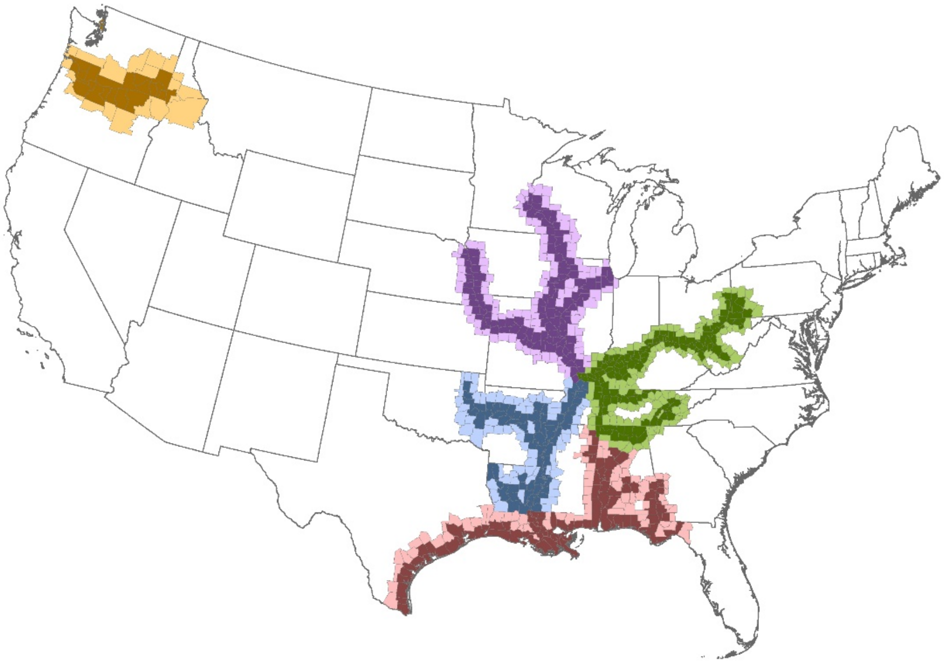

INLAND NAVIGATION IN THE UNITED STATES

An Evaluation of Economic Impacts and the Potential Effects of Infrastructure Investment

Prepared by the
University of Kentucky
and the
University of Tennessee
November 2014

Sponsored by:

NATIONAL WATERWAYS
FOUNDATION

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Preface and a Note to Readers

The volume that follows describes an effort that has spanned more than two years during which time we have worked to provide a conservative evaluation of commercial navigation's system-wide economic impact, both as this system is currently configured, and as it might be through a course of renewed infrastructure investment. Beginning with a basic analytical framework that is anchored in navigation's role as a productive input in various industrial processes, and extending through the myriad technical choices necessary to implement that framework, the research team has attempted to reflect actual, real-world economic interactions.

By simple luck, this study's timing is fortuitous. The United States stands at the brink of a watershed era where transportation planning tools will be of increased importance. As a direct result of large and unforeseen increases in available and affordable domestic energy resources, there is a growing sense that the U.S. economy can look forward to increasing productivity and attendant prosperity. However, realizing this opportunity requires the nation's transportation sector to quickly adapt to energy-related changes in freight volumes and flows. While not yet quantifiable, changed system demands that reflect future energy production and flows are discussed at various places within the current study where appropriate.

The study authorship includes the names of the three principal investigators who are responsible for the current study's design, its execution, and for the reported empirical results and who are exclusively accountable for any errors or omissions. However, the study team actually included a much wider circle of experts, without whom the work reported here would have been impossible. Chief among these are Mike Murphree and Chris Dager from the University of Tennessee, Ben Blandford, Len O'Connell, and Tim Brock from the University of Kentucky, and Chris Brown from REMI, Inc. The study's execution was also helped immeasurably by personnel from by the U.S. Army Corps of Engineers' Huntington District. Finally, all work was painstakingly reviewed by Dr. Jake Haulk of the Allegheny Institute, who provided informal comments at every juncture, and by Dr. David Vogt (retired, Oak Ridge National Laboratories) who was retained by the project sponsors to provide an independent external review.

Ted Grossardt
Larry Bray
Mark Burton

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ONE

Summary of Methods and Findings

1.1 INTRODUCTION

Inland navigation has traditionally played a vital role in what is a uniquely American transportation landscape. Navigation's history is long and storied. Nonetheless, the waterways' *future* function as a freight resource is still unclear. Demands for surface freight transportation capacity seem to be changing in ways that point to an increased role for waterborne commerce. But the continued reliability and consequent economic value of inland navigation depends on a new generation of supporting infrastructure. These investments will require fiscal resources to be marshaled and combined into a national policy that capitalizes on the comparative efficiencies of all freight transport modes.

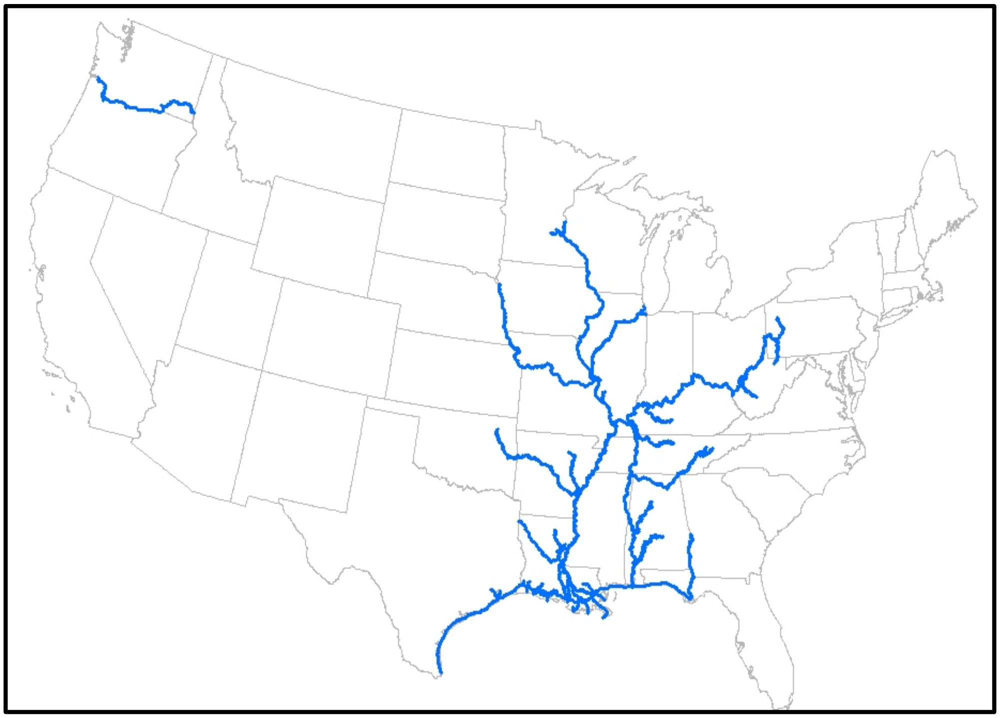
Evaluating the desirability of a forward-looking federal policy that supports inland navigation requires information that has, heretofore, been incomplete: *reliable* information describing the current value of inland freight transportation as well as information describing the likely economic impacts of renewed investment in navigation infrastructure. The goal of this current research is to partially address this information shortfall.

Our work contains two elements. We first evaluate the total economic importance of commercial inland navigation to the country in navigation's present form and assume only sufficient investment to maintain current system performance. This is followed by a scenario that considers the economy-wide impacts of proposed *improvements* to navigation system capacity and performance under traffic demands that are similar to current freight flows. Ideally, a third element would be added. Truly understanding the value of revitalized inland navigation requires clear predictions of the demands that coming generations will place on freight transport. At present, we see enough of this future to suspect these demands will be different than today and that they will add further value to available navigation, but the data needed to validate this (*or any*) view of the future are not available.

1.2 THE CURRENT SETTING

Section 2 provides a detailed description of the nation's inland navigation system. To briefly summarize, this system is comprised of over 12,000 miles of navigable waterways that touch 38 states. In 2012, this system accommodated 565 million tons of freight valued at $214 billion. The geography of the inland navigation network is depicted in Figure 1.1.

Figure 1.1 – The Inland Navigation System



Two basic facts about inland navigation drive this analysis: (1) More than one-half billion tons of freight move an average of 450 miles each year by barge, and (2) There are no better ways to move, store, and otherwise manage this freight. If there were, shippers would choose them. This simple reality forms the basis for the work that follows.

In spite of a notable increase in recent waterway traffic, the waterways share of total U.S. commercial traffic has not kept up with the growth in total freight volumes, particularly the growth in rail traffic. However, this outcome is partially the result of changed railroad traffic and not a reflection of any reduction in navigation efficiency. In 1980, U.S. Class I railroads were largely deregulated, with effects that were wide-ranging.[1] In less than two decades inflation-adjusted rail rates fell roughly 30%. Railroads recaptured a measurable share of traffic previously lost to truck, and railroad shipments became larger, often involving longer shipment distances.[2] During the same period the railroad movement of ocean-going merchandise containers grew at a rate that averaged well above 10% per year. Thus, any

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[1] There are a variety of published works that carefully describe the impacts of railroad deregulation on various aspects of industry performance. For example see, Clifford Winston, "The Success of the Staggers Rail Act of 1980," Brookings Institution, 2005; Russell Pittman, "The Economics of Railroad 'Captive Shipper' Legislation," U.S. Department of Justice, Economics Analysis Group, 2010; or Christensen Associates, *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition*, prepared for the Surface Transportation Board, November 2008.

[2] Demand theory suggests that lower prices yield greater consumption of the good. In the world of freight transportation, this "good" can be larger shipments, longer shipments, or both.

reduction of navigation's overall share of freight traffic actually reflects relatively stable barge traffic volumes compared to rapidly growing railroad ton-miles.[3]

The comparative resurgence in railroad freight volumes has led some to speculate that inland navigation is no longer relevant. This idea raises three interlinked questions– (1) Can (or could) Class I railroads serve existing inland waterway customers as efficiently as barge carriers; (2) If not, does the efficiency advantage of navigation justify public investment to continue and improve navigation capacity; and (3) Does existing freight traffic, as we currently observe it, adequately reflect future freight transport needs? These topics are revisited often throughout this study.

Later sections of the analysis describe how investment intended to modernize the navigation system could increase the economic benefits attributable to inland navigation. First, however, the analysis captures the impacts of the system as it is currently configured, with current levels of performance and existing demands.

1.3 VALUING THE EXISTING SYSTEM: SUMMARY OF METHODOLOGY AND DATA

Somewhat ironically, it is a system *abandonment* scenario that provides the basis for evaluating the economic impacts of the inland navigation system. Specifically, we compare the transportation and related supply-chain costs faced by current waterway users to the costs they would face if the system was to become permanently unavailable and they were forced to consider the "next best" transportation alternative.[4] As discussed in Section 3.2, this approach differs markedly from studies that assume all waterway-linked production would simply disappear in the absence of inland navigation.

The data required to reflect this potential scenario were obtained and prepared in a process depicted in Figure 1.2. Base data were obtained from a series of transportation rate studies performed for the U.S. Army Corps of Engineers. This work was done between 2002 and 2012 and includes transportation activity on nearly every segment of the inland waterway system. The movement-specific rate information was developed by analysts at the Tennessee Valley Authority or the University of Tennessee Center for Transportation Research.

Fully assembled, the data include information on more than 11,000 individual barge movements. This information details both currently observed charges and transport-related charges for the alternatives. All monetary values were converted to 2012 dollars and the

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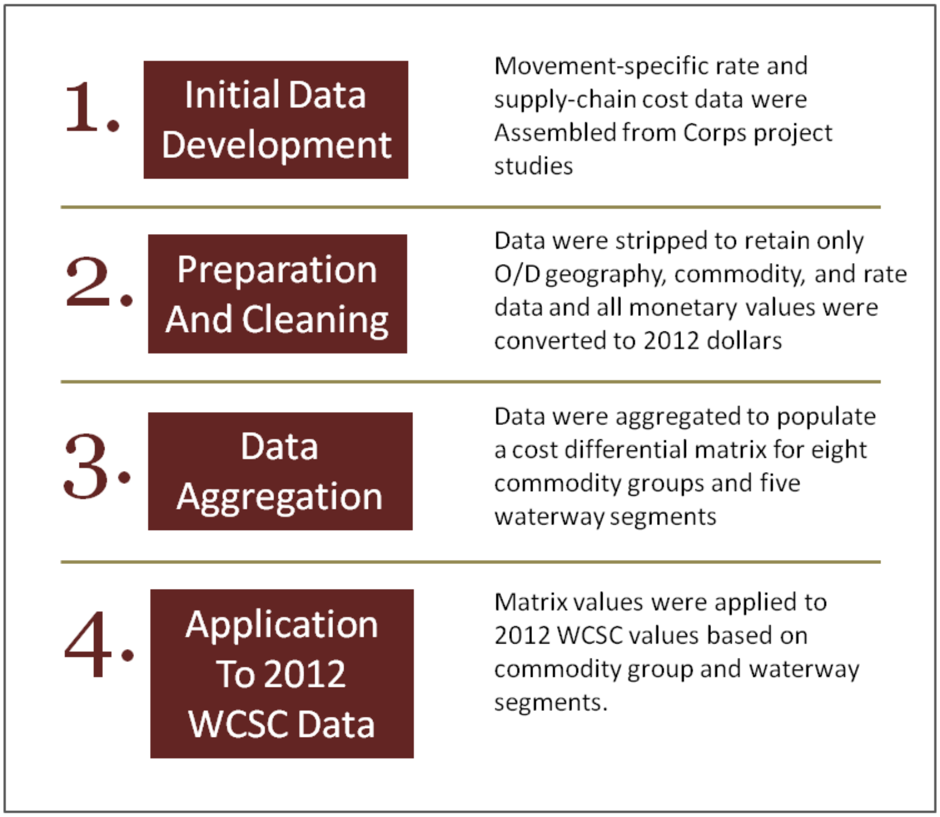
[3] During the 1980-2009 period corresponding railroad ton-miles increased by nearly 70%.

[4] In some cases, the lack of suitable alternative transportation facilities led to the assumption that the shippers would cease operations. In other instances, the higher alternative shipping costs would reduce shippers' competitive ability, causing either a reduction in output or shut down. In the latter cases, the ultimate shipper response is derived by the economic simulation software.

data were used to impute values for the small number of waterway segment/commodity combinations where observed data was unavailable. The processed data were then aggregated into a matrix that represents supply chain cost

Figure 1.2 – Data Development and Preparation



Movement-specific rate and supply-chain cost data were Assembled from Corps project studies

Data were stripped to retain only O/D geography, commodity, and rate data and all monetary values were converted to 2012 dollars

Data were aggregated to populate a cost differential matrix for eight commodity groups and five waterway segments

Matrix values were applied to 2012 WCSC values based on commodity group and waterway segments.

differentials across eight commodity groups and five waterway segments. These data are further described in Section 4.2. The final data preparation step involved applying the cost differentials to the 2012 inland navigation data obtained through the Waterborne Commerce Statistics Center (WCSC).

As noted, the inland system was divided into five analysis segments. Each waterway segment was bordered on both sides by a buffer two counties deep to approximate navigation's reach.[5] These bounded segments then formed the simulation regions, with all areas outside the bounded areas forming a final region referred to as "Rest of U.S." The resulting study regions are shown in Figure 1.3. A further discussion of regional definitions is found in Section 4.1.

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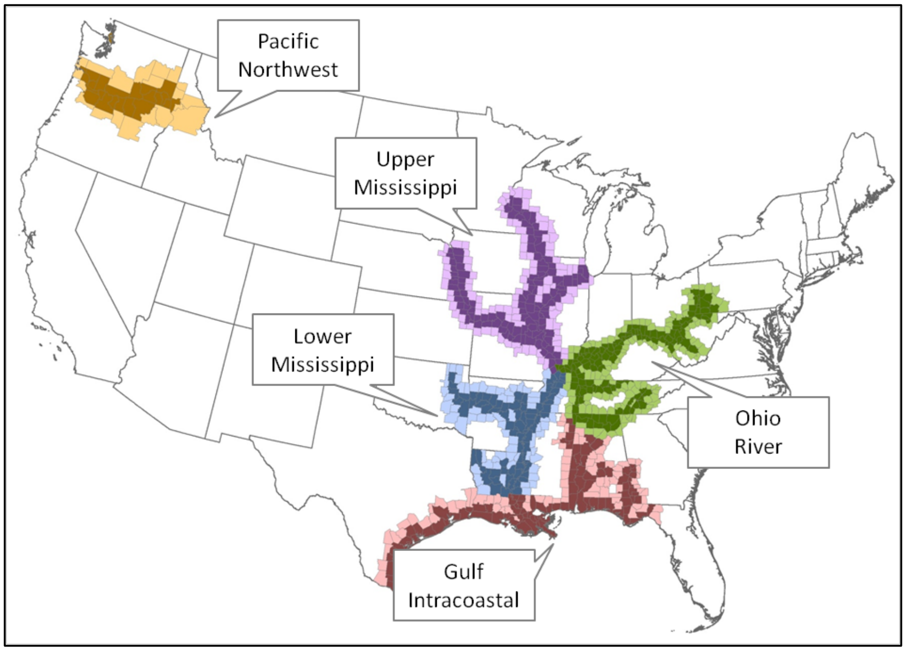
[5] Past studies indicate that, with a few exceptions, the competitive influence of available navigation is exhausted at a distance of 40 miles or less. This distance roughly correspond to the two county regional boundary established on each side of navigable waterways.

The long-term effects of the loss of inland waterway transportation in the various regions were simulated using Regional Economic Models, Inc. (REMI) proprietary software. For all non-coal commodity groups, the cost differential data was allocated as increased production costs in the appropriate REMI regions, by corresponding REMI industry definitions (steel to steel production, aggregates to stone preparation, etc.) In the case of coal, the transportation cost differential was used to calculate differences in electricity generating costs for facilities that are river-served and that burn coal as a primary fuel source. The resulting impact on electricity rates (both residential and industrial) was then distributed to the appropriate region(s).

Figure 1.3 – Study Regions, with "Rest of U.S." in white

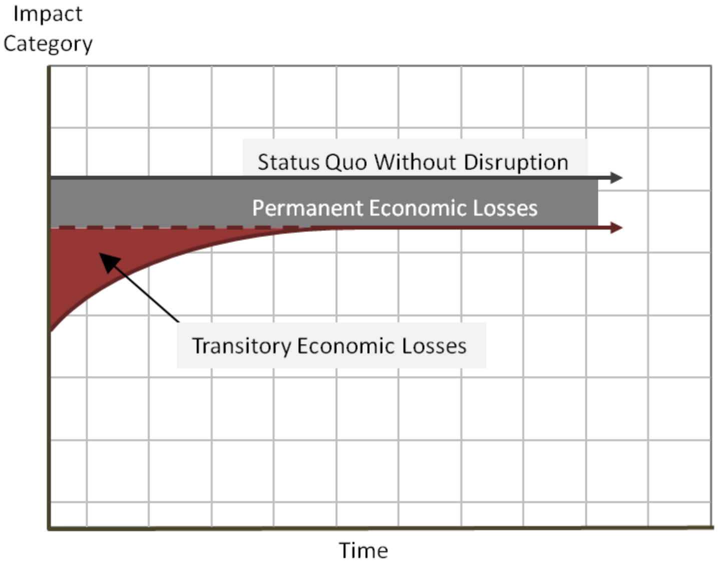


1.4 SUMMARY OF FINDINGS – EXISTING SYSTEM IMPACTS

Figure 1.4 depicts the theoretically predicted economic impacts of eliminating a commercial navigation alternative within a representative study region. Aggregated REMI simulation results are provided in Tables 1.1 – 1.4. Based on estimated navigation project lives, estimates were produced over a 50-year planning horizon. However, monetary values in "out years" were discounted to form an aggregate present value based on a three percent real discount rate. Fully disaggregated simulation results are provided and discussed in Section 4.

For each of the water-served study regions, the REMI results provide a depiction that is both predictable and disturbing. The all-or-nothing loss of navigation has a significant and immediate impact on economic activity, whether this is measured in output, employment, or incomes. Indeed, in Year-One, job losses summed across all regions are estimated to total nearly 550,000, with a corresponding loss of incomes of nearly $29 billion.

Figure 1.4 – Depiction of Typical Impact results



However, one of the advantages of the REMI simulation software is its dynamic nature. It models the likely response of the affected industries, as they begin to adjust to the shock posed by the elimination of available navigation. Based on the resulting changes in production costs structures, factor prices, and output demands, the model estimates how producers begin to substitute alternative inputs and change production locations. In essence, the economy begins to heal, as well as possible, from the damage caused by increased transportation costs. By Year-10 in the analysis, annual job losses have been reduced by nearly 30% and reductions in total output have stabilized. Still, the recovery is not complete. Permanent damage remains, especially concentrated in the counties served by waterways, while the "Rest of U.S." begins to recover over the course of two decades.

Section 4's presentation, description, and discussion of the simulation outcomes are expansive. However, even the summary tables provided here reveal a great deal of information about specific outcomes. For example, the most pronounced economic impacts are in the Gulf and Lower Mississippi Region. This outcome reflects three underlying facts. First, moving the chemical petroleum products that tend to dominate industrial production within these regions is relatively expensive compared with other industries. Second, the availability of alternative transportation of any kind is very limited for many chemical producers and refiners. And finally, the vitality of the overall regional economy is very closely tied to these industries.

It is also interesting to note that overall employment in transportation is increased by a scenario that eliminates commercial navigation. This outcome reflects the fact that both trucking and rail carriage are substantially more labor intensive than commercial navigation. Thus, even though aggregate output and overall demands for transportation are diminished, the labor required to transport the remaining traffic is greater than the labor required under the status quo.

Finally, the non-navigation scenario's impact on construction employment is telling. Even in the face of an overall decline in national economic activity, construction activity in the "Rest of U.S." region is increasing. Again, recalling REMI's dynamic nature and the linkages that capture changed investment, this construction outcome reflects the migration of economic activity away from river-served regions toward other parts of the country where a lack of navigation capacity is no longer a competitive handicap.

Table 1.1 – Summary of Existing System Employment Impacts

Region	Year 1	Year 10
Ohio River	-68,000	-72,000
Upper Mississippi	-59,000	-60,000
Lower Mississippi	-82,000	-83,000
Gulf Intracoastal	-153,000	-163,000
Pacific Northwest	-5,000	-5,000
Rest of U.S.	-173,000	-6,000
Total Jobs	**-541,000**	**-388,000**

Table 1.2 – Summary of Existing System Earning Impacts

Region	Year 1 (2012 billion)
Ohio River	-$2.474
Upper Mississippi	-$3.976
Lower Mississippi	-$4.057
Gulf Intracoastal	-$9.916
Pacific Northwest	-$0.251
Rest of U.S.	-$8.466
TOTAL	**-$29.140 billion**
Income per Job	$53,863

Table 1.3 – Summary of Existing System Output Effects (Billions)

Region	Year 1	Year 10
Ohio River	-$10.724	-$16.755
Upper Mississippi	-$12.180	-$18.571
Lower Mississippi	-$19.909	-$25.427
Gulf Intracoastal	-$48.775	-$63.080
Pacific Northwest	-$0.935	-$1.525
Rest of U.S.	-$31.629	-$6.600
Total	**-$124.152**	**-$131.958**
10 – Year Present Value	-$1.063 Trillion	

Table 1.4 – Sector-Specific 2025 (Year 10) Employment Outcomes

SECTOR	Ohio River	Upper Mississippi	Lower Mississippi	Gulf Intracoastal	Pacific Northwest	Rest of U.S.	TOTAL
Agricultural Production	-27,205	-2,040	-20,461	-6,527	-105	-2,958	-59,296
Resource Extraction	-1,997	-1,030	-4,562	-4,902	-60	-7,926	-20,477
Construction	-3,740	-3,913	-6,271	-13,779	-53	12,471	-15,285
Chemical / Petroleum Products	-1,768	-1,829	-4,180	-7,475	-31	-1,796	-17,079
Manufacturing	-4,581	-4,883	-8,143	-29,884	-657	-16,698	-64,846
Trade and Food Service	-10,150	-12,352	-11,883	-29,972	-971	-287	-65,615
Service Sector	-11,847	-17,892	-11,612	-34,828	-1,480	-9,404	-87,063
Financial Services	-3,162	-4,254	-1,867	-6,743	-417	1,177	-15,266
Utilities and Telecom	-728	-924	-624	-1,962	-124	-1,853	-6,215
Transportation Services	1,261	-977	-380	2,114	35	18,037	20,090
Government and Gov. Services	-5,046	-5,950	-10,149	-21,899	-721	2,251	-41,514
All Other	-1,751	-2,714	-1,751	-5,347	-233	-4,222	-16,018
Grand Total	**-70,714**	**-58,758**	**-81,883**	**-161,204**	**-4,817**	**-11,208**	**-388,584**

1.5 THE EFFECTS OF NAVIGATION SYSTEM MODERNIZATION

To this point, we have described the economic transportation value of the current commercial inland navigation system. However, this system has undergone continued use for decades beyond its original design life. Thus, many navigation-related infrastructure assets could be modernized to yield greater capacity and improved reliability.

Consequently, we now turn to consider the broader economic benefits of investment in navigation infrastructure modernization. The results suggest that, beyond yielding generations of new freight capacity, it would also lead to the creation of roughly 12,000 new full-time, permanent jobs each year with annual incomes in excess of $500 million.[6] These results are based on the assumption of the continuation of current commodity flows, and do not include the potential traffic growth tied to the core changes in the U.S. economy that now seem to be happening.

The methodology used to evaluate the overall economic impacts of proposed navigation system investments was similar to the baseline estimates described above. Within that work, simulation scenarios considered the shipper cost increases that would arise from the loss of commercial navigation. Now, scenarios are to focus on two different aspects – (1) the regional economic impacts of investment-related construction and (2) the shipper savings that would arise based on the results of proposed system investments.

Overall Scenario Development

New additions to Trust Fund totals, as reflected in WRRDA 2014's new cost-share for Olmsted's completion, would mean a larger number of additional navigation projects could be undertaken more quickly than would otherwise be possible. This probable expansion of resources available for lock construction and rehabilitation, exclusive of the Olmsted project, makes it possible to realistically consider the economic impacts of a relatively aggressive inland navigation reinvestment program. Accordingly, the reinvestment scenario is based on two elements. These include:

- The assumption that Olmsted's completion will require measurably less funding from the Inland Waterways Trust Fund going forward; and
- The hypothetical completion of 21 additional navigation improvements within a 10-year planning and construction horizon.[7]

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[6] The *one-time* "cost-to-complete" for the set of non-Olmsted navigation investments considered here is approximately $5.8 billion or less than 15% of the federal sum spent *annually* to build and maintain roadways.

[7] There is no expectation that this 10-year construction program will actually be undertaken. Rather, the scenario is intended to negate the effects of project sequencing on estimated impacts and to capture what *might* be attained.

It should be stressed that neither an increase in waterway fuel taxes nor the expeditious completion of Olmsted at lower cost to the Trust Fund is certain. However, basing the current work on these potential policy outcomes provides a rich depiction of inland navigation's increased value if these initiatives come to fruition.

Project Identification and Investment Timing

The 21 projects included in the current work are drawn directly from the investment agenda developed within the Inland Marine Transportation System (IMTS) capital investment strategy program which details a series of recommended navigation system investments. [8] These investments reflect lock rehabilitations, lock replacements, and, in some cases, expanded lock facilities. The geographic location of these projects and their relationship to the already established REMI simulation regions are depicted in Figure 1.5.

In addition to project identification, the IMTS provides a timeline for investments based on what was, at the time, believed to be achievable construction funding. Even though this timeline included the potential impacts of increased fuel tax revenues, the IMTS timeline extends over several decades. The protracted nature of this IMTS timeline, combined with the effect of discounting, would greatly diminish the present values for all delayed projects.[9]

The approach chosen for the current work was to analyze a policy scenario based on a more aggressive timeline in which non-Olmsted projects are undertaken simultaneously, all to be completed and placed in service within a 10-year construction window. This allows for a clearer picture of how rapidly regional and national benefits that can accrue to these improvements, should Congress decide to invest in them more rapidly.

Construction Expenditures

Annual construction expenditures per each REMI region for the 10-year construction timeframe was developed by summing estimated cost-to-complete values across each of the REMI regions. It is common within small-scale impact simulations to ignore the economic impacts of such construction expenditures. These expenditures are typically considered transient in nature and draw in material and service purchases from regions that are distant from the actual construction site location.

However, these projects are different. First, even the accelerated construction timeline would require significant construction activity in each affected region for a period of 10 years. This is long enough to result in the *permanent* relocation of additional construction and materials production to the region's long-run array of resources. Second, each study region is so large that it is likely that construction activity sited in a region will entail significant expenditures within that region. Third, the structure of the REMI model also

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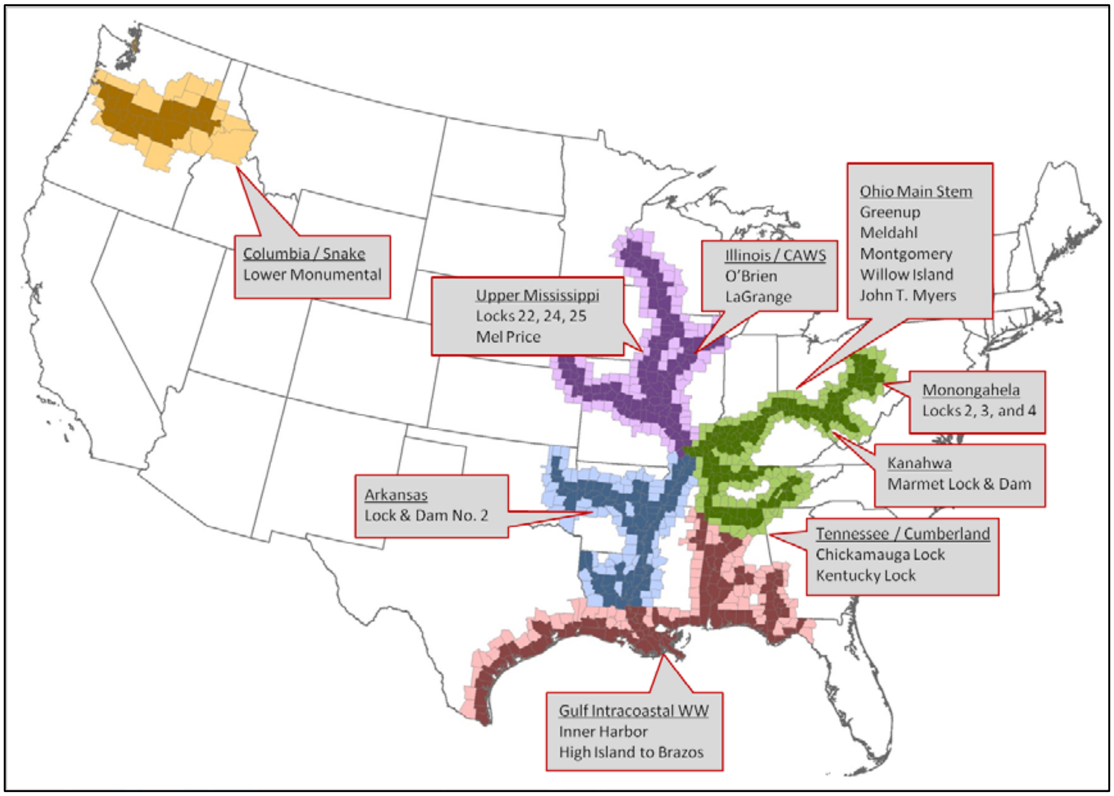
[8] This strategy team was comprised of representatives from the towing and barge industries, waterway users, and the U.S. Army Corps of Engineers.

[9] For example, using a discount rate of 5%, the present value of $1.00 in benefits derived 20 years in the future is only 38 cents.

includes the “Rest of the U.S.” Thus the general impact of the construction activities on the entire U.S. economy is captured. Given these three considerations, the study team elected to include the economic impacts of construction activities in the simulation. The resulting values are provided in Table 1.5.

Figure 1.5 – Reinvestment Scenario Projects by REMI Simulation Region



Assessing Investment Project Benefits

The IMTS evaluated navigation projects based on the same criteria that are prescribed within the Principles and Guidelines (P&G) mandated for navigation project benefit calculations – primarily the effects the proposed project will have on system efficiency and reliability.[10] However, the IMTS reports do not provide the specific project benefit values needed here.

To remedy this problem, CTR staff, in consultation with the Corps Huntington District, combined benefits estimates from Chief’s reports were available and assumed that the other projects had benefit-cost ratios greater than one and therefore have benefits slightly greater

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[10] See, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,* U.S. Water Resources Council, Washington, DC, March 1983.

than projects costs presented in the IMTS report cited above. The resulting benefits estimates were aggregated based on project location and the REMI regions as defined earlier, and were then made available to the study team for use here. These estimates are used as the direct inputs that drive the REMI simulations of overall economy-wide economic impacts. Cost-to-complete estimations were also aggregated by REMI region to provide the direct regional effects of construction-related economic activity as the structures are built. Table 1.5 summarizes these inputs.

Table 1.5 – Average Annual Project Benefits and
10-Year Annualized Cost-to-Complete Values for Modernization Program
(2012 Dollars)[11]

Region	Average Annual 10-Year Construction Cost (Millions)	Average Annual Direct Project Benefits (Over Project Life) (Millions)
Ohio River	$258.0	$474.6
Upper Mississippi	$182.3	$235.9
Lower Mississippi	$3.9	$22.7
Gulf Intracoastal	$134.4	$165.7
Pacific Northwest	$2.9	$3.3
Total	**$581.5**	**$902.2**

1.6 MODERNIZATION SIMULATION RESULTS

The economy-wide impacts of both construction and the resulting efficiency gains in navigation are summarized in Tables 1.6 – 1.8 and depicted in Figures 1.7 – 1.9. Each is discussed in turn in the text that follows.

Output Effects

The theoretical form of the output impacts of both the investment-related construction, and the resulting efficiency improvements, are illustrated in Figure 1.6. Here, the constant level of expected construction-related increase is represented by the rectangular shape labeled "construction." The expected effects of the investment-related improvements on overall output are represented by the triangular figure labeled "efficiency effects." Figure 1.7 depicts the economy-wide output effects actually estimated within the REMI simulation. The similarities between the theoretically suggested outcome and the REMI estimated impacts

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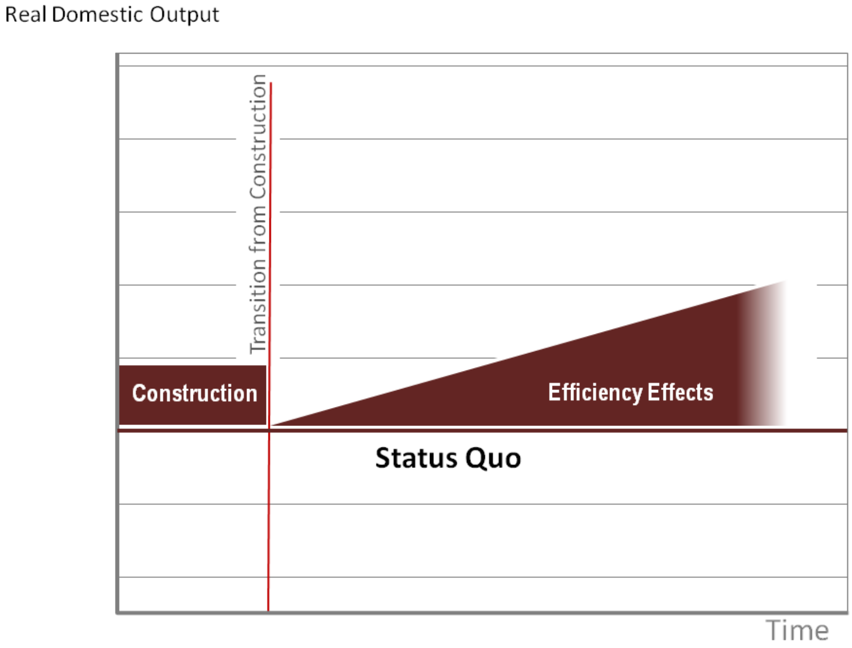
[11] Construction cost data for individual projects can be found in the final IMTS report document (pp. 63-65). Data used here represent the sum across regions of annualized expenditures as reported in that document.

are immediately clear, and the differences are readily explained by the way the REMI framework mimics business behaviors.[12]

Figure 1.6 – Hypothesized Output Effects due to Navigation Modernization



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[12] Specifically, at the beginning of the construction, some firms will invest in new construction capacity that continues in service through subsequent time periods. Thus, there is a one-time burst in construction-related investment. This also happens with construction-induced employment.

Figure 1.7 – REMI-Estimated Output Increases above the Status Quo due to Navigation Modernization

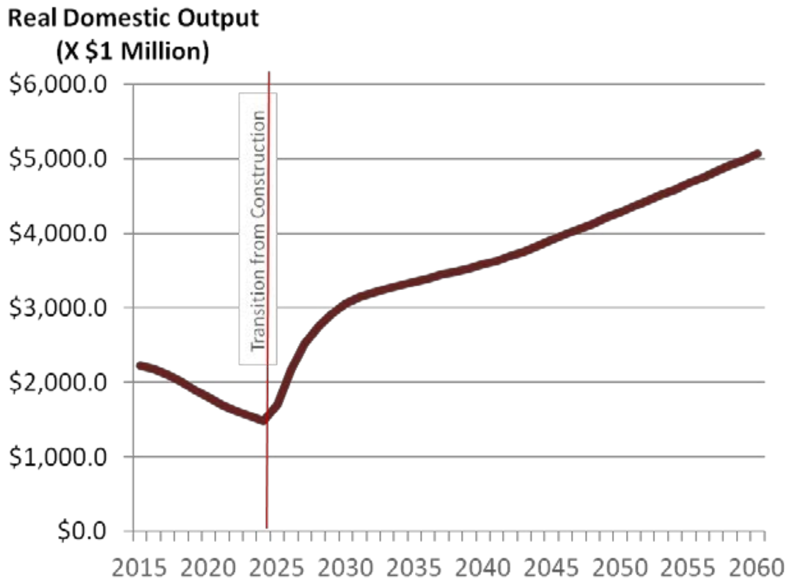

Table 1.6 – REMI-Estimated Output Effects due to Navigation Modernization
(Real 2012 X $1M)

Region	First Year Construction Effects	Final Year Construction Effects	First Year Navigation Effects	Year-10 Navigation Effects	Year-20 Navigation Effects
Ohio River	$590.0	$487.3	$323.4	$1,352.8	$1,609.5
Upper Mississippi	$565.3	$455.8	$365.3	$1,112.0	$1,410.5
Lower Mississippi	$31.5	$19.3	$70.4	$167.5	$199.8
Gulf Intracoastal	$350.4	$282.3	$177.8	$496.0	$583.5
Pacific Northwest	$11.7	$2.9	$10.6	$7.5	$6.3
Rest of Nation	$670.0	$238.0	$754.0	$212.0	$96.0
Total	**$2,218.9**	**$1,485.6**	**$1,701.5**	**$3,347.8**	**$3,905.6**

Employment and Income Effects

Prior to actual simulation, the study team expected employment and income impacts to be similar to the hypothetical scenario depicted in Figure 1.6. Actual estimation results are illustrated in Figures 1.7 and 1.8, while tabular results are provided in Tables 1.5 and 1.6. Both individually and, particularly when combined, these results forecast an interesting story.

In sum, the first 30 years of the simulated scenario are predicted to produce an increase of nearly 350,000 job-years of fulltime employment due to the modernization investments. Even discounted at a real rate of 5% (relatively high), the present value of the associated incomes over this same 30-year period is estimated at more than $14 trillion (or a real annual salary of roughly $41,000 per job).

The largest burst in employment is during the construction phase when the average annual employment increase is estimated to be approximately 12,700 jobs per year. At this phase in the scenario, additional employment is widely distributed across the U.S., much like output. As construction progresses toward completion, the increase in employment dips to only to 9,000 jobs in the eleventh year. However, when the new navigation capacity comes on line, employment again rises rapidly, presumably as waterway users take advantage of reduced navigation costs. Over the years that follow, the overall level of *additional* employment declines, but associated wage earnings *do not*. This indicates rising wages associated with more productive capital stock in the industries benefitting from improved inland navigation.

Figure 1.8 – REMI-Estimated Employment Increases above the Status Quo due to Navigation Modernization

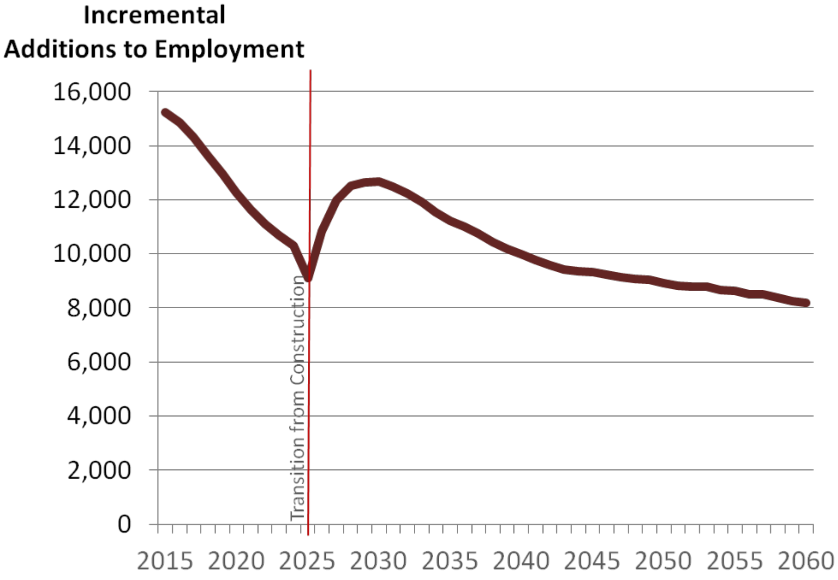

Table 1.7 – REMI-Estimated Employment Changes due to Navigation Modernization (Fulltime Equivalent Jobs)

Region	First Year Construction Effects	Final Year Construction Effects	First Year Navigation Effects	Year-10 Navigation Effects	Year-20 Navigation Effects
Ohio River	4,936	3,933	1,590	4,947	4,836
Upper Mississippi	3,940	3,062	1,868	3,816	3,810
Lower Mississippi	197	113	419	660	597
Gulf Intracoastal	2,375	1,871	756	1,465	1,368
Pacific Northwest	76	25	66	10	-28
Rest of U.S.	3,712	1,296	4,416	640	-1232
Total Jobs	**15,236**	**10,300**	**9,115**	**11,538**	**9,351**

Figure 1.9 – REMI-Estimated Income Increases above the Status Quo due to Navigation Modernization

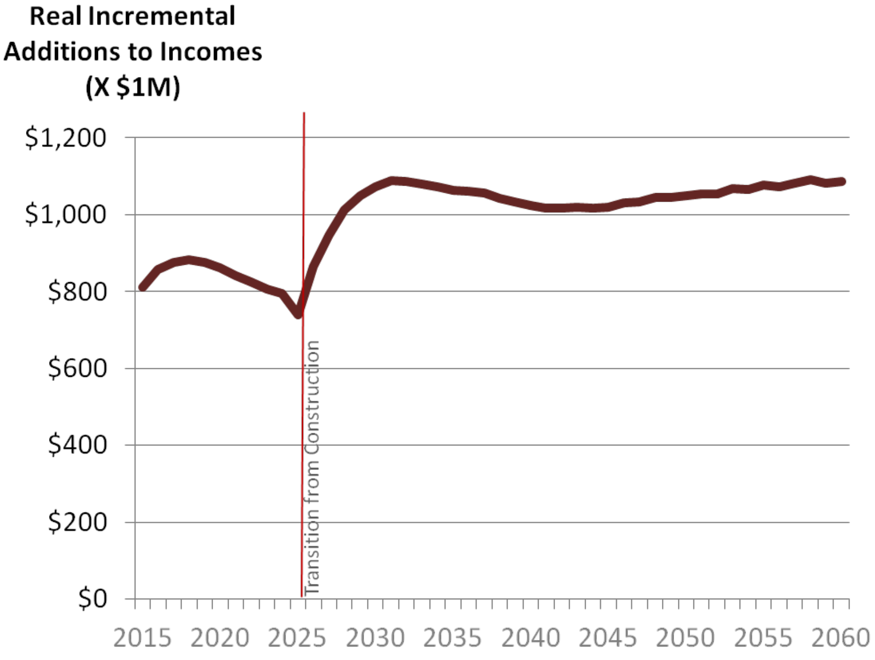

Table 1.8 – REMI-Estimated Income Changes due to Navigation Modernization
(Real 2012 X $1M)

Region	First Year Construction Effects	Final Year Construction Effects	First Year Navigation Effects	Year-10 Navigation Effects	Year-20 Navigation Effects
Ohio River	$241.9	$288.4	$173.6	$431.5	$520.4
Upper Mississippi	$224.4	$253.4	$199.5	$384.6	$468.5
Lower Mississippi	$8.8	$6.9	$27.9	$54.8	$60.1
Gulf Intracoastal	$136.4	$157.3	$91.8	$154.3	$175.1
Pacific Northwest	$3.4	$1.3	$4.4	$1.9	-$2.5
Rest of Nation	$195.0	$87.0	$243.0	$46.0	-$204.0
Total	**$809.9**	**$794.3**	**$740.2**	**$1,073.1**	**$1,017.6**

1.7 RECAP AND CONCLUSIONS

The study process first considers the impact of the sudden and complete elimination of navigation as a freight alternative. Not surprisingly, this would result in profound economic losses and displacements in terms of jobs, incomes, and aggregate economic activity. Indeed, the initial job losses alone would total more than one-half million full-time positions. Given the resilience of the U.S. economy and the functioning of markets, a portion of the sustained damage would be "repaired" through the relocation of economic activity and a rebalancing of productive inputs. However, even in the long-run, economic adjustments could only restore about 40% of the initial losses, so that the permanent, unrecoverable loss of jobs would still approach 350,000. These jobs and their associated incomes represent benchmarks against which navigation's future economic impacts can reasonably be compared.

Next, the study team simulated the construction and simultaneous introduction of a set of navigation improvements roughly analogous to the investments recommended under the IMTS. Based on lengthy discussions with the study's sponsor and other stakeholders, this simulation assumes the Olmsted Locks and Dam will be completed expeditiously and focuses instead on the economic impacts of other improvements throughout the inland system.

The results show that both the construction itself and the resulting efficiency improvements would generate significant new economic activity. In order to be consistent with Corps' methodologies, the post-construction time horizon was extended to 50 years for the projects used in this analysis. However, even if the post-construction period is limited to the first 20 years, the combination of construction and increased efficiencies are estimated to generate nearly 350,000 job-years of new employment, with incomes that have a present value of more than $14 billion. By any measure, these are important numbers.

Finally, while the results provided by the study's simulations are valuable measures of specific navigations impacts, they are by no means all-encompassing, nor are they as forward-looking as we would like. Waterborne freight movements do not take place in isolation from other economic interactions. To the contrary, they are an integral part of a global system of supply chain activities. Thus, the vitality of commercial navigation both affects, and is affected by, changes to other freight modes and by change in the product markets these modes serve. As noted earlier, there is likely a link between the effects of railroad deregulation and the modest growth in barge traffic since 1990. At the same time, there is ample evidence that available navigation effectively constrained railroad rates during the same period. It has only been during the last decade – since railroad capacity has become scarce – that "water-compelled" rail rate effects have diminished. Section A.1 provides additional context for this discussion.

Now, more than any time in recent memory, there is a great deal of uncertainty about freight demands and the roles that respective modes will play in satisfying the need for freight movement. The current boom in domestic petroleum, natural gas, and chemical production has placed unanticipated stresses on segments of the nation's freight system. This rapid and unforeseen change, combined with an increasingly apparent scarcity of railroad capacity, has led to a new-found optimism among some navigation advocates.

TWO

Current System and System Use

2.1 PHYSICAL EXTENT OF INLAND NAVIGATION RESOURCES

The introduction includes a brief description of the nation's overall system of navigable waterways. The system actually analyzed within the current work is slightly less extensive. The modest restrictions imposed here reflect the exclusion of waterway segments that (1) are used almost entirely for recreation, (2) have had historically limited freight traffic, or (3) are not among the set of fuel-tax waterways.[13]

The characteristics of the individual waterway segments, organized by study region, are summarized in Table 2.1. This table depicts characteristics and uses that vary across river reaches. For example, the Lower Mississippi River generally features large tows moving relatively long distances over open river. In contrast, tows on the Ohio River are smaller and move shorter distances that do not always require traversing any of the Ohio's 20 navigation locks. However, both the Ohio and the Lower Mississippi have a relatively large share of the system's overall freight traffic (17% and 41% respectively. Each component of the current analysis is further described in the text that follows.

Upper Mississippi Region

As a rule, the 29 locks and dams that maintain navigation pools on the Upper Mississippi are first generation 20th century structures that are older and smaller than their Ohio River counterparts. Nearly all of the upper Mississippi projects were authorized as a part of the 1932 "Nine-Foot Draft" and the construction initiative that followed and all of the associated projects were opened prior to World War II. The only exceptions are Lock & Dam No. 2 which received a new lock chamber that opened to traffic in 1948, Lock & Dam No. 19 which opened in 1957, The Chain of Rocks Lock & Dam where construction was completed in 1967, and finally the Melvin Price Lock (No. 26) that was opened to barge traffic in 1990.

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[13] These are comprised mainly of small, intermittent waterway segments ancillary to the main reaches, and exempted from taxation, often by local authority.

Table 2.1 Study System Segment Descriptions

Waterway	Navigable Miles	2011 Tons (000)	Number of Dams with Operating locks	Oldest Lock by Year Opened	Dimensions of Smallest Main Lock	Average Shipment Distance by Trip Origin
UPPER MISSISSIPPI RIVER REGION						
Upper Mississippi River	858	168.2	29	1930	400 x 56	792
Missouri River	732	3.8	NA	NA	NA	8
Illinois Waterway	357	36.4	8	1933	600 x 80	812
OHIO RIVER REGION						
Ohio River Main Stem	981	215.0	20	1921	600 x 110	349
Cumberland River	381	20.7	4	1952	400 x 84	750
Tennessee River	764	36.8	10	1937	360 x 60	421
Other Ohio Tributaries	356	64.3	14	1933	360 x 56	455
LOWER MISSISSIPPI RIVER REGION						
lower Mississippi River	956	519.0	NA	NA	NA	642
McClellan- Kerr Arkansas System	462	10.6	15	1967	600 x 110	291
J. Bennett Johnston Waterway	218	8.2	5	1984	785 x 84	428
GULF INTRACOASTAL REGION						
Gulf Intracoastal WW	1,109	113.0	12	1923	425 x 75	392
GIWW: Morgan City Port Allen	64	17.0	2	1952	800 x 56	
Tennessee Tombigbee WW	233.7	5.9	10	1978	600 x 110	335
Black Warrior Tombigbee River	726	18.9	6	1954	600 x 110	335
Alabama-Coosa	340	0.0	3	1969	600 x 84	
PACIFIC NORTHWEST REGION						
Columbia River	337	9.9	4	1953	675 x 86	439
Snake and Willamette Rivers	259	3.7	4	1962	675 x 86	315

Table Notes:

1. Distance is extended on occasion to account for navigation at 6.5 feet of channel depth.
2. Other Ohio tributaries are the Big Sandy, Kanawha, Monongahela, and the Green and Barren Rivers.
3. Tennessee River mileage and tons reflect navigation on the main river (652 miles) and tributaries-Hiwassee (22 miles), Clinch (61 miles), and Little Tennessee (29 miles) Rivers.
4. Average shipment distance for the Tennessee Tombigbee Waterway and the Black Warrior and Tombigbee Rivers is the system average for these three waterways.

The navigable reach of the Missouri River is nearly as long as that of the upper Mississippi, extending roughly 735 miles from Sioux City, Iowa to the river's confluence with the Mississippi near St Louis. However, unlike the upper Mississippi, the navigable portion of the Missouri has no locks and dams. Instead river flows and elevation are controlled by releases from a series of upstream reservoirs located in the Dakotas and Montana.

The Illinois River Waterway is the final segment of the Upper Mississippi Region as defined here. In combination with the Chicago Area Waterway System (CAWS), the Illinois provides a direct navigation link between its confluence with the Mississippi near Grafton, Illinois and Lake Michigan at Chicago. Illinois system navigation is supported by locks and dams at eight locations – seven on the Illinois River itself and one on the Calumet River at Chicago. Constructed in the 1930s, the Illinois River locks are of the same vintage and design as most of the locks on the upper Mississippi, with 600-foot chambers. The exception is the O'Brien lock on the Calumet which was built in the 1960s and which has a 1,000-foot main chamber.

Ohio River Region

Most of the locks and dams on the Ohio are second generation, 20th century projects, built in the 1960s and 1970s. Accordingly, many of these locks are large, with one or more 1,200-foot chambers. The exceptions to this pattern lie at the extreme ends of the Ohio River main stem. At the upper end, the three locks near Pittsburgh (Emsworth, Dashields, and Montgomery) were built as a part of the 1929 Ohio River system, opening in 1921, 1929, and 1936 respectively. At its lower end the Ohio's last two lock and dams (52 and 53) are from the same 1920s era, although both have been substantially improved.

Within the current analysis, the remainder of the Ohio River Region includes a number of tributaries. Among these, four rivers - the Cumberland, the Tennessee, the Allegheny, and the Monongahela – are extensive in their reach. Navigation on the Tennessee extends more than 650 miles from upper East Tennessee, through Alabama, Mississippi, central Tennessee, and Kentucky, to the river's confluence with the Ohio near Paducah. Tennessee River navigation is supported by nine lock and dam combinations.

Five of the nine main lock chambers are a standard 600 foot length. The main chamber at Pickwick Lock and Dam is 1,000 feet in length and lock chambers on the upper three locks (Chickamauga, Watts Bar, and Fort Loudon) are 360 feet in length. Most structures were built during the 1930s and 1940s.

The Cumberland River also joins the Ohio just above Paducah, Kentucky. Navigation on the Cumberland extends roughly 300 miles above this confluence, across Kentucky and Tennessee. This navigation is supported by four lock and dam combinations, all constructed in the 1950s and 1960s. Main chambers on the two lower structures (Barkley and Cheatham) are 800 feet, while the chambers on the upper two locks (Old Hickory and Cordell Hull) are roughly 400 feet in length.

Lower Mississippi Region

Within the current context, the Lower Mississippi Region is defined to include the lower reach of the Mississippi River between Cairo, Illinois and Baton Rouge, Louisiana, the Kerr-McClellan (Arkansas) Navigation System, and navigable portions of the Red River in Louisiana.

Navigation capacity in the region is dominated by the lower Mississippi River. Like the Missouri, the lower Mississippi River is "open river," with no locks and dams. Accordingly, there is often significant variation in river elevation, depending on regional weather conditions and upstream flows from the upper Mississippi, Missouri, and Ohio River basins.

Mississippi River flows are also supplemented by resources from the Arkansas River basin. Commercial navigation between the Mississippi River and the Port of Catoosa near Tulsa is supported by over 18 locks, dams, and pools that constitute the Kerr-McClellan Waterway. Entrance to this waterway is via the White River, immediately north of the confluence of the Mississippi and Arkansas, but the majority of the waterway's length (roughly 400 miles) is directly on the Arkansas River. Opened in the 1970s, the Arkansas' system of locks and dams is relatively modern.

Finally, commercial navigation is also available on a portion of the Red River in Louisiana. This system is supported by five navigation locks that were collectively placed in service during the 1990s. Accordingly, this makes the Red River the most recent large-scale addition to the overall national system of available commercial navigation.

Gulf Intracoastal Region

The U.S. southern coastline is a natural outlet for most of the inland flows described above. Indeed, most of these flows ultimately funnel into the lower Mississippi River which enters the Gulf via a number of "passes" 100 or so miles below New Orleans. Many other natural watersheds collectively terminate at Mobile Bay via the Mobile River. Accordingly, the rivers, lakes, and marshy flatlands that form the Gulf region also provide the basis for an east-west navigation system that stretches from Florida, through Alabama, Mississippi, and Louisiana to a termination in extreme southern Texas near the U.S. border with Mexico. Collectively, this system is referred to here as the Gulf Intracoastal Waterway (GIWW). For study purposes, the Gulf Intracoastal *Region* also includes portions of what is traditionally the lower Mississippi, along with Mobile and Black Warrior Rivers and the Tennessee-Tombigbee Waterway.

2.2 FREIGHT TRAFFIC ON THE INLAND SYSTEM

The Waterborne Commerce Statistics Center (WCSC) of the U.S. Army Corps of Engineers (USACE) provides extensive tabulations of current and historical foreign and domestic waterborne commerce traffic. Statistics are aggregated by region, commodity, and waterway. Of particular interest to those making policy concerning the inland river system is the data series on domestic internal freight traffic. These are the vessel movements that take place solely on the inland waterways. This section of the report focuses on the regional and commodity distribution of these movements. The most recent data recorded in this file is for the year 2011.

Beginning in the year 1972, domestic freight traffic in the United States totaled 986.8 million tons with the internal component accounting for about one-half of the total. Both the data total and the inland series generally grew from 1972 but dipped during the 1982 business recession. Both came out of this recession to peak values in 1990. Total domestic freight tonnage declined from this peak into the major business recession of 2008. The internal domestic series remained fairly constant for a number of years, but also slipped during the 2008 recession before recovering slightly in 2010 and 2011. In 2011 domestic internal freight traffic stood at 553.6 million tons. Total waterborne traffic volumes for both the total U.S. and for the inland system are summarized in Figure 2.1.

As would be expected, the magnitude of total internal domestic freight traffic total is driven by traffic on the Mississippi River System which accounted for 80% of the total in 2011. When examined by commodity, the Mississippi River System is dominated by coal (29.0.4%), petroleum (23%), and grains (20.4%). Crude materials and chemicals products are also significant.

The Mississippi River main stem carried 499 million tons of freight traffic in 2011. Traffic fluctuated during the period 1992-2011 but has not changed drastically. Traffic is dominated by petroleum (28.7%) and farm products (27.3%). Coal, chemicals, and crude materials follow in tonnage with 10-12% in each commodity category.

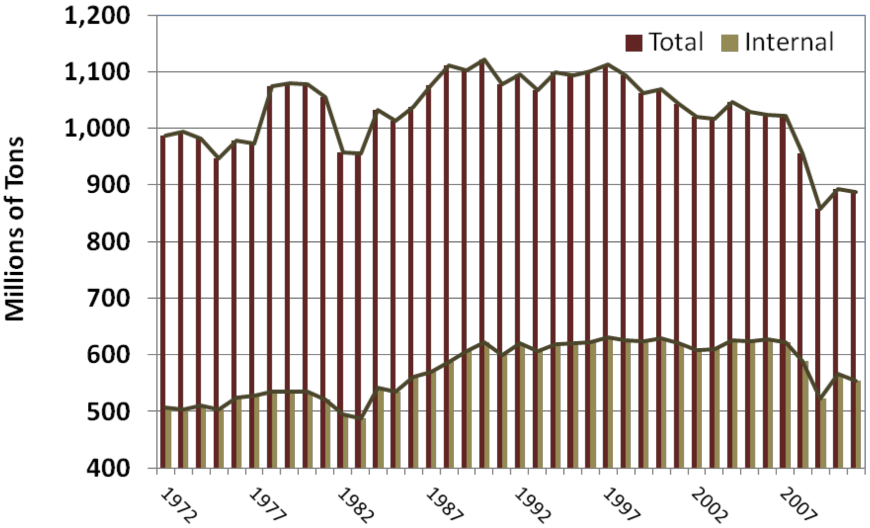
The Ohio River Systems (ORS) makes up about 54% of the domestic internal Mississippi River system traffic. The two major commodities carried on the ORS are coal and crude materials, accounting for 59 and 21.7% respectively. The shares of the remaining commodities, petroleum, chemicals, primary manufactured goods and farm products, are just about equally distributed at 4-5% apiece. Traffic on the ORS did not fall in the 2008 recession but did decline slightly in 2009. It recovered in 2010 but declined again in 2011. In the series reported by the WCSC (1992-2011), coal traffic peaked in 1992 and in 2011 stood at 89% of that series' high value.

Freight traffic on the Gulf Intracoastal Waterway stood at 112.6 million tons in 2011. Traffic is concentrated in petroleum products (55.3%), but chemicals and crude materials are also significant—19% and 16%, respectively.

In the western United States the Columbia and Snake Rivers each account for 54.2 and 2.7 million tons respectively. On the Columbia River farm products account for 50% of total freight traffic followed at a distance by crude materials (22.8%). Ninety percent of the freight traffic on the Snake River is farm products.

In summary, domestic internal barge freight traffic stood at 553.6 million tons in 2011, rising slightly from a low point in the 2008 business recession. Mississippi River main stem traffic, 499 million tons in 2011, is dominated by petroleum and farm products. On the Ohio River system which makes up over half of Mississippi river system traffic, almost 60% of total traffic is made up of coal and crude products. Traffic on the Gulf Intracoastal Waterway is primarily petroleum products (55.3%) but chemical and crude materials are also significant. In the western United States grain traffic dominates the Snake River and makes up 50% of Columbia River traffic. Crude materials traffic is also significant on the Columbia River.

Figure 2.1 – Total Domestic and Internal Waterborne Commerce in the United States



2.3 ENERGY, OPTIMISM, AND UNCERTAINTY: FUTURE WATERWAY VOLUMES

Freight traffic forecasts project the demand for future commodity movements based on the observed historical relationships between resource production, commodity and transportation prices and downstream market demands. This forecasting process can generally incorporate gradual changes in the economic basics that underpin the forecasts, including incremental additions to production capacity, modest changes in production locations, or gradual population trends. However, any large-scale or abrupt change in the economic factors that underlie freight forecasts limits forecasts' reliability and makes it exceedingly difficult to offer statistically defensible traffic projections.

Five years ago, as the U.S. economy slowly began its recovery from recession, observed freight movements signaled a return to pre-recession commodity flows in terms of both geography and freight volumes. At roughly the same time, however, data describing fuel flows – the movement of petroleum, natural gas, and coal – began to depict new, unanticipated movements from heretofore largely inactive production regions, specifically crude oil output from the upper Plains region, west Texas, and western Canada and natural gas production in the eastern U.S. (primarily Pennsylvania and West Virginia).

Initially viewed as transitory and/or anomalous, it is now increasingly clear that these new fuel flows are neither. Instead, it seems that new fuels production, its related impacts on existing fuel resource producers, and most importantly, its effects on the demand for freight transportation are only the earliest signs of a new domestic energy future that promises to differ radically from the past. In this environment, existing statistical modal traffic forecasts for these commodities lose much of their meaning, so that policy-makers and planners are left with only current observations, logic, and instinct to guide them.

Fuels as Freight: Petroleum

The casual observer may equate the lack of new petroleum refining *locations* with a paucity of refining industry *investment*. This perception is inaccurate. To the contrary, U.S. producers invest billions annually in improved refining capacity, but because of the difficulty and expense of developing new facilities, this investment is made almost exclusively at existing locations. Nonetheless, most 21st century U.S. refineries are now far more capable of adapting to varied crude supplies and/or altering the mix of refined outputs than they were only a generation ago.

The single most important take-away from this realization is that, regardless of changes in crude sourcing, refining locations are unlikely to change and, importantly, these locations are often (if not universally) more easily served by barge than by rail.[14] If it is impossible to quickly link new petroleum production regions to domestic refineries via pipeline, waterborne freight will almost certainly play an important role in the transportation alternative.

The DOE's Energy Information Administration (EIA) tracks waterborne crude oil movements on the inland river system. Crude oil shipments from the Midwest to the Gulf Coast have increased 10-fold from roughly 3.7 million barrels in 2009 to 37 million barrels in 2013, reflecting a sudden shift toward domestic sourcing of crude oil. The 37 million barrels shipped by barge equate to approximately 5.6 million tons. Barge shipments in 2014 are on a pace to at least match shipments in 2013. Figure 2.2 shows waterborne crude oil movements between selected regions. This domestic crude oil is sourced from the Bakken region of North Dakota, the Eagle Ford and Permian basins in Texas, and Western Canada. Again, while pipelines are the preferred mode for shipping crude oil to refineries, they often are not available or do not have adequate capacity for growth from new sources of production.

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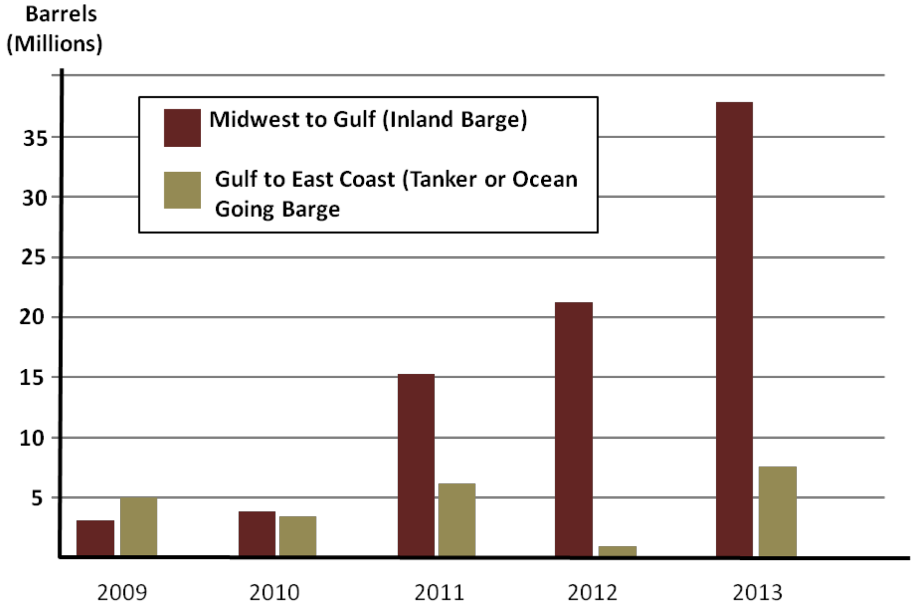
[14] Most coastal refineries have traditionally been supplied by imported crude petroleum and for this reason are not supplied by pipeline nor do they have rail service. Thus, crude domestic oil is moved from the production sites by truck or rail and transferred to the navigable river for delivery to the refineries, for example, to Gateway Terminals, the rail-to-barge transfer station located on the Mississippi River in Saint Louis, Missouri. Here, trains deliver about 60,000 barrels of oil about five times per week. This product, oil sand Canadian crude, is replacing the ethanol that was once was handled at this terminal.

Figure 2.2 – Barge Shipments of Crude Oil



Fuels as Freight: Coal

Much has been written about the future of the coal industry, coal burns at generating plants, and the future of coal shipments on the inland river system. At this point, however, fully defensible conclusions regarding the future role of coal as a source of waterway traffic are impossible to make.

The use of coal as a generating fuel has been under downward pressure due to both federal policies and from market forces attributable to new domestic natural gas production. Utilities face adapting aging plants to increasingly strict Environmental Protection Agency (EPA) emissions requirements. At the same time, domestic natural gas production continues to increase, so that gas prices per BTU are competitive with coal, while producing significantly lower combustion emissions.

Still, the EIA reports that in 2012 1,016.4 million short tons of coal were mined in 25 states, and 37% of the 4 trillion kilowatt hours of electricity generated in the United States were coal-fired production. In fact, the EIA projects an increase in coal production nationally from 20.6 quadrillion Btu in 2012 to 22.6 quadrillion Btu in 2040, an increase of 9.7%. Of course, this increase in production includes steam coal, metallurgical coal, and the export of both[15].

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[15] U.S. Energy Information Administration, http://www.eia.gov/coal/

Accordingly, Loren Steffy of *Forbes* has suggested that coal is making a comeback despite natural gas abundance and pricing. Writing at Forbes.com[16] he notes that the harsh winter of 2013-14 drove gas prices to "some of their highest levels in four years," making coal attractive to utilities again. In fact, he notes that the share of electricity generated by coal rose to more than 40% from the 37% reported by the EIA in 2012.[17]

It is reasonable to expect that waterway operators and rail carriers have already sustained the most precipitous drops in coal traffic volumes and that future declines will be more modest. For example, Sandor Toth, *River Transport News*, espoused this view.[18] In an article titled, "Southern Company To Slash Coal Use at Barge Served Plants," he observes that a variety of coal-fired plants owned by the Southern Company will be converted to gas, but Toth suggests these conversions will generally have only a limited impact on barge shipments to the plants because coal shipments have already been significantly reduced.

The pattern is evident elsewhere. For example Tennessee Valley Authority (TVA), a major shipper of barged coal, is in the process of retiring several plants that burn steam coal[19]. In 2011, TVA agreed to shut down 18 coal-fired generating units to settle litigation, and four units have been shut down so far. This shift has been accelerated through a proposal to shut down eight electricity generating units that burn a fifth of the utility's coal each year.

However, TVA is by no means abandoning coal. Also announced in 2013, the utility is investing one billion dollars to upgrade the 60-year old Gallatin Steam plant[20]. This plant burns 13,000 tons of coal per day or 4.7 million tons per year. Dr. Joe Hoagland, Senior Vice President of Policy and Oversight at TVA, noted that "we do want to reduce the share of power generated by coal, but we want to keep a balanced portfolio that includes coal as part of our mix."

In summary, the compound forces of more rigorous air quality standards and burgeoning natural gas production reduced coal's share of domestic electricity production by roughly 20% in less than a decade. This has affected the demand for the movement of coal by all modes.[21] Still, this occurred during a time when recession-related reductions curbed the

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[16] http://www.forbes.com/sites/lorensteffy/2014/02/14/coal-makes-a-comebackdespite-natural-gas-abundance

[17] For a roughly eight-week period between mid-January and mid-March, the Henry Hub natural gas prices hovered consistently in the $6 range and twice spiked to $8 per million, before returning to stability at just below $4. See EIA's *Gas Intelligence*.

[18] Toth, Sandor, *River Transport News*, Vol. 23, No. 16, August 18, 2014.

[19] Wines, Michael. "A Push Away From Burning Coal as an Energy Source." *New York Times*, November 14, 2013.

[20] Flessner, Dave. http:/www.timesfreepress.com/news/2013apr/07/tva-clearing-the-air.

[21] Preliminary Surface Transportation Board estimates suggest that railroad movements of coal during 2012 declined between 25 and 30%.

demand for electricity, regardless of fuel source. Further, as would be predicted, the easiest coal-to-gas conversions were made first. Thus, predicting that the demand for waterborne coal transport will mirror the past 10 years may be overly pessimistic.

Other Impacts: Chemical Production

While both petroleum and coal are relevant as existing and potential sources of waterway traffic, natural gas is not routinely moved by barge, nor is that likely to change. However, natural gas is a critical feedstock in the manufacture of many chemicals that are subsequently moved by both barge and rail. The impact of increased natural gas production on waterway system traffic is, as yet, uncertain. While chemical manufacturers have increased their consideration of new barge-served chemical production facilities, most such discussions have not yet led to actual construction. Like many natural gas users, chemical producers are likely anxious to see gas prices exhibit some degree of stability prior to actually making new natural gas-dependent investments.

Still, waterborne chemical traffic is extremely active. Bloomberg.com reported that in 2012 the largest owner of tank barges on the U.S. inland river system, the Kirby Corporation, was fully utilizing its fleet of chemical-carrying barges. The demand for barging services was reported to be due to lowered natural gas prices and the resultant increases in production of chemicals manufactured from the gas. In the same article it is stated that petrochemicals from plastics to paints account for 65% of the cargo loaded into Kirby’s tank barges.

Conclusions

Future growth in inland river traffic related to increased petroleum and natural gas production appears to be concentrated in liquid commodities including crude petroleum, petroleum products, and chemicals. Assuming that all of the announced liquid river terminals are constructed (new and expanded terminals), inland river liquids traffic could expand by 75 million tons. This represents an increase of roughly 80% from current levels of liquids traffic and an overall system traffic increase of more than 13%. This amount is in addition to the traffic increases that are likely to occur over existing refining and chemical facilities. Currently, it is not possible to determine whether or not this traffic growth will be less than or greater in volume than the probable continued decline in coal traffic. However, it is almost certain that the geography and economics of new traffic will be different than that associated with coal.

THREE

Methodology, Assumptions, and Modeling Platform

The overarching goal of this first analytical phase is to empirically capture the economic impact of the inland navigation as it is currently configured and operated. To achieve this goal it was necessary to simulate the functioning of regional economies in the absence of navigation and compare simulation results to the jobs, incomes, and output magnitudes currently observed in an environment that does benefit from barge transportation. As ancillary goals, the study team also sought a methodology that avoids some of the more common pitfalls evident in impact analysis and which produces results that are as consistent as possible with the methods and measures currently used by the U.S. Army Corps of Engineers. These goals required the effective execution of four specific tasks. These included:

- The designation of economic regions that best capture the influence of available navigation on commercial activity and that would also facilitate the post-processing of analytical results;
- The selection of a modeling platform that would accommodate the changes in user costs predicted under a loss of inland navigation capacity;
- The development of model inputs that accurately capture the changes in costs associated with eliminating the water-inclusive freight alternative and that also conform to the demands of the selected modeling system; and
- The integration of data inputs into the modeling framework and the execution of economic simulations.

The remainder of this section describes how each of these tasks was addressed.[22]

3.1 DEFINING THE STUDY REGIONS

Figure 1.4 illustrates the final study regions designated for study. It is reproduced in this section as Figure 3.1. It depicts five waterway regions and a sixth region that accounts for the portion of the U.S. judged to be beyond the waterways' effective influence. The two most

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[22] The methods used here are an extension of those developed in earlier work for the Corps Huntington District. See [CITE].

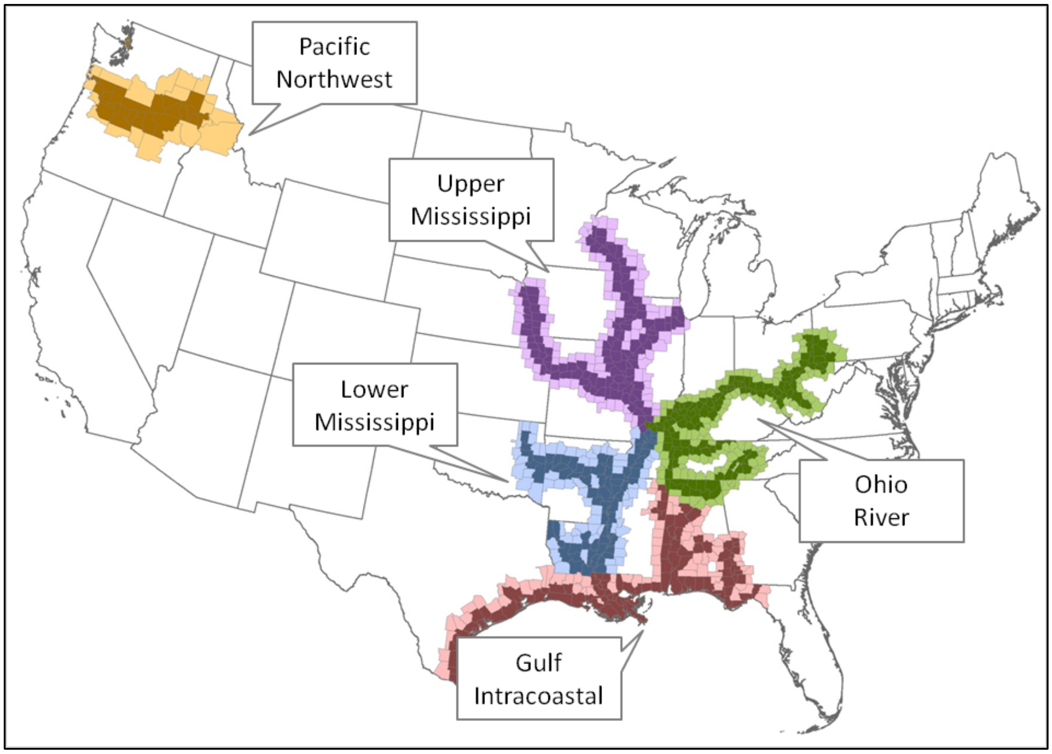
salient features are the divisions between waterway regions and the two-county reach on either side of the navigable waterway used to define regional boundaries.

The number of, and divisions between, waterway regions reflects various concerns. First, in order to keep the simulation process and, particularly, the volume of simulation results manageable, it was desirable to have as few waterway regions as possible. At the same time, the number of regions and their internal waterway boundaries must reflect operational, economic, and jurisdictional differences, where those differences have the potential to affect simulation results. For the most part, this was not difficult. For example, including the upper Mississippi, Missouri, and Illinois waterways within a single region is consistent with a variety of geographical, economic, and jurisdictional similarities. The same is true for the Ohio, Tennessee, and Cumberland Rivers.

Perhaps the most problematic waterway is the Tennessee-Tombigbee (Tenn-Tom) system. Historically the upper reaches of the Tenn-Tom are closely associated with the Tennessee River and Tennessee Valley. Conversely, the Tenn-Tom's lower reaches are equally tied to Mobile and the Gulf Intracoastal Waterway (GIWW).

Finally, from a commercial standpoint, the Tenn-Tom is often treated as an alternative (or complement) to the lower Mississippi River. Consequently, the Tennessee-Tombigbee might have been included among any of these three alternative regions. Ultimately and partially as a matter of balance, the Tenn-Tom was combined with the GIWW.

Figure 3.1 – Study Regions, with "Rest of U.S." in white.



Next, the study team wrestled with defining the outer boundary of each region. Original depictions contained in early study materials suggest defining these regions based on state boundaries, but that approach was quickly judged as impractical. For example, given the regions depicted in Figure 4.1, Illinois could easily be associated with either the Ohio River region or the upper Mississippi region. Similarly, Louisiana might have been included with either the lower Mississippi or the GIWW. This problem of overlap was treated by defining specific waterway regions based on county definitions. Again, however, early depictions show waterway boundaries that include only those counties that have waterway shorelines. However, a number of previous studies conducted by both TVA and the University of Tennessee's Center for Transportation Research (CTR) demonstrate that the competitive influence of available navigation can reach as far as 50 miles from the water's edge. Based on that observation the region reach was extended to two counties deep on both sides of each navigable waterway. This approach also ensures that riverside metro areas are more completely included within the waterway regions.

3.2 MODELING PLATFORM SELECTION

The *REMI Policy Insight* (PI+) model used in this study was built specifically for the purpose of evaluating the economic value of changes in a regional system. REMI's PI+ models include disaggregated industry data for 23, 70, or 169 industrial sectors. The model for this study is a 70-sector model.

REMI *Policy Insight* lies at the elegant and complex end of the simulation software spectrum. Like all such software products it begins with a variant of an input-output construct. However, REMI'S developer, the late George Treyz, went to extraordinary lengths to modify the REMI products so that they overcome many of the traditional drawbacks associated with impact modeling. As a result, REMI products are fully dynamic. The analyst establishes a multi-year time horizon, after which the software generates annual iterations up to the final year of that horizon. With each year, changes in economic outcomes from the previous year are allowed to affect factor prices. For example, a given year generates economic changes that reduce capital costs, those capital costs are then made lower in subsequent model-run years and this, in turn, generates additional investments. Also by actually estimating Cobb-Douglas production functions and incorporating them within the products, the software's developer makes it possible to simulate cost-side changes within a regional economy.

This last attribute was critical to the current analysis. Freight transportation is a productive input, similar to labor, capital, or energy, in its treatment by profit-maximizing producers. Any policy that affects the rates offered by freight carriers affects production costs and must enter economic simulations as cost changes for effected producers. Any alternative treatment of transportation costs within the simulation process risks disastrous consequences. At present, REMI is the only simulation software product that offers this capability.

3.3 DATA AND DATA INPUTS

In modeling barge transport savings, as noted above, industry production costs will increase as transportation savings from the navigable waterways are eliminated. Importantly, no firm or industry will cease operation simply because of the unavailability of barge transportation, but instead users will respond in a variety of ways, based on their tolerance of the higher production cost. Some firms will switch modes and incur the higher transportation costs without altering their behaviors in any way; others will switch to the best transportation alternative, but reduce output quantities; and some will, in fact, exit the market(s) they operate in as a response, but these are all responses to higher production costs, not an allegiance to barge transportation.

The transportation savings data underlying the inputs into the REMI model were developed through the careful preparation and integration of shipper savings data originally collected in the course of various Corps project NED analyses. The raw data span an approximately 10-year timeframe and, together, represent barge movements across the whole of the inland navigation system. Access to these confidential data was provided by the Corps' Huntington District with the understanding that CTR would prepare a non-confidential input data set that could be shared with other researchers. Toward that end, the base shipper savings, exclusive of the Pacific-Northwest (PNW) are presented here as Table 3.1. All data have been converted to 2012 dollars.

3.4 COAL AND ELECTRICITY GENERATION

There are good reasons to believe commercial transportation savings for coal shipments to electric power generating plants may not adequately capture the full direct effects of a navigable waterway on the facilities; for example, the waterway may also facilitate plant maintenance and affect plant design with respect to cooling water. Therefore, transportation savings direct effects for electric power utilities are not used as an input in simulations, but instead, direct effects of the waterway on the utilities are entered through policy variables reflecting electric rate changes. This approach necessitates additional preparation of data inputs amenable to the model's capabilities.

Specifically, the model requires percentage changes in regional electric rates due to loss of navigable water. In earlier work, these effects were accounted for only in the areas very near the actual utility. The resulting impacts, however, displayed very little differences from using only transportation savings as a direct effect on utility production costs. This prompted the study team to consider whether the electric rate effects should be extended further beyond the utility, reflecting a more realistic distribution of electricity effects by Power Service Area (PSA).

Table 3.1 – Water Route Rate Savings per Ton by Origin, Destination, and Commodity (2012 Dollars)

COMMODITY	ORIGIN	DESTINATIONS			
Aggregates	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	6.58	18.93	8.46	37.50
	Lower Mississippi	28.50	4.40	9.10	7.57
	Ohio	7.11	15.29	9.22	26.62
	Gulf Intracoastal	45.76	6.59	21.01	11.29
All Other	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	15.96	30.33	25.88	47.79
	Lower Mississippi	26.01	25.15	11.48	0.84
	Ohio	28.83	23.07	18.39	27.78
	Gulf Intracoastal	48.02	18.20	21.52	10.77
Chemicals	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	24.73	56.18	19.19	38.85
	Lower Mississippi	9.76	17.11	10.65	12.99
	Ohio	17.96	25.81	17.91	36.13
	Gulf Intracoastal	49.49	25.35	52.27	15.27
Coal & Coke	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	7.33	39.32	10.04	44.81
	Lower Mississippi	41.23	29.76	15.67	6.30
	Ohio	14.02	13.09	9.22	20.39
	Gulf Intracoastal	45.62	24.24	52.68	12.86
Grains	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	7.97	17.44	20.21	24.71
	Lower Mississippi	26.94	9.06	14.20	16.67
	Ohio	15.21	15.90	10.53	18.27
	Gulf Intracoastal	28.09	31.63	30.93	10.98
Iron & Steel	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	13.54	25.64	19.71	44.30
	Lower Mississippi	18.61	15.06	14.19	25.39
	Ohio	29.43	25.11	16.37	47.90
	Gulf Intracoastal	40.50	24.03	20.45	-1.11
Minerals & Ores	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	20.12	18.95	8.94	27.09
	Lower Mississippi	12.20	10.90	25.88	
	Ohio	16.59	14.26	15.14	42.21
	Gulf Intracoastal	45.44	27.20	40.95	8.35
Petroleum Fuels	Org. \ Dest.	Upper Mississippi	Lower Mississippi	Ohio	Gulf Intracoastal
	Upper Mississippi	11.16	16.90	16.03	22.32
	Lower Mississippi	36.40	15.64	22.68	23.78
	Ohio	32.71		19.38	44.98
	Gulf Intracoastal	34.50	17.24	39.54	17.24

This extended approach takes into account the fact that utilities relying on power from generating plants operating on the waterways have PSAs extending well beyond the model-defined waterway regions. To reflect this, the non-electric utility sector in each region is again altered by introducing both the transportation industry modal shift demand adjustments (described below) and the loss of navigation-related transportation savings to industries (excluding electric utilities) through the model's mechanism of production cost changes (or revenue or income changes, depending on the benefiting industry). The effects in the electric utility industry due to cost structure changes in this extended study, however, go beyond the waterway regions and are accounted for by exogenous estimates of the changes in electric rates in all affected on-river generating plant distributors' PSAs. As generating companies are expected to price their electricity on a system-wide basis, major tasks in this phase are to quantify their electric rate impacts attributable to one or more of their plants being on navigable water and to identify the applicable portions of distributor power service areas by county, ultimately quantifying those rate changes for all model regions and inputting them as appropriately formulated direct effects into the REMI model for impact simulation.

This estimation process was originally executed in CTR's 2011 study of navigation impacts in the Ohio River basin. In the current setting,[23] the earlier Ohio basin results were compared with similarly estimated results for the upper Mississippi basin. Given that the results for the upper Mississippi basin were nearly identical to those obtained for the Ohio River region, the study team opted to apply the resulting cost change estimates to each of the five water-served regions in the current analysis.

3.5 FINAL INPUT PREPARATION AND SIMULATIONS

The text above, describing the treatment of electric utility costs outlines the way in which the non-electric utility cost increases related to lost navigation were simulated in the current work. Again, for non-utility industries, this required a two-step process. First, it was necessary to manually reflect the modal shifts that would come with lost navigation. The second step involved simulating the production cost increase for affected industries.

Accounting for Modal Shifts

REMI contains input sectors for barge, rail, and truck. However, the demands for these sectors are not functionally linked. Accordingly, eliminating the use of commercial inland navigation – the first task in accounting for modal shifts – does not affect the regional demands for rail and truck transport. This must be done separately in a way that adequately reflects the Corps treatment of shipper demands (See Section 5.3). Specifically, some portion of the freight volume formerly transported by water would disappear as shipping

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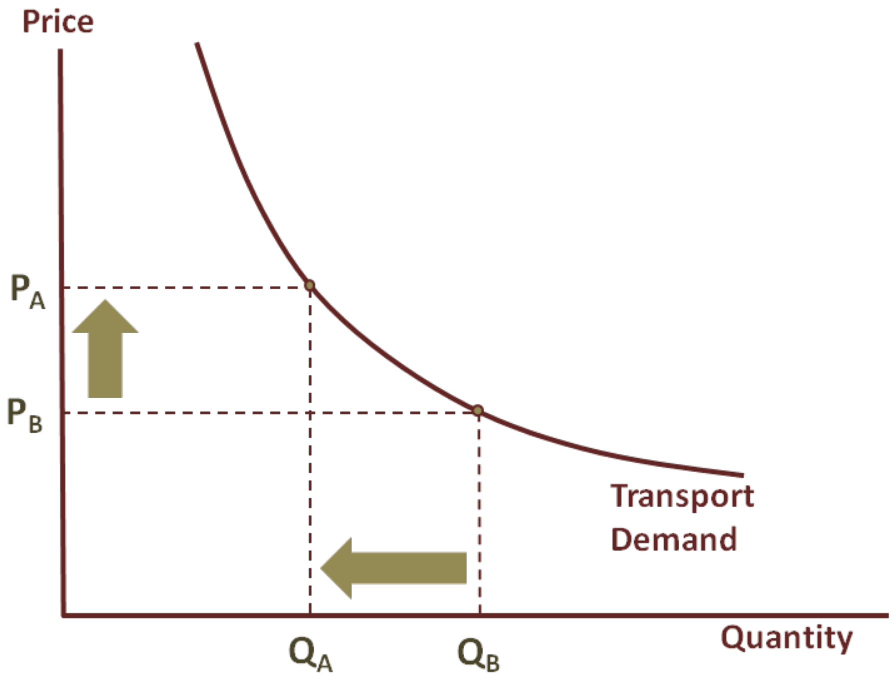
[23] *Ibid*.

costs move upward to reflect the higher rates charged under navigation's alternatives. This scenario is reflected graphically by the simple demand diagram provided in Figure 3.2.

The story portrayed in this figure is straightforward, but its empirical treatment is less so. Within the diagram, the subscript **B** represents the supply-chain cost and quantity of barge-inclusive movements and the subscript **A** represents price and quantity for the least expensive supply-chain alternative. As noted above, when the barge-inclusive alternative is withdrawn and transport costs move upward, some firms will reduce the quantities they ship. In this way, the demand for waterway traffic is reduced completely by Q_B, but depending on the shape of the demand curve and the difference between P_B and P_A, the increase Q_A will be less than Q_B by some amount. In order to complete the modal shift adjustment within REMI, these amounts must be estimated based on assumptions regarding the own price elasticity of demand for freight movement.[24]

If we reference the own price elasticity as ε, then $\varepsilon = \%\Delta Q_i \,/\, \%\Delta P_i$ where i is the commodity in question. The goal is to combine empirical estimates of this elasticity with available information regarding $\%\Delta P_i$ to estimate $\%\Delta Q_i$ and, thereby Q_A in the diagram. This provides a measure of the appropriate increase for the demands of truck and rail within REMI.

Figure 3.2 – Transport Demand and Diverted Quantities



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[24] This process also requires a number of more nuanced assumptions about the relationship between barge and the alternative, as well as assumptions regarding the alternative's cost structure and available capacity. Fortunately, the analytical structure mandated by the P&G supports these assumptions.

Existing estimates of the elasticity ε, developed through disparate methods and over many decades generally range between 0.75 and 1.50.[25] Thus, to make matters as simple as possible, we assume a value of 1.0. Based on this admittedly convenient assumption the percentage difference between the barge quantity and the diverted quantity is simply equal to the percentage change in shipper costs. Based on the values in Table 4.1 and other available transportation data, the percentage change in transport price – the difference between P_B and P_A –ranges between roughly 25 and 40%. Thus, within the current analysis we constrain the volume of diverted traffic to 75% of the volume moving under the water-inclusive supply-chain routing.

Accounting for Changed Production Costs

Having accounted for the amount of increased demand for rail and truck transport, the job of increasing firm production costs to reflect more expensive freight transportation is relatively straightforward. There are only two issues with which to contend. The first is to adopt assumptions regarding where geographically within the supply chain (origin or destination) the increased cost production cost is incurred. The second task is to link the increased commodity prices to the appropriate industries.

Regarding the first issue, the study team opted to apply the cost increase to the destination location or receiving region, except in the case of grain. For grain we assume that the additional transportation costs are borne by the producing regions.

Next, REMI is organized around industries defined by North American Industrial Codes (NAICs). The commodity groupings are based on Corp of Engineers' definitions. In order to increase production costs in response to higher transport rates it is necessary to match the commodities shipped to the industries that use them. This task was made manageable by two factors. First, in developing the aggregated data depicted in Table 4.1, the study team had access to confidential information describing the identities and business activities of actual shippers and commodity definitions that were far more specific than the roughly two-digit definitions provided in the table published here. Second, the study team has decades of experience making similar judgments. The resulting commodity-to-industry linkage is available upon request from the authors.

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[25] For a full discussion of freight demand elasticities, including various empirical estimates see, Friedlaender, Ann F. and Richard H. Spady, Freight Transport Regulation, MIT Press, 1980, pp. 52-54, Oum, Tae Hoon, W.G. Watters, II, and Jong-Say Yong, "Concepts of Price Elasticity of Transport Demand and Recent Empirical Estimates: An Interpretive Survey," *Urban Transport*, 2003, pp 16-37, Edward Elgar and Train, Kenneth and Wesley W. Wilson, "Spatially Generated Transportation Demands," *Railroad Economics*, pp: 97118, 2007, Elsevier JAI Press. For the purpose of this comparison, inland barge transportation demand elasticities were judged to be similar to railroad own price elasticities for the movement of similar commodities in similar shipment sizes.

FOUR

Simulation Results and Current System Impacts

All of the tasks described thus far were undertaken to facilitate the execution of REMI simulations predicting regional economic outcomes in the absence of an inland commercial navigation freight alternative. This section reports the results of those simulations. While these results are enlightening, readers should constantly be mindful that simulation results, by their nature reflect caricatures of outcomes based on carefully constructed estimates, and that reliance on any specific prediction would be well-served by additional supporting research.

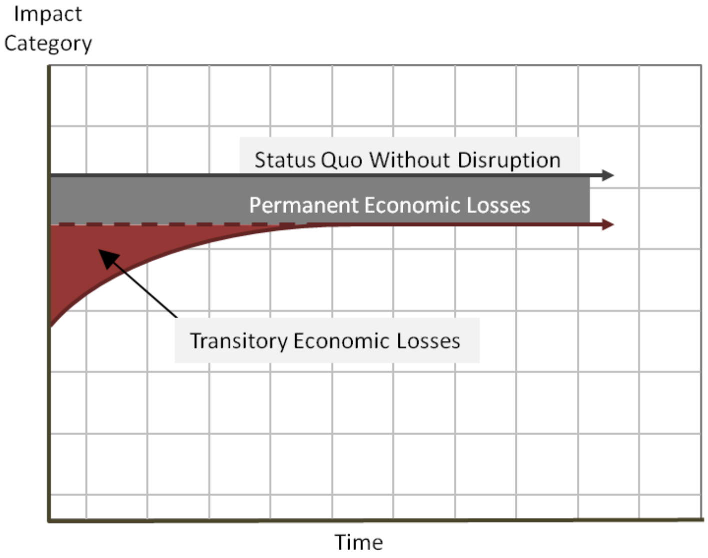
4.1 THE SIMULATION SCENARIO

The simulation scenario and hypothesized general economic response were depicted in Figure 1.5. This graphic is reproduced here as Figure 4.1. As represented, the onset of navigation's disruption is sudden, unannounced, and complete. It is as much of a shock to waterborne commerce as can be imagined.

There are, of course, a multitude of other possible scenarios under which a system closure would be announced in advance and / or undertaken incrementally over varying geographies. From a modeling perspective, the difficulty is that there are many such scenarios that are plausible, so that selecting only a small number for analysis is nearly impossible.

More importantly, modeling the extreme scenario through the use of REMI requires manipulating a relatively small number of parameters for each time period. The dynamic nature of the REMI construct effectively captures most subsequent interactions. However, any gradual or incremental simulated system shutdown would require a tremendous amount of well-informed work be performed outside of the REMI framework. For example, a less extreme disruption scenario that allows carriers to gradually adjust fleet sizes and shippers to gradually adjust commodity inventories would require that these fleet and inventory adjustments be modeled separately and that their implications for both transportation rates and commodity prices be integrated into the REMI simulation of a gradual shutdown. In the current context, this is not feasible, so that the abrupt termination scenario is the only tenable choice.

Figure 4.1 – Depiction of Impact Results



4.2 GENERAL SIMULATION RESULTS

Simulation outputs describing employment, income, and economic output effects by region are provided in Tables 4.1 –4.3. The general implications of these results are summarized in Section 1.4. The effect of the catastrophic disruption to navigation is immediate and pronounced across all economic measures and all regions. In year-one, overall employment falls by more than one-half million full-time equivalent jobs, corresponding income losses total nearly $30 billion, and the loss in aggregate economic output is nearly $125 billion. Not surprising, these losses are concentrated in the regions where navigation was previously available – 68%, 71%, and 75% respectively for employment, incomes and output.

From an analytical standpoint, the richness of the simulation results begins to unfold as we trace the intertemporal course of each of the economic series. Figures 4.2 – 4.4 illustrate these paths for employment loss, income loss, and reduced output. In these figures, impacts are divided between the total national effects and the impacts within the regions historically served by commercial navigation.

Table 4.1 – Employment Impacts of Ceasing Navigation (Thousands)

Year No.	Ohio River Region	Upper Mississippi	Lower Mississippi	Gulf Intracoastal Waterway	Pacific Northwest	Navigation Regions Total	Rest of U.S.	TOTAL
1	-67.9	-59.1	-81.8	-153.3	-5.5	-367.5	-173.4	-540.9
2	-72.6	-63.9	-85.3	-165.1	-5.9	-392.9	-155.8	-548.8
3	-75.2	-66.1	-86.8	-170.3	-6.1	-404.6	-134.6	-539.2
4	-76.4	-67.0	-87.3	-172.5	-6.2	-409.3	-113.8	-523.1
5	-76.5	-66.6	-87.0	-172.5	-6.1	-408.6	-92.3	-500.9
6	-76.0	-65.7	-86.5	-171.7	-5.9	-405.9	-71.8	-477.7
7	-75.4	-64.6	-85.9	-170.7	-5.7	-402.3	-52.5	-454.8
8	-74.0	-62.9	-84.7	-168.0	-5.5	-395.0	-35.2	-430.3
9	-72.7	-61.4	-83.7	-165.8	-5.2	-388.9	-20.3	-409.2
10	-71.5	-59.9	-82.7	-163.2	-5.0	-382.3	-5.7	-388.0
11	-70.3	-58.6	-81.7	-160.8	-4.8	-376.2	8.0	-368.2
12	-69.2	-57.3	-80.9	-159.2	-4.5	-371.2	20.6	-350.6
13	-68.1	-56.2	-80.1	-158.0	-4.3	-366.8	32.6	-334.2
14	-67.1	-55.2	-79.4	-156.9	-4.1	-362.8	43.9	-318.9
15	-66.1	-54.2	-78.8	-156.0	-4.0	-359.0	54.9	-304.2
16	-65.2	-53.3	-78.2	-155.1	-3.8	-355.6	65.4	-290.3
17	-64.3	-52.5	-77.7	-154.3	-3.6	-352.5	75.3	-277.1
18	-63.4	-51.7	-77.2	-153.4	-3.5	-349.3	84.8	-264.5
19	-62.6	-51.0	-76.6	-152.6	-3.4	-346.2	94.0	-252.1
20	-61.7	-50.3	-76.0	-151.5	-3.2	-342.7	103.1	-239.6
TOTAL	**-1,396.2**	**-1,177.3**	**-1,638.4**	**-3,231.3**	**-96.3**	**-7,539.5**	**-273.0**	**-7,812.5**

Table 4.2 – Income Impacts of Ceasing Navigation (Billions)

Year No.	Ohio River Region	Upper Mississippi	Lower Mississippi	Gulf Intracoastal Waterway	Pacific Northwest	Navigation Regions Total	Rest of U.S.	NATIONAL TOTAL
1	-2.482	-3.951	-4.053	-9.905	-0.249	-20.640	-8.511	-29.152
2	-2.959	-4.450	-4.481	-11.146	-0.285	-23.321	-7.898	-31.219
3	-3.339	-4.858	-4.847	-12.116	-0.314	-25.475	-7.091	-32.565
4	-3.623	-5.161	-5.134	-12.870	-0.334	-27.121	-6.229	-33.350
5	-3.813	-5.354	-5.337	-13.367	-0.347	-28.217	-5.206	-33.423
6	-3.951	-5.495	-5.497	-13.759	-0.353	-29.055	-4.154	-33.210
7	-4.050	-5.592	-5.631	-14.070	-0.356	-29.699	-3.086	-32.785
8	-4.091	-5.621	-5.701	-14.194	-0.353	-29.960	-2.090	-32.050
9	-4.121	-5.647	-5.772	-14.311	-0.349	-30.200	-1.194	-31.394
10	-4.141	-5.660	-5.824	-14.363	-0.345	-30.332	-0.308	-30.640
11	-4.151	-5.669	-5.870	-14.402	-0.338	-30.430	0.283	-30.147
12	-4.160	-5.682	-5.923	-14.491	-0.333	-30.588	5.200	-28.804
13	-4.169	-5.695	-5.972	-14.603	-0.328	-30.768	3.307	-27.461
14	-4.178	-5.713	-6.021	-14.728	-0.323	-30.963	4.007	-26.956
15	-4.189	-5.733	-6.074	-14.865	-0.317	-31.178	4.856	-26.322
16	-4.204	-5.761	-6.131	-15.014	-0.312	-31.422	5.749	-25.673
17	-4.222	-5.793	-6.191	-15.177	-0.308	-31.690	6.668	-25.022
18	-4.241	-5.831	-6.253	-15.328	-0.303	-31.957	7.594	-24.362
19	-4.264	-5.875	-6.317	-15.490	-0.300	-32.246	8.542	-23.704
20	-4.279	-5.906	-6.361	-15.627	-0.296	-32.469	9.520	-22.949
TOTAL	**-78.627**	**-109.445**	**-113.392**	**-279.824**	**-6.445**	**-587.732**	**9.960**	**-581.188**
PV (4%)	-52.223	-73.079	-75.293	-186.076	-4.379	-391.050	-10.526	-403.709

Table 4.3 – Economic Output Impacts of Ceasing Navigation (Billions)

Year No.	Ohio River Region	Upper Mississippi	Lower Mississippi	Gulf Intracoastal Waterway	Pacific Northwest	Navigation Regions Total	Rest of U.S.	TOTAL
1	-10.724	-12.18	-19.909	-48.775	-0.935	-92.523	-31.629	-124.152
2	-12.078	-13.708	-20.897	-51.969	-1.073	-99.725	-29.17	-128.895
3	-13.107	-14.845	-21.671	-54.108	-1.178	-104.909	-26.047	-130.956
4	-13.961	-15.757	-22.403	-56.041	-1.265	-109.427	-22.996	-132.423
5	-14.645	-16.455	-23.044	-57.625	-1.333	-113.102	-19.799	-132.901
6	-15.245	-17.056	-23.665	-59.124	-1.391	-116.481	-16.744	-133.225
7	-15.789	-17.596	-24.288	-60.611	-1.443	-119.727	-13.869	-133.596
8	-16.139	-17.936	-24.662	-61.45	-1.473	-121.660	-11.234	-132.894
9	-16.475	-18.281	-25.072	-62.392	-1.501	-123.721	-8.955	-132.676
10	-16.755	-18.571	-25.427	-63.08	-1.525	-125.358	-6.6	-131.958
11	-17.01	-18.845	-25.773	-63.746	-1.548	-126.922	-4.363	-131.285
12	-17.256	-19.118	-26.126	-64.557	-1.57	-128.627	-2.285	-130.912
13	-17.487	-19.384	-26.475	-65.387	-1.591	-130.324	-0.283	-130.607
14	-17.713	-19.65	-26.829	-66.234	-1.611	-132.037	1.646	-130.391
15	-17.932	-19.919	-27.194	-67.104	-1.63	-133.779	3.549	-130.23
16	-18.157	-20.199	-27.574	-68.005	-1.649	-135.584	5.412	-130.172
17	-18.384	-20.492	-27.964	-68.897	-1.672	-137.409	7.23	-130.179
18	-18.612	-20.796	-28.368	-69.799	-1.695	-139.270	9.031	-130.239
19	-18.844	-21.113	-28.785	-70.719	-1.718	-141.179	10.84	-130.339
20	-19.015	-21.363	-29.115	-71.431	-1.735	-142.659	12.664	-129.995
TOTAL	**-325.328**	**-363.264**	**-505.241**	**-1,251.054**	**-29.536**	**-2474.423**	**-143.602**	**-2,618.025**
PV (4%)	-214.292	-239.496	-335.377	-831.262	-19.432	-1639.859	-138.725	-1,778.585

In figure 4.2, the national employment series looks very much like the hypothetical representation in Figure 4.1. The curve depicting employment for the affected navigation region is similar but flatter. The indication here is that, while the loss of navigation is damaging to national employment as a whole, employment recovery is much more robust in those portions of the country that did not previously benefit from available navigation. Further an examination of Table 4.1 indicates that the employment impacts of lost navigation on this latter segment of the economy actually become positive after year 10. This suggests that as the national economy recovers from the initial shock, employment migrates away from the waterways and into other portions of the country.

The same general pattern is evident in Figure 4.3, the graphic depicting incomes. Not long after the initial shock, total national incomes begin a relatively robust recovery, but in this case, the income effects on the regions previously served by navigation become increasingly pronounced throughout the series. Thus, combining the employment and incomes patterns for the regions that had navigation prior to the shock suggests steadily falling wage rates throughout the 20-year period depicted.

Finally, Figure 4.4 depicts changes in overall economic activity as measured by total output, both for the directly affected region and for the nation as a whole. Here, the continued decline in output in the post-navigation region is even more severe than the fall in aggregate incomes. However, unlike employment and incomes, there is no corresponding improvement at the national level. Instead the impact, even in the region where navigation was never available, is negative for 15 of the 20 years and the national pattern is overwhelmingly flat after the initial decline attributable to the shock.

Figure 4.2 – National and Navigation Regions Employment Impacts

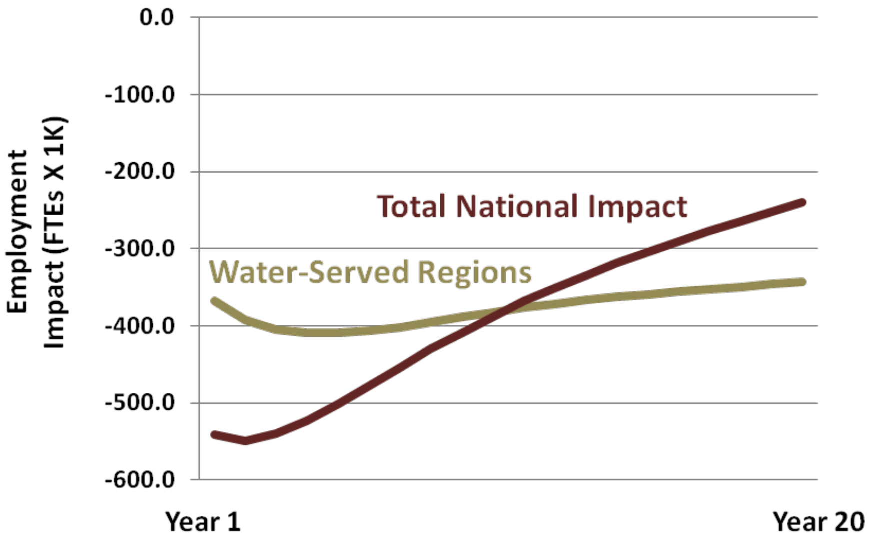


Figure 4.3 – National and Navigation Regions Incomes Impacts

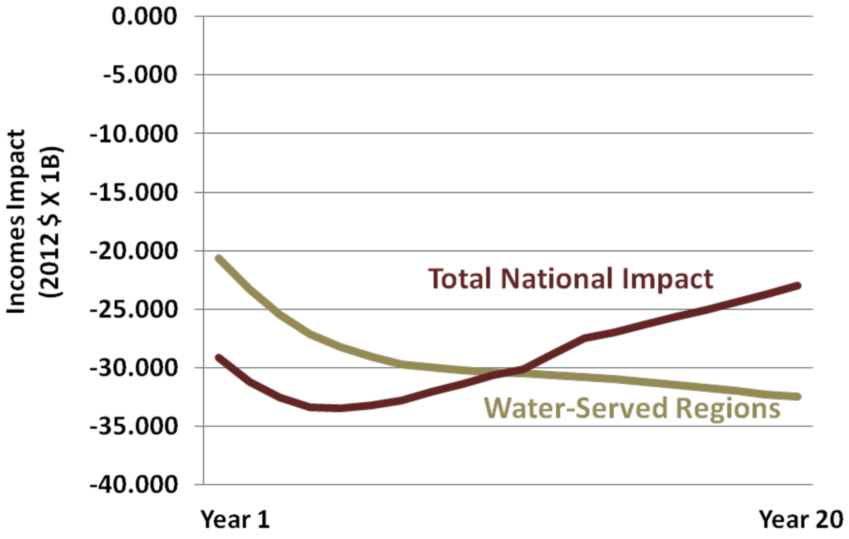
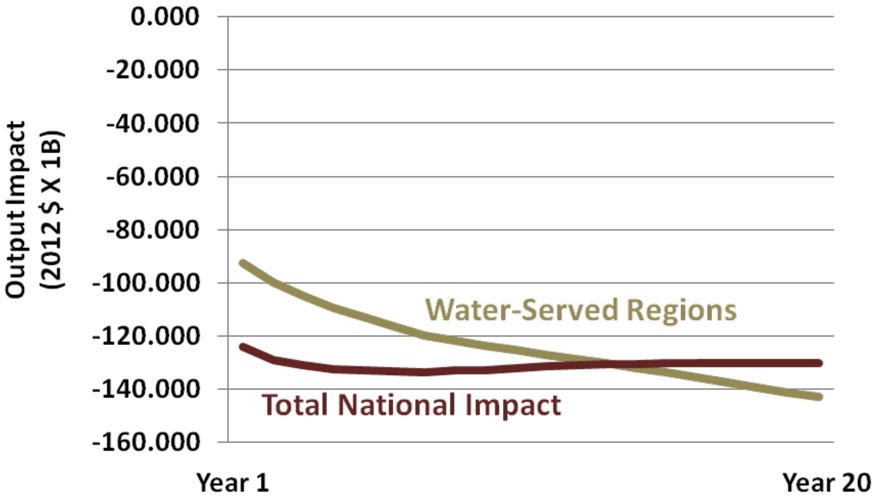


Figure 4.4 – National and Navigation Regions Output Impacts



4.3 REGIONAL DISTINCTIONS

Figures 4.5 and 4.6 depict the employment and output impacts for individual water-served regions and for the rest of the U.S. Incomes are not included because, in appearance, they are nearly identical to output. Only the scale is different.

There is an obvious homogeneity in the shapes of the individual representations for the water-served regions in both figures. This is predictable, both because of the economic simulation process in REMI and the similar economic function of commercial navigation in every region. Only the pattern for the remainder of the U.S. is materially different. This difference is discussed above in Section 4.2. Also, the general pattern of employment and of output change in each region is similar to the aggregate values discussed in Section 4.2. Essentially, a few years after the initial shock, employment begins a slow recovery in the water-served regions. The employment recovery in the remainder of the nation is much quicker and there is obviously a migration of jobs from navigation-reliant regions to other parts of the country. The pattern for aggregate output is similar except that a gradual recovery is replaced by a continued decline throughout the 20-year period.

As noted in Section 1.4, the truly interesting inter-regional difference is not in the form of the impacts, but in their magnitudes. In the cases of both employment and aggregate output, it is the Gulf Region (including the TTWW) that is hardest hit by the loss of navigation. Given the heavier annual tonnages on other waterway segments, this result is, at first, somewhat surprising. Again, repeating the explanation provided in the Executive Summary, we believe that the disproportionately (in terms of traffic) large economic impacts in the Gulf Region are attributable to (1) the relatively high commodity values of the petroleum and chemical products that dominate barge traffic in the region, (2) the fact that many petroleum refiners and chemical manufacturers have little or no viable alternative to navigation, and (3) the relative dominance of these industries within the region’s economy.

The other notable exception in the region-specific results is the relative modest economic impacts predicted for the Pacific Northwest.

Figure 4.4 – Region-Specific Employment Impacts

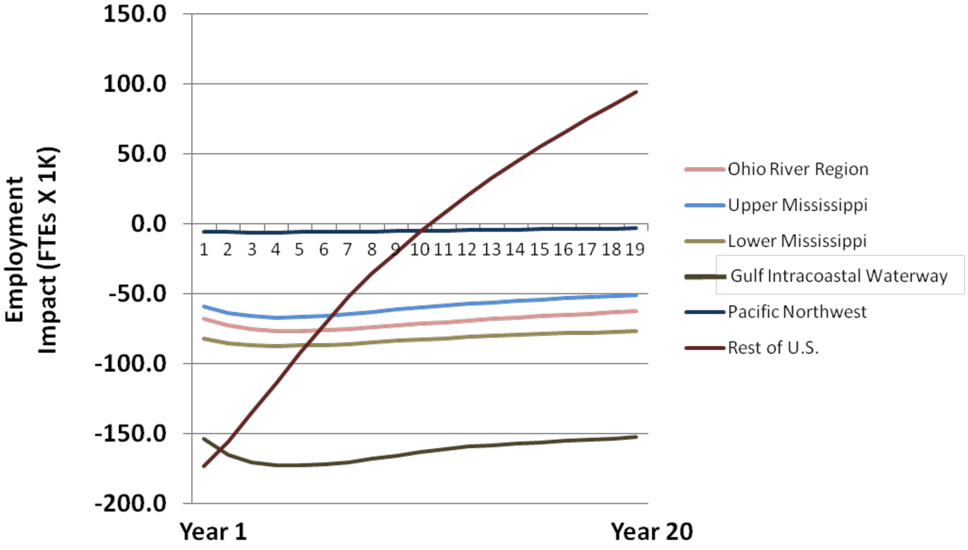
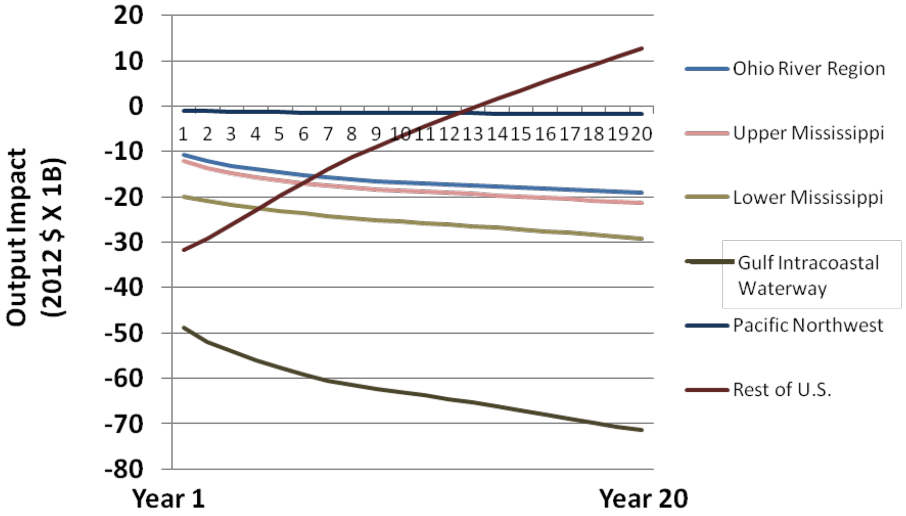


Figure 4.6 – Region-Specific Output Impacts



4.4 COMMODITY-SPECIFIC IMPLICATIONS

Industry-specific employment impacts for the first simulation year are provided in Table 4.4. Not surprisingly, these impacts are concentrated in related transportation industries, in the industries that are most barge-dependent, and in retail trade or other industries that are heavily dependent on consumer spending.

The latter of these three impacts is typical of simulations of any economy-wide contraction. Lowered levels of economic activity reduce personal incomes which, in turn, lead to immediate and obvious declines in consumer activity.

The role of incomes is also key to understanding the pronounced effects of lost navigation on farm employment. The study team, in consultation with REMI, carefully considered how to enter increased transportation costs for the movement of field crops – primarily grains and soybeans – into the simulations. Ultimately, it was decided that the burden of increased transport rates would fall most directly on farmers, so that the higher costs were entered as reduced farm incomes in the affected regions. The reduction in farm employment is a direct result. Arguably, farm households, facing these reduced incomes, would not exit, but would instead take other measures to increase household incomes. However, to do so would impose considerable hardship. The reductions predicted in agricultural employment are a measure of this distress even if farm households are not actually displaced.

Table 4.4 – Employment Changes by Region and Industry (Year 1)

REMI Industry	Ohio River	Upper Mississippi	Lower Mississippi	Gulf Intracoastal	Pacific Northwest	Rest of U.S.	Total
Retail trade	-5,048	-7,368	-5,515	-13,458	-722	-25,064	-57,175
Farm Employment	-26,284	-1,785	-19,380	-5,892	-56	-397	-53,794
State and Local Government Employment	-3,267	-4,201	-8,837	-18,094	-560	-16,217	-51,177
Construction	-3,352	-4,159	-4,820	-11,713	-388	-6,532	-30,963
Ambulatory health care services	-2,610	-3,818	-2,860	-7,597	-418	-13,373	-30,676
Administrative and support services	-2,202	-3,426	-3,078	-7,808	-275	-11,554	-28,343
Professional, scientific, and technical services	-1,946	-3,356	-1,911	-6,712	-294	-13,163	-27,382
Machinery mfg	-209	-337	-3,432	-20,438	-51	-2,903	-27,370
Wholesale trade	-1,759	-2,432	-2,729	-6,298	-213	-8,220	-21,651
Water transportation	-1,114	-523	-318	-3,068	-127	-12,596	-17,747
Food services and drinking places	-1,773	-2,311	-2,004	-5,260	-211	-4,711	-16,270
Chemical mfg	-1,137	-1,327	-3,603	-6,671	-26	-3,031	-15,795
Oil and gas extraction	-681	-269	-1,503	-4,090	-27	-7,744	-14,313
Real estate	-1,538	-1,821	-1,346	-3,747	-206	-5,488	-14,145
Private households	-800	-1,127	-1,099	-3,188	-148	-6,136	-12,497
Personal and laundry services	-931	-1,424	-965	-2,575	-122	-4,684	-10,701
Securities, commodity contracts, investments	-386	-1,352	-362	-1,295	-85	-5,995	-9,475
Management of companies and enterprises	-681	-1,308	-369	-1,258	-93	-5,606	-9,315
Fabricated metal product mfg	-664	-840	-481	-2,321	-72	-4,590	-8,968
Monetary authorities, Credit intermediation and related	-595	-1,099	-502	-1,525	-74	-4,124	-7,919
Primary metal mfg	-1,112	-594	-2,205	-1,140	-46	-1,777	-6,873
Mining (except oil and gas)	-1,191	-563	-2,252	-723	-11	-1,763	-6,502
Insurance carriers and related activities	-417	-803	-159	-548	-70	-4,468	-6,467
Scenic and sightseeing transportation	-259	-396	-147	-1,042	-76	-4,120	-6,040
Amusement, gambling, and recreation	-319	-646	-243	-754	-64	-3,104	-5,130
Agriculture and forestry support activities	-629	-241	-918	-602	-38	-2,556	-4,984
Hospitals	-559	-848	-644	-1,406	-50	-1,459	-4,965
Repair and maintenance	-450	-579	-626	-1,494	-53	-1,538	-4,740
Miscellaneous mfg	-428	-322	-525	-860	-261	-1,851	-4,246

REMI Industry	Ohio River	Upper Mississippi	Lower Mississippi	Gulf Intracoastal	Pacific Northwest	Rest of U.S.	Total
Educational services	-355	-730	-285	-886	-49	-2,387	-4,691
Utilities	-446	-616	-423	-1,181	-66	-1,472	-4,204
Membership associations and organizations	-392	-639	-425	-1,027	-38	-1,490	-4,011
Performing arts and spectator sports	-305	-501	-258	-760	-49	-2,122	-3,996
Accommodation	-281	-411	-293	-795	-51	-2,098	-3,929
Social assistance	-233	-531	-215	-504	-46	-2,387	-3,917
Food mfg	-531	-633	-288	-390	-48	-1,837	-3,727
Couriers and messengers	-281	-260	-252	-284	-38	-2,447	-3,561
Nursing and residential care facilities	-394	-569	-472	-850	-46	-1,114	-3,445
Warehousing and storage	-235	-354	-133	-230	-37	-2,435	-3,424
Petroleum and coal products mfg	-314	-171	-870	-1,548	-7	-327	-3,237
Plastics and rubber product mfg	-261	-308	-201	-499	-18	-1,609	-2,896
Telecommunications	-139	-290	-128	-372	-22	-1,519	-2,469
Nonmetallic mineral product mfg	-396	-480	-150	-296	-19	-955	-2,297
Computer and electronic product mfg	-83	-248	-21	-138	-81	-1,687	-2,258
Motor vehicles, bodies and trailers, and parts mfg	-267	-147	-75	-135	-10	-1,340	-1,973
Publishing industries, except Internet	-89	-226	-73	-160	-27	-1,173	-1,748
Waste management and remediation services	-146	-117	-123	-418	-46	-841	-1,690
Furniture and related product mfg	-122	-134	-31	-107	-16	-1,028	-1,438
Printing and related support activities	-107	-213	-82	-184	-13	-746	-1,345
Motion picture and sound recording industries	-57	-73	-14	-50	-16	-1,073	-1,282
Broadcasting, except Internet	-66	-104	-55	-164	-10	-733	-1,133
Paper mfg	-85	-117	-129	-126	-19	-611	-1,087
Support activities for mining	-43	-8	-106	-505	-1	-394	-1,058
Electrical equipment and appliance mfg	-106	-122	-81	-140	-7	-582	-1,037
Internet publishing and broadcasting; ISPs, et.	-49	-152	-44	-132	-11	-627	-1,015
Rental and leasing services	-71	-145	-224	-607	-9	57	-1,000
All Other Negatively Impacted Industries	-394	-413	-244	-720	-82	-2,192	-4,046
Other transportation equipment mfg	9	1	3	21	2	290	326
Truck transportation	659	-314	-179	2,367	59	9,944	12,536
Rail transportation	2,299	774	496	5,346	219	24,611	33,745
TOTAL	**-65,622**	**-57,526**	**-78,207**	**-147,050**	**-5,443**	**-187,083**	**-540,931**

Finally, the bottom three rows of Table 4.4 indicate first-year employment gains for three industries. These include transportation equipment, truck transportation, and railroads. This is a direct indication of the modal shift described in Section 3. Moreover, the sum of gains in rail in trucking – just over 45,000 workers – is more than twice number of navigation jobs lost. However, far from being a positive outcome, this result reflects a loss of efficiency and suggests that more than twice as much labor is needed to handle diverted barge traffic.

Additional industry-specific simulation results describing impacts on employment, incomes, and output are available for each of the 20 simulated years. While too voluminous to include, even as an appendix, these results are summarized both here and in Section 1 in an aggregated form.

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FIVE

Considering Navigation System Modernization

5.1 INTRODUCTION

Section 2 provides a description of the nation's inland navigation system as it has been treated here. This includes a summary of the more than 200 locks and dams that are used to sustain channel depths. The oldest navigation structures included in this analysis were constructed in the early 20th century. The majority of remaining system locks were constructed during the 1930s and early 1940s. Since that time, a smaller number of new locks have been added and other structures have been expanded or replaced. However, beginning in the 1970s, only a handful of major navigation projects have been undertaken each decade. As a result, compared to other forms of freight transport, the infrastructure supporting inland barge transport is relatively old.

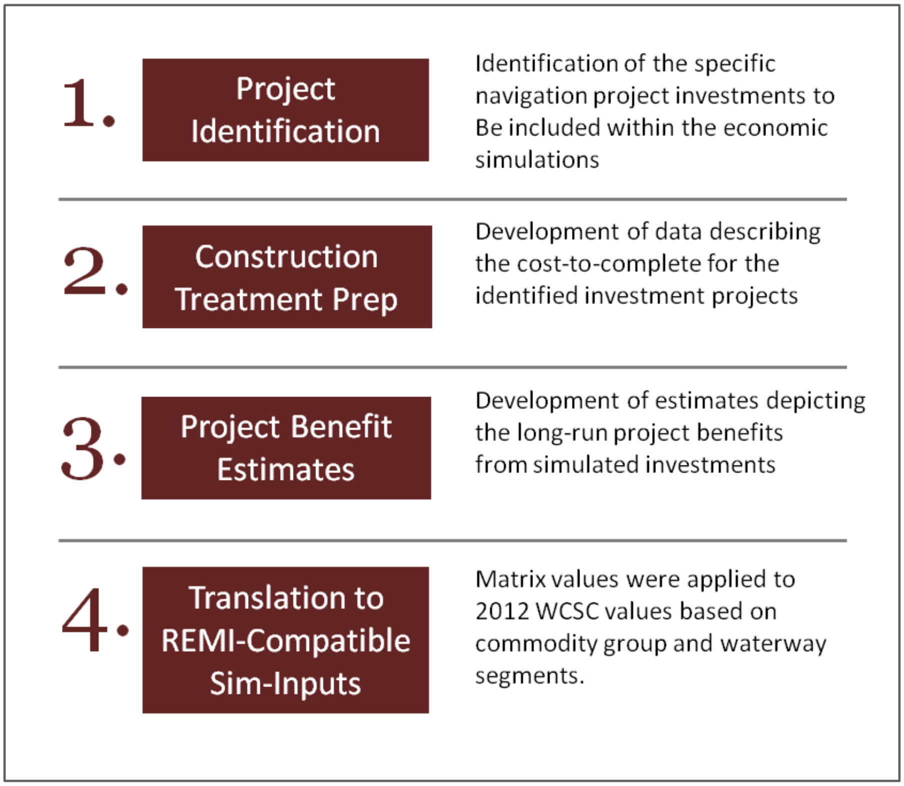
The U.S. Army Corps of Engineers is responsible for both building and maintaining most inland navigation structures and, to some degree, the effects of the advanced ages of many waterway structures have been offset by the extensive care the Corps has provided existing locks and dams. Nonetheless, there is an increasing sense that, without extensive modernization, the inland navigation system cannot continue to provide a reliable source of freight transportation capacity.

Against this background, in 2010 the Inland Waterways Users Board unanimously approved and adopted a report delivered by the joint industry/Corps team. This report was subsequently communicated by the Users Board to the current federal administration via the Assistant Secretary of the Army for Civil Works with a request that it be implemented. The report was similarly communicated to Congress with the request that Congress implement those recommendations that require legislative action.

The investment agenda proposed by the IMTS team continues to form the core focus for advocates of increased waterway investment. However, subsequent policy proposals have modified the way this agenda is used within the work presented here. First, towing companies, barge owners, shippers, and other stakeholders have voiced strong support for a measureable increase in the per-gallon tax levied against fuel purchased for use for barge transportation. Given this possibility and the role that fuel tax revenues play in navigation infrastructure financing, it is certainly possible that future waterway investments can occur as anticipated under the proposed IMTS program. This possibility is reinforced by the recent Olmsted cost-share change contained in WRRDA 2014.

Given these potential outcomes, the study team and project sponsor, together, agreed to focus the current analysis on the economic impacts attributable to accelerated investments in the IMTS projects subsequent to the Olmsted Locks and Dam. Based on these assumptions and the analytical process developed within the baseline analysis, the methodology necessary to estimate the effects of additional investment is depicted in Figure 5.1. Each component of this process is fully discussed in Section 6. However prior to providing these specifics, we turn to a short description of the institutional processes that bring about navigation project investments.

Figure 5.1 – System Modernization Process Summary



Identification of the specific navigation project investments to Be included within the economic simulations

Development of data describing the cost-to-complete for the identified investment projects

Development of estimates depicting the long-run project benefits from simulated investments

Matrix values were applied to 2012 WCSC values based on commodity group and waterway segments.

5.2 AN OVERVIEW OF NAVIGATION PROJECT PLANNING

One of the greatest challenges to effective multimodal planning lies in the disjointed way in which overall systems design unfolds. Within the U.S., distinct and often competing entities have responsibility for financing, planning, constructing and operating the nation’s modal networks. Over time, each mode develops investment processes based on industry-specific needs. Within the public sector, infrastructure needs typically reflect the concerns of users or are based on the characteristics of available data. Some of these processes also consider broader "external" impacts, but others do not.

The variety of approaches used to evaluate potential transportation investments has led to a predictable disparity in the types and scale of new infrastructure projects. Specifically, within the current context, planning guidelines for waterway investment must follow the P&G with attention to the additional guidance provided by the Council on Environmental Quality and released in 2009.[26] Highway projects are evaluated much differently under a highly varied set of standards. Further, the planning guidelines that apply to aviation projects are different from both the standards applied to proposed waterway projects and guidance used to evaluate roadway construction, so that at least three very different methodologies are used to evaluate federal transportation investments that sometimes compete for the same pool of infrastructure funds.

Among the various governmental entities that require (or *sometimes* require) the formal calculation of project benefits and costs, none is more experienced, consistent, or complete than the U.S. Army Corps of Engineers. The Corps has often required benefit- cost calculations since the late nineteenth century and has relied on a routine, prescribed set of processes since 1902. Moreover, the Corps not only plans network investments, it also builds, maintains, and operates these infrastructures. Other federal transportation agencies provide funding, but are frequently guided by regional influences within the planning and project selection processes. Further, because their programs are supported through federal funding, but not federally operated, most federal transportation administrations have only a small role in actual project construction, maintenance, or operation. If for no other reason, the uniquely federal perspective that guides Corps' infrastructure processes from project conception through retirement distinguishes the inland navigation infrastructure process.

Candidate waterway projects can emanate from a variety of sources that includes local, regional, and state jurisdictions; industrial, recreational, and agricultural users, or constituencies concerned with freight transportation. Given the number of possible projects and finite resources, the Corps must develop and follow project priorities in order to secure funding. However, all evaluations are centered on a federal system perspective.

The Corps requires study authorization and appropriations to initiate a study. This study authority allows the Corps to commit resources to determine if it is in the best interest of the federal government to proceed with a more detailed investigation. If there have been previous studies of similar proposals in the same geographic area, a new study can be authorized by a resolution from either the House Transportation and Infrastructure Committee or the Senate Environment and Public Works Committee. If not, Congress must

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[26] P&G refers to the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* See Note No. 10.

pass an Act to authorize work. After authorization, appropriations are received through annual Energy and Water Development Appropriations Acts. If a study determines that the federal government (and those on whose behalf it acts) would benefit from the proposed action, the Chief of Engineers may sign a final recommendation for the project, commonly referred to as a "Chiefs Report." Once authorized by Congress (usually in a multi-year water development bill), federal funds for project construction are sought through the annual energy and water development bills.

The Corps District in which a proposed project is located is ultimately responsible for the conduct of necessary studies. In the case of more modest projects, studies are typically performed by in-house Corps staff members. However, for large scale projects, the responsible Corps District generally relies on expertise from one or more of the Corps Centers of Expertise, the Institute for Water Resources, or from outside experts. Critical elements of the studies are also subjected to well-defined internal and external technical review processes.

In evaluating projects, the Corps must not only account for project impacts at a local level, but it must also consider its implications on the larger transportation system. Accordingly, the federal government must be able to demonstrate that national development goals will be served by developing specific waterways. The determination of federal interest requires that most civil works projects follow a multi-step planning process. This process seeks to ensure transparency, efficiency, and equity in the project formulation and selection process.

The same process is used for all new inland navigation construction projects across the United States. Once the projects are completed, the federal government accepts the role of maintaining the resulting structure in perpetuity. Considering the planning for a new project, the maintenance decision framework remains fairly straightforward. The scope of the Corps planning process is broader than other related agencies involved in transportation, as Corps projects require two different congressional authorizations. While critics argue that this may actually delay projects or result in the failure of approved projects to receive appropriations, the Corps approach helps ensure that planning documents develop in a fairly transparent manner.

5.3 THE USE OF BENEFIT-COST ANALYSIS

The Corps' use of benefit-cost analysis as a part of the project evaluation process dates to the early years of the 20th century.[27] Current benefit-cost direction, intended as guidance, is contained in the P&G approved by President Reagan in February of 1983. These replaced the Carter Administration's Principles Standards & Procedures (PS&P), which had been

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[27] Hammond, Richard J., "Convention and Limitation in Benefit-cost Analysis," *Natural Resources Journal* (6), 195-222, 1966.

promulgated as regulations in 1980. The 1983 P&G remain in effect, although section 2131 of the Water Resources Development Act of 2007 (P.L . 110-114) directed the Secretary of the Army to issue revisions to the P&G for use by the Secretary in planning and implementing water resources projects.

Like the PS&P, the 1983 P&G contain four analytical accounts, to be evaluated and utilized as appropriate: National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE), with the NED account mandatory and other information that is required by law or has a material bearing on the decision-making process included in the other accounts or in some other appropriate format. The stated federal objective of the 1983 P&G "is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements."

From the standpoint of economic theory, the reliance of NED benefits as the only legitimate benefit measure for inclusion in benefit-cost calculations is widely accepted. These benefits represent net, economy-wide efficiency gains that are otherwise unattainable without the subject investment. However, the *measurement* of NED benefits has not been without controversy.

In the early 1980s, the Corps concentrated its inland navigation efforts on construction of the Tennessee-Tombigbee Waterway (TTWW), which was completed in 1984. Beginning in 1987, following passage of WRDA 86, the Corps began work on several major lock expansion projects that, by 2009, consumed virtually all of the then-existing Trust Fund monies. In the middle 1990's the St. Louis District of the Corps began to examine the feasibility of navigation improvements on the upper Mississippi and Illinois Rivers.

The upper Mississippi studies relied heavily on lock capacity models wherein tows remained on the river in simulation exercises until congestion, brought on by assumed traffic growth, raised transportation rates sufficiently for traffic to shift modes to the next least costly alternative (which is generally rail transportation). These models typically assumed a perfectly "inelastic" response to rising barge transportation costs. Under such scenarios, the quantity of waterway traffic is assumed to not change until the diversion threshold is reached. At that point, the whole of river traffic diverts.

In 2000, a Corps economist working on the upper Mississippi River navigation improvement study argued for a new way to generate traffic forecasts.[28] Dr. Don Sweeney laid out his position in a paper later published by the Corps' Navigation Economic Technologies (NETS) program. Sweeney critiqued the demand modeling scenarios

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[28] Randall, Gretchen, "Corps of Engineers faces whistleblower charges," *Environment and Climate News*, May 2000.
http://www.heartland.org/full/9764/Corps_of_Engineers_faces_whistleblower_charges.html

described above, calling the resulting treatment of shipper demands an “unrealistic ‘all or nothing’ shipper’s modal choice decision in the model framework.”[29] If one assumes that shipper volumes are sensitive to rising transportation rates as the rates’ rise toward the alternative price, the resulting calculations produce different results in which system benefits are smaller[30].

The policy response resulted in a five-year-long intensive re-examination of the ways that shipper responses to changing transportation rates are measured and subsequently incorporated into the system models that identify NED project benefits. This outcome has shaped the course of the Corps’ analyses since that time and has direct implications for the methods used in the current study.

In the 2007 Water Resources Development Act[31], Congress instructed the Secretary of the Army to develop a new set of governing principles and application guidance for use in evaluating water resource projects. Further, the Administration issued Executive Order 13563, *Improving Regulation and Regulatory Review*, that laid out the goal of parity in the national objectives of public health, welfare, safety and the environment, while promoting economic growth, innovation, competitiveness and job creation[32]. The Administration plans to expand the new P&G to all federal agencies that undertake water projects, in addition to the four federal agencies that are currently subject to the P&G. The revised P&G were released by the Council on Environmental Quality in 2009 and received generally unfavorable reviews by the National Academy of Sciences in 2010, and Congress.[33]

Regardless of study scale or duration, the Corps’ decision-making processes rests on the calculation of benefit-cost ratios that compare the incremental benefits and costs of proposed scenarios to the benefits and costs under the status quo. Cost calculations focus on the present value of construction costs and incremental differences in operating costs. Benefits are restricted to NED benefits, which generally represent net economic efficiency gains and exclude simple economic transfers between economic agents. Consequently:

> Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan; the value of output resulting from external

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[29] Sweeney, Don, “A Summary of Consideration and Recommendations for Incorporating the Results of “Shippers’ Responses to Changes in Transportation Costs and Times: The Mid-America Grain Study” into the Army Corps of Engineers ESSENCE Model, Prepared for the U.S. Army Corps of Engineers, July 2005 and made available on the NETS Web page.

[30] Sweeney, page 1.

[31] 2007 Water Resources Development Act, Section 2031.

[32] National Waterways Conference, letter to Mr. Cass R. Sunstein, April 4, 2011.

[33] See, P&G, p. 8.

economies caused by a plan; and the value associated with the use of otherwise unemployed or under-employed labor resources.[34]

5.4 “NED” BENEFITS, “RED” BENEFITS AND ECONOMIC IMPACT ANALYSES

The notion of “benefit” rests on a fundamental tenet economists refer to as “local non-satiation” or, quite simply that *more* is better. The fundamental difference between the NED benefits that are valued in benefit-cost calculations and the Regional Economic Development (RED) benefits that play no real role in a national-level policy decisions is the source of *more*.

If an economic event affects productivity so that, on net, the same amount of resources can be used to produce a greater quantity of welfare-enhancing goods and services, then the change is judged to have improved economic efficiency and the incremental increase in the value of goods and services represents an economy-wide (or national) benefit. Alternatively, if an economic event simply redirects an unchanged amount of value from one group to another, the outcome is viewed as an economic transfer that has no meaningful impact on the overall, aggregate well-being. In this latter case, the gains to the winners in this transfer are *regional benefits* and, by implication, some other group has sustained a corresponding *regional loss*.

While this distinction seems simple enough in theory, actually dividing complex and interrelated, real-world economic change into the appropriate efficiency and transfer groupings is difficult. Further, the political force exercised by winners and losers in a regional transfer scenario is often not equal, particularly if one group is more geographically, economically, or socially concentrated than the other. There are powerful incentives and often a corresponding ability to misrepresent the nature of specific “benefits.”

Economic *impact* analyses simulate the region-wide effects of *any* economic change, regardless of whether its source is an efficiency gain (NED benefit) or an economic transfer (RED benefit). Moreover, when a root economic change leads to simultaneous efficiency gains *and* economic transfers, impact modeling will not necessarily distinguish between the two very different causes as contributors to changed regional outcomes even though it is theoretically possible to do so.

While perhaps tiresome, describing the distinction between NED and RED benefits and their role in generating economic impacts is essential to understanding the value of the methodology applied in the current work. The methodology adopted in the current analysis specifically identifies the NED benefits associated with more efficient transportation and

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[34] See, “A Review of Proposed Revisions to the Federal Principles and Guidelines Water Resources Document,” National Academies Press, Washington, DC, 2010

resulting shipper savings, then uses these benefits as the core impacts that drive the broader impact analysis.

5.5 A NOTE ON FUNDING

Beginning with the Water Resources Development Act of 1986, expenditures for construction and major rehabilitation projects on inland waterways have been cost-shared on a 50/50 basis between the federal government and commercial users through the Inland Waterways Trust Fund (IWTF). Operations and maintenance costs for inland waterways are a 100% federal responsibility and are funded through the appropriation of general funds.

IWTF revenues are derived through the imposition of a user fuel tax on major waterway segments (fuel tax waterways). This tax is currently levied at a rate of 20 cents per gallon and results in annual industry-generated revenues of roughly $80 million. The reported IWTF balance at the end of fiscal 2013 stood at $33.8 million.

In general, there is consensus among Congress, the Executive Branch, the Corps, and waterway users that revenues generated by the current fuel tax are not sufficient to adequately fund forward-looking waterway infrastructure needs. However, there is no agreement regarding remedies. Over the past decade, administrations of both political parties have called for lockage fees to either supplement or replace fuel tax revenues. For their part, users have rejected the suggestion of lockage fees in favor of an increased fuel tax levy. [35]

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[35] For a fairly comprehensive treatment of the investment funding issue see, Charles V. Stern, “Inland Waterways: Recent Proposals and Issues for Congress,” Congressional Research Service, 7-5700, May 3, 2013.

SIX

Modernization Impact Methodology

6.1 OVERALL SCENARIO DEVELOPMENT

At the core of our work, there is a desire to simulate commercial outcomes in ways that best reflect real-world economic decision-making and interactions. This means linking freight transportation policy to changes in shipper costs, then tracing successive market interactions through their various iterative twists and turns. In assessing the impacts of the existing system, the seed change that drove subsequent impacts was an increase in freight costs owing to navigation's elimination as a freight alternative. This allowed the team to evaluate the effects of the system that is currently in place. Evaluating the effects of modernization also involves manipulating shipper costs. This time, however, costs will be *decreased* to reflect the influence of new navigation investments. Following this course required the sequential execution of four tasks. These include:

1. Identifying specific investments to be included in the analysis;
2. Developing an implementation scenario that considers both the costs and timing of construction activities;
3. Identifying the affected freight traffic and extent to which the costs for its movement would change; and
4. Converting all construction and freight cost information to a form that is compatible with REMI.

6.2 PROJECT IDENTIFICATION, INVESTMENT TIMING AND CONSTRUCTION COSTS

The current analysis considers the effects of the set of projects that were drawn directly from the investment agenda developed within the IMTS plan. These investments reflect lock rehabilitations, lock replacements, and, in some cases, expanded lock facilities. The geographic locations of these projects and their relationships to the REMI simulation regions established in the estimation of existing system impacts are depicted earlier in

Section 1. Specific projects, along with the estimated costs *used here*, are summarized in Table 6.1.[36]

As Table 6.1 indicates, neither the construction activity nor the long-run commercial implications of Olmsted Locks & Dam are included in the current analysis. The only actual assumption regarding Olmsted that is necessary to the current simulations is that navigation capacity on the lower Ohio will be preserved in a way that does not negatively impact barge traffic volumes on that waterway or elsewhere on the inland system. *How* that assumption is satisfied does not affect this work.

In addition to project identification, the IMTS provides a timeline for investments based on what was believed to be achievable construction funding. This timeline included the potential impacts of increased fuel tax revenues. Nonetheless, it extends over several decades, so that the attendant economic impacts would be scattered across time.

Adhering to this sort of timeline, here, would seriously impair our ability to provide a generalized view of reinvestment's economic impacts. Moreover, the study team had the luxury of uncoupling investment and attendant efficiency gains from fiscal constraints. Consequently, we adopted an implementation scenario that departs vigorously from the IMTS timeline. Specifically, we assume that all projects are started (or resumed) at the beginning of a 10-year construction period and that all are completed and open to use at the end of that period. The 10-year construction period still requires that future monetary outcomes be discounted to attain present values, but the effects of that discounting are reasonably minimized and, more importantly, are made uniform for all system improvements.

6.3 ESTIMATES OF SHIPPER COST SAVINGS

Again, the seed change used to generate the REMI simulation is a change in the difference between the currently available water-inclusive cost and the water route costs that *would be* incurred as a result of the subject waterway investments.

As noted in Section 1, CTR staff consulted with the Corps Huntington District in developing average annual benefits estimates for each of the IMTS projects. Where data were not available in Chief's reports, the assumption was made that all had benefit-cost ratios greater than one and would therefore have benefits slightly greater than project costs presented in the IMTS report cited above. The resulting benefits estimates were aggregated based on project location and the REMI regions as defined in Section 1 and were then made available

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[36] The costs of completing the various projects considered here are constantly monitored and, when appropriate, are modified. Thus, *current* cost estimates for projects may vary from those used within our analysis.

to the study team for use here. These values, provided in Table 1.5, are reproduced here as Table 6.2.

As a final note, the analysis required that shipper savings be available in commodity-specific aggregations. Unfortunately, this level of detail was unavailable from the Corps. As a consequence the study team was forced to disaggregate the shipper savings based on the 2012 commodity tonnages observed on each waterway segment. This implies a constant level of per-ton savings in response to the navigation investments. To the extent that barge rates closely adhere to incurred costs this assumption is wholly tenable. However, if the downstream demand characteristics of the shipped commodity play a role in the formation of barge rates (as they do in rail), then the required assumption is more troublesome.

Table 6.1 – Study Projects and Estimated Completion Costs

	Project	Region	D/L	Type	Amount ($ X 1 Million
1	Locks 2,3 4 Monongahela Total	OR			$1,076.5
2	Chickamauga Lock	OR	L	Const	$189.2
3	Kentucky Lock addition	OR	L	Const	$399.9
4	Greenup Total	OR			$463.2
5	Meldahl	OR	D	Rehab	$69.7
6	Montgomery Dam S.	OR	D	Rehab	$245.2
7	Marmet LD	OR	D	Rehab	$49.5
8	Willow Island Ohio	OR	D	Rehab	$9.8
9	John T. Myers rehab	OR	D	Rehab	$51.8
10	Emsworth-safety	OR	D	Rehab	$19.7
11	Markland-major rehab	OR	L	Rehab	$5.4
	Ohio River TOTAL				**$2,579.9**
12	GIWW High Island to Brazos River	GIWW	C	Const	$18.6
13	Inner Harbor	GIWW	L	Const	$1,325.8
	Gulf Intracoastal TOTAL				**$1,344.4**
14	Joe Hardin Arkansas	LM	D	Rehab	$14.7
15	No 2 lock Arkansas	LM	L	Rehab	$24.6
	Lower Mississippi TOTAL				**$39.3**
16	Lower Monumental (Wash. St)	PNW	L	Rehab	$28.7
	Pacific Northwest TOTAL				**$28.7**
17	Lagrange-Illinois River	UM	L	Const	$453.1
18	LD 22 Upper Mississippi	UM	L	Const	$300.4
19	LD 24 Upper Mississippi	UM	L	Const	$473.2
20	LD 25 Mississippi	UM	D	Rehab	$28.9
21	LD 25 Upper Mississippi	UM	L	Const	$456.8
22	Mel Price U. Miss	UM	L	Rehab	$85.5
23	Thomas Obrien Ill WW	UM	L	Rehab	$25.1
	Upper Mississippi TOTAL				**$1,369.9**
	ALL PROJECTS TOTAL				**$5,362.2**

Table 6.2 –Average Annual Project Benefits
(2012 Dollars in Millions)

Region	Average Annual Direct Project Benefits (Over Project Life) (Millions)
Ohio River	$474.6
Upper Mississippi	$235.9
Lower Mississippi	$22.7
Gulf Intracoastal	$165.7
Pacific Northwest	$3.3
Total	**$902.2**

6.4 INTEGRATING INPUTS INTO THE REMI FRAMEWORK

The final steps of introducing the construction measures and shipper savings data into the REMI platform were nearly identical to those described in Section 3.5.The one notable exception is that the current analysis did not require any manipulations to manually account for transportation mode shifts.

Readers will recall that, when the barge alternative was eliminated from the modeling work, the study team manually increased the use of rail transport and trucking to reflect the demand increases attributable to diverted barge traffic. In the current exercise, there are no such diversions. To the extent that lower production costs (owing to more favorable barge rates) induce greater output volumes from water-served producers, REMI should increase transportation usage. Moreover, given the nature of the underlying scenario, the study team infers that a measurable portion of that increased transportation would involve barge movements. The study team did, in fact, confirm that the REMI output files included an increase in freight transportation activity. However, no attempt was made to disaggregate this increase by freight mode.

SEVEN

System Modernization Simulation Results

7.1 AGGREGATE RESULTS

Section 1.8 introduces and summarizes the REMI results derived by simulating the economic effects of increased inland navigation system investment. Aggregate employment, income, and output time paths are depicted in Figures 1.7 – 1.9. The regionally disaggregated data supporting the Section 1 summaries is presented here in tables 7.1 – 7.3.

In combination these data and associated figures tell a story that is completely consistent with economics-based expectations. As described in Section 3, the modeled investments were introduced through constant annual expenditures over a 10-year construction period. Even so, the impacts on employment, incomes, and output are, by no means, constant. Instead, the results predict patterns in which early expenditures are weighted toward labor and the production of construction-related capital. Toward the end of the construction period, the productive effects of the new capital are realized, so that output continues to increase, while actual labor usage declines somewhat compared to its early period peak.

The post-construction impacts of the new navigation investments follow a similar course. There is an early and obvious increase in employment owing to more affordable barge transportation. And, this increased employment remains fairly constant over the forecast period. However, as waterway users avail themselves of the increased navigation capacity, there is a notable increase in output and in worker compensation, suggesting that labor has been made more productive by the navigation investment and is, therefore, rewarded more liberally. This is, in fact, a textbook example of investment-led efficiency gains and the very real economic benefits these efficiencies create.

Table 7.1 – Waterway Investment Impacts on Employment

	Simulation Region						
Year	Upper Mississippi	Lower Mississippi	Ohio River	Gulf Intracoastal	Pacific Northwest	Rest of United States	Total
INVESTMENT / CONSTRUCTION PERIOD							
1	3,940	197	4,936	2,375	76	3,712	15,236
2	3,877	192	4,908	2,387	69	3,424	14,857
3	3,777	183	4,802	2,344	61	3,136	14,303
4	3,648	172	4,650	2,269	54	2,832	13,625
5	3,518	161	4,499	2,191	47	2,528	12,944
6	3,396	150	4,355	2,110	42	2,224	12,277
7	3,284	138	4,217	2,032	36	1,920	11,627
8	3,196	129	4,109	1,970	31	1,664	11,099
9	3,122	121	4,012	1,918	28	1,472	10,673
10	3,062	113	3,933	1,871	25	1,296	10,300
POST-INVESTMENT IMPROVEMENT IMPACTS							
11	1,868	419	1,590	756	66	4,416	9,115
12	2,456	536	2,440	972	69	4,384	10,857
13	2,894	613	3,133	1,139	67	4,144	11,990
14	3,204	656	3,675	1,262	60	3,648	12,505
15	3,428	678	4,094	1,350	52	3,040	12,642
16	3,588	686	4,405	1,410	42	2,544	12,675
17	3,692	687	4,633	1,447	34	2,000	12,493
18	3,754	680	4,790	1,466	25	1,504	12,219
19	3,800	671	4,890	1,469	17	1,056	11,903
20	3,816	660	4,947	1,465	10	640	11,538
21	3,820	649	4,974	1,448	5	336	11,232
22	3,822	639	4,977	1,437	0	128	11,003
23	3,818	630	4,967	1,426	-4	-96	10,741
24	3,800	622	4,939	1,409	-9	-320	10,441
25	3,790	613	4,915	1,395	-13	-528	10,172
26	3,786	607	4,899	1,385	-15	-688	9,974
27	3,780	602	4,878	1,376	-19	-864	9,753
28	3,788	598	4,863	1,373	-22	-1,024	9,576
29	3,792	598	4,848	1,367	-24	-1,152	9,429
30	3,810	597	4,836	1,368	-28	-1,232	9,351
TOTAL	**105,326**	**13,997**	**132,114**	**48,187**	**782**	**46,144**	**346,550**

Table 7.2 – Waterway Investment Impacts on Incomes
(2012 Dollars X 1 Million)

	Simulation Region						
Year	Upper Mississippi	Lower Mississippi	Ohio River	Gulf Intracoastal	Pacific Northwest	Rest of United States	Total
INVESTMENT / CONSTRUCTION PERIOD							
1	224.4	8.8	241.9	136.4	3.4	195.0	809.9
2	241.5	9.1	264.7	149.8	3.2	189.0	857.3
3	251.6	9.3	278.1	157.4	3.0	177.0	876.4
4	256.4	9.1	285.4	161.2	2.7	167.0	881.8
5	258.3	8.9	289.1	162.3	2.4	154.0	875.0
6	257.3	8.6	289.9	161.9	2.2	141.0	860.9
7	255.5	8.0	289.4	160.5	1.9	125.0	840.3
8	254.6	7.7	288.7	159.3	1.7	112.0	824.0
9	253.9	7.3	288.6	158.1	1.5	97.0	806.4
10	253.4	6.9	288.4	157.3	1.3	87.0	794.3
POST-INVESTMENT IMPROVEMENT IMPACTS							
11	199.5	27.9	173.6	91.8	4.4	243.0	740.2
12	235.3	36.0	215.4	103.0	4.9	270.0	864.6
13	266.5	41.9	256.4	113.8	4.9	265.0	948.5
14	293.1	46.2	294.0	123.5	4.8	251.0	1,012.6
15	315.8	49.2	327.1	131.9	4.5	220.0	1,048.5
16	335.3	51.3	355.8	138.6	3.9	188.0	1,072.9
17	350.4	52.9	380.1	144.1	3.4	158.0	1,088.9
18	363.5	53.9	400.4	148.3	3.0	116.0	1,085.1
19	374.8	54.4	417.1	151.6	2.3	78.0	1,078.2
20	384.6	54.8	431.5	154.3	1.9	46.0	1,073.1
21	392.9	55.1	442.6	155.6	1.4	16.0	1,063.6
22	401.0	55.4	452.8	157.5	1.0	-8.0	1,059.7
23	408.8	55.6	460.5	159.5	0.5	-30.0	1,054.9
24	415.8	56.1	468.5	160.6	0.1	-60.0	1,041.1
25	423.0	56.5	476.6	162.9	-0.3	-86.0	1,032.7
26	431.3	56.9	484.9	164.4	-0.7	-112.0	1,024.8
27	439.0	57.4	493.1	167.0	-1.2	-138.0	1,017.3
28	448.8	58.1	501.9	169.8	-1.6	-160.0	1,017.0
29	458.0	59.1	511.0	172.3	-1.9	-180.0	1,018.5
30	468.5	60.1	520.4	175.1	-2.5	-204.0	1,017.6
TOTAL	**9,912.8**	**1,122.5**	**10,867.9**	**4,509.8**	**56.1**	**2,317.0**	**28,786.1**
PV (5%)	4,606.4	447.5	5,029.3	2,282.2	36.4	1,819.9	14,221.7

Table 7.3 – Waterway Investment Impacts on Output
(2012 Dollars X 1 Million)

	Simulation Regions						
Year	Upper Mississippi	Lower Mississippi	Ohio River	Gulf Intracoastal	Pacific Northwest	Rest of United States	Total
INVESTMENT / CONSTRUCTION PERIOD							
1	565.3	31.5	590.0	350.4	11.7	670.0	2,218.9
2	563.5	31.1	592.8	355.4	10.6	624.0	2,177.4
3	553.8	29.9	584.3	351.5	9.6	576.0	2,105.1
4	537.3	28.3	568.8	341.5	8.3	522.0	2,006.2
5	520.3	26.7	551.9	330.5	7.1	464.0	1,900.5
6	502.8	25.0	535.0	318.5	6.1	408.0	1,795.4
7	487.0	23.1	519.5	307.0	5.0	352.0	1,693.6
8	474.5	21.7	506.8	297.3	4.1	308.0	1,612.4
9	464.3	20.5	496.0	289.0	3.5	270.0	1,543.3
10	455.8	19.3	487.3	282.3	2.9	238.0	1,485.6
POST-INVESTMENT IMPROVEMENT IMPACTS							
11	365.3	70.4	323.4	177.8	10.6	754.0	1,701.5
12	516.0	96.4	526.9	249.3	12.1	766.0	2,166.7
13	638.8	115.6	699.5	307.8	12.7	742.0	2,516.4
14	738.8	129.6	843.5	354.0	12.4	676.0	2,754.3
15	821.0	139.6	963.8	390.8	11.8	596.0	2,923.0
16	891.5	147.4	1,063.3	420.0	10.9	520.0	3,053.1
17	948.8	153.6	1,145.3	443.0	10.1	444.0	3,144.8
18	997.0	158.1	1,212.0	461.0	9.4	368.0	3,205.5
19	1,039.5	161.7	1,267.5	475.5	8.4	308.0	3,260.6
20	1,077.5	164.8	1,314.0	486.8	7.8	248.0	3,298.9
21	1,112.0	167.5	1,352.8	496.0	7.5	212.0	3,347.8
22	1,145.0	170.4	1,386.5	505.5	7.3	184.0	3,398.7
23	1,176.0	173.3	1,415.5	514.5	7.0	164.0	3,450.3
24	1,202.5	175.8	1,441.0	522.0	6.8	140.0	3,488.1
25	1,230.0	178.6	1,465.8	529.8	6.6	120.0	3,530.8
26	1,258.5	181.7	1,490.0	538.0	6.6	112.0	3,586.8
27	1,286.5	184.6	1,513.5	547.0	6.3	92.0	3,629.9
28	1,317.0	188.0	1,537.8	556.0	6.4	92.0	3,697.2
29	1,347.0	191.9	1,561.3	565.3	6.4	84.0	3,755.9
30	1,378.5	195.8	1,585.3	575.3	6.1	88.0	3,829.0
TOTAL	**25,611.8**	**3,401.9**	**29,541.1**	**12,338.8**	**242.1**	**11,142.0**	**82,277.7**
PV (5%)	11,251.2	1,340.6	12,728.3	5,784.7	127.2	6,658.7	37,890.7

7.2 REGIONAL VARIATIONS IN SIMULATION RESULTS

In addition to showing aggregate results, Tables 7.1-7.3 provide a detailed depiction of regional variations in the estimated impacts of additional waterway investments. These regional differences are illustrated graphically in Figures 7.1-7.3.

To some extent, these results are as expected. The aggregate pattern of continually increasing incomes and output, along with relatively flat post-construction employment, is evident within each of the individual regions. Again, this combination represents a desirable outcome in which the cost savings attributable to improved navigation infrastructure lead to ever-increasing labor productivity that is rewarded through higher compensation.

The regional results also suggest that the greatest rewards to investment would be in the Ohio River and upper Mississippi basins. This result also makes sense. First, these are the basins with the largest number of lock and dam projects. Therefore, improved system performance would be expected to generate relatively larger shipper savings in those regions. More importantly, in the Ohio basin, much of the traffic that originates there stays there, so that overall shipment costs are not as often influenced by system performance outside the region. Finally, in the case of the upper Mississippi, the importance of grain as a waterborne commodity, coupled with the way the current study links shipping costs to farm incomes, captures the importance of available navigation to the agricultural community.

Figure 7.1 – Regional Variations in Employment Impacts

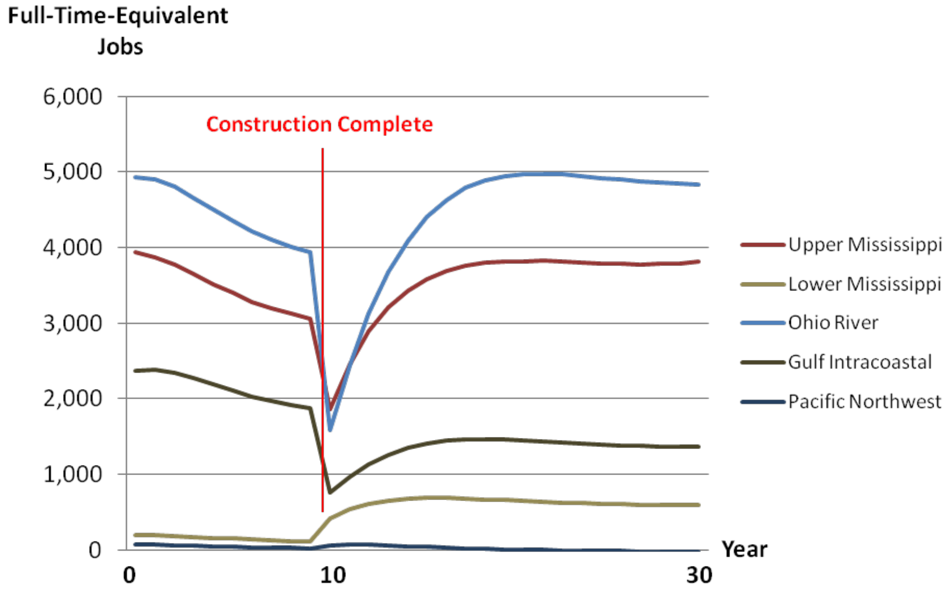


Figure 7.2 – Regional Variations in Income Impacts

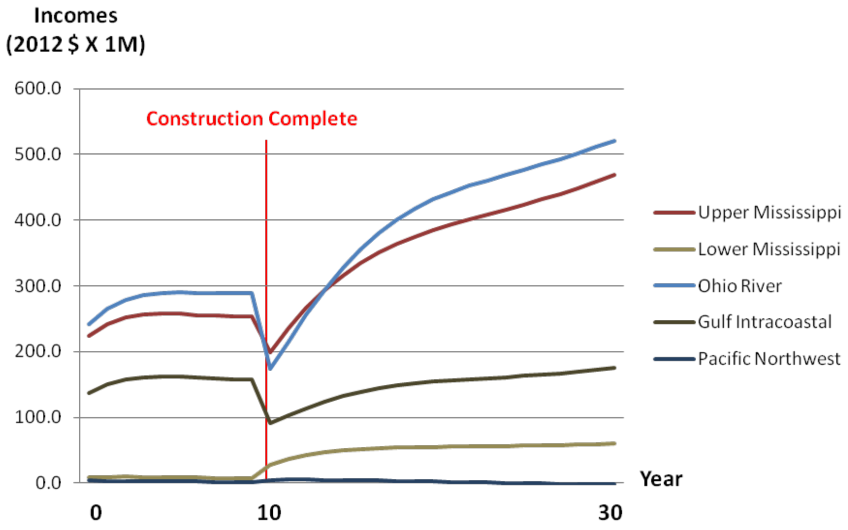
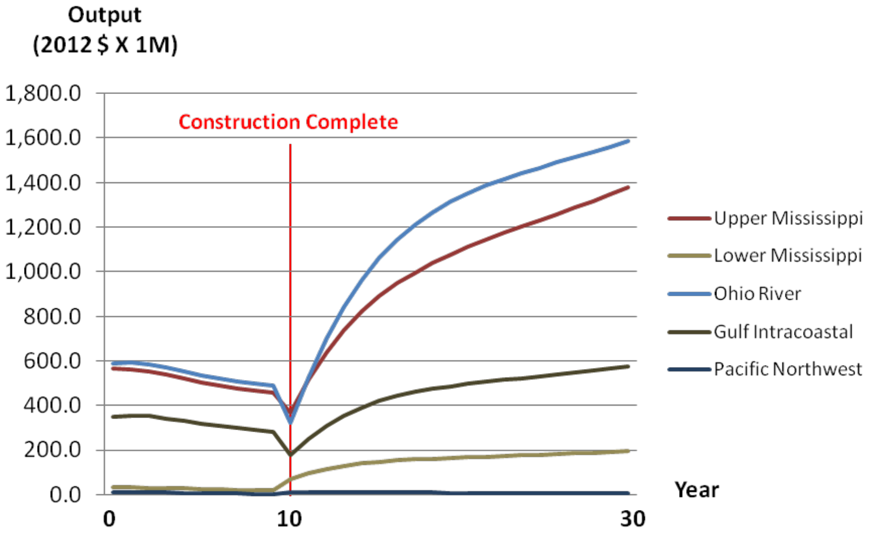


Figure 7.3 – Regional Variations in Output Impacts



There are three additional points worth noting with regard to the region-specific outcomes. First, as with the baseline case developed earlier in the study, the economy of the Pacific Northwest seems immune to changes (good or bad) in the cost and availability of *inland* navigation. We can offer no explanation for this finding, but believe it is worthy of further inquiry. Second, while there is clearly a correlation between the amount of construction spending and the related benefits realized in the post-construction period, this relationship is, by no means, complete in its explanatory power. For example, in the lower Mississippi basin, where post-construction benefits are anticipated to be low (due to new system efficiencies elsewhere) they are still robust. The same point also emerges through a comparison of the upper Mississippi and Ohio River basins. In this case, the projected investments are very similar in magnitude, but the impacts are measurably greater in the Ohio's region. Finally, while it is not illustrated in the figures, Tables 7.1 – 7.5 make it clear that efficiency gains attributable to inland navigation investments can redirect economic activity from non-water-served regions to those regions with access to commercial navigation. Thus, the relationship between navigation and economic growth observed in the analysis appears to be symmetrical.

7.3 INDUSTRY SPECIFIC RESULTS

The simulations actually capture two distinct sets of activities in each of the waterway regions. The first 10 years simulate the regional impacts of significant federal infrastructure investments and resulting construction expenditures. For Year 11 and beyond, the simulations measure the effects of lowered user costs attributable to the waterway improvements.

Tables 7.4 and 7.5 segregate industry specific changes in employment based on the construction / post-construction dichotomy. Each table provides two annual snapshots of regional employment during both the "construction" and "post-construction" phases of the analysis.

The industrial employment pattern during the construction phase is precisely what would be predicted: a heavy emphasis on construction trades and a corresponding increase in consumer-oriented economic activity. However, the post-construction employment pattern is somewhat surprising. Rather than predicting a strong employment uptick in the industries that are directly dependent on barge transportation, the REMI simulations suggest employment patterns that are consistent with much more broadly-based economic growth, particularly in the construction and professional services sectors. By appearances, the more modest increases in manufacturing and resource sector employment associated with less expensive barge transport seem to induce a much broader regional economic surge. At present, we can offer no precise explanation for this result.

Table 7.4 – Construction Phase Employment for Top 10 Affected Industries
(Ranked High to Low by Total)

REMI Industry	Ohio River	Upper Mississippi	Lower Mississippi	Gulf Intracoastal	Pacific Northwest	Rest of U.S.	Total
Year-1 (First Year of Construction Phase)							
Construction	3,090	2,045	36	1,248	27	257	6,703
Retail trade	353	311	15	182	5	261	1,126
State and Local Government Employment	302	258	19	168	6	299	1,052
Professional, scientific, and technical services	148	185	9	96	5	396	839
Administrative and support services	135	146	14	89	3	274	661
Ambulatory health care services	146	131	8	87	3	174	548
Wholesale trade	91	92	6	50	2	121	363
Food services and drinking places	99	92	4	55	1	65	316
Real estate	53	50	3	33	1	83	223
Private households	42	36	5	38	1	93	215
Year-10 (Last Construction Year)							
Construction	2,763	1,813	30	1,111	24	220	5,961
Retail trade	246	214	6	128	-1	-4	589
Professional, scientific, and technical services	74	121	8	68	2	294	567
State and Local Government Employment	232	192	7	126	-1	-3	554
Administrative and support services	67	86	10	55	1	161	380
Ambulatory health care services	84	77	4	52	1	86	304
Food services and drinking places	126	111	-1	66	-3	-126	173
Wholesale trade	62	57	3	33	0	13	166
Fabricated metal product manufacturing	19	25	3	15	0	51	114
Truck transportation	10	17	5	10	1	67	109

Table 7.5 – Post-Construction Phase Employment for Top 10 Affected Industries (Ranked High to Low by Total)

REMI Industry	Ohio River	Upper Mississippi	Lower Mississippi	Gulf Intracoastal	Pacific Northwest	Rest of U.S.	Total
Year-21 (10th SS Benefits Year)							
Construction	1,153	545	114	228	4	-40	2,004
Retail trade	491	381	64	148	4	145	1,234
Professional, scientific, and technical services	421	378	44	118	2	209	1,171
State and Local Government Employment	424	329	75	141	0	-81	888
Administrative and support services	290	285	50	96	2	140	862
Ambulatory health care services	243	225	38	93	5	192	796
Wholesale trade	131	102	17	52	2	75	379
Food services and drinking places	310	203	27	75	-6	-315	295
Private households	37	40	11	28	2	138	256
Securities, commodity contracts, investments	28	94	9	16	1	98	245
Year 31 (20th SS Benefits Year)							
Construction	973	510	94	198	0	-270	1,506
Professional, scientific, and technical services	504	437	48	132	0	126	1,246
Retail trade	464	345	55	131	0	-45	950
Administrative and support services	331	327	54	101	0	58	871
State and Local Government Employment	408	335	72	130	-2	-133	811
Ambulatory health care services	284	260	39	104	1	-4	684
Wholesale trade	132	94	15	53	1	29	324
Securities, commodity contracts, investments	28	98	9	15	1	75	225
Food services and drinking places	312	196	25	67	-7	-387	205
Private households	33	36	9	24	1	94	197

7.4 SIMULATION RESULTS SUMMARY

Public discussions often focus on the job growth associated with policy options. Economists, however, are motivated by efficiency gains and economic growth. The REMI simulation results presented here suggest that reinvestment in inland navigation capacity can yield both.

For the regions in question, the permanent addition of 12,000 to 15,000 highly compensated full-time jobs is sure to garner notice. However, from an economic standpoint it is the impact that modernized navigation infrastructure can have on productivity, ongoing output growth, and the rewards paid to labor that are most remarkable. As Table 7.3 suggests, the real annual growth in output incremental to improved navigation infrastructure begins at roughly $1.8 billion and grows at roughly 3.3% per year over the 20 year period considered here. Ultimately, the REMI simulations suggest that the 20-year sum of output growth would exceed $82 billion. Even with a real discount rate of five percent, this suggests the present value of incremental output growth would be nearly $38 billion. Incremental wage growth over the same timeframe is estimated to have a sum and present value of $28.8 billion and $14.2 billion respectively. Thus, while the employment growth associated with waterway investment is significant, the value that employment would create is also noteworthy.

EIGHT

Final Summary of Combined Impact Results

The first set of simulation results describe a case in which commercial inland navigation becomes completely unavailable to existing and future users. This was followed by the simulation of robust navigation system investment where prescribed improvements are completed and placed in service with as much speed as possible. These scenarios produce lower and upper boundary outcomes that are unlikely to be observed. Hopefully, however, these simulations give policy-makers some sense of the broader economic gains from renewed waterway investment, as well as the formidable costs attributable to policies that allow system degradation.

It is not surprising that the results of the scenarios considered here are asymmetric. The scenarios, themselves, are obviously unequal in magnitude. The inland navigation system, as it stands, represents a minimum of five generations of federal infrastructure investment. In 2014 dollars, the replacement value of those investments would, perhaps, exceed $200 billion. On the other hand, the improvements used to generate the modernization simulations have an incremental cost of between $5 and $7 billion – an amount that is relatively small compared to either the overall system value or the magnitude of other ongoing federal infrastructure investment programs.

Table 8.1 combines both sets of results as a means of comparing current system impacts with estimated post-investment impacts. The first column in this table provides the estimated *long-run magnitude* of annual economic output attributable to commercial navigation in each region.[37] The second column is the *long-run addition* to annual economic output in each region expected to result from the prescribed investments (excluding all transitory construction impacts). The third column is the sum of the first two columns and the fourth column indicates the percentage change in long-run output levels.

Readers should be clear that the annual economic output values contained in this table do not constitute benefits of the sort used in an appropriately conducted benefit-cost analysis.

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[37] In terms of the Phase I analysis, this is the amount of output loss *20 years after* the elimination of the navigation alternative.

In fact, present values and accompanying cost-to-construct values are excluded from this table to discourage such mistakes.

Table 8.1 – Summary and Comparison of Current System Value and Modernization/Investment Results (2012 $ X 1 Million)

Study Region	Annual Value of Navigation-Related Output	Incremental Annual Value of Investment-Related Output	Total Annual Post-Investment Navigation-Related Output	Percentage Difference in Annual Navigation-Related Output
Ohio River	16,755.0	1,609.5	18,364.5	9.6%
Upper Mississippi	18,571.0	1,410.5	19,981.5	7.6%
Lower Mississippi	25,427.0	199.8	25,626.8	0.8%
Gulf Intracoastal	63,080.0	583.5	63,663.5	0.9%
Pacific Northwest	1,525.0	6.3	1,531.3	0.4%
Rest of U.S.	6,600.0	96.0	6,696.0	1.5%
TOTAL	**131,958.0**	**3,905.6**	**135,863.6**	**3.0%**

Still, the combined values do highlight important outcomes that may be less obvious in the individual output discussions. First, as noted, it is the Gulf Intracoastal region, including the Tennessee-Tombigbee Waterway, which has the greatest amount of economic activity directly tied to navigation access. This reflects the barge-only transportation situation of many refineries and chemical manufacturers in the region.

The Lower Mississippi region ranks second in terms of navigation's importance to long-run total output. However, system improvements, regardless of where they are located, add only one percent to this annual value. In terms of increased output, it is the Ohio and upper Mississippi regions that would benefit most from the prescribed investments. Annual navigation-related output in the Ohio River region is estimated to increase by 9.6%, while the corresponding annual increase in the upper Mississippi region is predicted to be 7.6%.

In conclusion, the nation's inland navigation system, through its annual movement of roughly 550 million annual tons of freight, leads to reduced freight costs of roughly $12.5 billion, is directly responsible for roughly one-quarter million jobs and $132 billion in output that would not exist otherwise, and reduces the need for U.S. railroad capacity by as much as 20%. Further, relatively modest investments in this system's modernization could assure the availability of current waterway capacity for future generations and increase the existing productive impacts of the waterway by as much as 10% in some navigation-served regions.

If the cost of attaining these outcomes was sufficient to preclude the development of alternative freight capacity, the decisions facing policy-makers would be more complex. However, given the relatively modest total expenditures required to complete the improvements considered here and the likelihood that, at a minimum, 50% of this cost will be funded through user charges, the prudent policy course seems clear.

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ADDENDUM

Context and Trends: Background and Case Studies

The analyses reported here represent a careful attempt to capture the economic impacts of the inland navigation system as it currently functions, and as it might function if modernized. The results suggest that this system is remarkably important and almost certainly under-valued for its contributions to various regional economies. As with any such analysis, these results sit within an every-changing economic context. Because of that, what follows are some observations about how that context may be changing, and some tangible examples of how inland navigation provides benefits to different sectors of the economy.

A.1 RAILROAD CAPACITY

The report's discussion of a rapidly changing energy future highlights uncertainties about the need for additional modal capacity investment and also underscores the complex relationships that exist between available freight modes – particularly inland barge and rail. Sometimes, navigation provides a distinct service that is neither competed for nor complemented by railroads and the converse is also true. However, when barge and rail are both available, they routinely compete for traffic *or* they combine to form intermodal services that are better than either could provide independently. Either way, their fates are often interdependent.[38]

When evaluating the probable effects of proposed waterway investments, current guidelines assume necessary railroad capacity is (or can be) available, but the validity of this assumption is sometimes challenged. From the mid-1980s through the early years of the current century real railroad costs per ton-mile of freight service fell steadily and, in most cases, the rates charged to shippers mirrored cost reductions. During the same period railroads consolidated operations and rationalized networks, trimming thousands of route-

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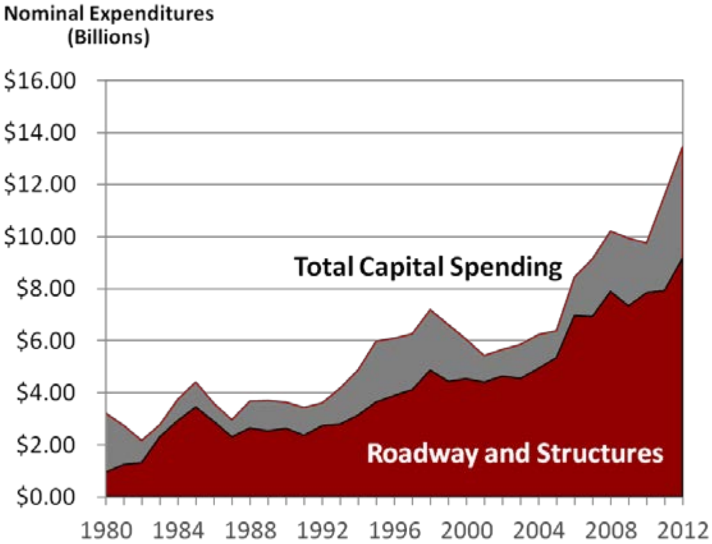
[38] For students of economic history, the relationship between barge and rail is rich. Prior to railroad regulatory reform, the Interstate Commerce Commission openly imposed "umbrella pricing" which held railroad rates unnecessarily high to protect waterborne commerce. Not surprisingly, in the wake of the 1980 Staggers Rail Act, railroads, freed of constraint, lowered rates to capture, at least some of, the previously protected barge traffic. However, as rail capacity disappeared during the 1990s, and the pressure to lower rates lessened, rail rates nearer the waterway remained among the lowest available, evidencing the outcome known as "water-compelled" rail rates. For a discussion of umbrella pricing by the ICC, see Richard D. Stone, *The Interstate Commerce Commission and the Railroad Industry*, Praeger Publishers, New York, 1991. As an example of water-compelled rail rates, see Mark L. Burton, "Rail Rates and the Availability of Barge Transportation: The Missouri River Basin," U.S. Army Corps of Engineers, Omaha, Nebraska, 1996.

miles, while simultaneously investing billions of dollars in the trackage they retained. Class I railroad investments are depicted in Figure A.1.

However, even setting aside the impact of increased domestic energy production, freight railroads are neither prepared for, nor necessarily desirous of, the *existing* traffic moved on the nation's inland waterway system. First, there is the issue of both equipment and line-haul track capacity. A wholesale diversion of waterway traffic to the nation's rail network would require roughly 100,000 additional railroad freight cars and 2,500 additional locomotives.[39] It would also increase total annual railroad tonnage by roughly 30%.[40] The additional traffic could be readily absorbed on some route segments. On others, however, it would require substantial capacity expansions through the addition of mainline tracks, sidings, and signal upgrades. In an era where record-breaking private rail industry investment is barely sufficient to accommodate existing traffic growth, this would be difficult.

Figure A.1 – Rail Industry Capital Expenditures for Track and Equipment



Additionally, commercial navigation moves a significant amount of tonnage that railroads do not want or simply cannot accommodate. Over the past decade, Class I carriers have actively worked to shed their most hazardous chemical traffic, contending that the costs associated with this traffic are simply unrecoverable under current rate structures. The same is also true of less perilous, but equally troublesome, cargoes such as salt and asphalt. Finally, the weight and/or dimensions of a small number of waterborne shipments simply

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[39] These are representative calculations based on 96 tons of freight per loaded car, five-day freight car cycle times, 2.5 6,000 hp. locomotives per train set.

[40] This calculation is based on average annual barge traffic of 600 million tons and 1.8 billion tons of annual railroad traffic (Association of American Railroads).

exceed anything that can be reasonably moved by any other freight mode – including rail. Again, without the waterway the shipments would simply not take place.

Finally, the assumption regarding normal railroad capacity may be tenable under historical traffic. However, as we will discuss in the next section, the rapid growth in domestic energy production has displaced "normal" for the foreseeable future. Western railroads, particularly BNSF and the Canadian Pacific, are currently struggling under the weight of additional "crude by rail" (CBR) traffic, even while petroleum output in the Bakken and in western Canada are at only 30% of planned levels. Incremental rail industry capacity investment is expected to top $20 billion during 2014. Still, even this level of investment will likely be insufficient to afford any spare capacity.[41]

A.2 TRENDS IN DOMESTIC ENERGY

Inescapably, however, the modeling techniques used here are tightly tied to historical patterns of commerce and the underlying economic factors that produced those patterns. While this dependence is inevitable, it is also frustrating when even a casual look forward suggests a foreseeable future that is measurably different from the immediate past. In the current setting, there is *well-reasoned* speculation that inland navigation may take on additional importance as the future unfolds, but at this point, it is still speculation.

At issue is the impact that dramatic increases in domestic fuel production will have on the value of various freight resources. Discussions outlining the current study began in early 2012. In the previous year, 2011, daily U.S. petroleum production averaged roughly six million barrels per day. By June of this year, daily production volumes had increased by 44% to 8.5 million barrels.[42]

Much of this new production – approximately 70% – is moving *toward* refineries by rail. Indeed, between 2011 and 2013 U.S. and Canadian rail car loadings of crude increased by 520% from 65,751 to 407,761 per year.[43] Still, a significant amount of refining capacity along the Gulf of Mexico, on the Great Lakes, and even along the nation's Eastern Coast cannot be directly accessed by rail and must receive crude oil shipments by either pipeline or vessel. Thus, as reported in Section 2.3, inland barge shipments of crude petroleum nearly doubled between 2012 and 2013, climbing from roughly 22 million barrels to more than 37 million barrels in one year.[44]

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[41] Overall service issues and grain rates have plagued western Class I railroads for more than a year. Accordingly, both services and rates have been the subject of various Surface Transportation Board proceedings. See, for example see STB EP 665 Sub 1, December 12, 2013 regarding rail rates for grain movements or STB 724, Sub 2, June 20, 2014, regarding service quality.

[42] http://www.eia.gov/petroleum/ To place this volume in perspective, U.S. consumption of finished products requires a daily refining capacity of between 17 and 20 million barrels of crude petroleum inputs.

[43] https://www.aar.org/newsandevents/Freight-Rail-Traffic/Pages/2013-02-21-railtraffic.aspx

[44] See Section 2.3 for additional details.

The growth in U.S. natural gas production has been more gradual and more geographically diverse. Still, since 2000, gas production has increased by 32% from to a 2013 annual total of 26.6 trillion cubic feet. Moreover, this production increase has been sufficient to hold spot market natural gas prices at roughly $4 per million Btu for the past four years even in the face of significantly increased utility use[45]. Of course, very little natural gas moves by either rail or barge, but natural gas is a critical feedstock in the production of various chemicals that *do* require freight transportation. Again, as reported in Section 2.3, planned increases in chemical and petroleum products production are currently estimated to add as much as 75 million new tons to inland waterway system traffic.

On the negative side of the traffic ledger, increased natural gas production, relatively soft natural gas prices, clean air concerns, and a recession-related decline in electricity demand have combined to significantly reduce coal production and related transportation. In total, U.S. coal production peaked in 2008 and has fallen roughly 13% from a high of 1.1 billion tons.[46] However, the decline in coal consumed for electricity generation has been more pronounced. This consumption peaked in 2005 and had fallen more than 30 percent by 2012. However, 2013 produced a modest rebound in domestic steam coal consumption (-24.8% against the 2005 peak).[47] The impact on both rail and barge traffic has mirrored the reduction in utility coal consumption, with both modes seeing a drop in coal traffic of between 25% and 30%. From a raw tonnage or ton-mile standpoint, it is unlikely that increased petroleum or natural gas-related traffic will offset lost coal volumes. However, when viewed through the lens of economic value added, the increased movement of petroleum and chemicals products may, in fact, be equal or greater than the lost value-added from reduced coal shipments.[48]

With each passing month, additional data suggest that the changes in domestic energy production and resulting freight volumes are not transient. To the contrary, not only does this changed energy future appear to be long-lived, but its full extent and the long-run impacts on fuel-related prices, so far, defy reliable prediction. Early estimates concluded that current new production is at one-third of what is achievable based on the scale of currently recoverable oil and gas deposits. However, more recent information suggests that preliminary assessments may have significantly understated the volume of petroleum and natural gas that can potentially be made available.[49]

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[45] http://www.eia.gov/naturalgas/

[46] http://www.eia.gov/coal/

[47] *Ibid.*

[48] From a NED benefit standpoint, this distinction may be of considerable importance in the re-evaluation of potential navigation infrastructure projects.

[49] http://www.eia.gov/naturalgas/crudeoilreserves/

A.3 WATERWAYS CASE STUDIES

There are many millions of dollars in industrial and commercial infrastructure adjacent to waterways that are dependent on waterborne transportation. These include ports, industrial processing facilities, grain distribution centers, mining operations, petroleum and chemical refineries and metallurgy production sites. In an effort to assess the economic value and workforce impact of the waterways, the amount of land-side fixed infrastructure investment must be considered. Many of these industrial and commercial facilities rely nearly exclusively on waterborne transportation.

Vital components of the North American energy sector rely on waterways transportation. For some coal mines and petroleum refineries, their facilities are designed for shipments that are exclusively waterborne. While most oil and gas products have a choice of several modes of transportation – waterways, rail and pipeline – the resource extraction process is heavily dependent on waterway transport. Canada's oil shale projects require specialized over-sized equipment that can only be shipped along the Columbia-Snake River system. Additionally, some chemicals and minerals involved in the extraction and drilling process are shipped exclusively via waterways. Currently, the U.S. Coast Guard is establishing a permitting process to transport wastewater from natural gas extraction along America's river system.

Waterways serve an important role in transporting much of the oversized cargo and equipment shipping within the United States. In addition to the large equipment in the oil, gas and coal energy sector, large construction components such as bridge sections and rocket components are transported almost exclusively on the U.S. inland waterway system. Waterways transportation is an important means of shipping construction supplies into dense water-adjacent cities, like Chicago, that could not ship steel and cranes by roadway. Floating construction docks for road infrastructure repairs are vital for maintaining the nation's highway infrastructure.

This section presents three case studies that explore many of the benefits of inland waterways transportation and, in many cases, the exclusive means of transporting goods and services.

Case Study One: Transport of Oversized Cargo and Equipment on the Inland Waterways

America's inland waterway system is a valuable resource for transporting many natural resources, industrial materials and finished goods. Inland waterways are used to transport oversized cargo and equipment both within the United States and to coastal ports for export markets. Oversized cargo such as rocket boosters, wind turbines, oil refinery drums, bridge components and construction materials, are transported on the U.S. inland waterway system. Assisting the U.S. highway and Interstate system, floating construction platforms, staging docks and oversized bridge components allow the construction of large bridges and infrastructure maintenance that maintains connections within some of the country's largest river cities.

Much of the over-sized cargo that moves along the inland waterways is vital to the energy industry. While inland waterway transportation plays a more conspicuous role in facilitating the movement of coal along the Ohio River and potentially for petroleum movements on the Mississippi River, it also serves a more subtle role in the U.S. Department of Energy's (DOE) research agenda. This case study looks at the DOE's recent use of America's waterway transportation network for a unique and highly publicized waterways movement that utilized both the near-shore intra-coastal waterways and the heart of the inland waterways system. Specifically, the movement of a 17-ton electromagnet on the nation's waterway system.

In the summer of 2013, the DOE transported a large, powerful electromagnet from the Brookhaven National Laboratory in New York to the Fermi National Accelerator Laboratory just outside Chicago, Illinois. The 50 foot wide electromagnet required a stable ride for its 3,200 mile journey, as moving or twisting the semiconductor coils even a few millimeters would destroy the device. The only practical means by which the DOE could transport the electromagnet was via inland waterways – moving the equipment from Long Island down the east coast, up the Tennessee-Tombigbee, the Mississippi River, Illinois River and Des Plaines River into Lemont, Illinois.

Figure A.2: 50-foot diameter electromagnet to be moved from New York to Chicago

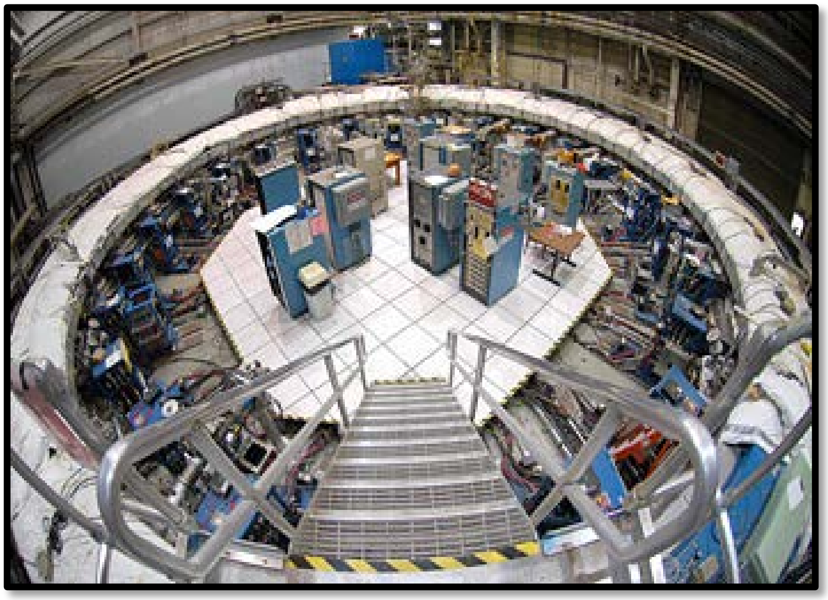
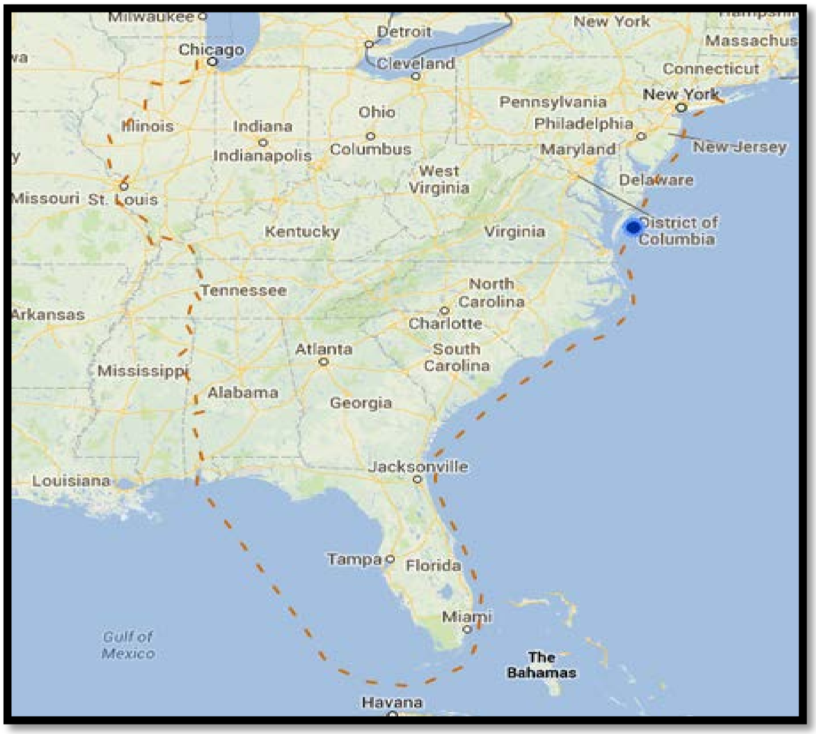


Figure A.3: All-water transportation route chosen. Images from: FNAL.gov



The electromagnet, while not a part of everyday energy production, is a key component in energy research. The DOE electromagnet will allow researchers to conduct experiments with subatomic particles that could reshape our understanding of physics and provide us with valuable future energy sources. The electromagnet can store tiny subatomic particles called muons, which only exist for two millionths of a second. The device can measure the 'magnetic wobble' of the muons in an effort to discover new subatomic particles. It is this type of game-changing research that may ultimately lead to affordable, domestic and environmentally friendly energy independence. Furthering this research requires more sensitive equipment than the Brookhaven National Laboratory has, so the electromagnet was moved to the Fermilab in an effort to complete these studies.

Given the distance and sensitive nature of the device, only a few options existed for transporting it from Long Island to the Chicago area. Three modes of transportation were considered – trucking, helicopter and waterways transport. Trucking the electromagnet would have required travel on main highways and interstates with extended right-of-way. To achieve this, roads would have to be closed down, allowing the electromagnet to only move at night. The process would have taken almost a year and would have exposed the delicate equipment to the dangers of road travel and daytime waiting periods along roadways. For example, it took three days to truck the electromagnet the final 32 miles of its journey, from the riverport in Lemont, IL to the research laboratory in Batavia, IL.

A second option considered was moving the electromagnet by helicopter. While this mode of transportation would have been quicker, it would also require complex permitting from the states and municipalities the equipment flew over. It would also require extensive safety measures to ensure the 17-ton device would be secure enough to be flown over highly populated areas. Both of these measures would have been very expensive and more logistically complex than waterway transportation. It was decided that the only feasible and cost-effective means by which the DOE could transport the electromagnet was via inland waterways.

The Department of Energy turned to Emmert International, a company that specializes in multi-modal transportation for heavy-haul equipment. The company assembled a 45-ton apparatus to protect and stabilize the delicate electromagnet, trucked it to a port, shipped it down the East coast and around the Gulf and then proceeded up through the inland waterways system. Starting at the Tennessee-Tombigbee River, the equipment moved though the Mississippi River, Illinois River and Des Plaines River until it reached the greater metro Chicago area. It took a mere 32 days to move the 17-ton electromagnet along its 3,200 mile journey. After departing the Brookhaven Laboratory on June 22, 2013, the equipment arrived safely at the Fermilab on July 26, 2013. The inland waterways system delivered on its promise by delivering a safe, efficient and reliable transportation option for this highly sensitive piece of scientific equipment.

Figure A4: Images of the Electromagnet Move from New Jersey to Chicago

Images from: FNAL.gov

Other over-sized waterways movements

Following are examples of other important over-sized objects shipping using the inland waterway transportation system. These projects and photos were collected and published by Dr. Larry Bray, University of Tennessee Center for Transportation Research.

TVA used barge transportation to move pollution-control equipment to its steam generating plants. It was cheaper to assemble the devices at the manufacturing plant in Iuka, Mississippi and transport by barge than ship by truck and assemble at the power plant.

Widows Creek Scrubber Component Installation, June 2003

Electric utilities use water transportation to move heavy and oversized equipment to power plants. TVA has shipped nuclear steam generators weighing 350 tons to its nuclear plants and plans for an additional movement in 2011.

Watts Bar Nuclear Plant Steam Generators, October 2005

USACE and TVA maintain barge-mounted cranes that are used for maintenance of various structures located in the inland rivers or on shorelines. For example, in the cleaning of trash racks at hydropower facilities, large cranes require 79 trucks and two weeks for assembly and disassembly. This is one benefit of movement by barge.

USACE Crane and Equipment Barge

Case Study Two: U.S. Grain Exports - A Closer Look

In the last several decades, agricultural products have been the fourth largest commodity group on the US inland waterway navigation system, after coal, petroleum and crude materials (such as aggregate and forestry resources). Historically, the largest volumes of agricultural barge movements originate in Illinois River and the Upper Mississippi, as grains from the Upper Plains are transported to New Orleans for export[50].

Increased global population pressure is producing increases in world demand for grain products, for food production and livestock feed, and oilseed, for biofuel production. In an effort to capitalize on grain prices that are buoyed by biofuels, many American farmers are foregoing wheat production and planting more acres of corn and soybeans[51]. Of specific importance is the rapidly expanding Chinese grain import market and the ability of the U.S. to ship to Asia. Over half of U.S. corn and soybean exports are shipped out of Gulf Coast ports, which could be boosted by the Panama Canal expansion project. Coming online soon, the expanded canal capacity should help further reduce U.S. shipping cost to the Asian market and keep it competitive with Brazil. The U.S. inland navigation system, however, must be maintained in order to provide efficient and reliable transport options to ship grain exports to Gulf Coastal ports.

The major international competition for U.S. corn and soybean growers are the grain producers of Brazil. In 2013, Brazil was estimated to overtake the U.S. as the major world producer of oilseed and produce 90 million tons of soybeans[52]. While Brazilian grain and oilseed is less expensive to produce, the inefficient nature of the country's transportation infrastructure has given U.S. producers the price advantage on the world market. Most Brazilian soy and corn products must be shipped between 1,000 and 1,500 miles by truck before reaching a more efficient mode of transportation. Once the commodities find an inland port, it will still take another 1,000 miles of travel to reach one of the three southern Brazil coastal ports, where nearly 75 percent of all Brazilian grains exports originate[53].

Accordingly, under the "complete loss of navigation" scenario, REMI model outputs estimated reductions of agricultural exports from all five of the river basin regions. The largest impacts on U.S. agricultural exports would occur in the Lower Mississippi region, followed by the Ohio River and Gulf Intracoastal Waterway, reflecting the connections between the corn and soybean areas of the Ohio River Valley and their export down the river

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[50] Casavant, Ken. 2010. *Issues Affecting Barge Transportation in the Pacific Northwest*. FPTI Research Report No. 7, Washington State University.

[51] Informa Economics. 2013. *Grain and Oilseed Crop Supply and Demand Outlook*. Presented at Annual Grain, Oilseed and Energy Transportation Conference on October, 2013, Memphis, TN.

[52] Merco Press: http://en.mercopress.com/2013/12/12/brazil-expects-a-90-million-tons-soybean-crop-making-it-the-world-s-top-producer

[53] Flaskerud, George. 2003. *Brazil's Soybean Production and Impact*. NDSU Extension Service. Report 58105. July, 2003.

system. These 2012 annual export losses are estimated by REMI to *triple* by 2030 and *quadruple* by 2040, so the impact is ongoing and not ephemeral.

Another consideration regarding the competitive export grain transportation rates emerges from the rapidly-growing crude petroleum production regime in the U.S. As detailed in Section 2, the volume of barge crude oil movements from the Upper Midwest, where wheat, corn and soybeans are all grown for export, to the Gulf, where grain export elevators are located, increased by nearly 1000% from 2009 to 2013. As noted in Section A.1, rail capacity may be in question along this corridor, with the possibility of grain shipping costs to the Gulf being driven by crude oil shipping demands. The ultimate outcome of this is unknown at the present time.

Nevertheless, it is clear that without reliable and efficient navigation along the nation's rivers the transportation cost of grain movements would increase and our competitive ability to export would be diminished systematically and long term.

Table A.1: This cost table, prepared by the Soy Transportation Coalition, demonstrates the dramatic difference in transportation costs for U.S. export soybeans vs. Brazil. Note that waterways represent the lowest long-haul cost, and likely help to control the rates charged by the rail alternative.

Cost (in US$/MT)	**United States**				**Brazil**			
Farm	**Iowa**		**Illinois**		**Mato Grasso**		**Goias**	
Truck	11.72	11.72	10.17	10.17	110.75	30.58	103.37	31.50
Wait for Loading	1.13	1.13	1.32	1.32	4.2	4.2	4.2	4.2
Country Elevator								
Truck	11.72	11.72	10.17	10.17				
Wait for Loading	1.13	1.13	1.13	1.13				
Long Haul						**Rondopolis**		**Rondopolis**
Barge Loader		20.97		17.40				
Rail Shuttle	29.74		21.99			17.60		17.60
Wait for Loading								
Export Elevator								
Wait for Loading								
Load Vessel	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Sail	**PNW**	**Gulf**	**PNW**	**Gulf**	**Santarem**	**Santos**	**Santos**	**Santos**
Rotterdam		31.55		31.55	34.9	34.9	34.9	34.9
Shanghai	27.80	61.36	27.80	61.36	71.9	71.9	71.9	71.9
TOTAL COST								
TOTAL to ROTTERDAM		**85.22**		**78.74**	**149.8**	**69.6**	**142.4**	**70.5**
TOTAL to SHANGHAI	**90.24**	**115.03**	**79.58**	**108.55**	**186.8**	**124.3**	**179.5**	**125.2**

Case Study Three: Steel Production Reliance on Inland Navigation

The significant spatial relationship of the inland navigation system to the steel industry is illustrated by the following table, which enumerates the number of steel plants, by type, on the inland system, including the Gulf Intracoastal Waterway. This data is derived from state-by-state reports provided by the American Iron and Steel Institute (AISI). The member companies of the Institute produce more than 80% of the nation's steel and employ about 70%t of the country's 153,000 steel industry workers. Consequently, it is representative of the nationwide pattern of steel production and fabrication, but not an exhaustive accounting.

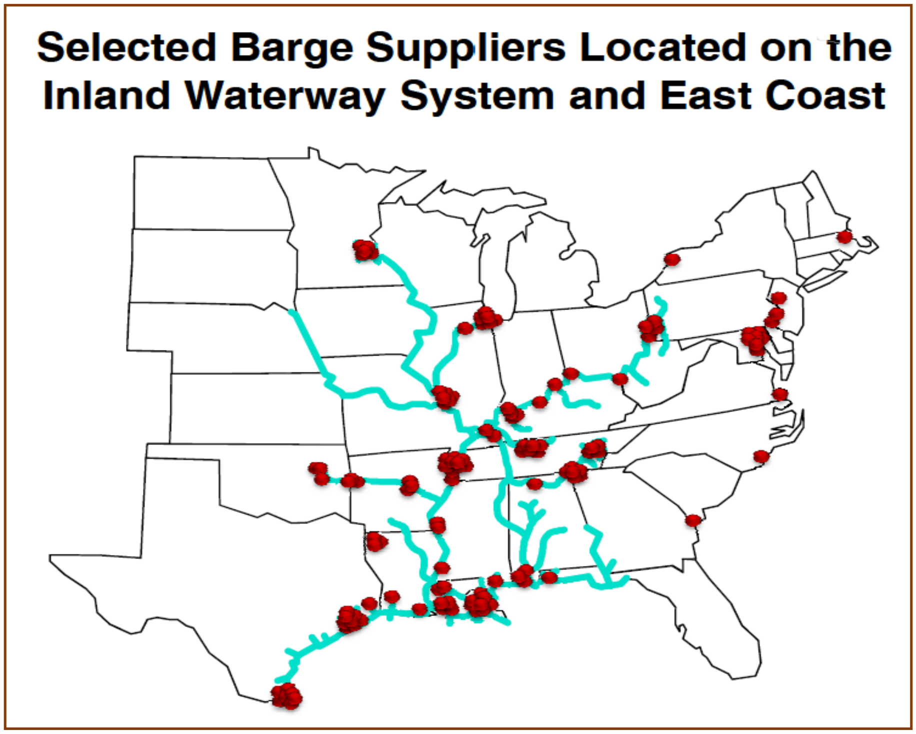
Table A.2: A.I.S.I. Member Steel Facilities by Type, Steel Jobs, and Orientation to the Inland Waterways System

States on Inland Navigation System	Steel Industry Jobs	Raw Steel Plants	Number On Inland System	Steel Products/ Added Process Plants	Number On Inland System	Other Facilities	Number On Inland System
Alabama	8,282	7	7	5	4	3	2
Arkansas	4,949	4	4	5	4	2	2
Illinois	9,128	3	3	9	3	1	1
Indiana	23,185	6	0	11	4	11	4
Iowa	1,026	2	2	2	1	1	1
Kentucky	3,065	2	2	3	3	3	3
Louisiana	1,252	0	0	6	4	1	1
Minnesota	637	4	1	4	4	6	1
Mississippi	1,013	3	2	3	1	0	0
Missouri	1,627	0	0	6	5	1	1
Ohio	17,957	5	0	12	0	13	2
Oregon	Not Available	0	0	2	2	0	0
Pennsylvania	19,878	7	5	13	8	11	5
Tennessee	2,813	3	2	7	2	1	1
Texas	8,497	3	1	25	13	6	1
West Virginia	2,088	1	1	1	1	3	0
Total	**106,202**	**50**	**30**	**118**	**59**	**63**	**25**

These data show that 30 of the 50 A.I.S.I. plants that produce raw steel (60%) are located in proximity to the inland waterways. These plants produce steel from iron ore and coal, and use barge traffic on the waterways to transport raw materials and finished products. The contribution of water transport to raw steel production is further highlighted by the fact that six of the remaining 20 plants are on or near the Great Lakes. Of course, the steel industry is multifaceted and produces a range of products, but these too are frequently produced on or near to the inland waterways. Half (59 of the 118) of the facilities categorized as “steel process / added process” plants are on, or near, the inland system. Even a substantial percentage of the distribution and corporate headquarters facilities are on or close to the inland waterways—25 of 63 facilities (40%).

The following maps, prepared by Nucor Steel and its subsidiary the David J. Joseph Company, show the waterways orientation of its raw steel consumers and their barge-based suppliers. This pattern is typical of the industry’s geographical pattern. Further, the company’s use of inland navigation has increased steadily over the past two decades.

Figure A.5: Source: Nucor Steel Presentation “Goin’ With the Flow.” 2013 Annual Waterways Symposium, October 2, 2013. Memphis, TN.



In short, it is noteworthy that the industry, despite its considerable transformation over the past 40 years, still relies substantially on the inland river system for transportation and continues to make great contributions to the economic viability of the cities and towns along the watercourse, and the nation as a whole.

Figure A.6: Source: Nucor Steel Presentation “Goin’ With the Flow.” This demonstrates one steel company’s increasing use of inland navigation capacity, especially since the early 1990’s, as a part of their overall industrial activity.