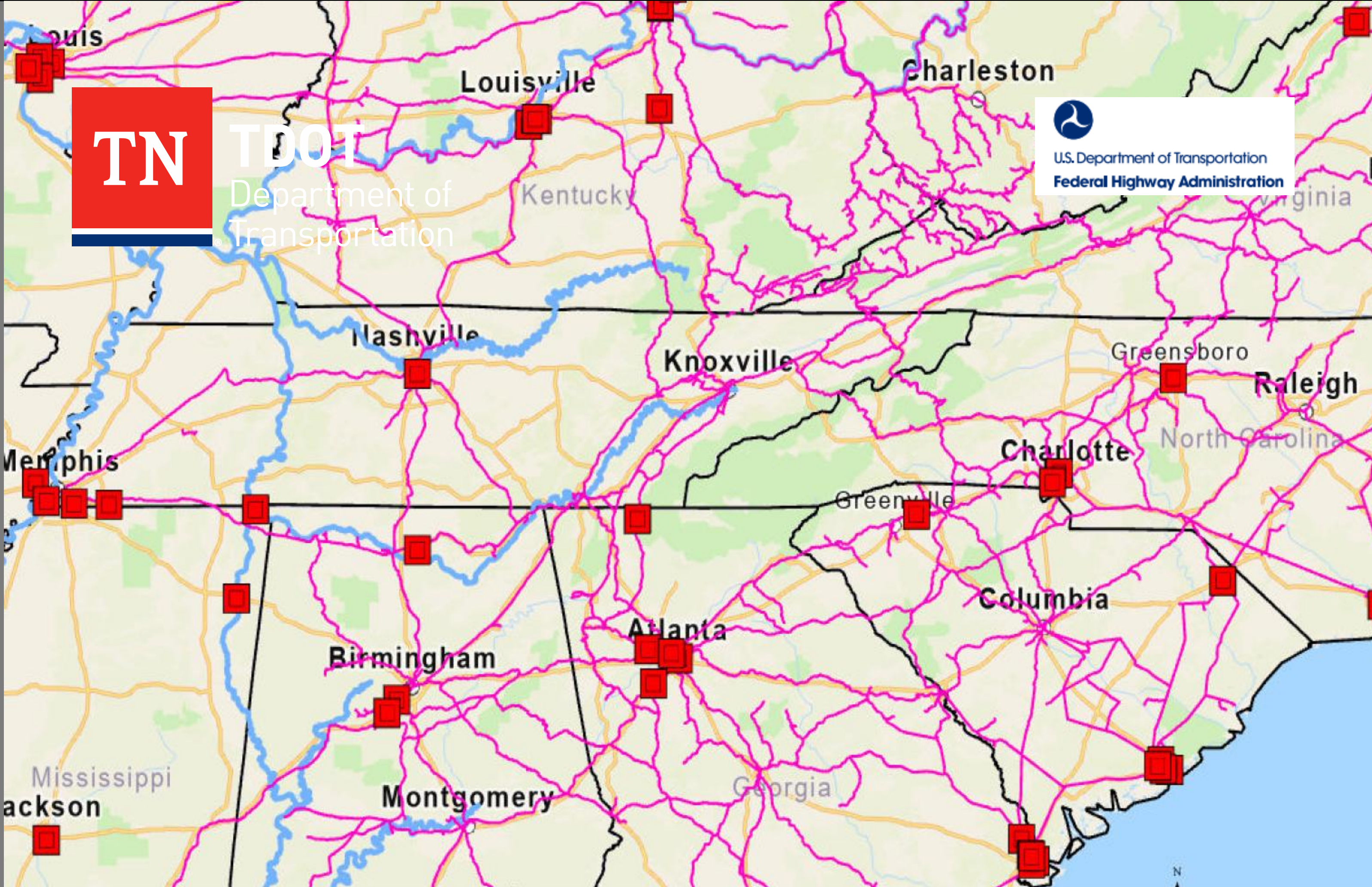

Navigating Possibilities: Unlocking Tennessee's Waterways for Interstate Freight Transportation

Research Final Report from the University of Tennessee-Knoxville | Donald Maier, Jeffrey Trombly, Andrew Balthrop, Yemisi Bolumole| International Association of Maritime Port Executives Mihalis Golias, David Arnold | February 14, 2026

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16. Abstract

The study evaluated the inland waterways and port facilities of the State and analyzed their potential for transportation services as part of the overall State Transportation plan. The focus of the study evaluated the current flows and costs of cargo movement and commodity class; the path related to origin and destination; the viability of potential port assets that could be utilized; the effectiveness of optimizing current State infrastructure and connecting waterways for enhancing the transportation network. By leveraging its inland waterways and investing in transportation infrastructure, Tennessee can enhance its competitiveness, promote sustainable development, and build a more resilient and prosperous future. Tennessee's geographical location creates both challenges and opportunities as a strategic multi-modal hub for national commerce. By developing its waterways for freight transportation, the state can capitalize on its central location to facilitate the movement of goods well beyond the state which would serve to attract businesses seeking efficient transportation routes, expand market access for Tennessee-based industries, as well as connect other industries to Tennessee.

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THE UNIVERSITY OF TENNESSEE KNOXVILLE
SUPPLY CHAIN MANAGEMENT

Executive Summary

Transportation, across all modes, accounted for $987.3 billion in GDP 2024, or 3.4% (BEA). Bureau of Transportation Statistics (BTS) indicate the water share of for-hire transportation services was $24.9 billion or 2.6%. These measures tend to understate the value of transportation. This is because much of transportation, and freight transportation in particular, is a derived demand, meaning the value of transportation does not come because customers value transportation directly, but because they value the types of products to which efficient, low-cost transportation networks provide access. This makes valuation more difficult than simply measuring the gross revenues of for-hire transportation providers. Were it not for efficient transport, customers would lose access to many products.

Tennessee's waterways offer a unique opportunity for intra/interstate freight transportation, with the potential to connect the Great Lakes to the Gulf of Mexico through the various ports in Tennessee (TN) including the Ports of Chattanooga, Knoxville, Nashville, and Memphis (listed alphabetically). Despite being landlocked, Tennessee possesses a crucial saltwater connection through its inland waterways. This study completed a feasibility study to determine the viability of utilizing Tennessee's waterways for inland barge traffic between the Great Lakes and the Gulf of Mexico. While all metropolitan areas in Tennessee were investigated, more focus was placed on Knoxville and East Tennessee. It is understood that any infrastructure investment anywhere in the state would benefit the rest of the state.

The study evaluated the waterways and port facilities of the State in order to assess how the State's waterway system will add value to the overall transportation network thereby benefiting both operators and shippers alike. The study evaluated the current flows and costs of cargo movement; the path related to origin and destination; the effectiveness of optimizing current State infrastructure and connecting waterways to advance new markets and increase the State's industrial employment opportunities in an attempt to less the freight imbalance.

Tennessee has a strategic location advantage that provides multiple gateways connecting its inland waterways to major trade routes both domestic and global. While including Knoxville and points east (Morristown, Kingsport, Johnson City for example), in that strategic advantage, those areas are also constrained by the absence of an intermodal rail facility to connect multiple modes of transportation. Additionally, the limited capacity of the Watts Bar and Ft. Loudon locks also inhibits Knoxville due to the significant time constraints of locking through.

Tennessee also suffers from the lack of a comprehensive and collective voice advocating on behalf of all ports and terminals throughout the state. Port governance models such as port authorities, port councils, port districts, and the like, have proliferated in other neighboring and regional states. Not only do those efforts create a unified strategy for their state, county, and municipalities and thereby attracts more economic growth and less wasted spending, a port governance structure is also a requirement for many federal funding opportunities. Before proceeding with significant investment of resources, it was essential to conduct a thorough study to assess the economic, environmental, and logistical impacts of utilizing Tennessee's waterways for interstate freight transportation which remained the focus of this study.

Key Findings

- Using only benefits that accrue to shippers along Tennessee origins or destinations, the direct savings from a 5% cost reduction amount to $47.9M in direct annual economic benefits. These benefits correspond to shipping an additional $23.5M to and from Tennessee counties. Modal substitution from road and rail to water, reduces transportation costs, which has potential positive “knock-on” benefits for Tennessee business – carriers and shippers alike. Tennessee’s waterway system should be viewed similar to a less-than-truckload operation, or a container ship that carries cargo for many different customers moving cargo in lower quantities at one time.
- While waterway transportation to Knoxville is feasible, it remains economically marginal under current conditions and is dependent on system-level investments rather than standalone local improvements. Increasing waterborne freight through Knoxville and points east, hinges on lock modernization, enhanced intermodal integration, and coordinated efforts to build sufficient waterborne volumes. Any location advantage for Knoxville and points east are significantly reduced in the absence of an intermodal rail facility. As such, waterway transportation costs in Tennessee will remain higher since cargo in that area has limited head-haul or backhaul opportunities forcing parties to pay a roundtrip rate for one-way cargo.
- Tennessee’s inland waterway system has an imbalance of supply and demand with adequate supply-side support (operators/terminals) yet suffers from a lack of demand (shippers and freight).
- Economic growth will continue to place additional burden on the road and rail network in the state yet creates an opportunity to encourage shippers to use the Tennessee river system. The State may consider developing means to incentivize companies to use the waterway system to support operations.
- The Tennessee and Cumberland Rivers provides a continuous inland waterway link between the Great Lakes and the Gulf of Mexico, creating a significant north–south freight corridor that connects multiple domestic and international markets. Preserving and strengthening this connectivity supports long-term network resilience, future modal

shifts, and evolving shipper priorities such as emissions reporting and supply chain resilience through diversification. As infrastructure, demand, and market conditions evolve, the Great Lakes-Gulf transportation corridor may become increasingly competitive and strategically valuable to Tennessee and the nation.

- Support for a statewide port governance model, systematic collaborative strategic planning are essential to improving the competitiveness, reliability, and economic impact of Tennessee's waterway transportation network. Not addressing the situation restricts Tennessee's ability to compete with neighboring states and regions in creating more resilient global supply chains.

Key Recommendations

- The State needs to enhance and continue development of the Passenger Transportation, Rail, and Freight Division (PTRF). The Division has a great opportunity to continue collaborating with various freight stakeholders and the Tennessee Economic and Community Development (TNECD) office. Doing so ensures that modes of transportation operate in a connected fashion and advances the State's location as a national multimodal operation, potentially creating a logistics cluster.
- The PTRF Division could develop a data-driven location tool to help concentrate demand and also host a digital-twin program to conduct scenario testing of transportation networks for other state departments and private industry interested in locating or expanding in Tennessee.
- Through legislative support, the State needs to investigate and establish the most appropriate form of a state-level, port governance structure. The new 'port governance' would have the responsibility to coordinate the state's diverse ports and terminals; develop a comprehensive strategic plan for port operations; create a holistic marketing and promotion program to advocate for and speak on behalf of all ports located in the State (one voice advocating for the collective whole); establish a program to seek and manage federal funding opportunities in support of local ports and terminal operators; where appropriate, administer funds as directed for public and private port improvement; review all proposed federal projects, set State priorities and coordinate with key agencies to ensure attention is given to key issues that impact the State involving the waterway system and intermodal operations.
- Through the PTRF Division, coordinate efforts with rail and road interests to support and grow industry clusters. More emphasis should be placed on advocating for an intermodal terminal in Eastern Tennessee where no intermodal facility exists.

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SUPPLY CHAIN MANAGEMENT

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Chapter 1 Costs and Economic Impact

1.1 Introduction

This chapter discusses the results of an economic and commodity analysis to assess the costs and benefits of increasing Tennessee's inland waterway transportation efficiency utilizing various terminal operations throughout the state, including Knoxville. The task includes estimating the upfront investment required for infrastructure development, dredging, terminal upgrades, and maintenance costs. Additionally, the task will evaluate potential economic benefits that include reduced transportation costs, reduced costs along alternative modes, such as reduced emissions, congestion and accidents on US rail and roadways, as well as increased trade volume, job creation, and economic growth.

The National Importance of Inland Waterways

Inland waterway transportation has increased nationally, even as the infrastructure supporting the inland system continues to age. According to the Bureau of Labor Statistics Current Employment Statistics (BLS-CES), water modes of transportation (which include ocean, NAICS 4831 and 4832) accounted for 71,900 jobs as of August 2025. National employment in the sector has increased 10.6 percent over the past 10 years.

Transportation, across all modes, accounted for $987.3 billion in GDP 2024, or 3.4% (BEA). Bureau of Transportation Statistics (BTS) indicate the water share of for-hire transportation services was $24.9 billion or 2.6%. These measures tend to understate the value of transportation. This is because much of transportation, and freight transportation in particular, is a derived demand, meaning the value of transportation does not come because customers value transportation directly, but because they value the types of products to which efficient, low-cost transportation networks provide access. This makes valuation more difficult than simply measuring the gross revenues of for-hire transportation providers. Were it not for efficient transport, customers would lose access to many products.

An alternative statistic for understanding the value a mode of transport offers is the value of the cargo transported along a particular lane (Donaldson 2025). The inland waterway transported $388 billion dollars of goods in 2023 (Bureau of Transportation Statistics), with the top sectors being critical inputs to the national economy, including 1) Fuel oils, 2) Gasoline, 3) Crude Petroleum, 4) Basic Chemicals and 5) Natural Gas.[1]

[1] While measuring for-hire transportation market revenues tends to understate the value of transportation, valuing transportation by assessing shipment values tends to overstate the value of the particular mode or link. Shipments can be re-routed via other modes, or across different links. The US Army Corps of Engineers estimates that inland waterways provide $13.36 billion in *net* benefits, measured as cost savings compared to shipments via railroad (US Army Corps of Engineers 2020).

1.2 Economic Impact of Waterway Transport in Tennessee

The inland waterway transportation sector accounted for 2,234 jobs in 2024 in the State of Tennessee (BLS Quarterly Census of Employment and Wages, 2024).[2] Primary occupations in this industry include sailors, captains, mates, pilots, ship engineers, motorboat operators, and bridge and lock tenders. The industry also includes occupations more broadly aligned within Tennessee's competitive advantage in supply chain management and transportation, including freight handlers, crane and conveyor operators, freight tenders, logisticians, supply chain managers, and office and administrative staff. The value of goods transported by the inland waterway sector in 2024 of $9.5 billion is more evenly diversified across economic sectors, including agriculture, manufacturing, and minerals extraction, but concentrated along the Mississippi, and to a lesser extent the Cumberland and Tennessee rivers. The waterway system provides transport for agricultural products, fuel oils, and chemicals, but also higher value-added goods including motorized vehicles and parts. Using Bureau of Transportation Statistics (BTS), the study found the real value of goods transported across all of Tennessee's metropolitan areas along its river system has increased more than 10% from 2017. While the annual growth rate over the past eight years is low, given existing infrastructure there appears to be a larger opportunity for growth.

Memphis CFS (Memphis-Forrest City, AR TN-MS-AR CSA)

Memphis is Tennessee's largest metropolitan origin and destination for waterborne freight, with $4.5 billion of freight originating (Figure 1-1) or destined (Figure 1-2) to the area in 2024. Fuel oils, crude petroleum and basic chemicals are the most important imports. Cereal grains and other agricultural products account for the largest share of exports. What is noteworthy is that the value of imports and exports is generally balanced, allowing operators to manage operating costs with revenue. In other words, head-haul and backhaul volume and rates are equalized making for a more efficient supply chain.

[2] Jobs are located at establishments in Tennessee but not necessarily held by Tennessee residents.

Figure 1-1 Origin: Memphis CFS 2024

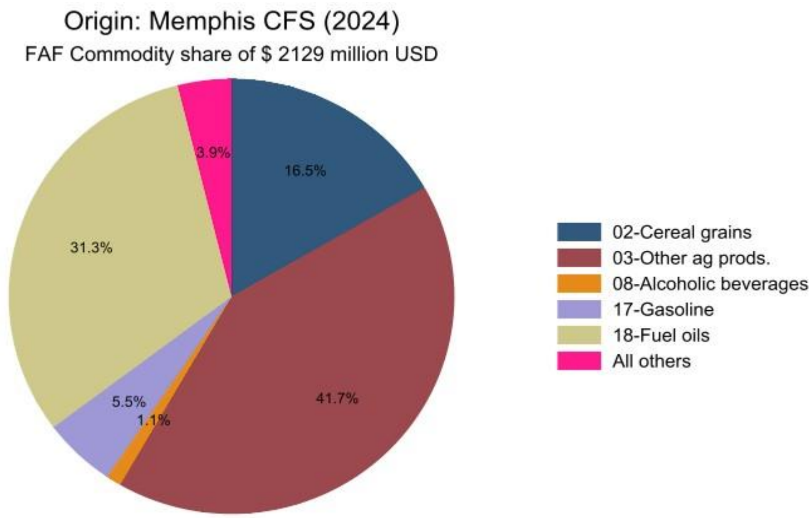
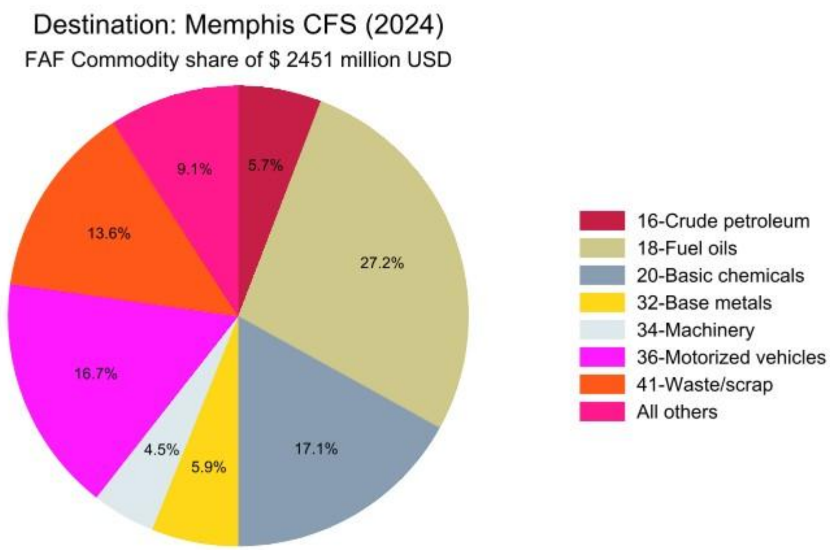


Figure 1-2 Destination: Memphis CFS 2024



Nashville CFS (Nashville-Davidson-Murfreesboro CSA)

Unlike Memphis, Nashville is not balanced in terms of the value of products flowing in and out of the port. $289 million in origin freight flows (Figure 1-3) were highly fragmented across commodity sectors. The three largest commodities include alcoholic beverages, newsprint/ paper and waste/scrap. Freight destined to the Nashville CFS (Figure 4-1) accounted for $1.2 billion, dominated by base metals, machinery and motorized vehicles. The imbalance impacts the head-haul and backhaul operation which increases the cost of transportation.

Figure 1-3 Origin: Nashville CFS 2024

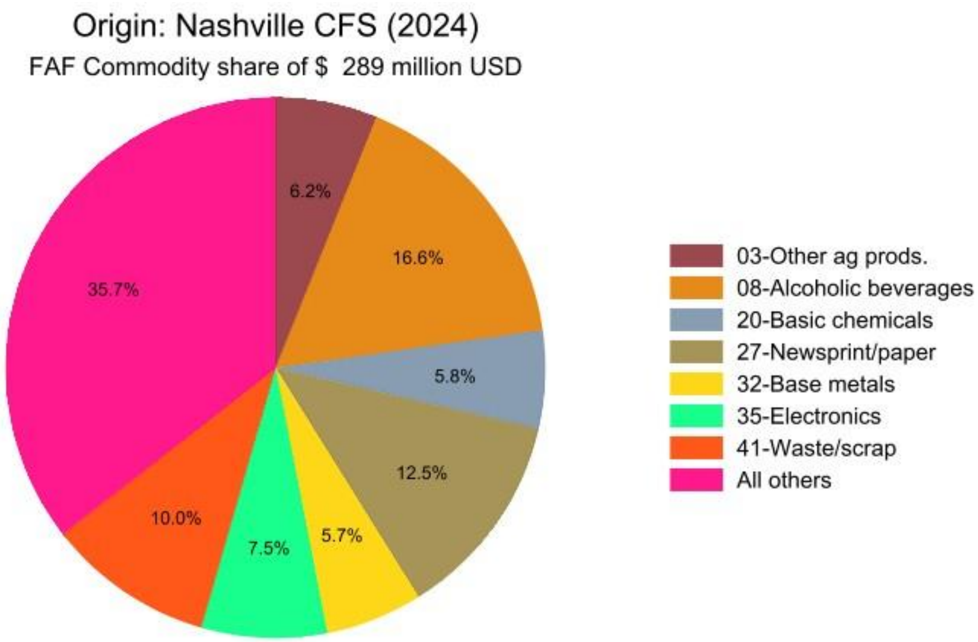
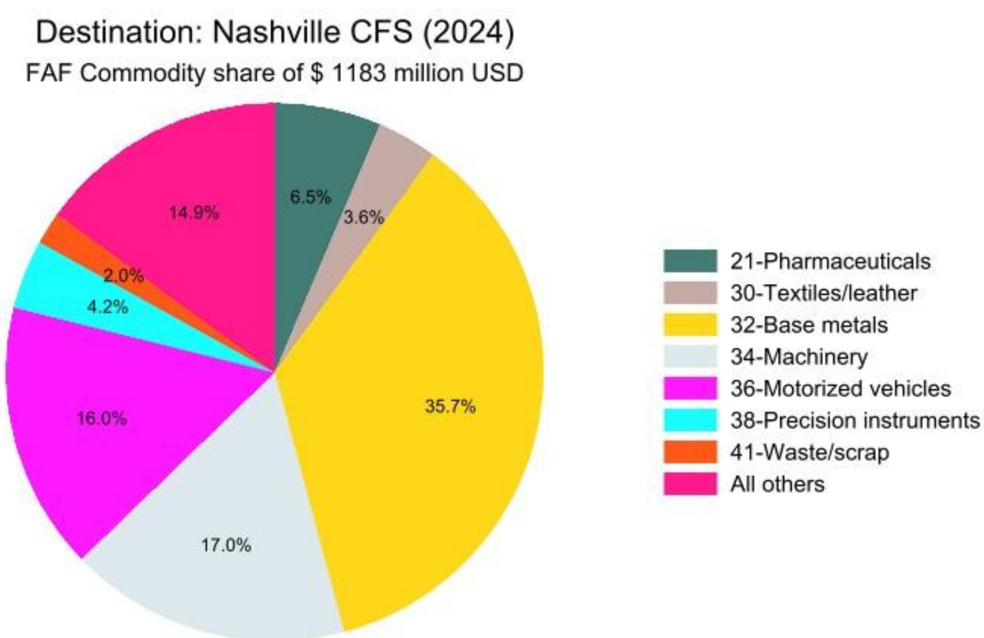


Figure 1-4 Destination: Nashville CFS 2024



Knoxville CFS (Knoxville-Morriston-Sevierville CSA)

Knoxville is comparatively under-utilized. Water transport in the area serves the end of the supply chain (waste/scrap) and is also under-diversified. The overwhelming majority of originating commodities were waste/scrap, valued at $13 million (Figure 1-5), and $15 million for commodities destined (inbound) to Knoxville (Figure 1-6). This type of situation creates a disadvantage for the area to potentially attract other users for lack of head-haul and backhaul use.

Figure 1-5 Origin: Knoxville CFS 2024

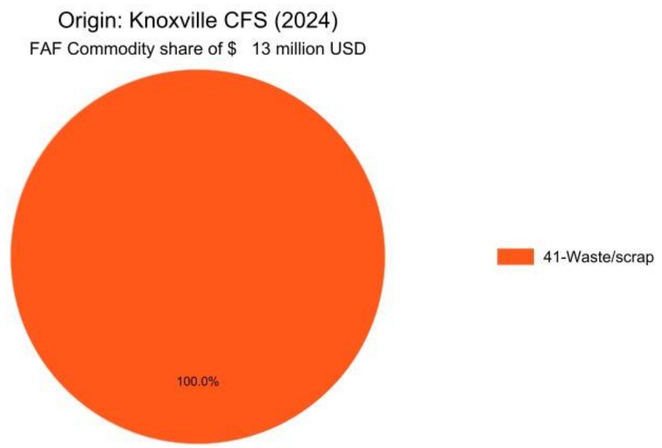
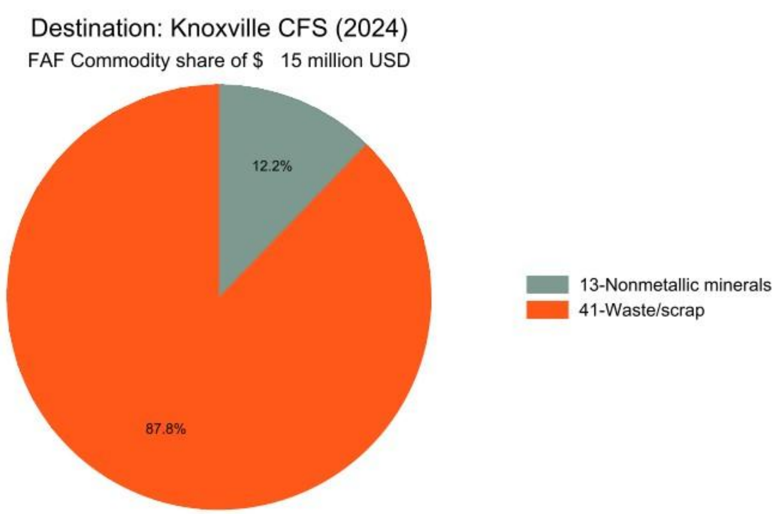


Figure 1-6 Destination: Knoxville CFS 2024



Chattanooga CFS (Chattanooga- Cleveland-Dalton CSA)

The Bureau of Transportation Statistics does not disaggregate Chattanooga data from the rest of Tennessee in its Freight Analysis Framework (FAF). Instead, county-level shipment values were used from TransSearch for Hamilton County Tennessee to approximate shipment values for Chattanooga. FAF data is reported by SCTG codes, TransSearch data is reported by NST-R code. Outbound, or originating freight, shipment values of $143M were much lower than inbound, or destination, shipment values of $1.524B. The primary shipments originating from Chattanooga, in terms of shipment values, are ores and metal waste (Figure 1-7). The largest inbound sectors are metal products and chemicals (Figure 1-8).

Figure 1-7 Origin: Chattanooga-Hamilton County CSA 2024

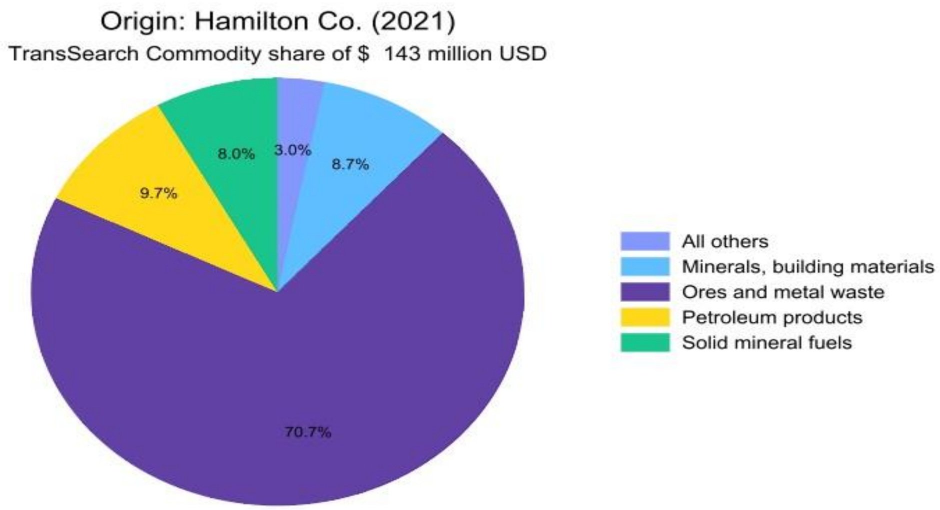
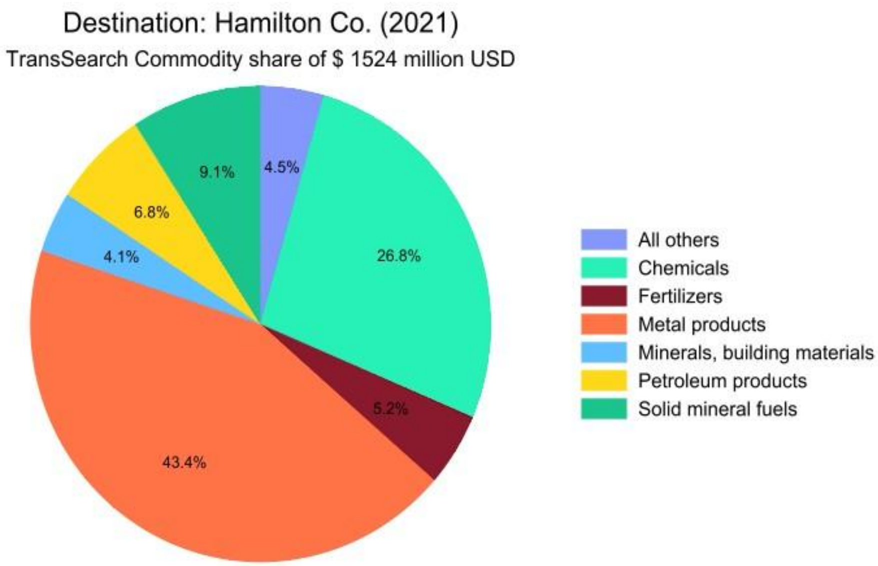


Figure 1-8 Destination: Chattanooga-Hamilton County CSA 2024



1.3 Valuing Benefits from Projects that Improve Navigability of Tennessee Waterways

The values provided by efficient water transportation systems are manifold. These values include the direct income to the contractors, employees and owners of waterway transport companies, the cost reduction in transport to shippers using waterways to move freight, the additional goods made available to consumers, and the new markets opened to producers as a result of low-cost transport. More generally, more efficient transportation systems change the locations of where people live, where business is done, and what gets made where. This, in turn, changes underlying land values. Transportation improvements have multiplier effects on local economies, which are important for local stakeholders to consider. For example, every dollar spent on infrastructure expenditure goes on to be recycled multiple times through the region. Waterways provide direct recreational benefits to users, while reducing public nuisances, such as roadway congestion, pollution, and crashes from use of alternative transportation modes. As such, comprehensive and precise assessment of waterway transportation improvement is difficult.

Broadly speaking, assessors take one of two complementary approaches to valuation: regional economic modeling, or transportation market-based assessment.[3] Regional assessment models (e.g., Grossardt *et al.* 2014) are better at capturing the regional economic reverberations of transportation improvements, including employment and tax-base changes. Transportation market analysis provides more targeted assessment of how transportation improvement directly benefits users of the transportation system.

In this study, we take the transportation market approach, evaluating the benefits of inland waterways by focusing directly on the markets for inland waterway freight transportation as well as the market of potential alternative transport modes (road and rail). We consider the benefits of marginal efficiency improvements in terms of how these improvements directly lower prices for shippers and increase profitability for carriers; alternatively, we also consider how marginal reductions in transport costs result in increased value of total shipments for consumers.[4]

Our focus on marginal efficiency improvements is important because it provides estimates relevant to the types of decisions policymakers face, including how much additional public spending is warranted in navigational improvements, dredging, lock modernization, port construction, and market coordination. In contrast, studies that value inland waterways by considering non-marginal scenarios, such as the instantaneous impossibility of inland water transport at any price, would yield very large value estimates owing to the catastrophic disruption to the US transport system.

Nonetheless, our focus, limited to transport markets, with valuation based on marginal efficiency changes, yields value estimates that support recent inland waterway investments. A 5%

[3] In technical terms, these approaches are general and partial equilibrium modeling.

[4] These are theoretically distinct but related valuation concepts. The value of a ton of cargo transported is the prevailing market price of moving that ton of cargo. The cargo transported also has value to end-use consumers. This value is partially determined by transportation costs, but also by other downstream factors.

efficiency improvement in Tennessee Waterways generates annual benefits ranging from $23.5M-$49M. These improvements compare favorably with even high-cost transportation infrastructure, such as the Chickamauga Lock Chamber Contract (annualized cost: $22.9M). We compare the scales of benefits and infrastructure costs at the end of this chapter.

Three scales of efficiency improvements were used in the form of marginal cost reductions to barge operators: small, medium and large. We are agnostic about the way these efficiency gains are made but discuss potential projects that might result in improvements on these scales. These comparisons are superficial—specific investment projects that require rigorous and specific economic evaluation. The comparisons nonetheless support the conclusion that continued maintenance and improvement of Tennessee waterways generates large economic benefits.

1.4 Valuation Technique

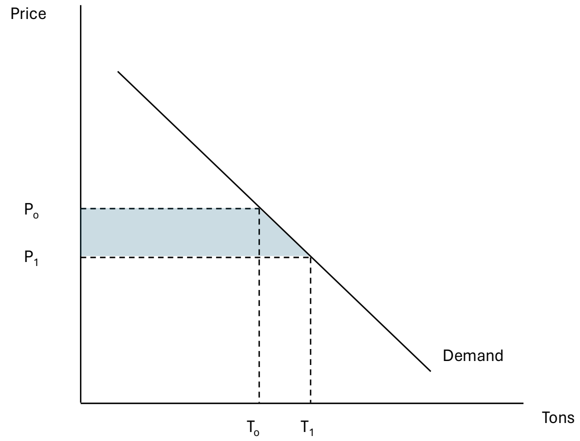


Figure 1-9 Valuation Technique

As described in Figure 1-9, under competitive market assumptions, efficiency improvements that reduce the marginal cost of transportation result in a price reduction ($P_0 \rightarrow P_1$). Well-being increases along two dimensions: the direct price reduction, and a corresponding increase in tonnage shipped ($T_0 \rightarrow T_1$) which is determined by a demand responsiveness parameter (the price elasticity of demand). Benefits can be measured by the blue shaded area (additional consumer surplus). Alternatively, we measure the efficiency improvement by the value of additional shipments, *Value*(T_1-T_0) (Donaldson 2025). This latter approach is significant because it uses an entirely different set of data (i.e., the value of goods), than the transportation-market approach (transportation rates and volumes). which provides an important means of triangulating benefits for evaluation purposes.[5] Given stable demand, a reduction in operating

[5] The two approaches can yield different measures for theoretically valid reasons, such as pricing power in transportation or goods markets.

cost of waterway transport equates to a lower price paid, which helps businesses using the inland waterway system and operating in Tennessee. If demand increases, the value of water transportation significantly increases as exemplified by the increased prices.

Price reductions in waterway transport also result in modal substitution. Freight that was previously shipped via railway or roadway may be substituted onto waterways. This substitution has potential side benefits of reducing harmful environmental emissions and easing roadway wear, congestion, and crashes, which provide additional public benefit.

To better understand the potential benefits associated with waterway improvements, we model the changes in transport benefits (water, rail, road) associated with three different scales of potential waterway improvements: small (5% waterway price reduction), medium (10% price reduction) and large (25% price reduction). In appendix analysis, we also examine the effect of price increases on other freight transport modes.

1.5 Data and Methodology

Aside from the movement of goods itself, the primary benefit water transport provides is the reduction of externalities (e.g., pollution, congestion, crashes) as freight is shipped via water instead of road or rail. When the price of water transport falls under each of our scenarios, freight moves away from road and rail, and onto water. Yet substitution possibilities between modes are constrained by the type of freight, and the origin-destination link. While water per-mile rates are less expensive than road or rail, it is also significantly slower, and more geographically restricted. Commodities can only be shipped by water if the origin and destination are linked by water, while the extent of substitution is specific to the type of commodity. For example, coal is more likely to be substituted from rail to water than are consumer packaged goods.

To more precisely assess the benefits of waterway improvement in Tennessee and the potential for modal substitution, data from TransSearch was used providing county-level origin to destination flows by transport mode disaggregated along 10 different commodity classes in 2021and 2045. For each commodity flow (defined by the 4-tuple: (origin, destination, mode, commodity)), we assess the value of efficiency improvements quantified by 5%, 10% and 25% price reduction in water transport using responsiveness parameters from Beuthe et al. (2001) (specifically, own-price and cross-price elasticities of demand). We constrain modal substitution possibilities to modes that have non-zero shipments for that commodity along the origin-destination link.[6]

[6] For example, we assess no possibility of substitution from rail to water for agricultural products between Knox County Tennessee and Custer County Idaho, because no existing inland water transport occurs between these counties. In technical terms, our benefits estimates allow for no increase in water transport along the *extensive* margin.

Commodity Classification

Table 1 describes the analysis codes using the NST-R (Standard Goods Classification for Transport Statistics) system, mapped to SCTG2 codes used in TransSearch.

Table 1 NST-R Commodity Code and Description

NST-R Code	Description
0	Agricultural products
1	Foodstuffs
2	Solid mineral fuels
3	Petroleum products
4	Ores and metal waste
5	Metal products
6	Building materials
7	Fertilizers
8	Chemicals
9	Machinery and equipment

1.6 RESULTS

Water Freight Baseline

The TransSearch data includes four flow types relative to Tennessee: Inbound, Outbound, Intra-regional and Through-Freight as shown in Table 2.

Table 2 Water Freight Baseline by Flow Type

Year	Flow Type	Tons	Shipment Value
2021	Inbound	22.0M	$8.8B
2021	Outbound	5.4M	$2.5B
2021	Intra-regional	2.1M	$0.1B
2021	Through	883.5M	$762.8B
2045	Inbound	27.4M	$13.2B
2045	Outbound	6.8M	$2.7B

2045	Intra-regional	5.3M	$0.2B
2045	Through	995.9M	$956.3B

Through traffic represents the largest share of waterway freight value, reflecting Tennessee's strategic position along major inland waterway routes, primarily the Mississippi River (M-55), but also the M-65 and M-24. Improvements on the M-55 would benefit Memphis, Tennessee's largest port, but would primarily drive large external benefits outside of the state because of the significant through traffic volume. Having through traffic does have potential to benefit users of the inland rivers (whether originating in or destined for Tennessee) through potential network economies similar to less-than-truckload shipments. For example, it is less costly to add an additional barge to a tow of eight barges that was already traveling through, than to tow the single barge individually. In this way through traffic contributes to marginal cost reductions, promoting additional shipments.

TransSearch also includes projections for shipment values in 2045 (in 2021 real dollars). The value of Origin + Destination shipments is projected to increase roughly 25% over the next 20 years. The Water Freight Baseline Table illustrates Tennessee's integral position within the US inland waterway system. Inland waterways provide direct benefits to Tennessee through cargo originated and destined to Tennessee ports. The state, straddling three crucial marine highways, also serves a conduit of commerce for much of the rest of the nation thereby contributing to Tennessee's standing as a crucial multi-modal hub.

Small Improvement Scenario (5% Real Cost Reduction)

From the Water Freight Baseline Analysis a 5% reduction in barge rates, evaluated at a baseline price of $35 / ton and price elasticity of demand of -0.5 yields $48.56M in additional economic surplus annually for lanes originating or destined for Tennessee. Table 3 describes the reduction in waterway transport costs and results in the following mode shifts of shipment values:

Table 3 Small Improvement

Year	Water Value	Road Value	Rail Value	Water Tons	Road Tons	Net CO2
2021	+$2.13B	-$2.62B	-$0.05B	+2.93M	-2.85M	-354M kg
2045	+$2.13B	-$2.80B	-$0.07B	+3.18M	-3.08M	-384M kg

The value of goods transported along water increases by $2.13B when including through shipments. Including only Tennessee origin and destination values, a 5% reduction in barge rates would result in a $23.5M increase in shipment values, which is consistent with the $48.56M surplus estimate. The substitution away from road and rail generates environmental benefits totaling 345 M kg in reduced CO2 emissions, equivalent to the removal of 0.34 coal-fired power plants (Environmental Protection Agency 2024). The reduction of road transport in favor of water is expected to result in 1.6 fewer fatal heavy truck crashes.[7]

The small improvement scenario shows patterns that are consistent across all three improvement scenarios: shipment values including through shipments are much larger than shipment values including only Tennessee origins and destinations. This indicates that any improvement in Tennessee waterways (and especially navigation improvements along the M-55) will have substantial spillover benefits nationally, and not just to Tennessee waterway users. Additionally, economic surplus calculations are generally larger than benefit calculations based on additional shipment values because the surplus calculations capture the direct benefits to inland waterway shippers and carriers. Benefits from the 5% improvement scenario can be thought of as stemming from localized navigational improvements at key bottlenecks on Tennessee waterways.

Medium Improvement Scenario (10% Real Cost Reduction)

More costly improvements are justifiable when they generate larger operational efficiency gains (i.e., marginal cost reductions) that result in larger price reductions for transportation customers (or cost reductions for waterway operators) as shown in Table 4. A 10% reduction in waterway transport costs results in approximately $98.42M in additional economic surplus annually, translating to approximately $4.19 B in additional goods shipped (including through goods).

Table 4 Medium Improvement

Year	Water Value	Road Value	Rail Value	Water Tons	Road Tons	Net CO2
2021	+$4.19B	-$5.11B	-$0.11B	+5.73M	-5.57M	-692M kg
2045	+$4.18B	-$5.45B	-$0.14B	+6.21M	-6.02M	-750M kg

Focusing only on the value of TN origin or destination shipments, the value of additional shipments is $34.5 million. The pattern of substitution reduces environmental emissions. Measured by CO2, equates to a reduction of 692 M kg in 2021, which is roughly equivalent to the annual emissions from 0.67 coal-fired power plants. The reduction in road vehicle miles is expected to result in 3.0 fewer fatal heavy truck crashes.

Relative to the 5% price reduction scenario, the 10% scenario generates more economic benefits. Note that origin and destination surplus calculations scale with the size of the improvement, roughly doubling, while the increase in shipment values displays diminishing marginal returns.

[7] This is calculated based on table A.4.1, an average heavy truck loading of 20 tons, and a fatal accident rate of 1.03 fatal crashes per 100 million heavy truck miles driven (Teoh 2025).

Efficiency gains from the 10% scenario represent generalized efficiency improvements across Tennessee waterways.

Large Improvement Scenario (25% Real Cost Reduction)

Large improvements corresponding to a 25% reduction in waterway transport costs would result in approximately $256.96M in additional economic surplus annually, corresponding to the shipment of an additional $82.7M with origins or destinations in Tennessee (Table 5). Including through shipments, the value of increased shipments is $9.98B. Substitution away from road transport results in 7.2 fewer fatal heavy truck crashes. The combined substitution away from road and rail results in 1,621 M kg reduction in carbon emissions, equivalent to 1.6 coal-fired power plants.

Table 5 Large Improvement

Year	Water Value	Road Value	Rail Value	Water Tons	Road Tons	Net CO2
2021	+$9.98B	-$11.98B	-$0.25B	+13.42M	-13.05M	-1621M kg
2045	+$9.94B	-$12.78B	-$0.33B	+14.56M	-14.08M	-1758M kg

25% cost reductions represent large efficiency improvements, stemming from very large investments, and potentially wholesale modernization of inland waterway infrastructure. Nonetheless, realized benefits do support large infrastructure investment. Discounted at 7% over a 50-year horizon, these annual benefits (measured by Tennessee origin-destination economic surplus) total $3.54 billion. The benefits are much greater when considering through shipments.

Mode Shift Results by Commodity (10% Cost Reduction)

Changes in transportation prices have differential benefits to different economic sectors. The following tables (6, 7, and 8) present mode shift results aggregated by NST-R commodity code for the medium (10%) cost reduction scenario. Petroleum and Ores/Waste returned the largest results in terms of change in shipment values in 2021, (through shipments included). Much of the positive gains stem from a modal shift from road transport to water. For Tennessee origins and destinations, NST-R 4 “Ores/ Waste” has the largest increase in shipment value ($15.70M).

Table 6 Mode Shift by Commodity - 2021

NST-R	Commodity	Water Base	Water Δ	Road Δ
0	Agricultural	$37.5B	+$72M	$-113M
1	Foodstuffs	$17.7B	+$254M	$-286M
2	Solid fuels	$55.9B	+$230M	$-164M
3	Petroleum	$263.4B	+$2463M	$-2346M
4	Ores/waste	$76.0B	+$761M	$-1280M
5	Metals	$50.9B	+$67M	$-118M

6	Building mat.	$20.4B	+$98M	$-360M
7	Fertilizers	$25.4B	+$106M	$-75M
8	Chemicals	$129.8B	+$108M	$-339M
9	Machinery	$97.2B	+$27M	$-31M

Table 7 Mode Shift by Commodity - 2045

NST-R	Commodity	Water Base	Water Δ	Road Δ
0	Agricultural	$51.9B	+$98M	$-149M
1	Foodstuffs	$25.1B	+$454M	$-466M
2	Solid fuels	$63.2B	+$211M	$-138M
3	Petroleum	$298.0B	+$2253M	$-2029M
4	Ores/waste	$155.9B	+$546M	$-1399M
5	Metals	$88.3B	+$96M	$-165M
6	Building mat.	$22.8B	+$137M	$-424M
7	Fertilizers	$33.6B	+$172M	$-110M
8	Chemicals	$133.4B	+$164M	$-518M
9	Machinery	$100.3B	+$46M	$-54M

Table 8 Comparison 2021 vs 2045 Mode Shift Totals (Medium 10% Scenario)

Year	Water Value Change	Road Value Change
2021	+$4.19B	$-5.11B
2045	+$4.18B	$-5.45B

Key finding: The 2045 projections show similar water value impacts, but larger road value impacts compared to 2021, reflecting projected freight growth patterns throughout Tennessee.

Most Affected Tennessee Counties (10% Cost Reduction Scenario)

Transportation improvements also differentially affect locations. The largest beneficiary, Shelby County, is the county with the largest existing shipments, as expected. The following table (9) show Tennessee counties with significant waterway freight impacts from a 10% reduction in waterway transport costs.

Table 9 Medium 10% Scenario by County and Value Gained

Year	County	Water Value Gain
2021	Shelby	$14.20M
2021	Davidson	$5.59M
2021	Hamilton	$2.03M
2021	Montgomery	$0.42M
2021	Loudon	$0.30M
2045	Shelby	$13.60M
2045	Davidson	$7.73M
2045	Hamilton	$2.21M
2045	Montgomery	$1.05M
2045	Loudon	$0.45M

Note: Shelby County (Memphis) and Davidson County (Nashville) show the largest impacts, reflecting their roles along Tennessee's waterway system. It should also be noted that Hamilton County (Chattanooga area) and the absence of Knox County represent significant opportunity to create East Tennessee as a multi-modal logistics hub.

Benefits calculations indicate that Tennessee inland waterways provide substantial economic stimulus to the state. In table 10, we contextualize these benefits with recent infrastructure expenditures to maintain and improve inland waterways. Inland waterway infrastructure is expensive, with outlays often spanning decades. We therefore annualize infrastructure costs over the indicated horizon at 7% interest, assuming all costs are paid "up-front." While these comparisons should not be interpreted directly as cost-benefit calculations for specific projects, they do indicate the benefits from even small transport efficiency gains that support the current scale of inland waterway investment. For example, the annualized cost of the Chickamauga Lock Chamber contract ($22.4 million) is less than additional economic surplus from a 5% cost-reduction scenario.

Table 10 Contextualizing Benefits and Infrastructure Costs

Project Name	Real $ Year	Up-Front Cost	Horizon	Annualized Cost
Chickamauga Lock Replacement: Risk Based Total	**2023**	**$ 954,400,000**	**50**	**($69,155,680)**
Chickamauga Lock Chamber Contract	**2017**	**$ 309,000,000**	**50**	**($22,390,094)**

Chickamauga Lock Upstream Approach Wall	**2021**	**$ 68,000,000**	**50**	**($4,927,270)**
FY 2025 Work Plan (operations)--Nashville District	**2025**	**$ 173,000,000**	**1**	**($173,000,000)**
Dredging (270,000 cubic yards)	**2023**	**$ 8,950,000**	**1**	**($8,950,000)**

1.7 Cost and Economic Opportunity Summary

The analysis demonstrates that waterway improvement in Tennessee generates measurable economic benefits through:

- Direct cost savings for shippers using waterway transport: Using only benefits that accrue to shippers along Tennessee origins or destinations, the direct savings from a 5% cost reduction amount to $47.9M in annual surplus. This surplus corresponds to shipping an additional $23.5M to and from Tennessee counties.
- Modal substitution from road and rail to water, reducing transportation costs: Reduction in transportation operating costs has potential positive “knock-on” benefits for Tennessee business – carriers and shippers alike.
- Geographic concentration of benefits in major metropolitan counties (Shelby, Davidson, Hamilton, and Knox County) have the potential to attract additional growth through support services and suppliers.
- Environmental benefits from reduced CO_2 emissions as freight shifts to more efficient water transport

For a 10% cost reduction scenario, Tennessee county waterway freight gains approximately $22.8M in value (2021 baseline) and $25.5M (2045 projection), with the largest impacts in Shelby County (Memphis), Davidson County (Nashville), and Hamilton County (Chattanooga).

1.8 Chapter Summary and Key Findings

- The chapter summarizes the importance of inland waterways to the Tennessee economy. The sector directly employed 2,234 people in 2024 while moving $9.5 billion in goods to or from Tennessee.
- Marginal efficiency improvements provide substantial economic benefits. Navigation improvements resulting in 5% marginal cost reductions generate direct economic benefits to the state of $48.56M, a 10% marginal cost reduction would generate $98.42M annually, and a 25% marginal cost reduction provides approximately $256.96M in additional economic surplus annually, corresponding to the shipment of an additional $82.7M. Such improvements result in an increased movement of goods valued from $23.5M (5%), $34.5M (10%), and $82.7M (25%).
- Improvements, especially those concentrated on the M-55, M-65, and M-24 generate substantial spillover benefits nationally. When benefits are measured by shipment values, greater benefits accrue to Tennessee in through-traffic than to Tennessee origin-destination traffic.
- Inland waterway improvements reduce environmental emissions, while improving roadway safety. A 10% marginal cost reduction in waterways results in carbon emissions reductions equivalent to the removal of 0.67 coal-fired power plants. The resultant substitution of freight from roadways to inland waterways results in three fewer fatal heavy truck crashes annually in the state.
- The benefits of waterway improvements are concentrated in Shelby and Davidson County. The primary commodity sectors that currently benefit are Petroleum, and Ores & Waste.
- There is more commodity diversification in the Memphis and Nashville areas than in the Chattanooga and Knoxville areas. What appears to be a discouraging factor for those areas, should be viewed instead as a market opportunity as any mode of transportation is generally less concerned about what is shipped (a barge will carry stone, sand, or heavy construction equipment without the need for a barge built specifically for a commodity similar to a 53’ dry van which is designed to carry any type of freight).
- The type of commodity is less significant compared to the frequency of shipments (how often), the volume shipped (number of barges), and the location of the cargo (whether origin or destination) providing cargo is along a given route at a particular time.
- In essence, one tow of 9 barges could potentially have 9 different commodity types, one barge for each type. As such, the inland waterway system may need to be viewed similar to a less-than-truckload operation, or a container ship that carries cargo for many different customers without impacting the transportation cost.

Chapter 2

System Feasibility and Market Foundations

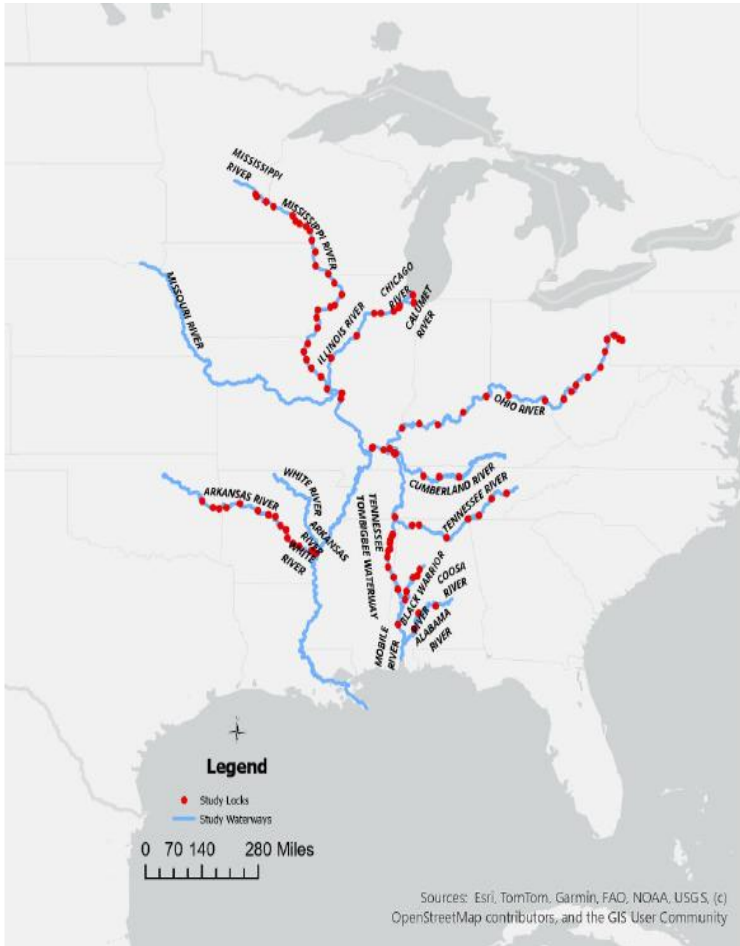
This chapter describes the physical and operational characteristics of Tennessee's waterway system. The discussion establishes the feasibility of utilizing barge transportation to access the Great Lakes and the Gulf of Mexico to and from regions in the state, including the Knoxville region. Factors discussed include water depth, channel width, navigational challenges (e.g., locks, dams), infrastructure capacity, and seasonal impacts, all of which determine waterway system performance.

2.1 Waterway and Lock Characteristics

As described in Figure 2-1, the commercial inland waterway system within the State of Tennessee is comprised of two rivers: the Tennessee and the Cumberland. Those rivers are connected to the wider Mississippi River and Ohio River systems that provides access to markets in the central regions of the United States although the primary focus of the study is centered on the more inland rivers. Export and import access to and from Tennessee and Cumberland to the south are provided via the Lower Mississippi River through the Port of New Orleans, LA and via the Tennessee-Tombigbee Waterway through the Port of Mobile, AL. Access for potential import and export to the north is provided via the Upper Mississippi and Illinois River via Chicago through the Great Lake system.

By connecting the Great Lakes to the Gulf, a vertical north to south transportation corridor is created. This corridor remains critical to support both interstate and international trade, and positions barge transport as a long-term, emissions friendly vital connector. The Great Lakes-Gulf corridor serves as a strategic asset of national significance reflecting network reach, connects multiple markets, and has long-term strategic potential, which serve as key factors regarding infrastructure investment and national freight policy. In essence, the Great Lakes–Gulf corridor also ensures long-term connectivity, enhances supply chain flexibility, and secures Tennessee's role in national freight strategy.

Figure 2-1 Inland Waterway Network and Locks



Also shown in Figure 2-1 are the locks that operate on these rivers to support barge movements through changes in waterway elevation. The processing of barge flotillas through a lock is a major source of delay within any waterway. A flotilla must wait for lock availability and dividing large tows into multiple sections when they exceed lock capacity. Additional delays are introduced while securing the tow in the chamber, during the controlled flooding or emptying of the lock, and subsequently retying the barges together after exiting each lock.

Inland waterborne cargo transportation is slower than other modes of cargo transportation, and frequently less direct. The primary advantage of moving goods on rivers is the ability to move large volumes of cargo cost effectively. Maximizing the cost advantage over other modes requires moving the largest volumes of cargo at one time with the minimum amount of added cost. This section will examine the constraints present on Tennessee's inland waterways and those that they connect to, in order to gain an understanding of the volumes of cargos might be able to move cost effectively on those waterways.

River cargoes are transported on barges which are pushed or pulled by towboats, tugboats, push boats, and other vessels designed for that purpose (hereafter, "towboats"). Generally, multiple barges are secured together into a "tow" and moved through the river by a single river towboat.

The greater the size of the tow (i.e. the more barges that can be moved at once), the greater the commercial advantage.

Cargo flows on the inland rivers are constrained by the smallest "opening" along a route: the narrowest lock chamber, the lowest bridge, or the shallowest draft depth will define any cargo that passes that point. Navigable inland waterways are constrained by draft depth (how deep the water is below the surface), air draft (the space between the surface of the water and the lowest obstacle – typically a bridge – that passes above the water), and the dimensions of lock chambers.

For the Cumberland River (which connects Nashville to the Ohio and Mississippi Rivers) and the Tennessee River, points are understood as "upriver" or "downriver" from one another – in both cases upriver is generally east and downriver is generally west. This is useful for representing where constraints or obstacles appear along a given lane (or route). For example, Knoxville is upriver from Chattanooga on the Tennessee River which means that any transits to Knoxville will encounter all constraints or obstacles that a transit to Chattanooga would, plus any additional such constraints upriver from Chattanooga on the voyage to Knoxville.

Draft depth and air draft present "go/no-go" obstacles to river navigation: vessels that are too deep in the water or too high above (including cargo), simply cannot transit a waterway safely. Lock chamber dimensions present a similar obstacle – if a barge or cargo is too large for a lock, it cannot pass through it – but also present transit time, cost, and reliability constraints on given lanes. Transit times are constrained by the time it takes for "locking through": the time it takes to bring a vessel(s) into a lock, fill-drain it, and pass through. Additional time increases operating cost which may impact rates charged. Reliability - the probability that cargo arrives when expected - is affected by lock equipment failures. The reliability of any mode of transportation impacts the shipper's decision to utilize a particular mode over another.

The number of locks on rivers connected to the state include 29 on the Mississippi, 21 on the Ohio River, 15 on the Arkansas, and 10 on the Tennessee-Tombigbee. As presented in Figure 2-2, the Tennessee River includes 8 locks, and the Cumberland River includes 4 locks. Moving from east to west, locks on the Tennessee include Ft. Loudon, Watts Bar, Chickamauga, Nickajack, Guntersville, Gen Wheeler, Wilson, Pickwick and Kentucky. Locks on the Cumberland, moving from east to west, include Cordull Hull, Old Hickory, Cheatham, and Barkley.

Figure 2-2 Tennessee River and Cumberland River Locks

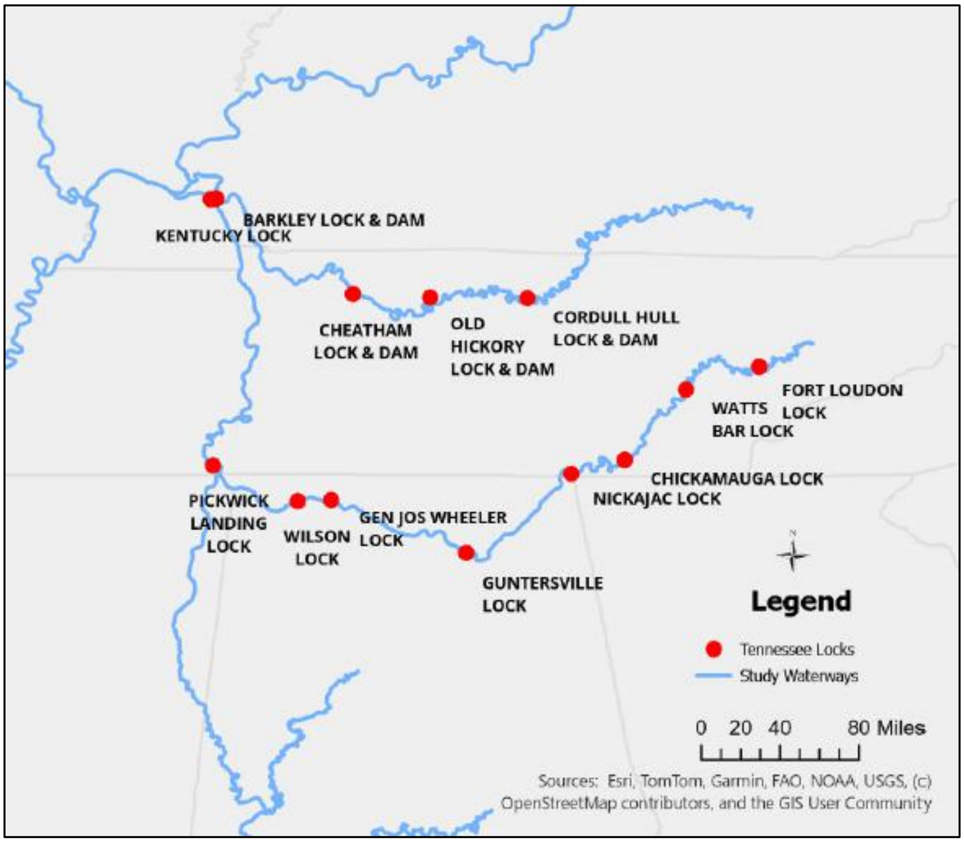


Table 11 summarizes river lengths and the number of locks over the distance of the inland river system. These rivers include the nation's longest navigable waterway and cover significant distances. The Mississippi River is 1850 miles in length stretching from Minneapolis, MN in the north to New Orleans, LA in the south. Other significant rivers connected to the Mississippi include the Ohio River, 969 miles long, the Missouri River, 788 miles long, and the Arkansas River, 500 miles in length. The Tennessee and the Cumberland Rivers are connected to the Mississippi River via the Ohio River and are also among the nation's longest rivers with the Tennessee River covering 641 miles and the Cumberland River covering 552 miles.

Table 11 Waterway Network Length and Number of Locks

River	River Length (miles)	Number of Locks on River
Alabama River	271	3
Arkansas River	500	15
Black Warrior River	168	4
Calumet River	6	1
Chicago River	6	1
Chicago River Entrance Channel	1	0
Chicago Ship Canal	4	0
Coosa River	37	0

Cumberland River	552	4
Illinois River	289	7
Mississippi	1850	29
Missouri River	788	0
Mobile River	42	0
Ohio River	969	21
Tennessee River	641	8
Tennessee-Tombigbee River	235	10
Tombigbee River	174	2
White River	418	1

Table 12 below provides information about the locks on the Tennessee and Cumberland Rivers. As shown in this table, many of the locks were multiple decades ago, with the newest lock opened over forty years ago (1984). Operating hours are generally 24 hours a day, with a few exceptions that range from eight hours to twenty hours. One lock, Cordull Hull, operates under a reservation system to operate its lock for river traffic.

The navigation channel depths are a uniform nine feet across all the locks and largely unaffected by seasonal rain patterns, unlike the Mississippi and Ohio River system. However, there is some variation from a navigation channel width of 360 feet on the Cumberland with the channel narrowing to 150 at two locks (Cordull Hull and Old Hickory locks) and 200 feet for one lock (Cheatham lock). Water levels on both of these rivers are consistently maintained at this nine-foot level by the Tennessee Valley Authority (TVA) and the United States Army Corps of Engineers (USACE). The Tennessee River depth is maintained by TVA, and the Cumberland River depth is maintained by the USACE, with the Cumberland River depth in the vicinity of the Barkley lock jointly managed by TVA and USACE. According to one barge operator, 'unlike the Mississippi River, periods of drought are less impactful on the Tennessee and Cumberland Rivers due to the TVA's efforts to manage proper depth'.

Table 12 Description of Locks on Cumberland and Tennessee Rivers

River	Lock Name	Year Open	River Mile Marker	Navigation Channel Width (ft)	Navigation Channel Depth (ft)	Operating Hours
Cumberland	Barkley Lock & Dam	1964	30.6	360.0	9.0	24.0
Cumberland	Cheatham Lock &Dam	1952	148.7	200.0	9.0	24.0
Cumberland	Old Hickory Lock & Dam	1954	216.2	150.0	9.0	20.0
Cumberland	Cordull Hull Lock & Dam	1973	313.5	150.0	9.0	Reservation Only
Tennessee	Kentucky Lock	1944	22.4	360.0	9.0	24.0
Tennessee	Pickwick Landing Lock	1984	206.7	360.0	9.0	24.0
Tennessee	Wilson Lock	1959	259.4	360.0	9.0	24.0

Tennessee	Gen Jos Wheeler Llock	1963	274.9	360.0	9.0	24.0
Tennessee	Guntersville Lock	1965	349.0	360.0	9.0	20.0
Tennessee	Nickajack Kock	1967	424.7	360.0	9.0	20.0
Tennessee	Chickamauga Lock	1937	471.0	360.0	9.0	24.0
Tennessee	Watts Bar Lock	1941	529.9	360.0	9.0	20.0
Tennessee	Fort Loudoun Lock	1943	602.3	360.0	9.0	8.0

Table 13 summarizes 2024 lock performance data for the Cumberland and Tennessee Rivers. The Kentucky lock is the center of most lock activity with over 73 barges and over 12 lockages processed per day. It should be noted that Kentucky Lock is operating at capacity and is undergoing major expansion. (Mannion, 2025, March 14) On average, lockage processing time for most locks in Tennessee is over one hour in duration. Commercial lock activity tapers off for Watts Bar and Fort Loudon locks upstream of Chickamauga due to the size constraint of each lock of one barge per lockage.

Table 13 Lock Performance Data for Cumberland and Tennessee River Locks

River	Lock Name	2024 Barges Per Day	2024 Commercial Lockages Per Day	2024 Average Lockage Processing Time (hrs.)	Lockages Per Day Capacity
Cumberland	Barkley Lock & Dam	28.5	5.6	1.04	17
Cumberland	Cheatham Lock &Dam	32.9	5.7	0.95	19
Cumberland	Old Hickory Lock & Dam	8.5	3.4	0.82	18
Cumberland	Cordull Hull Lock & Dam	N/A	N/A	N/A	N/A
Tennessee	Kentucky Lock	73.1	12.1	1.37	13
Tennessee	Pickwick Landing Lock	28.5	4.9	0.93	19
Tennessee	Wilson Lock	23.0	5.7	2.00	9
Tennessee	Gen Jos Wheeler Llock	22.9	4.9	0.90	20
Tennessee	Guntersville Lock	9.6	2.0	0.73	21
Tennessee	Nickajack Lock	4.6	1.1	0.63	24
Tennessee	Chickamauga Lock	1.3	1.6	0.85	21
Tennessee	Watts Bar Lock	0.9	1.5	1.21	12
Tennessee	Fort Loudoun Lock	0.6	1.1	1.00	8

Table 14 below contains a summary of the current barge capacity for each lock, as well as the expanded lock capacity that results from planned expansions at Kentucky and Chickamauga. The Tennessee River upstream of the Chickamauga lock has a restricted lock capacity with the capability to process only a single barge per lockage. Therefore, without an upgrade in barge capacity, the time required to move barges through these locks (Chickamauga, Watts Bar, and Ft.

Loudoun) significantly increases travel time for freight moving through these facilities to and from the Knoxville region in which any additional increase in time will also increase operating costs as well.

Table 14 Barge Capacity for Cumberland and Tennessee River Locks

River	Lock	Chamber Dimensions (Length × Width) ft	Barges Long	Barges Wide	Total Barges
Cumberland	Barkley Lock & Dam	800×110	4	3	12
Cumberland	Cheatham Lock &Dam	798×110	4	3	12
Cumberland	Old Hickory Lock & Dam	397×84	2	2	4
Cumberland	Cordull Hull Lock & Dam	400×84	2	2	4
Tennessee	Kentucky Lock	600×110	3	3	9
Tennessee	Pickwick Landing Lock	1000×110	5	3	15
Tennessee	Wilson Lock	600×110	3	3	9
Tennessee	Gen Jos Wheeler Llock	600×110	3	3	9
Tennessee	Guntersville Lock	600×110	3	3	9
Tennessee	Nickajack Kock	600×110	3	3	9
Tennessee	Chickamauga Lock	360×60	1	1	1
Tennessee	Watts Bar Lock	360×60	1	1	1
Tennessee	Fort Loudoun Lock	360×60	1	1	1
Tennessee	*Kentucky Lock (Updated)*	*1200x110*	*6*	*3*	*18*
Tennessee	*Chickamauga Lock (Updated)*	*600x110*	*3*	*3*	*9*

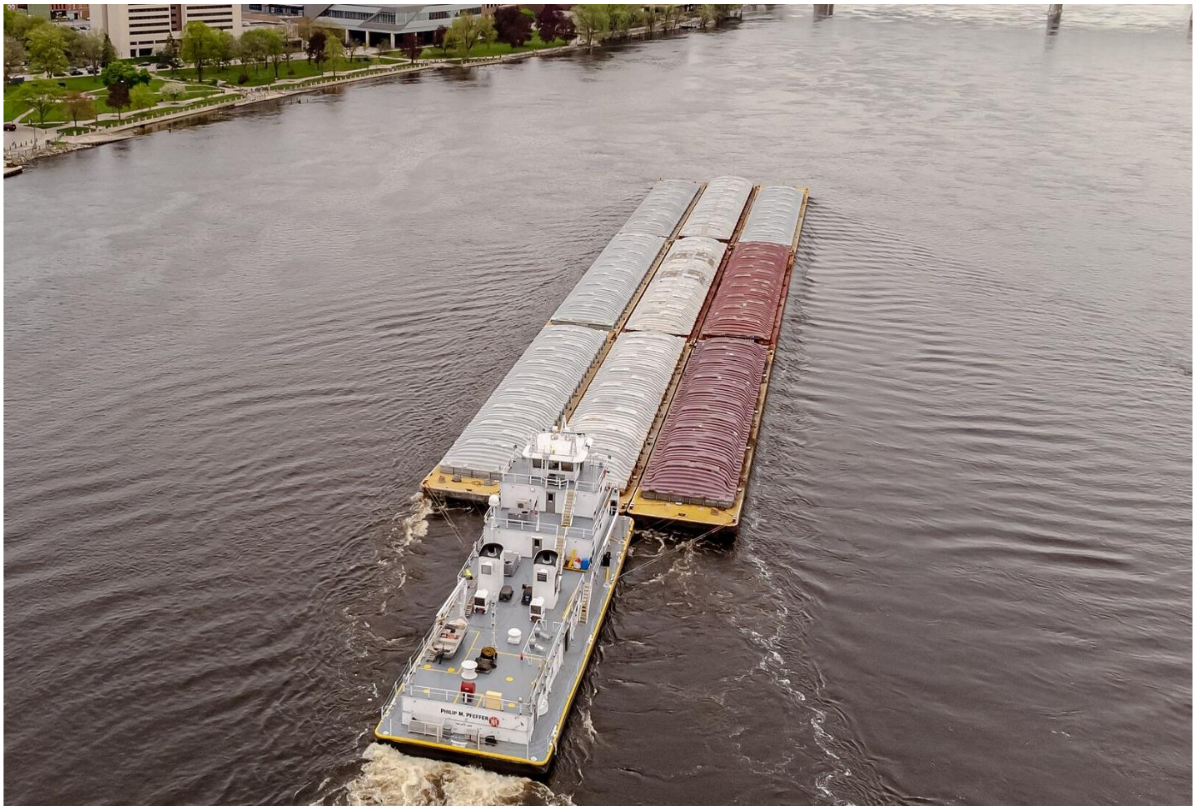
Lock chamber dimensions define the number and size of vessels (towboats, barges) that can pass through a lock in a single lockage. In the event the lock chamber is not large enough for the tow, the tow must be separated into units that can "lock through" (Figure 2-3) or transit through the lock. This means unlashing the barges, sending the barges through the lock based on the size capacity of a particular lock at one time, and then lashing the barges back together once all have locked through. As a result, lock chamber dimensions present the most dramatic constraint on cost-effective inland river transportation due to the considerably amount of time needed to transit a lock.

Figure 2-3 Tow Locking Through

Lock dimensions allow for a three-by-three tow (seen in Figure 2-4) of standard inland barges (nine barges in all) to lock through in a single lockage. This does not leave room for the towboat to pass through at the same time. Some locks have an auxiliary lock: a second, typically smaller, lock that can be used in the event that the primary lock is unusable[8]. Tows passing through such a lock may do a "fast double," whereby the barges lock through the primary lock while the towboat locks through the auxiliary lock. Alternatively, the towboat may simply lock through the primary lock after the barges pass through. Some operators may choose to assemble tows of eight barges in order to leave room for the towboat to complete the lockage with the rest of the tow.

[8] Often, when a lock is expanded, a new lock chamber will be built to be used as the primary lock, and the existing lock will remain as the auxiliary lock.

Figure 2-4 Towboat with a 3x3 tow



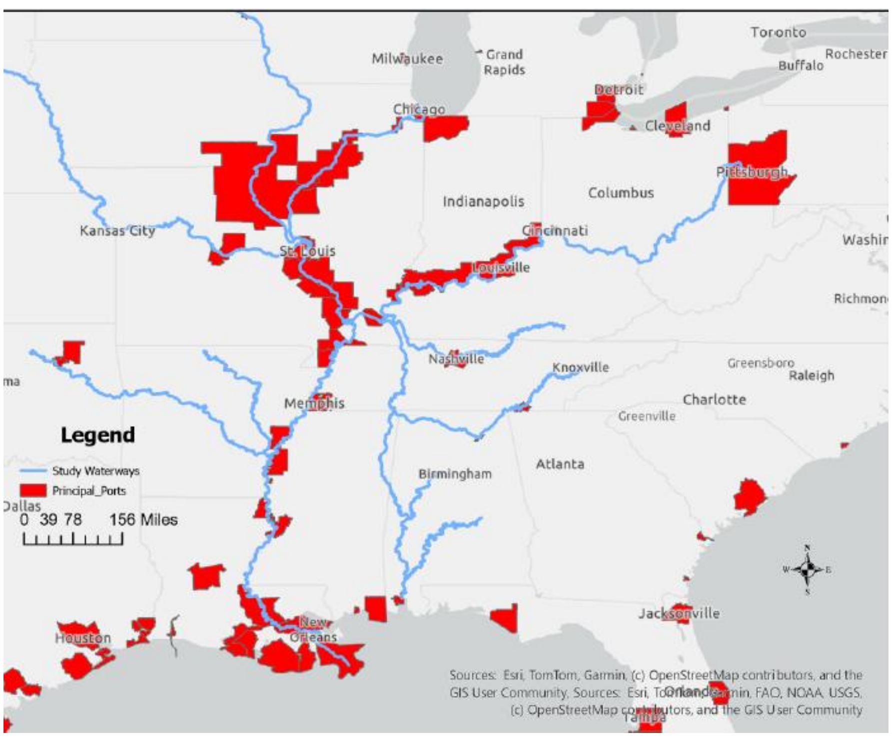
Accessing Knoxville requires locking through seven locks on the Tennessee River in addition to any locks encountered along the route to reach the Tennessee River. Of the seven locks, there are four locks downriver from Chattanooga that are built to the 110’ X 600’ standard dimensions (the Wilson, Wheeler, Guntersville, and Nickajack locks). Upriver of Chattanooga, on the route to Knoxville, are three locks built to a smaller dimension of 60’ X 360’ (the Chickamauga, Watts Bar, and Fort Loudoun locks). These locks can only accommodate a single barge per lockage thereby one tow of eight barges would entail eight hours to transit each separate lock. The Chickamauga lock is in the process of expanding: a lock with interior dimensions of 110’ X 600’ is being constructed and the existing lock will be filled in. Currently, there have been no plans stated by USACE or the Tennessee Valley Authority (TVA) to expand either the Watts Bar or Fort Loudoun locks which will remain an inhibitor for any transit towards Knoxville and East Tennessee.

Knoxville is connected by water to the Gulf by two routes: either via the Tennessee-Tombigbee Waterway (reaching the Gulf at Mobile) or via the Mississippi River (reaching the Gulf downriver of New Orleans). Geographically, the shortest route from Knoxville to the Gulf by water is via the Tennessee-Tombigbee. However, 12 locks must be transited in order to complete this route (in addition to the seven locks on the Tennessee River). Additionally, failure of any of these locks closes the route until the lock is repaired. As recently as 2024, the Demopolis Lock failed and was closed for four consecutive months – effectively shutting down navigation from all upriver points to the Gulf on that route (McCormack, 2024)[9]. The river route from Knoxville to the Gulf via the Mississippi River has only three additional locks on the route: the Pickwick (110’ X 1,000’), Kentucky (110’ X 600’), and Olmsted (110’ X 1,200’) locks yet also increases in total transit time.

2.2 Principal Ports

Figure 2-5 presents a map of Principal Ports throughout the majority of the inland river system. The United States Corps of Engineers (USACE) designates a principal port if it handles at least 1 million short tons of total waterborne commerce. All waterborne tonnages are included such as bulk commodities (e.g. coal, grain, petroleum, aggregate), breakbulk and containerized cargo. Designation as a principal port affects federal navigation planning (e.g., channel maintenance priorities) and infrastructure funding justification which may limit available federal funding sources. Figure 2-5 also illustrates a number of Principal Ports along the Ohio River and the Upper Mississippi River just north of the junction of the Ohio and Mississippi rivers. Of note, are the number of and volume (size) of “red” throughout Tennessee particularly in comparison to other regional, inland river states highlighting a potential gap in port-designated and related activity in the state. In other words, other states have implemented policy and regulations to precipitate the use of their inland waterway system by incorporating more port authorities, councils, or districts such as the Port of Tulsa, OK, and Jeffersonville, IN (Ports of Indiana).

Figure 2-5 USACE Principal Ports



As presented in Table 15, there are only three principal ports in Tennessee: Chattanooga, Memphis and Nashville which includes total tonnage moved in 2023 and ranked based on the tonnage moved of all principal ports per USACE.

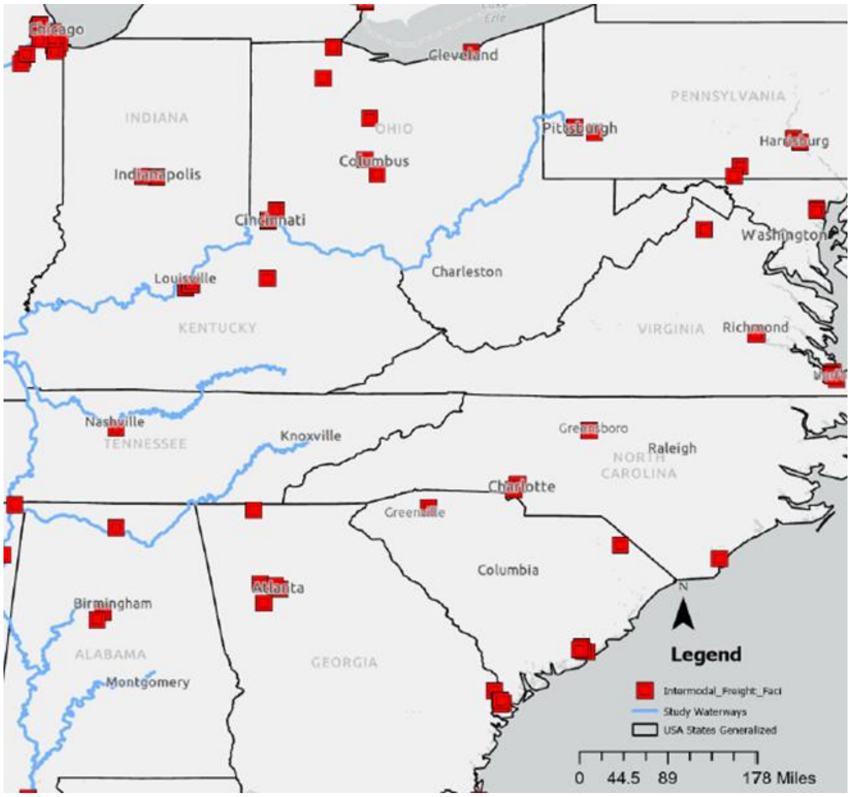
Table 15 Principal Ports in Tennessee

Port	Tons	Rank
Chattanooga	2,138,974	118
Memphis-Shelby County Port	7,195,444	64
Nashville	7,557,647	60

2.2 Rail Intermodal Facilities

Intermodal connections between barges and freight rail transportation can provide shippers with a wider market reach. Combining the carrying capacity of barge with the speed of rail transport can result in lower unit transport costs and travel time reductions for shippers. Figure 2-6 displays the location of intermodal rail facilities in the east-central region of the nation.

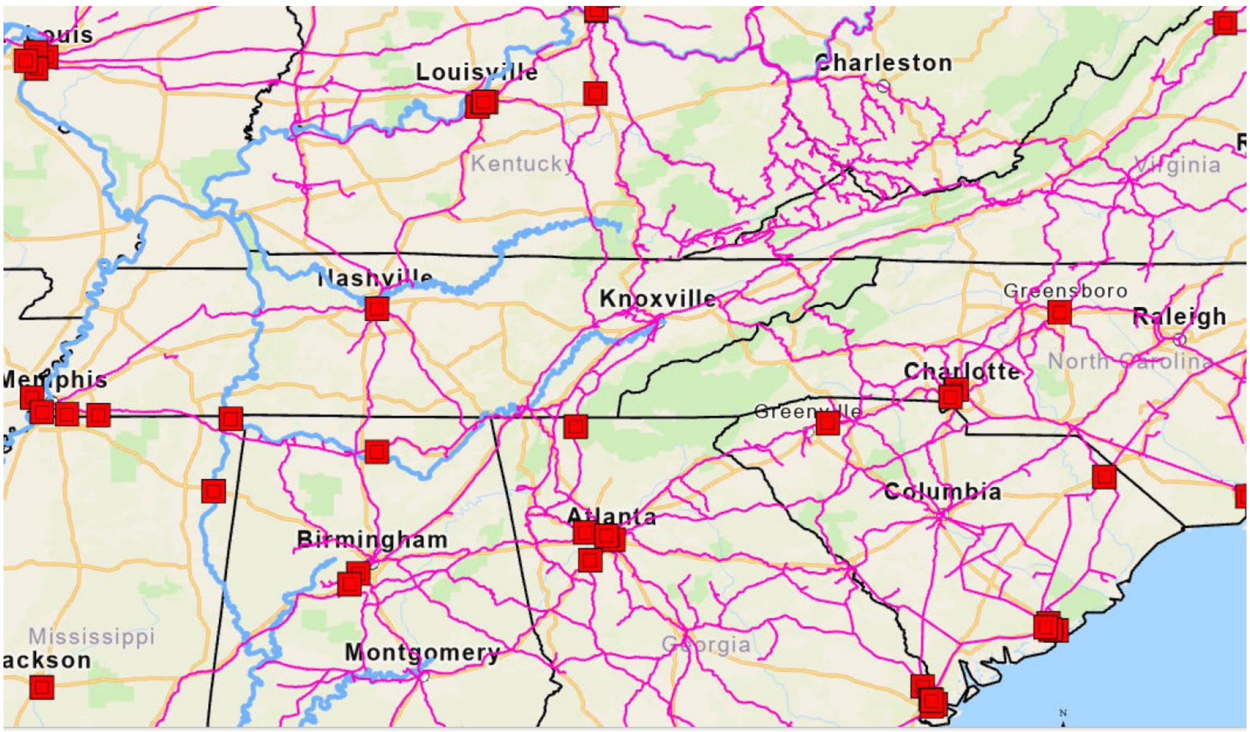
Figure 2-6 Class I Intermodal Facilities



Memphis and Nashville have direct access to Class-I intermodal rail operations, and Chattanooga is located near the Norfolk-Southern Blue Ridge Connector intermodal facility. What's more significant is the clear lack of an intermodal rail facility near Knoxville and east Tennessee region.

Similarly, figure 2-7 indicates that while intermodal rail lines operate in the Knoxville area, there is no intermodal rail facility within a four-hour travel time by truck, which eliminates the possibility of combining barge and rail movements and subsequently any potential benefits for a shipper. Shippers are thereby forced to pay for a roundtrip movement since no intermodal facility is nearby to connect the supply of recently full containers with the demand for an empty container to be loaded. What remains is an imbalance of head-haul and back-haul causing significant cost increase for trade in or with Tennessee businesses.

Figure 2-7 Class I, Short-line Rail, Interstate, and Waterway Network



One should note the number of rail lines that exist nearly alongside the Tennessee River highlighting the opportunity for supporting more multi-modal operations. Furthermore, while a rail line connects Memphis to Nashville, no direct rail line exists to connect Memphis to Nashville, onto Knoxville and east Tennessee markets thereby forcing freight to travel north to Louisville and then south to Knoxville, or south towards Chattanooga and then northeast to Knoxville. Either option increases the transit time and cost for industry operating or considering operating in Tennessee.

2.3 Water Transload Facilities

The U.S. Freight Transload Facilities Dataset provides location information for more than 9,000 facilities across the nation where freight may be transferred between waterways, railways, and roadways. The dataset identifies known modes and available intermodal freight transfers at each facility as of 2024. Figure 2-8 identifies the location of water transload facilities in Chattanooga (18), Knoxville (3), Memphis (74 not depicted in Figure 2-8) and Nashville (19). Table 16 presents the number of water transfer facilities that provide access to rail and road modes. All of the facilities provide access to road transport, and a significant number provide access to rail. Knoxville has the least number of water-to-road transload facilities.

Figure 2-8 Transload Facilities Connected to Tennessee Waterways

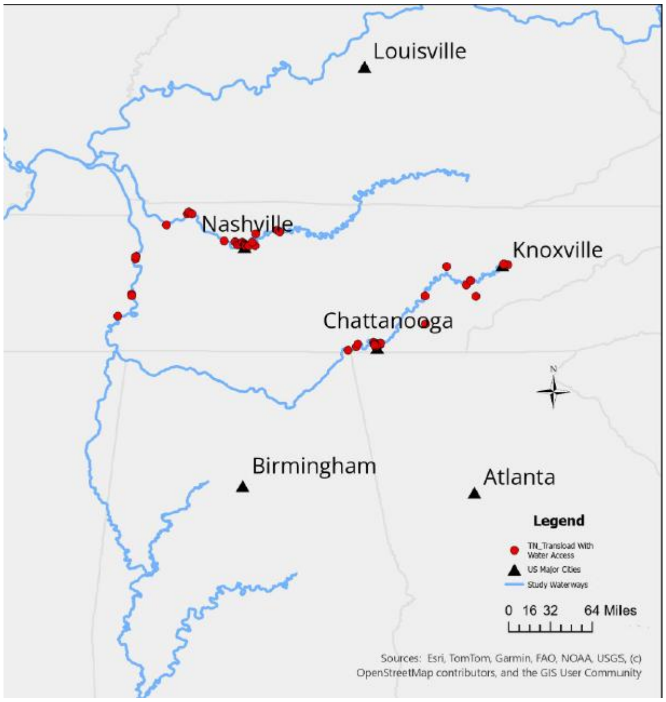


Table 16 Transload Facilities with Rail and Highway Connectivity in Metropolitan Tennessee

City	Number of Water Transload Facilities	% With Water/Rail Connectivity	% With Water/Highway Connectivity
Chattanooga	18	72%	100%
Knoxville	3	100%	100%
Memphis	74	81%	100%
Nashville	19	47%	100%

2.4 Rates and Transit Times

RATES AND TRANSIT TIMES

Based on information collected, the team developed price and transit time estimates for route pairings between Tennessee ports and other points on the US inland river system (Table 17). Findings are represented in the table below. Understanding the relationship between transit time and cost per ton significantly impacts a shipper's decision to utilize the inland river system and more effectively manage their supply chain particularly for resiliency.

Table 17 Rate and Transit Times

Route	Estimated Transit (in Days)	Estimated Cost per Ton
Knoxville – Mobile	30	$48.33
Knoxville – Chicago	33	$36.96
Knoxville – Memphis	22	$34.29
Knoxville – New Orleans	27	$37.28
Nashville – Mobile	20.5	$37.22
Nashville – Chicago	21	$29.94
Nashville – Memphis	9.5	$27.27
Nashville – New Orleans	15	$30.08

*Freight flows from Chattanooga would be a few days less than Knoxville to listed destinations since any freight from Knoxville will sail through Chattanooga.

2.4 Statewide Inland Waterway System Feasibility for Tennessee, with Implications for Knoxville

Based on the system characteristics and operational performance presented in this chapter, Tennessee's inland waterway system is both fundamentally feasible and strategically important at the statewide level. The Tennessee and Cumberland Rivers provide reliable, year-round navigation with a uniformly maintained nine-foot channel depth, controlled water levels, and direct connectivity to the Ohio and Mississippi River systems, enabling access to both Gulf and Great Lakes markets and beyond. These physical attributes, managed by the Tennessee Valley Authority and the U.S. Army Corps of Engineers, establish a strong baseline for barge transportation as a competitive and resilient freight mode within the state and subsequently aiding the nation.

From a system perspective, Tennessee's system feasibility is reinforced by the presence of three United States Army Corps of Engineers (USACE) designated Principal Ports, including Memphis, Nashville, and Chattanooga, that benefit from access to higher lock capacities and stronger intermodal connectivity. Ongoing and planned investments at key bottlenecks—most notably at the Kentucky and Chickamauga Locks—further strengthen the long-term feasibility of the Tennessee River as a freight corridor thereby increasing the state economy and employment.

The on-going expansion of the Chickamauga lock will have a positive impact on the regions economy all the way upstream to the Watts Bar lock. However, feasibility is not uniform across all regions of Tennessee, and conditions from the Watts Bar lock upstream illustrate the limits of system performance. The Knoxville region, while physically connected to the inland waterway network, faces challenges due to infrastructure, institutional, and market constraints. Single-barge lock chambers at Watts Bar and Fort Loudoun impose severe throughput limitations and magnify delay impacts for freight traffic moving to and from East Tennessee. Institutionally, Knoxville's absence from the list of Principal Ports weakens its position in federal navigation planning and complicates benefit–cost justification for targeted investments.

Market conditions further limit feasibility: Knoxville and East Tennessee lacks an intermodal rail terminal and is served by a small number of transload facilities compared to other major Tennessee and regional ports. This greatly reduces its ability to support high-volume or long-haul intermodal freight volume. Low existing barge volumes (demand) upstream of Chickamauga reinforce a cycle in which limited traffic constrains investment justification, while constrained infrastructure suppresses future demand.

2.5 Chapter Summary and Key Finding

- The chapter summarized Tennessee's inland waterway system as broadly feasible and nationally significant, supported by strong physical infrastructure, principal port activity, and strategic connectivity. Knoxville and East Tennessee represents a localized exception within this otherwise robust system.
- The State and USACE's effort to expand the Chickamauga lock will soon provide additional economic and business development upstream to the Watts Bar lock. While beyond the scope of this study, the expansion creates opportunity for communities and industry along those banks. Support to expand the Watts Bar and Ft. Loudon locks would subsequently provide additional economic and business development opportunities beyond Knoxville.
- While barge transportation to Knoxville is technically feasible, it remains economically marginal under current conditions and dependent on system-level investments rather than standalone local improvements.
- Within the broader Tennessee context, Knoxville's future feasibility hinges on upstream lock modernization, enhanced intermodal integration, and coordinated efforts to build sufficient waterborne volumes to align with statewide and national navigation priorities.
- Other than lock modernization efforts, Tennessee's inland waterway system has the available capacity to support a significant amount of additional tonnage thereby illustrating that the supply-side of waterway system already exists.
- Whereas other states have supported the creation, development, and expansion of port authorities, councils, or districts, most Tennessee port areas appear to be less pronounced which may create an opportunity for other states to grow, or for Tennessee to enhance.

- Existing waterway, rail, and interstate physical infrastructure exists throughout the state although there is no intermodal or multi-modal operations in East Tennessee, southwest Virginia, southeast West Virginia, or eastern Kentucky. Shippers and recipients' transportation costs will remain high since cargo in that area has very limited head-haul or backhaul opportunities forcing the parties to pay a roundtrip rate for one-way cargo.

Chapter 3

Alternative Routing, Constraints, and Risks

This chapter explores alternative strategies to increase the use of the state's waterway system. Alternative routes, intermodal strategies, and possible partnerships are discussed. Constraints and risks that may arise from implementation of these strategies are also examined.

3.1 Alternative Routing Strategies

As demonstrated earlier in this report, water levels on the inland waterway system in Tennessee are actively managed by the TVA and USACE and do not present a constraint to barge operations. Elevation changes over the length of the waterway system are managed by a series of locks with varying age and capacity. The greatest capacity limitations are present in East Tennessee upstream from Chattanooga where locks capacities are much lower than other sections of the Tennessee River and thereby reduces the amount of freight that can be efficiently processed in locks between Chattanooga and Knoxville. The expansion of lock capacity in this section of the Tennessee River would improve the feasibility of waterway transport to and from Knoxville.

Commercial waterways in Tennessee are among the largest and longest in the nation and directly connect with key waterways in the central portions of the country. This connection provides waterway access to the state's major metropolitan areas including Memphis, Nashville, Chattanooga, Clarksville and Knoxville (the 5 largest metropolitan areas in Tennessee). This connection links Tennessee's metropolitan areas to major internal Principal Ports, along the Ohio and Upper Mississippi, as well as the Great Lakes (through Chicago), and New Orleans (through the Mississippi), and Mobile (through the Tennessee-Tombigbee) enhancing the Great Lakes-Gulf corridor as a vital strategic asset. Having such a vibrant connection to other ports provides greater opportunity for shippers and recipients throughout the state helping them to connect to both inter-and-intra national markets.

This access provides the opportunity for barge movements to and from Knoxville to points located both to the north and to the south. Moving products through the Great Lakes to and from Knoxville, while feasible, would require long travel times due to the number of locks along this route as well as the waterway distance (miles) from Knoxville. Movements from Knoxville to and from ports along the Ohio River and Upper Mississippi are feasible and much shorter than movements through the Great Lakes. In addition, ports along the Ohio and Upper Mississippi Rivers contain sufficient equipment to facilitate water transfer to and from both highway and rail modes.

Movements to and from Knoxville to the south are also feasible as the Ports of Mobile and New Orleans are currently importing and exporting products from Knoxville. Each port also has the necessary terminal infrastructure providing the flexibility to handle a variety of commodities that may originate or are destined throughout Tennessee. Table 18 illustrates the tonnage moved in 2024 to and from Knoxville to select multi-modal hubs.

Table 18 Knoxville Imports and Exports in 2024 listed in Thousands of Tons

	FAF Region		
Movement	**New Orleans**	**Mobile**	**Chicago (IL portion)**
Exports from Knoxville	42.5	4.0	2.3
Imports to Knoxville	146.4	5.3	7.4
Total	188.9	9.3	9.7

Industry facing organizations such as the Tennessee Department of Community & Economic Development (TNECD) and others throughout the southeast, have been successful attracting more companies to locate or expand in the state or region. While such efforts are highly commendable, it may serve as a double-edged sword as the additional growth places greater strain on the highway system. For example, Korea Zinc announced in December 2025 an investment of $7.43B for a new smelting plant in Clarksville, TN. While it is unclear the precise location of the new facility, Clarksville is located on the Cumberland River which could act as a mode of transportation for both the inbound raw materials and outbound finished products. Based on the annual volumes provided in the article, table 18 represents a comparison of the number of trucks and barges needed just to transport the finished minerals from the plant (inbound volume of raw materials to produce the finished products was not provided). Based on the capacity of each mode, payload of an inland deck barge is 1400 short tons (1270 mt) whereas the payload of a 53' heavy duty trailer - 25 short tons[10].

Table 19 Barge vs. Truck Comparison

	Trucks w/ 25 short ton trailers	**Inland barges[11]**	**9-barge tows**
300,000 mt of lead	13,228	237	27
200,000 mt of lead	8,819	158	18
35,000 mt of copper	1,544	28	4
Totals per mode	23,591	423	49

The comparison is the difference between nearly 24,000 additional trucks on the Tennessee roadways compared to 49, 9-barge tows on the Cumberland River. Since Ingram Barge Company is based in Nashville, if Korea Zinc were to use the Cumberland River a Tennessee company would directly benefit as well as creating additional opportunities in throughput volume.

[10] Higher payload trailers exist, but would require special permits for each transit

3.2 Intermodal Strategies

Intermodal rail facilities are directly available in Memphis and Nashville as well as available in a location proximate to Chattanooga. However, there is no intermodal rail facility in Knoxville nor within a five-hour drive by truck (Nashville and Greenville, SC are the closest). The development of an intermodal rail facility, with connections to the Tennessee River in Knoxville, would create an opportunity to combine the speed advantages of rail with the low-cost advantages of waterway. Under the right circumstances, intermodal movements make the use of waterway transport more feasible to shippers and increase the use of the Tennessee River in the Knoxville region. Of course, the development of a rail intermodal facility should be combined with lock capacity increases to maximize potential benefits from intermodal movements.

3.3 Partnership Strategies

The planning, design, operation, and use of waterway transportation in Tennessee engages at number of stakeholders. Public agencies, including the USACE and TVA, are responsible for the construction and operation of river and lock systems. Multiple towboat operators move barges under contract to shippers in response to customer freight movement demands. Terminal operators provide access to waterways and inventory storage as well as serving as an interface for intermodal movements. Examples of public-private partnerships exist including the recent announcement between TDOT, Cheatham County, and the Ingram Marine Group to create the Ashland City River Port project to enhance multimodal operations in the area.

Many states have found that coordinating intermodal and economic development efforts around their waterways can greatly enhance the feasibility of waterway usage (Limbourg, Macharis, et.al., 2014). In response, states have legally enabled the designation of special bodies, such as Port Councils, to promote waterway development and use. For example, a Port Council can serve an entity to focus development and promotion of waterway assets among stakeholders and provide a meeting place to raise awareness about waterway transportation opportunities. Without a focus, waterway transport investment becomes more random and opportunistic rather than more predictable and systematic. Systematic investments in the waterway can improve the overall performance of the entire network and overcome some of the challenges of moving freight by barge.

3.4 Constraints and Risks

Freight movement to-and-from Knoxville, Nashville, and Chattanooga is constrained largely by the locks present on the routes that involve each port – none more so than Knoxville. The locks add transit time, cost, and unpredictability to supply chains that utilize the rivers. Encouraging use of the rivers for cargo transportation is largely a function of managing the constraints and finding freight that will still move in spite of them.

Reaching Knoxville via the Tennessee River requires transiting three locks that are built to a smaller standard than the rest of the US inland river system. One of these is the Chickamauga Lock, currently being expanded to the standard of 110’ X 600’ – enough to accommodate a 3x3 river tow. Shifts in transits after the expanded lock open may be an indicator of how expanding a lock affects activity through the lock and volumes at river terminals upriver of the lock.

At present, lock expansions are considered unwarranted due to a lack of use. However, tow operators are not going to be able to competitively utilize a lock that is too small – so volumes are unlikely to increase without expansion of the locks. The Chickamauga lock expansion's stated rationale is not due to freight volumes: the existing lock is becoming structurally unsound and must be replaced. Rather than replace the lock at its current dimensions, USACE and TVA elected to expand the lock dimensions to conform to the standard.

Replacing and expanding locks is also expensive: the Chickamauga lock expansion project has an estimated total budget of over $950 million. As a result, it's possible that any future expansion of the Watts Bar and Fort Loudoun locks may only occur in the event that they require replacement, as with the Chickamauga lock.

Ample air and water drafts along the river routes provide an opportunity for project cargo: large, frequently heavy, cargo pieces. Some examples of project cargo include assembled equipment or machinery such as industrial generators, reactors, or cranes. With cargo weights restricted only by the payload of barges (not by road or rail infrastructure), cargoes can move by water that are extraordinarily heavy which would need to be divided into smaller units to move over land by rail or road. Likewise, the infrastructure and some equipment necessary to discharge heavy pieces can be mobilized via water as well. In fact, current Ro-Ro (roll-on, roll-off) terminal exists a few miles upriver from Knoxville. Figure 3-1 and Figure 3-2 shows the Burkhart Enterprise terminal in Knoxville and an example of a mobile home being shipped on a barge in New Bedford, MA. (June 2025). A more expansive example of project cargo moving on the Tennessee River is the *R/S RocketShip* owned by United Launch Alliance (Weaver, A., 2025) in Figure 3-3. Such examples demonstrates the versatility of the inland river system and the opportunity for mode shift from road or rail to the Tennessee waterways.

Figure 3-1 Knoxville Roll-On/Roll-Off Terminal

Figure 3-2 Mobile Home on Barge

Figure 3-3 *R/S RocketShip*

For Tennessee to encourage the use of the inland rivers for project cargo, one could view Indiana by using the Ohio River terminals to support manufacturing operations in the state by moving project cargo through the ports of Mt. Vernon (Figure 3-4) and Jeffersonville (Figure 3-5). A similar example of project cargo flowing upstream towards Port Catoosa from the Mississippi River on the Arkansas River can be found in Figure 3-6.

Figure 3-4 Project Cargo, Mt. Vernon, IN

Figure 3-5 Steel Coils, Port of Jeffersonville, IN

Figure 3-6 Project Cargo, Port Catoosa, OK

The feasibility of increasing the use of the Tennessee's waterway system is constrained by three factors: limited infrastructure investment, limited terminal capacity, and low stakeholder collaboration.

Capital investment for inland waterways is very limited and typically entails federal and state funding. Modernization requires sustained and increased funding for operations, maintenance, rehabilitation, and new construction, with taxpayers and the Inland Waterways Trust Fund currently investing about $920 million annually, but with a backlog of roughly $800 million. Completing priority projects, expanding capacity, and adopting sustainable funding mechanisms (e.g., revising cost-sharing or user-pay strategies) are widely cited as essential to avoid rising shipment costs, supporting supply chains, and sustaining economic benefits such as job creation and export competitiveness.

Limited waterway terminals focused on transloading freight from water to either rail or road, particularly in the Knoxville region, greatly constrain the efficiency, reliability, and capacity of waterborne freight transportation. Limited intermodal connections, where cargo can be transferred between modes (e.g., barge to truck/rail), constrains the geographic reach and flexibility of waterway transportation. It can also increase transport costs as more expensive modes must be used. Expanding and modernizing inland terminal infrastructure is crucial to unlock the full economic and operational benefits of waterway transport by improving connectivity, capacity, and competitive positioning with respect to other freight modes. Such investment would necessitate the efficient and effective movement of cargo on the waterway system by managing the trade-off of time as described earlier in the report.

Low stakeholder collaboration can result in lost economic development benefits due to limited awareness of waterway transportation opportunities. Lower collaboration results in missed investment opportunities due to fragmented project planning and implementation. Furthermore, weak collaboration can result in reduced reliability and competitiveness due to bottlenecks and service variability, pushing shippers towards higher cost road or rail alternatives. That sort of proposition also increases the maintenance cost, volume moved, and congestion on Tennessee roadways.

The combined risks from these constraints include:

Reinforcement of highways and rail congestion: Failure to shift freight to waterways increases pressure on already congested highways and rail corridors, raising public infrastructure costs, emissions, and long-term system inefficiencies. As Tennessee and the southeast continue to grow and attract more industrial development, more freight will pass-through Tennessee to reach its destination thereby increasing congestion but also wear-and-tear on the highways and rail system. The situation is further exacerbated if the cargo is more oversized and over-dimensional or project related or hazardous material such as electric automobile batteries.

Cost escalation and loss of competitiveness: Continued underinvestment and project backlogs increase delays, unreliability, and lifecycle costs, pushing shippers toward higher-cost road and rail modes and eroding the cost advantage of water transport.

Underutilization of the waterway network: Limited terminal capacity and less than optimal intermodal connectivity restricts market access and cargo diversity, resulting in stranded infrastructure capacity even where navigable waterways exist.

Foregone economic development and private investment: Fragmented planning and weak stakeholder collaboration reduce awareness of waterway opportunities, discourage private terminal and logistics investment, and limit job creation and export growth.

3.5 Chapter Summary and Key Findings

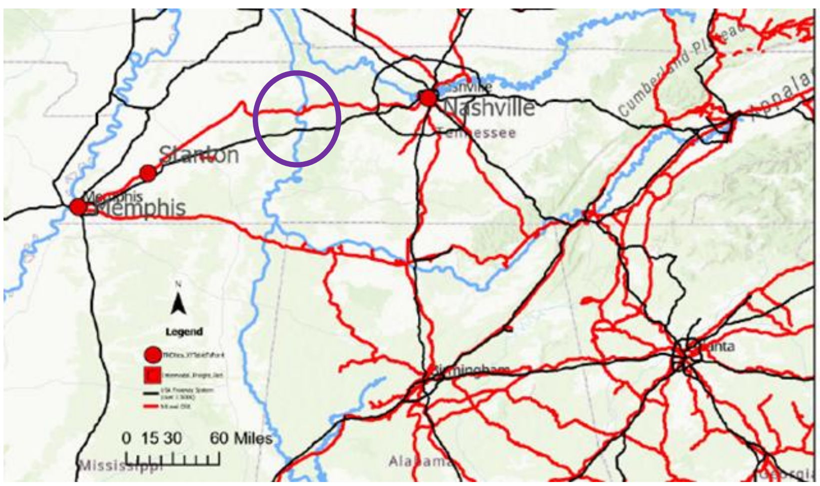
- This chapter examined the opportunities, constraints, and risks associated with increasing use of Tennessee's inland waterway system through alternative routing, intermodal strategies, and partnership models.
- The chapter highlighted how targeted lock expansions, intermodal rail–water connections and coordinated partnership structures such as port councils could significantly enhance system performance.
- Economic growth will continue to place additional burden on the road and rail network in the state yet creates an opportunity to encourage shippers to use the Tennessee river system. In particular, attention needs to be given to the Great Lakes-Gulf transportation corridor by realizing the long-term capability as a national strategic asset by shipping freight with lower emissions.
- Tennessee's waterways provide extensive connectivity to major domestic and international ports and offer feasible north–south and regional freight movement options, capacity limitations—particularly aging and undersized locks upstream of Chattanooga eastward towards Knoxville —and the absence of intermodal rail facilities in Knoxville constrain full utilization.
- Limited capital investment, insufficient terminal capacity, and weak stakeholder collaboration pose substantial risks, including higher transportation costs, underutilized infrastructure, increased highway and rail congestion, and missed economic development opportunities.
- Addressing these constraints through sustained investment, support for a statewide port governance model, terminal modernization, and systematic, collaborative planning is essential to improving the competitiveness, reliability, and economic impact of Tennessee's waterway transportation network.
- Not addressing those constraints limits Tennessee's ability to compete with neighboring states on both a domestic and global scale particularly in the absence of a multi-modal operation in East Tennessee.
- Tennessee's inland waterway system has an imbalance of supply and demand with ample supply-side infrastructure yet suffers from a lack of demand (users).
- Bulk cargo, project cargo, overweight, oversized, and other non-standard sized cargo presents a unique opportunity for inland waterway shipping.

Chapter 4 Conclusion and Recommendations

Building from the previous study (RES 2023-07), this study concludes that Tennessee's inland waterway system is significantly underutilized and creates an opportunity for the state to capture significant economic, environmental, and infrastructure benefits. Tennessee has the ability to leverage its inland waterways to enhance its competitive position, promote sustainable development and build a more resilient supply chain.

By developing its waterways for freight transportation, the state can attract businesses seeking efficient transportation routes and expand market access to Tennessee-based industries. Additional benefits can be created by connecting the state's waterways with other modes of transportation. For example, figure 4-1 illustrates an intermodal opportunity between Memphis and Nashville that integrates water, road, and rail transportation. This site includes access to I-40, the CSX rail line, and the Tennessee River eventually the Port of Mobile, AL, via the Tennessee-Tombigbee waterway. The location is also only 30-minutes further from Stanton, TN, than Memphis, which creates an alternative transshipment location for the Tennessee Truck Plant.

Figure 4-1 Intersection of Multiple Modes



4.1 Associated Costs and Economic Benefits

The study found that medium investments in navigation improvements would result in a 5-10% marginal operating cost reduction and generate direct economic benefits to the state ranging from $48.56M to $98.42M annually. Just as important are the ancillary benefits, or "knock-on benefits" to support services and the ability to attract additional users to the Tennessee river system.

Investments will be beneficial and important for the State to attract new companies and incentivizing existing companies to expand operations in Tennessee particularly on routes to East Tennessee. An excellent example is the public-private partnership between TDOT, Cheatham

County, and Ingram Barge mentioned earlier. Determining what type and cost of potential incentives should be the focus of future studies.

Advancing the commodity (or product) diversification on the inland river system also increases the economic benefit for the users but also improves the opportunity for creating 'logistics cluster'. Rather than viewing the inland system for only aggregate related commodity classes use, the state has the opportunity to potentially be the nationwide leader for project cargo, manufactured modules for the maritime industry related to the SHIPS Act and other heavy manufacturing industries such as Caterpillar and John Deere which both firms have operations near other inland rivers that connect to the Tennessee waterway.

Korea Zinc, described earlier, serves as an exceptional example of a potential user for the Cumberland River. The Port of Galveston, TX is now connected to the Hudson River through the Erie Canal for component and breakbulk operations illustrating what is possible through an inland river system. The recent announcement of a $560M investment in Oak Ridge by Centrus for its new centrifuge manufacturing facility, or the Kairos Power development of a low-power reactor, provides additional examples of potential waterway users. In fact, the overall investment in the Oak Ridge area is nearly $10B. Each project will require not only a significant amount of aggregate but also large, heavy construction supplies (steel coils) and equipment (generators, transformers, HVAC) all of which would be suitable for shipment on the inland river system (this also assumes the origin is connected near the inland river system but not necessarily on) rather than adding further strain on Tennessee highways.

On the other hand, Tennessee may be faced with considerable use of its highways by users merely passing through the state without providing any significant economic benefit. Toyota announced in November 2025 a $912M investment to increase production of hybrid vehicles in the mid-south/south region. The Tennessee facility in Jackson will benefit from receiving $71.4M of that investment. Toyota also announced a $14B plant located in Randolph, North Carolina that will produce batteries for their hybrid vehicles produced in Kentucky (Toyota's largest plant globally), Mississippi, Missouri, and West Virginia (although not enroute through Tennessee). Siemen's "plans to spend $1 billion to boot its manufacturing of grid and power-generation equipment" at locations in North Carolina, Mississippi, Alabama, and elsewhere to supply grid and power-generation equipment to support national demand for data-centers.

While the investment in US operations is applauded, the primary impact to Tennessee communities is more congestion on rail and roadways. Although longer in transit time, Toyota could transfer to use the intercoastal and inland waterway system, given incentives coordinated between Tennessee and other states.

Just as significant and as describe in the study RES 2023-07, Tennessee includes the marine highways M-55, M-65, and M-24 managed through the U.S. Maritime Administration (MARAD). The designation of a marine highway provides additional federal financial assistance on a number of marine related projects including those that support the inland river system. If a terminal operator located in Tennessee had an opportunity to attract a new customer yet the customer's need would require the purchase of new equipment such as a spreader bar for a wheel-mounted mobile harbor crane, the operator would need to finance the full purchase themselves and more than likely pass on the opportunity. Yet, with the designation of a marine highway, the terminal operator has another outlet to apply for federal assistance. However, to be considered for federal assistance, the terminal operator's application must also have the support of the State of Tennessee Department of Transportation, a port authority, port district, or port council.

4.2 Infrastructure System and Navigable Routes with a focus on East Tennessee

The study has also shown the critical importance and condition of the State's lock system. Although USACE has the authority and responsibility for the maintenance of all locks in the U.S. inland river system, TVA also has some ability to manage river depth by managing the various dams throughout the state. One of the more significant findings of the study was validating that if one lock on a given a route should be placed inoperable, the entire route upriver from that lock is also inoperable. With that assessment, any current or potential user of the river system would be challenged to consider the Tennessee inland river system in order to develop and manage a more resilient supply chain. If a shipper shifted modes from road or rail to the inland river to save on cost and environmental measures and then was faced with the river route shutting down for 3 months, for example, they would then need to shift back to the original mode of transportation. While the shift back would generally be manageable, the user would more than likely be faced with a higher cost by road or rail operators. Therefore, any measures Tennessee can support to mitigate the critical nature of that chokepoint is vitally necessary for any user to even consider using the river system.

Fortunately, only two locks exist in the state that severely limit the use of the river system (Watts Bar and Ft. Loudon) with only one barge locking through at a time. Since barge operators need an eight-barge tow as the minimum tow to cover their operating costs, operators will lose nearly a full day transiting those two locks.

Should the state be successful in securing funding to expand each lock for future economic growth, the existing older lock should also be maintained. Doing so drastically supports a more resilient and sustainable supply chain in that if one lock should be inoperable, the other lock can still operate even if less efficient, it's still effective to support a supply chain.

To further support findings and recommendations from the previous section, the study also supports investigating the use of technology to improve river navigation and supply chain modeling. The use of autonomous vessels is already in use in northern Europe on cargo and ferry vessels and has been used intermittently on some U.S. harbor pilot vessels, incorporating autonomous technology on inland river push boats should be investigated.

With the Chickamauga Lock Modernization project near completion, it is recommended that the state support a future study on the economic impact of the project on counties and communities upstream from the lock. Such a study should also measure and potentially quantify any positive or negative results on existing and new users of the inland river system.

Furthermore, to support companies, TDOT should develop a more resilient and sustainable supply chain, the state should support studies that use digital twins for scenario testing either by commodity shifts by mode and develop supply chain or lane options for potential new users. TND or another state agency could then use a tool to model a potential customers supply chain to determine the transit time and transportation costs. environmental savings, and total landed cost of the user's origin-destination volume. DPRA, one of the leaders in digital-twin modeling technology is located in Knoxville and manages multiple modeling scenario testing for the U.S. Department of Defense and the U.S Postal Service. Besides supporting a Tennessee company, additional research should investigate the use and benefit of digital twins on the inland river system particularly if coupled with autonomous vessels.

4.3 Potential Challenges and Strategies

Earlier in the study, the challenges of the inland river system in Tennessee were described. The waterways provide ample connectivity to other ports for both domestic and international trade. For example, East Tennessee is connected to international ports to the north (e.g., Chicago and the Great Lakes) and to the south (e.g., New Orleans, LA and Mobile, AL) creating a critical north-south transportation freight corridor. However, lock capacity limitations, aging lock infrastructure, (particularly between Chattanooga and Knoxville) and the absence of an intermodal rail facility in East Tennessee will continue to constrain utilization of the waterway in this region. Such constraints dissuade potential shippers from using the waterway network as delays will cause supply chain disruptions. However, economic growth will continue to place additional burden on the road and rail network in the state and incentivize an opportunity that encourages shippers to consider using the Tennessee river system.

Development through Legislative Support

In addition to investment support, the Tennessee inland waterway system needs one, aligned voice. Similar to the previous study (RES2023-07), this study also learned from waterway operators and current shippers that there is no state-level office dedicated to advocating for the waterway. Instead, what remains then is a collection of diverse interests without a clear vision advancing the interests of waterway transportation for ports, terminal operators, barge operators, and private industry. The result is underutilization, lack of coordinated investment and missed funding opportunities for the system.

Establishing appropriate port governance structures throughout the state provides the required support to take advantage of federal financial assistance. If a private terminal operator had an opportunity to seek new business yet lacked the financial resources to purchase new equipment or restore the river wall, a 'port entity' would have to co-apply and co-sponsor the application for maritime funding under the Marine Highway Program (M-55, M-65, M-24) sponsored through MARAD.

A number of examples may provide guidance such as the City of Tulsa-Rogers County Port Authority (Tulsa Ports), Port of Jeffersonville (IN), Arkansas Waterways Commission, Illinois River Port District, Lowndes County Port Authority (MS), and even the Memphis & Shelby County Ports Commission (although focused on its local area). The Port Office of Multimodal Commerce at the Port of South Louisiana, or the Multi-Modal and Planning (MM&P) Division of the Oklahoma Department of Transportation, help to support and secure funding for ports, waterways, rails, aviation, and trucking. In fact, the ODOT, MM&P Office now oversees the Oklahoma Port Infrastructure Revolving Fund (OPIRF). To further advance Louisiana's waterway interests, the

Louisiana Ports & Waterways Investment Commission brought together five of the state's ports on the Lower Mississippi River to develop regional alignment and focus on strategic plans.

Another potential federal funding source is the proposed Maritime Prosperity Zones by Senator's Baldwin (WI) and Young (IN) to support the maritime industries outside of the traditional coastal areas. Without the existing 'port entity', users of the waterway system are left to fund projects on their own or wait for federal assistance for private users and in which case, competition ensues for all interested parties in Tennessee leaving few to benefit.

Essentially, the Tennessee inland waterway system needs one, aligned voice. The port entity would also help to advance additional market opportunities throughout the state and help Tennessee industry and communities collaborate rather than compete.

4.4 Conclusion

A key finding from this study found that the Tennessee waterway system suffers from an imbalance in supply and demand. The available infrastructure on the waterway system, in general, has available capacity (supply) to support current users as well as any future growth particularly in the Memphis and Nashville areas. The constraint for Chattanooga, Knoxville and east Tennessee, is a lack of cargo volume (demand), or freight imbalance.

Transportation rates are generally based on having cargo move in both directions: head-haul (cargo going to a destination) and back-haul (cargo originating from that destination). If either side of the origin-destination model lacks cargo, the shipper is paying for a round-trip rate even though they are only moving cargo one-way. Because of the lack of demand, those users will be more likely to use road or rail as the primary mode of transportation due to cost and time constraints. One barge operator commented, 'if you can get me some freight out of Knoxville, I can get you a really good rate going in'.

Connecting multiple modes of transportation also helps shippers manage costs and reduces congestion. Finding a site in the state to create an intermodal operation would help to manage freight balance. This study learned investigated some of the commodity flows throughout the state and additional work is needed to determine specific locations particularly in East Tennessee.

As with many economic development projects, one opportunity has the potential to create positive 'knock-on' effects. Implementing an intermodal operation would attract other users creating an innovation, or logistics, cluster in support of a key user, key industry, or combination of both. Intermodal operations currently exist near Memphis and Nashville, but East Tennessee may have great potential to host an intermodal operation and logistics cluster.

Similar to the first study (RES2023-07), this study also found that Tennessee ports and terminal operators do not have a state entity to advocate on the user's behalf. A port entity has the opportunity to create a vision for Tennessee ports, it could also speak as one voice, assist in gaining financial resources for users, and work to develop both the intermodal operation and logistics cluster as demonstrated by other regions and states.

4.5 Recommendations:

Based on the results of this study, the following recommendations are offered for consideration to increase the utilization of the waterway system in the State of Tennessee:

- **Develop a methodology to identify promising locations for intermodal facilities** – The report finds that Tennessee's waterways have available infrastructure capacity but a freight imbalance—especially in East Tennessee—therefore a data-driven location methodology can concentrate demand and reduce head-haul/back-haul imbalances.

- **Analyze the potential to create logistics clusters** – Freight imbalance in Chattanooga and Knoxville reflects insufficient freight density rather than infrastructure gaps. Therefore, developing logistics clusters can co-locate freight-generating activities and improve freight balance.

- **Evaluate port governance models** – Regional freight imbalances and fragmented coordination limit the system's ability to attract funding and generate demand. The implementation of a unified governance approach can better align ports with statewide economic development and advocacy efforts.

- **Investigate how ports can be improved to serve fast-growing industries** – Underutilization of waterways stems from weak alignment between port capabilities and industry needs. A targeted set of port improvements can generate freight balance and strengthen multimodal supply chain integration.

- **Examine how expanded logistics and maritime services could improve supply chain reliability** – Shipper's default to truck or rail when water service lacks consistency and cost certainty. Expanding scheduled and value-added maritime services can enhance reliability and increase utilization.

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Appendices

Appendix 1: Complete Mode Shift Results

This appendix presents complete mode shift results for all metrics across all investment scenarios and both analysis years (2021 baseline and 2045 projection).

A.1 Value Changes by Commodity (Billions USD)

Table A.1.1: Value Changes - Water Cost Change Scenarios

Year	Cost Δ	Water Δ$B	Road Δ$B	Rail Δ$B
2021	5%	+2.13	-2.62	-0.05
2021	10%	+4.19	-5.11	-0.11
2021	25%	+9.98	-11.98	-0.25
2045	5%	+2.13	-2.80	-0.07
2045	10%	+4.18	-5.45	-0.14
2045	25%	+9.94	-12.78	-0.33

Table A.1.2: Value Changes - Road Cost Change Scenarios

Year	Cost Δ	Water Δ$B	Road Δ$B	Rail Δ$B
2021	5%	-1.84	+4.20	-0.63
2021	10%	-3.64	+8.21	-1.24
2021	25%	-8.57	+19.31	-2.85
2045	5%	-1.84	+5.13	-1.12
2045	10%	-3.62	+10.00	-2.19
2045	25%	-8.55	+23.49	-5.03

Table A.1.3: Value Changes - Rail Cost Change Scenarios

Year	Cost Δ	Water Δ$B	Road Δ$B	Rail Δ$B
2021	5%	-0.53	-1.39	+0.69
2021	10%	-1.02	-2.72	+1.36
2021	25%	-2.26	-6.37	+3.15
2045	5%	-0.50	-2.16	+1.19
2045	10%	-0.97	-4.26	+2.34
2045	25%	-2.14	-9.92	+5.44

A.2 Tonnage Changes by Commodity (Millions of Tons)

Table A.2.1: Tonnage Changes - Water Cost Change Scenarios

Year	Cost Δ	Water ΔM tons	Road ΔM tons	Rail ΔM tons
2021	5%	+2.93	-2.85	-0.08
2021	10%	+5.73	-5.57	-0.15
2021	25%	+13.42	-13.05	-0.37
2045	5%	+3.18	-3.08	-0.10
2045	10%	+6.21	-6.02	-0.20
2045	25%	+14.56	-14.08	-0.48

Table A.2.2: Tonnage Changes - Road Cost Change Scenarios

Year	Cost Δ	Water ΔM tons	Road ΔM tons	Rail ΔM tons
2021	5%	-3.24	+3.76	-0.52
2021	10%	-6.38	+7.39	-1.01
2021	25%	-15.06	+17.39	-2.33
2045	5%	-3.41	+4.26	-0.85
2045	10%	-6.69	+8.35	-1.66
2045	25%	-15.80	+19.63	-3.83

Table A.2.3: Tonnage Changes - Rail Cost Change Scenarios

Year	Cost Δ	Water ΔM tons	Road ΔM tons	Rail ΔM tons
2021	5%	-0.12	-0.47	+0.60
2021	10%	-0.24	-0.93	+1.17
2021	25%	-0.53	-2.19	+2.71
2045	5%	-0.15	-0.80	+0.95
2045	10%	-0.30	-1.56	+1.86
2045	25%	-0.67	-3.66	+4.33

A.3 CO2 Emissions Changes (Million kg)

Table A.3.1: CO2 Changes - Water Cost Change Scenarios

Year	Cost Δ	Water ΔM kg	Road ΔM kg	Rail ΔM kg	Net ΔM kg
2021	5%	+35	-387	-2	-354
2021	10%	+68	-757	-3	-692
2021	25%	+159	-1773	-8	-1621
2045	5%	+38	-419	-2	-384
2045	10%	+74	-820	-4	-750
2045	25%	+174	-1921	-10	-1758

Table A.3.2: CO2 Changes - Road Cost Change Scenarios

Year	Cost Δ	Water ΔM kg	Road ΔM kg	Rail ΔM kg	Net ΔM kg
2021	5%	-38	+531	-13	+480
2021	10%	-76	+1044	-25	+944
2021	25%	-179	+2457	-58	+2220
2045	5%	-41	+618	-22	+556
2045	10%	-80	+1211	-42	+1089
2045	25%	-189	+2845	-98	+2558

Table A.3.3: CO2 Changes - Rail Cost Change Scenarios

Year	Cost Δ	Water ΔM kg	Road ΔM kg	Rail ΔM kg	Net ΔM kg
2021	5%	-2	-84	+15	-71
2021	10%	-3	-166	+29	-140
2021	25%	-7	-389	+67	-329
2045	5%	-2	-143	+24	-122
2045	10%	-4	-281	+47	-238
2045	25%	-9	-660	+109	-560

A.4 Ton-Mile Changes (Billions)

Table A.4.1: Ton-Mile Changes - Water Cost Change Scenarios

Year	Cost Δ	Water ΔB t-mi	Road ΔB t-mi	Rail ΔB t-mi
2021	5%	+2.48	-2.40	-0.07
2021	10%	+4.85	-4.70	-0.14
2021	25%	+11.37	-11.01	-0.34
2045	5%	+2.71	-2.61	-0.09
2045	10%	+5.30	-5.09	-0.19
2045	25%	+12.42	-11.93	-0.45

Table A.4.2: Ton-Mile Changes - Road Cost Change Scenarios

Year	Cost Δ	Water ΔB t-mi	Road ΔB t-mi	Rail ΔB t-mi
2021	5%	-2.74	+3.30	-0.56
2021	10%	-5.40	+6.49	-1.10
2021	25%	-12.76	+15.26	-2.54
2045	5%	-2.91	+3.84	-0.94
2045	10%	-5.71	+7.52	-1.84
2045	25%	-13.48	+17.67	-4.25

Table A.4.3: Ton-Mile Changes - Rail Cost Change Scenarios

Year	Cost Δ	Water ΔB t-mi	Road ΔB t-mi	Rail ΔB t-mi
2021	5%	-0.11	-0.52	+0.64
2021	10%	-0.21	-1.03	+1.25
2021	25%	-0.48	-2.42	+2.91
2045	5%	-0.14	-0.89	+1.04
2045	10%	-0.27	-1.75	+2.03
2045	25%	-0.62	-4.10	+4.74