fair share of new traffic finds its way to rivers and canals. Additional intermodal movements will be needed as a result of pressures from the shipping public. In several recent instances, railroads have found that their earnings are maximized by an intermodal movement rather than an all-rail proportional rate. This is encouraging in that it profits all concerned with transportation, including--and most importantly--the customer or consumer.

For 30 years after World War II, the barge and towing industry lived in an atmosphere of quiet growth and general prosperity. However, we suddenly realized during the struggle for authorization of the replacement of Locks and Dam 26 and the debate over user charges that we could no longer afford, as an industry, to sit back quietly hoping that others would understand our role, our purpose, and our problems. Our message must be taken to the public, particularly to those who are in a position to influence public policy. We need a balanced and unbiased national transportation policy that addresses the interests of all modes and, more importantly, the needs and desires of the shipping public. The barge and towing industry stands ready to play a part in the formulation of that policy.

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Impacts of Inland Waterway User Charges

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The potential impacts of imposing user charges on inland waterways are estimated by using models and data of the U.S. Army Corps of Engineers inland navigation systems analysis program. Fee schedules designed to recover 50 and 100 percent of Corps of Engineers operations, maintenance, and rehabilitation expenses plus Coast Guard costs of providing navigation aids are developed. Two types of fees are considered: a uniform, systemwide fuel tax and a set of segment megagram-kilometer fees that provide for local recovery of local costs. The principal impacts examined are changes in waterway transportation costs and modal shares of interregional freight traffic. Impacts of user charges are found to vary considerably throughout the waterway network based on the type of fee, the level of cost recovery, existing (without user charges) towing industry costs, and the waterway traffic base. Segment fees generally produce greater impacts than a fuel tax.

Inland waterway user charges constitute one issue in the emerging broader policy issue of the role of inland waterways in the nation's transportation system. User charges have been proposed to increase federal revenues and to require commercial waterway users to bear directly at least some right-of-way costs. There is, however, no consensus on the best type of user charge. The study summarized in this paper developed estimates of the potential impacts of selected types of inland waterway user charges as an aid to policy makers who will be carefully scrutinizing various user charge proposals. A more detailed account of the study is available elsewhere (1).

SCOPE OF STUDY

The array of potential inland waterway user charges includes megagram-kilometer fees, lockage fees, the fuel tax, equipment registration fees, direct shipper fees, and congestion tolls. This study examines a megagram-kilometer fee and a fuel tax. These are the mechanisms that have been suggested respectively by the Office of Management and Budget (OMB) and the U.S. Department of Transportation (DOT).

A wide variety of implementation options exist for each type of potential user charge. A user charge can vary according to the types of costs recovered, the level and the timing of cost recovery, and whether costs are recovered by uniform systemwide fees or by a fee schedule designed for local recovery of local costs. This study examines potential impacts of recovering 50 and 100 percent of U.S. Army Corps of Engineers operations, maintenance, and rehabilitation (OM&R) expenses plus Coast Guard costs of providing navigation aids. Partial recovery of future construction costs is also briefly considered. Impacts are estimated for current traffic bearing the burden of current costs. Within this implementation framework, estimated potential impacts of imposing a megagram-kilometer fee or a fuel tax on U.S. inland waterway transportation are presented. Impacts of partial recovery of federal costs for the Mississippi River plus tributaries and the Gulf Intracoastal Waterway (GIWW) portions of the inland waterway system are estimated.

Inland waterway user charges could have a variety of economic impacts. This paper examines only costs in the towing industry and impacts of modal traffic shares. Further, only waterway and rail competition for movement of fixed intercity traffic is considered. Pipelines and intercity trucking are not included, and origin-destination patterns and volumes of freight traffic are held constant. Actual economic impacts require considerable time to occur. However, because of limited study time, this paper describes impacts as they might occur in a base year rather than attempting to predict an evolving economic adjustment through

time. It is felt that the base-year impacts, estimated to reflect considerable market system response to user charges, can suggest the size and location of potential long-run impacts. The base year for this study is 1972, the most recent year for which detailed economic and multimodal traffic data are available.

ASSUMPTIONS

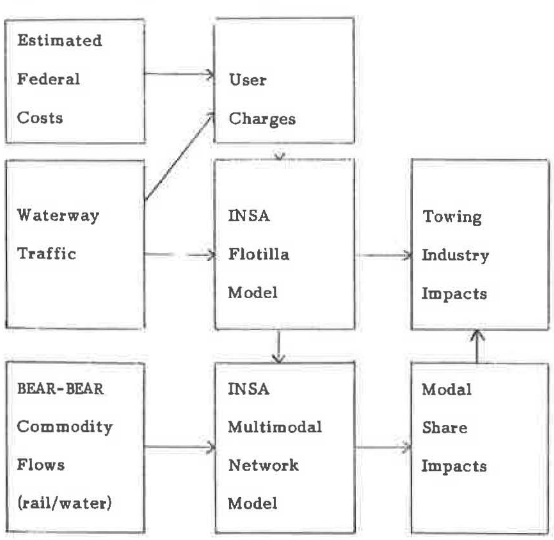
The basic premise of the study is that inland waterway transportation is one component of a multimodal transportation market and that the economic impacts of waterway user charges can be estimated by simulating market responses to the proposed user charges. Specific working assumptions included the following:

1. The towing industry is sufficiently competitive that all firms face essentially the same costs.
2. Rail and waterway technology remains unchanged in the face of waterway user charges.
3. Competition and efficient regulation allow transportation costs to adequately represent transportation market prices.
4. Each shipper is rational, fully informed, and able to shift modes freely.
5. There is no vertical integration involving the towing industry or the railroads, and market transactions are guided only by market prices.
6. Grain for export is gathered from the hinterlands of fixed inland waterway ports and travels to fixed export points.
7. Federal costs for waterway operation, maintenance, and rehabilitation and for provision of navigation aids are known precisely enough for each individual waterway to permit accurate assessment of user charges.

METHODOLOGY

A schematic of the study methodology is shown in Figure 1. Estimates of base-year federal expenditures on inland waterways were provided by the Corps of Engineers and the Coast Guard. These were used in conjunction with base-year waterway traffic to prepare fee schedules for each type of user charge and level of cost recovery. The waterway traffic data were port-to-port flows obtained by aggregating the detailed dock-to-dock flows compiled by the Waterborne Commerce Statistical Center of the Corps of Engineers.

Figure 1. Study methodology.



Estimates of user charge impacts were made by using models and data developed for the Corps of Engineers inland navigation systems analysis (INSA) program (2). Indeed, this study represents the first attempt to apply INSA to a major problem. The principal INSA models used in this study include the following:

1. Flotilla model--The flotilla model is an engineering cost simulator that combines commodity traffic patterns, waterway network characteristics, equipment performance, and seasonal variations to estimate the towing industry's waterway transportation costs and fleet requirements.
2. Multimodal network model--The multimodal network model represents intercity freight transportation and predicts transportation prices and service levels as jointly determined by traffic patterns and volumes and by network structure, costs, and capacities.

In addition to the basic INSA models, several detailed modal simulators (3, 4, 5) were also used to develop estimates of rail and waterway cost and performance characteristics for input to the network model.

The method used to estimate potential user charge impacts consisted of the following sequence:

1. Simulate base-year transportation markets to estimate equilibrium prices, traffic volumes, and modal shares in the absence of waterway user charges.
2. Estimate impacts of user charges on costs to the inland waterway towing industry.
3. By using revised towing industry costs, simulate base-year transportation markets to estimate potential impacts of user charges on equilibrium prices, traffic volumes, and modal shares.

Each of these elements contains several major tasks. Estimating transportation market equilibrium, for instance, requires estimates of transportation demand and supply, which are then combined to estimate market equilibrium. Transportation demand estimates were supplied by DOT in the form of 1972 commodity flows among the 173 Bureau of Economic Analysis regions (BEARs) defined by the U.S. Department of Commerce (6). Transportation supply curves were defined for each node and link in the national multimodal network. For this study, multimodal network elements describe only rail, waterway, local trucking, and modal interchange, but the capability exists to include pipelines and long-distance trucking in an expanded study. The total study network contains about 2000 nodes and 4000 links.

Given transportation demand and supply, the multimodal network model estimates transportation market equilibrium prices, traffic volumes, and modal shares. In essence, the direct impacts of waterway user charges are represented by their effects on the transportation costs and supply schedules of the waterway network. Market response to these changed costs then depends on the interaction of supply and demand throughout the multimodal system.

USER CHARGE ESTIMATES

Megagram-kilometer fees are estimated on both a system basis and a segment basis. Waterway traffic data used for calculating user charges are given in Table 1. For the system fee, systemwide government costs are partially or fully recovered by imposing a uniform systemwide megagram-kilometer fee. For the segment fee, government costs are partially or fully recovered by imposing a set of megagram-kilometer fees calculated so that each segment's costs are borne by that segment's traffic. A waterway fuel tax is cal-

Table 1. Estimated traffic and federal costs for major river segments.

River Segment	Megagram-Kilometers of Traffic[a] (000 000s)	Expenditures ($000) Corps OM&R[b]	Coast Guard[c]	Total
Mississippi River, Cairo to Baton Rouge	95 660	8 965.4	1 830.0	10 795.4
Upper Mississippi River	31 343	20 811.6	2 297.4	23 109.0
Arkansas River	688	12 814.5	299.9	13 114.4
White River	82	356.4	2.0	358.4
Ohio River	44 860	13 836.7	830.5	14 667.2
Monongahela River	2 207	2 543.3	42.7	2 586.0
Allegheny River	123	1 196.1	2.3	1 198.4
Tennessee River	4 789	2 437.3	93.1	2 530.4
Cumberland River	1 229	1 814.3	25.5	1 839.8
Kanawha River	1 175	1 470.3	18.6	1 488.9
Green and Barren rivers	1 959	910.2	37.1	947.3
Kentucky River	64	1 264.4	1.2	1 265.6
Illinois Waterway	11 883	6 131.1	805.8	6 936.9
GIWW West	24 700	9 194.6	1 145.0	10 339.6
GIWW East	4 213	1 405.8	1 026.1	2 431.9
Pearl River	-[d]	275.6	23.2	298.8
Alabama-Coosa rivers	184	1 187.1	-	1 187.1
Black Warrior-Tombigbee-Mobile rivers	6 502	11 421.0 (3 069.3)[e]	5 652.8 (427.1)[e]	17 073.8 (3 496.4)[e]
Missouri River	1 918	14 015.2	488.0	14 503.2
Apalachicola-Chattahoochee-Flint rivers	149	3 546.5	137.2	3 683.7
Atchafalaya River	3 585	841.2	14.9	856.1
Red River	35	14.0	21.1	35.1
Black and Ouachita rivers	181	1 861.1	3.1	1 864.2
Total	237 500	120 015.6	14 797.5	134 813.1

Notes: 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a]Actual port-to-port 1972 traffic on the Mississippi-GIWW network captured by the flotilla model.
[b]Estimated average annual OM&R costs for 1971 through 1975.
[c]Estimated 1974 navigation aids costs.
[d]All traffic is too localized to be captured for analysis.
[e]Revised costs for the Black Warrior-Tombigbee-Mobile rivers reflect costs when Bankhead Lock and Dam rehabilitation costs are excluded and when revised Coast Guard estimates are used. System totals use original estimates rather than parenthetical values. It should be noted that, because all federal cost estimates in this table have been derived from accounting systems neither designed nor intended for user charge impact analysis, these estimated costs may be subject to considerable revision.

culated by assuming a systemwide uniform fuel tax. The tax burden falls on the traffic of each segment according to estimated fuel consumed to move commercial traffic.

Both megagram-kilometer fees and fuel tax have been calculated for 50 and 100 percent recovery of Corps OM&R costs and Coast Guard navigation aids costs. Preliminary agency estimates of these costs are given in Table 1. These cost estimates have been derived from accounting systems neither designed nor intended for analysis of user charge impacts. As a result, these estimated costs may be subject to considerable revision. As an example, recently revised federal estimates for the Black Warrior-Tombigbee-Mobile rivers indicate a substantial change in costs. Similar revisions may occur elsewhere in the network.

Fuel Tax

Several runs of the INSA flotilla model were used to calculate uniform systemwide fuel taxes. The first model run assumed no tax and was used to estimate baseline fuel consumption. The second model run included a 50 percent cost recovery fuel tax based on without-tax fuel consumption. However, fuel consumption decreased as the model simulated the towing industry's adjustment to increased fuel price. Similar attempts at 100 percent cost recovery produced even further shortfalls. As these sample results indicate, successively higher fuel taxes lead to successively more strenuous attempts at fuel conservation. As a result, the 100 percent recovery fuel tax rate is more than twice the 50 percent recovery tax rate because of shrinkage in the fuel consumption tax base.

Data given in Table 2 show how successively higher fuel taxes might lead to more intensive fuel conservation. The first column gives possible levels of a uniform systemwide fuel tax. The second column gives estimates by the flotilla model of fuel consumed at each level of the fuel tax. The third column displays the potential fuel savings that could result from fuel conservation at each level of a uniform systemwide fuel tax.

It should be noted that these potential fuel savings do not reflect any loss in waterway traffic but

Table 2. Estimated impact of waterway fuel taxes on fuel consumption.

Fuel Tax ($/L)	Flotilla Model Estimates of Liters of Fuel Required (000 000s)	Potential Fuel Savings (%)	Estimated Total Liters of Fuel Consumed (000 000s)	Revenue Given Fuel Savings ($000 000)	Cost Recovery (%)
0	1605	0	2124	0	0
0.040	1488	7.3	1969	78	58
0.046	1477	8.0	1954	90	67
0.079	1408	12.3	1863	147	109
0.096	1393	13.2	1844	148	132

Notes: 1 L = 0.264 gal.
All data are preliminary and subject to change.

Table 3. Estimated 1972 megagram-kilometer fees and fuel taxes required for recovery of federal costs.

Type of Charge	Cost Recovery: 50 Percent, Same Traffic	Cost Recovery: 50 Percent, Traffic Loss	Cost Recovery: 100 Percent, Same Traffic	Cost Recovery: 100 Percent, Traffic Loss	Towing Industry Cost Without User Charges[a] (mills/Mg·km)
System fuel tax, $/L	3.4	3.6	7.3	7.9	
System fee, mills/Mg·km	0.27	0.34	0.55	0.62	
Segment fee by river segment, mills/Mg·km					
Mississippi River, Cairo to Baton Rouge	0.07	0.07	0.14	0.14	1.6
Upper Mississippi River	0.34	0.41	0.75	0.75	1.8
Arkansas River	9.5	225	19.0	2246	2.3
White River	2.2	3.5	4.4	18.9	5.8
Ohio River	0.14	0.21	0.34	0.34	1.8
Monongahela River	0.62	0.62	1.2	1.2	3.4
Allegheny River	4.9	68	9.8	821	5.3
Tennessee River	0.27	0.27	0.55	0.62	1.9
Cumberland River	0.75	0.75	1.5	2.1	1.8
Kanawha River	0.62	0.68	1.3	1.4	2.5
Green and Barren rivers	0.27	0.27	0.48	0.55	5.7
Kentucky River	9.9	1095	19.7	2189	7.7
Illinois Waterway	0.27	0.34	0.62	0.68	2.1
GIWW West	0.21	0.21	0.41	0.41	2.1
GIWW East	0.27	0.34	0.55	0.62	2.3
Pearl River	-	-	-	-	-
Alabama-Coosa rivers	3.2	407	6.4	815	3.2
Black Warrior-Tombigbee-Mobile rivers	1.3	14.8	2.6	34.5	1.6
	0.27[b]	1.8[b]	0.55[b]	4.0[b]	
Missouri River	3.8	6.0	7.5	20.4	2.1
Apalachicola-Chattahoochee-Flint rivers	12.4	1262	24.7	2523	4.8
Atchafalaya River	0.14	0.14	0.21	0.27	2.1
Red River	0.48	1.2	1.0	3.0	3.3
Black and Ouachita rivers	5.1	638	10.3	1277	2.9

Notes: 1 L = 0.264 gal; 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a] Estimated by the flotilla model.

[b] Reduced segment megagram-kilometer fees correspond to recently revised federal estimates of OM&R and navigation aids costs. Similar revision may occur elsewhere in the system (see footnote e in Table 1).

rather arise as the flotilla model simulates the towing industry's attempts to conserve a resource that has become more expensive. In all cases, the same traffic is moving between the same ports of origin and destination. The only difference among these simulations is the price of fuel, which is modified by imposing a fuel tax.

The flotilla model tends to understate actual fuel consumption. In Table 2, the fourth column gives estimates of actual total waterway fuel consumption at each level of the fuel tax. These estimates are derived by applying the estimates of fuel savings in the third column to the estimated total 1972 consumption of 2.12 billion L (561 million gal). These estimates of total fuel consumption are then multiplied by their corresponding fuel taxes to yield the estimated federal revenues in the fifth column and the percentage of cost recovery in the sixth column of Table 2.

Results indicate that a fuel tax ranging from $0.032 to $0.034/L ($0.12 to $0.128/gal) would have recovered 50 percent of federal OM&R and navigation aids costs in the 1972 base year; the higher numbers indicate the higher tax necessary to offset reduced fuel consumption. Recovery of 100 percent of federal costs would have required a tax ranging from $0.063 to $0.073/L ($0.24 to $0.278/gal); again, the higher numbers reflect the higher tax necessary to offset reduced fuel consumption. Analysis of the modal traffic share suggests that a uniform systemwide fuel tax for 50 percent recovery would reduce system megagram-kilometers by about 5.5 percent. A similar fuel tax for 100 percent recovery would reduce system traffic by about 7.1 percent. If it is assumed that reduced traffic further proportionately reduces fuel consumption beyond the fuel savings already achieved by conservation in the towing industry, the $0.034/L ($0.128/gal) tax increases to $0.036/L ($0.135/gal) for 50 percent recovery, and the $0.073/L ($0.278/gal) tax increases to $0.079/L ($0.298/gal) for 100 percent recovery.

Megragram-Kilometer Fees

Table 3 gives estimated megagram-kilometer fees for several possible conditions. The fees are calculated for 50 and 100 percent cost recovery. For both levels of cost recovery, fees are calculated for both existing base-year traffic (Table 1) and traffic remaining after estimated losses occur. In addition, fees are calculated on both a uniform systemwide basis and a segment basis so that the fees of each segment recover the segment costs.

As Table 3 indicates, a uniform systemwide fee of 0.27 mill/Mg·km (0.4 mill/ton-mile) would provide 50 percent cost recovery assuming no traffic loss. If we take into account potential traffic loss, given this fee structure, the uniform systemwide fee increases to 0.34 mill/Mg·km (0.5 mill/ton-mile) on remaining traffic. For 100 percent cost recovery, the uniform systemwide fee is 0.55 mill/Mg·km (0.8 mill/ton-mile), which increases to 0.62 mill (0.9 mill) given potential traffic losses.

Segment fees, calculated so that the fees for each segment recover the costs for that segment, vary widely among waterway segments. For instance, the lower Mississippi segment fee is 0.07 mill/Mg·km (0.1 mill/ton-mile) for 50 percent cost recovery and 0.14 mill (0.2 mill) for 100 percent cost recovery. Under a segment fee approach, the lower Mississippi would lose so little traffic that the fees would remain unchanged. As another example, the Illinois Waterway segment fee is 0.27 mill/Mg·km (0.4 mill/ton-mile)

for 50 percent cost recovery and 0.62 mill/Mg·km (0.9 mill/ton-mile) for 100 percent cost recovery assuming no traffic loss in each case. Given potential traffic loss, these fees increase to 0.34 mill (0.5 mill) for 50 percent recovery and 0.68 mill (1.0 mill) for 100 percent recovery. By contrast, segment megagram-kilometer fees increase much more rapidly on some other waterway segments. On the Missouri River, for example, the 50 percent recovery fee of 3.8 mills (5.5 mills) increases to 6.0 mills (8.8 mills) after potential traffic loss. Similarly, the 100 percent recovery fee of 7.5 mills (11.0 mills) increases to 20.4 mills (29.8 mills) after potential traffic loss.

Fees for Partial Recovery of Future Construction Costs

Parametric analysis was used to estimate megagram-kilometer fees and equivalent fuel taxes to recover various percentages of preliminary OM&R and new construction costs for fiscal years 1980 through 1984. The results (which are not included here) indicate that the $0.011 to $0.016/L ($0.04 to $0.06/gal) fuel tax proposed by the Congress is approximately equivalent to the combination of 10 percent OM&R and 5 percent construction cost recovery. It is emphasized, however, that 100 percent OM&R and 50 percent new construction cost recovery, as suggested by some, would require an estimated fuel tax of more than $0.18 ($0.70), which is twice the current cost of diesel fuel. The impact of such heavy fuel taxes on waterway carriers and industries would likely be substantial, as demonstrated in the following section.

ESTIMATED IMPACTS OF USER CHARGES

Towing Industry Cost

The last column of Table 3 gives estimated towing industry costs without user charges. These costs represent estimates by the flotilla model of fully allocated expenditures for equipment, fuel, supplies, maintenance and repairs, labor, and overhead. The flotilla model was also used to estimate towing industry costs given the user charges in Table 3. These estimates show how base-year industry costs would appear with a user charge if the industry could adjust its fleet and operating patterns to mitigate the cost burdens of user charges.

Results provided in detail elsewhere (1) indicate that individual rivers would experience a cost increase of 0.14 to 0.55 mill/Mg·km (0.2 to 0.8 mill/ton-mile) with a 50 percent recovery fuel tax assuming no traffic loss. At the 100 percent recovery level, the increase would be 0.34 to 1.2 mills (0.5 to 1.7 mills). Traffic losses caused by the fuel tax produce towing industry cost increases that are slightly greater than these figures.

The picture is substantially different in the case of segment fees. For some waterways, such as the Arkansas, Allegheny, and Kentucky rivers, segment megagram-kilometer fees shrink the traffic base so much that the remaining traffic moves at an average cost of more than $1/Mg·km ($1.46/ton-mile). For rivers such as these, the results represent a "snapshot" in an iterative analysis process. Modal-share

Table 4. Estimated system impacts of user charges on waterway-rail modal split.

Commodity	Total (000 000s)	Waterway Share With No User Charge[a] (%)	Segment Fee (100 percent recovery) Waterway Share[a] (%)	Segment Fee (100 percent recovery) Change (%)	Fuel Tax (100 percent recovery) Waterway Share[a] (%)	Fuel Tax (100 percent recovery) Change (%)
Megagrams						
Coal	398	21.5	19.0	-2.5	19.3	-2.2
Petroleum	181	39.7	36.2	-3.5	36.5	-3.2
Chemicals and fertilizer	24	66.4	62.6	-3.8	64.0	-2.4
Metals and products	37	21.1	19.3	-1.8	19.4	-1.7
Ores and scrap	90	14.4	8.1	-6.3	9.2	-5.2
Cement, stone, sand, and gravel; shells; and products	120	29.4	26.5	-2.9	26.9	-2.5
Agricultural, marine, and forestry products	124	10.7	9.2	-1.5	9.6	-1.1
Grain	83	32.2	30.9	-1.3	32.1	-0.1
Manufactured products	31	6.0	4.7	-1.3	6.0	0.0
Miscellaneous	77	10.0	9.1	-0.9	11.0	+1.0
Total	1165	23.9	21.3	-2.6	21.9	-2.0
Megagram-Kilometers						
Coal	254 000	15.9	14.4	-1.5	14.6	-1.3
Petroleum	145 000	37.7	36.1	-1.6	37.2	-0.5
Chemicals and fertilizer	26 000	77.7	72.7	-5.0	75.1	-2.6
Metals and products	47 000	22.6	20.2	-2.4	20.4	-2.2
Ores and scrap	66 000	18.7	11.3	-7.4	14.2	-4.5
Cement, stone, sand, and gravel; shells; and products	63 000	31.3	29.1	-2.2	29.1	-2.2
Agricultural, marine, and forestry products	147 000	9.2	7.8	-1.4	8.1	-1.1
Grain	99 000	40.6	39.2	-1.4	40.5	-0.1
Manufactured products	55 000	2.6	2.0	-0.6	2.6	0.0
Miscellaneous	85 000	6.7	6.9	+0.2	8.6	+1.9
Total	987 000	22.4	20.5	-1.9	21.4	-1.0

Notes: 1 Mg = 1.1 tons; 1 Mg·km = 0.685 ton-mile.
All data, which were estimated by base year (1972) simulations by using the INSA multimodal model, are preliminary and subject to change.

[a]Waterway share of total inter-BEAR waterway and railroad traffic (1972) excluding Great Lakes, Pacific Coast, and Atlantic Coast shallow-draft waterway traffic and all domestic deep-draft traffic.

analysis would undoubtedly reveal an even greater traffic loss and a resulting further increase in subsequent fees. Such waterways appear well on their way to shutdown under a megagram-kilometer segment fee at the 100 percent recovery level.

Potential Traffic Impacts

The INSA multimodal network model was used to develop preliminary estimates of the potential traffic impacts of a uniform systemwide fuel tax and a set of segment megagram-kilometer fees. In this impact analysis, the immediate effects of each user charge are represented by adjusting cost curves to reflect the user charge burden. Then, by using the adjusted cost curves to represent towing industry supply schedules for each waterway segment, the multimodal model simulates modal selection by individual shippers and aggregates these individual decisions to estimate the resulting transportation market prices, traffic volumes, and service levels.

Table 4 gives the predicted impact of 100 percent recovery user charges on the waterway-rail modal split of interregional freight traffic. On an overall basis, segment fees would cause a 2.6 percent reduction in the waterway megagram share and a 1.9 percent reduction in the megagram-kilometer share. The fuel tax impact is slightly smaller and causes a 2 percent reduction in the megagram share and a 1 percent reduction in the megagram-kilometer share. In general, larger reductions occur for most commodities in megagrams than in megagram-kilometers, which indicates that it is the shorter haul waterway traffic that is diverted to rail. This agrees with the conventional wisdom that holds that the waterway cost advantage over rail increases with the distance of the haul. This partially explains the relatively small loss of grain traffic by waterways in the face of user charges; there is a very little short-haul grain traffic to be diverted to rail, and the long-haul traffic has a large cost margin that can easily absorb the increased costs. Caution must be exercised in considering these results, however, because the ultimate origins of waterway grain traffic are not effectively captured in the commodity flow data input to the model. That is, only the proximate origin port of the traffic is known. A detailed analysis at a sub-BEAR geographical scale of waterway hinterlands for grain movements would likely show quite different user charge impacts. In addition, changing destination ports--a possibility not explored in this preliminary study--might increase waterway user charge impacts.

Table 5 gives the estimated net impact of revised modal-choice decisions on Mississippi-GIWW network traffic. In this table, estimated total megagram-kilometer traffic by waterway segment is shown for no user charge and for 50 and 100 percent cost recovery with a uniform systemwide fuel tax or a set of segment megagram-kilometer fees. The megagram-kilometer estimates in this table reflect actual base-year (1972) port-to-port flows as modified by BEAR-to-BEAR percentage traffic losses estimated by the multimodal network model.

These results suggest that, for 50 percent cost recovery, a systemwide fuel tax would reduce system megagram-kilometers by about 5.5 percent; a comparable cost recovery segment fee structure would reduce system megagram-kilometers by about 8.6 percent. The fuel tax would evidently have its greatest impact on the Black Warrior-Tombigbee-Mobile rivers. A segment megagram-kilometer fee would affect, in addition to these rivers, the Arkansas, Allegheny, Kentucky, Alabama-Coosa, Apalachicola-Chattahoochee-Flint, Missouri, Red, and Black and Ouachita rivers. By contrast, such major waterways as the lower and upper Mississippi, the Ohio, the Illinois, and the Tennes-

Table 5. Potential impacts of user charges on waterway traffic.

	Megagram-Kilometers (000 000s)				
		50 Percent Recovery		100 Percent Recovery	
River Segment	No User Charge	Fuel Tax	Segment Fee	Fuel Tax	Segment Fee
Mississippi River, Cairo to Baton Rouge	95 660	92 981	90 208	91 547	90 088
Upper Mississippi River	31 343	30 716	30 026	30 152	29 712
Arkansas River	688	607	29	523	6
White River[a]	82	72	51	63	19
Ohio River	44 860	42 706	42 436	42 213	42 168
Monongahela River	2 207	2 185	2 185	2 185	2 185
Allegheny River[a]	123	115	9	105	1
Tennessee River	4 789	4 626	4 310	4 411	4 310
Cumberland River	1 229	1 191	1 191	1 191	876
Kanawha River	1 175	1 118	1 112	1 106	1 105
Green and Barren rivers[a]	1 959	1 701	1 889	1 487	1 794
Kentucky River[a]	64	58	0	51	0
Illinois Waterway	11 883	11 456	11 005	11 324	10 647
GIWW West	24 700	24 008	23 310	23 637	23 292
GIWW East	4 213	4 094	3 975	4 032	3 972
Pearl River	-	-	-	-	-
Alabama-Coosa rivers[a]	184	161	1	137	1
Black Warrior-Tombigbee-Mobile rivers	6 502	890	578 871[b]	813	495 800[b]
Missouri River	1 918	1 899	1 209	1 899	709
Apalachicola-Chattahoochee-Flint rivers[a]	149	131	1	115	1
Atchafalaya River	3 585	3 549	3 516	3 430	3 500
Red River	35	16	15	15	12
Black and Ouachita rivers	181	180	1	139	1
Total	237 500	224 461	217 059	220 575	214 897

Notes: 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a] Traffic impact estimates for these rivers with mostly local traffic are based on a preliminary parametric analysis of other rivers with similar costs and traffic. This analysis tentatively suggests that, for local traffic, moderate cost increments, and relatively high initial cost, traffic will decline at about the same rate as the increase in cost.

[b] Estimates reflect smaller segment fees resulting from revised federal cost estimates (see Table 1).

see rivers and the GIWW, which collectively account for more than 90 percent of system base-year megagram-kilometers, remain relatively untouched.

For 100 percent cost recovery, results suggest a 7.1 percent systemwide loss of megagram-kilometers with a fuel tax and 9.5 percent with a segment megagram-kilometer fee. The 100 percent recovery fuel tax would have major impacts (more than 20 percent traffic loss) for the Arkansas, White, Green and Baren, Kentucky, Alabama-Coosa, Black Warrior-Tombigbee-Mobile, Apalachicola-Chattahoochee-Flint, Red, and Black and Ouachita rivers. A comparable segment megagram-kilometer fee would effectively close the Arkansas, Allegheny, Kentucky, Alabama-Coosa, Apalachicola-Chattahoochee-Flint, and Black and Ouachita rivers to commercial traffic. The segment fee would also greatly reduce traffic on the White, Cumberland, Missouri, Red, and Black Warrior-Tombigbee-Mobile rivers.

In general, and for the network as a whole, traffic losses with 100 percent cost recovery fees are not double those with 50 percent recovery fees. This occurs because for many rivers, such as the Arkansas, Allegheny, Kentucky, and Alabama-Coosa and several others, traffic losses caused by user charges designed to recover 50 percent of federal costs are so great that there is very little traffic left to be lost with 100 percent cost recovery user charges. This also helps to explain why traffic losses tend to increase by only 1 or 2 percent on major waterways such as the Mississippi and Ohio rivers, the Illinois waterway, and the GIWW when the cost recovery level goes up from 50 to 100 percent. Much of the traffic loss on these waterways is caused by traffic losses on the tributaries that feed them, particularly in the case of segment megagram-kilometer fees. Since there is not much opportunity for further traffic losses on the tributaries as the cost recovery level increases, there is also less opportunity for traffic losses on main navigation arteries. A second reason is that user charges at 50 percent cost recovery eliminate most of the main-stem traffic that is moving at costs only slightly lower than rail costs. The remaining waterway traffic tends to be longer haul traffic with a more substantial cost advantage, and thus less of it is diverted to rail when user charges are increased to recover 100 percent of federal costs.

Impacts of a \$0.011 to \$0.016/L (\$0.04 to \$0.06/gal) fuel tax would likely be in the range of 50 to 100 percent of the impact of the 50 percent recovery fuel tax. The nonlinear nature of the relations between impacts and cost recovery level precludes making a more precise estimate without further experimentation.

ACCURACY OF THE RESULTS

Several precautions must accompany these findings.

1. Later impacts may exceed estimated base-year impacts. Estimated base-year impacts, which attempt to capture long-term market adjustments, may differ from the impacts that might occur during an actual first year of inland waterway user charges. For instance, towing industry cost impacts might exceed those reported here because the base-year analysis used here includes attempts by the towing industry to mitigate user charge impacts. Some of these industry adjustments would require a revised fleet, which would be difficult to accomplish within a year. This limited ability to adjust might cause actual cost impacts to exceed estimated base-year impacts. Conversely, estimated base-year impacts on modal shares may exceed actual modal shifts during the first year of a waterway user charge. However, cumulative impacts may exceed estimated impacts.

Exploratory simulations of base-year economic patterns (not reported in this paper) reveal that traffic origin-destination patterns might soon begin to change. Shifts in origin-destination patterns tend to reduce waterway traffic in two ways. First, a shift in the supply region may require a shift from waterway to rail. Second, preliminary results indicate that a shift in the supply region usually reduces the distance from origin to destination even when traffic stays on the waterway. The result in either case is to reduce the waterway traffic base. To maintain a given cost recovery level with reduced traffic, user charges would have to be increased in succeeding years. This additional increase in waterway transportation costs might lead to still further modal diversions and origin-destination shifts. The potential base-year origin-destination shifts are small--less than 1 percent of all rail and waterway traffic. However, simulating economic patterns through time might reveal a much larger cumulative impact after 15 or 20 years.

2. Changing grain export locations may increase base-year impacts. This study assumes constant port hinterlands for grain exports. However, imposing a waterway user charge might cause Iowa grain, for instance, to move by rail to Houston for export rather than by waterway to New Orleans. This change of export ports would further reduce the waterway share of grain traffic. Limited study time prevented us from investigating this possibility.

3. Smaller waterways are sensitive to cost estimates. Existing federal cost accounts for waterways are designed for financial control rather than analysis of user charge impacts. As a result, it is very difficult to allocate costs of navigation aids to waterway segments and to allocate OM&R costs to navigation versus other benefits. Therefore, the actual costs to be recovered may vary from those used in this study. A change in federal cost estimates would probably not appreciably affect impact estimates for major waterways but might dramatically change impacts for smaller segments. Smaller waterway segments are sensitive to cost changes because of a smaller traffic base to absorb the costs.

4. The results presented here are preliminary in nature. This study, which used the recently developed INSA models of the Corps of Engineers, represents an initial attempt to simulate transportation in great detail. Because the models and data bases are so large, the study results must contain some errors. The study supports the INSA methodology, but many of the data inputs could be improved, and revised data could lead to substantial changes in impact estimates.

5. A longer, more comprehensive study would provide more precise and accurate estimates of user charge impacts. A more comprehensive study would allow better data assimilation, more complete model calibration, and sensitivity analysis. Sensitivity analysis would allow thorough testing of the study's working assumptions, which include the competitive structure of the towing industry, constant technology and productivity, constant hinterlands for grain export, and flexible decisions on modal choice.

Before any user charge is implemented, a comprehensive impact study should examine the complete array of user charge mechanisms, implementation options, and economic impacts. Sensitivity analyses and estimates of cumulative impacts through time are especially important.

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