TIGER Planning Grant Application Cost-Benefit Economic Analysis

Appendix

All materials are available online at: **www.iowadot.gov/TIGER14-river**

SUPPLEMENTAL MATERIALS

- Letters of Support
- USACE Priority Project List
- **TIGER Planning Grant Application Cost-Benefit Economic Analysis**
- Iowa Department of Transportation's "U.S. Inland Waterway Modernization Reconnaissance Study" April 2013
- Iowa Department of Transportation's Lock and Dam Modernization Handout
- Iowa Department of Transportation's UMRS Action Plan Workshop Summary
- M-35 Application for Marine Highway Corridor Designation

ONE COMPANY | *Many Solutions®*

IOWA DEPARTMENT OF TRANSPORTATION

UPPER MISSISSIPPI RIVER SYSTEM

TIGER PLANNING GRANTS PROGRAM

ECONOMIC ANALYSIS SUPPLEMENTARY DOCUMENTATION

APRIL 10, 2014

TABLE OF CONTENTS

LIST OF TABLES

1. Executive Summary

The Iowa Department of Transportation (IowaDOT) performed a study in early 2013 that documented the importance of the Upper Mississippi River System (UMRS) lock and dam system as well as the need for repairs and operational improvements in order to maintain and enhance its efficiency and reliability.[1] The average age of a lock is 72 years, yet only minimal funding is allocated to the U.S. Army Corps of Engineers (USACE) for repairs, let alone any major improvements that may be necessary.

This TIGER VI planning grant application seeks to access funding to further explore opportunities to enhance the UMRS lock and dam efficiency and reliability. This planning study would involve the following steps:

- An assessment of the current state of river navigation on the Upper Mississippi;
- Evaluation of activities that could be undertaken to increase the efficiency and reliability of the Upper Mississippi Lock and Dam System; and,
- Evaluation of opportunities for the Upper Midwest states to increase utilization of the Upper Mississippi.

This economic analysis supplement to the planning grant application provides evidence of the long-term benefits of rehabilitating and modernizing the UMRS lock and dam system. Estimates of lock and dam system benefits are provided under the following two scenarios:

- **Benefits of Barge Transportation:** Represents the overall national economic benefit of barge transportation on the Upper Mississippi River System for current and the past 5-year historical levels versus other modes of transportation. This scenario shows the total gross impact on the economy if barge movements along the Upper Mississippi were not a feasible mode of transportation.
- **Reliability Benefit:** Represents the benefit to shippers and other external stakeholders if there was an increase in reliability in service on the Upper Mississippi due to rehabilitation and modernization. Enhanced reliability represents the benefit of modal switch from other modes to barge.

The total gross barge benefits of existing freight (CY 2013) passing through the Upper Mississippi as opposed to being shipped by other modes is $843.3 million. In other words, if the lock system failed and all traffic moved to other modes, there would be a total national economic loss of $843.3 million per year assuming volumes remain constant. Table 1 shows how this figure varies over the last 5 years of historical lockage data.

In the period 2006-2010, the reliability of the Mississippi River System decreased significantly which led to a major shift in market share away from barge to rail for the transport of many commodities, but especially the export of agriculture products such as soybeans. Unscheduled maintenance time leading to unavailable lock usage has increased by a factor of 5 from the

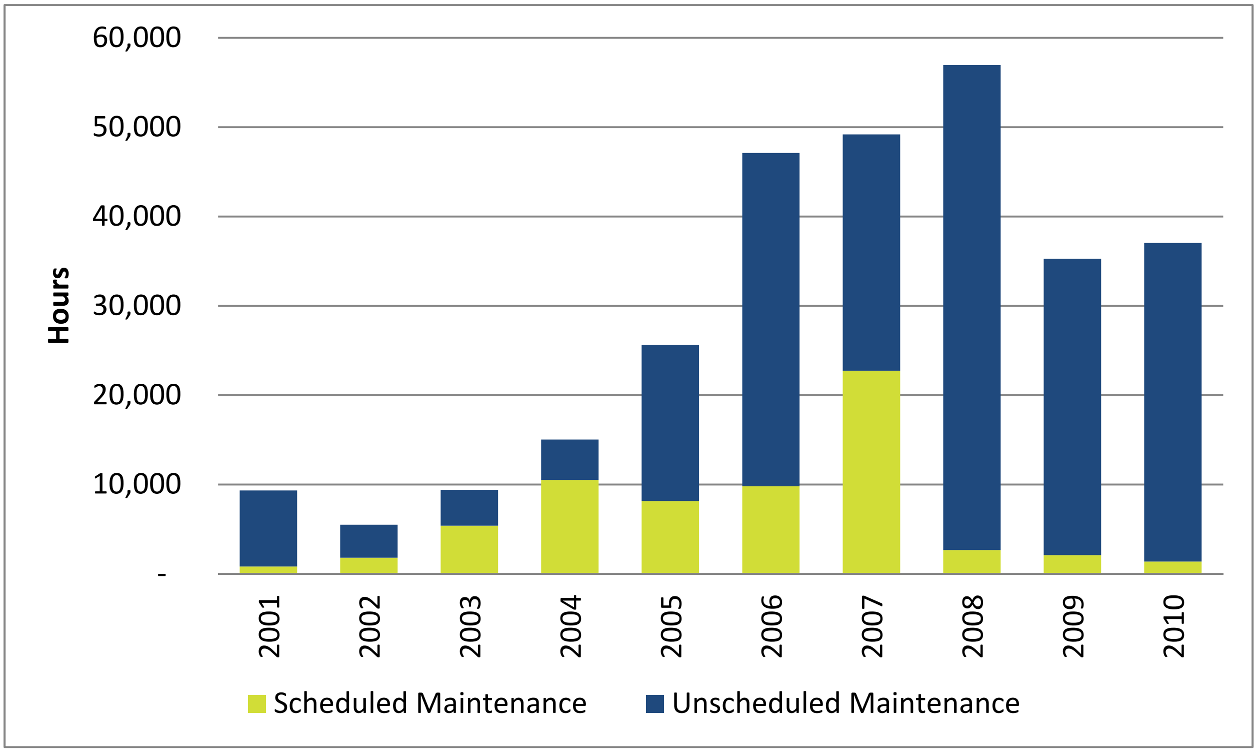
[1] U.S. Inland Waterway Modernization: A Reconnaissance Study. Prepare for the Iowa Department of Transportation. HDR Engineering, Inc. April 2013.

previous 5 year period. Scheduled and unscheduled maintenance hours for the Mississippi River Locks are shown in Figure 1.

Table 1: Historical Economic Benefits of Barge Freight Traffic Passing Through Upper Mississippi

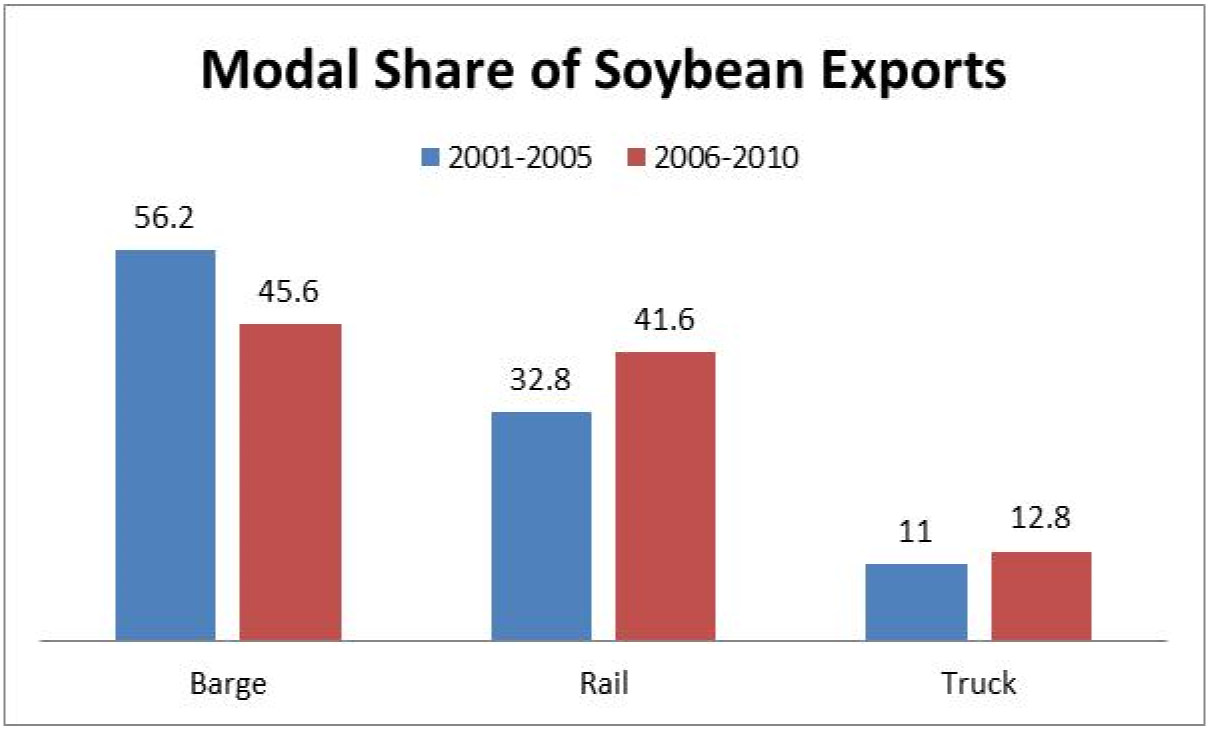
Impact Category	Annual Economic Benefits ($2013M)				
	CY2009	CY2010	CY2011	CY2012	CY2013
Economic Competitiveness	$752.7	$696.9	$669.8	$641.8	$487.8
Environmental Sustainability	$64.4	$59.7	$57.3	$54.9	$41.7
Safety	$329.7	$305.3	$293.4	$281.1	$213.6
State if Good Repair	$112.7	$104.4	$100.3	$96.1	$73.1
Quality of Life	$41.8	$38.7	$37.2	$35.7	$27.1
Total Economic Benefits	**$1,301.3**	**$1,205.0**	**$1,158.1**	**$1,109.6**	**$843.3**

Figure 1: Mississippi River Locks – Lock and Dam Maintenance Hours per Year (2001-2010)



During the 2006-2010 period, coincident with the decrease in the reliability of the Mississippi River lock and dam system, the proportion of the U.S. exports of grains/soybeans, transported by barge declined by roughly 10 percentage points from 56% to 46%. Rail transport picked up these volumes (See Figure 2). The decline in barge modal share was at least in part due to the decline in system reliability over that timeframe resulting in about a 20% drop in total barge tonnage at a time when overall crop production was increasing.

Figure 2: Modal Share of Soybean Exports by Transportation Mode



For the purposes of this quantitative analyses, and to demonstrate the significant impact that a decline on reliability has on shippers and the overall U.S. economy, we have had to make an assumption as to how much of this decline in barge modal share and resulting volumes transported through the Upper Mississippi River system is specifically attributable to reliability changes. We have assumed that half of the drop in barge modal share and total tonnage, or roughly 10%, is due to a decrease in lock system reliability. Studies by the US Army Corps of Engineers have quantitatively estimated the importance of reliability when it comes to shippers making mode choice decisions and our assumptions are reasonable within this context.

If the lock and dam system were to see improved reliability due to rehabilitation and modernization, **there would be an $81.2 million increase in transportation benefits in the first year and roughly $920.5 million in benefits over 20 years**.[2] We recognize that all estimates of economic benefits associated with improved reliability are subject to uncertainty. As such, our economic analysis contains sensitivity analysis to accommodate any precision related concerns. Regardless, we find that the economic benefits of an improved system on the Upper Mississippi River system are substantial with estimates in the range of hundreds of millions of dollars, even when quite conservative assumptions are employed.

[2] All cost estimates in this section are in millions of dollars of 2013, discounted to 2014 using a 7% real discount rate.

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Planning Grant Application for the U.S. Inland Waterway System Upper Mississippi River Navigation System Planning Study.

After this brief introduction, the appendix is structured as follows: Section 3, Methodological Framework, introduces the conceptual framework used in the Benefits Analysis. Section 4, Project Overview, provides an overview of the project, including a brief description of existing conditions and proposed planning activities; and a description of the types of effects that the Upper Mississippi River System is expected to generate. Section 5, General Assumptions, discusses the general assumptions used in the estimation of project benefits, while estimates of cargo demand and bare traffic growth can be found in Section 6, Demand Projections. Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in Section 7, Benefits Measurement, Data and Assumptions, along with associated benefit estimates. Estimates of the project's Present Value (PV) and other project evaluation metrics are introduced in Section 8, Summary of Findings. Sensitivity analysis is provided in Section 9.

3. Methodological Framework

Benefits, as presented in this appendix, are broadly defined. They represent the extent to which people are impacted by potential improvements to the UMRS are made better-off, as measured by their own willingness-to-pay. In other words, central to the benefits calculation is the idea that people are best able to judge what is "good" for them, what improves their well-being or welfare.

This is a forward-looking exercise, seeking to anticipate the welfare impacts of the proposal over its entire life-cycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

The specific methodology developed for this application was developed using the above principles and is consistent with the TIGER guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the enhanced reliability scenario;
- Assessing benefits with respect to each of the five long-term outcomes identified in the Notice of Funding Availability (NOFA);
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects; and,
- Discounting future benefits and costs with the real discount rates recommended by the DOT (7% and 3% for sensitivity analysis).

4. Project Overview

The Mississippi River system is of vital importance to the economy of the United States as it enables efficient movement of goods and services. The Upper Mississippi River system is especially important as a facilitator of exports of grains to markets around the world. With the soon to be completed expansion of the Panama Canal, the Upper Mississippi River lock and dam system is a critical piece of transportation infrastructure that can facilitate significant increases in the exports of grains from the U.S. Midwest to meet the high demand of Asia Pacific markets. This increase in exports can provide a significant impetus to overall U.S. economic growth for decades to come. Unfortunately, this growth potential is at risk due to actual and perceived declines in the reliability of this transportation system.

Over the course of the last century, a network of federally owned locks and dams constructed and operated by the U.S. Army Corps of Engineers (USACE) have facilitated commerce along the river. Many of these facilities have reached or even far exceeded their designed life cycle and rehabilitation and modernization is becoming critical to keep the waterways commercially viable.

For the purposes of this economic analysis, the effects of a more reliable Upper Mississippi River lock and dam system are explicitly quantified. Therefore, the effects of the "Project" are manifested through an improvement in system performance relative to a Base Case without the "Project". The improved reliability results in more cargo being transported by barge transportation relative to the competitive alternatives of truck and rail.

4.1 Proposed Planning Activities

Iowa DOT is requesting TIGER Planning Grant funds in support of a proposed planning study for further exploration of opportunities to enhance the Upper Mississippi River lock and dam operational efficiency, reliability, and utilization. This five-state planning study would involve the following elements:

- Assessment of the current state of river navigation on the Upper Mississippi River
  - Inventory assessment of public and private ports, terminals, locks and dams, and intermodal facilities along the M-35 marine highway corridor
  - Lock and dam infrastructure condition and operations assessment
  - Operational efficiency of the lock and dam system
  - Impact analysis for extended failure/shutdown of each lock and dam along M-35 for identification of potential impacts to other state's highway and railway modal networks
- Evaluation of activities that could be undertaken to increase the efficiency and reliability of the Upper Mississippi River lock and dam system
  - Technological (e.g. optimization of real-time barge location data with lock and dam system operations)
  - Infrastructure (e.g. guidewall improvements)
  - Operations (e.g. utilization of strategically placed helper boats)
  - Governmental partnerships
- Evaluation of opportunities for the Upper Midwest states to increase utilization of the Upper Mississippi River

- Benefits of M-35 designation
- Commodity flow analysis of future demands, needs, and opportunities
  - Industry/user survey and interviews
  - Commodity type (agriculture, energy, aggregate, manufactured goods)
  - Product type (bulk, liquid, oversized, container-on-barge, etc.)
  - Panama Canal expansion
- Port development opportunities
  - Multimodal facility options including the Burlington, Iowa option as outlined in the Vickerman Report appended to the Iowa DOT feasibility study, available at www.iowadot.gov/TIGER14-river<http://www.iowadot.gov/TIGER14-river
- Public-private partnerships
- Regional marketing/communication initiatives

- Recommendation of activities for enhancement of efficiency, reliability, and utilization of the Upper Mississippi River M-35 corridor
  - Planning/Policy (i.e. means for incorporating maritime opportunities into State Freight Strategic Plans)
  - Operations
  - Infrastructure
  - Public and private stakeholder outreach
  - Intergovernmental and public-private partnerships

4.2 Effects on Long-Term Outcomes[3]

The main benefit categories associated with an improved Upper Mississippi River lock and dam system are mapped into the five long-term outcome criteria set forth by the DOT in Table 2.

Table 2: Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Monetized	Quantified	Qualitative
State of Good Repair	Operation and Maintenance Savings	Maintaining and/or diverting cargo to barge will reduce the overall O&M costs on U.S. highways.	√		
Economic Competitiveness	Shipper Cost Savings	Maintaining and/or diverting cargo to barge will reduce the overall cost to ship goods and benefit the U.S. economy.	√		
Quality of Life	Traffic Congestion Reduction	Maintaining and/or diverting cargo to barge from truck will reduce overall traffic congestion levels on U.S. highways.	√		
Environmental Sustainability	Emission Reduction	Maintaining and/or diverting cargo to barge will reduce transportation emission levels.	√		

[3] All cost estimates in this section are in millions of dollars of 2013, discounted to 2014 using a 7% real discount rate.

Long-Term Outcomes	Benefit or Impact Categories	Description	Monetized	Quantified	Qualitative
Safety	Accident Exposure Reduction	Maintaining and/or diverting cargo to barge will reduce the accident exposure risk leading to safer transportation of goods.	√		

5. General Assumptions

The monetized benefits are estimated in 2013 Dollars with future dollars discounted in compliance with TIGER requirements using a 7% real rate, and sensitivity testing at 3%. The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2014 dollars;
- The period of analysis begins in 2014 and ends in 2033. It includes 20 years of lock and dam operations (2014-2033);
- A constant 7% real discount rate is assumed throughout the period of analysis. A 3% real discount rate is used for sensitivity analysis; and,
- First year demand is an input to the analysis and is assumed to be equal to 2013 volumes, with growth in volumes equal to 2% over the period of analysis.

6. Demand Projections

6.1 Methodology

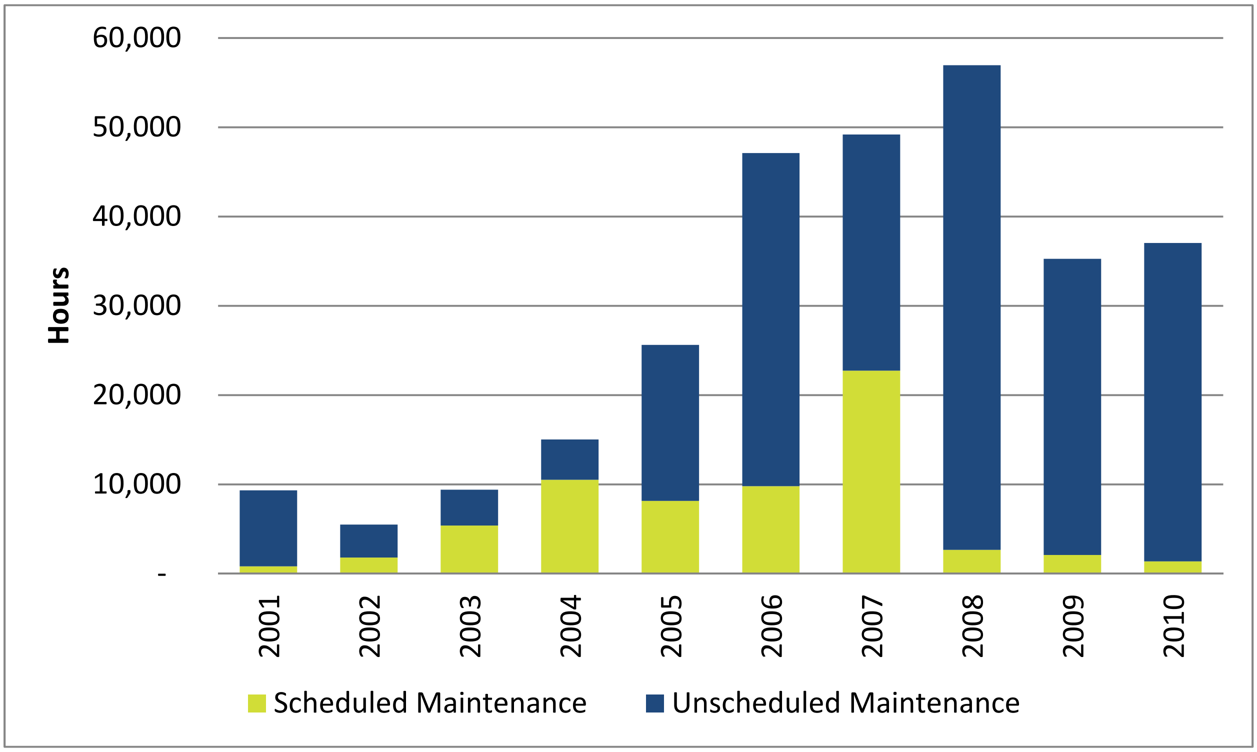
Demand projections are based on data retrieved from the USACE Navigation Data Center (NDC) which provides lock and dam tonnage data. The lock data provides a monthly summary and year-to-date totals of commodity tonnages and barge traffic for locks on the inland waterways, including the Upper Mississippi. Tonnage data for Lock 19 on the Upper Mississippi was used as a representative lock to gauge total tonnage volume passing through the Iowa lock and dam system.[4]

6.2 Assumptions

In the period 2006-2010, the reliability of the Mississippi River System decreased significantly which led to a major shift in market share away from barge to rail for the transport of many commodities, but especially the export of agriculture products such as soybeans. Unscheduled maintenance time leading to unavailable lock usage has increased by a factor of 5 from the previous 5 year period. Scheduled and unscheduled maintenance hours for the Mississippi River Locks are shown in Figure 3.

[4] USACE NDC Lock Use, Performance, and Characteristics may be accessed here: http://www.navigationdatacenter.us/lpms/lpms.htm

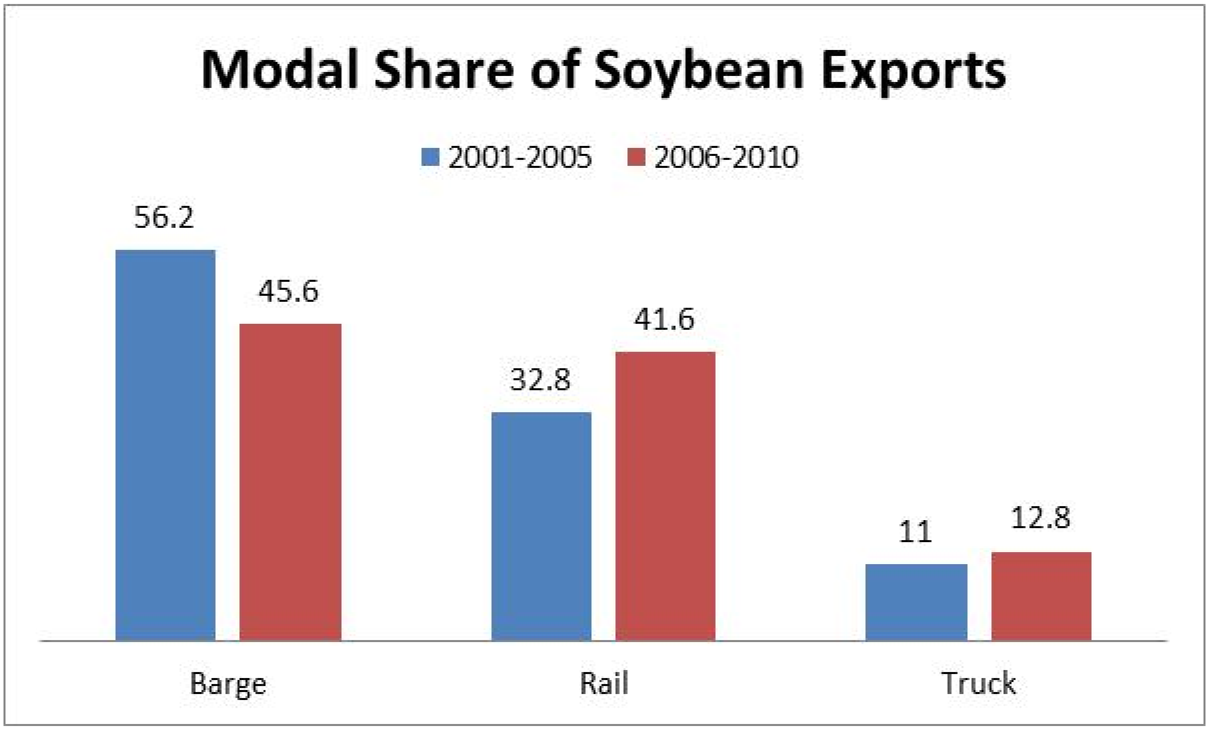
Figure 3: Mississippi River Locks – Lock and Dam Maintenance Hours per Year (2001-2010)



Using the latest available USACE NDC data, lock tonnage volume projections were developed using an annual growth rate and transportation to estimate future year volumes and modal switch respectively. The key assumption with respect to demand levels is the change in modal share associated with the "Project" versus without the "Project". With the Project, we have a more reliable lock and dam system on the Upper Mississippi River system which translates into more cargo being shipped by barge relative to rail (or truck).

Most of the cargo being moved on the Upper Mississippi River system (through Lock 19) is grains/soybeans produced in the U.S. Midwest shipped for export through Louisiana ports. During the 2006-2010 period, coincident with a significant decrease in the reliability of the Mississippi River lock and dam system, the proportion of the U.S. exports of grains/soybeans, transported by barge declined by roughly 10 percentage points from 56% to 46%. Rail transport picked up these volumes. The decline in barge modal share was at least in part due to the decline in system reliability over that timeframe resulting in about a 20% drop in total barge tonnage at a time when overall crop production was increasing.

Figure 4: Modal Share of Soybean Exports by Transportation Mode



For the purposes of this quantitative analyses, and to demonstrate the significant impact that a decline on reliability has on shippers and the overall U.S. economy, we have had to make an assumption as to how much of this decline in barge modal share and resulting volumes transported through the Upper Mississippi River system is specifically attributable to reliability changes. We have assumed that half of the drop in barge modal share and total tonnage, or roughly 10%, is due to a decrease in lock system reliability. Studies by the US Army Corps of Engineers have quantitatively estimated the importance of reliability when it comes to shippers making mode choice decisions and our assumptions are reasonable within this context.[5]

Therefore, we have assumed that this Project will result in improved reliability and a recovery of 50% of the lost cargo that switched modes from barge to rail in the 2006-2010 period.

Table 3: Assumptions used in the Estimation of Demand

Variable Name	Unit	Value	Source
Annual Growth in Barge Cargo Traffic on the Upper Mississippi River	%	2.0%	HDR derived based on historical production volumes from the US Department of Agriculture.
% Increase in Volumes Transported Through Lock 19 in a More Reliable System (with "Project"). *Note: This volume levels assumes 50% of Lost Modal Share Due to Reliability Issues.*	%	10.0%	HDR derived based on an examination of barge modal share declines for grain exports when the system reliability of the Upper Mississippi River was impaired in the 2006-2010 period.

[5] USACE. Transportation Demand for Grain Shipments. NETS. November 9, 2004.

6.3 Demand Projections

The resulting projections for total annual tons and modal switch based on a reliability increase are presented in Table 4. For the purposes of this analysis, it has been assumed that half of the historical drop in total tonnage, or roughly 10%, is due to a decrease in lock system reliability. As a result the demand projections shown in Table 4 reflect a 10% increase in lock system reliability due to rehabilitation and modernization.

Table 4: Demand Projections (Tons) with the Project

	2014	2023	2033
Total Annual Tons – Lock 19	15,243,697	18,217,629	22,207,188
Diversion from Rail to Barge	949,510	1,134,752	1,383,256
Diversion from Truck to Barge	517,542	618,510	753,961

7. Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table 2 (Expected Effects on Long Term Outcomes and Benefit Categories) and provides an overview of the associated methodology, assumptions, and estimates.

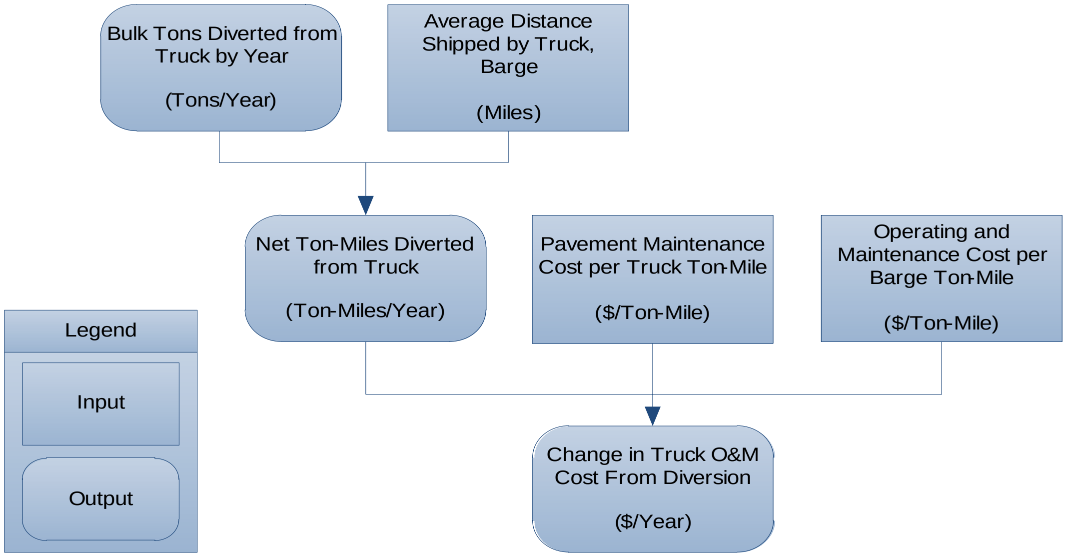
7.1 State of Good Repair

To quantify the benefits associated with maintaining the existing transportation network in a state of good repair, the reduction in potential wear and tear on U.S. highways due to modal diversion from barge to truck is estimated.

7.1.1 Methodology

A general representation of the methodology used in the calculation of reduced infrastructure costs is shown in the Structure and Logic (S&L) diagram in Figure 5.

Figure 5: Operation and Maintenance Cost Impact due to Modal Diversion



7.1.2 Assumptions

The assumptions used in the estimation of the State-of-Good-Repair benefit are summarized in Table 5.

Table 5: Assumptions used in the Estimation of State-of-Good-Repair Benefit

Variable Name	Unit	Value	Source
Maintenance Cost per Train Ton-Mile	$/Ton-Mile	N/A	HDR Calculations. Rail maintenance costs are captured in the rail rates and passed on to the shipper.
Maintenance Cost per Barge Ton-Mile	$/Ton-Mile	$0.00066	HDR Estimate.
Pavement Maintenance Cost per Truck Ton-Mile	$/Ton-Mile	$0.01637	HDR Calculations based on the Addendum to the 1997 Federal Highway Cost Allocation Study, Final Report, U.S. Department of Transportation and Federal Highway Administration, May 2000. Assumes 90 percent rural truck traffic.
Average Distance Shipped by Rail, Barge	Miles	1074	Barge Distance HDR calculated based on barge distance travelled from Davenport, IA to New Orleans, LA. Truck Distances then calculated using road distances from Davenport, IA to New Orleans, LA. Rail Distance Calculated using circuity factor of 1.1:1 rail, road. See: Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007.
Average Distance Shipped by Truck, Barge	Miles	976	
Average Distance Shipped by Barge, Barge	Miles	1269	

7.1.3 Benefit Estimates

The benefits shown in Table 6 represent the overall O&M benefit. This benefit would be realized if reliability is improved by 10% on the Upper Mississippi allowing truck shipments of commodities to switch modes to barge. This benefit is a public State-of-Good-Repair benefit as it prevents O&M costs which would otherwise be borne by taxpayers and increases the lifespan and/or time between maintenance periods on highways.

Table 6: Estimates of State-of-Good-Repair Benefits, 2013 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Operation and Maintenance Savings	$7,172,798	$170,862,870	$86,636,565

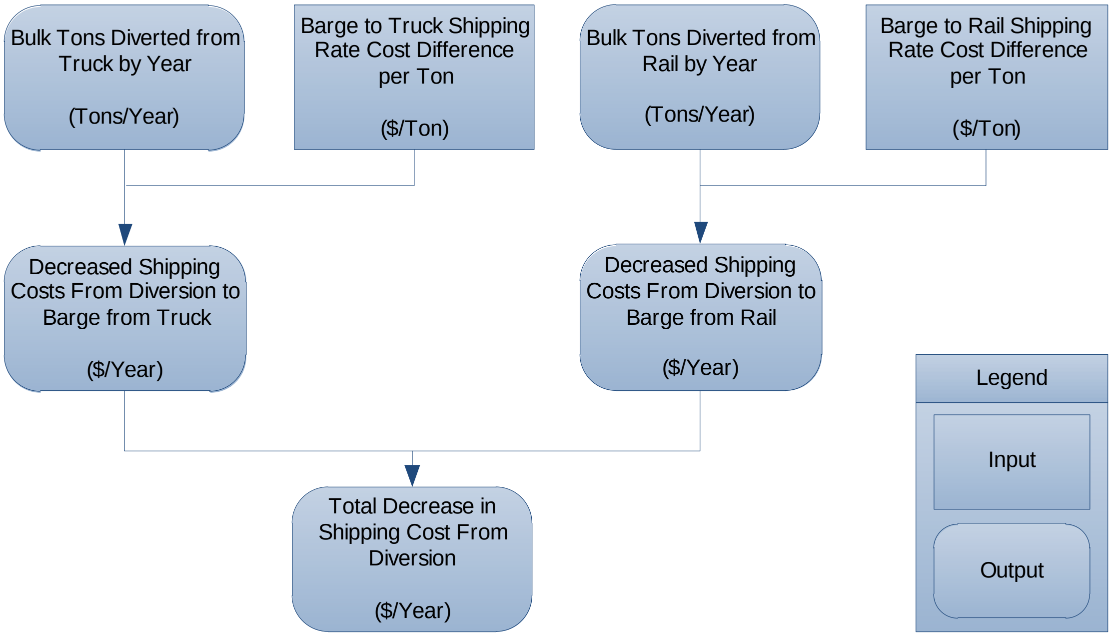
7.2 Economic Competitiveness

Any lock and dam rehabilitation and modernization resulting from the proposed planning work would contribute to enhancing the economic competitiveness of the nation through improvements in the mobility of goods within and across the study area. In this analysis, economic competitiveness is calculated as the total shipper cost savings due to the potential modal switch from truck and rail to barge due to improvements in reliability on the Upper Mississippi. The differential between rail/truck and barge rates per ton provides for significant cost savings which may be passed onto the shipper and through to the average U.S. consumer in terms of cheaper goods.

7.2.1 Methodology

A general representation of the methodology used in the calculation of reduced shipping costs is shown in Figure 6.

Figure 6: Shipper Cost Savings Impact due to Modal Diversion



7.2.2 Assumptions

The assumptions used in the estimation of travel time savings are summarized in Table 7.

Table 7: Assumptions used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Rail Shipping Rate	$/Ton-mile	$0.0406	Association of American Railroads, Class I Railroad Statistics. 2012 revenue per ton mile, inflated using the U.S. Bureau of Labor Statistics – Consumer Price Index.
Truck Shipping Rate	$/Ton-mile	$0.0696	Dial-A-truck or DAT Solutions. Average national truck freight contract rate of $1.60 per mile divided by maximum FHWA truck tonnage of 23 tons.
Barge Shipping Rate	$/Ton-mile	$0.0154	USDA Agricultural Marketing Service. Rates taken as average of the last year of Mid-Mississippi to NOLA southbound rates. Northbound rates are assumed to be the same as southbound rates.

7.2.3 Benefit Estimates

The benefits shown in Table 8 represent the overall shipper cost savings which would be realized due to improved reliability on the Upper Mississippi. This is a public benefit as reduced shipper costs may be passed on to consumers in the form of cheaper goods.

Table 8: Estimates of Shipper Cost Savings, 2013 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Shipper Cost Savings	$46,994,025	$938,880,506	$497,325,673

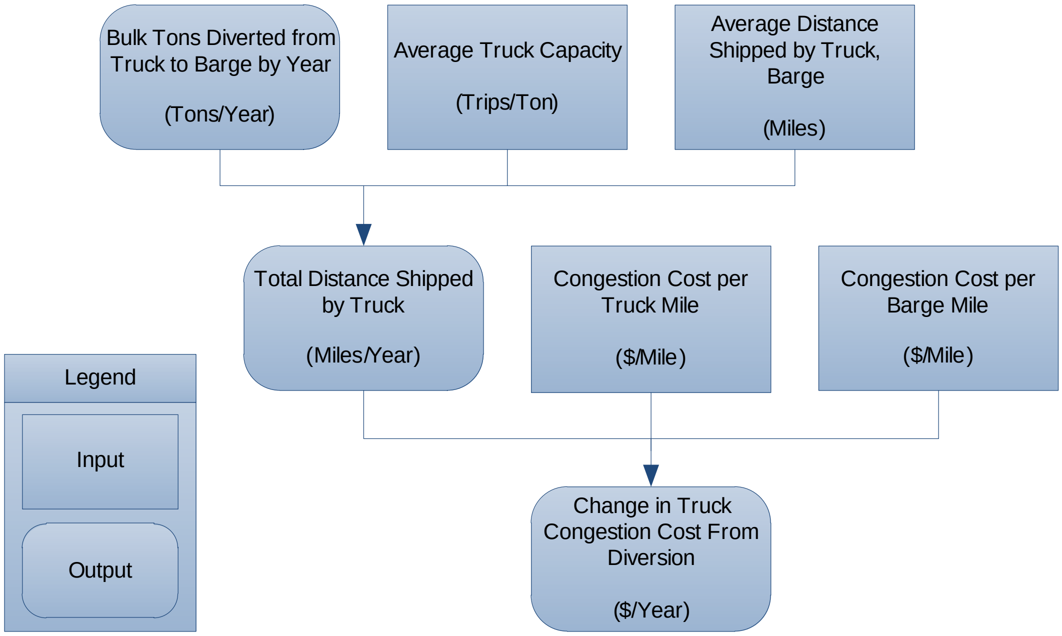
7.3 Quality of Life

The proposed project would contribute to enhancing quality of life in the study area through reduced traffic congestion on U.S. highways. Congestion would be reduced due to a modal switch in heavy truck traffic resulting from improved reliability on the Upper Mississippi inland waterways.

7.3.1 Methodology

A general representation of the methodology used in the calculation of reduced heavy truck traffic congestion costs is shown in the S&L diagram in Figure 7.

Figure 7: Congestion Cost Savings Impact due to Modal Diversion



7.3.2 Assumptions

The assumptions used in the estimation of quality of life benefits are summarized in Table 9.

Table 9: Assumptions used in the Estimation of Quality of Life Benefits

Variable Name	Unit	Value	Source
Capacity - Highway Truck Trailer	Tons	23	FHWA maximum weight of interstate trucks.
Capacity - Rail Bulk Car	Tons	110	Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007. Amended 2010. (All congestion Numbers).
Capacity - Barge - Dry Bulk	Tons	1,546	
Capacity - Highway Truck Trailer	Tons	23	One tractor with a 53 ft trailer. Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007.
Capacity - Unit Train	Tons	11,880	108 cars, 3 locomotives. Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007.
Capacity - Tow (Dry Cargo)	Tons	26,250	15-barge tow (5x3). Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007.
Congestion Cost per Truck Mile	$/Mile	$0.1188	HDR Calculations based on the Addendum to the 1997 Federal

Variable Name	Unit	Value	Source
			Highway Cost Allocation Study, Final Report, U.S. Department of Transportation and Federal Highway Administration, May 2000. Quoted in: National Highway Traffic Safety Administration, "Corporate Average Fuel Economy for FY 2011 Passenger Cars and Light Trucks", March 2009, Table VIII-5, page VIII-60

7.3.3 Benefit Estimates

The benefits shown in Table 10 represent the Quality of Life benefits which would be realized due to a reduction in traffic congestion on U.S. highways. Modal switch from heavy truck to barge would displace a considerable amount of trucks from the highways and reduce overall traffic congestion levels, especially in urban areas.

Table 10: Estimates of Quality of Life Benefits, 2013 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Traffic Congestion Reduction	$2,608,583	$63,381,697	$32,137,892

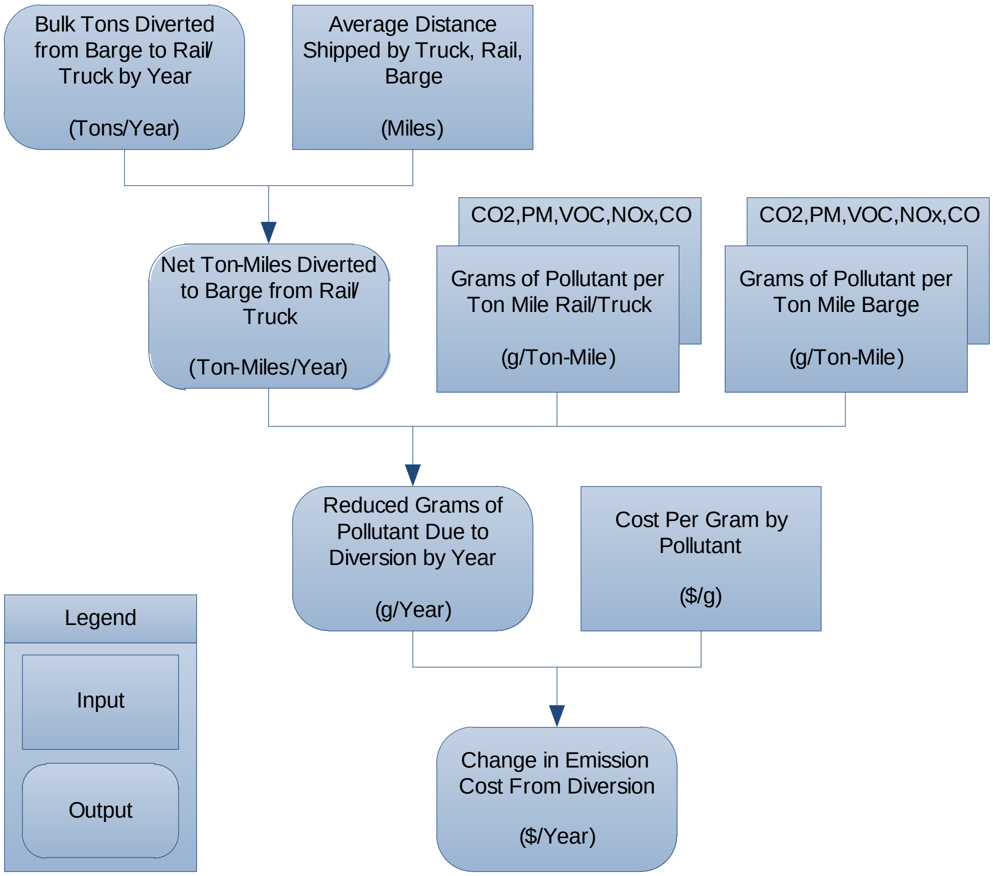
7.4 Environmental Sustainability

The proposed project would contribute to environmental sustainability through a reduction in emission levels due to modal switch from truck and rail to barge. On a per ton-mile basis, barge has the lowest emission factors in terms of nitrous oxide (NOx), carbon dioxide (CO2), particulate matter (PM10), carbon monoxide (CO), hydrocarbon (HC), and volatile organic compound (VOC) emissions.

7.4.1 Methodology

A general representation of the methodology used in the calculation of reduced truck and rail emission costs is shown in Figure 8.

Figure 8: Emission Cost Savings Impact due to Modal Diversion



7.4.2 Assumptions

The assumptions used in the estimation of sustainability benefits are summarized in Table 11.

Table 11: Assumptions used in the Estimation of Environmental Sustainability Benefits

Variable Name	Unit	Value	Source
Grams of NOx per Ton Mile Rail	g/Ton-Mile	0.653	TTI Study focuses on five pollutants that are tracked by the EPA: hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NOx), particulate matter (PM10), and carbon dioxide (CO2). Texas Transportation Institute. A Modal Comparison of Domestic Freight Transportation Effects on the General Public. December 2007. Amended 2010.
Grams of CO2 per Ton Mile Rail	g/Ton-Mile	24.390	
Grams of PM10 per Ton Mile Rail	g/Ton-Mile	0.016	
Grams of CO per Ton Mile Rail	g/Ton-Mile	0.064	
Grams of HC per Ton Mile Rail	g/Ton-Mile	0.024	
Grams of VOC per Ton Mile Rail	g/Ton-Mile	0.025	
Grams of NOx per Ton Mile Barge	g/Ton-Mile	0.469	
Grams of CO2 per Ton Mile Barge	g/Ton-Mile	17.480	
Grams of PM10 per Ton Mile Barge	g/Ton-Mile	0.012	

Variable Name	Unit	Value	Source
Grams of CO per Ton Mile Barge	g/Ton-Mile	0.046	
Grams of HC per Ton Mile Barge	g/Ton-Mile	0.017	
Grams of VOC per Ton Mile Barge	g/Ton-Mile	0.018	
Grams of NOx per Ton Mile Truck	g/Ton-Mile	0.732	
Grams of CO2 per Ton Mile Truck	g/Ton-Mile	64.960	
Grams of PM10 per Ton Mile Truck	g/Ton-Mile	0.018	
Grams of CO per Ton Mile Truck	g/Ton-Mile	0.136	
Grams of HC per Ton Mile Truck	g/Ton-Mile	0.020	
Grams of VOC per Ton Mile Truck	g/Ton-Mile	0.021	
Cost per Ton of PM	$/Ton	$360,946	TIGER VI guidelines. Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (February 2010), page 39, Table A-1 "Annual SCC Values 2010-2050 (in 2007 dollars)"
Cost per Ton of VOC	$/Ton	$2,002	
Cost per Ton of NOx	$/Ton	$7,890	
Cost per Ton of CO	$/Ton	$0	

7.4.3 Benefit Estimates

The benefits shown in Table 12 represent the Environmental Sustainability benefits which would be realized due to a reduction in air pollutants caused from truck and rail emissions.

Table 12: Estimates of Environmental Sustainability Benefits, of 2013 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Environmental Sustainability	$4,017,976	$101,632,153	$51,061,228

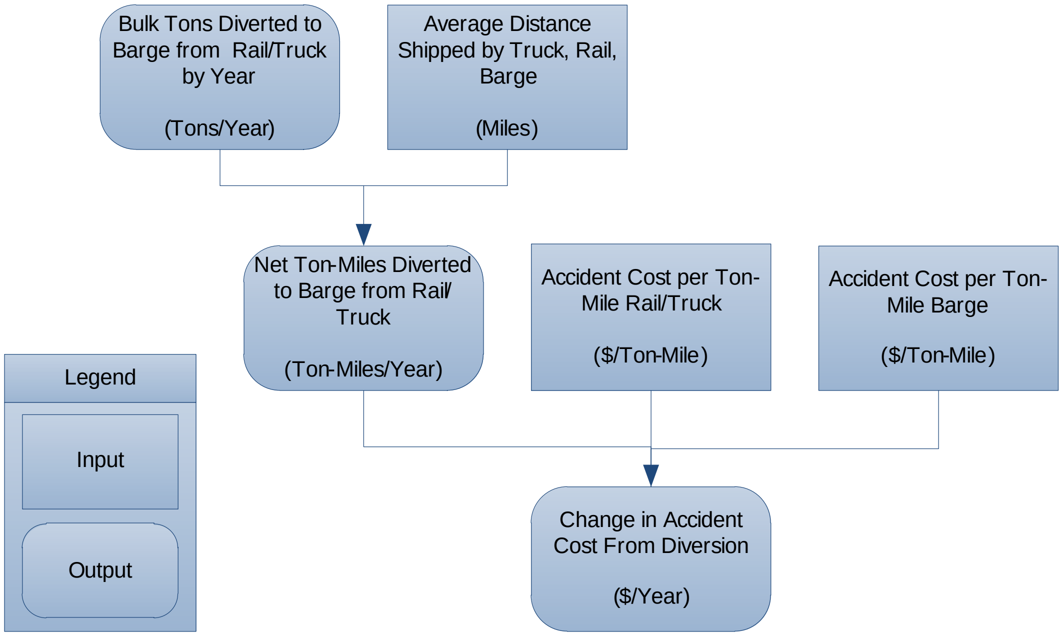
7.5 Safety

The proposed project would contribute to promoting DOT's safety long-term outcome through a reduction in accident risk due to displacing cargoes from heavy trucks and rail to barge on inland waterways. Accident risk is evaluated at an individual level based on the average fatalities and injuries per ton-mile by mode.

7.5.1 Methodology

A general representation of the methodology used in the calculation of reduced accident exposure risk is shown in Figure 9.

Figure 9: Accident Cost Savings Impact due to Modal Diversion



7.5.2 Assumptions

The assumptions used in the estimation of safety benefits are summarized in Table 13.

Table 13: Assumptions used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Accident Cost per Ton-Mile Truck	$/Ton-Mile	$0.03272	HDR Calculated.
Accident Cost per Ton-Mile Rail	$/Ton-Mile	$0.00414	HDR Calculated.
Accident Cost per Ton-Mile Barge	$/Ton-Mile	$0.00010	HDR Calculated.
Fatalities - Truck	Fatalities per Billion Ton-Miles	2.54	Government Accountability Office. A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers. January 2011.
Fatalities - Rail	Fatalities per Billion Ton-Miles	0.39	
Fatalities - Barge	Fatalities per Billion Ton-Miles	0.01	
Injuries - Truck	Injuries per Billion Ton-Miles	56.05	
Injuries - Rail	Injuries per Billion Ton-Miles	3.32	
Injuries - Barge	Injuries per Billion Ton-Miles	0.05	
Cost of a Fatality	$	$9,200,000	U.S. Department of Transportation, Treatment of the Economic Value of a Statistical Life in Department Analyses.
Cost of a Injury - Serious Injury	$	$166,778	

7.5.3 Benefit Estimates

The benefits shown in Table 14 represent the Safety benefits which would be realized due to a reduction in accident risk as a result of modal switch from truck and rail to barge.

Table 14: Estimates of Safety Benefits, 2013 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Accident Exposure Reduction	$20,560,743	$499,571,966	$253,309,564

8. Summary of Findings

Table 15 summarizes the analysis findings. Annual benefits are computed over the lifecycle of the study period (20 years) and are shown in Present Value (PV). Benefits accrue during the full study period.

Table 15: Benefits by Long-Term Outcome for 10% Improved Reliability, Millions of 2013 Dollars

Long-Term Outcomes	Benefit Categories	7% Discount Rate (Present Value)	3% Discount Rate (Present Value)
State of Good Repair	Operation and Maintenance Savings	$86.6	$124.7
Economic Competitiveness	Shipper Cost Savings	$$497.3	$698.4
Quality of Life	Traffic Congestion Reduction	$32.1	$46.2
Environmental Sustainability	Emission Reduction	$51.1	$73.8
Safety	Accident Exposure Reduction	$253.3	$364.5
Total Benefit Estimates		**$920.4**	**$1,307.6**

9. Sensitivity Analysis

The outcomes presented in the previous sections rely on a large number of assumptions and long-term projections; both of which are subject to considerable uncertainty. The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the outcomes: the “critical variables.”

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the “preferred” or most likely value for the variable; and
- Assess the robustness of the analysis and evaluate, in particular, whether the conclusions reached under the “preferred” set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis are presented using a 7% discount rate and are summarized in Table 16. The table provides the percentage changes in project PV associated with variations in variables or parameters (listed in row), as indicated in the column headers.

The key finding here is that even if we decrease significantly the demand assumptions regarding the shift in modal share due an improved Upper Mississippi River system, the level of economic benefits is still very significant – we are still seeing impacts of hundreds of millions of dollars.

Table 16: Quantitative Assessment of Sensitivity, Millions of 2013 Dollars

<table>
<tr><th>Parameters</th><th>Change in Parameter Value</th><th>New PV</th><th>Change in PV</th></tr>
<tr><td rowspan="4">Increase in Cargo Volumes</td><td>2.0% Increase in Volumes Transported Through Lock 19 in a More Reliable System (with “Project”).
Note: This volume levels assumes 10% of Lost Modal Share Due to Reliability Issues</td><td>$184.1</td><td>-20.0%</td></tr>
<tr><td>5.0% Increase in Volumes Transported Through Lock 19 in a More Reliable System (with “Project”).
Note: This volume levels assumes 25% of Lost Modal Share Due to Reliability Issues</td><td>$460.2</td><td>-50.0%</td></tr>
<tr><td>15.0% Increase in Volumes Transported Through Lock 19 in a More Reliable System (with “Project”).
Note: This volume levels assumes 75% of Lost Modal Share Due to Reliability Issues</td><td>$1,380.7</td><td>+50.0%</td></tr>
<tr><td>18.0% Increase in Volumes Transported Through Lock 19 in a More Reliable System (with “Project”).
Note: This volume levels assumes 90% of Lost Modal Share Due to Reliability Issues</td><td>$1.656.8</td><td>+80.0%</td></tr>
<tr><td rowspan="2">Cargo Growth Rate</td><td>0% Cargo Growth Rate</td><td>$853.9</td><td>-7.2%</td></tr>
<tr><td>4% Cargo Growth Rate</td><td>$1,003.8</td><td>9.1%</td></tr>
</table>