# The Impacts of Unscheduled Lock Outages

Prepared for:

The National Waterways Foundation and
The U.S. Maritime Administration

Center for Transportation Research
The University of Tennessee

Vanderbilt Engineering Center for
Transportation and Operational Resiliency
Vanderbilt University

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This study was developed through a cooperative agreement between the U.S. Department of Transportation (DOT), Maritime Administration and the National Waterways Foundation [DTMA-91-H1-400009]. Opinions or points of view expressed in this document are those of the authors and do not necessarily reflect the official position of, or a position that is endorsed by, the U.S. Government, DOT, or any sub-agency thereof. Likewise, references to non-Federal entities and to various methods of infrastructure funding or financing in this document are included for illustrative purposes only and do not imply U.S. Government, DOT, or subagency endorsement of or preference for such entities and funding methods.

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*Cover Photograph courtesy of Andrew M. Turner*
*Clarion, Pennsylvania*

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# Executive Summary

*The summarized work is the result of a study commissioned by the National Waterways Foundation and the U.S. Department of Transportation's Maritime Administration (MARAD). The goal of this study is to highlight the economic benefits associated with reliable inland navigation.*

## E.1 PROJECT CONTEXT

America's inland waterway system was essential to the nation's early colonial prosperity and it has been vital to U.S. commerce ever since. As navigation more fully developed in the 20th century, the waterway network became a perennial contributor to the nation's economic success. Today, America's waterways quietly provide an irreplaceable transportation resource that is key to the nation's global success in the 21st century.

Unfortunately, toward the end of the 20th century, this fundamental part of U.S. transportation infrastructure became more visible, but for all the wrong reasons. Many of the nearly 200 infrastructure projects were reaching their design life of 50 years and choke points were adversely affecting more and more commercial users. The upper Mississippi's Locks & Dam 26 and the Ohio River's Locks & Dam 52 are examples.

Today, most navigation projects are more than 75 years old and have suffered from a persistent lack of reinvestment and environmental stresses associated with extreme weather events that magnify the system's vulnerability.

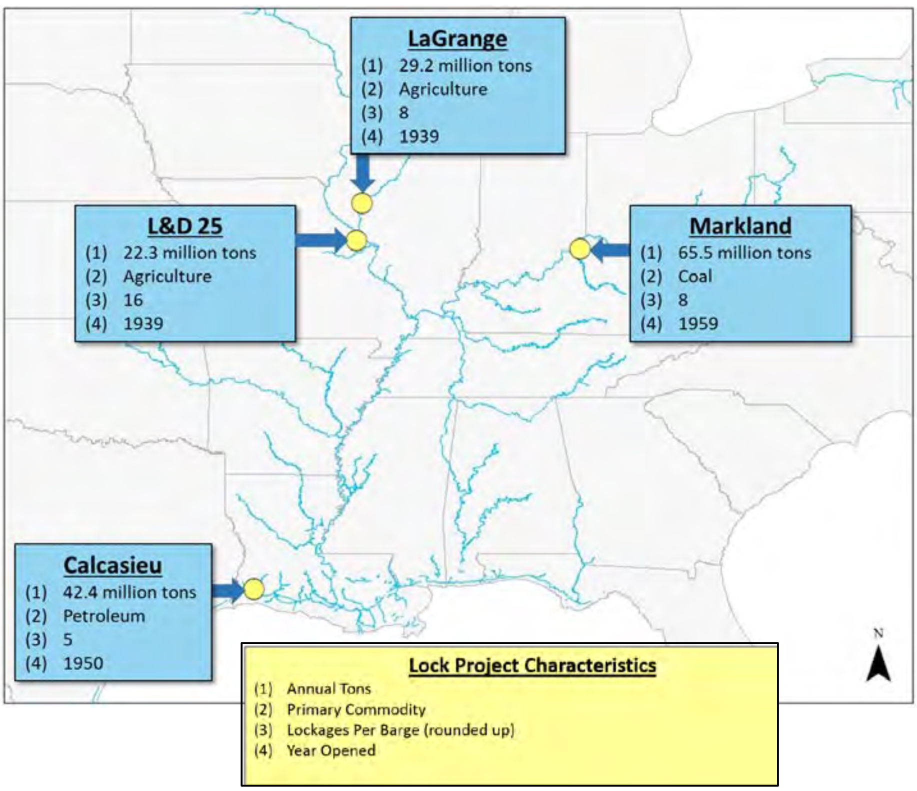
It is within this context that the National Waterways Foundation and MARAD commissioned this study to explore the expected impacts of an extended unscheduled outage at a number of important Lock and Dam projects.

## E.2 LOCK AND DAM PROJECTS SELECTED FOR DETAILED ANALYSIS

In order to assess the impact of lock availability and outages, the study team developed and used a methodology to identify a small subset of locks for closer analysis. The initial screening approach included a carefully reconciled cross-section of data describing the characteristics and performance of roughly 170 navigation locks located throughout the nation's interior navigation system. The study team prepared and presented this information to the study's sponsors who then selected four locks for further study based on their characteristics and performance metrics. The map below indicates the locks selected and includes several of the key characteristics of the lock reliant traffic.

Of particular note were new metrics to assess a lock's importance to the overall network. One such metric, noted on the map below for each project, describes the average number of locks on the system that an individual loaded barge traversing the subject lock passes through during a single movement (represented as System Lockages/Project Lockage). An additional measure shows the traffic in the pools above and below the lock that originates or terminate in the pool but does not transit the lock. While this study did not investigate the particular modalities of an unscheduled outage, it is possible that the outage could be accompanied by impacts on the pool traffic as well.

Figure E.1 – Study Projects and Summary Characteristics




## E.3 DIRECT SHIPPER SUPPLY CHAIN COST BURDENS FROM AN UNSCHEDULED CLOSURE

Estimating the direct efficiency losses associated with an unplanned lock closure provided the core information on which further analysis is built. These cost estimates were derived through methods that adhere to the same *Principles and Guidelines* that govern U.S. Army Corps of Engineers' navigation studies.

For each lock examined, the analysis compares an estimate of each shipper's current costs for waterway-inclusive movements to the cost of the next best available modal alternative. Three existing models were employed that allowed a comparison of the costs associated with the use of barge service against the cost to make such a movement by rail and/or truck. For each of the four locks analyzed, the model estimates predicted the Direct Shipper Supply Chain Cost Burden if barge service becomes unavailable and, at each location, these costs would be expected to exceed $1 billion per year, as described in the Table below:

Table E.1 – Estimated Direct Unplanned Closure Costs

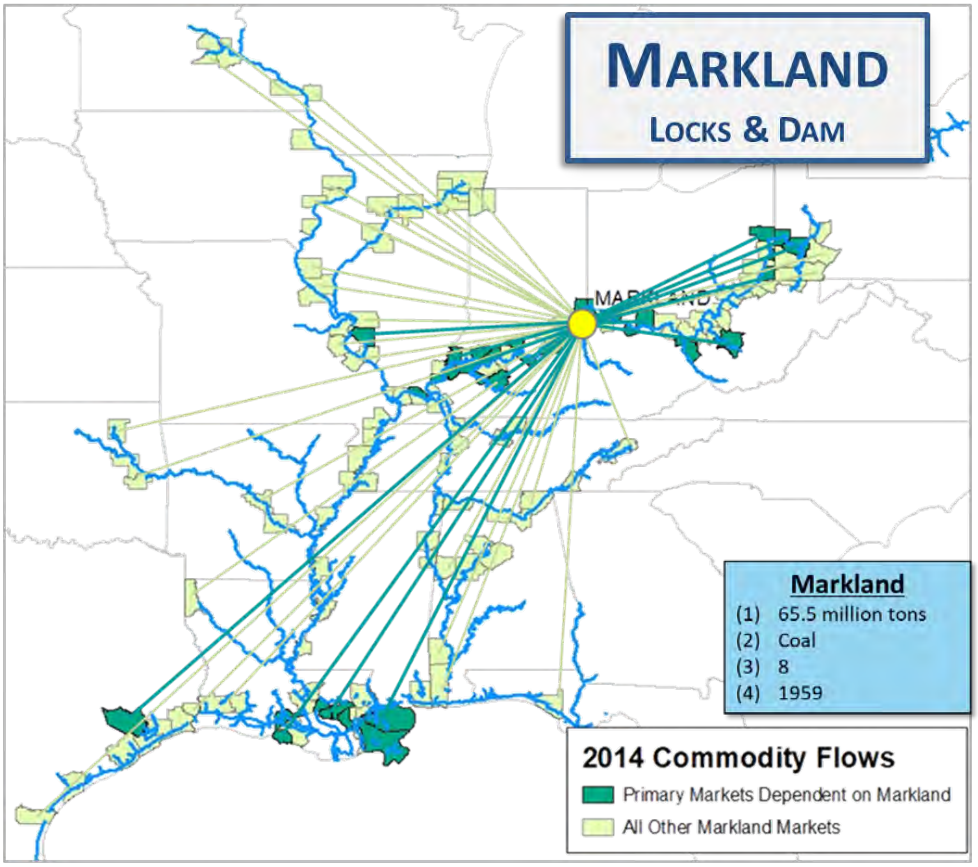
| COMMODITY | MARKLAND LOCKS & DAM | | LAGRANGE LOCK &DAM | |
|---|---|---|---|---|
| | Total 2014 Tons | Total Direct Costs | Total 2014 Tons | Total Direct Costs |
| Coal | 30,788,869 | $221,987,745 | 443,288 | $20,291,015 |
| Petroleum Products | 7,440,371 | $368,253,302 | 5,623,494 | $182,914,135 |
| Chemicals | 3,898,264 | $276,416,124 | 4,888,770 | $251,529,491 |
| Crude Materials | 14,339,508 | $242,729,791 | 3,401,419 | $208,236,345 |
| Primary Manufactured Goods | 4,896,902 | $160,394,481 | 3,344,289 | $103,524,351 |
| Farm Products and Food | 4,089,324 | $38,460,711 | 11,460,988 | $932,684,606 |
| Equipment | 55,525 | $1,818,681 | 5,632 | $477,986 |
| TOTAL | 65,508,763 | 1,310,060,835 | 29,167,880 | 1,699,657,928 |

| COMMODITY | CALCASIEU LOCK | | L&D 25 | |
|---|---|---|---|---|
| | Total 2014 Tons | Total Direct Costs | Total 2014 Tons | Total Direct Costs |
| Coal | 245,836 | $6,629,552 | 660,624 | $25,696,959 |
| Petroleum Products | 24,988,887 | $542,287,348 | 320,411 | $15,103,646 |
| Chemicals | 9,078,337 | $230,953,087 | 4,171,737 | $248,899,601 |
| Crude Materials | 3,937,379 | $179,789,257 | 3,082,613 | $208,863,996 |
| Primary Manufactured Goods | 2,744,157 | $120,009,771 | 1,667,149 | $38,225,955 |
| Farm Products and Food | 843,753 | $22,753,806 | 12,433,825 | $1,033,977,564 |
| Equipment | 9,222 | $248,693 | 6,602 | $542,606 |
| Scrap and Waste | 626,896 | $16,905,741 | | |
| TOTAL | 42,474,467 | 1,119,577,255 | 22,342,961 | 1,571,310,327 |

## E.4 GEOGRAPHIC DISTRIBUTION OF THE DIRECT AND REGIONAL IMPACTS

Using the information about the origins and destinations of the traffic relying on each lock, it was also possible to describe the system-wide nature of the impact which each individual lock's closure is expected to have as illustrated on the four network maps below.

Figure E.2 – Markets Dependent on Markland Locks & Dam




**MARKLAND LOCK & DAM**

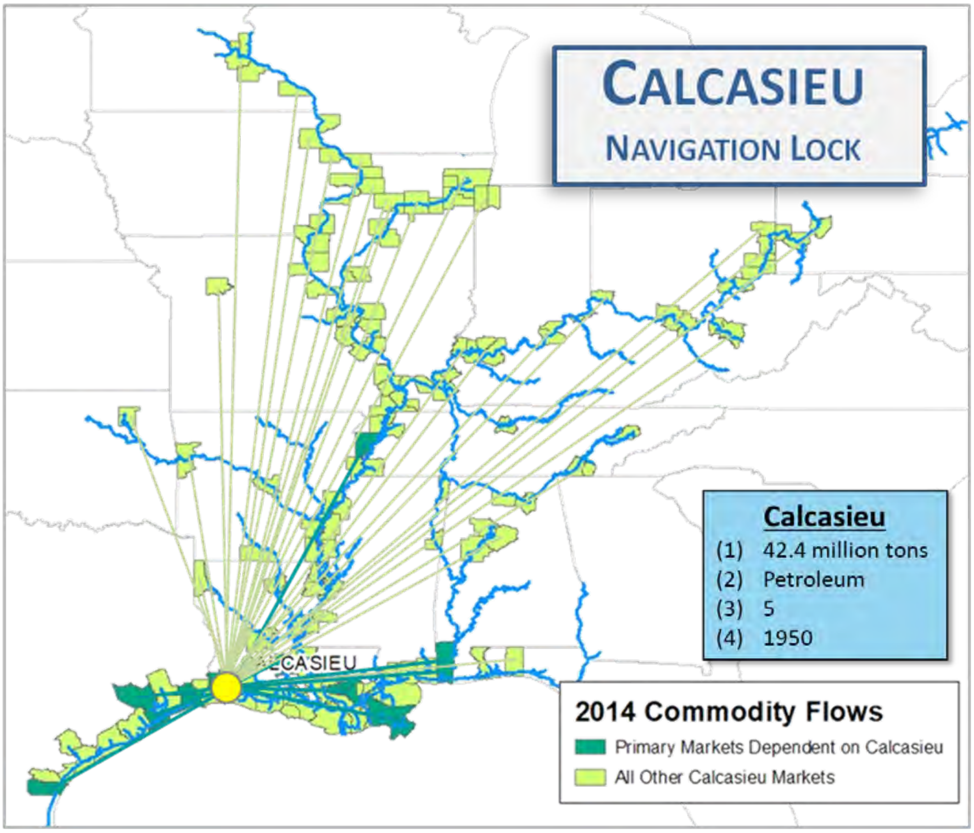
Markland is a key element in the waterway thoroughfare that moves 60 million tons of freight through the Ohio River basin each year. Markland and the system it supports are a vital commercial conduit within the basin that:

- Is essential to affordable energy.
- Efficiently connects the upper Midwest to the resource-rich Gulf.
- Integrates the Midwest with wide-ranging domestic and global trade.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 175 counties in 18 states.
- Cost the shipping public more than $1.3 billion annually in additional transport charges.
- Disrupt the affordable delivery of electric power throughout the eastern U.S.
- Require the availability and use of 40,000 additional rail carloads and 60,000 additional truckloads.
- Discourage 80 percent of users from ever returning to the waterway.

Figure E.3 – Markets Dependent on Calcasieu Lock



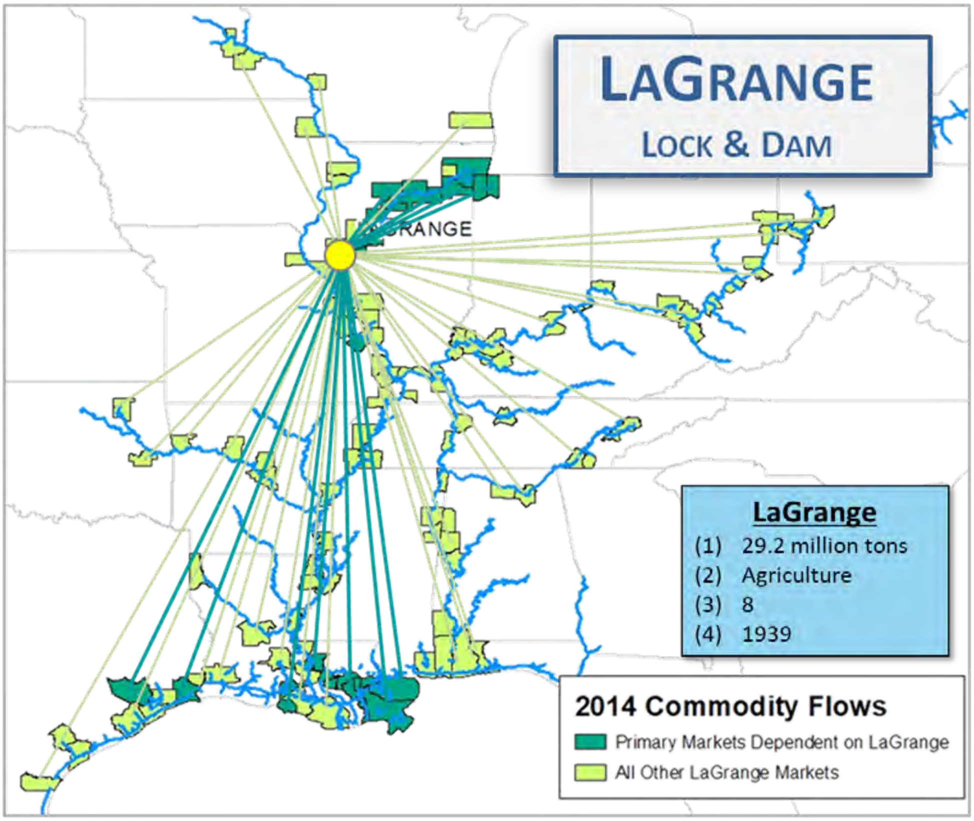

**CALCASIEU LOCK & DAM**

Calcasieu is a critical piece of the high-density waterway corridor that serves plastic and chemical producers and petroleum refiners throughout the Gulf region. Unseen to most, Calcasieu moves 40 million tons of freight through the Gulf each year. This facility, and the system it supports, are vital commercial links within America's freight network that (1) are essential to affordable energy production, (2) efficiently connect the Gulf region to global trade, and (3) integrate the Gulf region's vital production into the core U.S. economy.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 170 counties in 18 states.
- Cost the shipping public more than $1.1 billion annually in additional transport charges.
- Require the availability and use of 10,000 additional rail cars and several hundred locomotives.
- Result in the loss of 17,000 full-time, highly-compensated jobs.

Figure E.4 – Markets Dependent on LaGrange Lock & Dam




**LAGRANGE LOCK & DAM**

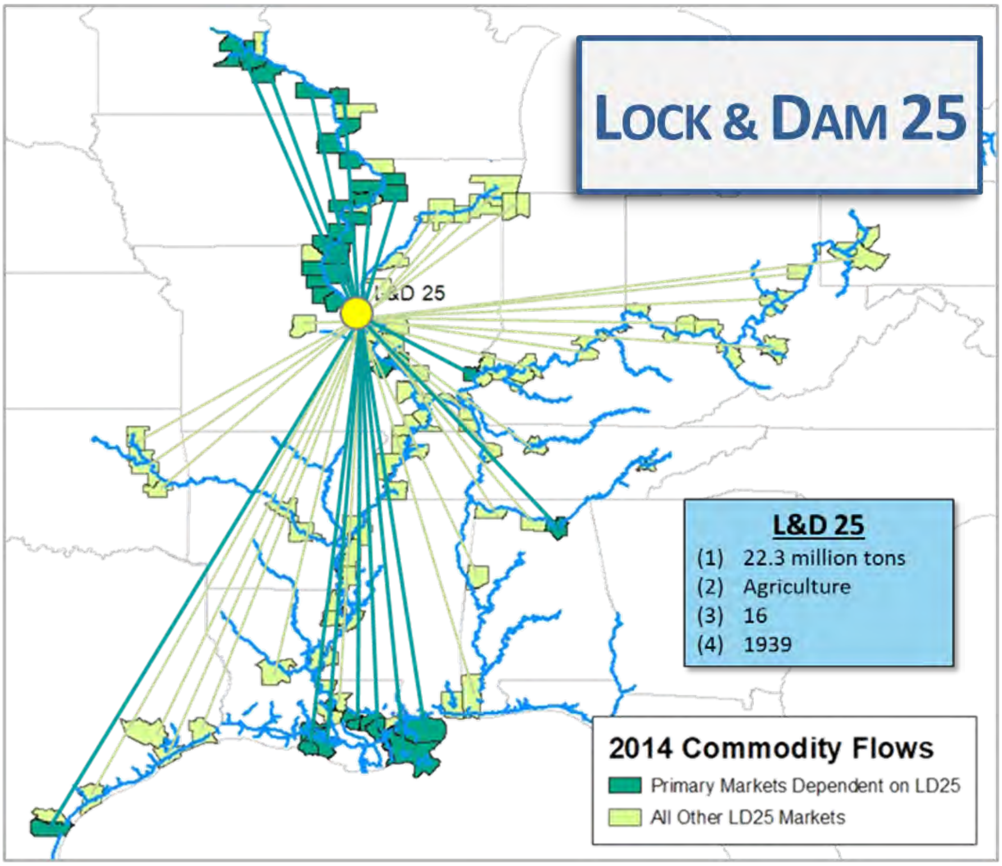
LaGrange is a critical piece of the marine highway that links the upper Mississippi and Illinois basin farmlands to export markets reachable through the Louisiana Gulf. Each year, more than ten million tons of corn and soybeans transit this lock down-bound, for export and the region's agriculture is equally served by up-bound fertilizer movements.

In addition to agricultural commerce LaGrange also is an integral component in the navigation system that links the Chicago Area Waterway System (CAWS) to the rest of the U.S.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 135 counties in 18 states
- Threaten the nation's primary path for corn and soybean exports.
- Cost the shipping public nearly $1.7 billion annually in additional transport charges.
- Severely stress the nation's railroad infrastructure.
- Lead to a $2.1 billion loss in farm-dependent incomes.

Figure E.5 – Markets Dependent on Lock & Dam 25




**LOCK & DAM 25**

**L&D 25** is a second essential piece of the inland waterway system linking the upper Mississippi and Illinois basins to global farm product markets reachable through the Louisiana Gulf. Like LaGrange, each year, more than ten million tons of corn and soybeans transit L&D 25 down-bound, for export , while up-bound fertilizer movements account for more than 4 million tons of the lock's up-bound traffic.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 132 counties in 17 states.
- Immediately affect the nation's primary path for corn and soybean exports.
- Cost the shipping public nearly $1.6 billion annually in additional transport charges.
- Severely test the nation's railroads.
- Discourage 80 percent of users from ever returning to the waterway.

These figures point to the overall value of each lock. But, looking at traffic for individual commodities adds further to the story. Appendix 3 provides an expansive set of commodity-specific graphics. However, their value is worth demonstrating here. As described in Section 2, Ohio River traffic is being affected by two countervailing forces – a decreased reliance on coal and the increased ability to affordably produce chemical and plastics products. The commodity-specific graphics for Markland illustrate how related changes in transportation demands may affect the composition of traffic at Markland.

Figure E.6 – Distribution of Chemical Shipments Transiting Markland Locks & Dam

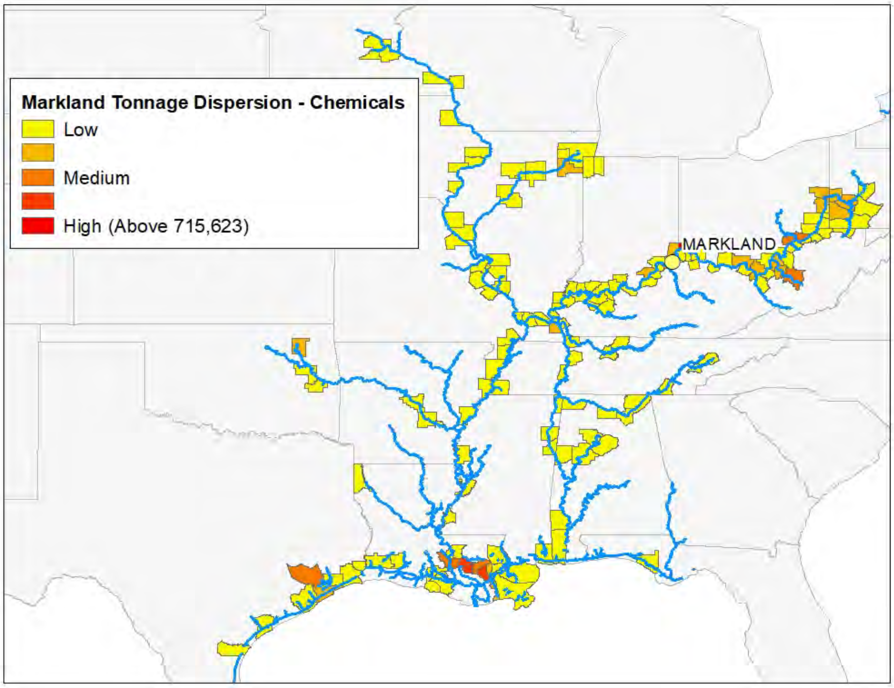
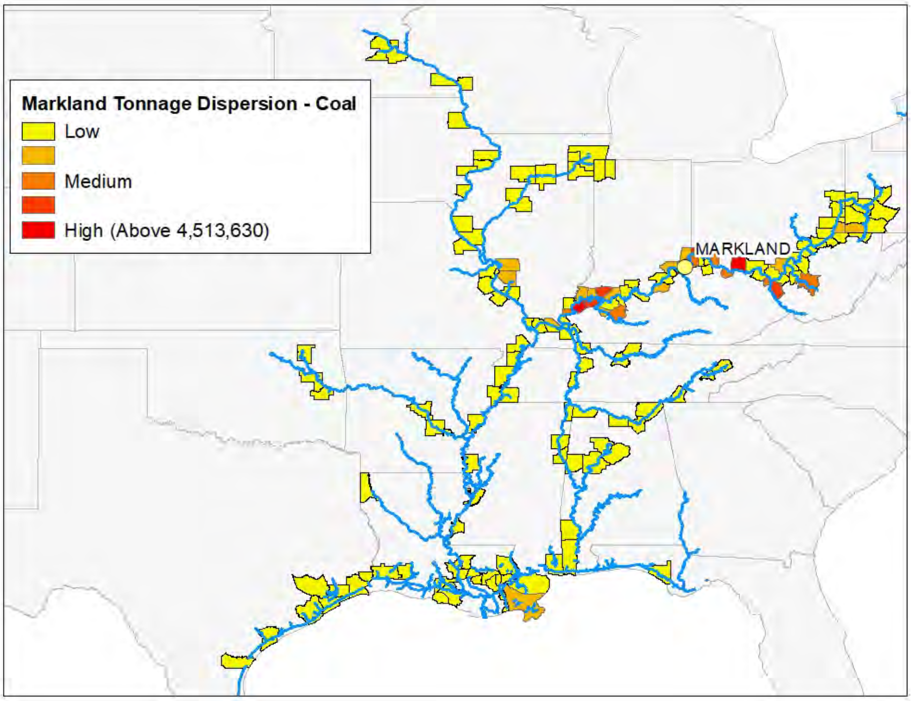



Figure E.7 – Distribution of Coal Shipments Transiting Markland Locks & Dam




Finally, the direct results described above were combined with a 2014 National Waterways Foundation analysis to estimate upper bounds for the regional economic impacts associated with an unplanned lock closure. The regional impact – lost incomes and lost jobs –are summarized below.

**Table E.2 – Estimated Regional Impacts**

| | Markland | Calcasieu | LaGrange | UM L&D 25 |
|---|---|---|---|---|
| Regional Output | $2,520,578,383 | $4,347,871,315 | $5,188,761,521 | $5,242,759,485 |
| Regional Incomes | $657,544,177 | $1,094,959,385 | $1,462,470,596 | $1,570,516,397 |
| Regional Employment | 13,210 | 17,487 | 24,447 | 24,250 |

Note: These impacts cannot be summed across the four locks.

## SUMMARY AND FINDINGS

The historical importance of the inland navigation system to the United States has been tied to the network's coverage of the heartland and its efficient connectivity covering over 12,000 miles. This comes from the standardization of system capabilities, and especially the minimum channel depth and "standardization" of the more than 170 lock and dam structures, that allows the same equipment to efficiently traverse the entire system and from which the success of the system has been derived.

Unfortunately, the connectivity of the system also creates vulnerability, and this study documents and illustrates the magnitude of the impact from the prolonged loss of any single lock and dam project. If an unscheduled and extended outage were to occur at any of the four locks analyzed here, the impact would reach across all of the states served by the system and cause billions of dollars in economic harm to shippers, the commerce that depends on those shippers, and the communities that rely on this substantial business activity.

### A FEW KEY FINDINGS

- Each of the four locks considered within the study helps shippers avoid more than $1 Billion in additional transportation costs each year.
- The important roles played by individual navigation projects span a broad range of both geographies and economic purposes, and in some cases provide freight mobility that could not be easily replaced by other transport modes.
- While every state that originates or terminates traffic supported by the four locks benefits from inland navigation's availability, the results reflect the waterway's *extraordinary* commercial value to 18 states, especially Louisiana, Texas, and Illinois.
- In the cases of LaGrange Lock & Dam and Lock & Dam 25, trucking to alternative waterway locations would mean an additional 500,000 loaded truck trips per year and an additional 150 million truck miles in the affected states. This is not tenable.

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# 1 Research Motivation, Context, and Approach

The National Waterways Foundation (NWF) has partnered with the U.S. Department of Transportation's *Maritime Administration (*MARAD*)* to sponsor this research project which estimates the specific economic consequences resulting from the unscheduled and extended closure of four representative navigation locks. At each of the four locks selected, the impact on shippers currently using the locks, called the *Shipper Supply Chain Cost Burden* is estimated to exceed $1 billion per year with very significant additional regional economic and employment impacts extending widely over the territory served by the inland waterway system.

Through this work the sponsors also seek to demonstrate an analytical framework that can be applied to additional locks and in some contexts, measurably reduce the resources needed to undertake robust waterway system project evaluations.

## 1.1 PROJECT OVERVIEW AND APPROACH

The more than 12,000 miles of navigable waterways in the U.S. are composed of segments with characteristics that vary considerably. On some segments of the system, like the lower Missouri and lower Mississippi Rivers, the combination of upstream water management and naturally occurring river flows allow for "open river" where barge traffic can move, unimpeded, from one end of the segment to the other. More commonly, however, maintaining dependable, year-long navigation requires the use of dams that help maintain acceptable channel depths within the pools they create. On these segments, passage around the necessary dams requires navigation locks that lift or lower vessels, including commercial towboats and barges, allowing them to pass from one pool to the next.

On waterway segments where dams and locks are necessary, any disruption in a lock's operation can significantly inhibit barge transportation. In some cases, lock outages are scheduled to allow for necessary maintenance. These scheduled outages are announced months or even years in advance so that impacted waterway shippers can adjust commodity inventories or otherwise prepare for the service disruption. In other cases, however, weather, accidents, or mechanical failures lead to unscheduled lock closures of varying durations. Because carriers and shippers have no opportunity to prepare for unscheduled lock outages, these closures can be tremendously disruptive to water-dependent commerce. It is this latter type of outage on which the current work is focused.

The overall effort has been divided into four broad sets of tasks:

- The development of a methodology for selecting a small number of locks for careful analysis;
- The collection and analysis of the data necessary to defensibly estimate the direct economic costs of the subject lock closures;
- The extension of the direct closure-related costs to estimate the broader, economy-wide regional indirect impacts, and
- The documentation of the approach to allow use of the methodology in future analyses.

Additionally, the study team was charged with using visualization tools that enhance the interpretation of the team's analytical results. The sections that follow are organized around these goals.

Finally, while the topics and methods described here are anchored to rigorous economic and statistical principles, the research team has attempted to use a practical, applied approach suited for real-world practitioners.

## 1.2 REPORT STRUCTURE

Chapter 2 provides the primary results that have been generated by this research effort. For each of the four locks selected for detailed analysis, tables and graphical representation summarize Shipper Supply Chain Cost Burden and the resulting regional economic impact that would result from an unanticipated closure of the analyzed lock and dam project. Chapter 2 concludes with an assessment of how rail capacity may impact these shipper costs.

Beyond developing the results for these four selected locks, an additional goal of the work reported here is to demonstrate efficient methods that will facilitate future project analyses. To that end, we include fairly detailed and technical descriptions of both data and methodologies. Chapters 3, 4, and 5 fully describe application of the data and existing tools used to screen and select locks, calculate the costs averted by preventing unscheduled lock closures, and estimate the regional economic impacts. Additional supporting material is provided in three Appendices.

2

# Study Methodology and Findings

## Lock Selection, Shipper Supply Chain Cost Burden Analysis, Regional Economic Impact Analysis

The analytical path summarized in the introduction produced three specific products – a screening tool that was used by project sponsors to select four individual locks for further analysis, estimates of the supply chain costs that would be imposed directly on waterway users when unplanned lock closures are not avoided, and estimates of subsequent regional impacts that extend the estimated closure costs to a broader set of economic effects. At the time that this project was begun in 2016, the most recent year for which complete data sets were available was 2014, and the reported findings are based on that year's information. These findings and applications are summarized below.

## 2.1 LOCK SELECTION

The screening tool described is a cross-sectional framework that compares fully disaggregated lock and dam infrastructure and performance characteristics to isolate navigation projects based on analytical purpose. For each lock, specific screening tool elements reflect:

- Physical characteristics (e.g., age, number/dimensions of chambers);
- Performance (e.g., tonnage, number of lockages, processing times); and
- Network role (e.g., system ton-miles, and associated lockages at other locations).

The current work developed corresponding data for a population of 170 navigation locks. By design, the screening tool coalesces data that allow an array of cross-sectional comparisons of lock attributes, performance, and network functions. In the current application, the study team did not apply a weighting scheme that favors or reduces the importance of any particular lock characteristic. Instead, screening tool data were provided without any presupposed preferences.

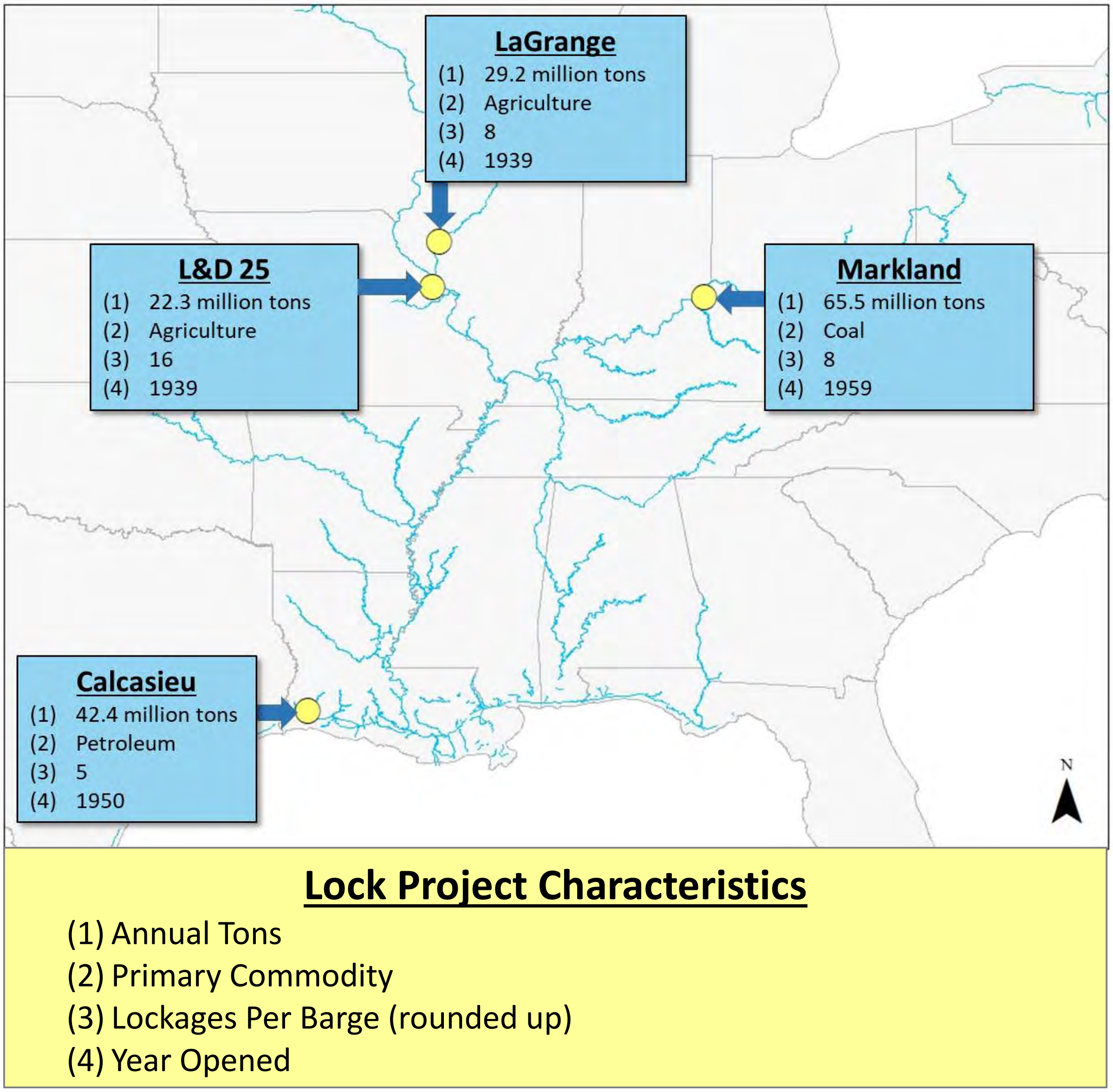
Based on these data, the project sponsor evaluated a subset of the whole universe of locks and ultimately selected four facilities for further analysis. These include Markland Locks & Dam on the Ohio River, near Cincinnati; Calcasieu Lock on the Gulf Intracoastal Waterway in Louisiana; LaGrange Lock & Dam, the southern-most of the navigation structures on the Illinois River; and Lock & Dam 25 (L&D25) on the Mississippi River, immediately north of St. Louis. These four locations are depicted graphically in Figure 2.1. Chapter 3 more fully describes the lock selection criteria and process. However, generally, these locks were selected to reflect a solid cross-section of geography, commodity mix, and network role. Table 2.1 provides sample screening tool data for the four locks selected for further study.

Table 2.1 – Screening Tool Results Summary

| | CALCASIEU | LAGRANGE | L&D 25 | MARKLAND |
|---|---|---|---|---|
| LOCK LOCATION INFORMATION | | | | |
| **River** | GIWW | ILLINOIS | MISSISSIPPI | OHIO |
| **River Mile** | 238.5 | 80.2 | 241.4 | 531.5 |
| **Bank** | R | R | R | L |
| **USACE Division** | MVD | MVD | MVD | LRD |
| **USACE District** | MVN | MVR | MVS | LRL |
| **State** | LA | IL | MO | KY |
| **Town** | Lake Charles | Beardstown | Winfield | Warsaw |
| **Latitude** | 30.088061 | 39.94507 | 39.003117 | 38.774413 |
| **Longitude** | -93.293273 | -90.53714 | -90.689209 | -84.966172 |
| **LOCK CHARACTERISTICS** | | | | |
| **Lift** | 4 | 10 | 15 | 35 |
| **Length** | 1205 | 600 | 600 | 1200 |
| **Width** | 75 | 110 | 110 | 110 |
| **Year Opened** | 1950 | 1939 | 1939 | 1959 |
| **Gate Type** | Sector | Miter | Miter | Miter |
| **Mooring Cells** | N | N | Y | Y |
| **AGGREGATE LOCK ACTIVITY** | | | | |
| **Lockages** | 3,987 | 3,659 | 3,172 | 4,071 |
| **LPMS Total Tons**[1] | 42,240,214 | 27,199,448 | 21,673,519 | 52,753,624 |
| **COMMODITY INFORMATION** | | | | |
| **WCSC Coal** | 245,836 | 443,288 | 660,624 | 30,788,869 |
| **WCSC Petroleum** | 24,988,887 | 5,623,494 | 320,411 | 7,440,371 |
| **WCSC Chemicals** | 9,078,337 | 4,888,770 | 4,171,737 | 3,898,264 |
| **WCSC Crude Materials** | 3,937,379 | 3,401,419 | 3,082,613 | 14,339,508 |
| **WCSC Primary Manufact. Prod.** | 2,744,157 | 3,344,289 | 1,667,149 | 4,896,902 |
| **WCSC Food and Farm Products** | 843,753 | 11,460,988 | 12,433,825 | 4,089,324 |
| **WCSC Machinery / Equipment** | 9,222 | 5,632 | 6,602 | 55,525 |
| **WCSC Waste Materials** | 626,896 | - | - | - |
| **WCSC Total Tons**[1] | 42,474,467 | 29,167,880 | 22,342,961 | 65,508,763 |
| **SYSTEM FUNCTIONS** | | | | |
| **System Ton-Miles Supported** | 2,330,362,699 | 35,764,883,159 | 29,499,570,937 | 48,278,194,662 |
| **Lockages per Barge** | 4.4 | 8.1 | 15.9 | 7.5 |
| **Total Tons - Pool Above** | 58,671 | 1,065,293 | 0 | 10,801,531 |
| **Total Tons - Pool Below** | 62,800 | 2,344,044 | 33,815 | 22,015,111 |

[1] Limitations in LPMS data collection methods (particularly pertaining to coal movements) often lead to deviations between LPMS and WCSC-based tonnage values. In such cases, the WCSC figures are generally considered more reliable

Figure 2.1 – Selected Lock Project Characteristics




## 2.2 SHIPPER SUPPLY CHAIN COST BURDEN (SSCCB) ANALYSIS

At its core, the current project is intended to simulate and measure the direct economic costs of unanticipated navigation lock closures using existing data and tools in ways that reduce the resources required to undertake this type of analysis. Meeting this goal required the execution of three primary task sets that included:

- Lock selection and data preparation;
- Scenario design and traffic diversion assessments; and
- The calculation of shipper supply chain costs both before and after an unanticipated lock closure.

As with all study elements and consistent with the *Project Proposal,* this work is designed to conform to the Principles & Guidelines (P&G) that govern the analysis of all federal inland navigation infrastructure projects by the United States Army Corps of Engineers (USACE).[2]

As noted, the study team estimated supply chain costs and navigation-related shipper cost burdens for unplanned outages at four individual locks. As expected, in terms of traffic and commercial function, LaGrange and L&D 25 are relatively similar. By contrast, Markland and Calcasieu differ from both each other and from the two upper Mississippi and Illinois River locks.

LaGrange and L&D 25 feature long-haul movements that consist mostly of down-bound corn and soybeans and up-bound fertilizer. Traffic at Markland is dominated by coal movements that are typically shorter in distance. However, the remaining Markland traffic is quite diverse, both in terms of commodities and shipment geographies. Finally, shipments through Calcasieu are somewhat shorter than Markland moves and often not even half the length of the shipments that transit LaGrange or Lock & Dam 25. Whereas, Markland is dominated by coal and LaGrange and L&D 25 are dominated by grain, Calcasieu traffic is primarily petroleum and chemical products.

These four locks support traffic on every segment of the Mississippi River system. Most of the traffic at LaGrange and L&D 25 flows the length of that main-stem and makes relatively lesser use of tributaries or intermediate terminal locations. By contrast, both the Ohio River coal traffic and, to a lesser degree, the traffic flows through Calcasieu routinely involve origins and destinations that are located along system tributaries or at intermediate spots between major terminal regions. To highlight this difference, the study team developed a *Corridor Concentration Metric* that combines data on traffic distributions with information describing shipment distances into a single measure called the *Corridor Concentration Index*. All else equal, a value closer to zero indicates that diverted shipments are less likely to face capacity constraints and a value closer to 1 signals the opposite, based both on the shipment distances and the limited number of available routes. The results of this calculation for the four subject locks are depicted in Figure 2.2. A shipper traversing a lock with a higher concentration metric score is more likely to face capacity issues in seeking to use alternative modes, especially rail, if lock operations are disrupted. This is more fully discussed in Section 2.4, and the data used and a discussion of the metric's calculation are provided in Appendix 1.

Finally, while nearly every state that originates or terminates traffic supported by the four locks clearly benefits from inland navigation's availability, analysis reflected the waterway's *extraordinary* commercial value in Louisiana, Texas, and Illinois.

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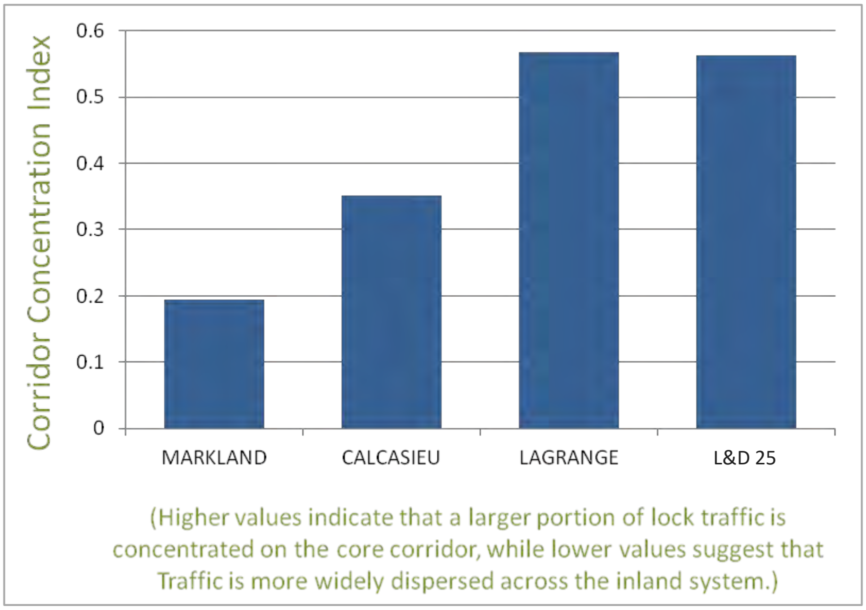
[2] See *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, Washington, DC, March 10, 1983.

Figure 2.2 – Corridor Concentration Metrics




## Markland Locks & Dam

The Shipper Supply Chain Cost Burden expected at Markland if an unscheduled closure of the lock were to occur is summarized in Table 2.2, and based on the 2014 data used in the study, the annual Cost Burden is estimated to exceed $1.3 billion.

The geographical distribution of this outcome is depicted in Figure 2.3. What is very clearly shown by the figure is that the impact of even a single lock closure can be system-wide and will be felt across the entire midsection of the United States. Appendix 3 provides similar graphics based on commodity-specific flows.

As noted in Section 2.1 (Lock Selection), the Markland traffic includes a substantial number of relatively short-haul coal movements that generally serve markets that are rail-competitive. While coal is the primary source of traffic volumes, both chemicals and petroleum products generate larger aggregate averted costs. Given the uncertainty of future coal volumes and the projected growth in chemical and plastics, this distinction is important. The distributions of current coal and chemical traffic that transits Markland are depicted graphically in Figures 2.4 and 2.5. The contrast is fairly striking.

The study-estimated 2014 tonnage at Markland, based on Waterborne Commerce Statistics Center (WCSC) data, is 12.8 million tons greater than the traffic volumes reported through the Lock Performance Monitoring System (LPMS). An examination of the commodity-specific values reveals that this variation is almost entirely attributable to differing values for coal. This sort of reporting differential is common to coal movements throughout the Ohio basin and is well-known to both the USACE and other transportation practitioners. Because the LPMS data sometimes depend on estimates by lock personnel who necessarily are focused principally on safe and expeditious vessel transits, the WCSC data more accurately capture instances of barge loadings to depths greater than 9 feet observed when river conditions allow.

## Calcasieu Lock

Located roughly halfway between Houston and Baton Rouge and immediately south of Lake Charles, Louisiana, the Calcasieu Lock is a critical element in inland navigation between Texas and Louisiana. The Shipper Supply Chain Cost Burden for Calcasieu is reported in Table 2.3 and depicted in Figure 2.6. In total, the cost burden is estimated to exceed $1.1 billion. Not surprisingly, traffic through the single-chamber lock is dominated by petroleum and chemical traffic that, together accounted for 80 percent of the project's 2014 tons. The shorter shipment distances impact the per-ton cost. However, on a ton-mile basis, these costs are consistent with the values attained elsewhere. Appendix 3 provides similar graphics based on commodities.

A forward-looking regional view suggests measurable traffic growth in coming decades. In, 2015, Texas and Louisiana, together, accounted for nearly two-thirds of all U.S. investment in "mobile" manufacturing capital. Much of this reflects what the *American Chemistry Council* estimates to be $164 billion in new natural gas-related chemical and plastics investment.

## LaGrange Lock & Dam and Lock & Dam 25

Volumes at LaGrange and at Lock & Dam 25 are dominated by Gulf-destined, down-bound flows of corn and soybeans. Ten million tons of farm products pass through each lock annually. The 20 million ton total is nearly six times greater than the volume of farm products moving by rail in the same corridor. In addition to down-bound corn and soybeans, both locks handle approximately four million tons of up-bound fertilizer annually. Finally, LaGrange tonnage also includes chemical, petroleum, and manufactured goods flows tied to commerce with origins and destinations along the Chicago Area Waterway System (CAWS).

The potential Shipper Supply Chain Cost Burden for grain passing through LaGrange and L&D 25 are large compared to corn and soybean movements elsewhere on the inland system. There are two reasons for this. First, below St. Louis, the Mississippi is open river, where tow sizes of 30 barges or more are common. Thus, total per ton barge charges are lower than elsewhere.

As important, both terminal capacity constraints and railroad line-haul capacities over relevant route segments suggest that, if forced from the river, most upper Mississippi and Illinois River basin corn and soybeans would divert to all-rail routings to locations in the Pacific Northwest (PNW).[3] Railroad per-ton costs (to any location) are significantly higher than the cost of barge transportation to the Louisiana Gulf and the distance to the Pacific Northwest is generally twice the distance to Gulf export locations. Thus, even though cost estimates were offset to reflect ocean rate differentials to Pacific Rim destinations, the relatively high cost of rail diversions leads to high potential supply chain costs. The Shipper Supply Chain Cost Burden for a closure at LaGrange and Lock & Dam 25 is reported in Tables 2.4 and 2.5 and depicted in Figures 2.7 and 2.8. The total cost burden of an unplanned closure exceeds $1.5 billion at either lock.

[3] While Canadian ports are not necessarily excluded, for the most part, use here to the "PNW" refers to West Coast locations in Oregon and Washington.

Table 2.2 – Closure-Related Supply Chain Cost Burden, Markland Locks & Dam

| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| Coal | 10 | 30,788,869 | 1,675 | 473 | $7.21 | $221,987,745 |
| Petroleum Products | 20 | 7,440,371 | 2,598 | 967 | $49.49 | $368,253,302 |
| Chemicals | 30 | 3,898,264 | 1,693 | 1,412 | $70.91 | $276,416,124 |
| Crude Materials | 40 | 14,339,508 | 1,673 | 757 | $16.93 | $242,729,791 |
| Primary Manufactured Goods | 50 | 4,896,902 | 1,658 | 1,294 | $32.75 | $160,394,481 |
| Farm Products and Food | 60 | 4,089,324 | 1,826 | 1,342 | $9.41 | $38,460,711 |
| Equipment | 70 | 55,525 | 1,586 | 1,216 | $32.75 | $1,818,681 |
| TOTAL | | 65,508,763 | | | | $1,310,060,835 |

Table 2.3 – Closure-Related Supply Chain Cost Burden, Calcasieu Lock

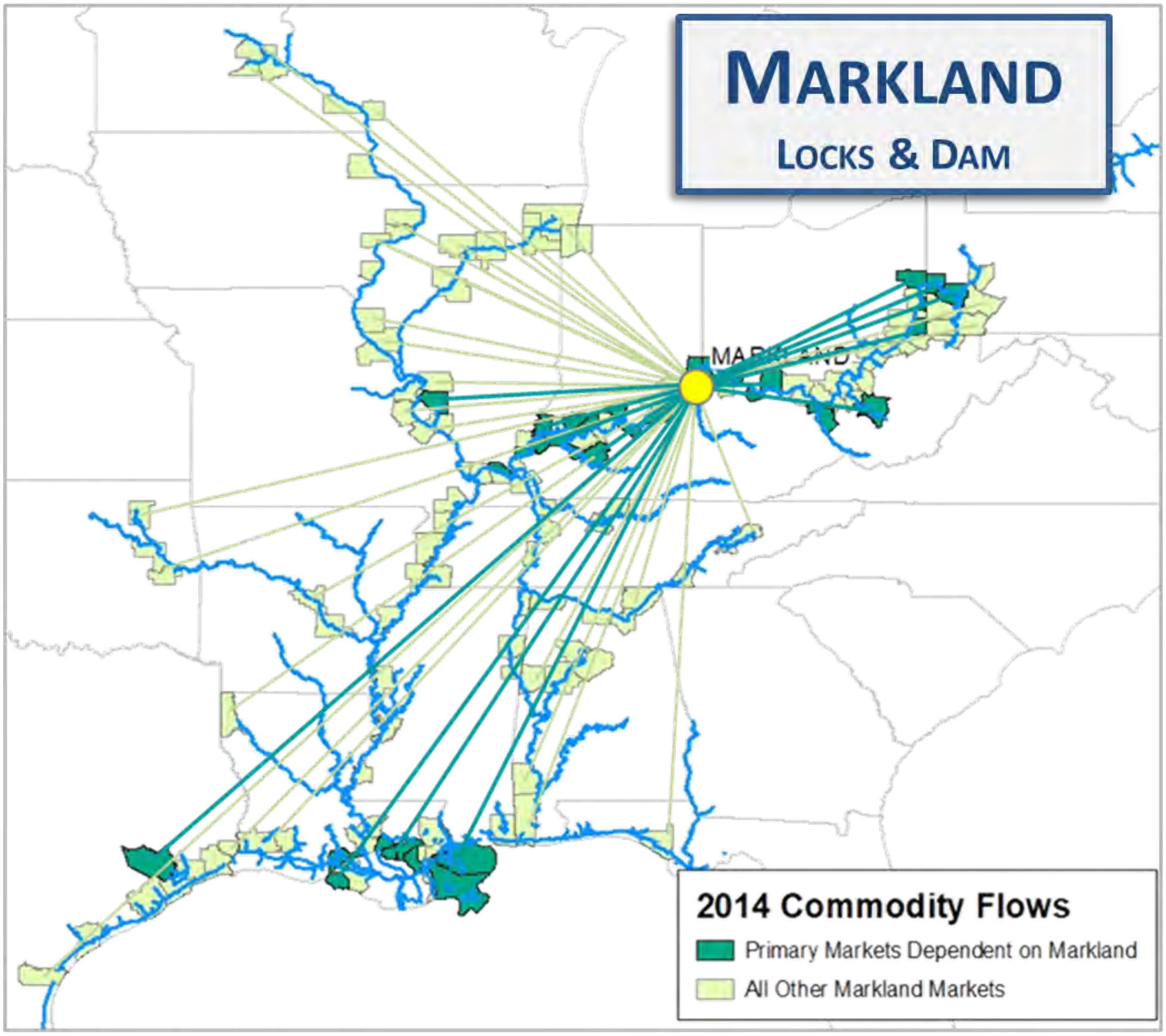
| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| Coal | 10 | 245,836 | 1,617 | 1,268 | $26.97 | $6,629,552 |
| Petroleum Products | 20 | 24,988,887 | 2,859 | 542 | $21.70 | $542,287,348 |
| Chemicals | 30 | 9,078,337 | 2,022 | 846 | $25.44 | $230,953,087 |
| Crude Materials | 40 | 3,937,379 | 1,578 | 1,230 | $45.66 | $179,789,257 |
| Primary Manufactured Goods | 50 | 2,744,157 | 1,568 | 1,114 | $43.73 | $120,009,771 |
| Farm Products and Food | 60 | 843,753 | 1,769 | 1,021 | $26.97 | $22,753,806 |
| Equipment | 70 | 9,222 | 307 | 524 | $26.97 | $248,693 |
| Scrap and Waste | 80 | 626,896 | 1,537 | 259 | $26.97 | $16,905,741 |
| TOTAL | | 42,474,467 | | | | $1,119,577,255 |

Table 2.4 – Closure-Related Supply Chain Cost Burden, LaGrange Lock & Dam

| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| Coal | 10 | 443,288 | 1,566 | 942 | $45.77 | $20,291,015 |
| Petroleum Products | 20 | 5,623,494 | 2,210 | 1,202 | $32.53 | $182,914,135 |
| Chemicals | 30 | 4,888,770 | 1,739 | 1,230 | $51.45 | $251,529,491 |
| Crude Materials | 40 | 3,401,419 | 1,552 | 1,270 | $61.22 | $208,236,345 |
| Primary Manufactured Goods | 50 | 3,344,289 | 1,513 | 1,056 | $30.96 | $103,524,351 |
| Farm Products and Food | 60 | 11,460,988 | 1,588 | 1,226 | $81.38 | $932,684,606 |
| Equipment | 70 | 5,632 | 704 | 1,416 | $84.87 | $477,986 |
| TOTAL | | 29,167,880 | | | | $1,699,657,929 |

Table 2.5 – Closure-Related Supply Chain Cost Burden, Lock & Dam 25

| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| Coal | 10 | 660,624 | 1,547 | 713 | $38.90 | $25,696,959 |
| Petroleum Products | 20 | 320,411 | 1,732 | 1,518 | $47.14 | $15,103,646 |
| Chemicals | 30 | 4,171,737 | 1,612 | 1,430 | $59.66 | $248,899,601 |
| Crude Materials | 40 | 3,082,613 | 1,568 | 1,488 | $67.76 | $208,863,996 |
| Primary Manufactured Goods | 50 | 1,667,149 | 1,677 | 845 | $22.93 | $38,225,955 |
| Farm Products and Food | 60 | 12,433,825 | 1,598 | 1,323 | $83.16 | $1,033,977,564 |
| Equipment | 70 | 6,602 | 660 | 1,270 | $82.19 | $542,606 |
| TOTAL | | 22,342,961 | | | | $1,571,310,327 |




**MARKLAND LOCK & DAM**

Markland is a key element in the waterway thoroughfare that moves 60 million tons of freight through the Ohio River basin each year. Markland and the system it supports are a vital commercial conduit within the basin that:

- Is essential to affordable energy.
- Efficiently connects the upper Midwest to the resource-rich Gulf.
- Integrates the Midwest with wide-ranging domestic and global trade.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 175 counties in 18 states.
- Cost the shipping public more than $1.3 billion annually in additional transport charges.
- Disrupt the affordable delivery of electric power throughout the eastern U.S.
- Require the availability and use of 40,000 additional rail carloads and 60,000 additional truckloads.
- Discourage 80 percent of users from ever returning to the waterway.

Figure 2.4 – Distribution of Chemical Shipments Transiting Markland Locks & Dam[4]

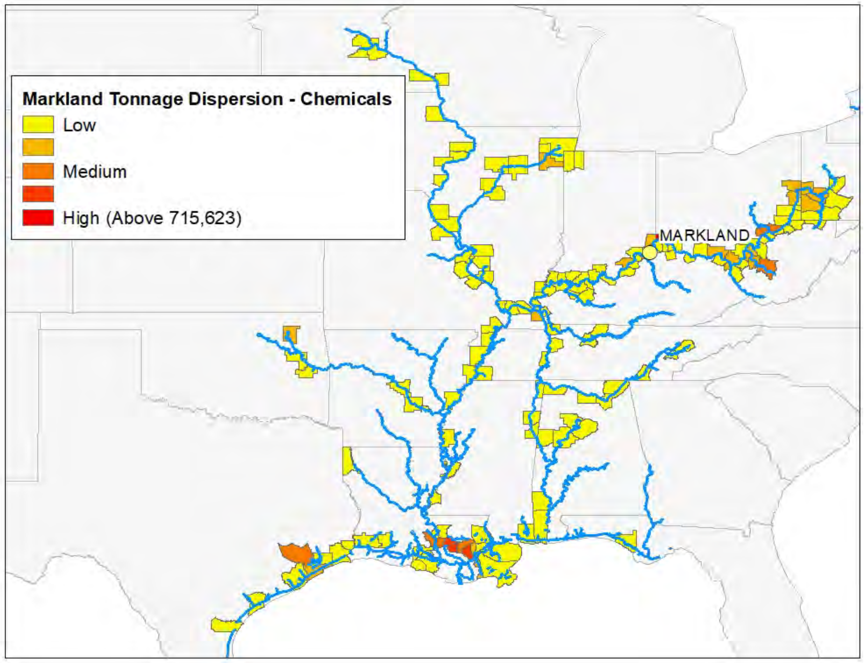
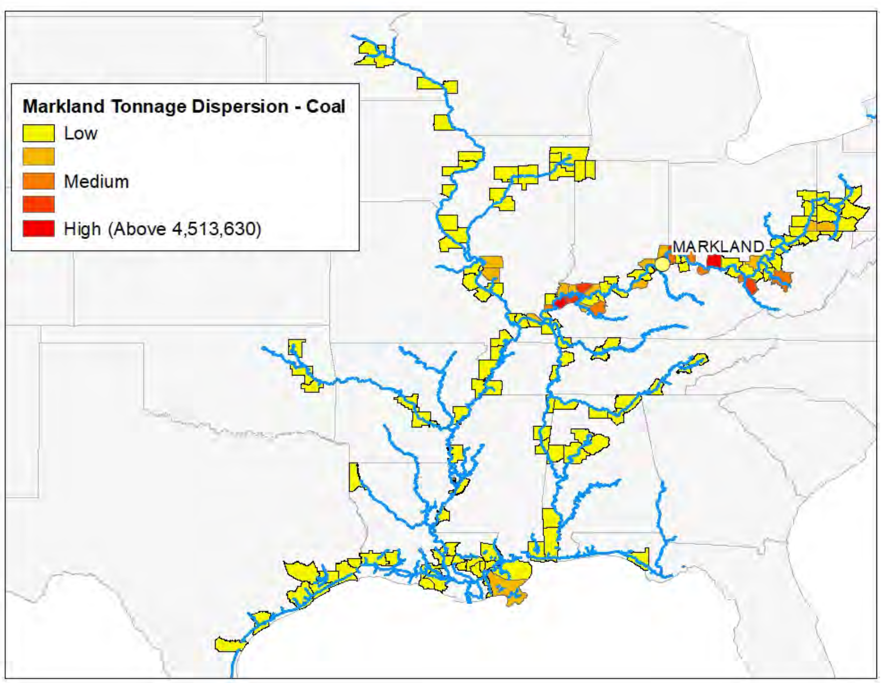
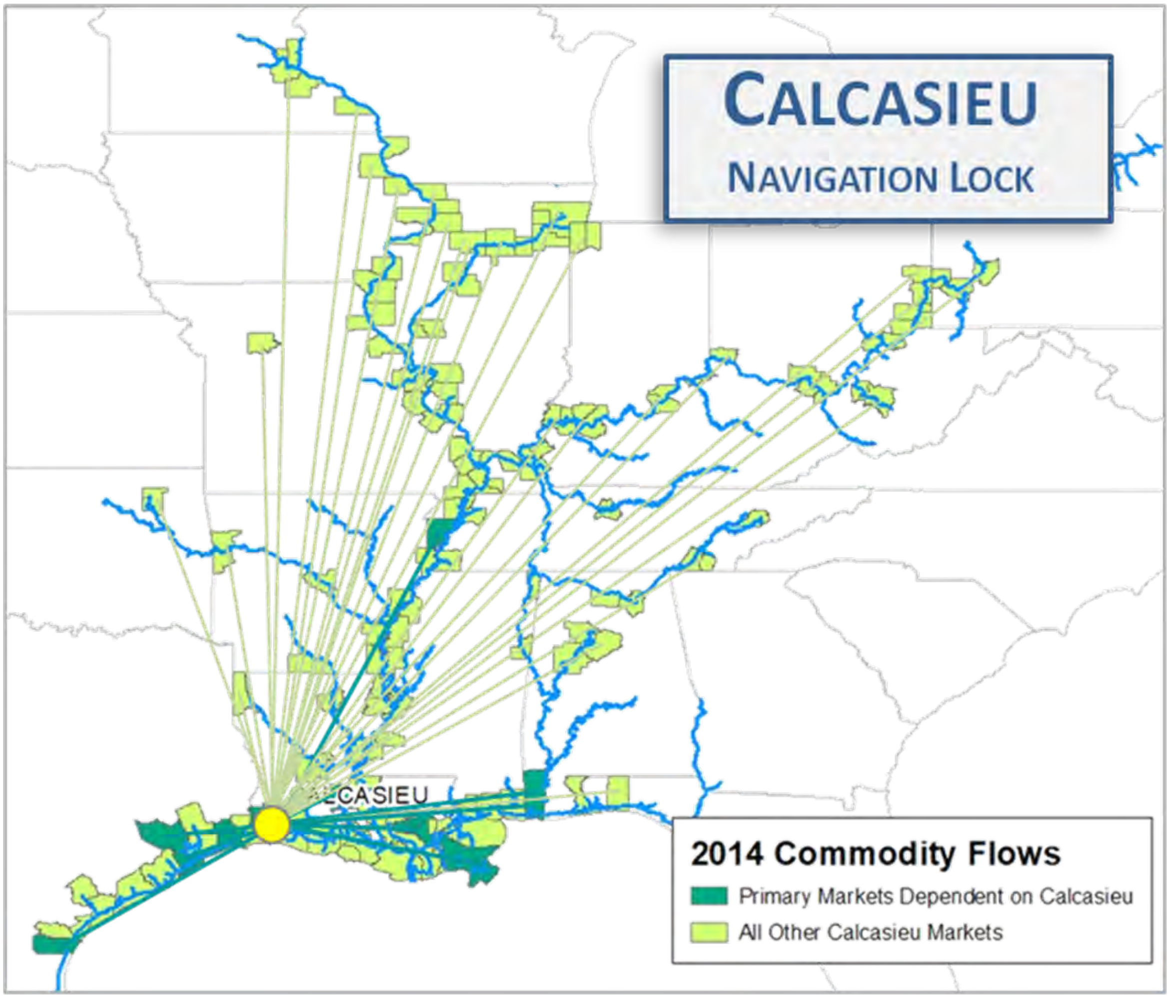



Figure 2.5 – Distribution of Coal Shipments Transiting Markland Locks & Dam




[4] These graphics are provided to emphasize the potential change in Ohio River traffic composition. Similar depictions for an array of commodities and encompassing all four locks can be found in Appendix 3.

**Figure 2.6 – Markets Dependent on Calcasieu Lock**[5]




**CALCASIEU LOCK & DAM**

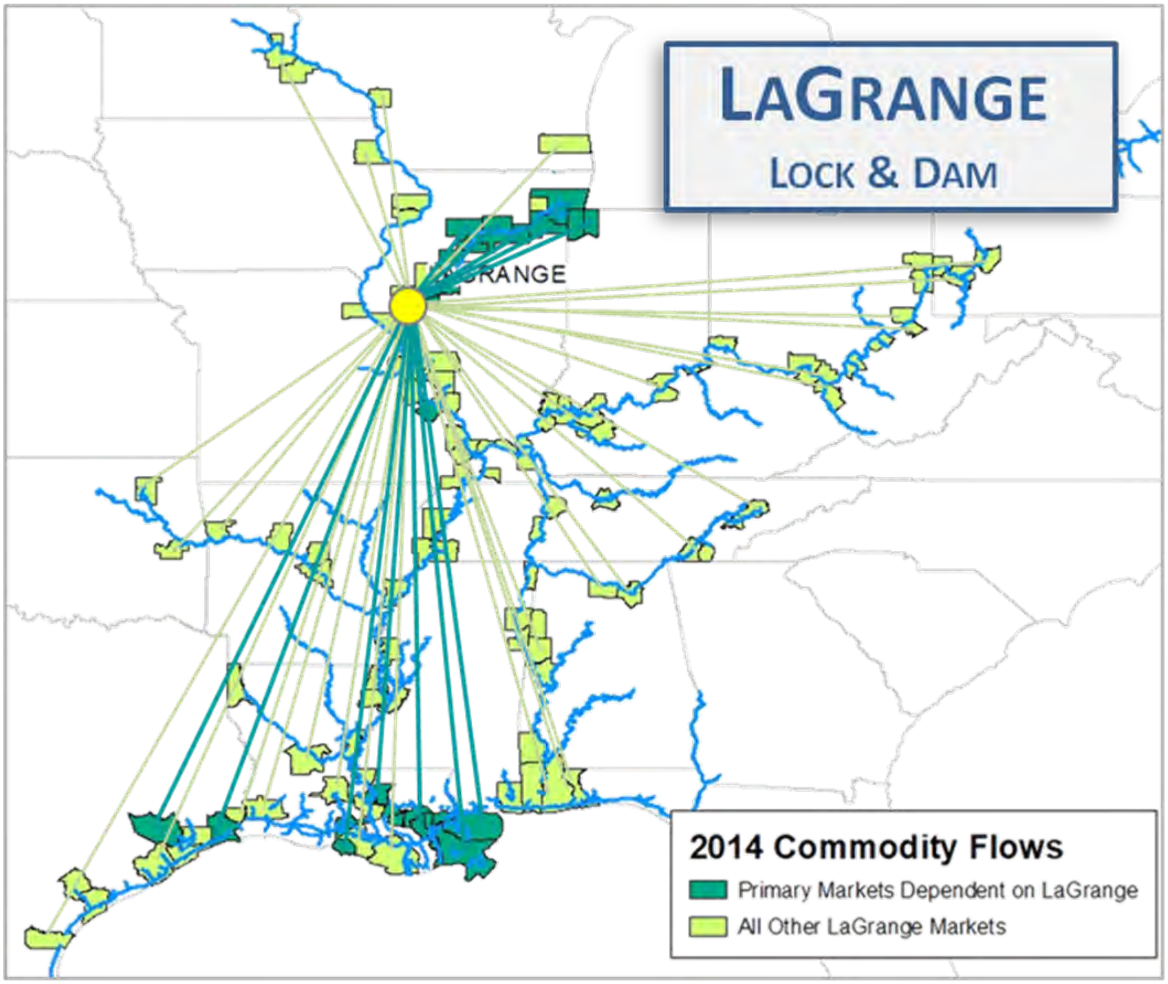
Calcasieu is a critical piece of the high-density waterway corridor that serves plastic and chemical producers and petroleum refiners throughout the Gulf region. Unseen to most, Calcasieu moves 40 million tons of freight through the Gulf each year. This facility, and the system it supports, are vital commercial links within America's freight network that (1) are essential to affordable energy production, (2) efficiently connect the Gulf region to global trade, and (3) integrate the Gulf region's vital production into the core U.S. economy.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 170 counties in 18 states.
- Cost the shipping public more than $1.1 billion annually in additional transport charges.
- Require the availability and use of 10,000 additional rail cars and several hundred locomotives.
- Result in the loss of 17,000 full-time, highly-compensated jobs.

[5] Depictions similar to that provided for Markland for Calcasieu commodities can be found in Appendix 3.

Figure 2.7 – Markets Dependent on LaGrange Lock & Dam[6]




**LAGRANGE LOCK & DAM**

LaGrange is a critical piece of the marine highway that links the upper Mississippi and Illinois basin farmlands to export markets reachable through the Louisiana Gulf. Each year, more than ten million tons of corn and soybeans transit this lock down-bound, for export and the region's agriculture is equally served by up-bound fertilizer movements.

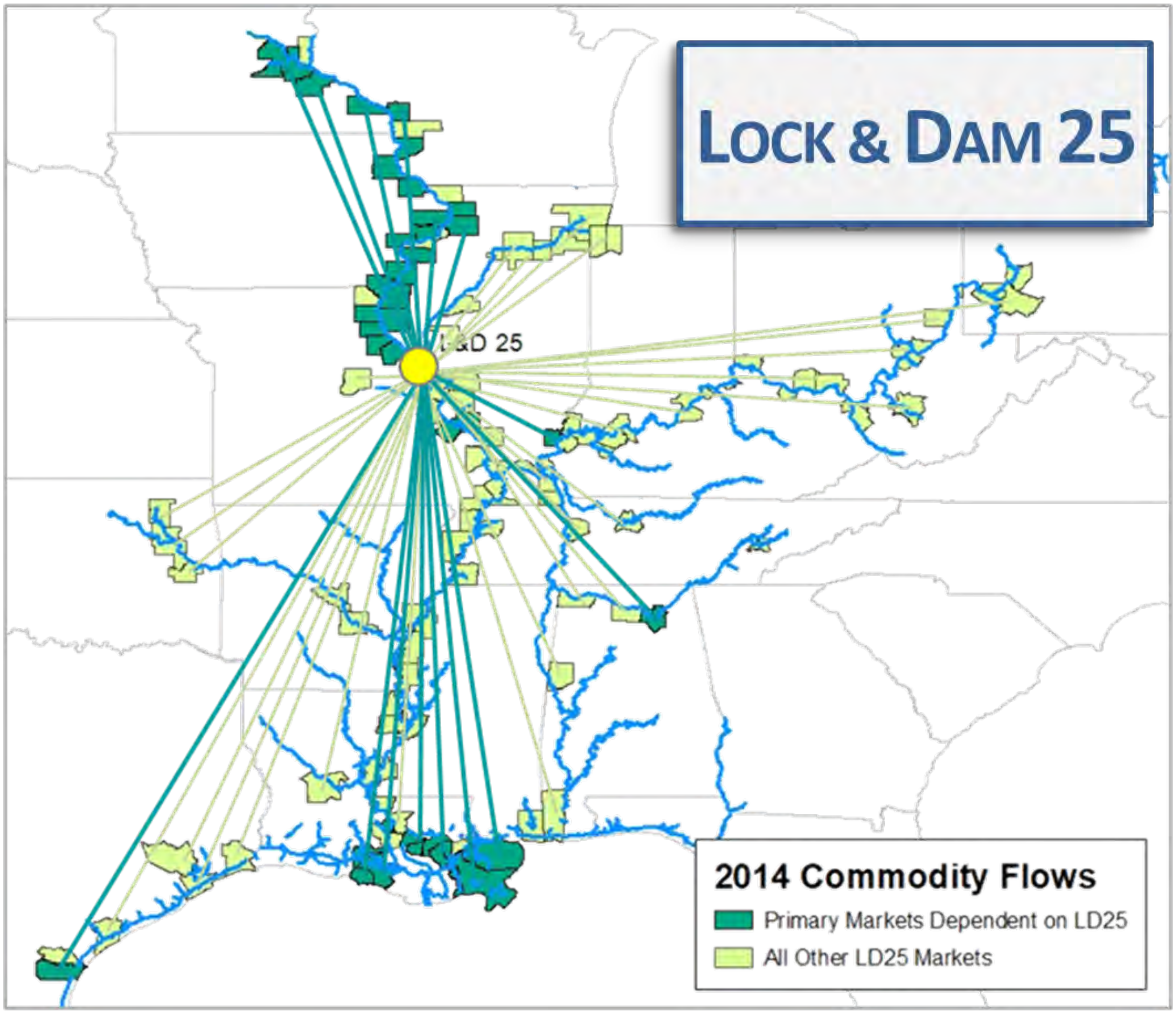
In addition to agricultural commerce LaGrange also is an integral component in the navigation system that links the Chicago Area Waterway System (CAWS) to the rest of the U.S.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 135 counties in 18 states
- Threaten the nation's primary path for corn and soybean exports.
- Cost the shipping public nearly $1.7 billion annually in additional transport charges.
- Severely stress the nation's railroad infrastructure.
- Lead to a $2.1 billion loss in farm-dependent incomes.

[6] Depictions similar to that provided for Markland for LaGrange commodities can be found in Appendix 3.

Figure 2.8 – Markets Dependent on Lock & Dam 25[7]




**LOCK & DAM 25**

**L&D 25** is a second essential piece of the inland waterway system linking the upper Mississippi and Illinois basins to global farm product markets reachable through the Louisiana Gulf. Like LaGrange, each year, more than ten million tons of corn and soybeans transit L&D 25 down-bound, for export , while up-bound fertilizer movements account for more than 4 million tons of the lock's up-bound traffic.

**AN UNPLANNED CLOSURE WOULD:**

- Immediately affect commerce in 132 counties in 17 states.
- Immediately affect the nation's primary path for corn and soybean exports.
- Cost the shipping public nearly $1.6 billion annually in additional transport charges.
- Severely test the nation's railroads.
- Discourage 80 percent of users from ever returning to the waterway.

[7] Depictions similar to that provided for Markland for Lock & Dam 25 commodities can be found in Appendix 3.

## 2.3 REGIONAL ECONOMIC DEVELOPMENT (RED) ANALYSIS

Consistent with the overarching goal to use existing resources more efficiently, results from a prior National Waterways Foundation sponsored-study were used to expedite the estimation of regional economic impacts for the four subject locks.[8] Section 5 describes the specific steps necessary to this application. The earlier NWF work involved converting lock-related efficiencies into production cost advantages that were used as drivers in economic simulations. Here, we combine the earlier study results with current estimates of avoided transportation costs to estimate upper bounds for regional economic impacts (output, incomes, and employment) attributable to the subject locks. Note "output" refers to the total value of all regional sales. These estimates are combined with an alternative methodology to estimate a corresponding lower bound for the same impacts. It is the midpoint or average for each estimated outcome that is reported here.

Before presenting the results of these estimations, it's useful to consider three points. First, even though there is often an overlap, *economic benefits* and *economic impacts* are not the same thing. Economic benefits are the *net efficiency gains* for which there is no offset. In this case these gains are the transportation costs avoided by ensuring reliable navigation infrastructures. Economic impacts are different. While they do account for the improved efficiency (direct effects), regional impacts also capture the ways that an economic improvement affects production, jobs, and incomes within a specific study area. These additional impacts often reflect economic transfers from one region to another. Nonetheless, they are a very real economic result of improved transportation access.

Next, calculating economic impacts requires an understanding of where a direct stimulus is likely to have its effects. It's easy to understand that a cost-constraining navigation project physically located in a remote rural location will not materially affect economic conditions in the region surrounding the lock. However, it's more difficult to determine where the direct effects *will* be felt. In response, the current analysis (and the earlier NWF-sponsored work) makes a strong simplifying assumption. In estimating regional economic impacts, the analysis assumes that for all non-farm product commodities, the economic stimulus associated with avoided transportation costs is divided equally between the region where the waterway shipment originates and the region where it terminates. As further explained in Section 5, this assumption is not tenable for farm products. Consequently, in the case of this commodity group, all direct effects are assumed to occur in the originating region.

Finally, unlike large-scale feasibility studies, this study does not adopt a *systems* approach, but instead examines each subject lock in isolation. For the estimated regional economic impacts, this methodology means that the results are *not* additive. Any attempt to sum effects across locks would result in double-counting.

[8] INLAND NAVIGATION IN THE UNITED STATES: An Evaluation of Economic Impacts and the Potential Effects of Infrastructure Investment, National Waterways Foundation, November 2014, http://www.nationalwaterwaysfoundation.org/documents/INLANDNAVIGATIONINTHEUSDECEMBER2014.pdf

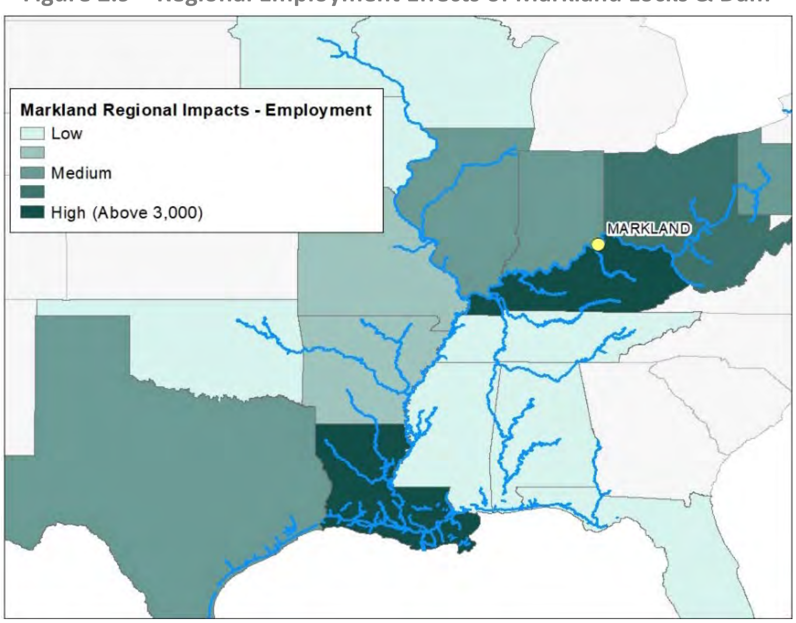
**Markland Locks & Dam** - Table 2.6 provides estimates of the economic impacts tied to the commercial use of Markland. These values reflect the importance of Markland as a means of shuttling Kentucky coal mid-Ohio basin power plants, but they also document economic activity generated in Louisiana by a lock so far upstream, due to the ability to affordably move chemicals and petroleum from manufacturing and refining facilities on the Gulf to the upper Ohio basin. Regional employment effects of Markland are shown in Figure 2.9.

**Table 2.6 – Economic Impacts Attributable to Markland Locks & Dam**

| State | Total Avoided Costs | Total Attributable Output* | Total Attributable Incomes | Total Attributable Employment |
|---|---|---|---|---|
| AL | 4,504,940 | 10,742,105 | 2,693,298 | 49 |
| AR | 6,474,484 | 16,184,170 | 5,185,339 | 81 |
| FL | 163,962 | 558,126 | 135,933 | 2 |
| IA | 814,055 | 2,033,786 | 650,840 | 10 |
| IL | 42,622,718 | 90,346,646 | 27,064,511 | 463 |
| IN | 78,141,984 | 115,728,190 | 31,296,844 | 719 |
| KY | 326,983,504 | 470,449,884 | 125,966,921 | 3,008 |
| LA | 257,103,456 | 853,703,317 | 206,841,402 | 3,240 |
| MN | 634,116 | 1,671,426 | 530,007 | 8 |
| MO | 14,157,717 | 36,993,878 | 11,669,365 | 177 |
| MS | 3,208,111 | 5,954,770 | 1,455,911 | 30 |
| OH | 264,459,882 | 401,523,540 | 109,226,097 | 2,433 |
| OK | 5,012,705 | 9,548,722 | 2,363,199 | 47 |
| PA | 65,205,206 | 98,410,103 | 26,584,599 | 600 |
| TN | 7,960,054 | 12,267,476 | 3,324,682 | 73 |
| TX | 37,597,321 | 131,395,819 | 31,967,086 | 474 |
| WI | 96,643 | 246,196 | 79,088 | 1 |
| WV | 194,919,978 | 262,820,230 | 70,509,053 | 1,793 |
| TOTAL | $1,310,060,836 | $2,520,578,383 | $657,544,177 | 13,210 |

* Output is the total value of all regional sales.

**Figure 2.9 – Regional Employment Effects of Markland Locks & Dam**



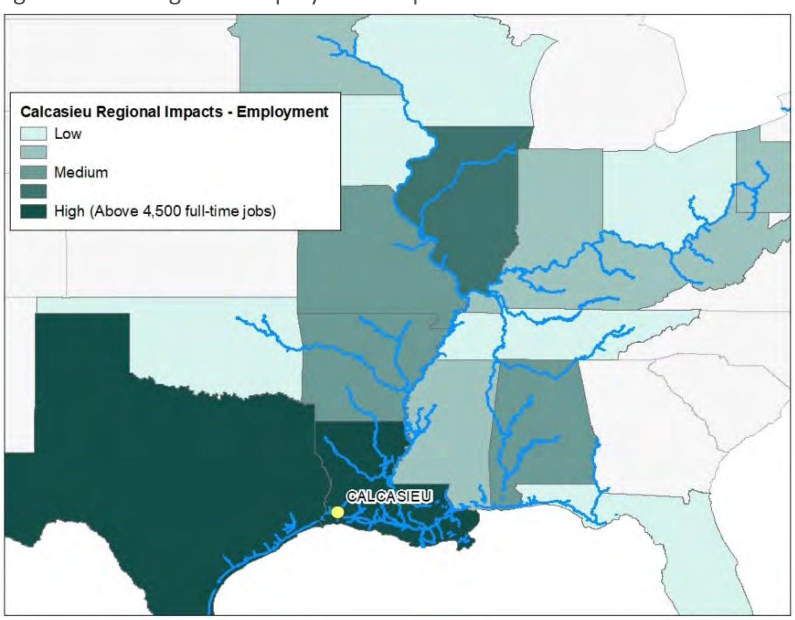
**Calcasieu Lock -** Calcasieu Lock is an essential component in a conduit that links oil refining and chemical manufacturing facilities in Texas with similar operations in Louisiana and other locations along the Gulf-Intracoastal Waterway. Thus, it is not surprising that Texas and Louisiana rank first and second in economic activity summarized in Table 2.7. Notably, however, Illinois ranks third in terms of Calcasieu's economic impacts. This importance, as it impacts regional employment, is depicted in Figure 2.10.

Table 2.7 – Economic Impacts Attributable to Calcasieu Lock

| State | Total Avoided Costs | Total Attributable Output* | Total Attributable Incomes | Total Attributable Employment |
|---|---|---|---|---|
| AL | 42,888,109 | 132,913,445 | 33,324,529 | 608 |
| AR | 33,118,475 | 107,593,798 | 34,472,595 | 515 |
| FL | 3,815,650 | 16,880,611 | 4,111,323 | 66 |
| IA | 764,635 | 2,482,772 | 794,522 | 12 |
| IL | 79,201,353 | 218,190,142 | 65,361,690 | 1,108 |
| IN | 33,631,545 | 64,734,109 | 17,506,308 | 394 |
| KY | 29,271,965 | 54,735,745 | 14,655,957 | 337 |
| LA | 283,789,119 | 1,224,690,717 | 296,726,908 | 4,554 |
| MN | 15,751,393 | 53,959,619 | 17,110,536 | 255 |
| MO | 26,871,911 | 91,257,134 | 28,786,190 | 436 |
| MS | 25,072,671 | 60,485,023 | 14,788,285 | 299 |
| OH | 12,189,517 | 24,053,005 | 6,543,118 | 151 |
| OK | 4,172,954 | 10,331,143 | 2,556,840 | 50 |
| PA | 15,370,275 | 30,148,846 | 8,144,438 | 180 |
| TN | 5,463,483 | 10,943,102 | 2,965,756 | 66 |
| TX | 486,123,401 | 2,208,018,996 | 537,185,533 | 8,236 |
| WI | 828,422 | 2,742,786 | 881,099 | 13 |
| WV | 19,236,622 | 33,710,319 | 9,043,758 | 209 |
| TOTAL | $1,117,561,501 | $4,347,871,315 | $1,094,959,385 | 17,487 |

* Output is the total value of all regional sales.

Figure 2.10 – Regional Employment Impacts Attributable to Calcasieu Lock



**LaGrange Lock & Dam and Lock & Dam 25 -** Tables 2.8 and 2.9 summarize the state-specific output, employment and income effects of LaGrange Lock & Dam and the Lock & Dam 25. Regional employment impacts are isolated in Figures 2.11 and 2.12. Together, these tables and figures point to the importance of available navigation to the agricultural regions defined by the upper Mississippi and Illinois River basins. There are several points worth noting.

Table 2.8 – Economic Impacts Attributable to LaGrange Lock & Dam

| State | Total Avoided Costs | Total Attributable Output* | Total Attributable Incomes | Total Attributable Employment |
|---|---|---|---|---|
| AL | 8,585,416 | 26,606,843 | 6,670,962 | 122 |
| AR | 5,472,911 | 17,780,146 | 5,696,683 | 85 |
| FL | 1,276,983 | 5,649,432 | 1,375,936 | 22 |
| IA | 226,791 | 736,392 | 235,656 | 4 |
| IL | 1,243,665,137 | 3,426,146,930 | 1,026,346,801 | 17,402 |
| IN | 43,902,241 | 84,503,180 | 22,852,538 | 514 |
| KY | 12,675,954 | 23,702,809 | 6,346,627 | 146 |
| LA | 270,539,494 | 1,167,512,015 | 282,873,239 | 4,341 |
| MN | 2,865,943 | 9,817,876 | 3,113,238 | 46 |
| MO | 6,600,766 | 22,416,232 | 7,070,986 | 107 |
| MS | 5,127,185 | 12,368,762 | 3,024,100 | 61 |
| OH | 11,597,985 | 22,885,763 | 6,225,594 | 143 |
| OK | 3,670,326 | 9,086,768 | 2,248,871 | 44 |
| PA | 4,905,791 | 9,622,725 | 2,599,492 | 57 |
| TN | 6,280,104 | 12,578,755 | 3,409,044 | 76 |
| TX | 72,471,408 | 329,172,070 | 80,083,765 | 1,228 |
| WI | 592,709 | 1,962,373 | 630,398 | 9 |
| WV | 3,545,102 | 6,212,449 | 1,666,667 | 38 |
| TOTAL | $1,704,002,248 | $5,188,761,521 | $1,462,470,596 | 24,447 |

* Output is the total value of all regional sales.

Figure 2.11 – Regional Employment Impacts of LaGrange Lock & Dam

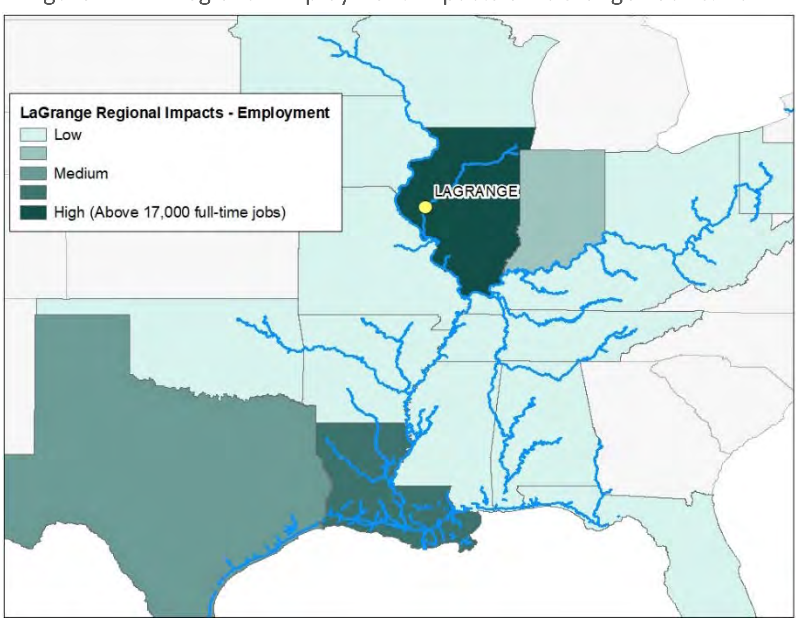
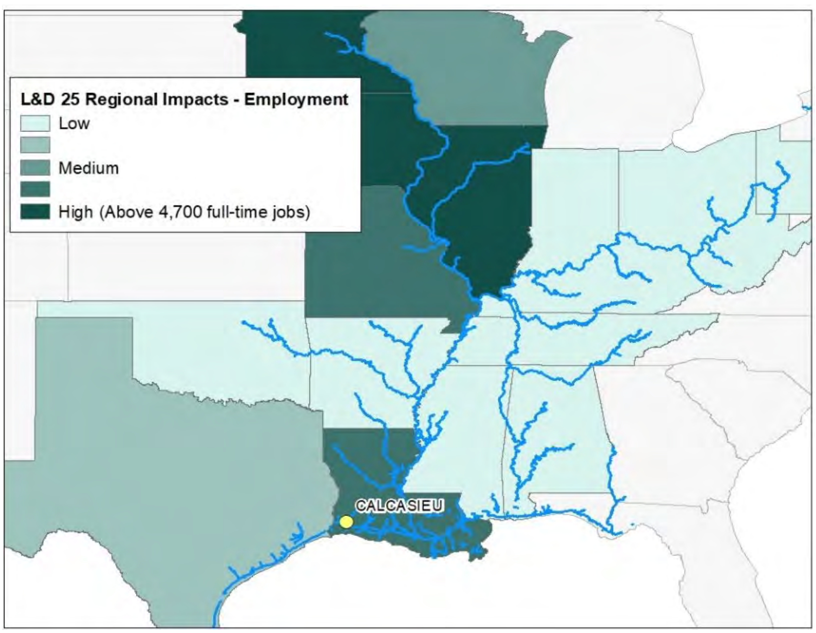


Table 2.9 – Economic Impacts Attributable to Lock & Dam 25

| State | Total Avoided Costs | Total Attributable Output * | Total Attributable Incomes | Total Attributable Employment |
|---|---|---|---|---|
| AL | 2,793,743 | 8,658,018 | 2,170,769 | 40 |
| AR | 6,801,464 | 22,096,288 | 7,079,557 | 106 |
| FL | - | - | - | - |
| IA | 369,628,309 | 1,200,184,825 | 384,076,031 | 5,763 |
| IL | 340,595,456 | 938,299,258 | 281,079,727 | 4,766 |
| IN | 2,812,857 | 5,414,196 | 1,464,183 | 33 |
| KY | 2,371,176 | 4,433,870 | 1,187,206 | 27 |
| LA | 211,309,773 | 911,906,412 | 220,943,268 | 3,391 |
| MN | 379,834,042 | 1,301,199,232 | 412,608,844 | 6,147 |
| MO | 130,893,626 | 444,515,357 | 140,218,116 | 2,123 |
| MS | 4,737,495 | 11,428,678 | 2,794,254 | 56 |
| OH | 2,182,266 | 4,306,163 | 1,171,402 | 27 |
| OK | 2,073,890 | 5,134,410 | 1,270,708 | 25 |
| PA | 848,134 | 1,663,618 | 449,411 | 10 |
| TN | 1,253,866 | 2,511,435 | 680,639 | 15 |
| TX | 24,780,404 | 112,554,967 | 27,383,324 | 420 |
| WI | 79,374,813 | 262,798,466 | 84,422,032 | 1,266 |
| WV | 3,226,594 | 5,654,293 | 1,516,926 | 35 |
| TOTAL | $1,565,517,907 | $5,242,759,485 | $1,570,516,397 | 24,250 |

* Output is the total value of all regional sales.

Figure 2.12 – The Regional Employment Impacts of Lock & Dam 25




First, as mentioned above, in the case of farm products, the whole of the economic impacts are assumed to reside in the origin regions. Also, as described in Section 2.4, the likely diversion of current waterborne shipments of corn and soybeans to the PNW would increase transportation costs significantly above present levels. Together, these combined influences predict a fairly dramatic decline in farm incomes within both river basins, with attendant indirect and induced impacts throughout the region.

However, even though down-bound grain is assumed to have no effect on the Louisiana Gulf economy, the effects of LaGrange and of L&D 25 are still pronounced in Louisiana (19 percent of the total for LaGrange, 14 percent of the total for L&D 25). Based on commodity disaggregations of the subject traffic, these impacts are almost exclusively attributable to the waterways' ability to constrain costs for up-bound movements of chemicals and petroleum products.

## 2.4 RAILROAD CAPACITY AND ITS IMPACT ON SHIPPER COSTS

There are several complexities that lie just below the surface of the navigation-attributable averted costs summarized in Section 2.2. Some of these are addressed by the P&G, but rarely treated in application. Other intricacies lie outside the P&G's normal bounds.

The basic questions are:

1. To the extent that railroads and rail-served terminals would be expected to absorb diverted waterway traffic, do they have the capacity to accommodate the additional demands?
2. If capacity is inadequate, would the railroads and terminal operators invest in new capacity to support the same routes currently used by waterway shippers?
3. If, instead of adding new capacity, traffic is diverted to alternative locations where transportation costs are higher, are those higher costs appropriately included in the calculation of navigation related benefits?
4. How do time horizons and uncertainty about modal availability affect the answers to the first three questions?

### The P&G and Capacity

With regard to the issue of capacity, the P&G (2.6.3 (a) 4, p. 50) state:

> In projecting traffic movements on other modes (railroad, highway, pipeline, or other), the without-project condition normally assumes that the alternative modes have sufficient capacity to move traffic at current rates unless there is specific evidence to the contrary.

Based on this guidance, USACE studies almost always assume that alternative modes or modal combinations have capacities that are sufficient to accommodate diverted traffic. When capacity has emerged as a potential issue, the assumption has been that it can be added without adversely affecting prevailing freight rates. In either case, this allows analysts to rely on currently observed values and relieves any need to estimate the cost of additional capacity or the extent to which those costs might affect project benefit calculations.

### Where and Why Is Capacity an Issue?

As noted, unless there is evidence to the contrary, the methods used to estimate averted shipper costs presume that there is transport capacity available from the other primary freight modes – truck and rail – to absorb the additional volumes presented as a result of the individual lock closure.

After reviewing the mix of commodities, transportation alternatives, and the pattern of origins and destinations that determine corridor concentration and length of haul, rail capacity does not appear to be an issue for Markland or Calcasieu traffic. In the cases of LaGrange and L&D 25, however, it appears that the capacity assumption is inappropriate and, if left treated, may lead to an understatement of the shipper costs that would result from an unplanned lock closure.

One useful way to illustrate why this concern is present at LaGrange and L&D 25 but less so at Markland and Calcasieu is to further examine the traffic concentration and length of haul. Figures 2.13 and 2.14 reflect the traffic concentration of the four locks and again illustrate that traffic flows through both L&D 25 and LaGrange are concentrated along north-south corridors and feature a line-haul that routinely extends more than a thousand miles.[9] Alternatively, Calcasieu (to some degree) and Markland (in particular) serve traffic in many corridors, with trip distances that are only 60 percent as long for LaGrange and L&D 25. Where it exists, this concentration of waterway traffic into narrowly-defined, heavy-haul corridors has implications regarding the adequacy of both line-haul and terminal capacities.

## Line-Haul Railroad Capacity Issues

Currently, LaGrange and L&D 25 support the movement of roughly 10 million tons each of corn and soybeans from the upper Mississippi and Illinois basins to export locations at or near New Orleans (the Louisiana Gulf). This grain is produced on farmland that has no meaningful alternative use. Even in the event of long-term decline in farm incomes and further restructuring to regional agriculture, there is no reason to suppose that a reduction in agricultural production would take place.

Table 2.10 summarizes current (2014) railroad movements from potentially affected upper basin states to the Louisiana Gulf. Figure 2.15 depicts the rail network serving those regions. Looking first at the data, it is clear that any attempt to substitute rail for barge toward the movement of 10 million additional down bound tons would represent a significant increase in north-south railroad traffic. LaGrange and L&D 25 both provide extreme evidence of potential congestion.

Virtually all waterway movements of corn and soybeans through LaGrange originate in Illinois, so that an unplanned lock outage would leave 10 million tons of corn and soybeans seeking a south bound routing along corridors that currently accommodate only 2.2 million tons of farm products annually.[10]

Grain movements through L&D 25 have more geographically dispersed origins that would allow a wider variety of potential line-haul routings. However, the percentage increase in southbound traffic would be even greater, with 10 million tons seeking movement along rail corridors that currently accommodate only 1.2 million tons of farm products annually.

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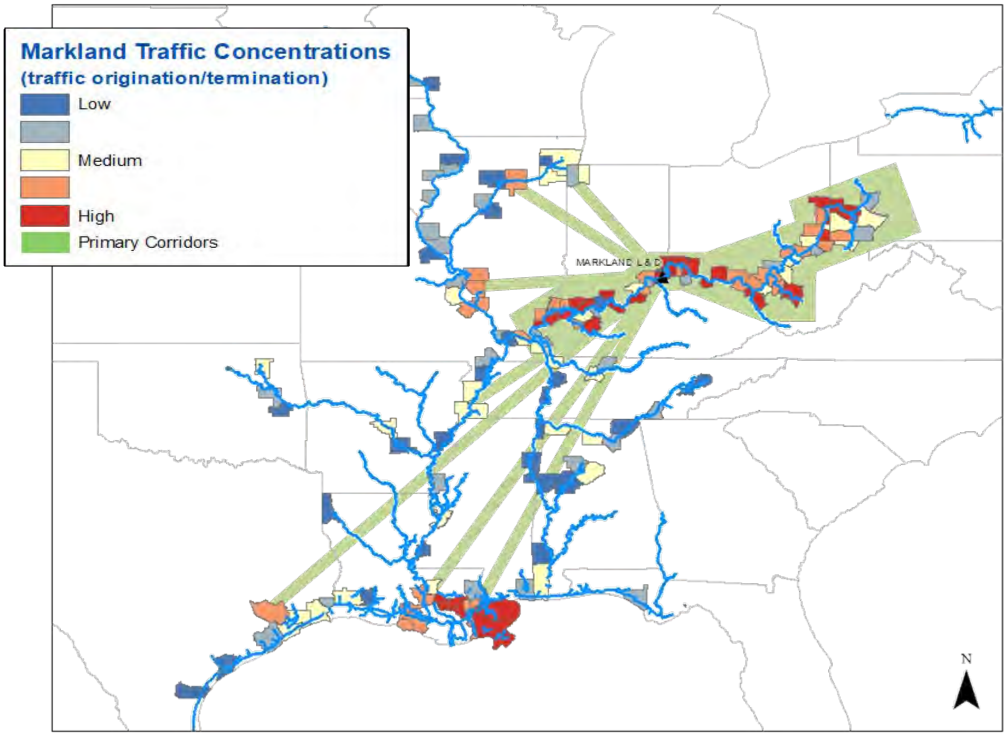
[9] The stylized (green) corridors are based on the study team's examination of the data used to generate the Corridor Concentration Index described in Section 2 and Appendix 1.

[10] The 2.2 million ton total is the total volume of soybeans and corn railed from Illinois, Iowa, Minnesota, Missouri, and Wisconsin to export locations in Louisiana as indicated through the Surface Transportation Board's 2014 Annual *Carload Waybill Sample*.

**Figure 2.13 – Corridors Served by Markland and Calcasieu**



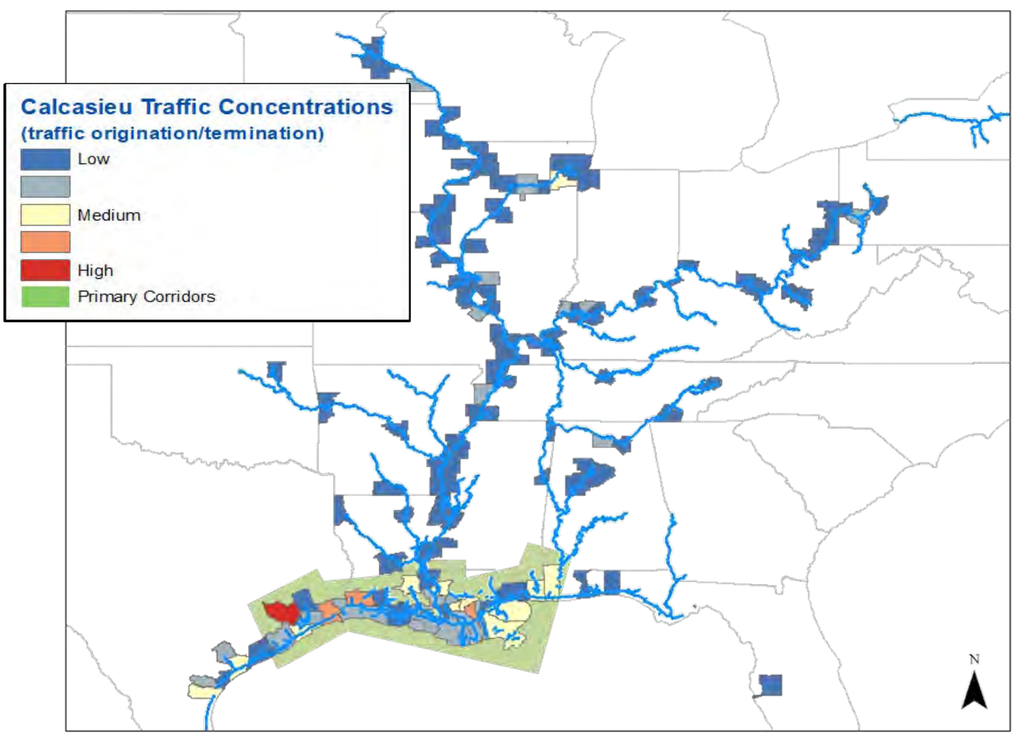



Figure 2.14 – Corridors Served by LaGrange and L&D 25

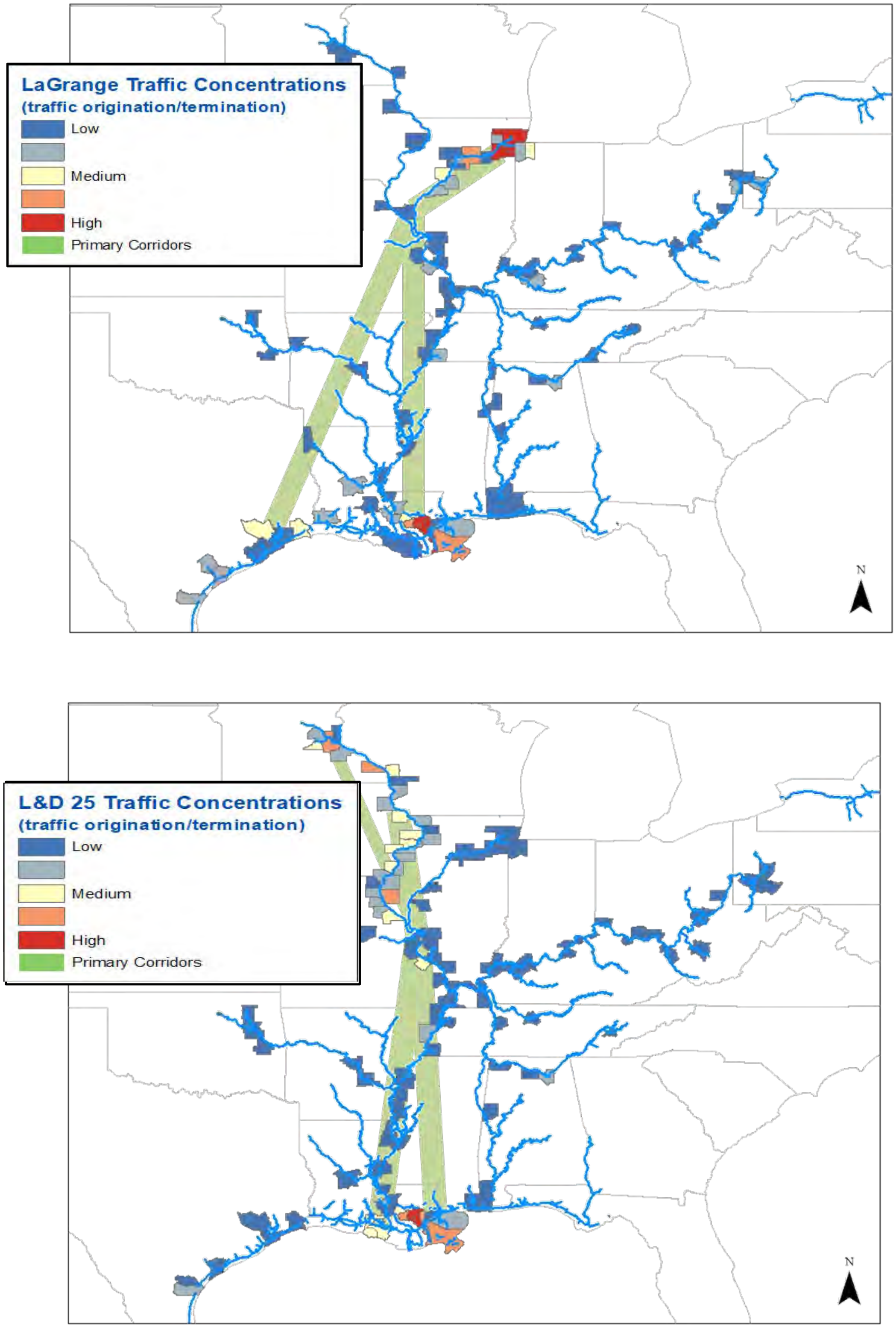
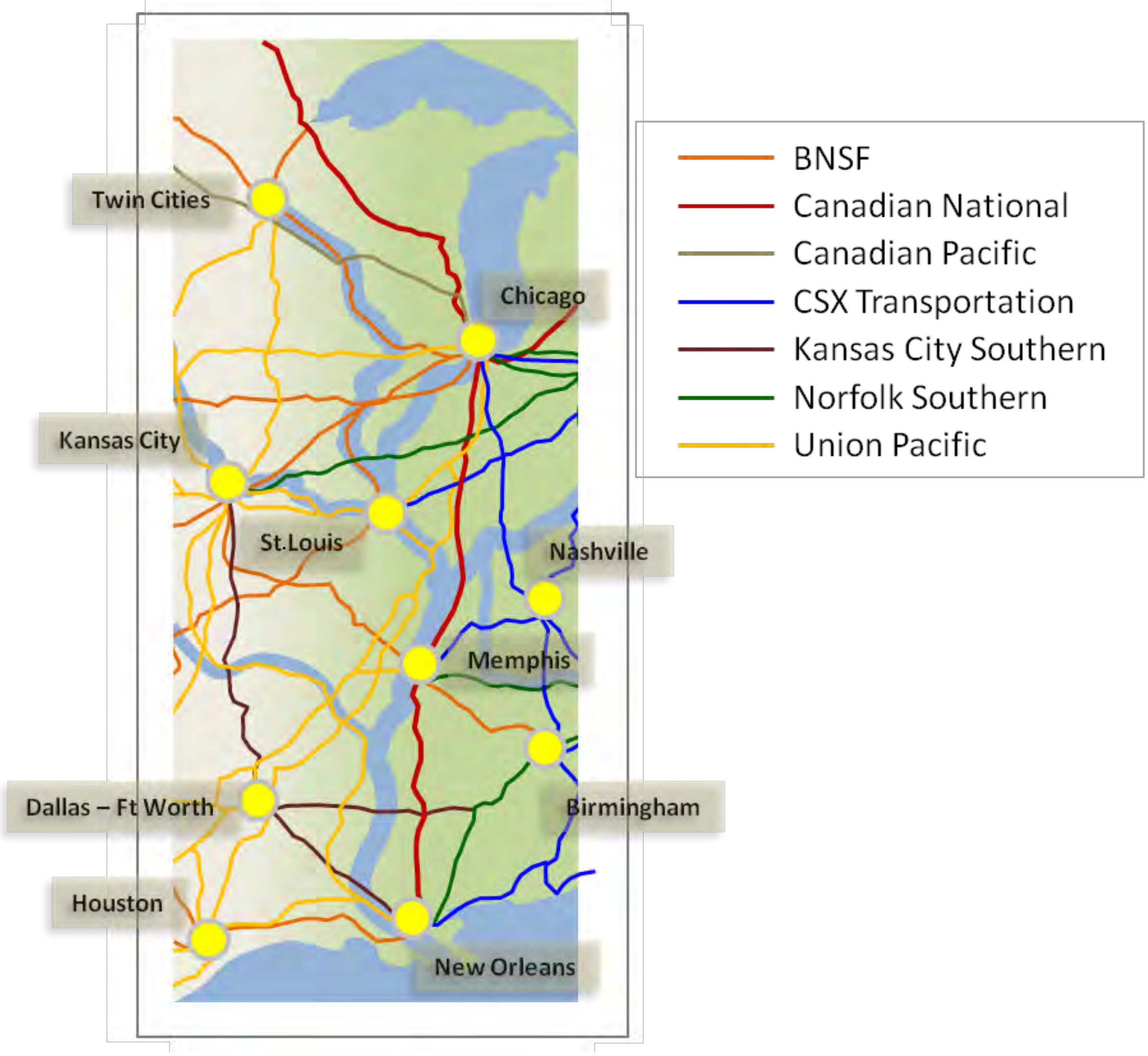


Table 2.10 – Summary of Railroad Traffic
(2014, Tons in Millions)

| Originating State | Farm Products by Rail to Louisiana | All Rail Movements to Louisiana | Farm Products by Rail to all Destinations |
|---|---|---|---|
| Illinois | 2.2 | 10.2 | 28.7 |
| Iowa | 0.7 | 1.4 | 7.6 |
| Minnesota | 0.2 | 0.4 | 13.1 |
| Missouri | 0.1 | 0.5 | 4.6 |
| Wisconsin | 0.2 | 0.6 | 2.8 |
| **TOTAL** | **3.4** | **13.1** | **56.8** |

Figure 2.15 – Core Regional Rail Network



Routing an additional 10 million tons to *any* location would require additional locomotives, covered hoppers, train crews, and track capacity. It would also require the use of nonexistent railroad capacity at many originating and destination terminal facilities. Setting aside the terminal issues for a moment, line-haul implications are relatively easy to explore.

Table 2.11 converts 10 million tons of additional annual demand for corn and soybean transport into line-haul railroad system characteristics based on an unplanned outage at LaGrange. Given *current* conditions, the equipment required to meet this additional demand is available. Data shows that presently there are more than 60,000 covered hoppers in storage. Similarly, both Union Pacific and BNSF have each stored hundreds of readily serviceable locomotives. Thus, under *current* conditions equipment is not an issue. However as recently as 2014, both locomotives and appropriate freight cars were much scarcer.

Again, almost without regard to export destination, the addition of the trains needed to accommodate a 10-million-ton increase would require between 200 and 300 additional qualified crew members. In some instances, displaced crews from unaffected locations could be expected to qualify and bid for jobs along affected routes. In other cases, it would be necessary to hire altogether new personnel to fill newly-created vacancies. Any attempt to accommodate the demands resulting from an unplanned lock closure through increased rail carriage could create at least temporary labor shortages.

In the case of LaGrange, both the Canadian National and Union Pacific could accommodate some of the incremental line-haul traffic. Doing so would require between three and four loaded trains originating toward the south each day and a corresponding number of originating north bound empties. Assuming that this traffic could be split between the two carriers, each affected segment of the railroad would see an additional three or four trains per day. Over the least active route segments, this would likely represent an immediate and unrelenting increase of train activity of roughly 25 percent.

In the end, any attempt to accommodate an unanticipated lock outage at LaGrange through the increased movement of corn and soybeans between Illinois and the Louisiana Gulf would place significant line-haul stresses on the Canadian National and Union Pacific Railroads. While it is likely that both carriers could adjust to accommodate the measurable increases in demand, doing so would not be accomplished quickly, easily, or without disruption to more general operations throughout the rail system.

An unanticipated outage at L&D 25 would present similar challenges with some important variations. On the positive side, the more westerly upstream origins for south bound corn and soybean movements would perhaps allow BNSF to play a larger role in addressing the sudden new demands. Unfortunately, the transit distance between most Iowa, Minnesota and Wisconsin origins are considerably longer than LaGrange-dependent traffic. Moreover, in some cases, traffic diverted to rail would necessarily transit Chicago, so that the car cycle times indicated for LaGrange would likely be much longer for L&D 25 movements.

Table 2.11 – Illustrative Rail System Impacts, LaGrange Outage

| Railroad System Impacts | |
|---|---|
| Additional Annual Tons from LaGrange | 10,000,000 |
| Average Car Loading (Tons) | 112 |
| Additional Annual Carloads | 89,286 |
| Average Car Cycle Time (Days) | 21 |
| Annual Cycles | 17 |
| Additional Freight Cars (Continuous) | 5,208 |
| Train Length (Cars) | 80 |
| Additional Daily System Trains (Loads & MTYS) | 65 |
| Locomotives per Consist | 2.5 |
| Additional Locomotives | 163 |
| Average RR Distance (Miles) | 1,000 |
| Daily Trains per 100 Mile Track Length | 7 |

## LaGrange, L&D 25 and Terminal Capacity Issues

Potential line-haul congestion issues likely pale in magnitude compared to the constraints that exist at the terminal ends of diverted waterway movements. At least some Louisiana Gulf grain terminals have only modest rail access; some have no rail access at all; and a significant volume of corn and soybeans are loaded to ocean-going vessels via mid-stream transfer, thereby avoiding downstream terminals altogether.

There are also possible terminal constraints at the origination end of Gulf-bound shipments of corn and soybeans. However, these limitations may not be as severe as the constraints faced at Louisiana Gulf destinations. Table 2.12 provides the characteristics of Iowa's water-served grain terminals. While these characteristics are not necessarily descriptive of off-river terminals, they suggest that rail car capacity is an issue.

Finally, if necessary, new export grain terminal capacity can be created in the upper Mississippi and Illinois basin, on the Louisiana Gulf, or anywhere else it is desired. However, creating this capacity would require substantial private sector investment. Within the current context, new investments in terminal track capacities at the basin states origins would only be predicted as a response to *extended* lock closures. Further, in the case of export terminals, new alternative rail-served capacity is only likely if there is a permanent closure of either LaGrange or L&D 25 or if there are significant and lasting changes in the global markets these terminals serve.

Table 2.12 – Iowa's Water-Served Grain Terminals

| Company | Iowa Location | Rail Car Storage | Dry Storage | Commodities |
|---|---|---|---|---|
| Cargill | Council Bluffs | 104 | 2.2 mb | Soybeans, corn |
| Ag Processing | Sergeant Bluffs | 250 | 3.5 mb | Soybeans, bean products |
| Colusa | Wever | 0 | 3.5 mb | Corn, soybeans, wheat |
| ADM/Growmark | Burlington | 54 | 0.5 mb | Corn, soybeans, wheat |
| AGRI | Burlington | 0 | 0.6 mb | Corn, Soybeans |
| Grain Processing Corp. | Muscatine | 0 | na | Corn |
| Cargill AgHorizons | Muscatine | 25 | 1.2 mb | Corn, Soybeans |
| Cargill AgHorizons | Buffalo | 30 | 0.9 mb | Corn, Soybeans |
| CHS Inc. | Davenport | 35 | na | Corn. Soybeans, General |
| CHS Inc. | Davenport | 25 | na | Corn, Soybeans |
| River/Gulf Grain Co. | Bettendorf | 0 | na | Corn, Beans, General Commodities |
| ADM/Growmark | Clinton | 0 | 0.7 mb | Corn, Soybeans |
| Cargill AgHorizons | Dubuque | 40 | 60,000 | Corn, Soybeans |
| Peavey | Dubuque | 45 | 0.4 mb | Corn, Soybeans, Others |
| Agri-Bunge, LLC | McGregor | 25 | 1.0 mb | Corn, Soybeans |

## Time Horizons and the Likelihood of New Capacity Investment

The P&G assumes that adequate alternative capacity is available *or* that additional capacity can be added with no adverse effect on costs. Clearly, the first part of this assumption is suspect in the cases of LaGrange and L&D 25. This leads to several additional questions – would railroads and terminal operators invest in new capacity? where would new (or modified) facilities be located? how much would additional capacity cost? and how would incremental capital costs be recovered?

Necessary improvements to railroad line-haul capacity can generally be made incrementally and at costs that do not adversely affect railroad costs or rates.[11] However, this is probably not true for terminal facilities. Estimating the cost of new or expanded rail-served grain terminals on the Louisiana Gulf is beyond the scope of our current work, but the magnitude of the necessary expenditures would be large.

Given this probability and the current dominance of barge transport in the movement of upper basin corn and soybeans to the Gulf, investors would likely be hesitant to build new, rail-served terminal capacity unless there is a *guarantee* that waterborne commerce would not be restored over a time horizon measured in several decades. This seems like an extraordinary hurdle. Moreover, even if investors were willing to build new soybean and corn export capacity, there is no reason to assume that it would be located on the Gulf as opposed to the Pacific Northwest or East Coast. Even in the long-run, the conclusion that alternative freight capacity for moving grain between the upper basin states and the Louisiana Gulf is or will be available is simply not supportable.

[11] See Mark L. Burton "Available Navigation and the Incremental Cost of Railroad Capacity: Preliminary Lessons from the Upper Mississippi Basin," Proceedings of the Agricultural Outlook Forum 98, , D.C., pp. 431-437, Washington, 1998.

## The Effect of a Lock Closure on Rail Charges for Export Soybeans and Corn

Using a short-run time horizon, a recent United States Department of Agriculture (USDA) study acts upon the same conclusions regarding capacity. The USDA analysis considered similar disruptions at LaGrange and L&D 25.[12] It concluded that roughly 60 percent of the waterway grain that currently is exported through the Louisiana Gulf would divert to rail carriage and be bound for alternative export destinations – primarily the Pacific Northwest. Moreover, in the USDA work, this diversion is bolstered by hypothetical rail rate increases to Gulf destinations of five and 15 percent. Based on our computations, the magnitudes of the USDA study's diversions appear reasonable, though depending on terminal capacities, they may reflect a lower bound.

Based on this study's analysis of railroad capacity, as well as findings provided in the USDA study, it appears that an unscheduled lock outage would divert a substantial portion of corn and soybeans from their current Louisiana Gulf export destinations to Pacific Northwest gateways. The estimated railroad charges associated with these PNW diversions are notably higher than existing rail charges to Gulf export locations. However, rates on the modest amount of corn and soybeans currently moving to the Louisiana Gulf by rail were not changed. These currently observed rail rates were also applied to the subset of currently waterborne corn and soybean shipments that were allowed Gulf coast diversions.

## Non-Grain Waterway Diversions

Table 2.13 provides the 2015 LPMS statistics for LaGrange and L&D 25. The aggregations of Food and Farm Products and All Chemicals obscure an important similarity. Traffic through both locks is characterized by roughly 10 million tons of down-bound corn and soybeans and four million tons of up-bound fertilizer. Together, these commodities account for more than half of the traffic at each lock.

It's possible that rail pricing for the movement of non-grain commodities – particularly fertilizer would be affected by a closure. However, the relatively smaller volume of these movements and their dispersed geography makes anything more than their traditional treatment impractical.

**Table 2.13 – LPMS Statistics: LaGrange and L&D 25**

| LPMS Commodity Groupings | 2015 Tons LaGrange | 2015 Tons L&D 25 |
|---|---|---|
| 00 - All Units (Ferried Autos, Passengers, Railway Cars) | - | - |
| 10 - All Coal, Lignite, and Coal Coke | 825,600 | 435,200 |
| 20 - All Petroleum and Petroleum Products | 3,282,660 | 295,000 |
| 30 - All Chemicals and Related Products | 5,220,730 | 4,222,345 |
| 40 - All Crude Materials, Inedible, Except Fuels | 2,742,110 | 2,347,780 |
| 50 - All Primary Manufactured Goods | 2,864,981 | 1,475,263 |
| 60 - All Food and Farm Products | 9,157,172 | 16,066,195 |
| 70 - All Manufactured Equipment & Machinery | 36,475 | 71,910 |
| 80 - All Waste Material | 3,200 | 4,800 |
| 90 - All Unknown or Not Elsewhere Classified - 90 | 13,900 | 1,600 |
| TOTAL | 24,146,828 | 24,920,093 |

[12] See: Yu, T.E, B.C. English and R.J. Menard. Economic Impacts Analysis of Inland Waterway Disruption on the Transport of Corn and Soybeans. Staff Report #AE16-08. Department of Agricultural and Resource Economics, University of Tennessee. September 2016.

# 3 Screening Tool Development

The purpose of the screening tool was to select locks on the inland waterway system that represent a balanced, cross-section. Section 2.1 summarizes the results of the current study's screening tool construction and application and these results are more fully provided in Appendix 2..

## 3.1 FREIGHT DATA AND DATA ACCESS

Compared to other industries, freight transportation data is plentiful. While each data product has limitations, access to and the use of these data is critical in this study and will be equally important for others who replicate these methods. The three most important data elements are:

- Lock Performance Monitoring System (LMPS) data;
- Waterborne Commerce Statistical Center (WCSC) data; and
- The Surface Transportation Board's annual Carload Waybill (CWS) data[13]

### Lock Performance Monitoring System (LPMS) Data

Each time a vessel transits a navigation lock, lock personnel log its passage and record a variety of data describing the specific lock operation, the vessel, and the vessel's contents. This information is collected, processed and made available by the USACE's National Data Center (NDC) as a part of its Lock Performance Monitoring System (LPMS).

The chief advantage of the LPMS data is that they are available quickly – usually with only a three-month lag. There are two primary limitations. First, LPMS data are only available for locations where the USACE operates navigation facilities. There is no corresponding set of information for reaches of open river. Second, tonnage information is estimated by the towboat operators transiting the locks and are not subject to verification.

The LPMS data are publicly released at a level of disaggregation that is sufficient for many analytical uses. Table 3.1 provides a sample of the publicly available summary for one navigation lock (Peoria Lock) for 2014-2016. As Table 3.2 illustrates, these same data are available on a monthly basis by direction (up-bound v. down-bound) from 1999 forward.

[13] The screening tool development described here did not use data from the CWS. However, it was used extensively in the evaluation of shipper supply chain costs described in Section 4. Moreover, from an organizational standpoint it seemed more sensible to describe all three primary data sources within a single subsection. This screening tool can be used by others who may wish to study additional locks on the inland waterway system.

Table 3.1 – Sample Annual LPMS Data[14]

| PEORIA LOCK & DAM | (Tons in Thousands) | | |
|---|---|---|---|
| Description | CY2016 | CY2015 | CY2014 |
| 10 - All Coal, Lignite, and Coal Coke | 3,705.2 | 3,605.6 | 4,299.8 |
| 20 - All Petroleum and Petroleum Products | 5,259.4 | 5,057.9 | 4,865.5 |
| 30 - All Chemicals and Related Products | 2,255.4 | 2,951.8 | 3,534.3 |
| 40 - All Crude Materials, Inedible, Except Fuels | 2,153.4 | 2,668.6 | 2,861.3 |
| 50 - All Primary Manufactured Goods | 8,161.6 | 7,056.7 | 7,558.7 |
| 60 - All Food and Farm Products | 34.3 | 44.8 | 70.9 |
| 70 - All Manufactured Equipment & Machinery | 9.5 | 1.4 | 27.0 |
| 80 - All Waste Material | - | - | - |
| TOTAL TONS | 21,578.8 | 21,386.8 | 23,217.5 |

Table 3.2 – Sample Monthly LPMS Data[15]

| PEORIA LOCK & DAM | JANUARY 2014 (Tons in Thousands) | | |
|---|---|---|---|
| Description | Up-Bound | Down-Bound | Total |
| 10 - Coal, Lignite And Coke | 45.3 | 56.0 | 101.3 |
| 20 - Petroleum and Petroleum Products | 87.8 | 173.4 | 261.2 |
| 30 - Chemicals and Related Products | 168.7 | 157.3 | 326.0 |
| 40 - Crude Materials, Inedible, except Fuels | 125.5 | 15.5 | 141.0 |
| 50 - Primary Manufactured Goods | 72.9 | 14.1 | 87.0 |
| 60 - Food and Farm Products | 22.4 | 459.1 | 481.5 |
| 70 - All Manufactured Equipment and Machinery | 7.5 | 5.0 | 12.5 |
| 80 - Waste Material | 3.2 | ----- | 3.2 |
| TOTAL TONS | 533.3 | 880.4 | 1,413.7 |

Finally, the LPMS data include entries noting arrival times, processing times, corresponding delays, and delay cause. While these data are potentially valuable, undetectable variations in reporting (both cross-sectional and longitudinal) remains a notable limitation of this dataset.

## Waterborne Commerce Statistics Center (WCSC) Data

All USACE data activities are organized under its National Data Center and all activities, but one are headquartered at offices in Alexandria, Virginia. The exception is the Waterborne Commerce Statistics Center (WCSC), located in New Orleans. The WCSC produces an array of valuable products describing waterborne activities on the inland system, in coastal waters, and at both deep-draft and inland ports.

Every vessel operator is required to report each commercial vessel movement to the WCSC on a quarterly basis. These data form the basis for the various WCSC products that are typically released annually. Like the LPMS data, public releases reflect a certain degree of aggregation. However, because this reporting is by waterway segment (as opposed to individual locks), the publicly available data support only limited applications. Table 3.3 provides a summary of often used WCSC data elements.

[14] Available at http://www.navigationdatacenter.us/lpms/lpms.htm

[15] Available at http://www.navigationdatacenter.us/lpms/lpms.htm

Table 3.3 – Base WCSC Data Record Contents

| Field No. | Variable Name | Description | Variable Type |
|---|---|---|---|
| 1 | **REFNO** | Team-assigned reference number | N |
| 2 | **OFIPS** | Origin state/county FIPS code | N |
| 3 | **OST** | Origin state (alpha) | A |
| 4 | **OLAT** | Origin latitude | N |
| 5 | **OLON** | Origin Longitude | N |
| 6 | **OZIP** | Origin ZIP Code | N |
| 7 | **TFIPS** | Destination state/county FIPS code | N |
| 8 | **TST** | Destination state (alpha) | A |
| 9 | **TLAT** | Destination latitude | N |
| 10 | **TLON** | Destination longitude | N |
| 11 | **TZIP** | Destination ZIP Code | N |
| 12 | **LPMS_GP** | LPMS commodity group | N |
| 13 | **LPMS2** | Two-digit LPMS commodity (numeric) | N |
| 14 | **LPMS2A** | LPMS commodity group (alpha) | A |
| 15 | **OWW** | Origin waterway (numeric) | N |
| 16 | **OLOC** | Origin location (numeric) | N |
| 17 | **ODOCK** | Origin dock code (numeric | N |
| 18 | **ORRMILE** | Origin river mile | N |
| 19 | **ODRAFT** | Origin draft | N |
| 20 | **ONAME** | Origin name (alpha | A |
| 21 | **OSNAME** | Originating shipper name (alpha) | A |
| 22 | **TWW** | Destination waterway (numeric) | N |
| 23 | **TLOC** | Destination location (numeric) | N |
| 24 | **TDOCK** | Destination dock code (numeric | N |
| 25 | **TRRMILE** | Destination river mile | N |
| 26 | **TDRAFT** | Destination draft | N |
| 27 | **TNAME** | Destination name (alpha | A |
| 28 | **TSNAME** | Destination shipper name (alpha) | A |
| 29 | **TONS** | Tons per loaded barge | N |
| 30 | **WWTRIPDIS** | Total waterway segment distance | N |
| 31 | **BRGTYPE** | Barge type | A |

The full population of disaggregated WCSC records can sometimes be obtained if project sponsors involve federal entities. However, the WCSC rules for the release of disaggregated confidential data are both strict and rigorously enforced.

## The Carload Waybill Sample (CWS)

In the U.S., railroad shipments are accompanied by *waybills*, documents that describe the shipments characteristics, equipment used, network routing, and (if a revenue movement) shipper charges. By statute, the Surface Transportation Board (STB) samples the population of waybills to develop its annual Carload Waybill Sample (CWS) that, with proper care, can be expanded to replicate full population characteristics.

The CWS is available in three forms – (1) a public use sample that obscures origin and destination information as necessary to protect confidentiality, (2) a confidential (but *masked*) version that contains complete shipment information, but wherein carriers can replace actual charges for contract rail movements with constructed rates, and (3) an *unmasked* version that contains actual charges for all movements. Most federal and state agencies can obtain access to the confidential CWS. However, access to the unmasked sample is heavily restricted.

From a use standpoint, the CWS is well-documented and easy to manipulate.[16] However, like all data products, it has limitations. First, the sampling the CWS introduces imprecision. This is particularly true as it is applied in more limited geographic or product settings. Second, the CWS is compulsory for Class I railroads, but it does not regularly reflect short-line or regional railroad (Classes II and III) activities unless those activities are in conjunction with a larger railroad. Finally, like the WCSC, there is a lag of, at least, two years in the CWS's availability.

## 3.2 ELEMENTS AND ANALYTICS – LOCK CHARACTERISTICS

The following lock characteristics are publicly available from the USACE:

### Lock Location

Although some lock data may include latitude and longitude information, the most common way to reference lock location is by river name and river-mile. However, it may also be useful to associate a lock facility with other jurisdictions (e.g., counties and states). Unfortunately, the use of waterways as jurisdictional boundaries sometimes makes these associations difficult.

### Lock Age

Most locks are built over multiple year periods, so that age is dated from when the subject lock was opened to traffic rather than when it was constructed. Also, available data routinely include notations regarding whether / when a subject lock has undergone major rehabilitation. From a reliability standpoint, the reopening date of a rehabilitated lock is often more meaningful than its original opening date.

### Chambers, Chamber Dimensions, and Other Chamber Characteristics

Most navigation facilities feature a single lock (main) chamber. However, some locations also have one or more auxiliary chambers. Tow configuration is often (but not universally) determined by lock dimensions. Therefore, information describing main chamber length and width is essential in evaluating lock capacity. Similarly, the availability and sizes of auxiliary

#### A NOTE ON GEOGRAPHY

Both the WCSC and LPMS records are geo-coded, with associated latitudes and longitudes. Additionally, the project descriptions include town, county, and state names. However, if analysts desire to combine these data with additional, geographically indexed data elements from other sources, it will often be necessary to append the associated Federal Information Processing Standardization (FIPS) codes to the navigation data.

A data bridge for accomplishing this is available upon request from the study team.

[16] For a full description of the CWS, See, Surface Transportation Board Carload Waybill Sample Reference Guide, October 18, 2013, available at: https://www.stb.gov/stb/docs/Waybill/2012%20STB%20Waybill%20Reference%20Guide%20-%20FINAL.pdf

chambers affect lock reliability. Therefore, information describing auxiliary chamber dimensions is also useful. Finally, data describing the lock lift at normal pool elevations can help analysts evaluate processing times and should be included where available.

### Ancillary Navigation Structures

Lock processing times can be affected by the availability of ancillary navigation structures such as mooring cells. Thus, the availability of these structures should be noted.

## 3.3 ELEMENTS AND ANALYTICS – LOCK PERFORMANCE

In most cases, individual locks are evaluated within a system context. Nonetheless, it is essential to isolate, measure, and understand individual lock uses and performance in order to establish realistic system relationships. Most (but not all) of the metrics described below are based on confidential WCSC and LPMS data.

### Tows, Vessels, and Lockages

The disaggregated LPMS data contain data describing the number of tows through a lock, the number of lockages, and the number of vessels. The number of lockages per tow is an important indicator of how carriers are using the subject lock and how well suited the lock is to those uses.

### Commodity-Specific Tonnages

The LPMS data contain information describing the commodities and corresponding tonnages passing through each lock. However, these data often reflect only the best estimates of lock personnel and/or vessel crews. The WCSC data contain more reliable commodity and loading information, but they record neither the movement of empty barges nor passage through individual locks. The remedy is to route each WCSC record and append lockage information based on the record's internal route string and the river-mile of each subject lock. The resulting records can then be compared to the LPMS values as a means of validation and calibration. This process is not absolutely necessary to the derivation of lock tonnages. It is, however, necessary to the development of the above and below pool metrics described below.

### Processing Times and Delays

The LPMS records contain information describing delay, and processing times. This information includes delay causes that can be used to make cross-sectional comparisons.

## 3.4 ELEMENTS AND ANALYTICS – NETWORK ROLE

As noted, most project evaluations are conducted in a network setting, so that the performance of one project both impacts and is impacted by the performance of other projects that are a part of that system. Capturing this interdependence leads to stronger analytics and better decision-making. Previously, however, the simple metrics available for the initial comparisons did not include measures that capture a project's network value. The current work addresses this by introducing three new measures. These are described below:

## System Ton-Miles

If WCSC records are used to compute lock tonnages as described above, it is a doable exercise to flag each record that passes through a subject lock, calculate the ton-miles of transportation attributable to that record, and sum the number of freight ton-miles of traffic associated with the subject lock. When combined with other metrics, this value provides numerous insights regarding the relative burdens of any potentially displaced waterway traffic.

## System Lockages

Assuming a reliance on the WCSC data, each record can be processed to include a total number of lockages. From this, it is possible to calculate the average number of lockages (both in aggregate or by commodity) for traffic passing through the lock. This results in a useful measure of the subject lock's interdependence with other system locks.

### COMMODITY DEFINITIONS

Within the USACE's data, the Waterborne (WCSC) data and Lock Performance (LPMS) data aggregate across differently defined commodity groupings. Fortunately, the disaggregated WCSC records are labeled under both systems.

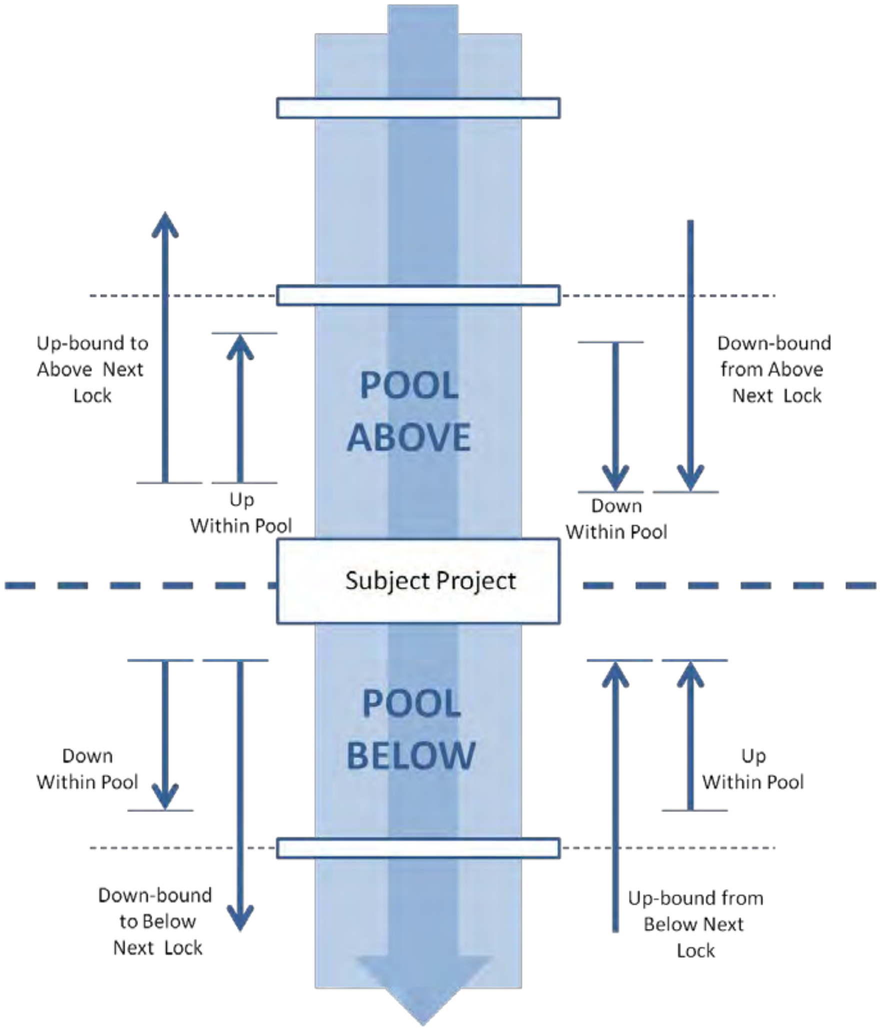
Further, if analysts elect to include railroad waybill data in the development of a screening tool, it will be necessary to bridge between USACE definitions and rail data that are organized under Standard Transportation Commodity Codes (STCCs).

Finally, the US Department of Commerce data are organized under the North American Industrial Classification System (NAICS).

## Above-Pool and Below-Pool Traffic

Navigation pools are created by dams that stabilize pool elevations. Navigation locks exist to allow vessel traffic to pass from one pool to another. Generally, locks and dams are combined at a single location. As a result, an event that leads to an unplanned lock closure could also disrupt up-stream and/or down-stream pools elevations. In this way, the possible disruption *could* affect commercial barge traffic that does not pass through the subject lock. This sort of scenario (See Figure 3.1) has not typically been considered within project analyses, but can often add valuable insight about possible disruption impacts. Again, using the WCSC records, shipments can be identified that originate or terminate in the pools above or below the subject structure.

**Figure 3.1 – Above and Below Project Pool Traffic**



# 4 Estimating Closure Related Shipper Supply Chain Cost Burdens

At the core of this project is the analysis of the direct economic effects of unanticipated navigation lock closures using existing data and tools in ways that measurably reduce the resources required to undertake this research. Accomplishing this aim requires the execution of three primary task sets including:

- Lock selection and data preparation;
- Scenario design and traffic diversion assessments; and
- The calculation of shipper supply chain costs before and after an unanticipated lock closure.

This work is designed to conform to the P&G that currently guide the analysis of all federal inland navigation USACE infrastructure projects.[17]

## 4.1 LOCK SELECTION, TRAFFIC SAMPLES, AND DATA PREPARATION

Section 3 describes the development and application of the screening tool used to identify four locks for inclusion in the current study. These locks included:

- Markland Locks & Dam on the Mid-Ohio, near Cincinnati;
- Calcasieu Lock on the Gulf Intracoastal Waterway, near Lake Charles, Louisiana;
- LaGrange Lock & Dam, the lowest of the navigation locks on the Illinois River; and
- Lock & Dam 25, north of St. Louis, near the Mississippi's confluence with the Illinois River.

The following process steps require the preparation of the navigation traffic data and other data resources necessary to identify and measure the effects of an unanticipated lock closure.

### Sampling Lock Traffic

When the volume of annual traffic through a subject lock is sufficiently small, it is sometimes possible to work with the entire population of annual traffic movements. However, in most cases, to do so is not feasible. Consequently, it is necessary to sample the annual traffic in a way that yields a manageable number of observations that can subsequently be used to accurately estimate population-wide impacts. This study used a stratified sample based on commodity groupings and the reported two-digit WCSC tonnages (described in Section 3.1). This sampling

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

pattern resulted in samples of between 900 and 1,400 records for each lock, representing 2-3 percent of all records and 10-12 percent of total 2014 tonnages.[18]

For each of the four subject locks, the result was a base sample dataset that included the data fields summarized in Table 4.1. Subsequent steps within the calculation of various supply chain cost components add many additional fields, but the initial WCSC record remains as the primary unit of observation throughout the analysis.

## 4.2 CLOSURE SCENARIOS, SHIPPER ALTERNATIVES, AND TRAFFIC DIVERSIONS

From a computation standpoint, the manipulation of the WCSC records is the most difficult task. However, in terms of analytical requirements, it is the identification of shipper alternatives and traffic diversions that poses the greatest challenge. Ultimately, meeting this challenge requires a variety of different approaches as described below.

When shippers encounter an unplanned lock outage, they are immediately faced with difficult questions. Some of these include:

- Does the disruption affect more than one lock and does it affect *system* operations?
- Is there available and reliable information about the probable closure duration?
- Is some portion of the waterway still useful and, if so, can the usual carrier(s) continue to provide service over open waterway segments?
- How large are existing user commodity inventories and how long will these last?
- What are the costs, characteristics, and availabilities of transportation alternatives?
- What are the potential penalties for delayed commodity delivery?
- Are rivals similarly affected and how will *they* respond?

Depending on the answers to these questions, each shipper is likely to exhibit a variety of behaviors over time. Those with the luxury to do so may, in the short-run, cease shipping and rely on existing inventories. If that is not possible, but the duration is expected to be brief, some shippers may opt for relatively expensive stop-gap, short-run measures. Ultimately, however, if the unplanned outage is sufficiently long or if there is uncertainty about its duration, all affected shippers will be forced toward long-run strategies. These may involve re-sourcing inputs elsewhere, abandoning certain downstream markets, capital expenditures for new non-water freight transport facilities, or even shutting down a facility (i.e., worst case scenario). This sequence is depicted graphically in Figure 4.1.

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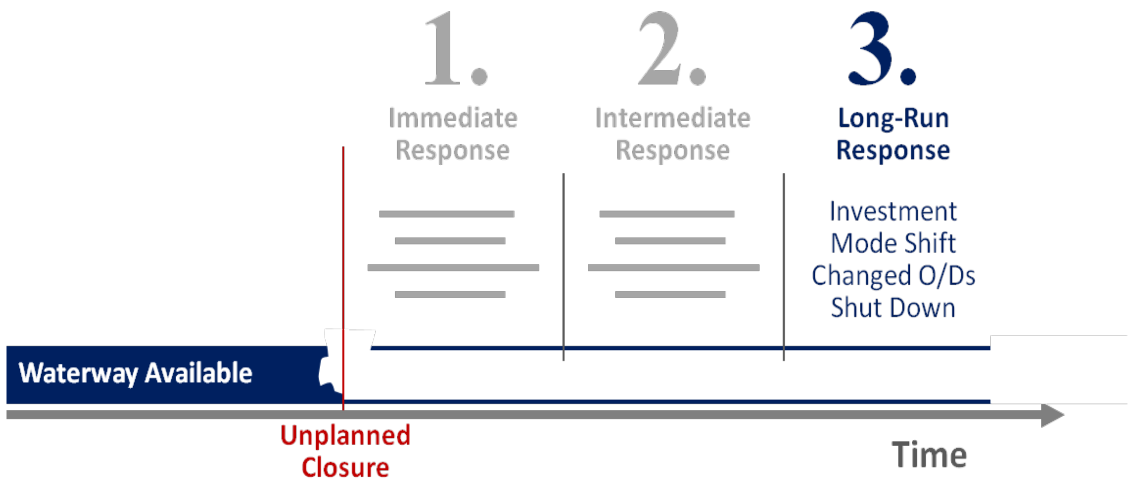
[18] In the late 1990s, study team members participated in a numerous USACE studies that experimented with a variety of different sampling methods. Then, as now, it appears that sampling techniques have little influence on analytical results.

Figure 4.1 – Shipper Responses to Unplanned Lock Closures




To capture these various shipper responses under uncertainty, past studies typically have relied heavily on shipper surveys that pose questions based on possible outage durations of between 15 and 180 days. Shippers are asked to outline their responses under each scenario. While the aim of this complex survey structure is important, it can also lead to considerable confusion, an equal amount of speculation, and poor survey response rates.

Ideally, the perfect study would evaluate every alternative available to every affected shipper, then let the least-cost alternative identify the diversion. Unfortunately, this is impractical. Comparative alternative costs were calculated to identify diversions when no other information was available. However, where at all possible, this analysis relied on information from six other sources to identify the most likely long-run shipper diversions. These are bulleted then discussed individually. Information included:

- Available Modal Alternatives
- Shipment Characteristics
- Ancillary Costs
- Railroad Pricing Practices and Rate Data
- Geographic Substitutes
- Shipper Surveys and Interviews

## Available Modal Alternatives

Generally, it was assumed that highway access is ubiquitous. However, this is not the case for rail. In most cases, it was possible to identify whether or not shippers have existing railroad access and again, in most cases, the rail capacity that shipper access affords. The P & G that guide USACE studies suggest that new modal access can be added as necessary to create shipping alternatives.

## Shipment Characteristics

Simple modal access does not necessarily guarantee that a modal alternative is viable. In some cases, shipment characteristics preclude an alternative even when that alternative is physically possible. For example, in our consideration of unscheduled outages at LaGrange or Lock and Dam 25 , all affected grain shippers are served by truck as are alternative port locations on waterways that would be unaffected by the outage. However, both LaGrange and L&D 25 accommodate approximately 10 million tons of corn and soybeans each year. Thus, while the economies evidenced by a limited number of longer truck movements suggest that trucking to alternative waterway locations might be a viable option, doing so for the whole of the *diverted barge shipments would involve an additional 500,000 loaded truck trips per year and an additional 150 million truck miles in the affected states*, an untenable solution.

## Ancillary Costs

As noted above, ancillary costs can be an important factor in shippers' supply chain decision-making. Accordingly, even when comparative line-haul rates suggest that a modal alternative is viable, requisite changes in loading, unloading, or storage costs make the alternative untenable.

## Railroad Pricing Practices and Rail Data

Section 2.4 provides an extensive discussion of railroad issues and their effect on navigation project evaluations. In some settings, railroads have exercised the ability to influence traffic diversions through rate-setting. In the extreme, our analysis included this reality in the determination of least-cost alternatives.

## Geographic Substitutes

For some waterway traffic, origins and/or destinations are unchangeable. In other cases, specific products can be sourced from multiple locations that provide multiple transportation alternatives to shippers who might be affected by an unplanned lock outage. For example, some fertilizer components can be shipped to the upper Mississippi and Illinois basins from a variety of locations that involve multiple carriers across differing freight modes. Where this sort of geographic substitution is possible, it was included in our treatment of potential diversions.

## Shipper Surveys and Interviews

The study team developed a simple shipper survey and enlisted members of the National Waterways Foundation Study Oversight Team to distribute to shippers with traffic through Markland Locks. Unfortunately, the response rate was low and for this reason were not judged to be analytically useful. Fortunately, field notes from earlier studies existed. While these earlier interview results did not apply specifically to this study's population of shippers, it was possible to identify patterns applicable to specific industries or commodities without regard to shipper specifics.

# 4.3 ESTIMATING TRANSPORTATION COSTS FOR EACH ALTERNATIVE

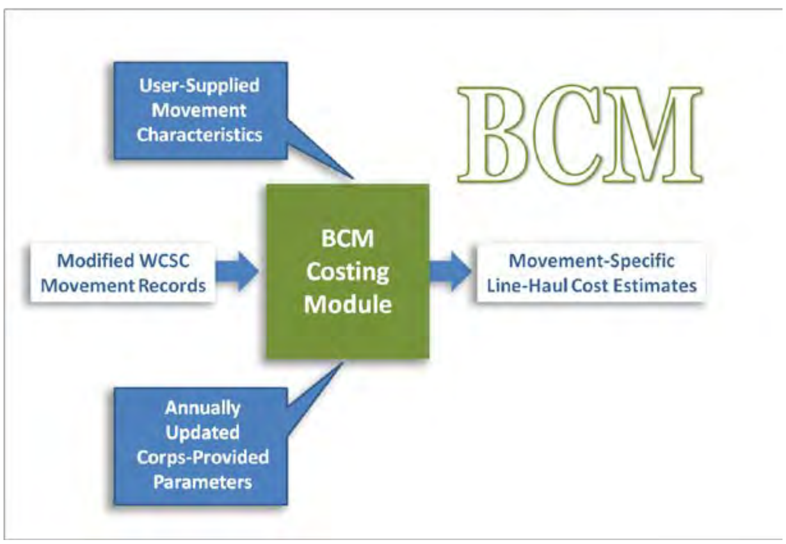
This analysis compares economic outcomes under differing scenarios. In a freight setting, meeting this need generally requires a comparison of shipper costs with and without a proposed project or a proposed policy. The most essential the most essential tools are those used to estimate modal line-haul and terminal costs. In addition to the data elements described in Section 3.1, the current analysis relied on three such tools. These included:

- A Barge Costing Model (BCM) developed by the Tennessee Valley Authority and certified for USACE applications;
- Elements of STB's Uniform Rail Costing System (URCS) cost estimates for CWS movements, along with supplemental information needed to produce railroad rate estimates; and
- A motor carrier costing model made available through the American Transportation Research Institute (ATRI).

## The Barge Costing Model (BCM)

The BCM is a deterministic waterway costing model originally developed by the Tennessee Valley Authority, but now formally approved for use by the USACE. Figure 4.2 depicts the BCM operation.

Figure 4.2 – Barge Costing Model




The model is most easily executed on a movement-by-movement basis. However, it also features a batch mode for the manipulation of multiple records. In either case, the basic inputs can be drawn from individual WCSC records and include origin dock, destination dock, tonnage, commodity, etc. Prescribing a specific barge type or dimensions can be done, users can allow the routine to select an appropriate barge based on tonnage and commodity. Users can also modify various parameters such as fuel price, empty-return ratios, carrier rates of return, and in some cases, shipment routings.

In addition to user supplied parameters, the model is updated periodically by the USACE to reflect changes in vessel horsepower, average vessel dimensions, average fuel costs, lock processing times, labor rates, etc. These parameters can also be manipulated by users, but only by those who are willing to explore the routine in areas beyond the typical user interface.

## Railroad Movement Costing

Given the economics and often limited competition that governs rail carriage, there is often a significant difference between estimated line-haul costs and observed railroad rates. Nonetheless, estimating incremental (or variable) costs, at least, provides a useful starting point for a more careful analysis of actual railroad rates.

Third-party logistics providers offer rail cost estimation software that functions much like the BCM described above. However, for those wishing to forego the expense of proprietary software, the CWS provides movement-specific cost estimates of variable costs based on the STB's Uniform Rail Costing System (URCS). URCS has been routinely assailed by academic economists.[19] Still, its use is mandated by the STB and its results govern the outcomes of regulatory proceedings, so that it is rarely successfully challenged.

Whether based on URCS or a proprietary product, any final rate estimates must scale variable costs so that the final rate estimates provide contributions toward the recovery of the fixed and common costs associated with network elements, as well as a competitive return on investment for rail carriers. In practice, railroads accomplish this by setting rates that reflect costs *and* the demand characteristics of rail shippers. Analysts can use observable shipment characteristics such as shipment size, distance, the number of competing railroads, the availability of modal substitutes, etc. as proxies for these demand characteristics.

Within the current analysis, URCS-based cost estimates were used and railroad rates for shipments with varying characteristics. The estimated rates and corresponding movements were submitted to third-party logistics providers who specialize in the subject commodities. Based on their feedback and insights, additional adjustments were made to obtain the rates used to reflect railroad costs.

## Motor Carrier Costs

As confounding as rail rates may be, truck rates are relatively simple to estimate. Because motor carriers face minimal fixed and virtually no common costs, and because motor carriage competition is, in most cases, intense, truck rates tend to closely follow operating costs.

In reality, it would be possible to independently assemble information describing motor carrier capital costs, vehicle maintenance costs, labor costs, fuel use, and administrative costs to generate an acceptable estimate of motor carrier costs that does not rely on any underlying model. However, in the current setting, this work is based on a motor carrier cost model

[19] For example, see Wesley Wilson and Frank Wolak in Modernizing Freight Rail Regulation, Transportation Research Board Special Report 318, June 2015. Available at: http://www.trb.org/Publications/Blurbs/172736.aspx

developed by ATRI.[20] With the ATRI model as a benchmark, commodity-specific information developed by the Minnesota Department of Transportation to simulate commodity-based rate variability was used. The resulting motor carrier cost parameters are summarized in Table 4.1.

Table 4.1 – Motor Carrier Costs (Per Mile)

| | Total Truck Cost per Mile | |
|---|---|---|
| Commodity Grouping | Single Driver | Team Drivers |
| Overall | $2.09 | $2.71 |
| Rubbish | $4.67 | $6.06 |
| Dairy | $3.12 | $4.05 |
| Food Products | $2.73 | $3.54 |
| Paper | $2.58 | $3.34 |
| Petroleum | $2.46 | $3.19 |
| Timber | $2.30 | $2.99 |
| Aggregate | $2.12 | $2.75 |
| Industrial Supplies | $2.06 | $2.67 |
| Construction | $2.03 | $2.63 |
| Ag Chemicals | $1.88 | $2.44 |
| Agricultural | $1.85 | $2.40 |
| General Products | $1.82 | $2.36 |
| Beverages | $1.52 | $1.97 |

## Ancillary Supply Chain Costs

As transportation professionals, we tend to focus on the line-haul, fleeting, and switching activities that we're familiar with, but transportation decision-makers (shippers) are more inclined to focus on total supply chain costs when evaluating their choices. Therefore, it is important to represent these ancillary supply chain costs as accurately as possible when assessing a navigation project's value.

Ancillary costs include outlays necessary for loading, unloading, commodity storage, loss and damage, safety stocks, and administrative expenses. In some cases, these costs are invariant to decisions regarding line-haul mode, but in other cases, mode choice has significant impacts on the magnitude of ancillary costs. Since there are presently no readily available data sets describing these ancillary costs, other sources were relied upon, including past studies, shipper queries, and industry publications.[21]

[20] ATRI is a research organization supported directly by the American Trucking Association, See: An Analysis of the Operational Cost of Trucking: 2016 Update, September 2016. Available at: http://atri-online.org/wp-content/uploads/2016/10/ATRI-Operational-Costs-of-Trucking-2016-09-2016.pdf

[21] The USACE's *Planning Center of Expertise for Inland Navigation* (PCXIN) has developed an ancillary cost model that is scheduled for external review during the fall of 2017 and which will hopefully be made publicly available soon afterward.

## 4.4 ESTIMATING THE SHIPPER SUPPLY CHAIN COST BURDEN

Calculating averted shipper costs involves combining the data and tools with the diversion considerations described above to estimate both existing supply chain costs and the costs that would be incurred under the alternative scenario(s).

Table 4.2 illustrates a small portion of the summary spreadsheet developed as a part of the Markland analysis. The selected cells depict the rate calculations for several coal movements. Because of uncertainty regarding the most likely diversion, some movements required the calculation of supply chain costs under both all-rail and a combined, barge-rail alternative. Note also, that, while not used for the coal movements, the spreadsheet allows for the calculation of an all-truck alternative. Where the combined barge-rail alternative is tenable, it in fact, yields the lower alternative supply chain cost.

The estimation results yield Shipper Supply Chain Cost Burden – the increased supply chain costs associated with loss of the navigation alternative through the particular lock in dollars-per-ton. This value, multiplied by the tonnage yields an estimate total cost burden for the subject shipment. It is also often useful to use shipment distances to calculate both rates and averted shipper costs on a per-ton-mile-basis to be sure that the traditional distance-rate relationship is evident in the estimated rates. Finally, there may be instances in which the estimated averted costs are negative. On its face, this suggests either irrational behavior on the part of shippers or an error in the calculation of supply chain costs. Certainly, either of these is possible. However, there are also more reasonable explanations. Individual shippers may not immediately react to changing conditions. This is particularly true when there are significant costs to switching from one modal alternative to another. In fact, if these switching costs are sufficiently high, perfectly rational, profit-maximizing shippers may opt to suffer losses rather than switch at all if they view those losses to be tied to transient market conditions (say, for example, low water).

If conditions allow and the number of annual movement is not overwhelming, it is possible to estimate averted costs for the entire population of traffic using a subject lock. In such cases, the work of estimating supply chain cost differentials is finished. If, however, as in this work, the number of records is large so that movements are sampled, it is necessary to expand the averted shipper costs estimated for sample movements to the entire traffic population.

In the four cases treated here, the expansion of the sample findings was accomplished through the estimation of simple quadratic regression equations, where averted shipper costs served as the dependent variable and shipment distance and distance squared formed the independent variables. In those instances where the quadratic term failed to attain statistical significance, a simple linear form was used in place of the quadratic.

Table 4.2 – Sample of Calculated Averted Supply Chain Costs

| REF NO. | COMMODITY | TONS | WW ROUTE COST PER TON | ALL-RAIL ROUTING COST PER TON | SPLIT BARGE-RAIL ROUTE COST PER TON | ALL-TRUCK ROUTING COST PER TON | AG-TRUCK ROUTE COST PER TON | AVERAGE ALTERNATIVE COST PER TON | SHIPPER SAVINGS PER TON | SHIPPER SAVINGS PER TON-MILE |
|---|---|---|---|---|---|---|---|---|---|---|
| 234 | Coal | 1755 | $ 16.45 | | $ 23.33 | | | $ 23.33 | $ 6.88 | $ 0.0192 |
| 235 | Coal | 1550 | $ 16.45 | | $ 23.33 | | | $ 23.33 | $ 6.88 | $ 0.0192 |
| 236 | Coal | 1589 | $ 12.56 | | $ 15.60 | | | $ 15.60 | $ 3.04 | $ 0.0140 |
| 237 | Coal | 1817 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 238 | Coal | 1555 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 239 | Coal | 1592 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 240 | Coal | 1917 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 241 | Coal | 1411 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 242 | Coal | 1719 | $ 8.07 | | | $ 9.31 | | $ 9.31 | $ 1.24 | $ 0.0270 |
| 243 | Coal | 1436 | $ 32.18 | $ 53.40 | $ 44.55 | | | $ 48.97 | $ 16.80 | $ 0.0132 |
| 244 | Coal | 1413 | $ 32.18 | $ 53.40 | $ 44.55 | | | $ 48.97 | $ 16.80 | $ 0.0132 |
| 245 | Coal | 1814 | $ 31.80 | $ 35.16 | $ 34.85 | | | $ 35.01 | $ 3.21 | $ 0.0039 |
| 246 | Coal | 1532 | $ 31.80 | $ 35.16 | $ 34.85 | | | $ 35.01 | $ 3.21 | $ 0.0039 |
| 247 | Coal | 1526 | $ 31.80 | $ 35.16 | $ 34.85 | | | $ 35.01 | $ 3.21 | $ 0.0039 |
| 248 | Coal | 1674 | $ 48.46 | $ 35.16 | $ 43.18 | | | $ 39.17 | $ (9.29) | $ (0.0114) |
| 249 | Coal | 1875 | $ 47.47 | $ 35.16 | $ 42.68 | | | $ 38.92 | $ (8.55) | $ (0.0105) |
| 250 | Coal | 1643 | $ 38.79 | $ 60.69 | $ 59.83 | | | $ 60.26 | $ 21.47 | $ 0.0138 |
| 251 | Coal Coke | 1510 | $ 22.66 | $ 84.83 | $ 65.18 | | | $ 75.00 | $ 52.34 | $ 0.0237 |
| 252 | Coal Coke | 1504 | $ 22.72 | $ 52.65 | $ 43.76 | | | $ 48.20 | $ 25.48 | $ 0.0203 |
| 253 | Coal | 1510 | $ 22.57 | $ 36.39 | $ 35.44 | | | $ 35.92 | $ 13.35 | $ 0.0158 |
| 254 | Coal | 1732 | $ 33.17 | $ 36.55 | $ 35.56 | | | $ 36.06 | $ 2.89 | $ 0.0034 |
| 255 | Coal | 1744 | $ 22.94 | $ 36.39 | $ 35.47 | | | $ 35.93 | $ 12.99 | $ 0.0154 |
| 256 | Coal | 1832 | $ 22.63 | $ 36.39 | $ 35.47 | | | $ 35.93 | $ 13.30 | $ 0.0157 |
| 257 | Coal | 1891 | $ 27.12 | $ 36.55 | $ 35.59 | | | $ 36.07 | $ 8.95 | $ 0.0105 |
| 258 | Coal | 1966 | $ 33.17 | $ 36.55 | $ 35.56 | | | $ 36.06 | $ 2.89 | $ 0.0034 |
| 259 | Coal | 2027 | $ 22.63 | $ 36.55 | $ 35.59 | | | $ 36.07 | $ 13.44 | $ 0.0158 |

5

# Estimating Regional Economic Development Impacts

## 5.1 THE DIFFERENCE BETWEEN BENEFITS AND IMPACTS

Discussions of public sector investments in transportation infrastructure involve a variety of economic concepts and terminology, including references to economic *benefits* and economic *impacts*. While functionally related, benefits and impacts are distinct concepts and their measures play decidedly different roles in the decision-making process.

Investments in transportation infrastructure are undertaken because they improve economic outcomes – they either provide additional capacity that can accommodate *more* economic total activity or they relieve congestion and, thereby, avoid increasing transportation costs. Either way, there is a net improvement in aggregate welfare measured across the whole of the jurisdiction. In cases of federal investments, this implies that a subject investment provides net benefits to the nation as a whole. As specified in the P&G, these gains are referred to as National Economic Development (NED) *benefits*.[22]

Projects that improve economic efficiency usually attract economic activities from other regions. This attraction is a predicable response to the efficiency-enhancing investment, but rarely does it further increase the overall national benefits attributable to that investment. Instead, regional impacts represent a movement of economic activity in response to attainable efficiencies. Therefore, while these regional impacts may be important, they do not usually affect the national decision-making process. The P&G refer to these interregional transfers as Regional Economic Development (RED) benefits.[23] Federal-level decision-makers rarely compute these RED benefits. Instead, if they are estimated, it is usually by regional-level stakeholders who wish to explore the regional benefits associated with national-level investments. It is just this sort of regional impact analysis that provides the results described in Section 2.3.

## 5.2 THE GENERAL STRUCTURE OF REGIONAL MODELS

Typically, regional impact analyses are conducted in settings similar to the one depicted in Figure 5.1. A direct, exogenously imposed stimulus begins an iterative series of economic activities within a region. To begin with, those affected by the stimulus will often need to acquire additional goods and services from other sellers within the subject region. These are the *Indirect Effects* noted in the figure. Moreover, this iterative set of impacts changes incomes within the region which, in turn, leads to further changes in the magnitude of regional activity. These are represented by the *Induced Effects* depicted in Figure 5.2. These economic impacts are revealed

[22] National Economic Development (NED) benefits are discussed throughout the P&G. However, the account definition is provided in Chapter 1 (1.7.1). Measurement issues are discussed in Chapter 2.

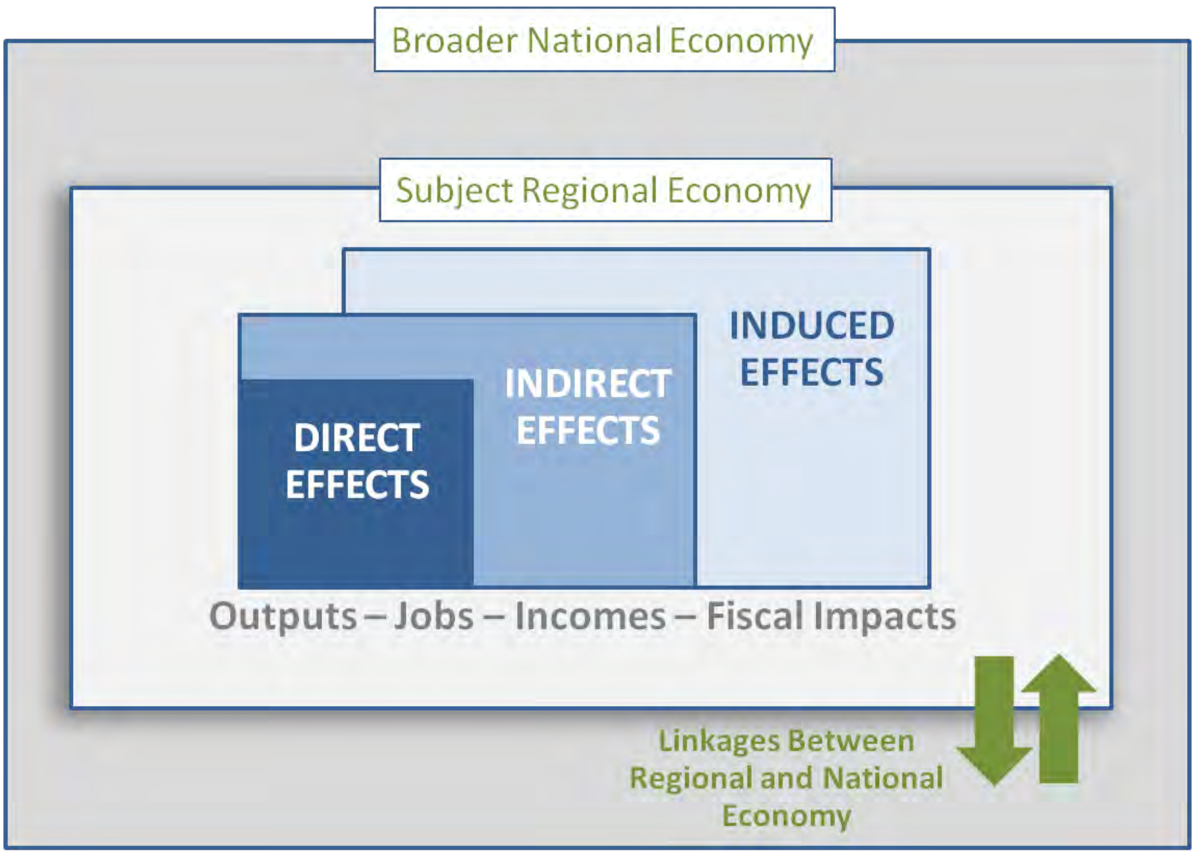
[23] Regional Economic Development (RED) benefits are defined in Chapter 1 (1.7.4).

in regional changes to output (sales), employment, incomes, and public sector fiscal effects. Finally, regional economies seldom exist in isolation, but instead, buy goods and services *from* and sell goods and services *to* other regions within the overall economy.

The magnitude of the regional impacts attributable to a stimulus depends on several things, including, the nature and magnitude of the stimulus, the size and economic composition of the regional economy, and the size and composition of the larger national economy, and the linkages between the regional and the national economy.

Figure 5.1 and the relationships it depicts describe the estimation of regional impacts for the four locks considered here.

Figure 5.1 – Representative Regional Economic Impact Construct




## 5.3 ESTIMATING BASIC ECONOMIC IMPACT BENCHMARKS

As with most forms of economic modeling, the level of approach in impact analyses ranges between the very basic and the very complex. The form used here combines two of the simpler alternatives to form hybrid estimates. Nonetheless, this approach (1) builds upon earlier NWF-sponsored work that was both theoretically and empirically sophisticated, (2) also incorporates standard impact techniques (3) is easily replicated, and (4) produces results that are robust and informative.

## Economic Form of Direct Effects

The stimulus or Direct Effect depicted in Figure 5.1 can come in one of two forms. It can be a demand-side stimulus, where their exogenous force increase or decrease demands for goods or services produced in the subject region or the stimulus can be a supply shock, where there is an exogenous change in the cost of producing goods or services within the region. Changes in the availability or performance of transportation infrastructures are almost always among this latter group. Specifically, in this study, the stimulus (or shock) is the substantial increase in transportation cost that is predicted under an unscheduled lock closure. This form of stimulus is identical in nature to the overall system outage that was the basis for the 2014 NWF-sponsored study: *Inland Navigation in the United States: An Evaluation of Economic Impacts and the Potential Effects on Infrastructure Investment.*

## Geography of Direct Effects and Consequent Impacts

The increased transportation costs attributable to a lock closure are tied to the locations of the producers who originate waterborne shipments and the subsequent users of the shipped commodities, not the location of the lock itself. In this analysis, the initial river origin and final river destination are used as proxies for the geographical distribution of impacts. In addition, the analysis estimates with one exception, that the increased cost of transportation owing to a lock outage would be split evenly between the waterway origin and destination locations. In the case of farm products, the stimulus (increased costs) is placed exclusively at the origin, reflecting that most are export shipments

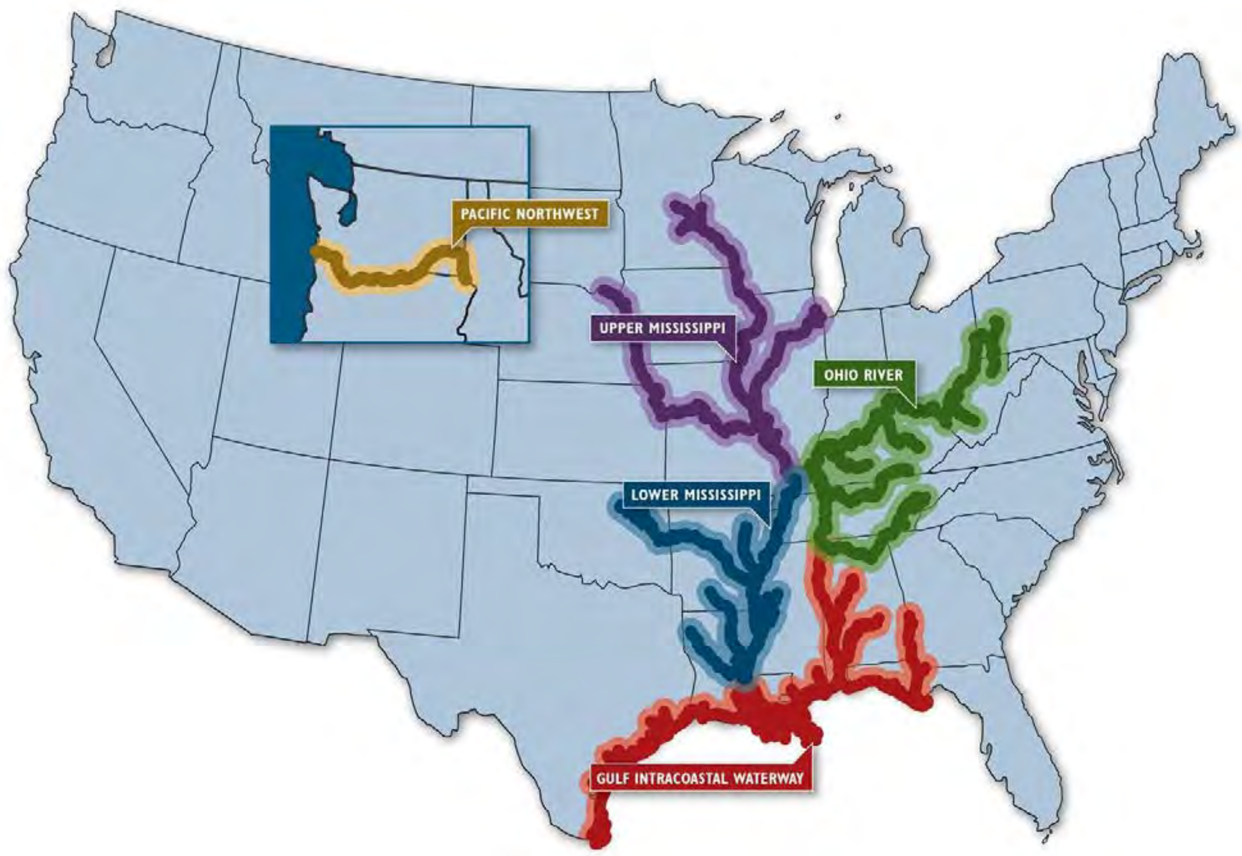
There are two reasons for the asymmetric treatment of farm products, particularly in the current application. First, the vast majority of down-bound grain transiting LaGrange and L&D 25 is bound for export over the Louisiana Gulf. Thus, these shipments generate relatively little economic activity at their domestic destinations. As importantly, there is a widely held conclusion that level of corn and soybean production in the Illinois and upper Mississippi basins is unlikely to be impacted by increased transportation costs and that changes in the export availability of these goods would not affect final market prices in the global markets where they compete. This implies that basin producers would likely absorb the majority of transportation cost increases in the form of lost incomes.

## Determination and Effects of Study Regions

The extent of region or regions in which economic impacts are evaluated can be varied based on the purpose of the analysis and the availability of data. However, the scale of subject regions does affect the magnitude of the estimated effects. Referring again to Figure 5.1, there are linkages between the study region and the world beyond. Among other things, these linkages include leakages of economic consequences from the study region into the broader economy. The extent of these leakages depends on the extent to which regional demands can be satisfied internally. This, in turn, usually depends on the size of the study region. As a rule, larger regions are better able to self-supply economic resources, so that impacts are generally greater than would be generated by a similar shock in a geographically smaller region.

Figure 5.2 depicts the study regions used in the NWF's 2014 work. In the current application, the earlier empirical results are used to generate state-level predictions. On its face, this application may seem tenuous. However, the study team judged that use of the 2014 results is, in fact, appropriate. Specifically, the amount of economic activity and resources available in any of the affected states is roughly analogous to the total economic activity evidence in the study region where that state is located. Moreover, the economic characteristics within a specific state tend to mirror those observed within the larger region.

Figure 5.2 – 2014 Study Region Geography




## Current Study Impact Benchmark Estimation

For a variety of reasons, the methodology outlined above yields what may be interpreted as upper boundaries for output, income, and employment effects. Consequently, earlier reviewers of the current study suggested that these upper bound estimates be accompanied by corresponding estimates of what are likely to be lower boundaries for the same estimated outcomes. Following this suggestion, the study team produced high and low impact estimates for each affected state. It is the midpoint or average of these estimates that are reported in Section 2.

Upper-Bound Estimates Within the current study, the Direct Effects depicted in Figure 5.1 are the avoided increases in supply chain costs that would result from an unscheduled lock outage. Their analogue in the 2014 study is the increase in system-wide user costs that would occur from a full system outage. Given this ready comparison it was relatively easy to derive transportation cost based multipliers and apply them to current study cost projections. Specifically, for each multiplier i, multipliers are calculated as:

$$\mathrm{MULT}_i = \frac{\mathrm{IMPACT14}_i}{\mathrm{COST14}_i}$$

Based on this construct, the multipliers applied here are provided in Table 5.1.[24]

Table 5.1 – Study-Derived Economic Impact Multipliers
(Based Against Navigation-Related Avoided Costs)

| State | Output Multiplier per $1 of Avoided Cost | Income Multiplier per $1 of Avoided Cost | Employment Multiplier per $10 Million of Avoided Cost |
|---|---|---|---|
| **AL** | 5.125 | 1.229 | 18.3300 |
| **AR** | 5.549 | 1.793 | 22.5400 |
| **FL** | 7.597 | 1.767 | 22.7500 |
| **IA** | 5.549 | 1.793 | 22.5400 |
| **IL** | 4.101 | 1.242 | 18.2200 |
| **IN** | 2.654 | 0.691 | 13.9000 |
| **KY** | 2.654 | 0.691 | 13.9000 |
| **LA** | 5.718 | 1.326 | 18.6400 |
| **MN** | 5.549 | 1.793 | 22.5400 |
| **MO** | 5.549 | 1.793 | 22.5400 |
| **MS** | 3.246 | 0.788 | 14.2100 |
| **OH** | 2.654 | 0.691 | 13.9000 |
| **OK** | 3.839 | 0.885 | 14.5200 |
| **PA** | 2.654 | 0.691 | 13.9000 |
| **TN** | 2.654 | 0.691 | 13.9000 |
| **TX** | 5.718 | 1.767 | 22.7500 |
| **WI** | 5.549 | 1.793 | 22.5400 |
| **WV** | 2.654 | 0.691 | 13.9000 |

Lower-Bound Estimates There are numerous alternatives to the methodology described above. To estimate the lower bound of potential economic impacts, the study team applied multipliers made available by the U.S. Bureau of Economic Analysis as part of its RIMS II Regional Input-Output Modeling System.[25]

[24] Some states are served by waterway segments that lie in more than one of the 2014 regions. In these cases, the multipliers were calculated as the simple mean of the corresponding regional average.

[25] For a full description of the RIMS II economic simulation products and their use see: *RIMS II, An Essential Tool for Regional Developers and Planners*, available at: https://www.bea.gov/regional/pdf/rims/RIMSII_User_Guide.pdf

Like most input-out packages, the RIMS II products are easily applied to simulate demand-side stimuli, but are more difficult to use in the case of a supply-side disturbance as is modeled here. Typically, in such cases, supply-side shocks are treated as overall changes to regional incomes. This tends to understate the magnitude of impacts or, as was desired here, produce a lower bound on probable output, income, and employment impacts. The correspond RIMS II multipliers are reproduced here in Table 5.2.

Finally, it is the average or blended results from these alternative methods that are reported in Section 2, Tables 2.6 – 2.9.

Table 5.2 – RIMS II Impact Multipliers (Household Incomes)
(Based On Navigation-Related Avoided Costs)

| State | Output Multiplier per $1 of Avoided Cost | Income Multiplier per $1 of Avoided Cost | Employment Multiplier per $10 Million of Avoided Cost |
|---|---|---|---|
| AL | 1.0728 | 0.3250 | 10.0086 |
| AR | 0.9482 | 0.2884 | 8.5720 |
| FL | 1.2510 | 0.3876 | 11.6335 |
| IA | 0.9447 | 0.2848 | 8.6470 |
| IL | 1.4083 | 0.4085 | 9.7650 |
| IN | 1.1960 | 0.3504 | 9.5203 |
| KY | 1.0862 | 0.3107 | 9.0880 |
| LA | 1.0339 | 0.3238 | 9.3414 |
| MN | 1.3021 | 0.3792 | 9.8312 |
| MO | 1.2427 | 0.3491 | 9.9061 |
| MS | 0.9858 | 0.2950 | 9.3012 |
| OH | 1.2929 | 0.3829 | 10.8242 |
| OK | 1.1125 | 0.3408 | 9.6592 |
| PA | 1.2694 | 0.3691 | 9.4631 |
| TN | 1.3523 | 0.3950 | 10.3448 |
| TX | 1.4871 | 0.4427 | 11.1339 |
| WI | 1.0724 | 0.3338 | 9.3603 |
| WV | 0.8512 | 0.2496 | 7.8008 |

# 6 Final Thoughts

The objective of this analysis was to develop detailed information cataloguing the economic effects of unplanned lock outages at four locations. However, a second important goal was to demonstrate that primary and secondary data can be combined with existing (or slightly modified) modeling platforms to estimate these navigation outcomes with less extensive, expensive, and time-consuming field work.

Within the course of this work, the study team developed two new metrics for measuring the nature and extent of inland navigation's commercial influence. These include the *Corridor Concentration Metric* presented in Section 2 and further described in Appendix 1 and the *Above and Below Pool* traffic measures described in Sections 2 and 3.

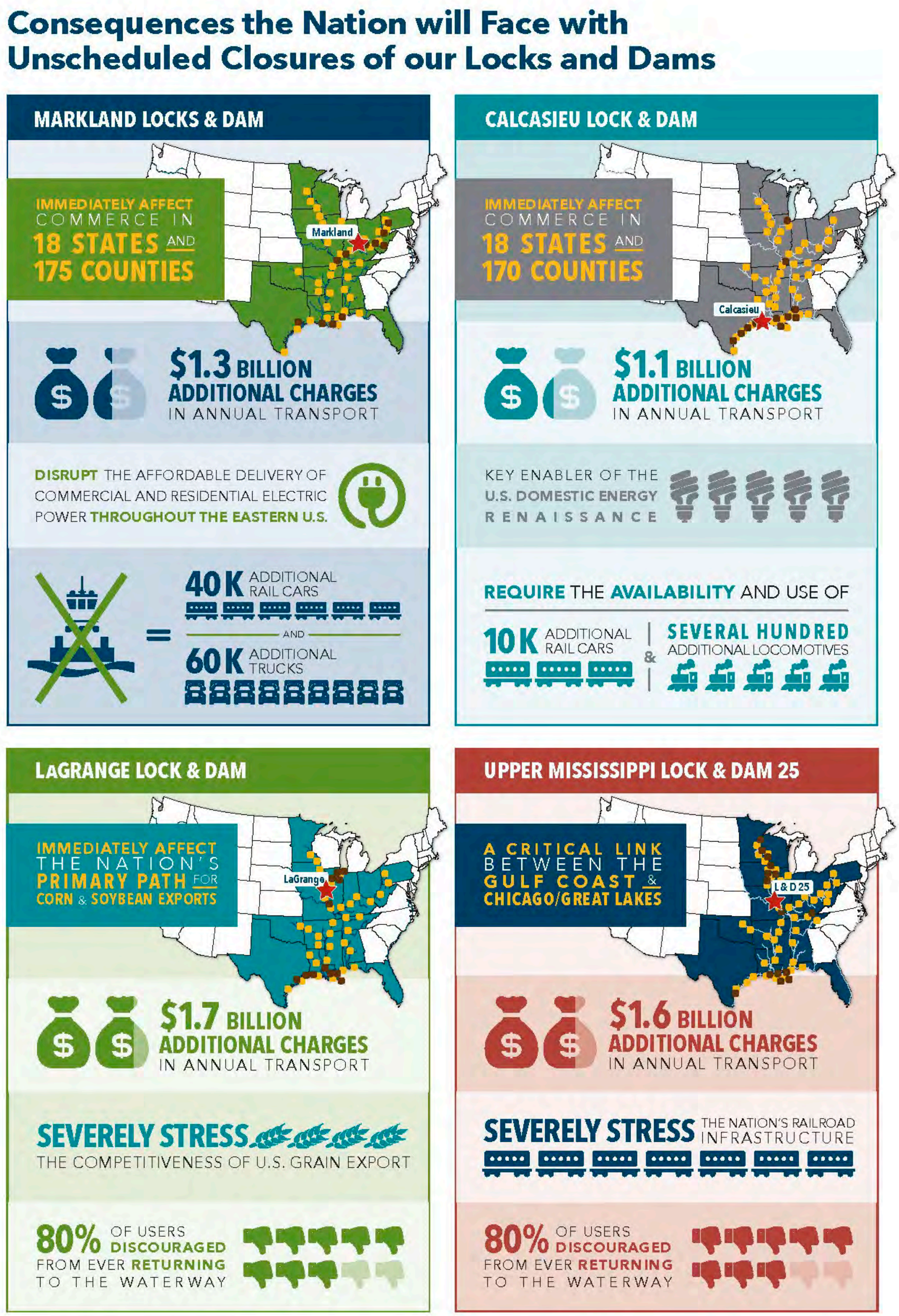
Both measures provide easily calculable metrics that capture important aspects of commercial navigation. Both the corridor concentration metric and the above and below pool tonnage measures emerged in response to specific sponsor questions and both have potentially important implications in the future evaluation of inland navigation investments. Accordingly, we would strongly urge others to further develop both the calculation and use of these metrics and to explore additional ways to quantitatively address relevant system use and performance.

Finally, the study's results confirm many long-held beliefs, but also offer new insights. A few (though not all) key findings are summarized in the Executive Summary. These are repeated here for emphasis and with the hope that readers will find it useful to carry these results forward in other uses. It is clear, to the study team at least, that the nation's navigable waterways represent an important linkage that is essential in its long-run value to both domestic commerce and global trade. We hope this is a message that will be communicated effectively going forward.

## A FEW KEY FINDINGS

- Each of the four locks considered within the study helps shippers to avoid more than $1 Billion in additional transportation costs each year.
- The important roles played by individual navigation projects span a broad range of both geographies and economic purposes, and in some cases provide freight mobility that could not be easily replaced by other transport modes.
- While every state that originates or terminates traffic supported by the four locks benefits from inland navigation's availability, the results reflect the waterway's *extraordinary* commercial value to Louisiana, Texas, and Illinois.
- In the cases of LaGrange Lock & Dam and Lock & Dam 25, trucking to alternative waterway locations would mean an additional 500,000 loaded truck trips per year and an additional 150 million truck miles in the affected states. This is not tenable.

Figure 6.1 – Further Communication of Study Findings



# Appendix One

## The Corridor Concentration Metric

The Corridor Concentration Metric (CCM) is a simple construct that combines the state-wise distribution of lock traffic measured in ton-miles with average shipment distances to derive a general measure of traffic concentration. Specifically, the CCM is defined as:

$$CCM_L = \frac{D_L}{\sum_{i=1}^{n} R_i \times 1{,}000}$$

where:

$CCM_L$ = the Corridor Concentration Metric for a subject lock "L"

$D_L$ = the tonnage weighted average shipment distance for traffic through lock "L"

$R_i$ = The ratio of the total ton-miles to or from state *i* to the maximum number of ton miles to or from any individual state.

The table below uses the calculation of the CCM for Markland as an example:

| State | Total Originating Ton Miles | Total Terminated Ton-Miles | Total All Ton-Miles | Ratio of Total Ton-Miles to the Maximum |
|---|---|---|---|---|
| LA | 14,399,474,691 | 10,240,748,471 | 24,640,223,162 | 1.0000 |
| OH | 4,051,434,666 | 14,710,792,680 | 18,762,227,346 | 0.7614 |
| KY | 10,331,298,804 | 5,704,384,151 | 16,035,682,955 | 0.6508 |
| WV | 7,057,660,488 | 5,790,115,034 | 12,847,775,522 | 0.5214 |
| PA | 1,344,088,656 | 4,936,857,314 | 6,280,945,970 | 0.2549 |
| IN | 3,661,044,210 | 1,619,888,897 | 5,280,933,107 | 0.2143 |
| IL | 3,030,052,592 | 1,495,883,204 | 4,525,935,796 | 0.1837 |
| TX | 1,908,576,169 | 1,159,450,906 | 3,068,027,075 | 0.1245 |
| MO | 866,830,173 | 125,487,478 | 992,317,651 | 0.0403 |
| AL | 210,183,417 | 550,622,631 | 760,806,048 | 0.0309 |
| AR | 179,246,839 | 268,612,332 | 447,859,171 | 0.0182 |
| TN | 100,801,333 | 340,366,581 | 441,167,914 | 0.0179 |
| OK | 130,661,110 | 237,662,945 | 368,324,055 | 0.0149 |
| MS | 164,447,667 | 39,204,414 | 203,652,081 | 0.0083 |
| IA | 35,540,072 | 99,296,485 | 134,836,557 | 0.0055 |
| MN | 24,128,679 | 98,490,685 | 122,619,364 | 0.0050 |
| FL | 0 | 55,613,031 | 55,613,031 | 0.0023 |
| WI | 0 | 21,992,327 | 21,992,327 | 0.0009 |
| TOTAL | 47,495,469,566 | 47,495,469,566 | 94,990,939,132 | 3.8551 |
| | | | Sum of $R_i$ | 3.8551 |
| | | | Average Trip Distance | 751 |
| | | | CCM | 0.1948 |

# Appendix Two

## Additional Screening Tool Results

| No. | Lock | River | Year Open | Rehab | Status | Num Chambers | Bank | Lift | Chamber Length | Chamber Width | Mooring | State | Vessels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Claiborne | Alabama | 1969 | none | operational | 1 | L | 30 | 600 | 84 | N | AL | 77 |
| 2 | Millers Ferry | Alabama | 1969 | none | operational | 1 | L | 45 | 600 | 84 | N | AL | 114 |
| 3 | Robert F. Henry | Alabama | 1972 | none | operational | 1 | L | 45 | 600 | 84 | N | AL | 62 |
| 4 | Great Bridge | Albemarle and Chesap | 1932 | none | operational | 1 | L | 3 | 600 | 72 | N | VA | |
| 5 | L&D 2 | Allegheny | 1934 | none | operational | 1 | L | 11 | 360 | 56 | Y | PA | 5,501 |
| 6 | L&D 3 | Allegheny | 1934 | none | operational | 1 | L | 14 | 360 | 56 | Y | PA | |
| 7 | L&D 4 | Allegheny | 1927 | none | operational | 1 | R | 11 | 360 | 56 | Y | PA | 1701 |
| 8 | L&D 5 | Allegheny | 1927 | none | seasonal | 1 | R | 12 | 360 | 56 | N | PA | 1121 |
| 9 | L&D 6 | Allegheny | 1928 | none | seasonal | 1 | R | 12 | 360 | 56 | N | PA | 377 |
| 10 | L&D 7 | Allegheny | 1930 | none | seasonal | 1 | R | 13 | 360 | 56 | N | PA | 14 |
| 11 | L&D 8 | Allegheny | 1931 | none | seasonal | 1 | L | 18 | 360 | 56 | N | PA | |
| 12 | L&D 9 | Allegheny | 1938 | none | seasonal | 1 | L | 22 | 360 | 56 | Y | PA | |
| 13 | Jim Woodruff | Apalachicola | 1954 | none | operational | 1 | R | 33 | 450 | 82 | N | FL | |
| 14 | Arthur V. Ormond | Arkansas | 1969 | none | operational | 1 | R | 19 | 600 | 110 | Y | AR | 875 |
| 15 | Col Charles D. Maynard | Arkansas | 1968 | none | operational | 1 | L | 17 | 600 | 110 | Y | AR | 1499 |
| 16 | Dardanelle | Arkansas | 1969 | none | operational | 1 | L | 55 | 600 | 110 | Y | AR | 898 |
| 17 | David D. Terry | Arkansas | 1968 | none | operational | 1 | L | 18 | 600 | 110 | Y | AR | 1250 |
| 18 | Emmet Sanders | Arkansas | 1968 | none | operational | 1 | R | 14 | 600 | 110 | Y | AR | 1402 |
| 19 | James W. Trimble | Arkansas | 1969 | none | operational | 1 | R | 20 | 600 | 110 | Y | AR | 2393 |
| 20 | Joe Hardin | Arkansas | 1868 | none | operational | 1 | L | 20 | 600 | 110 | Y | AR | 1284 |
| 21 | Murray | Arkansas | 1969 | none | operational | 1 | R | 18 | 600 | 110 | Y | AR | 1081 |
| 22 | Norrell (Post Canal) | Arkansas | 1967 | none | operational | 1 | L | 30 | 600 | 110 | N | AR | 1280 |
| 23 | Ozark - Jetta Taylor | Arkansas | 1969 | none | operational | 1 | L | 34 | 600 | 110 | Y | AR | 825 |
| 24 | Robert S. Kerr | Arkansas | 1970 | none | operational | 1 | L | 48 | 600 | 110 | N | OK | 1246 |
| 25 | Toad Suck Ferry | Arkansas | 1969 | none | operational | 1 | L | 16 | 600 | 110 | Y | AR | 878 |
| 26 | W.D. Mayo | Arkansas | 1971 | none | operational | 1 | R | 21 | 600 | 110 | N | OK | 1196 |
| 27 | Webers falls | Arkansas | 1970 | none | operational | 1 | L | 30 | 600 | 110 | N | OK | 1429 |
| 28 | WILBUR D MILLS | Arkansas | 1967 | none | operational | 1 | L | 20 | 600 | 110 | N | AR | 1350 |
| 29 | Berwick | Atchafalaya | 1950 | none | operational | 1 | R | 14 | 307 | 45 | N | LA | 3509 |
| 30 | Jonesville | Black | 1972 | none | operational | 1 | R | 30 | 600 | 84 | N | LA | 998 |
| 31 | Black Rock | Black Rock Canal | 1914 | none | operational | 1 | R | 5 | 650 | 70 | N | NY | 2069 |
| 32 | Armistead I. Selden | Black Warrior | 1957 | none | operational | 1 | L | 28 | 600 | 110 | N | WA | 1508 |
| 33 | Hohn Hollis Bankhead | Black Warrior | 1975 | none | operational | 1 | L | 22 | 600 | 110 | N | AL | 1193 |
| 34 | Holt | Black Warrior | 1966 | none | operational | 1 | L | 64 | 600 | 110 | N | AL | 1458 |
| 35 | William Bacon Oliver | Black Warrior | 1991 | none | operational | 1 | L | 68 | 600 | 110 | N | AL | 1341 |
| 36 | Calcasieu | Calcasieu River | 1968 | none | operational | 1 | L | 0 | 575 | 56 | N | LA | 13247 |
| 37 | Moore Haven | Caloosahtchee | 1953 | none | operational | 1 | R | 2 | 250 | 50 | Y | FL | 4281 |
| 38 | W. P. Franklin | Caloosahtchee | 1965 | none | operational | 1 | L | 3 | 400 | 56 | Y | FL | 7411 |
| 39 | Thomas J. Obrien | Calumet | 1960 | none | operational | 1 | R | 4 | 1000 | 110 | Y | IL | 10444 |
| 40 | 1 | Cape Fear | 1915 | none | operational | 1 | R | 11 | 200 | 40 | Y | NC | |
| 41 | 2 | Cape Fear | 1917 | none | operational | 1 | R | 9 | 200 | 40 | Y | NC | |
| 42 | William O. Huske | Cape Fear | 1935 | none | operational | 1 | R | 9 | 300 | 40 | Y | NC | |
| 43 | George W. Andrews | Chattahoochee | 1962 | none | operational | 1 | L | 25 | 450 | 82 | N | GA | 208 |
| 44 | Walter F. George | Chattahoochee | 1963 | none | operational | 1 | L | 88 | 450 | 82 | N | GA | 231 |
| 45 | Chicago | Chicago River | 1938 | none | operational | 1 | R | 4 | 600 | 80 | N | IL | 34979 |

| No. | Lock | River | Year Open | Rehab | Status | Num Chambers | Bank | Lift | Chamber Length | Chamber Width | Mooring | State | Vessels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Melton Hill | Clinch River | 1963 | none | operational | 1 | R | 58 | 400 | 75 | N | TN | |
| 47 | Barkley | Cumberland | 1964 | none | operational | 1 | L | 57 | 800 | 110 | Y | KY | 1367 |
| 48 | Cheatham | Cumberland | 1952 | none | operational | 1 | R | 26 | 800 | 110 | Y | TN | 2007 |
| 49 | Cordell Hull | Cumberland | 1973 | none | replaced | 1 | L | 59 | 400 | 84 | N | TN | |
| 50 | Old Hickory | Cumberland | 1954 | none | operational | 1 | L | 60 | 400 | 84 | Y | TN | 2134 |
| 51 | Deep Creek | Dismal Swamp Canal | 1940 | none | operational | 1 | L | 12 | 300 | 52 | N | VA | 1484 |
| 52 | South Mills | Dismal Swamp Canal | 1941 | none | operational | 1 | L | 12 | 300 | 52 | N | NC | 1433 |
| 53 | Freshwater Bayou | Freshwater Bayou | 1968 | none | operational | 1 | R | 4 | 600 | 84 | N | LA | 13511 |
| 54 | Bayou Boeuf | GIWW | 1954 | none | operational | 1 | R | 11 | 1156 | 75 | N | LA | 18251 |
| 55 | Calcasieu | GIWW | 1950 | none | operational | 1 | R | 4 | 1205 | 75 | N | LA | 14437 |
| 56 | Leland Bowman | GIWW | 1985 | none | operational | 1 | R | 5 | 1200 | 110 | N | LA | 14401 |
| 57 | Algiers | GIWW Algiers Canal | 1956 | none | operational | 1 | R | 18 | 797 | 75 | N | LA | 10915 |
| 58 | Bayou Sorrel | GIWW Morgan City Port Al. | 1952 | none | operational | 1 | R | 21 | 800 | 56 | N | LA | 7108 |
| 59 | Port Allen | GIWW Morgan City Port Al. | 1961 | none | operational | 1 | R | 45 | 1202 | 84 | N | LA | 7930 |
| 60 | Brazos East | GIWW Texas | 1943 | none | operational | 1 | C | 0 | 750 | 75 | Y | TX | 27755 |
| 61 | Brazos West | GIWW Texas | 1943 | none | operational | 1 | C | 0 | 750 | 75 | Y | TX | 25553 |
| 62 | Colorado River East | GIWW Texas | 1944 | none | operational | 1 | L | 12 | 1200 | 75 | Y | TX | 22069 |
| 63 | Colorado River West | GIWW Texas | 1944 | none | operational | 1 | L | 12 | 1200 | 75 | Y | TX | 22306 |
| 64 | Harvey | GIWW West | 1935 | none | operational | 1 | R | 20 | 425 | 75 | N | LA | 6003 |
| 65 | GREEN RIVER - 1 | Green | 1956 | none | operational | 1 | R | 8 | 600 | 84 | Y | KY | 3495 |
| 66 | GREEN RIVER - 2 | Green | 1956 | none | operational | 1 | R | 14 | 600 | 84 | Y | KY | 1431 |
| 67 | Inner Harbor Nav Canl Lk | GWW East | 1923 | none | operational | 1 | L | 17 | 640 | 75 | N | LA | 8500 |
| 68 | Brandon road | Illinois | 1933 | 1988 | operational | 1 | R | 34 | 600 | 110 | N | IL | 3446 |
| 69 | Dresden island | Illinois | 1933 | 1995 | operational | 1 | L | 22 | 600 | 110 | Y | IL | 3437 |
| 70 | Lagrange | Illinois | 1939 | 1988 | operational | 1 | R | 10 | 600 | 110 | N | IL | 3063 |
| 71 | Lockport | Illinois | 1933 | 1989 | operational | 1 | L | 39 | 600 | 110 | N | IL | 3342 |
| 72 | Marseilles | Illinois | 1933 | 1996 | operational | 1 | L | 24 | 600 | 110 | Y | IL | 3765 |
| 73 | Peoria | Illinois | 1938 | 1990 | operational | 1 | L | 11 | 600 | 110 | N | IL | 3316 |
| 74 | Starved Rock | Illinois | 1933 | 1996 | operational | 1 | R | 19 | 600 | 110 | Y | IL | 3886 |
| 75 | London | Kanawha | 1933 | none | operational | 2 | R | 24 | 360 | 56 | N | WV | 935 |
| 76 | Marmet | Kanawha | 2008 | none | operational | 3 | R | 24 | 360 | 56 | Y | WV | 2039 |
| 77 | Winfield | Kanawha | 1997 | none | operational | 3 | R | 28 | 360 | 56 | Y | WV | 1624 |
| 78 | Kaskaskia | Kaskaskia | 1973 | none | operational | 1 | R | 29 | 600 | 84 | N | IL | 1985 |
| 79 | Catfish Point | Mermentau | 1951 | none | operational | 1 | R | 0 | 500 | 56 | N | LA | 1087 |
| 80 | CHAINS OF ROCKS L/D 27 | Mississippi | 1953 | 2009 | operational | 2 | L | 21 | 1200 | 110 | N | IL | 2343 |
| 81 | LOCK & DAM 1 | Mississippi | 1930 | 1980 | seasonal | 2 | R | 38 | 400 | 56 | Y | MN | 2358 |
| 82 | LOCK & DAM 10 | Mississippi | 1936 | 2006 | seasonal | 1 | R | 8 | 600 | 110 | N | IA | 3678 |
| 83 | LOCK & DAM 11 | Mississippi | 1937 | 2012 | operational | 1 | R | 12 | 600 | 110 | N | IA | 5010 |
| 84 | LOCK & DAM 12 | Mississippi | 1939 | 2000 | operational | 1 | R | 9 | 600 | 110 | Y | IA | 2831 |
| 85 | LOCK & DAM 13 | Mississippi | 1938 | 1996 | operational | 1 | L | 11 | 600 | 110 | Y | IL | 2387 |
| 86 | LOCK & DAM 14 | Mississippi | 1922 | 1996 | operational | 2 | R | 11 | 600 | 110 | N | IA | 2292 |
| 87 | LOCK & DAM 15 | Mississippi | 1934 | 1993 | operational | 2 | L | 16 | 600 | 110 | N | IA | 2539 |
| 88 | LOCK & DAM 16 | Mississippi | 1937 | 1991 | operational | 1 | L | 9 | 600 | 110 | N | IL | 2723 |
| 89 | LOCK & DAM 17 | Mississippi | 1939 | 1988 | operational | 1 | L | 8 | 600 | 110 | N | IL | 2108 |
| 90 | LOCK & DAM 18 | Mississippi | 1937 | 1990 | operational | 1 | L | 10 | 600 | 110 | Y | IL | 2424 |

| No. | Lock | River | Year Open | Rehab | Status | Num Chambers | Bank | Lift | Chamber Length | Chamber Width | Mooring | State | Vessels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | LOCK & DAM 19 | Mississippi | 1957 | 2008 | operational | 1 | R | 38 | 1200 | 110 | Y | IA | 2164 |
| 92 | LOCK & DAM 2 | Mississippi | 1930 | 1995 | seasonal | 1 | R | 12 | 500 | 110 | N | MN | 3354 |
| 93 | LOCK & DAM 20 | Mississippi | 1936 | 1994 | operational | 1 | R | 10 | 600 | 110 | N | MO | 2385 |
| 94 | LOCK & DAM 21 | Mississippi | 1938 | 1990 | operational | 1 | L | 10 | 600 | 110 | N | IL | 2413 |
| 95 | LOCK & DAM 22 | Mississippi | 1938 | 1990 | operational | 1 | R | 10 | 600 | 110 | Y | MO | 2041 |
| 96 | LOCK & DAM 24 | Mississippi | 1940 | 2003 | operational | 1 | R | 15 | 600 | 110 | Y | MO | 2149 |
| 97 | LOCK & DAM 25 | Mississippi | 1939 | 1999 | operational | 1 | R | 15 | 600 | 110 | Y | MO | 2192 |
| 98 | LOCK & DAM 3 | Mississippi | 1938 | 1991 | seasonal | 1 | R | 8 | 600 | 110 | N | MN | 7749 |
| 99 | LOCK & DAM 4 | Mississippi | 1935 | 1994 | seasonal | 1 | L | 7 | 600 | 110 | N | WI | 4973 |
| 100 | LOCK & DAM 5 | Mississippi | 1935 | 1998 | seasonal | 1 | R | 9 | 600 | 110 | Y | MN | 3476 |
| 101 | LOCK & DAM 6 | Mississippi | 1936 | 1999 | seasonal | 1 | L | 6 | 600 | 110 | N | WI | 3898 |
| 102 | LOCK & DAM 7 | Mississippi | 1937 | 2002 | seasonal | 1 | R | 8 | 600 | 110 | Y | MN | 5286 |
| 103 | LOCK & DAM 8 | Mississippi | 1937 | 2003 | seasonal | 1 | L | 11 | 600 | 110 | N | WI | 3086 |
| 104 | LOCK & DAM 9 | Mississippi | 1938 | 2005 | seasonal | 1 | L | 9 | 600 | 110 | N | WI | 3946 |
| 105 | Lower Saint Anthony Falls | Mississippi | 1959 | none | seasonal | 1 | R | 25 | 400 | 56 | Y | MN | 2139 |
| 106 | MEL PRICE LOCK & DAM | Mississippi | 1990 | none | operational | 2 | L | 24 | 1200 | 110 | N | IL | 2343 |
| 107 | Upper Saint Anathjony Fall | Mississippi | 1963 | none | seasonal | 1 | R | 49 | 400 | 56 | Y | MN | 2040 |
| 108 | Hildebrand | Monongahela | 1959 | none | operational | 1 | L | 21 | 600 | 84 | Y | WV | 207 |
| 109 | LOCK & DAM 2 | Monongahela | 1905 | none | operational | 2 | R | 9 | 720 | 110 | Y | PA | 3021 |
| 110 | LOCK & DAM 3 | Monongahela | 1907 | none | operational | 2 | R | 8 | 720 | 56 | Y | PA | 4185 |
| 111 | LOCK & DAM 4 | Monongahela | 1932 | none | operational | 2 | R | 17 | 720 | 56 | Y | PA | 6171 |
| 112 | Maxwell | Monongahela | 1963 | none | operational | 2 | R | 20 | 720 | 84 | Y | PA | 4095 |
| 113 | Morgantown | Monongahela | 1950 | none | operational | 1 | L | 17 | 600 | 84 | Y | WV | 400 |
| 114 | Opekiska | Monongahela | 1964 | none | operational | 1 | R | 22 | 600 | 84 | N | WV | 260 |
| 115 | Point Marion | Monongahela | 1994 | none | operational | 1 | L | 19 | 720 | 84 | Y | PA | 1474 |
| 116 | L&D 52 | Ohio | 1969 | none | operational | 2 | R | 12 | 1200 | 110 | Y | IL | 7703 |
| 117 | L&d 53 | Ohio | 1980 | none | operational | | | | | | | | 7351 |
| 118 | Belleville | Ohio | 1969 | none | operational | 2 | R | 22 | 1200 | 110 | Y | OH | 3592 |
| 119 | Cannelton | Ohio | 1971 | none | operational | 2 | R | 25 | 1200 | 110 | Y | IN | 5740 |
| 120 | Captain Anthony Meldahl | Ohio | 1962 | | operational | 2 | R | 30 | 1200 | 110 | Y | OH | 4130 |
| 121 | Dashields | Ohio | 1929 | 1980 | operational | 2 | L | 10 | 600 | 110 | Y | PA | 3113 |
| 122 | Emsworth | Ohio | 1921 | 1986 | operational | 2 | R | 18 | 600 | 110 | Y | PA | 3404 |
| 123 | Greenup | Ohio | 1959 | none | operational | 2 | L | 30 | 1200 | 110 | Y | KY | 3957 |
| 124 | Hannibal | Ohio | 1973 | none | operational | 2 | R | 21 | 1200 | 110 | Y | OH | 3774 |
| 125 | John T. Myers | Ohio | 1975 | none | operational | 2 | R | 18 | 1200 | 110 | Y | IN | 5166 |
| 126 | Markland | Ohio | 1959 | 2011 | operational | 2 | L | 35 | 1200 | 110 | Y | KY | 4368 |
| 127 | McAlpine | Ohio | 1961 | none | operational | 2 | L | 37 | 1200 | 110 | Y | KY | 3276 |
| 128 | Montgomery | Ohio | 1936 | 1990 | operational | 2 | L | 18 | 600 | 110 | Y | PA | 3573 |
| 129 | New Cumberland | Ohio | 1959 | none | operational | 2 | R | 21 | 1200 | 110 | Y | OH | 2845 |
| 130 | NewBurgh | Ohio | 1975 | none | operational | 2 | R | 16 | 1200 | 110 | Y | IN | 6379 |
| 131 | Pike Island | Ohio | 1965 | none | operational | 2 | L | 18 | 1200 | 110 | Y | WV | 3128 |
| 132 | Racine | Ohio | 1967 | none | operational | 2 | L | 22 | 1200 | 110 | Y | WV | 3622 |
| 133 | Robert C. Byrd | Ohio | 1993 | 2002 | operational | 2 | L | 23 | 1200 | 110 | Y | WV | 1945 |
| 134 | Smithland | Ohio | 1980 | none | operational | 2 | R | 22 | 1200 | 110 | Y | IL | 4184 |
| 135 | Willow Island | Ohio | 1972 | none | operational | 2 | R | 20 | 1200 | 110 | Y | OH | 3405 |

| No. | Lock | River | Year Open | Rehab | Status | Num Chambers | Bank | Lift | Chamber Length | Chamber Width | Mooring | State | Vessels |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 136 | Ortona | Okeechobee | 1937 | none | operational | 1 | R | 11 | 250 | 50 | Y | FL | 5128 |
| 137 | Old River | Old River | 1963 | none | operational | 1 | R | 35 | 1200 | 75 | N | LA | 3376 |
| 138 | Columbia | Ouachita | 1972 | none | operational | 1 | L | 18 | 600 | 84 | N | LA | 393 |
| 139 | Felsenthal | Ouachita | 1984 | none | operational | 1 | R | 18 | 600 | 84 | N | AR | 263 |
| 140 | H.K. Thatcher | Ouachita | 1984 | none | operational | 1 | R | 12 | 600 | 84 | N | AR | 182 |
| 141 | L&D 3 | Red | 1992 | none | operational | 1 | L | 31 | 785 | 84 | N | LA | 1330 |
| 142 | Joe D. Waggonner | Red | 1994 | none | operational | 1 | L | 25 | 785 | 84 | N | LA | 2158 |
| 143 | John H. Overton | Red | 1987 | none | operational | 1 | L | 24 | 785 | 84 | N | LA | 1416 |
| 144 | Lindy Claiborne Boggs | Red | 1984 | none | operational | 1 | L | 36 | 785 | 84 | N | LA | 1657 |
| 145 | Port Mayaca | St. Lucie Canal | 1977 | none | operational | 1 | R | 2 | 400 | 56 | Y | FL | 4394 |
| 146 | St. Lucie | St. Lucie Canal | 1941 | none | operational | 1 | R | 13 | 250 | 50 | Y | FL | 5129 |
| 147 | Chickamauga | Tennessee | 1937 | none | operational | 1 | R | 49 | 360 | 60 | Y | TN | 3623 |
| 148 | Fort Loudoun | Tennessee | 1943 | none | operational | 1 | L | 72 | 360 | 60 | N | TN | 1453 |
| 149 | General Joseph Wheeler | Tennessee | 1963 | none | operational | 2 | R | 48 | 600 | 110 | Y | AL | 2003 |
| 150 | Guntersville | Tennessee | 1965 | none | operational | 2 | R | 39 | 600 | 110 | Y | AL | 1497 |
| 151 | Kentucky | Tennessee | 1944 | none | operational | 1 | R | 57 | 600 | 110 | Y | KY | 2986 |
| 152 | Nickajack | Tennessee | 1967 | none | operational | 1 | R | 39 | 600 | 110 | Y | TN | 1640 |
| 153 | Pickwick Landing | Tennessee | 1984 | none | operational | 2 | L | 55 | 1000 | 110 | Y | TN | 2394 |
| 154 | Watts Bar | Tennessee | 1941 | none | operational | 1 | L | 58 | 360 | 60 | Y | TN | 1592 |
| 155 | Wilson | Tennessee | 1959 | none | operational | 3 | R | 94 | 600 | 110 | N | AL | 2661 |
| 156 | Aberdeen | Tenn-Tombigbee | 1985 | none | operational | 1 | R | 27 | 600 | 110 | N | MS | 1969 |
| 157 | Amory | Tenn-Tombigbee | 1985 | none | operational | 1 | L | 30 | 600 | 110 | N | MS | 2008 |
| 158 | Fulton | Tenn-Tombigbee | 1985 | none | operational | 1 | L | 25 | 600 | 110 | N | MS | 2025 |
| 159 | G.V. Sonny Montgomery | Tenn-Tombigbee | 1985 | none | operational | 1 | L | 30 | 600 | 110 | N | MS | 1991 |
| 160 | Glover Wilkins | Tenn-Tombigbee | 1985 | none | operational | 1 | R | 25 | 600 | 110 | N | AL | 2020 |
| 161 | Howell Heflin | Tenn-Tombigbee | 1978 | none | operational | 1 | L | 36 | 600 | 110 | N | AL | 2020 |
| 162 | Jamie Whitten | Tenn-Tombigbee | 1985 | none | operational | 1 | L | 84 | 600 | 110 | N | MS | 2312 |
| 163 | John C. Stennis | Tenn-Tombigbee | 1980 | none | operational | 1 | R | 27 | 600 | 110 | N | MS | 2289 |
| 164 | John E. Rankin | Tenn-Tombigbee | 1985 | none | operational | 1 | R | 30 | 600 | 110 | N | MS | 2053 |
| 165 | Tom Bevill | Tenn-Tombigbee | 1979 | none | operational | 1 | L | 27 | 600 | 110 | N | AL | 2090 |
| 166 | Coffeeville | Tombigbee | 1960 | none | operational | 1 | R | 34 | 600 | 110 | N | AL | 2490 |
| 167 | Demopolis | Tombigbee | 1954 | none | operational | 1 | L | 40 | 600 | 110 | N | AL | 2594 |

| No. | Ktons | Lockages | WCSC Tons | LPMS Tons | WCSC Ton-Miles | System Lockages | System Lockages per Barge | Above Pool Tonnage | Below Pool Tonnage | Pool Above Total | Pool Below Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 65 | | | | | | 0 | 0 | 0 | 0 |
| 2 | | 98 | | | | | | 0 | 0 | 0 | 0 |
| 3 | | 34 | | | | | | 0 | 0 | 0 | 0 |
| 4 | | | 667896 | 941000 | 215389170 | 287 | 1 | 0 | 0 | 0 | 0 |
| 5 | 2148 | 3803 | 1732368 | 2148000 | 438768003 | 15628 | 10 | 0 | 0 | 0 | 0 |
| 6 | | | 1732368 | 2164000 | 438768003 | 15628 | 10 | 0 | 0 | 0 | 0 |
| 7 | 412 | 1117 | 294446 | 412000 | 173054654 | 2437 | 12.4 | 0 | 1,358,167 | 0 | 1,358,167 |
| 8 | 75 | 544 | 6593 | 75000 | 12183864 | 104 | 26 | 0 | 113,374 | 0 | 113,374 |
| 9 | 21 | 100 | 6593 | 21000 | 12183864 | 104 | 26 | 0 | 0 | 0 | 0 |
| 10 | 75 | 7.25 | 6593 | 14000 | 12183864 | 104 | 26 | 0 | 0 | 0 | 0 |
| 11 | | | | | | | | 0 | 0 | 0 | 0 |
| 12 | | | | | | | | 0 | 0 | 0 | 0 |
| 13 | | | | | | | | 0 | 0 | 0 | 0 |
| 14 | 6759 | 1189 | 6865895 | 6759000 | 6300563711 | 74708 | 17.7 | 0 | 493,143 | 0 | 493,143 |
| 15 | 8638 | 1711 | 8829595 | 8638000 | 7622745294 | 83444 | 15.5 | 4,874 | 474,968 | 4,874 | 474,968 |
| 16 | 6723 | 1184 | 6807975 | 6723000 | 6252996277 | 74262 | 17.7 | 0 | 18,845 | 0 | 18,845 |
| 17 | 8441 | 1581 | 8834469 | 8441000 | 7622802803 | 83486 | 15.5 | 1,089,395 | 0 | 1,089,395 | 0 |
| 18 | 8800 | 1713 | 9312829 | 8800000 | 7879113329 | 84641 | 14.9 | 4,921 | 42,491 | 4,921 | 42,491 |
| 19 | 7303 | 2431 | 22227660 | 7303000 | 6414502087 | 73530 | 6.4 | 704,200 | 0 | 704,200 | 0 |
| 20 | 8756 | 1643 | 9355320 | 8756000 | 7901242586 | 84722 | 14.9 | 0 | 398,688 | 0 | 398,688 |
| 21 | 6851 | 1363 | 7173279 | 6851000 | 6357914368 | 75112 | 17.2 | 3,344 | 2,476,789 | 3,344 | 2,476,789 |
| 22 | 9105 | 1653 | 9760696 | 9105000 | 8106186465 | 85217 | 14.3 | 0 | 0 | 0 | 0 |
| 23 | 6137 | 1147 | 6690500 | 6137000 | 6198273127 | 73464 | 17.9 | 800,260 | 93,525 | 800,260 | 93,525 |
| 24 | 5794 | 1446 | 6247617 | 5794000 | 5839927519 | 69661 | 18.2 | 0 | 0 | 0 | 0 |
| 25 | 6789 | 1202 | 7176623 | 6789000 | 6357954334 | 75132 | 17.2 | 439,178 | 0 | 439,178 | 0 |
| 26 | 5793 | 1414 | 6247617 | 5793000 | 5839927519 | 69661 | 18.2 | 0 | 1,784,821 | 0 | 1,784,821 |
| 27 | 5416 | 1475 | 5908615 | 5416000 | 5571702408 | 66340 | 18.4 | 0 | 57,595 | 0 | 57,595 |
| 28 | 9140 | 1679 | 9760696 | 9140000 | 8106186465 | 85217 | 14.3 | 0 | 0 | 0 | 0 |
| 29 | 22 | 2939 | 27079187 | 22000 | 23529847909 | 143368 | 10.2 | 0 | 0 | 0 | 0 |
| 30 | 1076 | 1045 | 980457 | | 310860181 | 1590 | 3.2 | 0 | 0 | 0 | 0 |
| 31 | 82 | 1532 | | 82000 | | | | 0 | 0 | 0 | 0 |
| 32 | 7693 | 1413 | 7496716 | 7693000 | 3094603079 | 31318 | 6.9 | 633,806 | 4,768,059 | 633,806 | 4,768,059 |
| 33 | 4505 | 1034 | 5776575 | 5941000 | 2181969077 | 25613 | 6.7 | 18,000 | 687,550 | 2,249,033 | 1,408,901 |
| 34 | 5941 | 1221 | 4385674 | 4505000 | 1681101232 | 20935 | 7.2 | 2,249,033 | 1,408,901 | 18,000 | 687,550 |
| 35 | 7071 | 1268 | 6748538 | 7071000 | 2479373640 | 28501 | 6.5 | 264,900 | 422,856 | 264,900 | 422,856 |
| 36 | 469 | 3987 | 6875951 | 469000 | 2330362699 | 14708 | 4.4 | 153,786 | 53,103,923 | 153,786 | 53,103,923 |
| 37 | 4 | 3511 | 1500 | 4000 | 216000 | 15 | 5 | 0 | 0 | 0 | 0 |
| 38 | 4 | 5598 | 1500 | 4000 | 216000 | 15 | 5 | 0 | 0 | 0 | 0 |
| 39 | 5916 | 4279 | 5742072 | 5916000 | 6164914723 | 39822 | 11 | 0 | 0 | 0 | 0 |
| 40 | | | | | | | | 0 | 0 | 0 | 0 |
| 41 | | | | | | | | 0 | 0 | 0 | 0 |
| 42 | | | | | | | | 0 | 0 | 0 | 0 |
| 43 | | 117 | | | | 6 | | 0 | 0 | 0 | 0 |
| 44 | | 117 | | | | | | 0 | 0 | 0 | 0 |
| 45 | 245 | 10959 | 5742072 | 245000 | 6164914723 | 39822 | 11 | 0 | 0 | 0 | 0 |

| No. | Ktons | Lockages | WCSC Tons | LPMS Tons | WCSC Ton-Miles | System Lockages | System Lockages per Barge | Above Pool Tonnage | Below Pool Tonnage | Pool Above Total | Pool Below Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | | | | | | | | 0 | 0 | 0 | 0 |
| 47 | 2848 | 1224 | 6486803 | 2843000 | 1666441011 | 10498 | 2.8 | 3,034 | 10,772,707 | 3,034 | 10,772,707 |
| 48 | 9103 | 1932 | 8393157 | 9103000 | 2676507498 | 19544 | 4.3 | 0 | 15,764,247 | 0 | 15,764,247 |
| 49 | | | | 2000 | | | | 0 | 6,422,021 | 0 | 6,422,021 |
| 50 | 3942 | 2340 | 3722409 | 3942000 | 910911877 | 8837 | 4 | 0 | 0 | 0 | 0 |
| 51 | | 762 | | | | | | 0 | 0 | 0 | 0 |
| 52 | | 727 | | | | | | 0 | 0 | 0 | 0 |
| 53 | 1767 | 10709 | 1932571 | 1767000 | 48649163 | 1210 | 1 | 0 | 0 | 0 | 0 |
| 54 | 27662 | 14410 | 27462258 | 27662000 | 17647599353 | 113798 | 9.3 | 6,894,997 | 2,446,334 | 6,894,997 | 2,446,334 |
| 55 | 42240 | 12662 | 42493113 | 42240000 | 29681602961 | 200403 | 10.4 | 58,671 | 62,800 | 58,671 | 62,800 |
| 56 | 41664 | 11943 | 42463776 | 41664000 | 29795802996 | 200802 | 10.5 | 203,675 | 1,227,654 | 203,675 | 1,227,654 |
| 57 | 26128 | 9160 | 25730654 | 26168000 | 16926752587 | 101171 | 9.1 | 0 | 0 | 0 | 0 |
| 58 | 20931 | 9123 | 25109528 | 20931000 | 14552636064 | 110247 | 7.4 | 248,162 | 650 | 248,162 | 650 |
| 59 | 22289 | 6238 | 42510954 | 22289000 | 29718256912 | 200534 | 10.4 | 0 | 350,007 | 0 | 350,007 |
| 60 | 26281 | 15723 | 42235018 | 26281000 | 29654587951 | 199893 | 10.5 | 0 | 5,920 | 0 | 5,920 |
| 61 | 26184 | 15653 | 42235018 | 26184000 | 29654587951 | 199893 | 10.5 | 0 | 5,920 | 0 | 5,920 |
| 62 | 26210 | 13818 | 42235018 | 26210000 | 29654587951 | 199893 | 10.5 | 0 | 0 | 0 | 0 |
| 63 | 24921 | 12577 | 49387493 | 24921000 | 31321763246 | 202261 | 9.1 | 2,136,995 | 0 | 2,136,995 | 0 |
| 64 | 1679 | 4988 | 2186522 | 1679000 | 1344642232 | 8693 | 7.3 | 10,822,601 | 0 | 10,822,601 | 0 |
| 65 | 7685 | 3072 | 7143955 | 7685000 | 3288738566 | 25678 | 5.7 | 0 | 0 | 0 | 0 |
| 66 | 6483 | 1384 | 5813336 | 6483000 | 2127604927 | 19130 | 5.2 | 0 | 0 | 0 | 0 |
| 67 | 15834 | 8431 | 16295127 | 15834000 | 8892738205 | 41423 | 5.6 | 457,815 | 0 | 457,815 | 0 |
| 68 | 12588 | 3384 | 11642182 | 12588000 | 11295143107 | 73149 | 10.4 | 0 | 4,011,986 | 0 | 4,011,986 |
| 69 | 16455 | 3692 | 15060210 | 16455000 | 16390111066 | 91425 | 10.7 | 944,703 | 1,802,965 | 944,703 | 1,802,965 |
| 70 | 27222 | 3659 | 29730341 | 27222000 | 35764883159 | 139837 | 8.1 | 1,065,293 | 2,344,044 | 1,065,293 | 2,344,044 |
| 71 | 12360 | 3264 | 11256415 | 12360000 | 11102816894 | 70946 | 10.5 | 0 | 393,134 | 0 | 393,134 |
| 72 | 17839 | 3892 | 16217395 | 17839000 | 18624286359 | 97485 | 10.5 | 535,134 | 1,932,045 | 535,134 | 1,932,045 |
| 73 | 25834 | 3889 | 25310546 | 25834000 | 29524869639 | 131837 | 9 | 625,092 | 4,431,271 | 625,092 | 4,431,271 |
| 74 | 19853 | 4081 | 18290793 | 19853000 | 21364870646 | 108591 | 10.3 | 1,650 | 7,726,854 | 1,650 | 7,726,854 |
| 75 | 1110 | 1186 | 1127521 | 1172000 | 320258774 | 3077 | 4.5 | 463,798 | 2,056,305 | 463,798 | 2,056,305 |
| 76 | 8310 | 1770 | 6328262 | 8310000 | 2533240087 | 24095 | 6.4 | 4,198,360 | 4,919,168 | 4,198,360 | 4,919,168 |
| 77 | 11285 | 1541 | 11463918 | 11319000 | 4832358078 | 41573 | 6 | 1,357,043 | 117,865 | 1,357,043 | 117,865 |
| 78 | 1366 | 1079 | 2038323 | 1366000 | 789234525 | 1126 | 1.2 | 0 | 0 | 0 | 0 |
| 79 | 123 | 970 | 91347 | 123000 | 6419736 | 314 | 2.8 | 0 | 0 | 0 | 0 |
| 80 | 25692 | 2302 | 62807436 | 61139000 | 75112819904 | 375344 | 10 | 0 | 0 | 0 | 0 |
| 81 | 713 | 1444 | 1361988 | 713000 | 274236910 | 4086 | 6.7 | 0 | 5,265,481 | 0 | 5,265,481 |
| 82 | 12506 | 2849 | 11524054 | 12506000 | 15216808424 | 167886 | 22.8 | 17,692 | 591,068 | 17,692 | 591,068 |
| 83 | 13154 | 3202 | 12115122 | 13154000 | 15236313668 | 169606 | 21.8 | 0 | 1,545,186 | 0 | 1,545,186 |
| 84 | 13904 | 2723 | 13124858 | 13904000 | 17085679764 | 183207 | 21.8 | 663,201 | 178,561 | 663,201 | 178,561 |
| 85 | 14133 | 2786 | 13306798 | 14133000 | 17327259882 | 184889 | 21.7 | 0 | 2,353,083 | 0 | 2,353,083 |
| 86 | 16100 | 2963 | 17054804 | 16103000 | 20005637897 | 202124 | 19.7 | 327,523 | 469,042 | 327,523 | 469,042 |
| 87 | 16433 | 2933 | 16478324 | 16453000 | 20443624506 | 203455 | 20.2 | 280,308 | 771,458 | 280,308 | 771,458 |
| 88 | 16832 | 3316 | 16789159 | 16832000 | 21405626625 | 204243 | 19.9 | 674,735 | 744,437 | 674,735 | 744,437 |
| 89 | 17652 | 2903 | 17775362 | 17652000 | 22349673753 | 211281 | 19.5 | 17,006 | 854,268 | 17,006 | 854,268 |
| 90 | 18584 | 3090 | 18674967 | 18584000 | 23392977411 | 216825 | 19 | 0 | 1,547,389 | 0 | 1,547,389 |

| No. | Ktons | Lockages | WCSC Tons | LPMS Tons | WCSC Ton-Miles | System Lockages | System Lockages per Barge | Above Pool Tonnage | Below Pool Tonnage | Pool Above Total | Pool Below Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | 18498 | 1932 | 19341938 | 19097000 | 24921165521 | 218523 | 18.5 | 919,500 | 414,383 | 919,500 | 414,383 |
| 92 | 6880 | 2452 | 6472877 | 6880000 | 8664991028 | 103859 | 25 | 2,042,902 | 0 | 2,042,902 | 0 |
| 93 | 19097 | 3272 | 19644803 | 19097000 | 25370303092 | 218870 | 18.3 | 124,136 | 1,654,891 | 124,136 | 1,654,891 |
| 94 | 20925 | 3358 | 21747261 | 20925000 | 27996972455 | 226968 | 17.1 | 193,085 | 699,192 | 193,085 | 699,192 |
| 95 | 21346 | 3158 | 21927735 | 21346000 | 28353386574 | 228495 | 16.6 | 255,763 | 1,010,250 | 255,763 | 1,010,250 |
| 96 | 21785 | 3190 | 23034787 | 21785000 | 29481889251 | 231220 | 16 | 17,887 | 0 | 17,887 | 0 |
| 97 | 21674 | 3172 | 23095753 | 21674000 | 29499570937 | 231348 | 15.9 | 0 | 33,815 | 0 | 33,815 |
| 98 | 6877 | 3775 | 6472877 | 6877000 | 8664991028 | 103859 | 25 | 0 | 369,221 | 0 | 369,221 |
| 99 | 7357 | 3077 | 6907949 | 7357000 | 9329578657 | 111152 | 25.1 | 19,570 | 0 | 19,570 | 0 |
| 100 | 7388 | 2542 | 6907949 | 7388000 | 9329578657 | 111152 | 25.1 | 0 | 1,629,210 | 0 | 0 |
| 101 | 9089 | 2726 | 8613564 | 9089000 | 12155104538 | 136811 | 24.8 | 7,828 | 0 | 7,828 | 0 |
| 102 | 9360 | 3577 | 8613564 | 9360000 | 12155104538 | 136811 | 24.8 | 0 | 342,226 | 0 | 342,226 |
| 103 | 9754 | 2395 | 9383024 | 9754000 | 13037758496 | 146631 | 24.4 | 0 | 795,258 | 0 | 795,258 |
| 104 | 11125 | 2948 | 10187441 | 11125000 | 13292571029 | 152382 | 23.4 | 0 | 1,314,816 | 0 | 1,314,816 |
| 105 | 716 | 1585 | 1361988 | 716000 | 274236910 | 4086 | 6.7 | 0 | 0 | 0 | 0 |
| 106 | 25692 | 2302 | 55234898 | 53661000 | 67665616432 | 368629 | 11 | 0 | 5,272,032 | 0 | 5,272,032 |
| 107 | 712 | 1207 | 1361988 | 712000 | 274236910 | 4086 | 6.7 | 0 | 0 | 0 | 0 |
| 108 | 5 | 61 | | 5000 | | | | 0 | 0 | 0 | 0 |
| 109 | 16071 | 3326 | 15603307 | 16235000 | 5309892425 | 130187 | 12.4 | 6,622,970 | 0 | 6,622,970 | 0 |
| 110 | 9794 | 4109 | 10151641 | 11216000 | 2928204921 | 88072 | 12.1 | 214,139 | 2,467,962 | 214,139 | 2,467,962 |
| 111 | 10235 | 5612 | 9554511 | 10235000 | 2673277896 | 83935 | 12.2 | 839,533 | 395,824 | 839,533 | 395,824 |
| 112 | 9884 | 3642 | 9547720 | 10147000 | 2302103863 | 80783 | 11.6 | 5,409,922 | 133,632 | 5,409,922 | 133,632 |
| 113 | 176 | 254 | 91340 | 176000 | 28224060 | 960 | 16 | 91,340 | 3,708,692 | 91,340 | 3,708,692 |
| 114 | 5 | 64 | | 5000 | | | | 0 | 0 | 0 | 0 |
| 115 | 3483 | 1274 | 3076966 | 3483000 | 550126040 | 32291 | 11.8 | 5,220,559 | 0 | 5,220,559 | 0 |
| 116 | 83238 | 7634 | 75636357 | 87931000 | 82094774301 | 328469 | 7.7 | 21,139 | | 21,139 | 4,576,482 |
| 117 | 76478 | 7177 | 75636357 | 76478000 | 82094774301 | 328469 | 7.7 | 10,637,443 | | 10,637,443 | 3,960,677 |
| 118 | 44486 | 3499 | 43515873 | 44813000 | 24233826273 | 191481 | 7.5 | 430,906 | | 430,906 | 412,894 |
| 119 | 68642 | 5686 | 72978248 | 69895000 | 58140399748 | 323646 | 7.7 | 10,604,472 | | 10,604,472 | 17,245,883 |
| 120 | 45270 | 4071 | 39888523 | 46181000 | 30322787757 | 199116 | 8.8 | 5,411,330 | 4,576,482 | 5,411,330 | 19,937,793 |
| 121 | 18073 | 3709 | 16408423 | 20309000 | 5678582399 | 143553 | 12.6 | 35,457 | 3,960,677 | 35,457 | 3,328,051 |
| 122 | 18171 | 3894 | 16408423 | 18615000 | 5678582399 | 143553 | 12.6 | 1,259,041 | 412,894 | 1,259,041 | 1,246,700 |
| 123 | 41345 | 3835 | 39888523 | 41704000 | 30322787757 | 199116 | 8.8 | 5,912,292 | 17,245,883 | 5,912,292 | 10,668,083 |
| 124 | 43435 | 3714 | 16408423 | 44241000 | 5678582399 | 143553 | 12.6 | 13,543,440 | 19,937,793 | 13,543,440 | 1,701,539 |
| 125 | 63670 | 5090 | 67676788 | 64174000 | 63097071542 | 311676 | 8.1 | 19,992,182 | 3,328,051 | 19,992,182 | 14,801,568 |
| 126 | 52314 | 4340 | 58789721 | 52754000 | 48278194662 | 253305 | 7.5 | 10,801,531 | 1,246,700 | 10,801,531 | 22,015,111 |
| 127 | 26011 | 3189 | 72978248 | 69930000 | 58140399748 | 323646 | 7.7 | 8,260,660 | 10,668,083 | 8,260,660 | 11,575,901 |
| 128 | 20296 | 4266 | 16408423 | 20966000 | 5678582399 | 143553 | 12.6 | 2,591,973 | 1,701,539 | 2,591,973 | 11,820,151 |
| 129 | 27956 | 2828 | 16408423 | 31208000 | 5678582399 | 143553 | 12.6 | 2,807,798 | 14,801,568 | 2,807,798 | 8,838,263 |
| 130 | 77055 | 6363 | 16408423 | 31208000 | 5678582399 | 143553 | 12.6 | 7,780,488 | 22,015,111 | 7,780,488 | 13,883,874 |
| 131 | 29082 | 3095 | 16408423 | 32238000 | 5678582399 | 143553 | 12.6 | 7,156,057 | 11,575,901 | 7,156,057 | 19,126,279 |
| 132 | 45889 | 3593 | 43515873 | 46287000 | 24233826273 | 191481 | 7.5 | 855,689 | 11,820,151 | 855,689 | 2,513,694 |
| 133 | 23832 | 1935 | 37087411 | 40833000 | 26555672336 | 194602 | 9.1 | 11,291,908 | 8,838,263 | 11,291,908 | 8,035,659 |
| 134 | 38754 | 3929 | 69018665 | 71042000 | 63809667860 | 312506 | 8 | 3,407,930 | 13,883,874 | 3,407,930 | 427,002 |
| 135 | 41127 | 3303 | 16408423 | 41886000 | 5678582399 | 143553 | 12.6 | 2,919,121 | 19,126,279 | 2,919,121 | 2,509,472 |

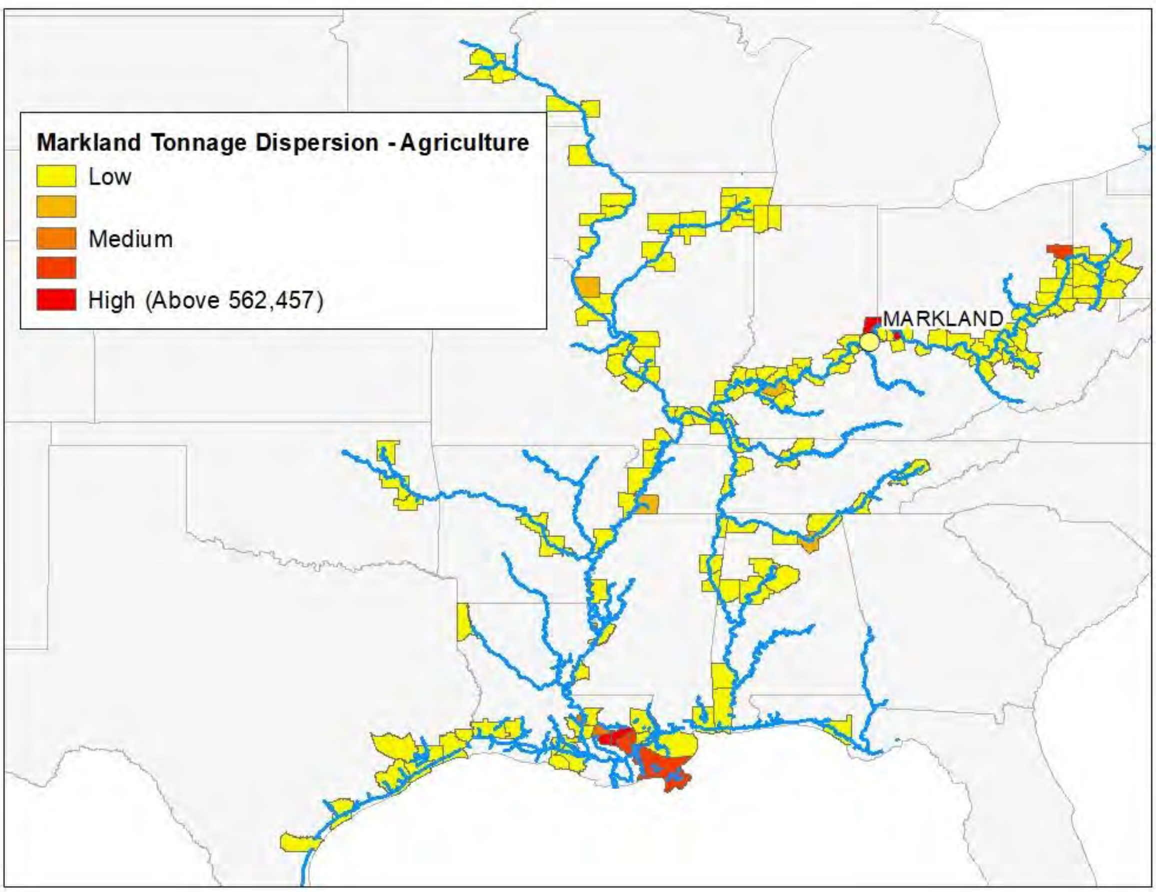
| No. | Ktons | Lockages | WCSC Tons | LPMS Tons | WCSC Ton-Miles | System Lockages | System Lockages per Barge | Above Pool Tonnage | Below Pool Tonnage | Pool Above Total | Pool Below Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 136 | 4 | 4021 | 1500 | 4000 | 216000 | 15 | 5 | 0 | 2,513,694 | 0 | 0 |
| 137 | 7321 | 3142 | | | | | | 0 | 8,035,659 | 0 | 0 |
| 138 | 544 | 474 | 502728 | 544000 | 171767632 | 896 | 4.1 | 0 | 427,002 | 0 | 12,007 |
| 139 | 67 | 251 | 60575 | 67000 | 38275490 | 400 | 9.3 | 0 | 2,509,472 | 0 | 341,295 |
| 140 | 6 | 126 | | 6000 | | | | 0 | 0 | 0 | 0 |
| 141 | 840 | 976 | 642970 | 840000 | 504037223 | 2004 | 5.8 | 0 | 0 | 0 | 3,231,362 |
| 142 | 695 | 1371 | 621380 | 695000 | 486575383 | 1920 | 5.7 | 0 | 12,007 | 0 | 0 |
| 143 | 3813 | 1313 | 4260574 | 3813000 | 2643987727 | 10387 | 4.1 | 0 | 341,295 | 0 | 6,125 |
| 144 | 3813 | 1569 | 3178822 | 3813000 | 2311689559 | 8738 | 4.5 | 0 | 0 | 0 | 0 |
| 145 | 3 | 3237 | 1500 | 3000 | 216000 | 15 | 5 | 0 | 0 | 0 | 0 |
| 146 | 6 | 3789 | 1500 | 6000 | 216000 | 15 | 5 | 0 | 6,125 | 0 | 0 |
| 147 | 831 | 2756 | 798482 | 831000 | 945065460 | 5363 | 11.1 | 0 | 0 | 0 | 2,983,967 |
| 148 | 459 | 1262 | 420489 | 459000 | 463077263 | 2486 | 10.5 | 1,320 | 3,231,362 | 1,320 | 133,025 |
| 149 | 8701 | 2183 | 8385549 | 9077000 | 8252933380 | 56484 | 12 | 596,107 | 0 | 596,107 | 300 |
| 150 | 4665 | 1362 | 3708313 | 4665000 | 3414826894 | 25760 | 11.2 | 14,807 | 0 | 14,807 | 6,685,001 |
| 151 | 29324 | 4748 | 22125836 | 29324000 | 14144444162 | 101665 | 7.9 | 1,624,541 | 0 | 1,624,541 | 12,008,713 |
| 152 | 2586 | 1242 | 2052613 | 2586000 | 2146049233 | 13672 | 10.8 | 1,449,158 | 2,983,967 | 1,449,158 | 2,049,281 |
| 153 | 12874 | 2346 | 12848401 | 13072000 | 10685848234 | 84840 | 11 | 8,055 | 133,025 | 8,055 | 4,783,509 |
| 154 | 623 | 1587 | 568212 | 623000 | 629658037 | 3606 | 10.9 | 3,180 | 300 | 3,180 | 1,400 |
| 155 | 9099 | 2559 | 8381699 | 9099000 | 8252393630 | 56432 | 12 | 300 | 6,685,001 | 300 | 2,926,413 |
| 156 | 5079 | 1708 | 5675570 | 5079000 | 3772566019 | 43572 | 15.1 | 553,196 | 12,008,713 | 553,196 | 371,869 |
| 157 | 5254 | 1796 | 5997641 | 5254000 | 4077779332 | 48525 | 15.6 | 0 | 2,049,281 | 0 | 177,345 |
| 158 | 5268 | 1814 | 5979703 | 5268000 | 4071088236 | 48431 | 15.6 | 0 | 4,783,509 | 0 | 0 |
| 159 | 5263 | 1806 | 5981203 | 5263000 | 4071302736 | 48436 | 15.6 | 310,760 | 1,400 | 310,760 | 0 |
| 160 | 5267 | 1810 | 5997641 | 5267000 | 4077779332 | 48525 | 15.6 | 0 | 2,926,413 | 0 | 0 |
| 161 | 6207 | 1850 | 6194409 | 6207000 | 3649069287 | 42483 | 13.6 | 52,854 | 371,869 | 52,854 | 574,200 |
| 162 | 5555 | 2042 | 6298947 | 5555000 | 4216896329 | 50152 | 15.2 | 214,211 | 177,345 | 214,211 | 3,000 |
| 163 | 5646 | 2080 | 5764165 | 5646000 | 3531862818 | 41801 | 14.4 | 81,486 | 0 | 81,486 | 102,900 |
| 164 | 5279 | 1813 | 5981203 | 5279000 | 4071302736 | 48436 | 15.6 | 0 | 0 | 0 | 0 |
| 165 | 5978 | 1917 | 6194409 | 5978000 | 3649069287 | 42483 | 13.6 | 25,800 | 0 | 25,800 | 178,800 |
| 166 | 10121 | 2286 | 9560008 | 10121000 | 4721385987 | 45708 | 8.3 | 129,769 | 574,200 | 129,769 | 4,446,210 |
| 167 | 10036 | 2318 | 9567952 | 10036000 | 4783812010 | 46208 | 8.5 | 5,662,515 | 3,000 | 5,662,515 | 104,889 |

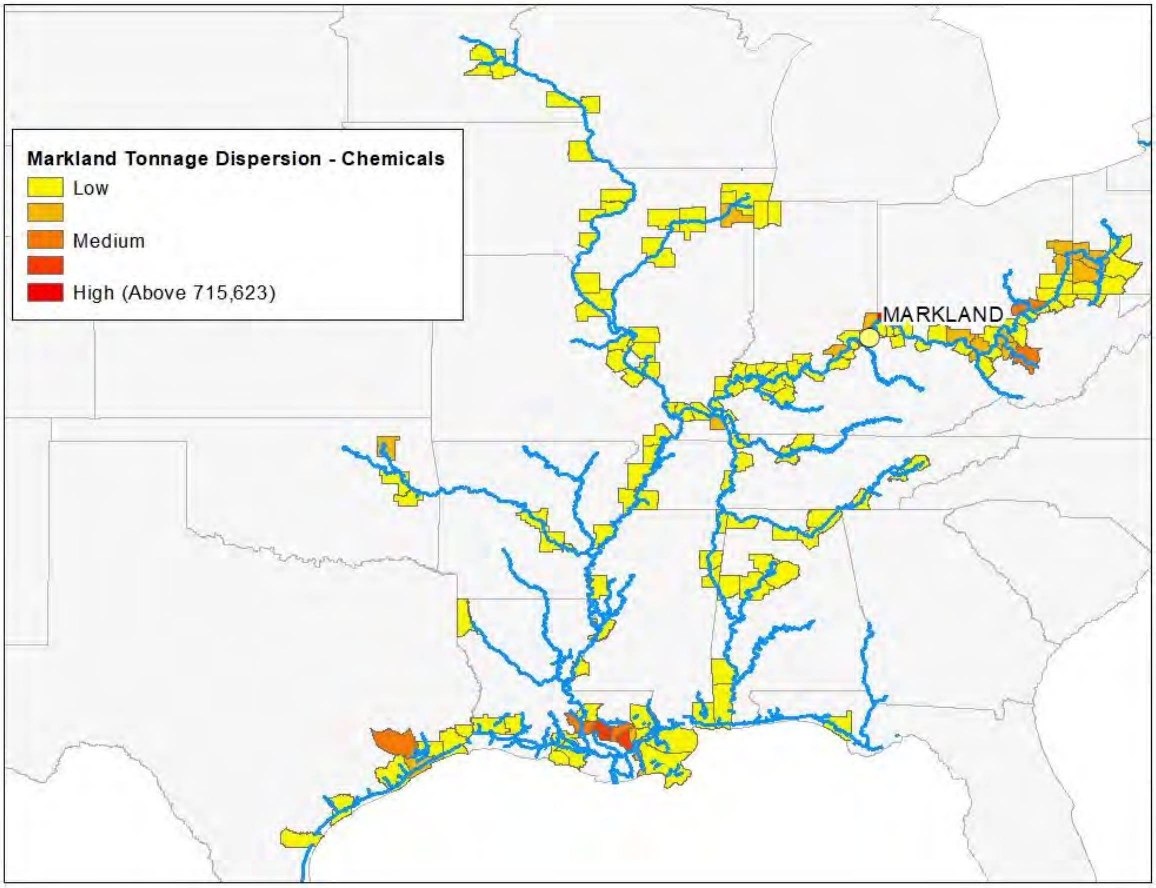
# Appendix Three

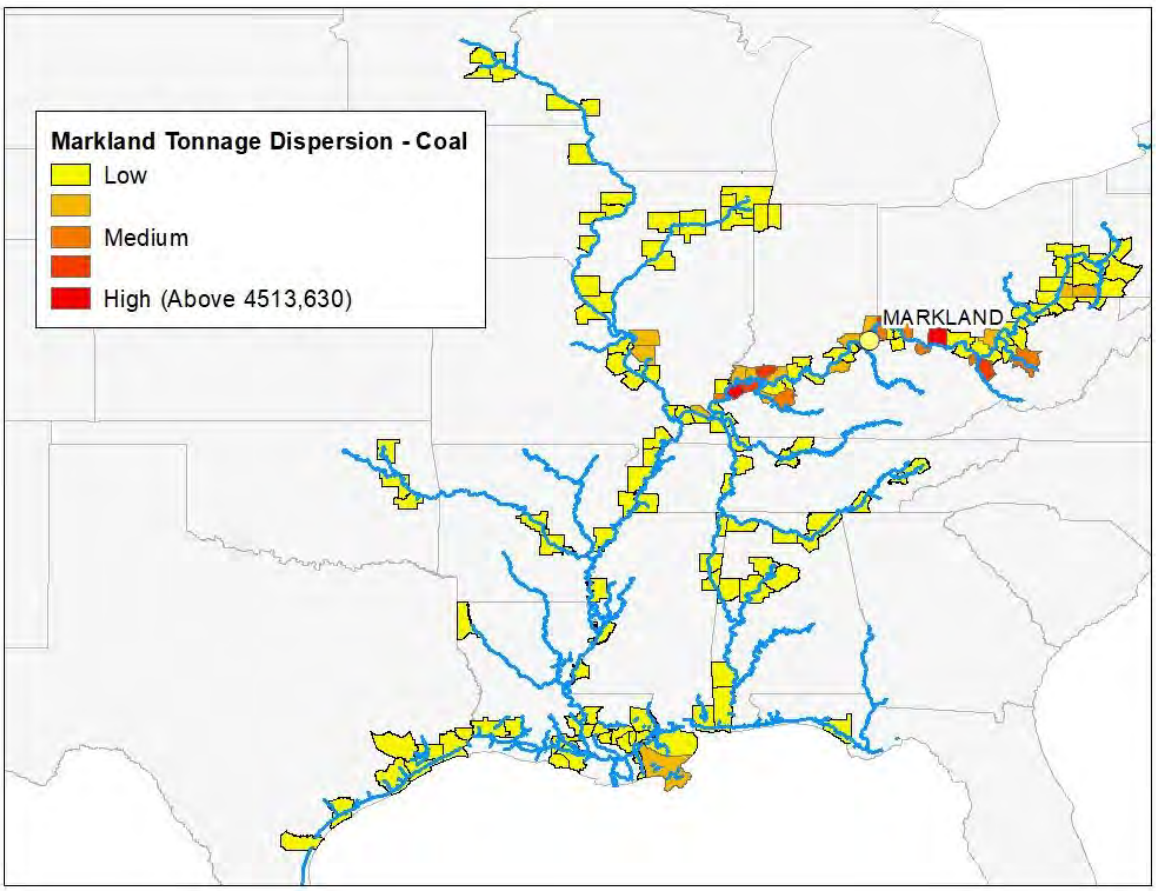
## Commodity-Specific Lock Traffic

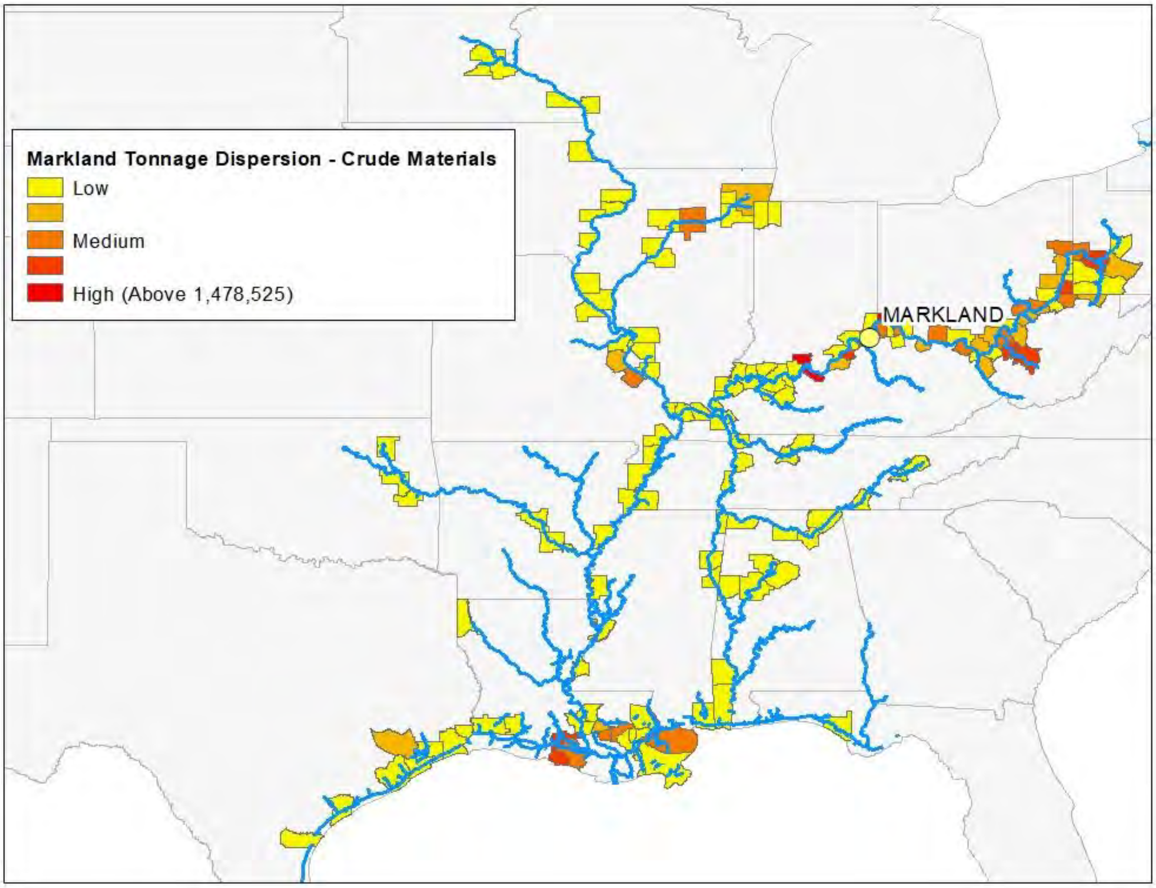
# Markland Locks & Dam

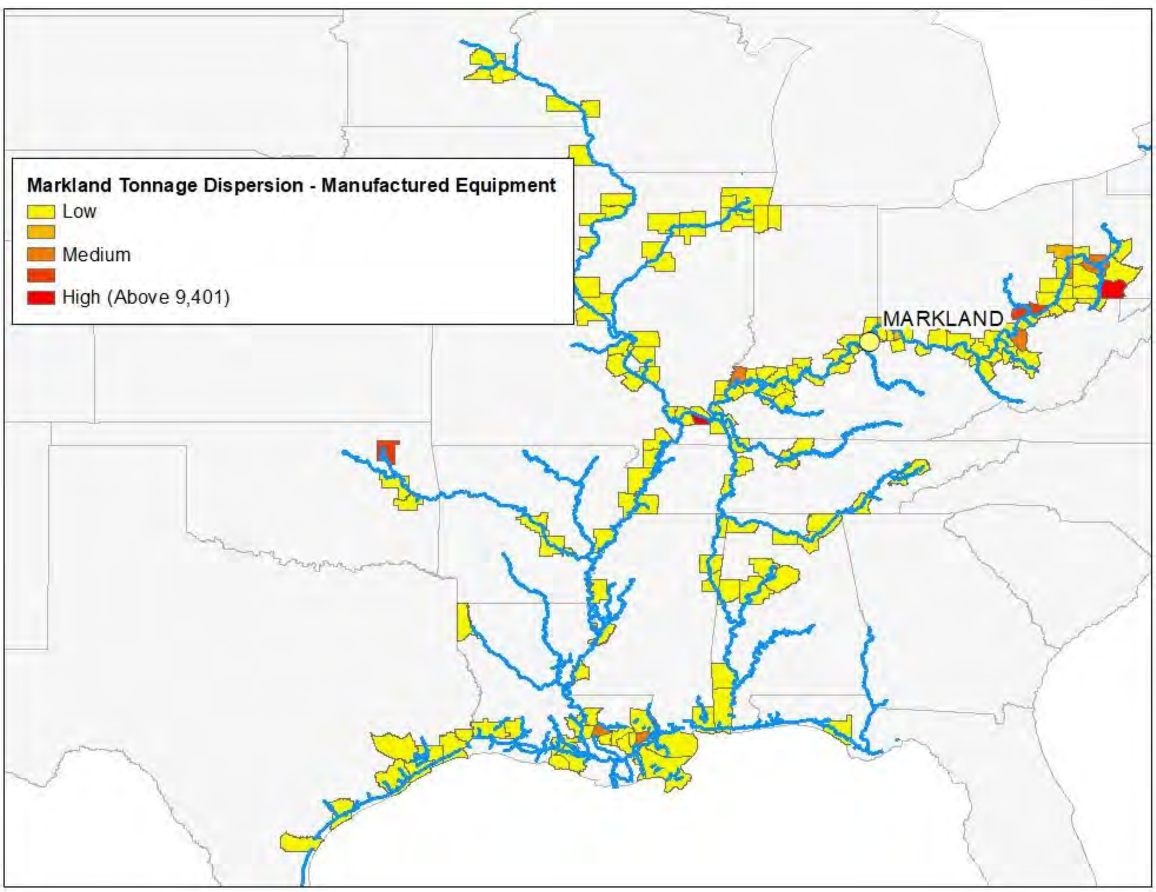
| | LPMS . Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| **Coal** | 10 | 30,788,869 | 1,675 | 473 | $7.21 | $221,987,745 |
| **Petroleum Products** | 20 | 7,440,371 | 2,598 | 967 | $49.49 | $368,253,302 |
| **Chemicals** | 30 | 3,898,264 | 1,693 | 1,412 | $70.91 | $276,416,124 |
| **Crude Materials** | 40 | 14,339,508 | 1,673 | 757 | $16.93 | $242,729,791 |
| **Primary Manufactured Goods** | 50 | 4,896,902 | 1,658 | 1,294 | $32.75 | $160,394,481 |
| **Farm Products and Food** | 60 | 4,089,324 | 1,826 | 1,342 | $9.41 | $38,460,711 |
| **Equipment** | 70 | 55,525 | 1,586 | 1,216 | $32.75 | $1,818,681 |
| **TOTAL** | | **65,508,763** | | | | **$1,310,060,835** |

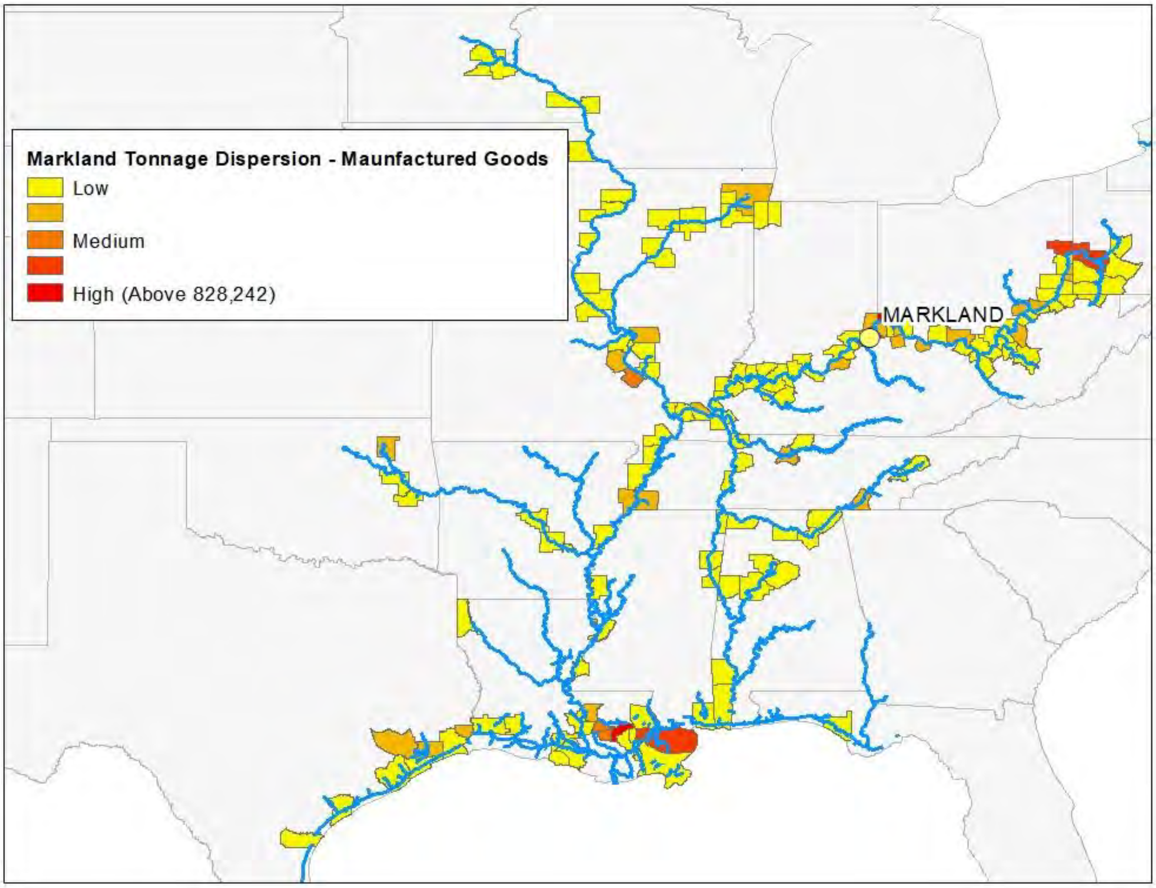


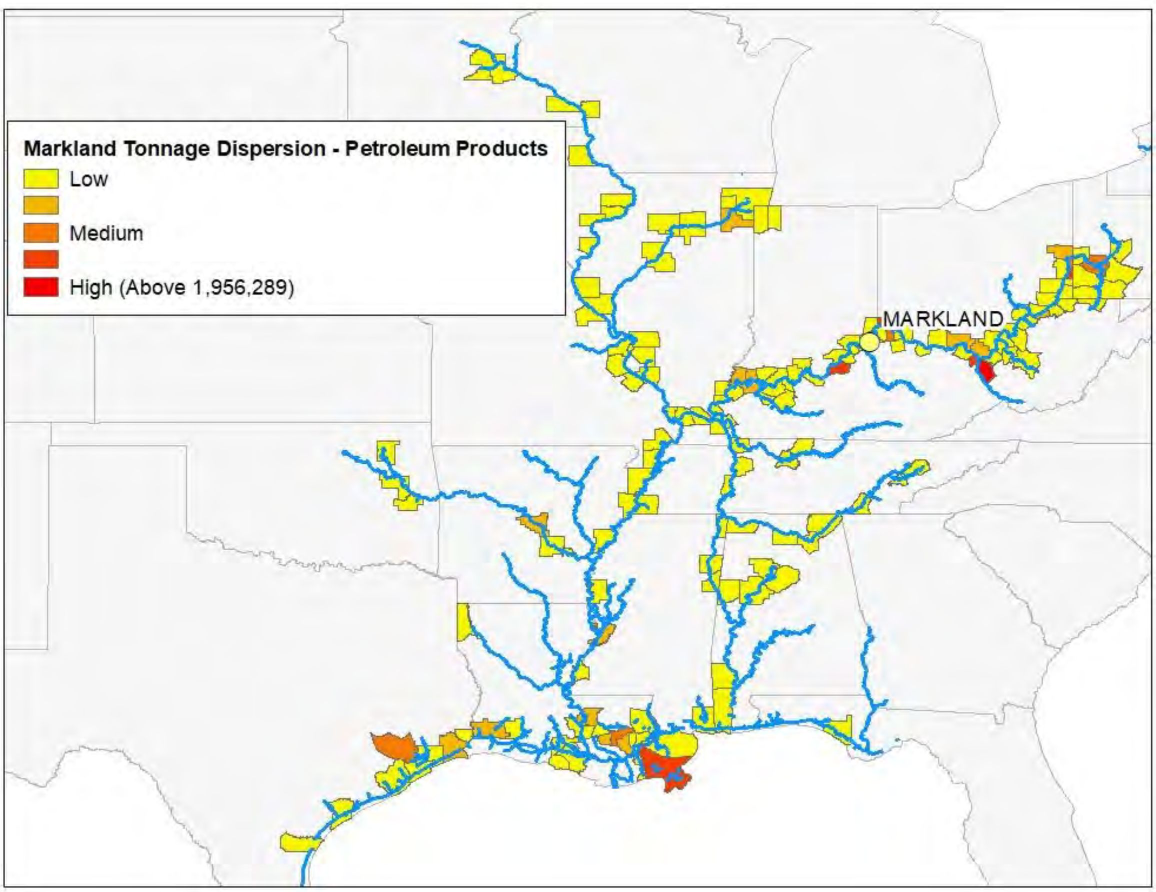

Markland Tonnage Dispersion - Chemicals
Low
Medium
High (Above 715,623)
MARKLAND


Markland Tonnage Dispersion - Coal
Low
Medium
High (Above 4513,630)
MARKLAND


Markland Tonnage Dispersion - Crude Materials
Low
Medium
High (Above 1,478,525)
MARKLAND

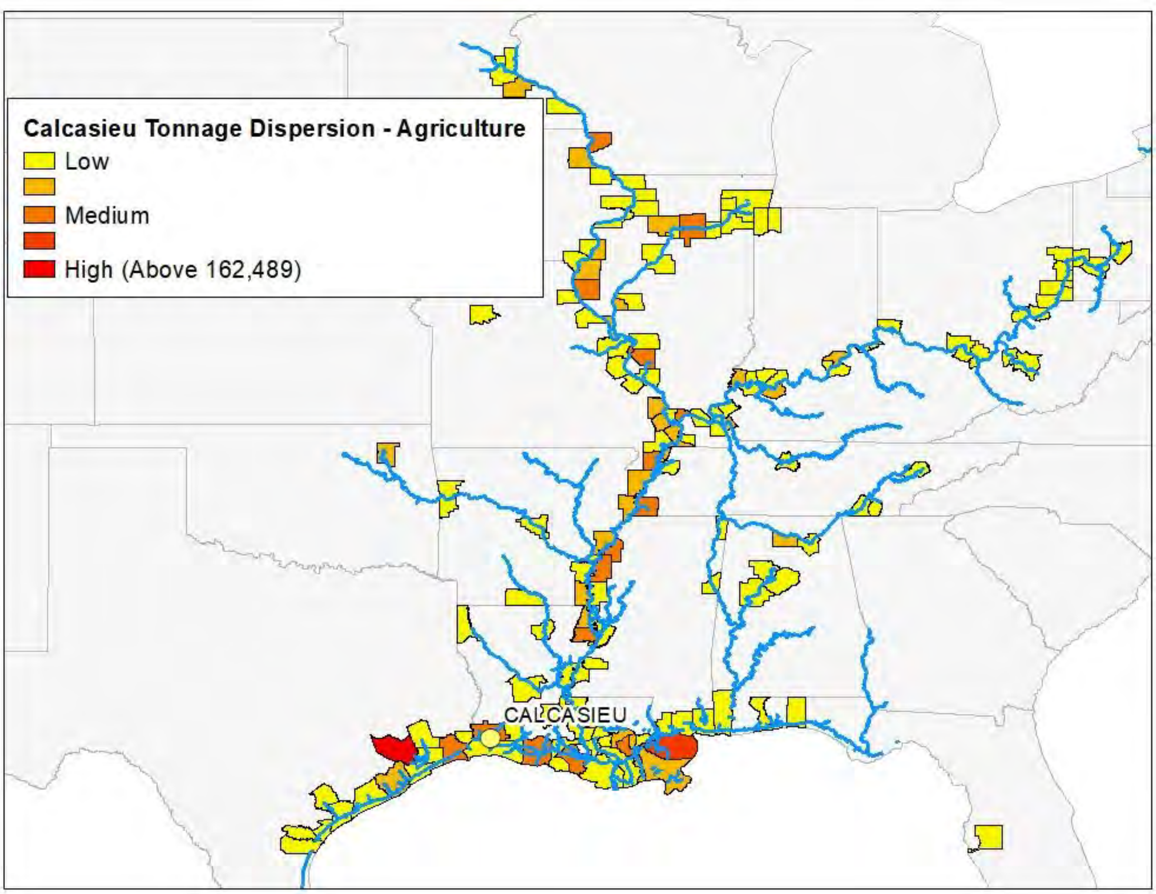

Markland Tonnage Dispersion - Manufactured Equipment
Low
Medium
High (Above 9,401)
MARKLAND

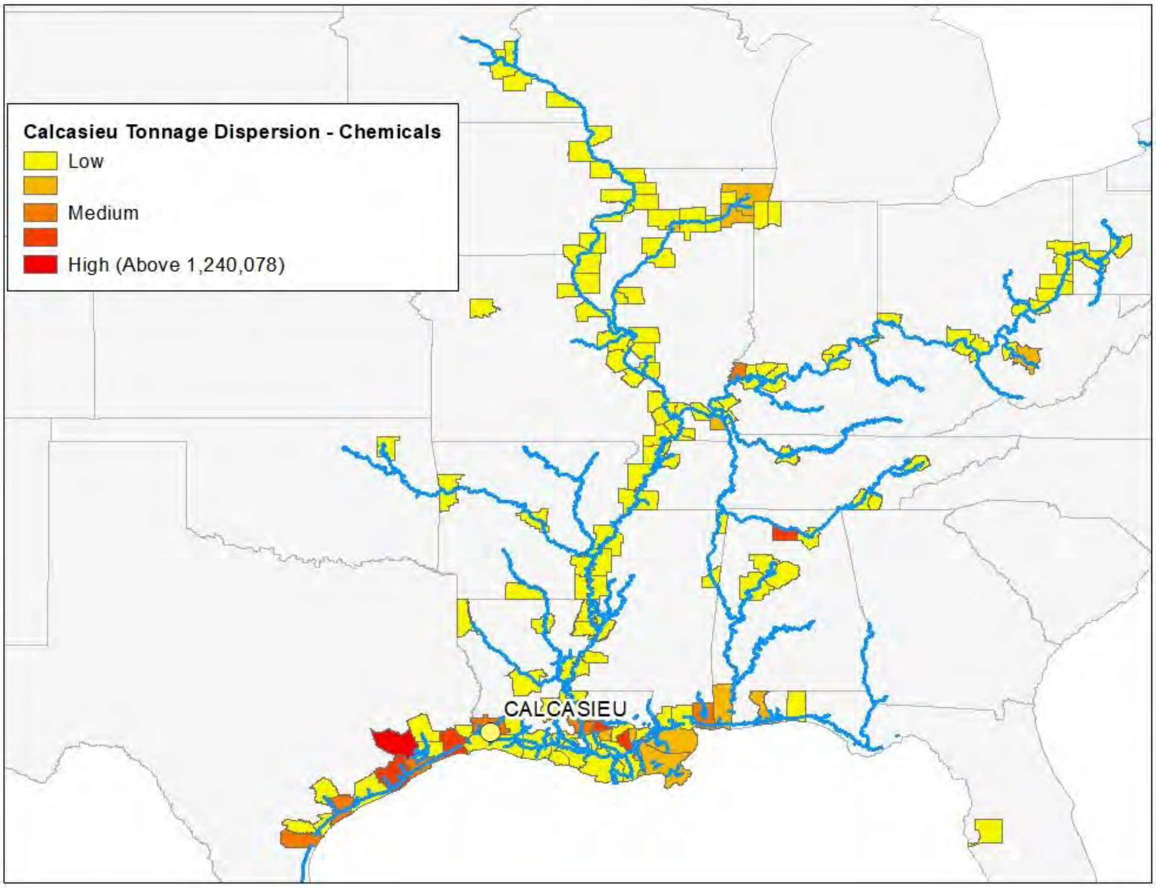

Markland Tonnage Dispersion - Maunfactured Goods
Low
Medium
High (Above 828,242)
MARKLAND

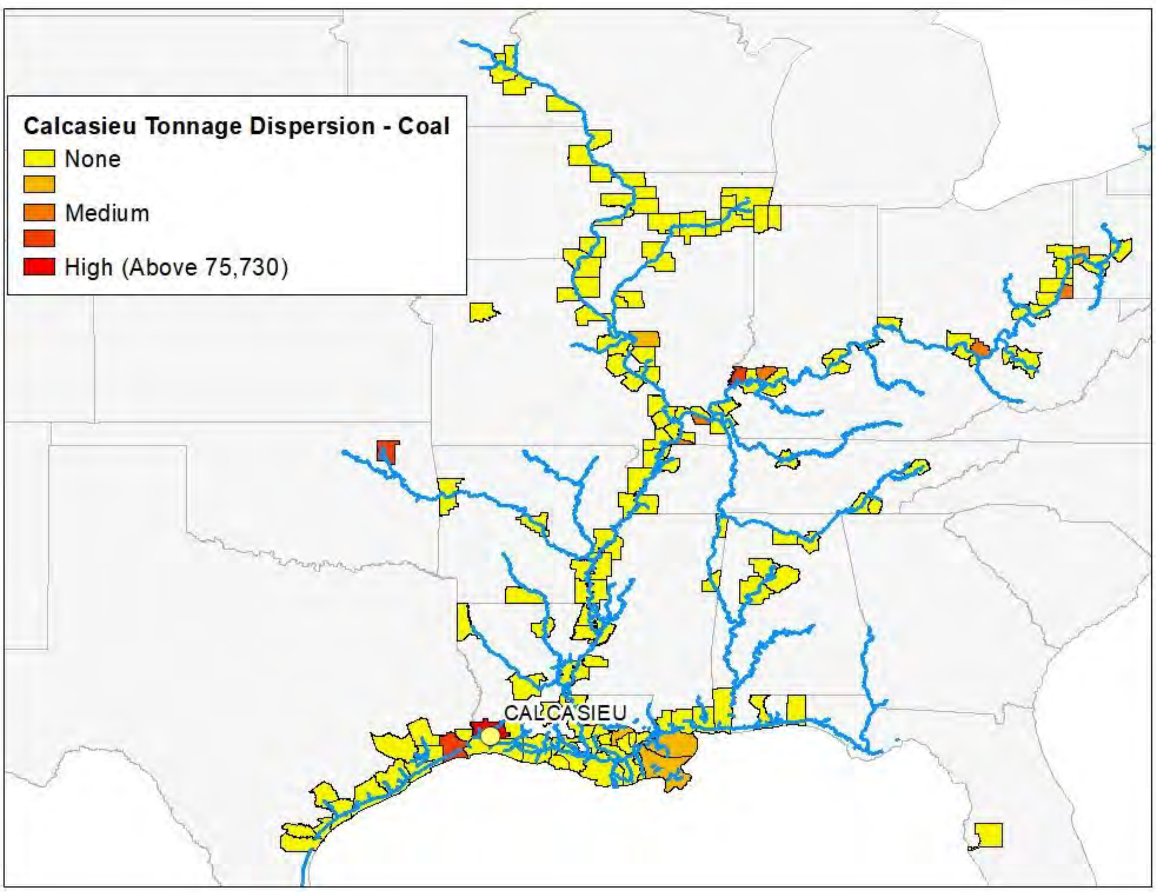

Markland Tonnage Dispersion - Petroleum Products
Low
Medium
High (Above 1,956,289)
MARKLAND

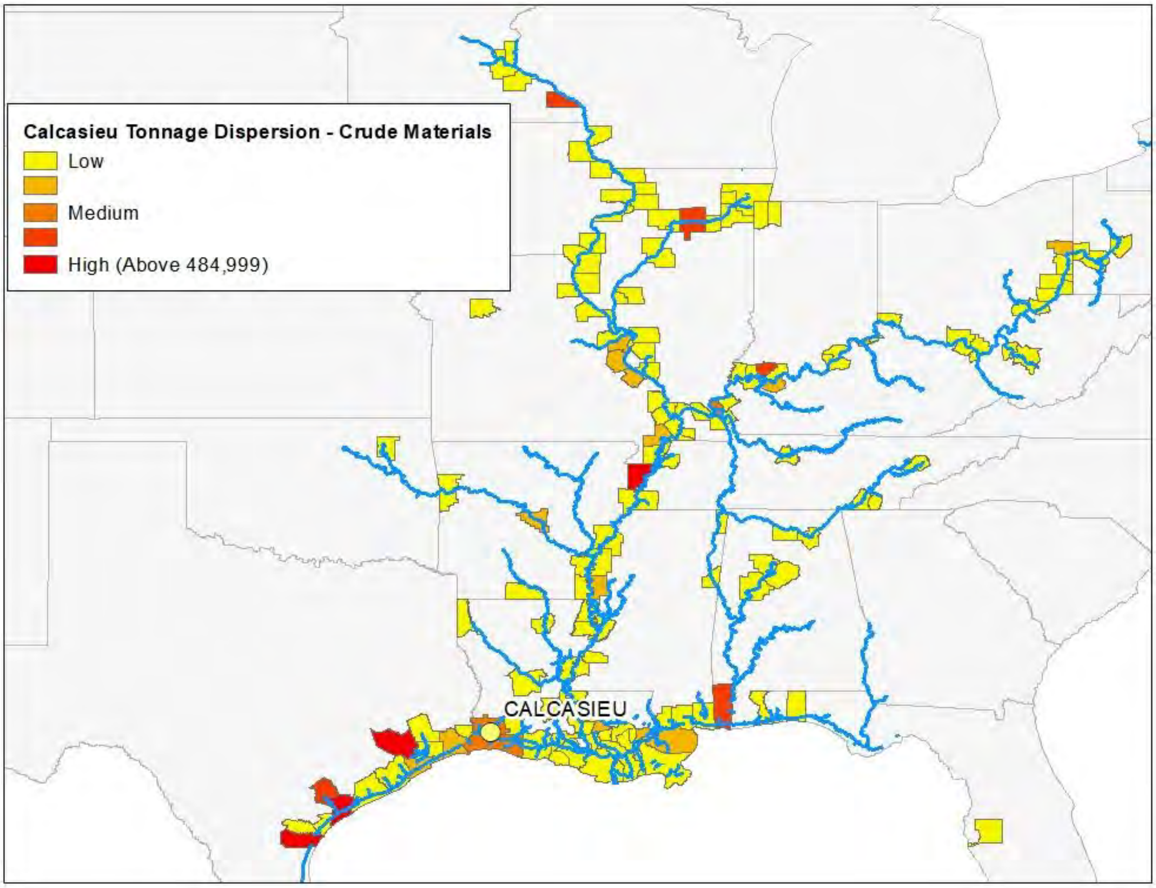
# Calcasieu Lock

| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| **Coal** | 10 | 245,836 | 1,617 | 1,268 | $26.97 | $6,629,552 |
| **Petroleum Products** | 20 | 24,988,887 | 2,859 | 542 | $21.70 | $542,287,348 |
| **Chemicals** | 30 | 9,078,337 | 2,022 | 846 | $25.44 | $230,953,087 |
| **Crude Materials** | 40 | 3,937,379 | 1,578 | 1,230 | $45.66 | $179,789,257 |
| **Primary Manufactured Goods** | 50 | 2,744,157 | 1,568 | 1,114 | $43.73 | $120,009,771 |
| **Farm Products and Food** | 60 | 843,753 | 1,769 | 1,021 | $26.97 | $22,753,806 |
| **Equipment** | 70 | 9,222 | 307 | 524 | $26.97 | $248,693 |
| **Scrap and Waste** | 80 | 626,896 | 1,537 | 259 | $26.97 | $16,905,741 |
| **TOTAL** | | **42,474,467** | | | | **$1,119,577,255** |

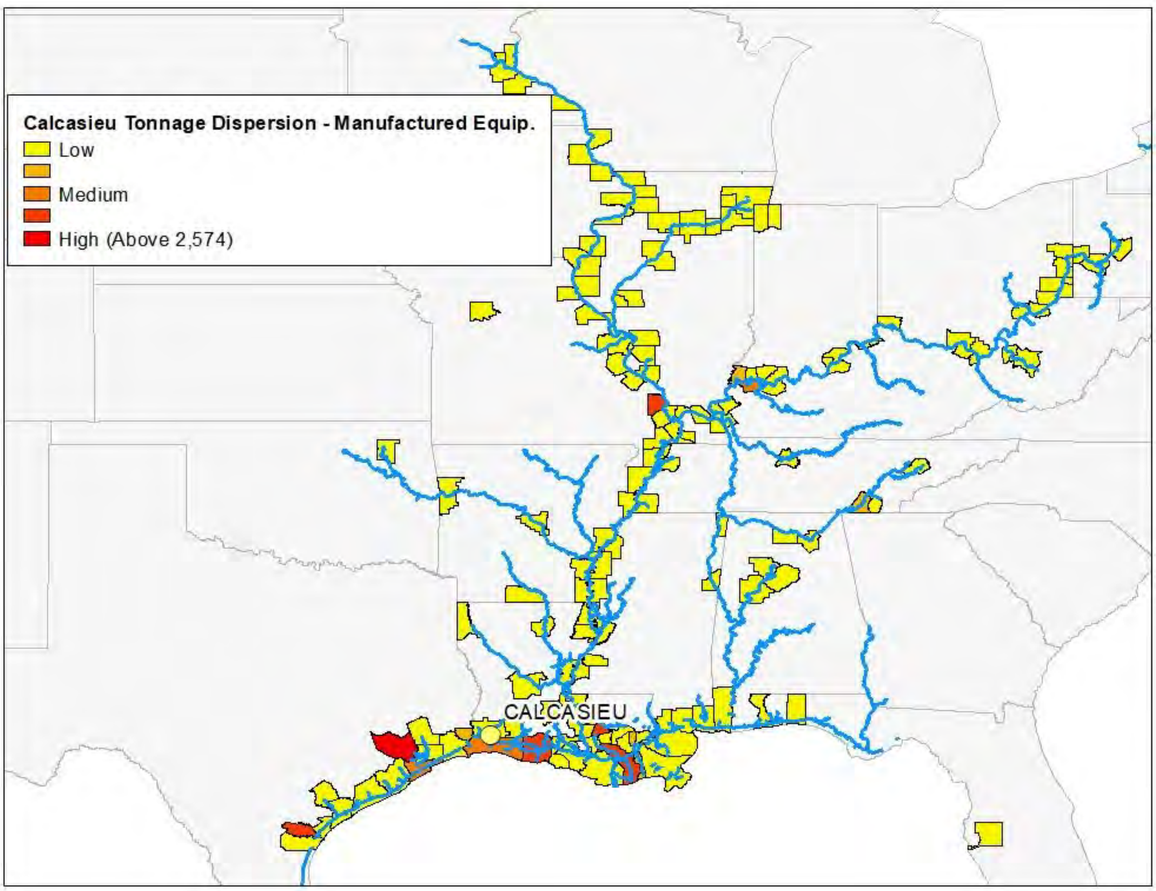



Calcasieu Tonnage Dispersion - Chemicals
Low
Medium
High (Above 1,240,078)
CALCASIEU

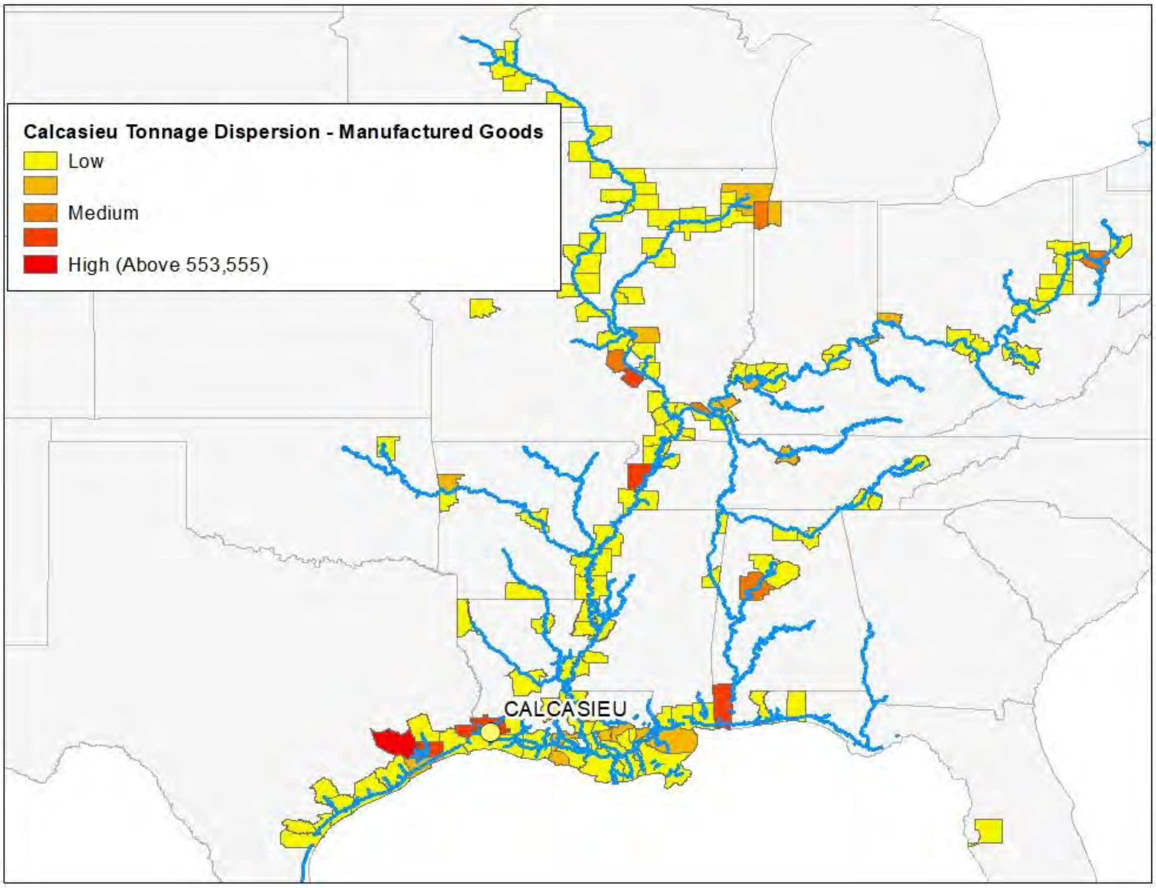

Calcasieu Tonnage Dispersion - Coal
None
Medium
High (Above 75,730)
CALCASIEU

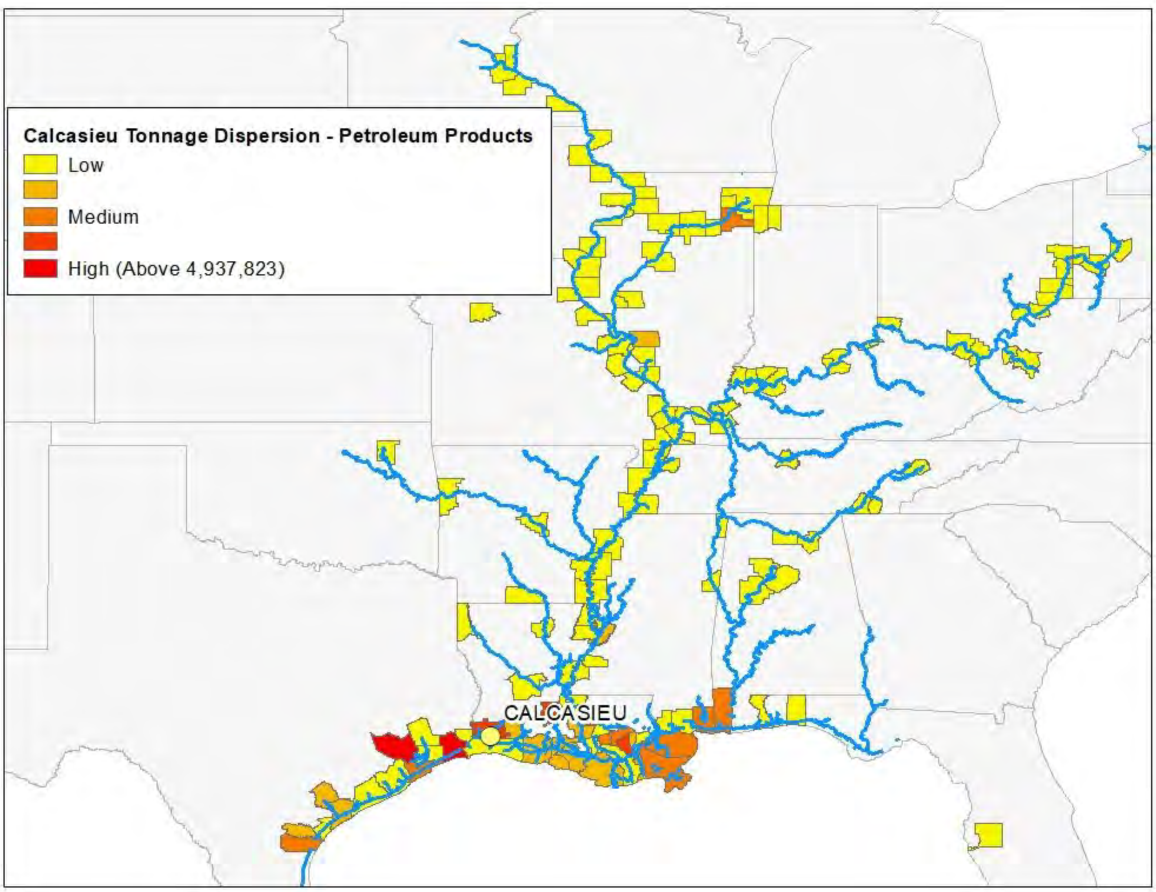


Calcasieu Tonnage Dispersion - Crude Materials
Low
Medium
High (Above 484,999)
CALCASIEU

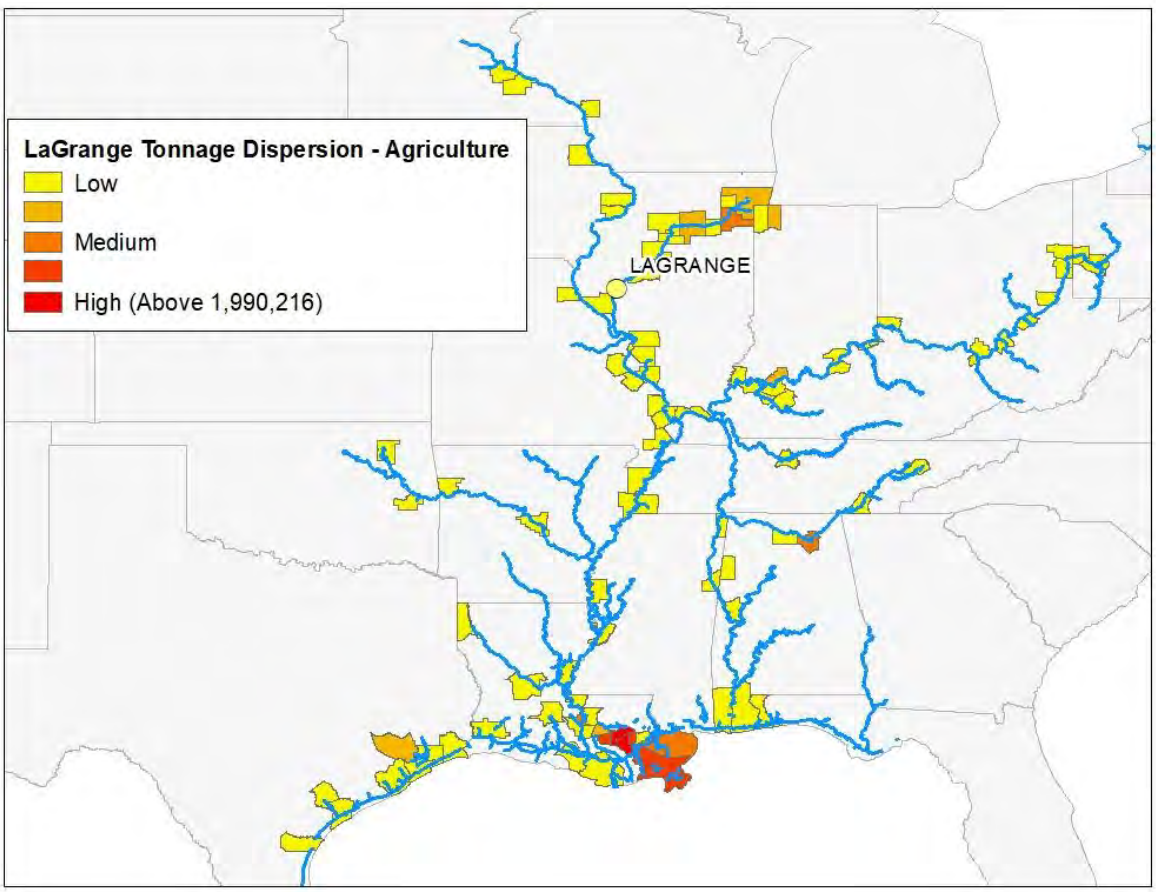
Calcasieu Tonnage Dispersion - Manufactured Equip.
Low
Medium
High (Above 2,574)
CALCASIEU

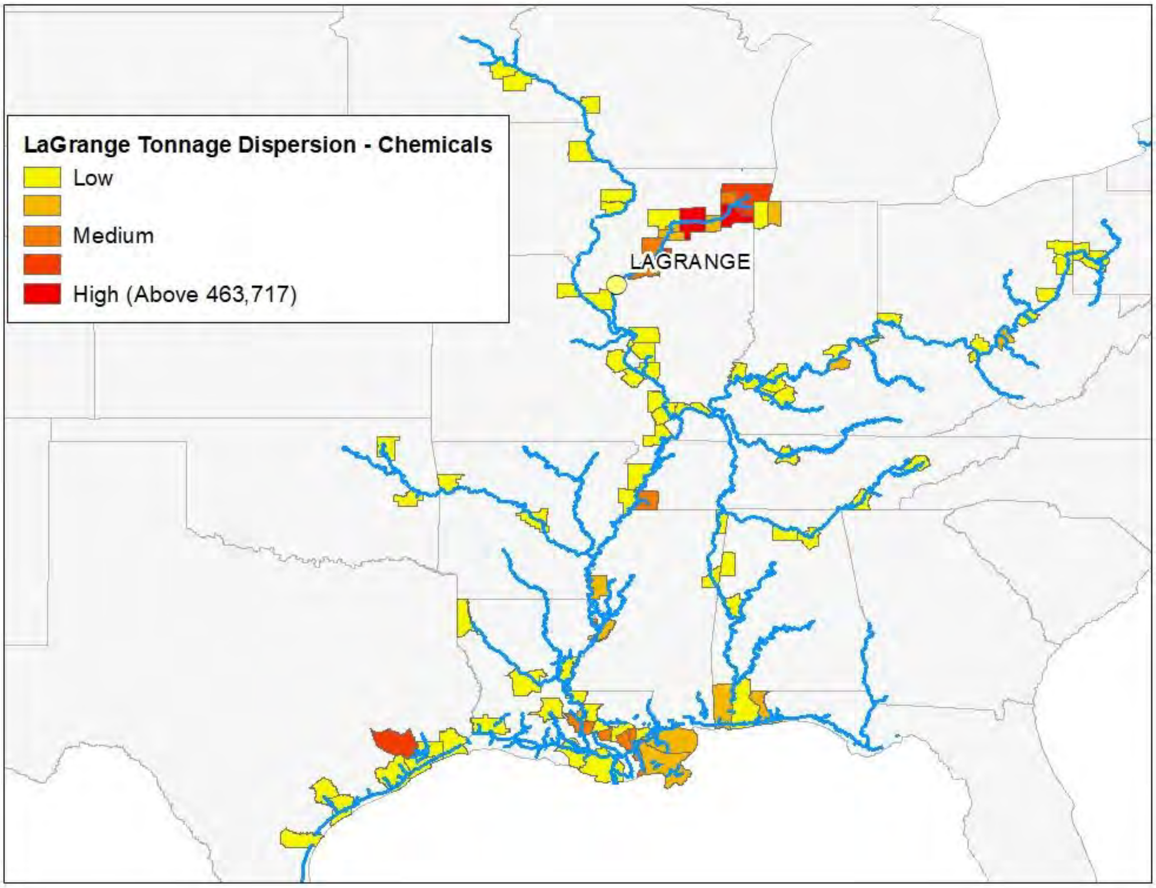

Calcasieu Tonnage Dispersion - Manufactured Goods
Low
Medium
High (Above 553,555)
CALCASIEU


Calcasieu Tonnage Dispersion - Petroleum Products
Low
Medium
High (Above 4,937,823)
CALCASIEU

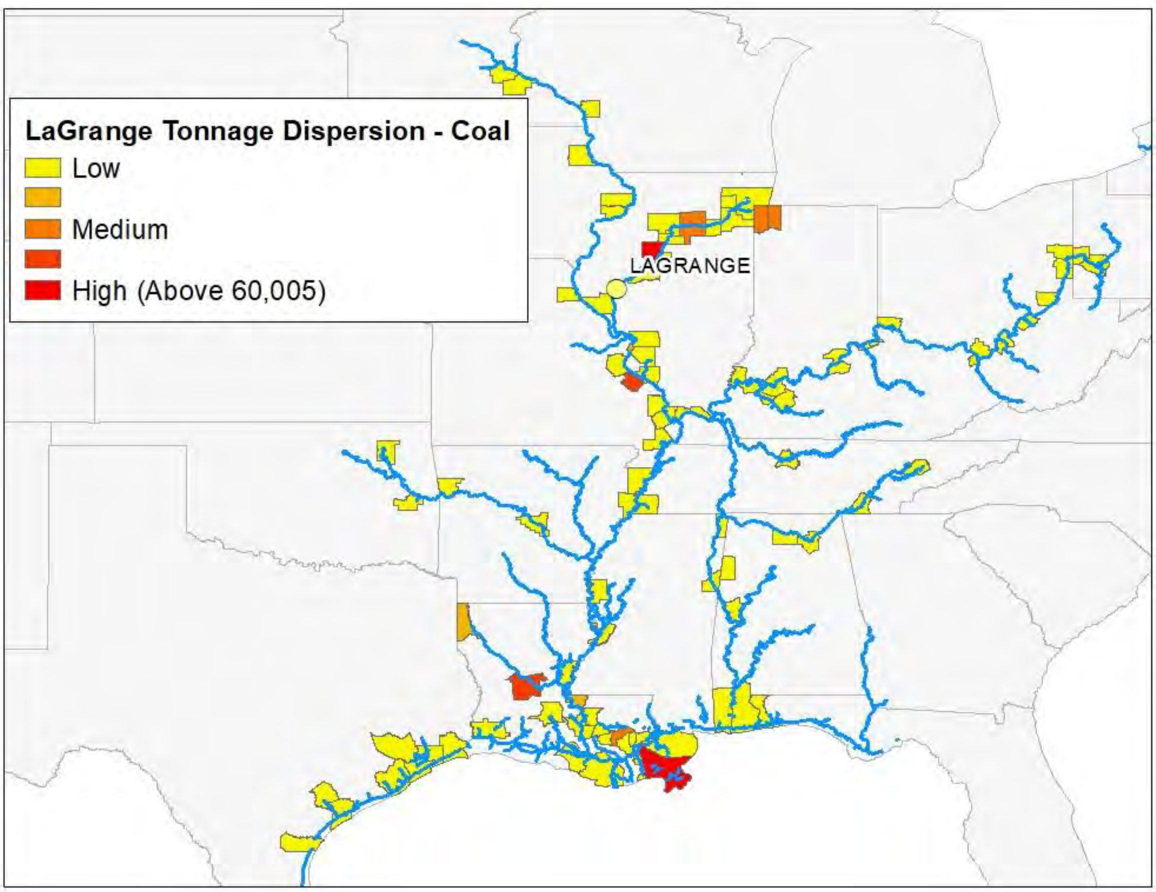
# LaGrange Lock & Dam

| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| **Coal** | 10 | 443,288 | 1,566 | 942 | $45.77 | $20,291,015 |
| **Petroleum Products** | 20 | 5,623,494 | 2,210 | 1,202 | $32.53 | $182,914,135 |
| **Chemicals** | 30 | 4,888,770 | 1,739 | 1,230 | $51.45 | $251,529,491 |
| **Crude Materials** | 40 | 3,401,419 | 1,552 | 1,270 | $61.22 | $208,236,345 |
| **Primary Manufactured Goods** | 50 | 3,344,289 | 1,513 | 1,056 | $30.96 | $103,524,351 |
| **Farm Products and Food** | 60 | 11,460,988 | 1,588 | 1,226 | $81.38 | $932,684,606 |
| **Equipment** | 70 | 5,632 | 704 | 1,416 | $84.87 | $477,986 |
| **TOTAL** | | **29,167,880** | | | | **$1,699,657,928** |

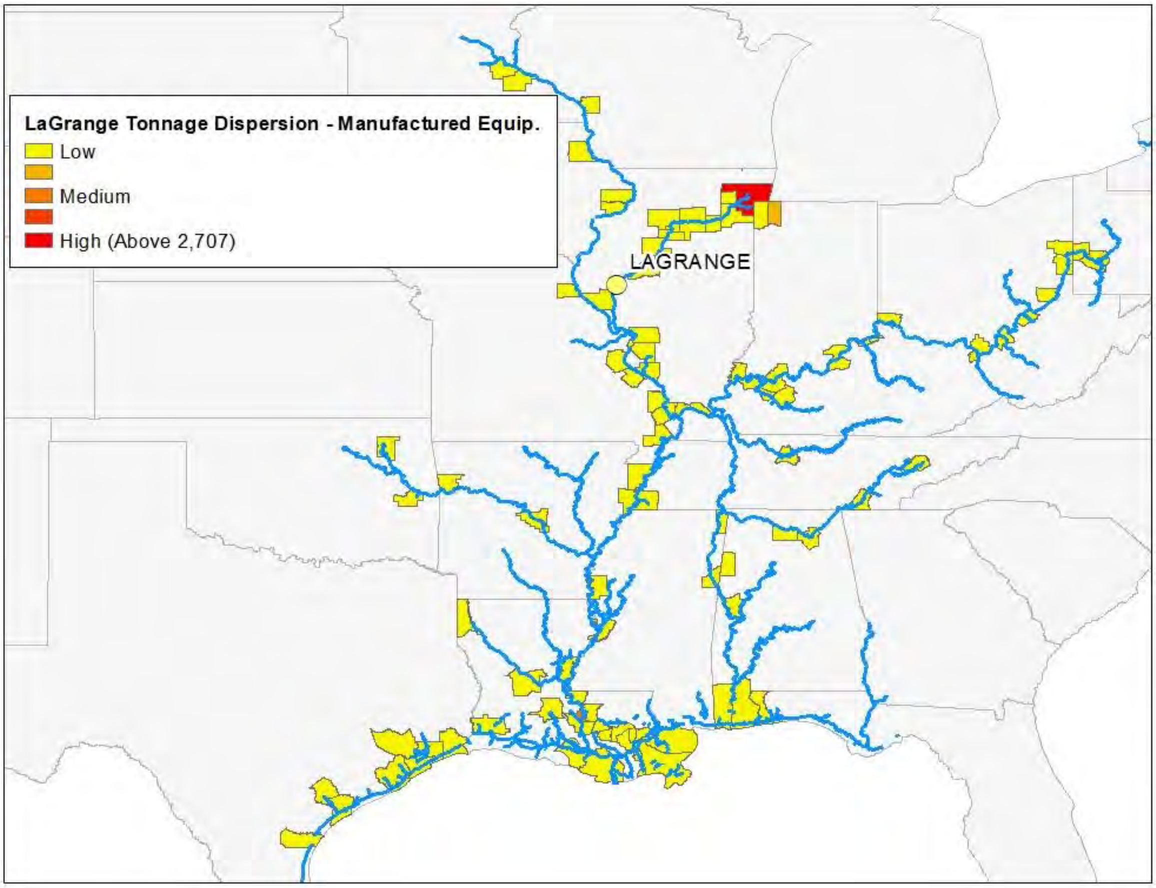




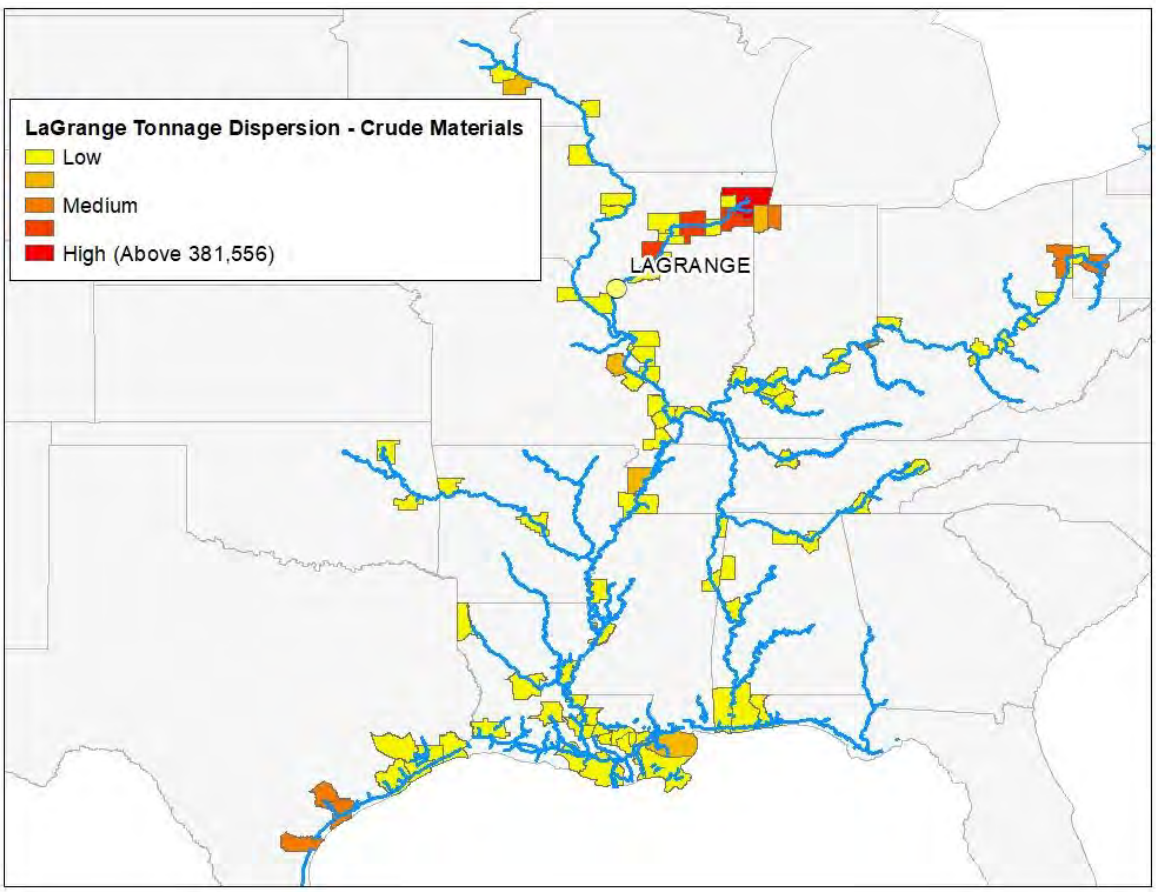
LaGrange Tonnage Dispersion - Chemicals
Low
Medium
High (Above 463,717)
LAGRANGE

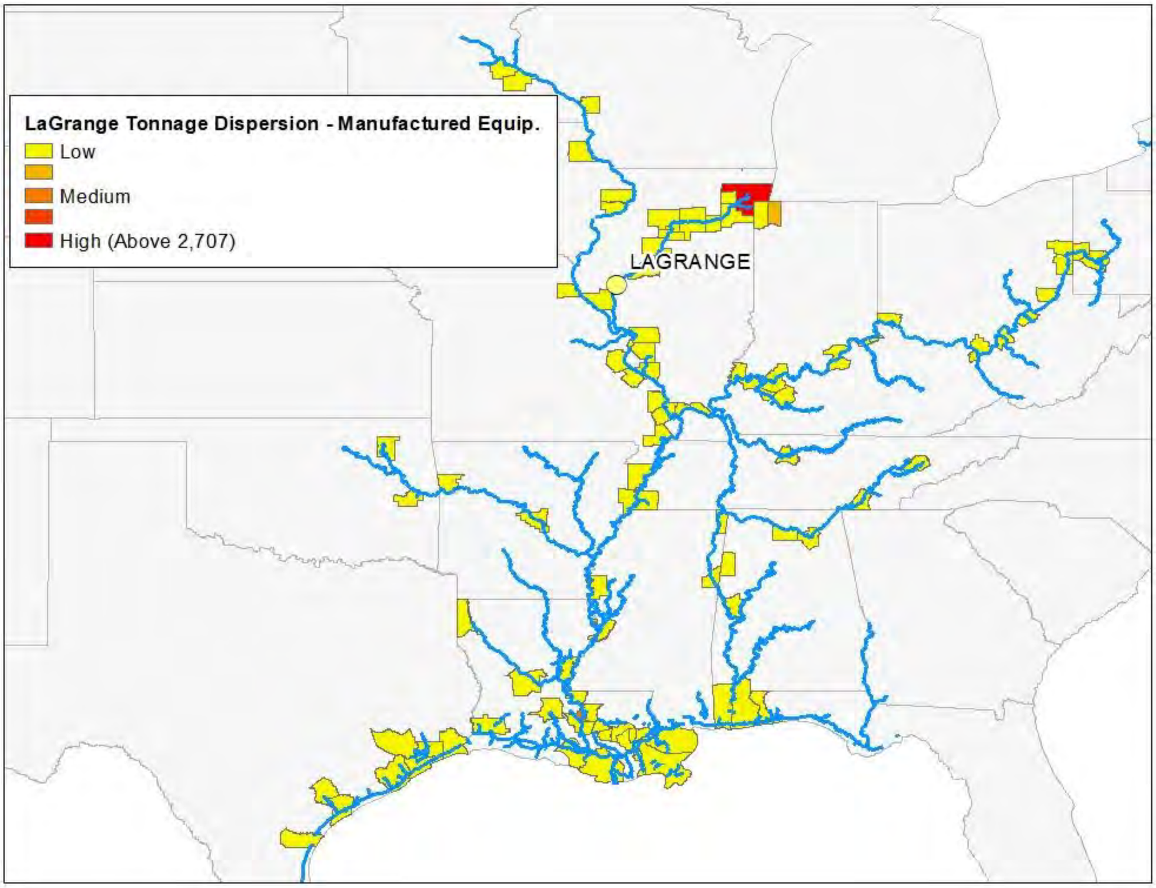
LaGrange Tonnage Dispersion - Coal
Low
Medium
High (Above 60,005)
LAGRANGE



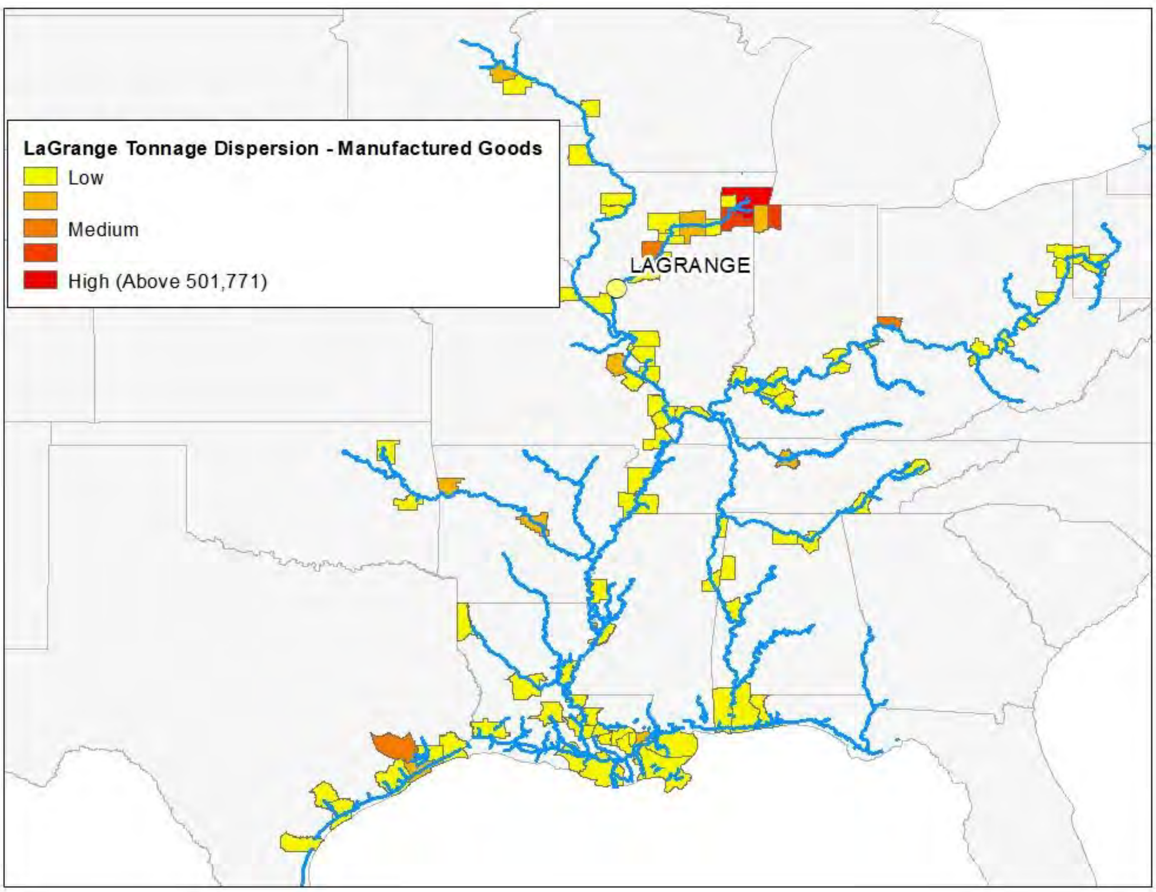
LaGrange Tonnage Dispersion - Manufactured Equip.
Low
Medium
High (Above 2,707)
LAGRANGE

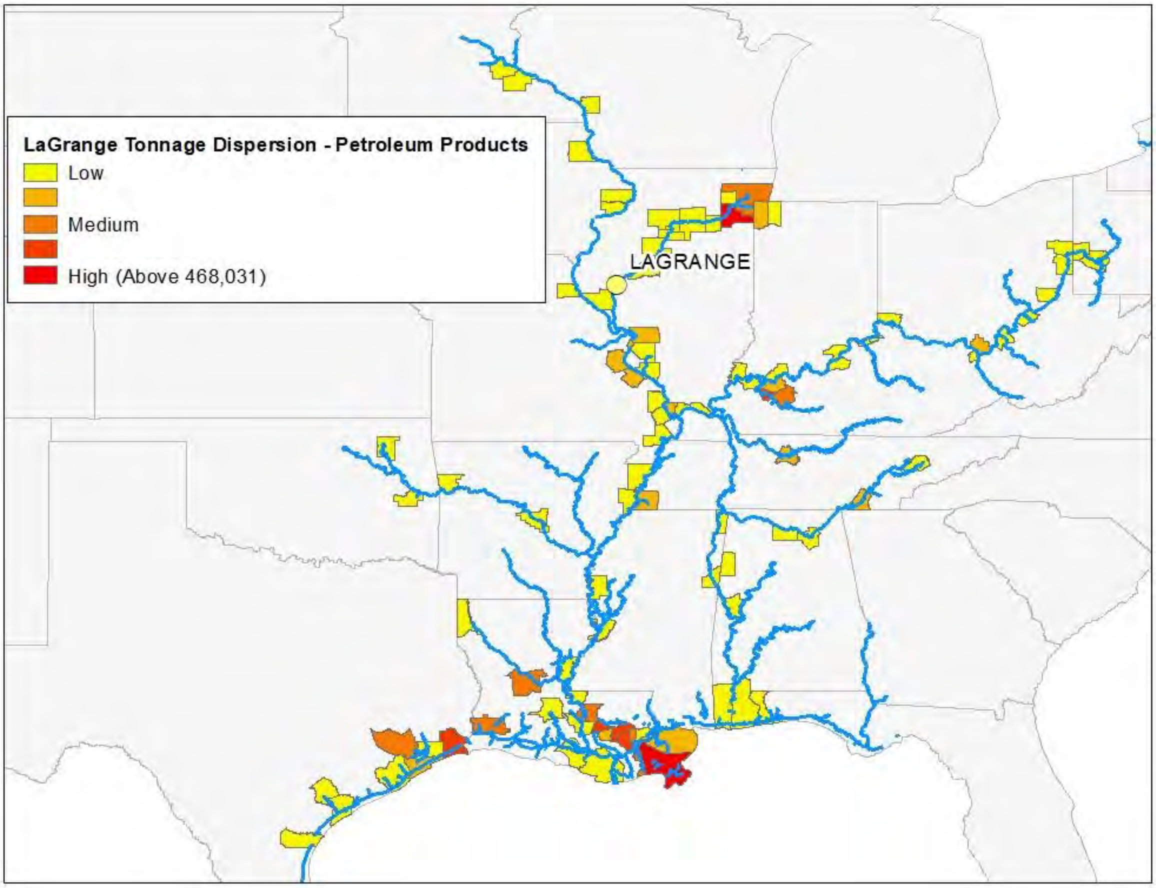
LaGrange Tonnage Dispersion - Crude Materials
Low
Medium
High (Above 381,556)
LAGRANGE



LaGrange Tonnage Dispersion - Manufactured Equip.
Low
Medium
High (Above 2,707)
LAGRANGE

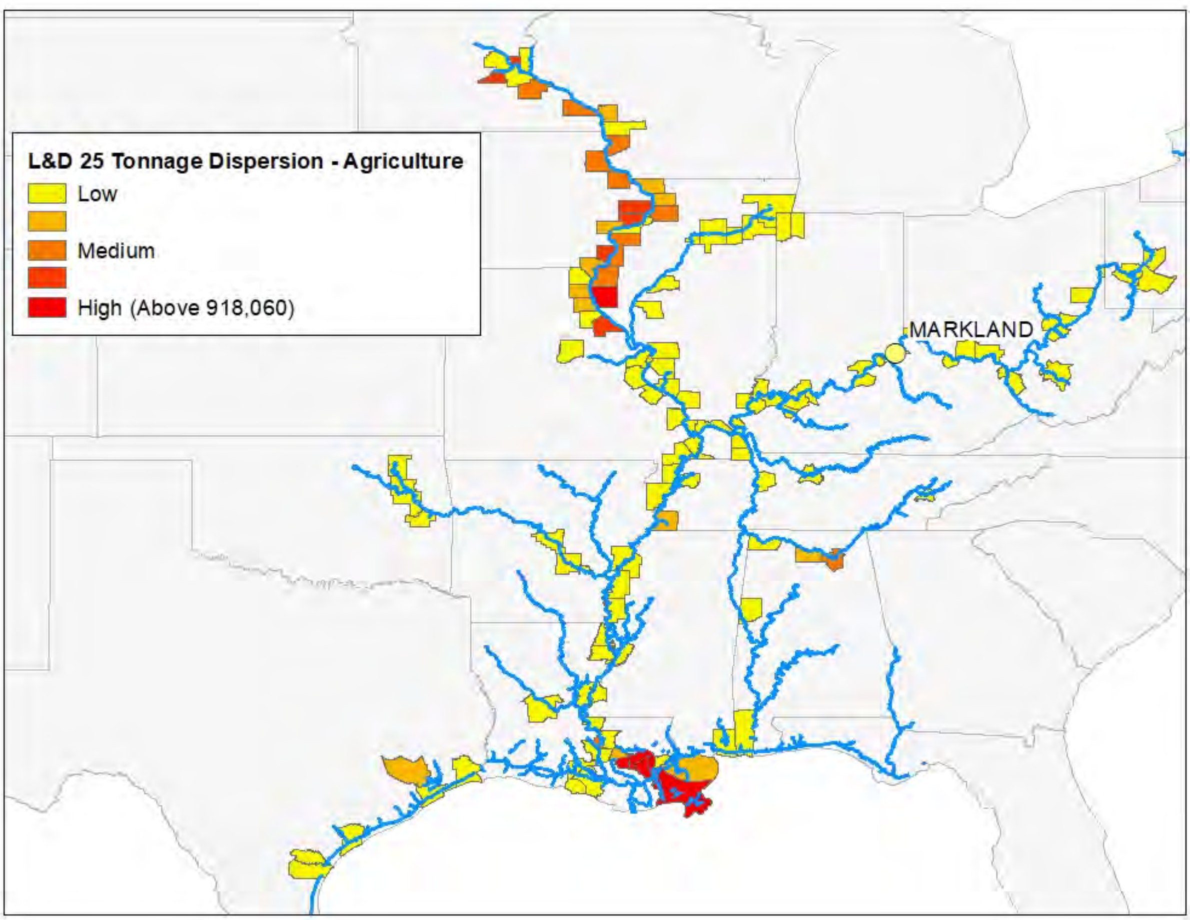



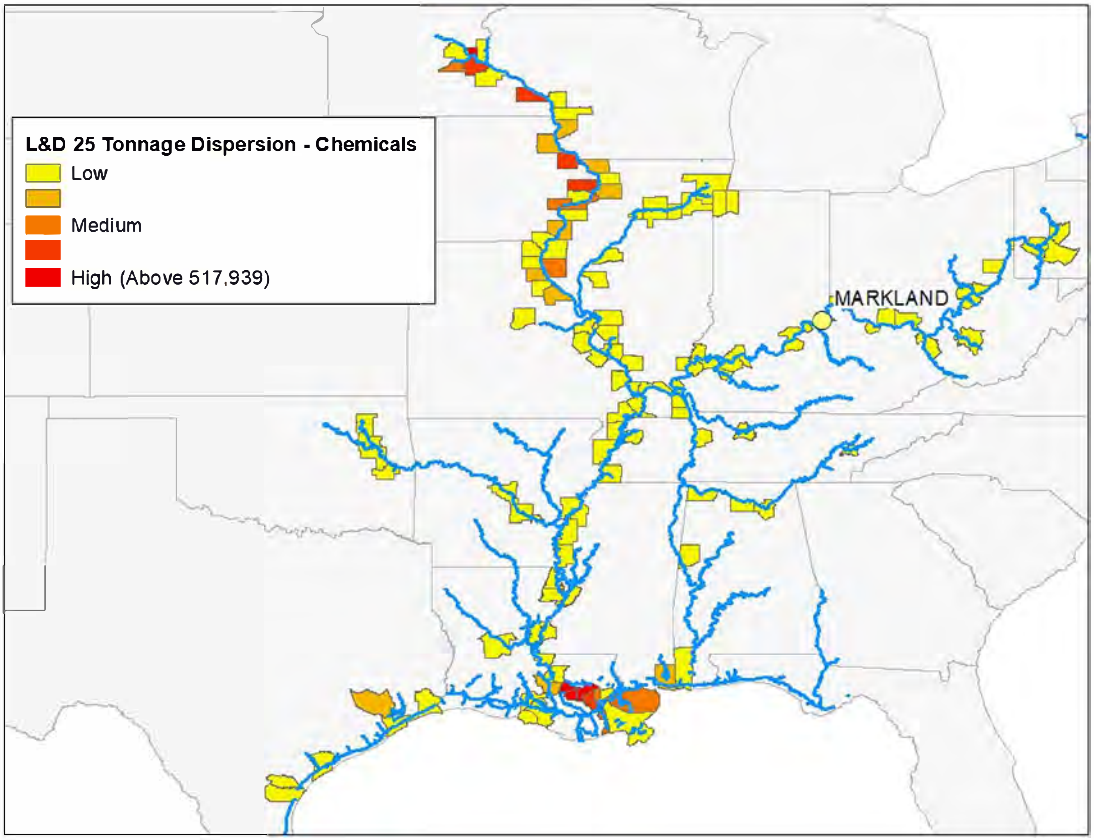
LaGrange Tonnage Dispersion - Manufactured Goods
Low
Medium
High (Above 501,771)
LAGRANGE

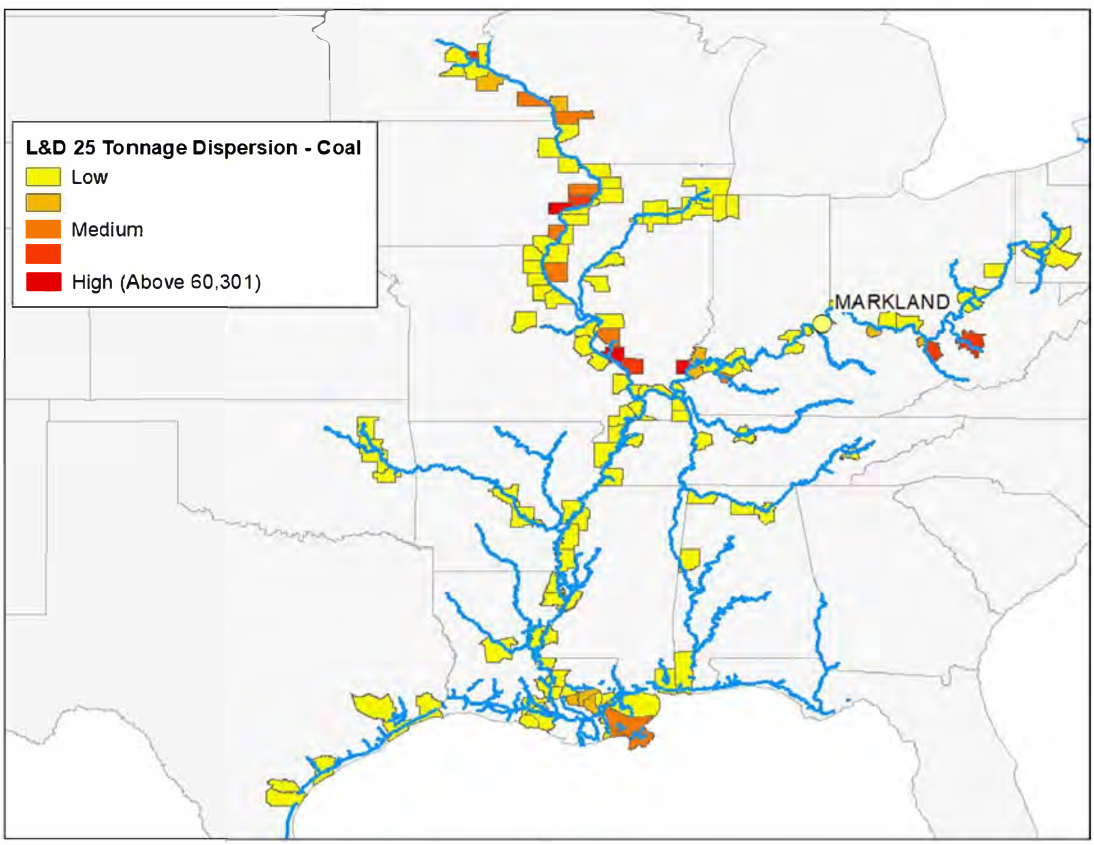

LaGrange Tonnage Dispersion - Petroleum Products
Low
Medium
High (Above 468,031)
LAGRANGE

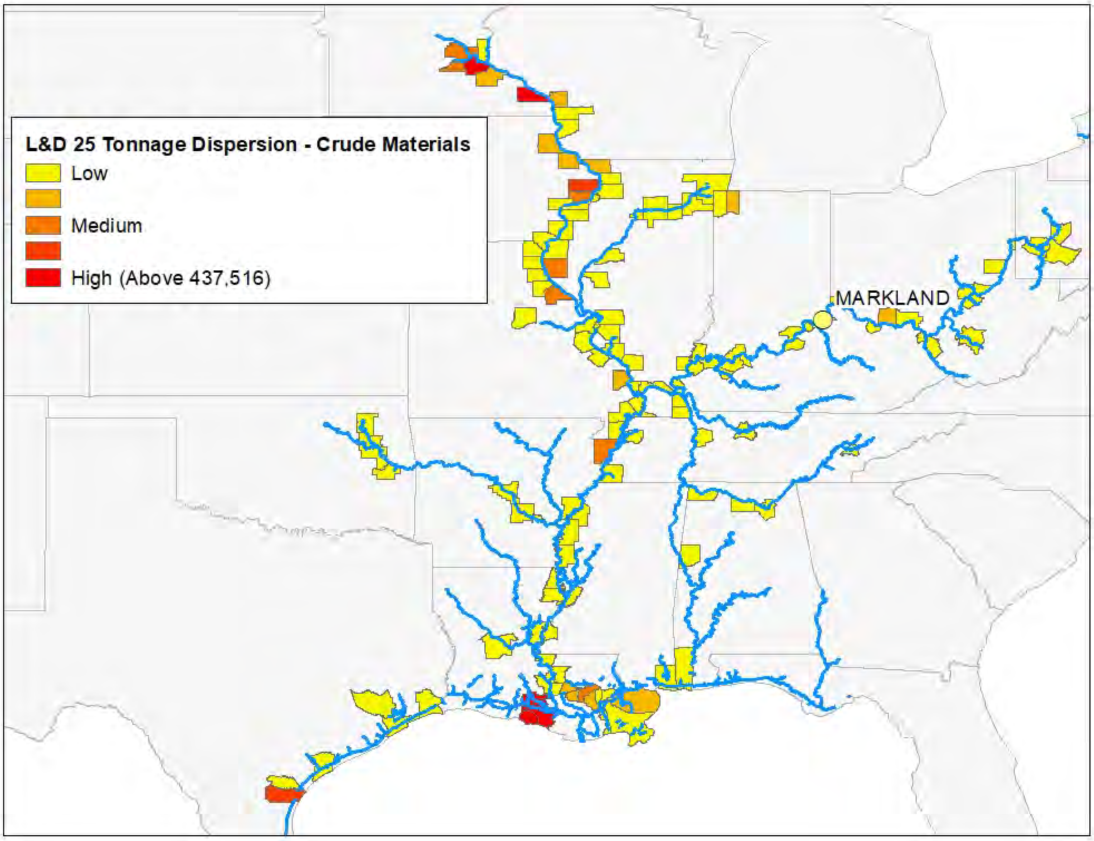
# L&D 25

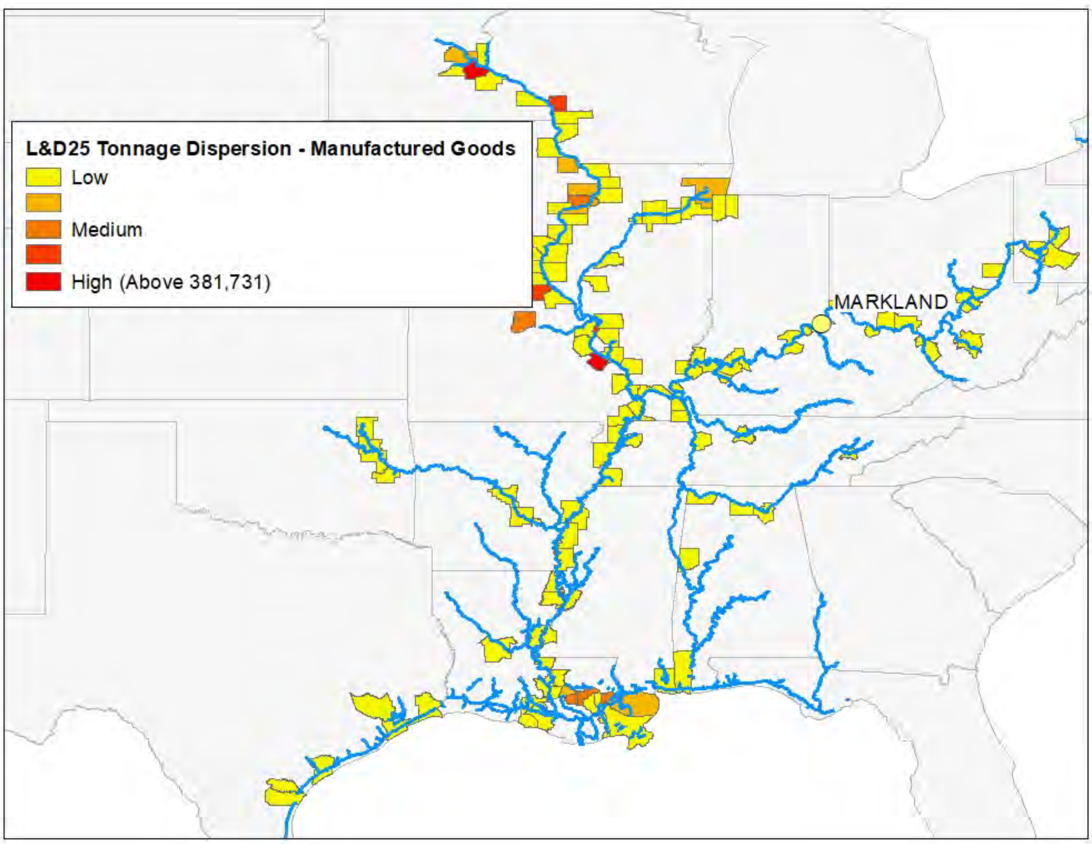
| | LPMS Group | Total 2014 Tons | Tons per Barge | Average Distance | Cost per Ton | Total Averted Costs |
|---|---|---|---|---|---|---|
| **Coal** | 10 | 660,624 | 1,547 | 713 | $38.90 | $25,696,959 |
| **Petroleum Products** | 20 | 320,411 | 1,732 | 1,518 | $47.14 | $15,103,646 |
| **Chemicals** | 30 | 4,171,737 | 1,612 | 1,430 | $59.66 | $248,899,601 |
| **Crude Materials** | 40 | 3,082,613 | 1,568 | 1,488 | $67.76 | $208,863,996 |
| **Primary Manufactured Goods** | 50 | 1,667,149 | 1,677 | 845 | $22.93 | $38,225,955 |
| **Farm Products and Food** | 60 | 12,433,825 | 1,598 | 1,323 | $83.16 | $1,033,977,564 |
| **Equipment** | 70 | 6,602 | 660 | 1,270 | $82.19 | $542,606 |
| **TOTAL** | | **22,342,961** | | | | **$1,571,310,327** |

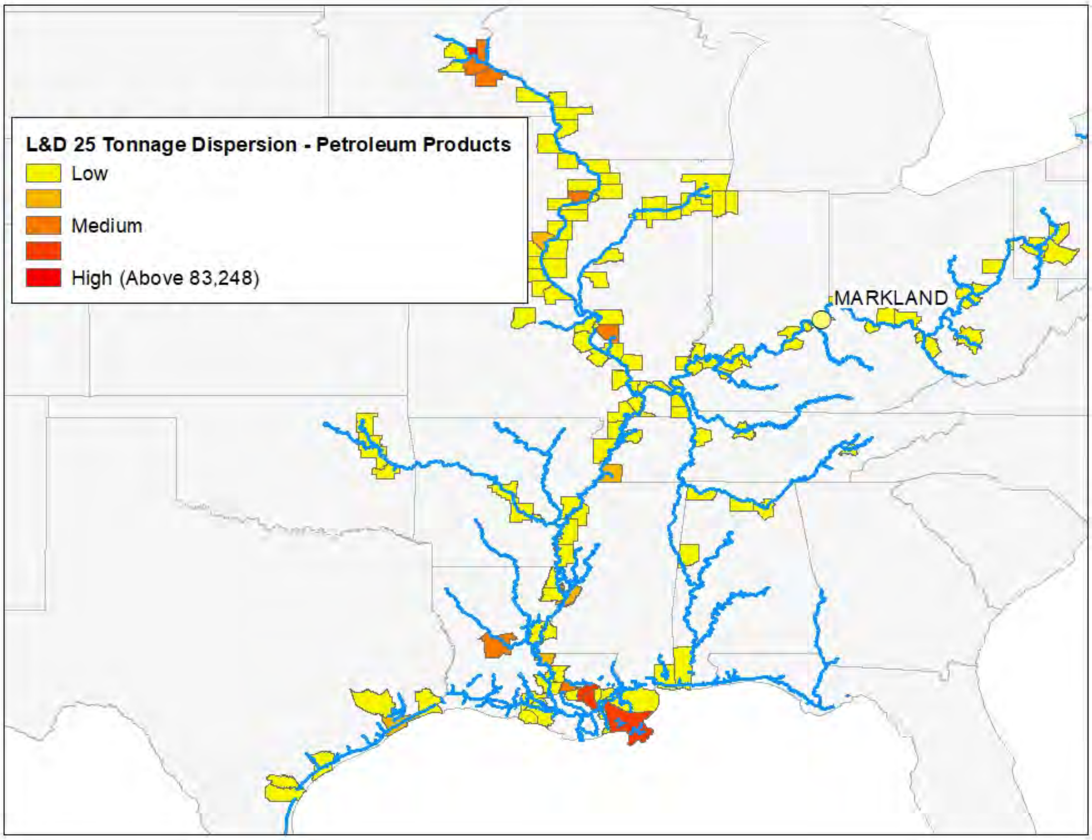



L&D 25 Tonnage Dispersion - Chemicals
Low
Medium
High (Above 517,939)
MARKLAND


L&D 25 Tonnage Dispersion - Coal
Low
Medium
High (Above 60,301)
MARKLAND


L&D 25 Tonnage Dispersion - Crude Materials
Low
Medium
High (Above 437,516)
MARKLAND


L&D25 Tonnage Dispersion - Manufactured Goods
Low
Medium
High (Above 381,731)
MARKLAND


L&D 25 Tonnage Dispersion - Petroleum Products
Low
Medium
High (Above 83,248)
MARKLAND