Toward A Full Accounting of the Beneficiaries of Navigable Waterways

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Executive Summary

During the 1920s and 1930s the federal government began construction of the dams and locks that form the foundation for the inland waterway system and commercially navigable channels we know today. These dams were constructed on the main rivers and on the tributaries to these rivers. Certain projects do not have navigation locks but are operated to provide water to facilitate barge transportation in the dry summer and fall months. Some of these projects were authorized for commercial navigation only, while others were authorized for multi-purpose use. Regardless, where these pools are available, multiple interest groups may receive benefits, some of which may not have been considered or mentioned in the authorizing legislation.

A failure of any portion of the system could negatively affect many who make use of or benefit indirectly from these pools in a variety of ways. Such failures are increasing likely because navigation locks have a designed life of roughly 50 years and 57 percent of them are now over this age. Some locks are in worse condition than others, such as Lock and Dam 18 on the Upper Mississippi River and Chickamauga Lock on the Tennessee River.

The U. S. navigable waterway system is vast and carries large amounts of cargo. It provides industries using the waterways with significant transport savings vis-à-vis the next least costly transport mode. This can benefit not only industry barge users in the affected river basins but, also, businesses and consumers distant from the river, resulting in increased economic efficiency and, ultimately, lower prices on a wide variety of goods and services. However, funding has not been sufficient to adequately maintain, operate, and upgrade the aging system. For decades, operations and maintenance (O&M) funding from the U.S. Treasury has declined in real terms, and funds for new construction have been limited, due in part to the inadequacy of the 20 cent per gallon tax levied on fuel consumed on fuel taxed waterways that has remained unchanged since 1995.

This report identifies and, further, begins to consider—perhaps, more comprehensively than has been done previously—the dollar value of sundry benefits (where available or where they can be derived fairly easily) to a broad range of potential beneficiaries of the waterway pools and channels. These values are taken or derived from published data and study results. At present, the available benefit quantifications for the various benefit categories are far from consistent with one another; nevertheless, an effort in the direction of estimating relative magnitudes appears worthwhile. The findings presented are at least suggestive of the relative significance of less oft-considered benefit categories, enhancing stakeholder's ability to make rational comparisons of the many categories of navigable waterway system beneficiaries.

The categories for classifying and reporting value to beneficiaries considered in this report are the following:

Shipping savings to navigation-using industry (commonly referred to as 'shipper savings' or 'SS') – the summed differences between the costs for tonnages of commodities shipped by barge and—had the shipper not used barge—that of the next least costly transport mode; commonly referred to as ‘shipper savings’ or ‘SS’

Economic impacts from commercial navigation– the additional value generated by the shipper savings (and, possibly, other navigational advantages such as electric utility maintenance or cooling efficiencies) that results from increased production efficiencies and lower prices, as the savings work their way throughout the economy

Shipping savings to industries using competitive modes – the summed differences between the costs for tonnages of commodities shipped by another mode and—had it not had to compete with barge—the rates that would have otherwise been in effect

Recreation impacts – the total regional value-add from visitor expenditures at all USACE recreational facilities

Flood damages avoided – property flood damages prevented by the national system of dams, some of which contain navigation locks, and some of the others were authorized to support navigation

Hydropower generation – the value of the gross revenue generated at USACE and TVA hydroelectric dams

Irrigation cost savings– savings to farmers and irrigators due to the availability of sufficient pool water for irrigation

Water supply value – value of water taken from the Ohio River Basin as a water supply to residential, commercial and industrial consumers

Sewage assimilation cost savings – savings in treatment costs due to the higher pool levels required for navigation

Property values – the premium attached to real estate on or near navigable water due to the presence of the waterway

Congestion and safety impacts – the social value of reductions in congestion and accidents due to using barge rather than an alternative transport mode; may include direct and indirect economic effects, including consequences to shipper savings as congestion increases

Environmental impacts – the social value of reductions in pollution; may include direct and indirect economic effects

Mosquito control – the operational savings from the lower cost biological method of control resulting from TVA dams controlling water levels; possibly, in addition, the added value to society of more effective disease control

The table below lists these sundry benefit categories along with reported estimates—where found available, from published reports, data, or estimates made by the study team, and deemed appropriate —of values associated with benefits for each for a specified scope (for example, for a regional or national scope, for a specific geographic area, or for a net or gross value). With regard to this scope, it must be noted that benefits estimated for important categories, most notably flood protection, hydropower, and recreation, were only available at a gross, total Corps project level, and, therefore, the navigation projects could not be isolated from the totals.

Reported Estimates of Benefits Accruing to
Sundry Waterway Beneficiaries

Beneficiary Category	***Reported Benefit Scope***	***Estimated Benefit****
Shipping savings to navigation-using industry (a.k.a. 'shipper savings' or 'SS')	Ohio River System; total barge transport cost savings due to transportation rate differentials	$3.10 B/yr
Economic impacts from commercial navigation freight transport savings (i.e., from SS)	Total value to U.S. economy (net of SS) from barged commodity shipments on the Ohio River System (ORS) plus ORS coal-fired electric utilities other use of water**	$17.40 B/yr
Shipping savings to industries using competitive modes (via 'water-compelled rates')	—	—
Recreation	Sum of regional impacts (value-add) for all Corps facilities in U.S.	$16.00 B/yr
Flood damages avoided	Corps. + TVA; savings	$10.23 B/yr
Hydropower generation	Corps. + TVA; revenues	$4.90 B/yr
Irrigation	Three states: Oregon, Washington, Idaho; irrigated farms on navigable water Net value of crops lost: Net value of farm income lost:	$5.99 B/yr $462 M/yr
Water supply	Ohio River system; value of water used	$954 M/yr
Property values	Fort Loudoun Reservoir – elimination of nine foot channel; *one-time loss of property value*	$1.12 B
Sewage assimilation	—	—
Congestion and safety impacts	Pittsburgh area freight diversions from barge to truck; impact per ton (includes pollution reduction), increasing as roadway congestion increases	$3-$50/ton of freight diverted
Environmental impacts	—	—
Mosquito control	—	—

* Generally, the dollar year base is in the range of 2002-2008. Values are in annual billion of dollars except where indicated otherwise.

** For coal-fired electric utilities, ORS impacts would include any 'water-compelled rate' benefits

These sundry beneficiary categories represent a wide range of public and private interests. The report provides further exposition and explanation of the benefit types and values, summarized as follows:

Shipper savings – In 2006, Ohio River Basin commercial navigation users saved $3.1 billion by using the Ohio River System (ORS) waterway to ship coal, steel, chemicals and other commodities by barge. For the entire U.S. inland river system, using an estimated $10-$12 per ton shipper savings, national transportation shipper savings would be in the neighborhood of $7.0 billion.

Economic impacts from commercial navigation – The freight cost savings accruing to industry allows firms to operate at a lower cost (or, in some cases, perhaps, receive a higher return) with the result being higher employment, income, and sales levels in the affected areas. Further, electric utilities can pass along their lower costs to customers in their power service areas, often extending far from the rivers. In the ORS, customers in 829 counties benefit from the operational savings the waterway affords Ohio River power companies. A University of Tennessee Center for Transportation Research (UTCTR) study found that barge navigation on the ORS navigable channel contributed a total of $497 billion in sales and 80,000 annual jobs to the nation's economy. This $497 billion in sales, discounted over 44 years at 3%, yields an annual $20.5 billion (of this, $3.1 billion is shipper savings, leaving $17.4 billion for the annual economic impact).

Shipping savings to industries using competitive modes – Where barge and rail compete to carry industry's freight, those industries may benefit from the inducement the barge alternative offers for the alternative mode to hold its rates as low as it reasonably can. Although it's generally acknowledged such beneficiaries exist, there is considerable controversy concerning calculations made to value these savings, and a wide range of estimates have resulted; therefore, no value is provided here.

Recreation – The locks and dams that make possible the navigable channel also create many recreational opportunities in the pools, in landside campgrounds and parks, in and around the tributary dams authorized for navigation, and in the tail waters of all of the dams authorized for navigation. The Corps of Engineers Lock Performance Monitoring System (LPMS) data show that a total of 383 thousand recreation vessels locked through navigation locks in 2009. In all, Corps of Engineers campgrounds and parks and related visitor spending supported 250,000 jobs and $16 billion in value added in the recreation regional areas. The deep navigation channel is a particular attraction to many boaters, providing an excellent venue for luxury pleasure boats, some of which have a fairly deep draft.

Flood damage avoidance – In 2008, the Corps of Engineers reported a flood damage avoidance savings of $10 billion on all rivers. In Tennessee, TVA reported a savings of $230 million on its system. The majority of the savings accrue in the tributary dams on the Missouri and Tennessee Rivers. Rainfall runoff is captured in the winter and spring months and released to support navigation in the summer and fall months. The capture of runoff in the winter and spring mitigates or avoids flood damages.

Hydropower generation – Seventy-five Corps hydropower plants generate over $4.0 billion in gross annual revenue. Additionally, TVA hydropower generation can be valued at approximately $900 million to $1.0 billion. Maintenance of a navigation channel strengthens stream flows and makes them more regular. The navigation system also assists servicing the hydro facilities by the barging of heavy replacement components and by performing barged-based general maintenance, such as cleaning out the trash racks using large barge-mounted cranes.

Irrigation – In support of the John Day Drawdown Study, the Corps of Engineers has considered the impact on irrigated land from a potential drawdown of the reservoir. Included in the study are the value of crop production on 182,000 acres of irrigated farmland in Oregon and Washington and the net impact on farm income were the reservoir lowered. The value of the crops, in 2008 dollars, is $2,263 per acre. Under a best case alternative that entails constructing canals from McNary Dam to the study area to provide water to all of the existing farms, the estimated net farm income loss is $30 million per year. UTCTR expanded this data to Oregon, Washington, and Idaho using the *2007 Census of Agriculture: 2008 Farm and Ranch Irrigation Survey* and, along with in-house estimates of irrigated farmland on navigable water and the market value of an alternative hay production, calculated annual losses for the three states, estimated at $6 billion in the value of crop production and $462 million in lost farm income.

Water supply – Of the 72 federally owned locks and dams on the Ohio River system, 63 have pools with active water intakes. In these reservoirs in the year 2008, there were 388 active intakes withdrawing water for consumptive and non-consumptive use. The quantity of water withdrawn was 23.3 billion gallons a day with an estimated value of $953.5 million per year. Without these pools of water, industrial, agricultural, and municipal water intakes could also be compromised. Some intakes are very shallow and the location (and elevation) of some intakes is unknown. Considerable expense could be required to reposition intakes given a loss of the navigation channel, and it is possible that certain industries would be forced to close or relocate given a lowered minimum depth in the channel proximate to their water intake.

Property values – The navigable streams and upstream dams and reservoirs have created substantial regional and national wealth in the form of lake view and lake front property. In a 2003 study, TVA estimated the impact on property values given several scenarios wherein proposed permanent changes in water management philosophy were examined. In one instance, a permanent elevation increase of 0.62 feet in the Fort Loudoun Reservoir at Knoxville, Tennessee yielded a 2.3 per cent increase in property values. Under the assumption that the nine foot navigation channel would no longer exist, property owners located on the Fort Loudoun reservoir of the Tennessee River would lose 34% of the value of their property, which would equate to about $1.1 billion. Both on the tributary and main river navigation pools, a lowering of the navigation channel would have a significant impact on regional wealth and thus on total income and spending.

Sewerage assimilation – A major factor in the permitting process for waste water discharge is the minimum volume of water passing the plant each day. A river operated such that nine foot pools of water are maintained has higher minimum flows compared to a run-of-the river flow, especially during drought conditions. A constant and predictable flow of water, as exists in the navigation pools, significantly lowers treatment costs. Without the navigation pool, existing sewerage plants would have to be re-licensed based on the least minimum flow at the plant. With these lower minimum flows, plant expansion might be required to provide the capability to remove the so-called fertilizer components of ammonia, nitrogen, and phosphorus.

Congestion and safety impacts – Unlike other modes, the barge portion of water-inclusive movements is almost completely physically segregated from other transportation activities and thus yields social benefits in the form of reduced highway congestion and improved public safety. Congestion also dynamically affects shipper savings as traffic volumes change over time.

Environmental impacts – Barge-inclusive freight routing usually consumes less fuel and emits fewer pollutants, especially as highway congestion increases. If one transportation mode can be favored for its environmental outcomes, it is barge.

Mosquito control – On the Tennessee River the navigation channel is raised and lowered periodically to control mosquito infestation. This biological method of killing mosquitoes is a superior way to eliminate the nuisance problem of excessive mosquitoes. This method also reduces the likelihood of certain mosquito-borne diseases such as West Nile Fever and Encephalitis. Without the navigation channel, this biological method for controlling mosquitoes would not be as effective and a doubling of current state control programs would be necessary, requiring additional tax revenues.

Again, it is evident that these sundry categories of benefits coincide with a wide range of public and private interests. Direct navigation users—those involved in the actual navigation function of barge transport of commodities and equipment from waterway origin to destination—receive only a small portion of the total benefits the navigable waterway makes available. Much of the benefits accrue, instead, to others: among them are users of facilities (e.g., recreation), consumers (e.g., of various manufactured goods, electricity, or water), property owners (e.g., flood damages avoided), or the general public (whose health is enhanced by mosquito control, e.g.), all made available or enhanced by the maintenance of navigation channels.

One hundred percent of the funding for operation and maintenance of the system of navigation locks and dams is provided by the federal government, while construction and major rehabilitation projects are funded by federal government general appropriations (50 percent) and the inland waterways trust fund (50 percent). From the operations and maintenance account, most of the funds are expended to support enabling and enhancing the capability for vessels to move up and down the waterways. This funding began to decline in the middle 1990's in real terms until an infusion of stimulus money reversed the trend in 2009. Funds available for new construction have fallen for a variety of reasons such that the balance in the Trust Fund for new lock construction and major rehabilitations is projected to be very small through 2013.

1. Introduction

A primary purpose of this paper is to demonstrate that a wide range of identifiable private and public groups benefit from the pools of water created and authorized to facilitate commercial navigation and other uses and, therefore, many would be substantively and detrimentally affected by a failure of the system or a portion of the system. The paper begins by briefly discussing the Corps of Engineers' navigation waterway infrastructure, its age and its physical condition. The paper then offers a collection of benefit categories, broadened beyond the usual candidates, and discusses how the navigation channel benefits each, offering economic evaluations of the benefits to each where it can, with whatever measurements can be presently obtained. Case studies of benefits of navigation are presented for the Tennessee Valley Authority's Chickamauga and Kentucky Reservoirs. In a final main section, consideration is given to funding sources and the Corps of Engineers' budget allocations in support of navigation, so that consideration can be given to their relationship to the broad range of beneficiaries identified and discussed.

2. Navigation Background

2.1. Inland Waterway System Characteristics

Approximately 12,000 miles of inland and intracoastal waterways in the United States are commercially navigable, including about 11,000 miles that are part of the fuel-taxed portion of the system. Inland navigation is made possible by locks and dams, ancillary navigation aids, landside terminals, and channel maintenance and dredging where necessary to maintain an appropriate channel depth. The U. S. Army Corps of Engineers (USACE) has constructed and maintains 238 lock chambers at 192 lock sites. Ten other dams with locks (nine mainstream and one tributary) are operated by the USACE but were constructed and owned by the Tennessee Valley Authority (TVA).

The USACE and TVA have also constructed multipurpose dams on rivers upstream from navigation channels that are authorized and operated for navigation and other purposes but are not a part of the navigation channel. During the dry seasons of the year, water is passed through these dams to augment water flows in support of commercial barge transportation. Operation of these "upstream" multipurpose dams, therefore, may contribute in a like manner to the dams in navigation channels.

Table 1 tallies current fuel tax waterway projects by project type. Most—299 of the 389 total projects—support commercial navigation ('floats boats') with activities directly applicable to locks, channel improvements, and dredging operations. Physical support includes, among other things, bank stabilization and removal of sunken vessels. Business support includes the development of the models and studies necessary to implement navigation programs: for example, *The Missouri River Master Manual Update*.

Table 1: Number of Fuel Tax Waterway Projects by Project Type

Project Types	*Number of Projects*
Business Support	18
'Floats Boats'[1] (Navigation)	299
Physical Support	72
Total	389

2.2. Tonnage Handled

During the calendar year 2008, all types of commercial barge transportation (that is, coast, lake, and inland) carried freight totaling 956.3 million tons, of which inland system tonnage totaled 588.5 million tons. In 2002 (the latest year available) commercial barge transportation represented about 8.6 percent of total tonnage shipped in the nation and about 11.0 percent as measured by ton-miles.[2] The inland river system is well suited for shipment of a variety of bulkier commodities and is invaluable to numerous major manufacturing plants, agricultural producers and electric utilities. The Ohio River system is a particularly important conduit for the shipment of coal, and the Mississippi River provides a means for the low cost shipment of large quantities of export grains. Other essential commodities and specialized freight and other river segments of the inland network serve a variety of markets and meet a variety of crucial common and special needs (for example, three nuclear steam generators, weighing roughly 350 tons each, shown in Figure 1, are destined for the Tennessee Valley Authority's Watts Bar steam plant).

[1] The term "floats boats" is used in the USACE OMBIL system to identify projects that support commercial navigation in the navigation channel.

[2] Bureau of Transportation Statistics, Research and Innovative Technology Administration. Table 1: "Commercial Freight Activity in the United States by Mode of Transportation: 2002". U.S. Department of Transportation, Washington D.C.

Figure 1: Steam Generators Moving to TVA's Watts Bar Nuclear Plant

2.3. Age of Facilities

The locks and dams that enable the many freight movements and massive tonnages each year have a design life of about 50 years. In fact, 57 percent of the navigation locks are over age 50, and thus are functioning well beyond their expected life. For example, the Corps of Engineers opened what is now the auxiliary lock at Wilson Dam on the Tennessee River in 1927.[3] On the upper Ohio River, the locks at Emsworth, Dashields, and Montgomery were opened, respectively, in 1921, 1929, and 1936. The lack of maintenance and rehabilitation at certain projects has resulted in a situation where functioning navigation infrastructure is seriously imperiled. The situation is so dire that the American Society of Civil Engineers prepared the following assessment:

[3] What is now Wilson Dam's main lock was opened in 1959, making this primary lock chamber 51 years old.

> Of the locks still in use in the United States, 30 were built in the 19th century, and another 92 are more than 60 years old. Nearly half of the inland waterways operated by the Corps are functionally obsolete. . . .Unless action is taken, by 2020 that figure will increase to 80 percent.[4]

3. Navigation Beneficiaries

3.1. Purposes and Uses of Navigation Infrastructure

Most USACE dams on the navigable channel are authorized for the single purpose of creating a nine foot channel depth.[5] However, these dams are operated for a variety of purposes that were enumerated in their authorizing legislation, in subsequent legislation, and in court decisions. Each purpose coincides with interests of groups who benefit from opportunities and services provided by these dams and locks. Beyond the authorized purposes, though, the interests of other groups are served. This paper attempts to account for a broad range of possible beneficiaries, even where they may have never been considered for purposes of authorization or subsequent consideration. These will include the consumer public (by lower residential electric or water costs, for example), employees and the businessmen who hire them (as a result of greater economic efficiency), the military and NASA (who sometimes need large, specialized transport), those who use the water for recreation, those protected from mosquito infestations, those who have their likelihood of being damaged by flooding reduced, those who use the water for irrigation, those who benefit from more environmentally friendly transportation, and those who have invested in property located with either lake access or lake view. Further, the paper makes an effort to provide some quantification of the relative values accruing to the sundry beneficiaries.

3.2. Identification and Evaluation of Beneficiary Categories

This section surveys sundry beneficiaries of the navigable waterway system. Within each beneficiary class identified, one or more measured indications of value are offered, where reasonably reliable information can be found from published reports or data or from relatively simple tabulations by the UTCTR study team. While the measurements vary with regard to certain parameters, such as whether the scope is national or regional, whether savings are direct or indirect, or whether the value is annual or a one-time savings, it is hoped the collection of values by beneficiary makes a meaningful contribution to discussions of the relative importance of the different categories of beneficiaries and, ultimately, to rational evaluations with respect to funding considerations.

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[4] U.S. Army Corps of Engineers, *Improving the Inland Marine Transportation System,* Executive Report, September 2008, page 5. Accessed on line June 14, 2010.

[5] U. S. Army Corps of Engineers (USACE), Annual Report of the Chief. Ohio River projects "Provides for improvement of the entire river by construction of locks and dams to provide a channel depth of 9 feet . . .". Also, a query from the USACE OMBIL system shows that most projects were authorized for a single purpose.

Savings to shippers who move commercial freight by water is a traditional measure of the efficiency gains associated with commercial navigation used by policymakers and is the most likely value against which benefits to other users might be compared. Consideration of a broad range of positive contributions made by navigable water, as presented in the following subsections, suggests a shipper savings focus may lead to substantially understating the total value of waterborne freight capacity.

3.2.1. Navigation Shipper Savings

In 2006 the Tennessee Valley Authority (TVA), on contract to the USACE, undertook a contract to estimate the savings that accrued to shippers in the Ohio River Basin (ORB). TVA data, obtained through interviews and application of models developed at the agency, found that ORB shippers saved $3.1 billion in 2006 for a selected sample of shipments. The shipping and receiving companies included electric utilities, steel producers, chemical and petroleum companies, minerals shippers, and many other barge transportation users. The savings are likely underestimated by 20 percent or more, as some high value tonnage movements were not included in the sample that TVA was asked to rate. The study methodology and data are discussed in the TVA report referenced below.[6]

For the U.S., at an estimated $10-$12 per ton shipper savings value for the entire U.S. inland river system, a rough estimate of recent national transportation shipper savings is $7.0 billion.[7]

3.2.2. Economic Impacts from Commercial Navigation

The UTCTR, under contract to the Nick J. Rahall, II Appalachian Transportation Institute, estimated the economic impact of the 2006 TVA shipper savings study for the Ohio River System (ORS). Using the highly regarded impact model developed by Regional Economic Models Inc. (REMI), UTCTR first established a base case economic scenario in employment, income, and sales. Next, and assuming that shipper savings would be lost to the region, non-utility shipper savings were added to each industry's cost of production. In the utility sector, for those plants located close to the navigable stream, a 16.6 percent increase in the cost of electricity generation (discussed below) was added to the electricity rates charged to consumers. Last, economic activity at the Boeing plant in Decatur, Alabama, was removed from the base case scenario as this facility is captive to the navigable stream (Boeing is discussed below); without navigation, Boeing would be forced to relocate out of the region.

The results of the REMI analysis showed that, discounted over 50 years, the navigable channel contributes a total of $497 billion in sales to the nation and 80,000 in annual employment. This $497 billion in sales, discounted over 44 years at 3%, yields an annual $20.5 billion (of this, $3.1 billion is shipper savings, leaving $17.4 billion for the annual

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[6] Tennessee Valley Authority. "Transportation Rate Analysis Ohio River System National Economic Development." July 2008.

[7] This estimate was made by the study team's member, Chris Dager, who estimated these values for the USACE over the last 15 years.

economic impact). The positive impacts are not confined to the Ohio River and tributaries. The navigable channel generates benefits well beyond through regional trade and, particularly as power rates, impacted by low cost transportation on the navigable streams, extend throughout each utility's power service area. The power system of these utilities is so vast that customers in over 829 counties benefit from transportation on the navigable ORS.

Both coal steam plants and nuclear generating plants benefit from being located on navigable streams. Lower generating costs at these water-side plants are likely passed on to power service area customers in lower electric rates. A TVA study concluded that coal-fired steam plants in the Ohio River Basin are, on average, 16.6 percent less expensive to operate as a result of being located on a navigable stream.[8] While it was not possible to isolate every likely component that influences the economies of locating on the water, it was surmised that coal steam plants across the board primarily benefit from a combination of transportation savings in coal and limestone[9] shipping and in plant maintenance. Many coal steam plants can be accessed by either rail or barge transportation, and, even if serviced by rail rather than barge, the presence of a competitive alternative can cause railroads to price their services more competitively. Where located on navigable streams, both coal-fired and nuclear generating plants are designed to be serviced from the water side of the plants. For example, cranes that are used for the transloading of extremely heavy generators, rotors, and other equipment are mounted on flat deck barges and are moved from pool to pool rather than moved by truck. The trucking alternative is expensive in that it can require weeks to assemble and disassemble each crane and a fleet of trucks to transport the disassembled parts.

The waterway is also used to service the hydropower system through shipment of heavy replacement components by water and by barged-based general maintenance. Large barge-mounted cranes are used to clean out the trash racks and install components at the hydropower facilities.

Although not included in the ORS impact estimate, power plants on navigable streams, in some instances, enjoy water supply and temperature control advantages. Older steam electric power plants typically use once-through cooling systems in the electric generation process.[10] Water is taken from the river, passed through the plant's cooling system, and returned to the river at a higher temperature. Newer plants have a closed-cycle cooling system that utilizes towers to cool the water leaving the plant. Permits are required that establish maximum temperatures that can exist in the river as a result of the use of once-through or closed cycle cooling. A constant and predictable flow of water maintaining a minimum nine foot channel can result in lower generation costs and, indeed, provide the means to keep the plant on line

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[8] *Large-Load and Special-Use Barge Movements on the Inland Waterway System: their Economic Impacts in the Tennessee and Cumberland River Valleys*, a Tennessee Valley Authority study, prepared for the USACE, October 2005.

[9] Limestone is shipped to steam plants as a commodity for use in sulfur reduction programs.

[10] Gies, Erica, *New York Times*, May 17, 2010: Although fallen out of favor, 43% of U.S. thermoelectric generation capacity is once-through cooling. This type of cooling is an inexpensive energy-efficient process that requires large volumes of water from stable pools of sufficient depth.

during the warmer summer months. And where possible, cool mountain water is released in the summer and fall seasons to not only augment stream flows (necessary for navigation) but, also, for cooling at the power plants.

The reported ORS impact estimates, calculated over 44 years, are derived using current point-in-time values projected into the future. Shipper savings can, of course, vary over time as transportation costs change in any or all transport modes. Congestion could become a significant factor affecting shipper savings. Although outside the scope of the ORS study, shipper savings can be tracked dynamically in response to projected congestion lock traffic levels. The USACE Navigation Economic Technologies Program[11] and Ohio River Navigation Investment Model[12] web site are good sources for information on the subject of dynamic estimation. In simulation, lock feasibility studies begin with shipper savings at a point in time. From this point river traffic is forecast 50 years or so into the future and, with fixed capacity, congestion at the affected navigation locks increases, diminishing the shipper savings value and thus constituting a basis for lock construction benefit calculations.

3.2.3. Non-Navigation Shipper Savings

Where barge and rail compete to carry industry's freight, those industries that prefer rail may benefit from the inducement the barge alternative offers for the alternative mode to hold its rates as low as it can to hold onto those customers. In the aforementioned TVA study on ORS navigation shipper savings and other utility advantages, these non-navigation shipper savings for coal-fired plants are likely accounted for in the impact estimation. However, to the extent that water-compelled rates exist in the region for the other industries, at least some of the non-utility savings and their impacts would not be captured in the estimated impacts.

Although it's generally acknowledged these non-navigation shipper beneficiaries exist, there is considerable controversy concerning calculations made to value these savings, and a wide range of estimates have resulted; therefore, no value is provided here. As is the case with recreation and, possibly other beneficiary categories, water-compelled rate savings, unlike navigation shipper savings, may represent in whole or part regional impacts (see Dager and Burton in the references section for more on this issue).

3.2.4. Recreation

It is not possible with current data to determine precisely how lack of the navigation system would affect recreation nationally. What can be said, however, is that 382,523 recreation vessels passed thorough navigation locks in 2009. These vessels were processed in 147,679 recreational lockages. This is often an enjoyable experience for recreation boaters, and the Corps of Engineers allows these boaters access to the locks with no lockage fee. The deep

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[11] See http://www.corpsnets.us for a good discussion of the program.

[12] See http://inspire.ornl.gov/Document/View/ac823ab7-2f34-4a5a-974b-42788c01a6e7?q=topic%3A%22Energy%20%26%20Transportation%20Science%22%20%2Bsource%3A%22Research%20Summaries%22 for a discussion of the model.

navigation channels provide an excellent venue for pleasure boats, some of which have a fairly deep draft.

Additionally, considering all Corps of Engineers recreational facilities, more than 372 million person-trips across the nation occurred in 2006. In that year, visitors to these lakes spend $18 billion on trip expenses and durable goods. Considering both these direct expenditures and the associated indirect economic impacts, visitor spending supported more than 250,000 jobs and $16 billion in the value added generated.[13]

Within the benefit assessment process, such 'regional' economic impacts may be considered to be primarily economic transfers and may thus be given less weight than "national" benefits (that is, than those raising GDP or increasing productivity). They are, nonetheless, important to the regions that benefit from the availability of recreation opportunities. Additionally, of course, some recreation would take place without commercially navigable water, or even without the pools created by the dams.

3.2.5. Flood Damage Avoidance

Untangling the statutory mandates and judicial decisions that define the purposes of waterway structures and operations is difficult. Differing reaches of the inland waterway system function with varying efficacy and are authorized for differing purposes. Historically, the three least challenged uses have been navigation, hydroelectric generation, and flood control.[14]

Concerning the flood control project purpose, the Corps of Engineers and TVA maintain data bases to quantify these benefits. Nationally, most of the flood control benefits occur in the headwaters of the Missouri River but they are also significant in the headwaters of the Tennessee River. Multipurpose dams in the tributaries of the main rivers operate to collect runoff in the rainy seasons of the year, maintain their pools for summer recreation and

[13] U. S. Army Corps of Engineers, Natural Resources Management Gateway, Institute for Water Resources. Assuming that these recreational expenditures would have been made for alternative activities, they represent yet another form of "regional" economic impacts.

[14] The Navigation function was integral to the development of most of the flood control storage in the inland river system. At the TVA, dams were constructed for multi-purpose operation that included the functions of navigation, flood control, and the sale of surplus hydroelectric power. In 1934 several coal and ice concerns sued TVA over its constitutional status. These firms, sponsored by the Edison Electric Institute, challenged the constitutional basis for TVA and attempted to obtain an injunction to the Agency's construction and power generation programs. TVA lost this court case in the so-called "Grub" decision in 1934 (United States District Court for the Northern District of Alabama). The district judge, William I. Grubb, however, did not question the power of the national government to improve the nation's streams for navigation under the commerce power of the federal government. The TVA Act was thus amended such that a nine foot channel had to be developed from Knoxville to the mouth of the river, and navigation became the "constitutional peg" of the Tennessee Valley Authority. It is mentioned first in the TVA Act. Other authorized purposes are flood control and power generation. Navigation is also a major project purpose on the multi-purpose Missouri River system. The USACE, which insisted on the development of a navigable channel on the lower Missouri River, compromised with up-stream proponents who insisted upon facilities built and operated for flood control and irrigation. Both parties insisted on the "fullest development" of hydroelectric power.

irrigation if needed, and then release the stored water in the dry part of the year to support navigation.[15] In 2008, the Corps of Engineers reported a savings of $10 billion on all rivers but the Tennessee; TVA reported as savings of $230 million on that river.[16,17]

3.2.6. Hydropower Capability

Hydropower production or value data for Corps facilities are reported by the Corps of Engineers in aggregated fashion, not for individual sites, some of which are on navigable water and some not. TVA reports production but not value. The Corps reports that 75 hydro plants and 350 generating units produce 21,000 MW of capacity, representing 24% of total national hydropower generation. These units generate approximately 70 billion KWH of energy annually, enough to meet the electricity demands of 30 cities the size of Seattle, Washington. This system generates over $4.0 billion in gross annual revenue.[18] TVA reports a hydropower production of 14.0 billion kWhs in 2010 but does not report value. Assuming that the generated power is priced at its wholesale rate, TVA hydropower generation in 2010 can be valued at approximately $900 million to $1.0 billion.

The support of navigation strengthens flows and makes these flows more regular. However, navigation can also require the release of water at times that are not beneficial to hydroelectric generation. Thus, the simultaneous pursuit of these purposes requires a careful balance between the water releases needed to preserve channel depth and the preservation of generating capacity for those times when electricity is most needed. Fortunately, the men and women charged with achieving this balance are well practiced so that intractable conflicts seldom arise.

The navigation system supports the hydropower system through the servicing of the facilities through shipment of heavy replacement components by water and through general maintenance that is barged based. Additionally, the large barge-mounted cranes mentioned above are also used to clean out the trash racks at the hydropower facilities.

3.2.7. Irrigation

The Corps of Engineers does not normally collect irrigation data or the value of associated crop production. However, the Corps is studying an alternative water control policy that would lower the pool behind the John Day Dam on the Columbia River for the purpose of improving survival rates of threatened and endangered stocks of anadromous fish. This would lower the navigation channel but would leave the possibility of some limited navigation. The idea in the study is to lower the navigation channel by five feet to the minimum operating pool.

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[15] Main river high dams on the Tennessee also incorporate some flood control storage.

[16] Mr. John Hunter, senior hydraulic engineer, U. S. Army Corps of Engineers and TVA River Scheduling Group, “Flood Reduction Benefits”.

[17] TVA River Scheduling Group, 2007.

[18] U. S. Army Corps of Engineers, Hydropower Business Line FY 2011 budget Brief for Ms. Jo-Ellen Darcy, Assistant Secretary of the Army (Civil Works), 28 August 2009, Tennessee Valley Authority 10-K Annual Report, November 25, 2009.

In support of the project, the Corps included the value of crop production on 182,000 acres of irrigated farmland in Oregon and Washington and the net impact on farm income were the reservoir lowered. The value of the crops, in 2008 dollars, is $2,263 per acre. Under a best case alternative that entails constructing canals from McNary Dam to the study area to provide water to all of the existing farms, the estimated net farm income loss is $30 million per year. Using this information and expanding it to Oregon, Washington, and Idaho using the *2007 Census of Agriculture: 2008 Farm and Ranch Irrigation Survey* in conjunction with in-house estimates of irrigated farmland on navigable water totaling 2.8 million acres and a $125 per acre market value of an alternative hay production, annual losses on a comparable basis of loss of pool level for the three states are then estimated at $6 billion in the value of crop production and $462 million in lost farm income.

3.2.8. Water Supply

Of the 72 federally owned locks and dams on the Ohio River system, 63 have pools with active water intakes. In these navigation pools in the year 2008, there were 388 active intakes withdrawing water for consumptive and non-consumptive use. The amount of water withdrawn was 23.3 billion gallons a day with an estimated value of $953.5 million per year. Municipal and industrial users account for all of the water withdrawals in the Ohio River System, as little irrigation occurs in this part of the nation. In 2008 municipal users and industrial users accounted for, respectively, 9.7 and 90.7 percent of withdrawals. Electric power plants accounted for 95 percent of industrial withdrawals.[19]

Water supply plants are designed and constructed to account for the minimum flows that existed there at the time of construction. Most of the navigation dams and locks are very old, and thus most treatment plants located in these navigation pools were built with the expectation of a minimum nine foot deep channel. Assuming that something happened to compromise these navigation channels, new channels might be required from the main river to the water intakes which would be constructed at considerable expense. Treatment cost would also rise due to increased turbidity which could affect taste and odor.[20]

Industrial water intakes could also be compromised with a loss of navigable channel. Considerable expense could be required to reposition intakes given a loss of the navigation channel, and it is possible that certain industries would be forced to close or relocate given a lowered minimum depth in the channel proximate to their water intake. Discharge permits could also be affected in such a circumstance.

3.2.9. Sewerage Assimilation

Sewerage treatment plants separate solid material from liquid material, process the liquids, and discharge the treated liquids into rivers. The processed solid material is disposed of through land application. A major factor in the permitting process for wastewater discharge is

[19] U. S. Army Corps of Engineers, *Water Intakes and Withdrawals from Navigation Pools within the Ohio River Basin*, Lakes and Rivers Division, January 2009.

[20] Mr. Ted Tyree, Manager, Kuwahee Sewerage Treatment Plant, Knoxville, Tennessee, November 2, 2009

the minimum volume of water passing the plant each day. It is much less costly to operate a sewerage treatment plant if the water volume is high such as is found in navigable streams. Lower water volumes require the costly removal of the so-called fertilizer components of the processed liquid material. Absent existing navigation support structures, waterways operated for other purposes would result in lower flow and require that chemicals such as ammonia, nitrogen, and phosphorus be removed prior to water treatment plant discharge.[21]

3.2.10. Property Values

The value of any property is determined by its utility-conferring amenities for owners and its relative usefulness in the production of crops, natural resources, manufactured goods, or other commercial outputs. Accordingly, navigation's impacts on the productive capacity of nearby properties are captured in the prices of related goods. To treat these effects separately here would tend to "double-count" their impact. This is not true of residential property values that are impacted by the maintenance of navigable waterways.

In a 2003 study, TVA estimated the impact on residential property values associated with permanent shifts in the reservoir levels on the tributary rivers and the main river channel.[22] The property value study was a component of a larger programmatic environmental impact study. Reservoirs chosen for analysis were taken from the main river and the tributaries. One study finding is that a permanent elevation increase of 0.62 feet in the Fort Loudoun Reservoir at Knoxville, Tennessee would yield a 2.3 per cent increase in property values for properties located on the river. Both on the tributary and main river navigation pools, a lowering of the navigation channel would have a significant impact on regional wealth, spending, and total income. TVA used the Regional Economic Model Inc. (REMI) model to measure this impact. Using the regression equations that map elevation into property values, loss of the entire nine foot navigation channel in the Fort Loudoun Reservoir alone would result in a loss of $1.12 billion in lake front property values. This equates to 34 percent of the value of this property.

3.2.11. Congestion and Safety Impacts

The external benefits associated with waterborne commerce are not limited to environmental outcomes. Barge traffic is largely physically segregated from other transportation mode operations. Thus, the movement of traffic by barge can reduce highway and rail network congestion and related costs, improve public safety and security outcomes, and generally contribute to a community's quality of life. Even in settings where commercial navigation and recreation (or other land uses) are seemingly in conflict, there are often remedies that can accommodate both purposes.

A recent study completed by the University of Tennessee Transportation Center, under contract to TVA, for the Emsworth, Dashields, and/or Montgomery locks examined the

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[21] Ibid

[22] Tennessee Valley Authority, *Programmatic Environmental Impact Statement Tennessee Valley Authority Reservoir Operations Study,* Record of Decision May 2004.

consequences of diversions of freight from barge to highway in the Pittsburg area, were the locks to experience outages for either 60 days or 180 days each year.[23] Table 2 summarizes the incremental air quality, safety, and congestion costs for the diversions for three potential traffic growth rates and two diversion scenarios. The patterns evidenced in the scenarios reveal the effect of increasing highway congestion over time, particularly where a relatively high linear traffic growth increment (1.6% of the initial year added annually) places more truck traffic onto an already burdened roadway network. The moderate traffic growth (1.07%), 180-day duration scenario results in barge savings that begin at $3.45 per ton and reach $12.90 in the 51st year. The highest growth increment (1.6%) scenario, however, reaches $46.54 per ton, reflecting the severe impact that greater highway congestion can cause (occurring even though the rate of growth—that is, the compound rate—actually declines).

Table 2: Savings from Truck Diversion to Barge in Pittsburg

		Average per Ton (2006 constant dollar)	
Year	Highway Traffic Growth Annual Increment (as % of Initial Year)	60-Day Outage Scenario	180-Day Outage Scenario
1	0.55%	$3.10	$3.45
10		2.92	3.28
25		3.20	3.61
51		4.30	4.91
1	1.07%	$3.10	$3.45
10		3.11	3.50
25		4.09	4.66
51		10.92	12.90
1	1.6%	$3.10	$3.45
10		3.34	3.76
25		5.95	6.90
51		38.47	46.54

Increasing waterway traffic congestion, on the other hand, can reduce shipper savings over time, and lock congestion could then become a significant factor affecting the evaluation of

[23] University of Tennessee Center for Transportation Research, *Social Costs of Barge Cargo Modal Diversions Due to Unscheduled Closures at Emsworth, Daschields, and Montgomery Locks*, Tennessee Valley Authority, 2008.

lock construction benefits (refer to the Shipper Savings section for additional discussion on dynamic modeling); this consideration, however, is outside the scope of this report.

3.2.12. Environmental Impacts

In virtually every case, the fuel consumed and pollutants emitted through a barge-inclusive freight routing compete favorably with fuel and emissions for competing modes and in the majority of cases, commercial barge transportation is measurably superior. In terms of ton-miles per gallon, the three modes rank as follows – barge: 525, rail: 424, and truck: 100. As a consequence, barge freight movement often measurably benefits air quality.[24]

In the Pittsburgh traffic diversion study discussed above, environmental costs were estimated as part of the impacts from closure of Emsworth, Dashields, and/or Montgomery locks.

3.2.13. Mosquito Control

Mosquito control manages the population of mosquitoes to reduce their damage to human health, economies, and enjoyment. Mosquito control is a vital public-health practice throughout the world because mosquitoes spread many serious diseases, such as malaria.

On the Tennessee River the navigation channel is raised and lowered periodically to control mosquito infestation. This same basic technique is used behind the Mississippi River levees to control this pest, but only on the Tennessee River is the navigation channel manipulated for vector control.

When the Tennessee River system of dams and locks was being constructed, TVA biologists learned about the breeding cycle of the mosquito and developed a control system whereby, after the eggs have hatched, the reservoirs would be lowered a few feet such that the larvae would die on the shoreline. Then, the reservoirs are raised to a level consistent with each of their respective guide curves.

This biological method of killing mosquitoes is a superior way to eliminate the nuisance problem of excessive mosquitoes. According to Dr. Robert J. Novak, University of Illinois entomologist, to manage mosquito populations we need to “. . . learn more about the aquatic states and then manage those populations while they are still larvae.” Novak went on to say:

“Whenever you have to spray large acreages of land with an aerial spray to try to kill adults, you’ve lost the battle. Once adults are flying around, it’s very difficult, if not impossible, to manage population.”[25]

This method also reduces the likelihood of certain mosquito-borne diseases such as West Nile Fever and Encephalitis. It also holds down taxes. Without natural control mechanisms, a doubling of current state control programs would be required, resulting in an additional cost

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[24] In small number cases the circuity of line-haul barge routes and / or longer associated truck legs, produce outcomes in which all-rail routings are more fuel efficient.

[25] Petterchak, Janice, *Taming the Upper Mississippi: My Turn at the Watch*, 1935-1999, Legacy Press, Rochester, Illinois, 2000.

to the taxpayers of about $25 million per year in the Tennessee River Valley.[26] Without the navigation channel, this biological method for controlling mosquitoes would not be as effective.[27] According to Novak, TVA "…learned about how to manage those reservoirs so that they could eliminate mosquitoes without using insecticides, by water manipulation. They spent a great deal of time and research dollars to gather the information in order to develop that strategy."[28]

3.3. Case Studies

3.3.1. Boeing, NASA, and the Military

The Boeing Corporation and Lockheed Martin Corporation merged in December 2006 to form the United Launch Alliance (ULA). Through the merger, one company was formed to produce the common booster cores (CBC) for the Delta II, Delta IV, and Atlas V satellite launch rockets. The CBC includes the first stage fuel tanks and the main engines for each rocket type. The rockets have carried a variety of payloads into space including weather and telecommunications satellites and equipment for deep space missions.[29]

The Boeing facility is a mammoth 1.5 million square feet in size. It is the "…largest and most state-of-the-art facility of its kind in the world."[30] The navigable inland river system gave Boeing the flexibility to construct such a large and expensive facility inland near a supply of aluminum and away from the severe weather that can occur in the coastal areas. Barge transportation is necessary at the plant because of the length, width, and fragility of the CBCs. Each unit measures 150 feet long and 16 feet wide. The specially designed ship, the *Delta Mariner*, can carry up to three CBCs in its cargo hold for delivery to coastal launch sites.[31] Concerning the fragility of the units, another site on the inland navigation system was considered and dismissed by Boeing due to the angle of descent to the river.

While the commercial navigation channel supports the launching of military, civilian, and commercial spacecraft, the Army and National Guard also ship equipment needed for military operations by barge transportation. Figure 2 depicts one such move. Their reasons for using water transportation include safety and security. Movement of troops by bus or air transportation is much safer than physically moving their equipment in slow-moving convoys on the highway. One person per barge can run the equipment engines periodically to keep the batteries charged while the others move to their bases of operation for training and other purposes. Being on the river, there is also little chance of vandalism or robbery. Conversely,

[26] Joseph Conlon, Technical Advisor, American Mosquito Control Association, September 30, 2009.
[27] Before TVA impounded the Wilson Dam Reservoir to create the navigation channel, a small town, Cottonport, Alabama was a thriving community that was abandoned by the 1850 due to mosquito infestation and resultant malaria epidemics. (Limestone County, Alabama Historical Society and Athens/Limestone County Tourism Council, 2003).
[28] Petterchak, page 144.
[29] "United Launch Alliance". http://en.wikipedia.org/wiki/United_Launch_Alliance
[30] "Delta 4 Fleet goes from 'Medium' to 'Heavy'. http://spaceflightnow.com/delta/d317/060624delta4.html
[31] "New Rocket Ship Carries Delta 4 Rocket Parts to Cape Canaveral". www.space.com/mission launches/launches.delta_mariner_010705-1.html

military equipment parked on rail sidings is subject to vandalism and theft. In some instances the speed of equipment delivery by barge is competitive with rail.

Figure 2: Tennessee National Guard (196th) in Transit to Summer Maneuvers (May 2005, departed from TVA's Raccoon Mountain pumped storage plant dock)

3.3.2. Chickamauga Reservoir

The Chickamauga Lock and Dam is located on the upper stretch of the Tennessee River at river mile 471, just upstream from Chattanooga, Tennessee. This facility has been chosen for examination because TVA maintains detailed and readily accessible data on various user functions. While not all of the functions discussed below are presented in the case study (discharges into the river for example), Table 3 effectively summarizes the benefits accruing to the many users of the Chickamauga Lock and Dam reservoir. It should be noted that TVA management has interpreted the TVA Act to mean that, on the navigable portions of the Tennessee River and tributaries, a nine foot channel is to be maintained with a two foot margin for safety; thus shippers on the river have a minimum eleven foot deep channel in which to navigate. The Chickamauga Lock measures 360 x 60 feet, which is small by modern standards.

Table 3: Value Accruing to Selected Beneficiary Groups in the Chickamauga Reservoir[32]

Group	*Value (Millions)*	*Percent*
Recreation*	$967.80	94.36%
Hydropower	$28.00	2.73%
Flood Control	$12.85	1.23%
Property Owners	$12.62	1.25%
Navigation	$4.00	0.39%
Water Supply	$0.37	0.04%
Total	$1,022.64	100.0%

* Includes only the direct effect and is a gross estimate that does not net out the recreational activity that might continue to occur given an absence of the navigation channel.

Recreation users receive the greatest benefit (94 percent) from the value generated by the navigation channel. In 2007, 568 Chickamauga Reservoir users were surveyed to update visitor expenditure data. Between May through mid-September in 2007, mean expenditures per trip were estimated to be $170.24. Based on this data, it is estimated that visitors boost the annual value added in the multi-county area around the reservoir by $1.8 billion including both direct and indirect effects. The direct effect is $967.8 million in total value added impacts. Total value added is defined to include wages and salaries including benefits, self-employed income, interest, rents, royalties, dividends profits, plus excise taxes and sales taxes.[33]

Residential and industrial water supply users withdraw 9.1 million gallons of water per day from Chickamauga Reservoir at an annual cost of $370 thousand.[34] The cost calculation reflects the charge for water drawn out of Corps reservoirs, capital costs, and the cost computed for currently negotiated water supply contracts. There is no accompanying estimate of the cost of replacing this water were pools not regularly deep enough to allow water withdrawal in a non-turbid state.

In 2003, TVA studied the impact on property values given several scenarios wherein there would be permanent changes in the elevations of several reservoirs. Econometric equations were developed for six reservoirs (including Chickamauga) that allowed the mapping of reservoir levels into additions or subtractions to base case home values. This paper assumes that the nine foot navigation channel would not be maintained and, instead, the river would be operated in run-of-the-river mode where the reservoir is used primarily for flood control. The study concludes that a loss of the navigation channel would reduce lakeside property

[32] Mr. Chris Dager of the UTCTR was a valuable source for the information provided in this table.
[33] Dr. Burton English, et. al., Department of Agricultural Economics, University of Tennessee Institute of Agriculture, *Tennessee Valley Authority's Chickamauga Reservoir*, 2006.
[34] U. S. Army Corps of Engineers, "Water Intakes and Withdrawals from Navigation Pools within the Ohio River Basin, January 2009, page 25.

values (wealth) by $421 million in the Chickamauga Reservoir. In a study by Maki and Palumbo (2001), the authors suggest a rate of 3% per year to convert the wealth effect on consumption or spending.[35] Hence, the annual impact on spending would be $12.62 million.

The Tennessee River was designed to provide protection from flooding in the Tennessee Valley and includes some protection for the lower Ohio and Mississippi River flood plains. On average, dams on the Tennessee River and tributaries prevent $217 million in annual flood in the Tennessee Valley and $236 of annual protection to the broader area that includes the Ohio and Mississippi basins. While most of the flood storage capacity is located in the tributaries of the Tennessee River, Chickamauga Dam provides about $12.8 million (6.5%) of annual flood damage protection benefits.[36]

Hydropower operations at TVA result from conventional hydropower plants, one pumped storage plant, and hydropower purchase agreements. It is estimated that the value of generation at the Chickamauga Power Plant is about $28 million annually.[37]

As previously noted, the primary value placed on commercial navigation by TVA and the Corps is based on shipper savings. This is the difference between the cost of barge shipping and the next least costly mode – generally rail transport. The shipper savings per ton at Chickamauga are about $4, and traffic at the lock has historically averaged one million tons per year. Thus, $4 million dollars of shipping benefits accrue to the lock annually.

As Table 4 shows, benefits accruing to the navigation function are dwarfed by several other beneficiary groups. The principal beneficiaries are recreational users, but the dam and reservoir produce significant benefits in hydropower generation, flood control, and property owner wealth and expenditures.

3.3.3. Kentucky Reservoir

Kentucky Lock on the Tennessee River is sized at 110 feet x 600 feet -- construction is underway to add an additional chamber which is 110 x 1200 feet. This small case study is added to the report to show that moving down the river to confluence with the Ohio River, the shipper savings component of total value generated by various user groups becomes significantly larger than higher on the river. Note in Table 4 recreation again dominates in the value calculation with $ 1.7 billion. The navigation component ranks second with a value of $384 million. The property values component, shown for Chickamauga Lock, is not available for the Kentucky Reservoir.

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[35] Maki and Palumbo, 2001, *Disentangling the Wealth Effect: A Cohort Analysis of Household Saving in the 1990's*. Board of Governors of the Federal Reserve System, Washington, D.C.

[36] Tennessee Valley Authority, River Scheduling Group.

[37] The value is estimated by UTCTR by using the nameplate capacity at Chickamauga Dam as a percent of total hydropower generation to allocate out power generated at the dam. This estimated generation is valued at its wholesale value.

Table 4 : Value Accruing to Selected Beneficiary Groups in the Kentucky Reservoir

Group	*Value (Millions)*	*Percent*
Recreation*	$1,687.20	79.14%
Navigation	$384.00	18.15%
Hydropower	$39.00	1.83%
Flood Control	$20.00	0.93%
Water Supply	$1.78	0.08%
Total	$2,131.98	100.0%

* Includes only the direct effect and is a gross estimate that does not net out the recreational activity that might continue to occur given an absence of the navigation channel.

4. Navigation Infrastructure Funding

4.1. Funding Sources

Operation and maintenance (O&M) for inland waterway navigation system is funded 100 percent by the federal government, while construction and major rehabilitation projects are funded by federal government general appropriations (50 percent) and the Inland Waterways Trust Fund (50 percent).

4.2. Funding Levels

The total nominal dollars expended on navigation projects by waterway and project type are shown below in Table 5 and Table 6.[38] The data show that virtually all of the expenditures were to support the 'Floats Boats' mission with activities directly applicable to enabling and enhancing the ability of the water to support the movement of waterborne vessels. 'Physical Support' includes, among other things, bank stabilization and removal of sunken vessels, while 'Business Support' includes the development of the models and studies necessary to implement navigation programs

As shown in Table 5, during the period 1999-2009, $13.572 billion was expended in the funding of all navigation projects. Deep draft harbors and channels required $6.454 billion, while fuel taxed waterways received $5.449 billion.

[38] These data were supplied to the Center for Transportation Research by Mr. David Grier of the U. S. Army Corps of Engineers' Institute for Water Resources.

Table 5: Navigation Expenditures on All Waterways by Waterway Type, 1999-2009

Waterway Type	*Ten-Year Expenditures ($ billions)*
All Projects	$13.572
Deep Draft Harbors and Channels	6.454
Shallow Draft Harbors and Channels	1.192
Fuel Taxed Waterways	5.449
Not Selected Subtype	0.477

Table 6 shows that, of the total dollars expended on navigation projects, virtually all of the expenditures were to support the 'Floats Boats' mission with activities directly applicable to enabling and enhancing the capability for vessels to move up and down the waterways. 'Physical Support' includes, among other things, bank stabilization and removal of sunken vessels, while 'Business Support' includes the development of the models and studies necessary to implement navigation programs

Table 6: Navigation Expenditures on Fuel Tax Waterways by Project Type, 1999-2009

Project Type	*Ten-Year Expenditures ($ thousands)*
All Projects	$ 5,448,639
'Floats Boats'	3,353,313
Business Support	174
Physical Support	95,151

Congressional appropriations in support of navigation O&M have been flat in nominal terms and have actually declined in real terms as prices for labor and materials have increased through the years. Historical data depicting nominal and real data allocated to navigation operation and maintenance are shown in Figure 3. In real dollars, O&M funds supporting navigation grew from the later 1970's until the middle 1990's, when expenditures then fell through 2008. An infusion of stimulus money reversed this trend in 2009.

Funds available for new construction and major rehabilitation projects are limited due to (1) a 20 cent per gallon tax only on fuel taxed waterways that has remained unchanged since 1995, (2) declining tax revenues beginning in 2001, and (3) inflation. Tax collections have declined due to (1) towing industry consolidations, (2) less long haul grain traffic, (3) more efficient towboats, (4) fewer empty moves, and (5) deeper draft barges.

Towing industry consolidations have made it possible for the industry to become more efficient, thus lowering costs, including the cost of fuel used. Grain on the Upper Mississippi River is being railed to Saint Louis due to favorable rail rates, bypassing the Upper Mississippi River. Newer towboats are becoming more fuel efficient. The technology mentioned above, along with the impact of rising fuel costs, has caused the industry to look for backhauls where possible. Last, improvements in communication and technology have allowed the use of deeper draft barges. All of these factors have resulted in decreased fuel consumption and thus decreased trust fund collections.

Figure 3: Inland Navigation Operation and Maintenance Funds
(Current and 1996 constant $s)

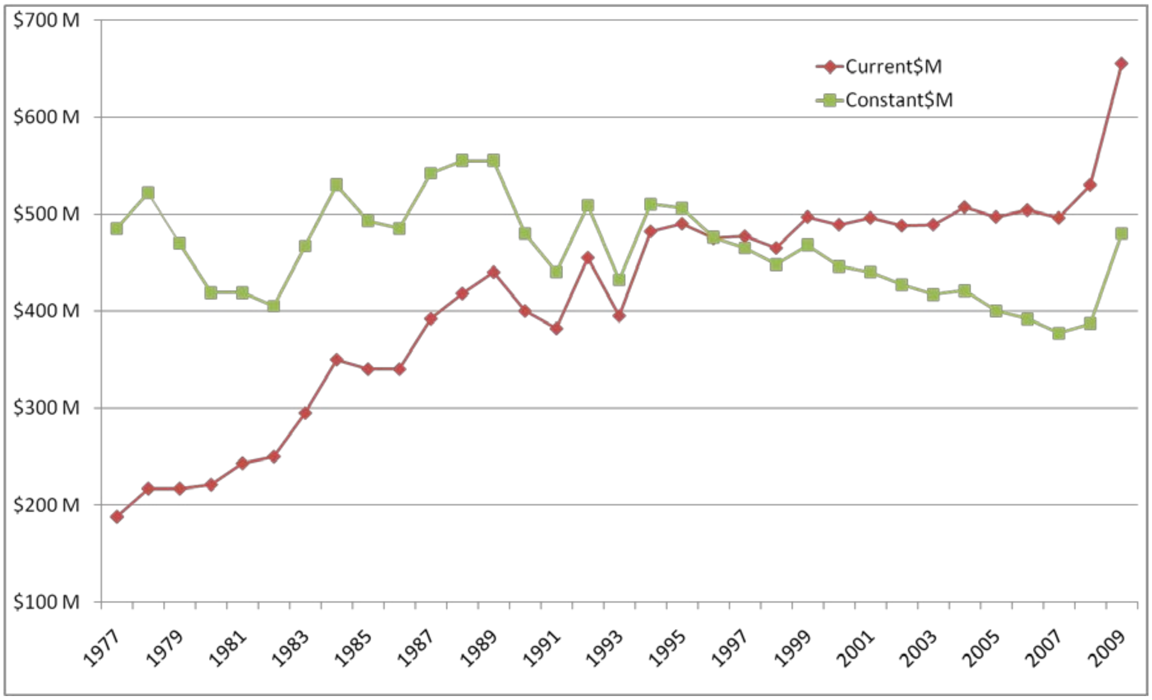
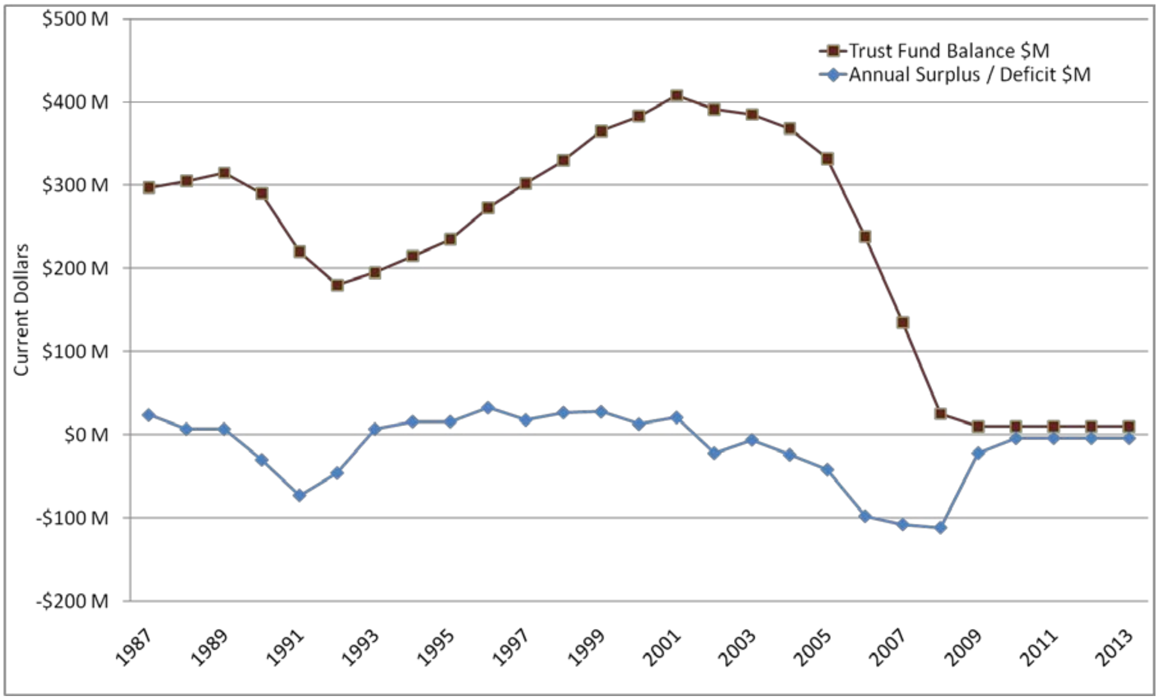


Figure 4 depicts the Inland Waterways Trust Funds available for new lock construction and major rehabilitations. As shown, the fund balance peaked in 2001 and began to fall in 2002. The balance is projected to be very small through 2013. There was a deficit in the trust fund balance in the early 1990’s which occurred again essentially from 2002-2010.

Figure 4: Inland Waterways Trust Fund History and Projections
(Projections at the current fuel tax rate)



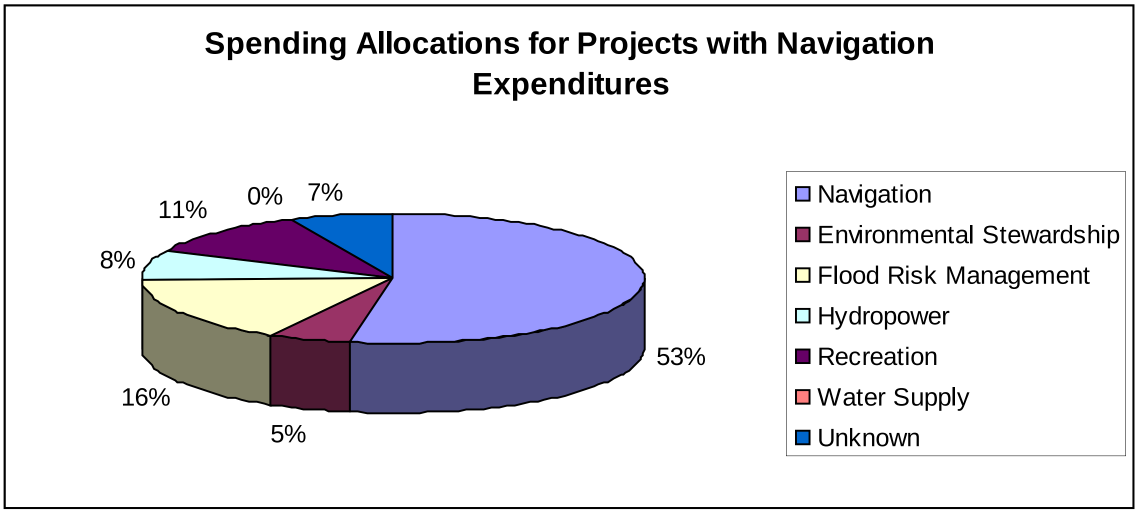
4.3. Fuel Tax Waterway Expenditures

Inland locks and dams are multipurpose projects and thus funds from various Corps business lines[39] are allocated to support their operation. Consider the Bonneville Project in the Columbia-Snake system where the principal authorized purposes are hydropower and navigation; other purposes are fish and wildlife, recreation, and water quality. On the Missouri River, the dominant functions are flood control and navigation,[40] while other purposes are water supply, water quality control, recreation, irrigation, fish and wildlife and threatened and endangered species. As shown in Figure 5, navigation (53%) accounts for the majority of national fuel tax waterway expenditures by business line (for those projects with any charges to the navigation account), followed by flood risk management (16%), recreation (11%), hydropower (8%), unknown (7%), environmental stewardship (5%), and water supply (<1%).

[39] The USACE was reorganized several years with designated "Business Line Managers" along functional lines. These include navigation, recreation, environmental stewardship, hydropower, water supply flood damage reduction and regulatory.

[40] A decision in July 2003 by the 8th District Court of Appeals, St. Louis, Missouri.

Figure 5: O&M Spending Allocations by Business Line for Projects with Navigation Expenditures



5. Summary and Conclusions

The opportunity to examine the scope and scale of the benefits associated with maintaining navigation capacity on the inland waterway system has revealed both expected and unexpected outcomes. Primarily, most reaches of this system were authorized or operated to provide navigation capacity, hydroelectric generation, and flood control, if designed into the system. Certainly, these uses currently produce tangible benefits and will continue to do so for the foreseeable future as long as the navigation infrastructure is maintained.

Perhaps somewhat surprising is the breadth and extent of other uses and consequences that very often generate benefits, possibly of equal or greater value. Very likely, air quality impacts, recreational usage, and freight network congestion mitigation were practically unheard of policy goals when the modern waterway system was designed, yet these uses are now important sources of project benefits and critical elements within system management plans.

Table 7 summarizes the beneficiary categories and, where feasible, the economic benefit valuations, which are discussed more fully in the report:

Table 7: Summary of Sundry Beneficiary Categories and Estimated Benefit Values

Beneficiary Category	*Reported Benefit Scope*	*Estimated Benefit**
Shipping savings to navigation-using industry (a.k.a. 'shipper savings' or 'SS')	Ohio River System; total barge transport cost savings due to transportation rate differentials	$3.10 B/yr
Economic impacts from commercial navigation freight transport savings (i.e., from SS)	Total value to U.S. economy (net of SS) from barged commodity shipments on the Ohio River System (ORS) plus ORS coal-fired electric utilities other use of water**	$17.40 B/yr

Beneficiary Category	*Reported Benefit Scope*	*Estimated Benefit**
Shipping savings to industries using competitive modes (via 'water-compelled rates')	—	—
Recreation	Sum of regional impacts (value-add) for all Corps facilities in U.S.	$16.00 B/yr
Flood damages avoided	Corps. + TVA; savings	$10.23 B/yr
Hydropower generation	Corps. + TVA; revenues	$4.90 B/yr
Irrigation	Three states: Oregon, Washington, Idaho; irrigated farms on navigable water Net value of crops lost: Net value of farm income lost:	$5.99 B/yr $462 M/yr
Water supply	Ohio River system; value of water used	$954 M/yr
Property values	Fort Loudoun Reservoir – elimination of nine foot channel; *one-time loss of property value*	$1.12 B
Sewage assimilation	—	—
Congestion and safety impacts	Pittsburgh area freight diversions from barge to truck; impact per ton (includes pollution reduction), increasing as roadway congestion increases	$3-$50/ton of freight diverted
Environmental impacts	—	—
Mosquito control	—	—

*Generally, the dollar year base is in the range of 2002-2008. Values are in annual billion of dollars except where indicated otherwise.

** For coal-fired electric utilities, ORS impacts would include any 'water-compelled rate' benefits

These sundry beneficiaries indicate a failure of the navigation system or a portion of the system most likely would negatively affect large numbers of people—more so than might have ever been anticipated when the system was conceived. Navigation locks have a design life of roughly 50 years and 57 percent of existing locks are over this age. Thus, while a catastrophic system failure is still improbable, it grows slightly more likely with each passing decade.

One hundred percent of the funding for operation and maintenance of the system of navigation locks and dams is provided by the federal government, while construction and major rehabilitation projects are funded by federal government general appropriations (50 percent) and the inland waterways trust fund (50 percent). From the operations and maintenance account, most of the funds are expended to support enabling and enhancing the capability for vessels to move up and down the waterways. This funding began to decline in the middle 1990's in real terms until an infusion of stimulus money reversed the trend in

2009. Funds available for new construction and major rehabilitations have fallen for a variety of reasons such that the balance in the Trust Fund for new lock construction and major rehabilitations is projected to be very small through 2013.

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