analysis considers benefits of avoided lock closure impacts due to the scheduled Poe Lock closures required for miter gate replacement. These closure impacts are mitigated in the with-project condition by the presence of the new lock.

Table 22. Historical Comparison of Benefits

Category	1986 Feasibility[1]	2005 LRR[2]	2018 VS
STUDY METRICS			
Price Level:	Jan-85	FY 2000	FY2018
Federal Discount Rate:	8.375%	5.625%	2.75%
PRIMARY BENEFITS			
Disruption Costs Avoided:			
Stockpile Drawdown Costs[3]:	-	$1,226,000	-
Diverted Traffic Costs:	$5,549,000	$2,740,000	$1,592,843
Vessel Layup Costs[4]:	-	$1,702,000	$1,331,584
Safety Costs:	-	$416,000	NC*
Unmet Demand Transportation Costs:	-	-	$39,749,357
Stockpile Inventory Savings:	$8,017,000	-	-
Reserve Fleet Costs:	$2,340,000	-	-
Emission Abatement Costs Avoided:	-	$381,000	NC*
Rehabilitation Costs Avoided:	-	$3,723,000	$4,135,633
Scheduled Maintenance Costs Avoided:	-	-	$3,033,975
Repair Costs Avoided:	-	-	$5,508
Vessel Delay Savings[5]:	$13,116,000	$3,013,000	$1,949,303
Recreation Benefits:	-	$2,235,000	$2,969,700
Decommissioning Cost Savings:	-	$948,000	$781,433
SUPPLEMENTAL BENEFITS INCLUDED IF BCR > 1.0			
Labor Resource Benefits[6]:	$2,284,000	$1,775,000	$1,607,854
Terrorist Disruption Avoided:	-	$1,382,000	NC
Subtotal Primary Average Annual Benefits:	**$29,022,000**	**$16,384,000**	**$56,565,563**
Total Average Annual Benefits (all categories):	**$31,306,000**	**$19,541,000**	**$58,173,417**
COSTS			
With Project Total First Cost:	N/A	$310,000,000	$903,158,305
Total Average Annual Cost[7]:	**$24,056,000**	**$22,564,000**	**$32,708,888**
COST-BENEFIT ANALYSIS:			
Net Incremental Annual Benefits:	$7,250,000	($6,180,000)	$25,464,528
Benefit-Cost Ratio:	1.3	0.73	1.78

[1] Benefit Reference: 1986 Soo Locks Final Interim Feasibility Report, Economic Appendix, Page I-54

[2] Benefit Reference: 2005 Soo Locks LRR, Economic Appendix, page B-91

[3] Included in the stockpiling component of unmet demand transportation costs

[4] Benefit category was named "idle vessel costs" in the 2005 Soo Locks LRR

[5] 2005 LRR estimate is an aggregation of two benefit categories; lock delay costs ($445,000) and vessel delay savings ($2,568,000)

[6] Category was named "area redevelopment benefits" in previous studies (1986 Feasibility and 2005 LRR)
[7] Includes Interest During Construction (IDC) and Operations and Maintenance (O&M) Costs
*NC - Not calculated. Safety Costs Avoided and Emission Abatement Costs Avoided – These benefit categories were not calculated for the 2018 report since benefits were expected to be relatively small compared to other benefit categories.

Emissions Abatement Costs Avoided and Safety Costs Avoided
The GLNS plays a key role in preserving our nation's fuel. The fuel economy of maritime transportation is significantly higher than any form of ground transportation. For example, a Great Lakes carrier averages 631 miles on one gallon of fuel per ton of cargo. In contrast, a truck averages 91 miles on one gallon of fuel per ton of cargo and a freight train only 553 miles on one gallon of fuel per ton of cargo. In one delivery, a 1,000-foot Great Lakes carrier supplies 70,000 tons of cargo. It would take nearly 3,000 semi-truckloads to haul the same load. The trucking mode of transportation not only is much less fuel efficient, it creates significant wear-and-tear on the nation's infrastructure and increases congestion on already clogged roadway arteries.

The amount of greenhouse gas emissions is also significantly lower in maritime transportation as compared to ground transportation. A cargo of 1,000 tons transported by truck emits over 537% more greenhouse gases than the same tonnage transported by Great Lakes carrier. The same cargo carried by rail would produce 21% more greenhouse gases than if the cargo was transported by Great Lakes carrier. The GLNS offers a fuel-efficient, low carbon producing and low-cost option of transportation for millions of tons of bulk material that are vital to this country's industrial strength.

In the event of a Poe Lock or MacArthur Lock closure some commodities would travel via overland methods such as rail or truck. Transporting tonnage overland typically results in higher probabilities of accidents which lead to an increase in property damage, injuries, and death.

The 2018 Validation Study does not include emissions abatement costs avoided or safety costs avoided as a benefit category though it is anticipated that these benefits exist with the construction of a new lock. In 2005, emissions abatement cost avoided made up less than 2% of the total benefits and safety cost avoided benefits made up less than 3% of the total benefits.

6.11. Section 902 Analysis

Section 902 of WRDA 1986 (as amended) established a maximum cost for water resources development and conservation projects. ER 1105-2-100, defines the Section 902 limit as, "The maximum project cost allowed by Section 902 includes the authorized cost (adjusted for inflation), the current cost of any studies, modifications, and action authorized by WRDA '86 or any other law, and 20 percent of the authorized cost (without adjustment for inflation)".

Concurrent with the Validation Study, a post-authorization change report (PACR) was produced. Table 23 outlines the key cost points based on the current cost estimate.

Table 23. Historical Cost Comparison from the 2007 Authorized Costs to the FY19 Certified Cost Estimate.

WRDA 2007 Authorized Cost (November 2007-FY08)		Current Certified Cost (October 2018-FY19)	
FY04 TPCE[1]	$341,714,000	FY19 TPCS	$922,432,000
Auth Cost+ Inflation	$341,714,000	Auth Cost + Inflation	$415,821,000
FY08 902 Limit	$409,200,000	FY19 902 Limit	$532,957,000
Total Construction Account Allocations to Date	$8,592,703	Total Construction Account Allocations to Date	$32,153,151

[1]The total project cost estimate used in the WRDA 2007 authorizing language ($341 million) was in October 2003 dollars and not escalated or inflated to 2008 dollars

Key cost drivers include items related to design changes, contingency, and cost-estimating practices and are explained in detail in the accompanying post authorization change report.

7. ENVIRONMENTAL CONSIDERATIONS

National Environmental Policy Act (NEPA): Environmental compliance for the proposed construction of the second Poe-sized lock is covered by the Detroit District's *Final Interim Feasibility Report and Environmental Impact Statement for the Great Lakes Connecting Channels and Harbors Study*, prepared in March 1985 (filed with the Environmental Protection Agency in August 1986), a subsequent record of environmental consideration dated February 2000, an information bulletin made available in 2008, and an updated record of decision signed on February 27, 2009.

For the Validation Study, a Supplemental Information Report (SIR) documents that an evaluation of the proposed action has been conducted to determine the sufficiency of existing environmental documents. (Appendix D). The SIR indicated that no significant new circumstances or substantial changes have been identified. At this stage/phase of the project, it has been determined that the existing environmental documentation adequately addresses the impacts of constructing a second Poe-sized lock at the Soo Locks Complex on the St. Marys River at Sault Ste. Marie, Chippewa County, Michigan. There is no plan to draft a supplemental NEPA document (Environmental Impact Statement or Environmental Assessment) as implementation of the proposed action will not cause impacts on the environment not previously addressed; and the effects from this action and effects from past, present and reasonably foreseeable actions will not result in any significant new cumulative impacts. Finally, the SIR serves to document that the required NEPA, and other federal law and regulation compliance for the proposed action has been met and the proposed action is environmentally acceptable. When the project moves into the implementation phase, an environmental compliance review will occur, accordingly.

Real Estate – The Soo Locks complex occupies approximately 194 acres, all under the accountability of the U.S. Army Corps of Engineers Detroit District. The 194 acres are sufficient for construction, operation, and maintenance of the proposed new lock. Access to the Soo

Locks complex is readily available from public streets and there is ample room for work and storage and docking facilities are available. The lands, easements, rights-of-way, relocations and disposal areas needed for new lock construction are located on the real property either owned in fee simple by the United States or are available via the right of navigation servitude. It is not anticipated that any additional land is required.

8. FUTURE SCHEDULE

A detailed project schedule developed in Primavera P6 scheduling software using detailed construction activities and associated network logic to determine project duration is included as an attachment to Appendix C (costs). Table 24 presents several key milestones:

Table 24. Key Project Milestones

Key Project Milestones	Date
Receipt of Design Funding	1-Oct-19
Notice to Proceed (NTP) Upstream Channel Deepening Contract	26-May-20
Upstream Channel Deepening Contract Complete	23-Nov-21
NTP Upstream Approach Wall Contract	2-Dec-20
Upstream Approach Wall Contract Complete	26-Oct-22
NTP Lock Contract	25-Jan-22
Lock Contract Complete	27-Aug-27

*Dates are from the Base Schedule (no contingency)

Three main contracts are proposed for the project. The three contracts would run fairly consecutively with minimal overlap. In short key points include:

- Upstream Channel Deepening (Contract #1) would occur from FY20—FY22.
- The Upstream Approach Walls (Contract #2) would occur from FY21—FY23.
- The New Lock construction (Contract #3) would occur from FY22—FY27.
- According to the base schedule, the project would be completed by FY27. The 80% confidence schedule includes an additional 36 months in the project duration which places project completion in FY30.
- Other key points to include is the development of a project management plan in FY19 and finalizing the new lock design and acquisition strategy in FY21. A key assumption for this schedule is the use of the continuing contract clause for contract actions. The schedule assumes an efficient funding stream.

9. CONCLUSIONS

The New Soo Lock Economic Validation Study provides an update to the proposed construction of a new, redundant lock at the Soo Locks complex. The proposed new lock would be constructed adjacent to the existing Poe Lock and have the same dimensions, as specified in the 2007 construction authorization. Key conclusions of the Validation Study include:

- The Poe Lock is the lynch pin of the Great Lakes Navigation System since it is the single point of failure in the system. Currently, the Poe Lock has no redundancy. It is considered National critical infrastructure due to nearly all domestic taconite pellets transiting through the Poe Lock. If there is a closure, taconite pellets would not be delivered to steel mills located on the lower Great Lakes. Depending on the closure length and when it occurs during the shipping season, the economic consequences could be severe.

- A Department of Homeland Security (DHS) Report estimated that a six-month closure of the Poe Lock would likely temporarily reduce gross domestic product by $1.1 trillion and would result in a loss of an estimated 11 million jobs. The Validation Study includes an assessment of regional and gross domestic product impacts and reached similar conclusions as the DHS report. The USACE effort concluded that change in GDP caused by an unplanned Poe Lock outage would be about $666.5 billion. This is due to the reliance of the U.S. steel industry on taconite pellets that are shipped through the Poe Lock and the reliance of U.S. automobile manufacturers on the U.S. steel industry for advanced high strength steel.

- An updated certified project cost estimate, which includes cost savings from the 2017 VE study, provides a project first cost of $922,432,000 at the FY19 price level with an 80% confidence.

- The FY19 cost estimate exceeds the Section 902 of WRDA 1986 limit by 66% and triggers the need for a post authorization change report and change control board review.

- The economic update corrected assumptions in regards to alternative delivery routes for taconite pellets in the event of a Poe Lock closure. Previous reports assumed that taconite pellets could be transported via overland routes such as rail. Hypothetical delivery modes were identified and used to value taconite pellets that would be stranded in the event of a Poe Lock closure. This value is captured in the “unmet demand transportation costs” benefit.

- The economic update used engineering reliability data about key components produced for the MRER. The previous Limited Reevaluation Reports for constructing the new lock did not have component engineering reliability data.

RECOMMENDATION

The Detroit District, U.S. Army Corps of Engineers recommends a new authorization for construction of a new lock at Sault Ste. Marie, MI with dimensions 1200'L x 110'W. The estimated cost of construction is $922,432,000 at FY19 price level. A new lock would eliminate the Soo Locks as the single point of failure within the Great Lakes Navigation System.

The Soo Locks Complex is Nationally Critical Infrastructure. The recommended project is necessary and prudent to ensure reliability at this critical node in the Great Lakes Navigation System, which is essential to U.S. manufacturing and National Security. The benefits of this project reflect a reduction in risk associated with the existing single point of failure for the Nation's value chain of taconite pellets, steel production, and manufacturing.

This report attempts to quantify the national economic risk associated with the Poe Lock. The project delivery team has taken exceptional care to calculate benefits through a proxy model. To construct this model, USACE defines several assumptions to quantify the likelihood of failure of major lock components and several accident scenarios. The model also includes assumptions, and underlying uncertainty, to hypothetical transportation modes. This was necessary because there is no existing alternate transportation mode to move taconite pellets to integrated steel mills. The basis and uncertainty in these assumptions is documented in this report, and a range of benefit-to-cost ratios (BCRs) calculated.

The range of BCRs all point to an economically justified project. Detroit District's recommendation is based upon a BCR of 2.42, and the evident need of the infrastructure for American steel production and National Security. The BCR represents the most likely commodity forecast, with median-level risks associated with mechanical failure and accidents. It does not, nor could it reasonably, include all possible failure modes, including criminal or terrorist activity, and human error. The BCR is calculated with an estimated minimum cost of a rail connection between mines and the port of Escanaba, MI. This would afford a minimal alternate route for the transportation of taconite pellets that is not reliant on the Soo Locks.

The hypothetical transportation modes are feasible and necessary to the proxy model, but are not intended as proposed alternatives to the new lock. Currently, disruptions to Poe Lock serviceability would have a direct impact on the supply chain, which would directly impact production of Advanced High Strength Steel. That disruption would, in turn, impact manufacturing, particularly the automobile industry. Though not considered the National Economic Development Benefits in accordance with the 1983 Principles and Guidelines, this present scenario illustrates the value of a new lock to the national economy and the GDP.

Considering the entirety of information presented herein, Detroit District recommends the approval of the New Soo Lock Economic Validation Study in order to seek an updated authorization for construction of a new lock at Sault Ste. Marie, Michigan.

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Commanding