limitations must be recognized. The modifications made to develop SIMGO3 are relatively minor in view of the overall task of developing the initial simulation model. They have increased the flexibility of the model to handle a wider range of navigation project studies at various depths of detail. However, this increased flexibility has added significantly to the cost of operating the model. The most direct cost is computer resources. Simulation programs are notoriously heavy users of computer time, and representational inefficiencies are magnified by the commonly specified requirement that series of runs be made under varying conditions, often by replicating individual runs to obtain statistical validity. Increased computer costs are not the only burden of increased detail. Frequently, the level of detail has been and is limited by the availability of data or simply by a lack of detailed knowledge of how the system actually works. The latter factor was particularly prominent where human decisions were involved. The dispatching of towboats in the waterway system was a prime example.

Selecting the optimum level of detail was and will be largely a matter of judgment based on the particular navigation study being undertaken. Recent validation tests have given only a general idea of the adequacy of the representation and analytical complexity of the model for the Ohio River system scale.

CONCLUSIONS

The inland navigation simulation model represents a key part of the systems analysis required for the navigation planning efforts of the Corps of Engineers. In conjunction with commodity flow and modal-split analysis, the simulation model provides, through network analysis, insight into system reactions to proposed changes. The verification and evaluation phase was most important in developing confidence in model results under new conditions.

Data collection and model testing and calibration for this large-scale simulation were extensive. There cannot be enough emphasis put on the importance of good input data. As with all types of computer modeling efforts, the "garbage in, garbage out" principle holds true here. The success of the historical comparison tests was largely dependent on the extensive data collection and analysis efforts. For each potential application of the model, the amount of detail desired will have to be balanced with the economic feasibility of data collection and computer resource limitations. In addition, in this context the degree of confidence desired is directly related to the effort required in specific model formulation. Trade-offs may be necessary to meet budgetary and time constraints in the application of the inland navigation simulation model to ongoing and future navigation program and project planning studies.

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Method for Estimating Nonphysical, Transportation-Related Business Losses Caused by Flooding on the Inland River System

Lonnie E. Haefner, Lee Hutchins, and Bigan Yarjani, Department of Civil Engineering, Washington University, St. Louis
Robert W. Meyer, National Marine Services, Inc., St. Louis

Research undertaken to develop and document a methodology for the estimation of secondary transportation-related flood losses to commercial and industrial firms is reported. The categories of loss estimated exclude physical damage, which is already included in current methodologies. The methodology categorizes transportation-related flood losses into three broad areas. The first area is losses in travel time and travel cost—estimated costs of additional route circuity and travel time, primarily for the movement of freight. The second area is that of business interruption losses, which relate to transportation in the sense that access is essential to the functioning of businesses. The third area of loss is consequences of flood conditions that are not measured solely in dollars. Typical of this category might be increases in energy consumption or air pollution as a result of flood conditions.

The objective of the research reported in this paper on the development of a methodology for the estimation of transportation-related flood losses is to describe the estimation problem, present alternative methodological approaches, and select an approach for further development. Before this work was undertaken, the estimation process for assessing transportation-related flood losses was restricted to direct physical losses. These include rehabilitation or replacement of roadways and bridges as well as property-damage losses for commercial and industrial establishments. These estimates have been based on postflood surveys of many sites.

The research described here develops an estimation methodology for other types of transportation-related flood losses, which can be categorized into three broad areas. The first of these is losses in travel time and travel cost. These are estimable costs of additional route circuity and travel time, primarily for the movement of freight. The second area is that of business interruption costs, which relate to transportation because access is essential to the functioning of businesses. The third area is consequences of flood conditions that are not measured solely in dollars. Typical of this category might be increases in energy consumption or air pollution as a result of flood conditions. It should be noted that these three categories specifically exclude physical damage, which is already included in current methodologies.

ALTERNATIVE METHODOLOGIES

The first candidate methodological approach, shown conceptually in Figure 1, uses monetary impacts only. Given substantive input on flood magnitude and duration and a business and shipment inventory, the various travel time and travel cost components can be estimated. Business interruption costs can be calculated for basic and nonbasic sectors and standard industrial classification (SIC) categories that are directly affected by flood conditions.

There are several private, corporate, and institutional fiscal impacts. The following impacts are worthy of record for both basic and nonbasic industry:

1. Income loss on ledger sheet, by day, attributable to loss of sales and/or cessation of deliverable production output of product;
2. Tax impacts, including those on personal income, corporate income, sales tax, and appraised value of business;

Figure 1. Conceptual methodology using monetary impacts only and regional multiplier effect.

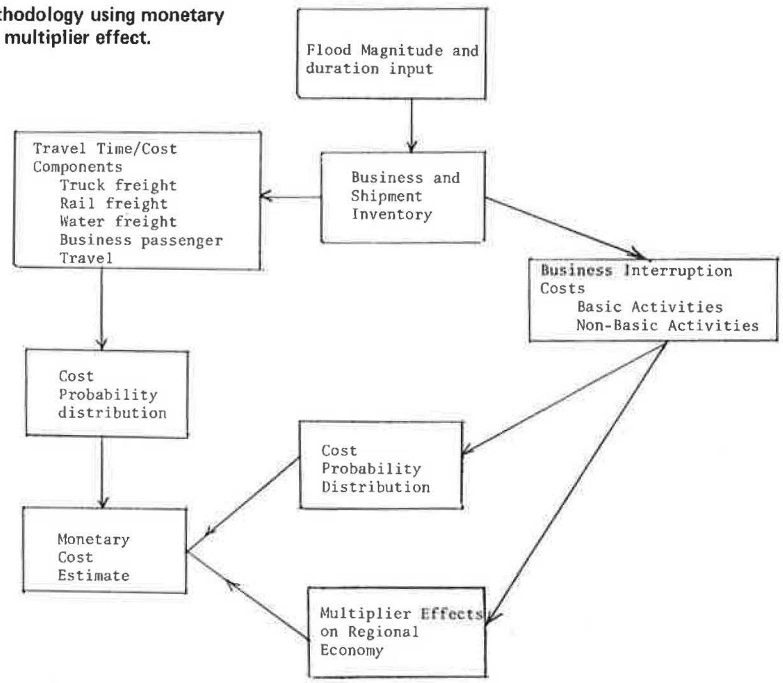


Figure 2. Conceptual methodology using monetary and nonmonetary impacts.

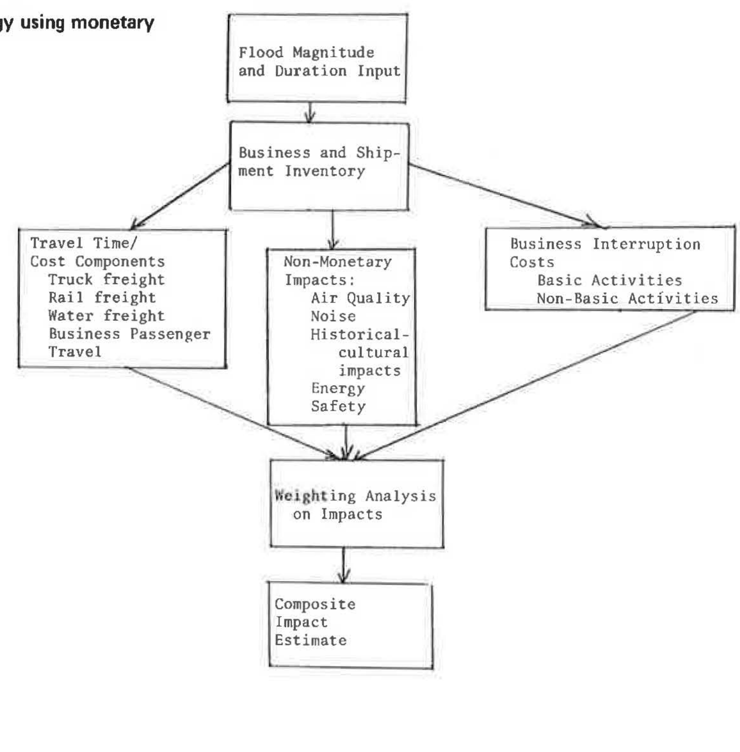
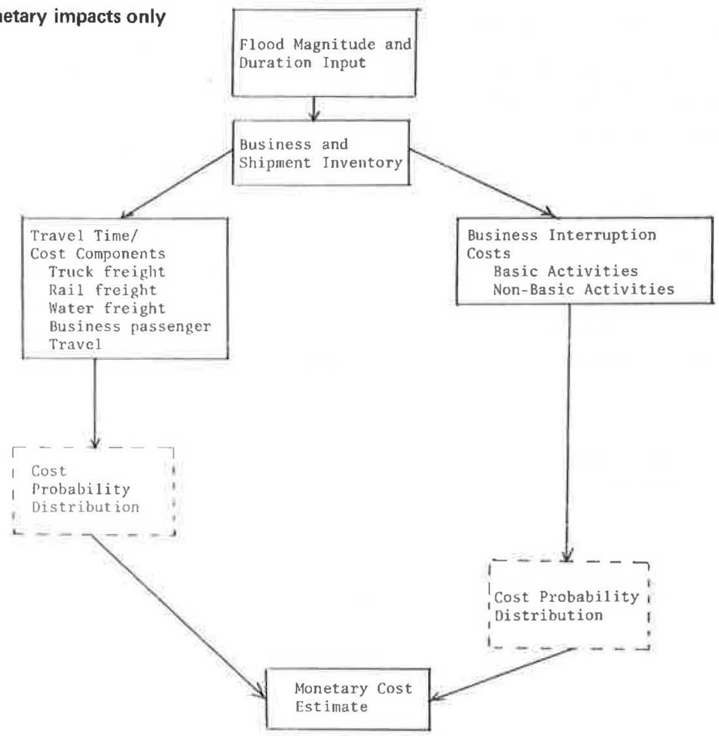


Figure 3. Conceptual methodology using monetary impacts only and optional cost probability distribution.



3. Loss in market value of real estate, attributable to loss of net income, in conjunction with an appraisal of income-producing real estate and use of specified capitalization rates (this yields resultant loss in assessed valuation and real estate taxing level); and
4. Loss in raw land value, as related to market comparables approach of appraisal.

Knowledge of such loss of basic or nonbasic income can be coupled with a regional multiplier to yield an estimate of total regional income or surrogate alteration of "regional value added" caused by a flood of particular magnitude and duration. The duration and magnitude of the flood could be given as probability distributions so that expected monetary costs would result. In addition, probability distributions could also be used on the component travel time and business interruption cost levels.

The second proposed methodological approach, which is shown schematically in Figure 2, is a broader derivation of the first one. Again, distributions on flood magnitude and duration and business inventories are used as input. Monetary impacts related to travel time and costs and business interruption are handled as before. In addition, however, calculable nonmonetary impacts, such as altered noise levels, energy differentials, changes in air quality levels, predicted changes in historical-cultural landmarks, and changes in hazardous incidents that involve personal injury, are also estimated. The monetary and nonmonetary impacts are weighted on a subjective weighting scale to yield a composite impact score for a flood of particular magnitude and duration.

The final approach (see Figure 3) is a variant of the first two. It uses first-round income stream losses only, deals only with monetary impacts, and ignores the multiplier effects included in the first method. As previously indicated, cost probability distributions can be used as an option to account for uncertainty in impact estimates for a particular flood magnitude and duration.

These three methodological approaches were reviewed with respect to the data and the complexity of information required, conceptual simplicity, and versatility for both pure cost estimation and consideration of nonmonetary consequences. The third methodology appears to be the most reasonable candidate for development and case study testing. It requires only readily visible and recorded first-round income stream changes and does not require the analyst to derive or be capable of manipulating regional multipliers. Further, the second approach, although esoteric in its conceptual analysis of multidimensional nonmonetary impacts, requires reasonably refined analyses of environmental impacts such as air and noise pollution and subjective estimation of the importance of these impacts to the region. Accurate calculation of such impacts is a state-of-the-art problem in constant flux, and conflicting viewpoints of important regional attributes may not render subjective weighting of impacts meaningful. Thus, on balance, the third candidate approach is pragmatic and capable of calculation and will be developed in full algorithmic form.

DISCUSSION OF LOSS-ESTIMATION METHODOLOGY

The detailed flow chart for the methodology of loss estimation is shown in Figure 4. As each component of the flow chart is discussed, data sources are mentioned as appropriate. The methodology tasks are referenced by letter and number: A-tasks refer to items related to first- and second-round business interruption costs, and B-tasks refer to transportation costs.

In task A.1, commercial and industrial land uses within the bounds of the floodplains are surveyed by using aerial photographs and business directories. By using this inventory, company reports, and interviews, daily salary and wage losses caused by business interruption can be estimated in task A.2. From this estimate of salary and wage loss, direct tax losses on personal income can be determined in task A.3 for the municipal, state, and federal levels on the basis of average tax rates. In addition, in task A.4, the survey and interviews will yield computation of the industrial and commercial income losses from foregone sales and lost production. This task, along with task A.2, can be used to estimate the secondary losses to other businesses attributable to the multiplier effect of lost wages and lost production on other businesses inside and outside the region, which is shown as task A.13. This information can be estimated on the basis of available ratios of basic industry wages paid to nonbasic wages generated.

From the estimates of task A.4, production and retail sales tax losses can be computed in task A.5. Based on the effects of lost production, in task A.4, on the firm's cash flow, the change in the firm's net worth can be estimated in task A.6. This loss results in commercial and industrial income tax losses in task A.9, which can be based on the net worth of the business. Discussions were held with a private certified public accountant versed in corporate income tax accounting, corporate net worth auditing, and business value appraisals to ascertain realistic treatment of tasks A.6 and A.9. By using the income stream losses determined in A.4 in conjunction with typical capitalization rates for commercial and industrial property in task A.10 and comparisons with other comparable properties in task A.8, the loss of property value can be determined through the income-producing property appraisal process in task A.7. Conclusions on these results in task A.11 also contribute to the net worth losses computed in task A.6. In addition, they also result in lost real estate taxes based on assessed valuation, computed as task A.12. The various sources of income losses, property and business value losses, and tax losses are synthesized in task A.14 as the total economic loss caused by business interruptions and the regional decrement in value added.

In dealing with the transportation cost aspects of the methodology of loss estimation, the focus is on additional transportation costs imposed by flood conditions. In task B.1, the probability information on flood duration and magnitude is reviewed. The contours and land-use maps of the area are reviewed in task B.2. As Figure 4 shows, these also serve as inputs to the business interruption estimates that begin in task A.1. In task B.3, the business inventory is reviewed for purposes of estimating business travel patterns and related trip generation in conjunction with task B.4, a review of regional origin-destination (O-D) travel patterns. From these and other historical travel studies, vehicle volumes of business passenger travel can be computed in task B.5, and commercial vehicle volumes related to the flood area can be estimated in task B.6. In task B.7, the location and number of kilometers of inundated highway routes are estimated by using the information from tasks B.1 and B.2. Realistic detour kilometers are estimated in task B.8 for highway travel, and cost factors are applied in task B.9 for additional (business) passenger and freight vehicle kilometers.

In task B.10, inundated rail routes are estimated from tasks B.1 and B.2. Typical detour kilometers are estimated in task B.11. Interregional commodity flows are estimated for rail for the flood area in question in task B.12. In task B.13, this information is converted to railcar volumes affected. That information, in addition to the detour kilometers in B.11, allows application of cost factors and the estimation of additional costs attributable to rail detours in task B.14.

Similarly, information from tasks B.1 and B.2 allows an estimation, in task B.15, of water routes that would become impassable. Typical interregional commodity flows by water are estimated in task B.12, and this yields, in task B.16, the estimated number of tows delayed. On the basis of information on flood duration and magnitude, the number of hours of delay is estimated in task B.17. Finally, in task B.18, cost factors are applied to find delay costs for the water mode. The highway, rail, and water costs are summed in task B.19 to yield transportation losses caused by flood conditions. In task A.15, these are then aggregated with business interruption costs over all SICs to yield total losses caused by flood conditions.

CASE STUDY APPLICATION

Because of some data limitations, the quantitative results reported here represent a fraction of the total economic loss brought about by flood-related business interruption. These limitations do not, however, reduce the validity of the computational approach used or its general applicability to the problem of economic loss in any study area.

Study Area

The study area consists of the Meramec River bottoms and adjacent areas that extend from the MO-141 bridge at Valley Park, Missouri, to the confluence of the Meramec and Mississippi Rivers. Seven major highway bridge crossings and three rail bridge crossings affect surface transportation patterns in the study area. There are many industrial and commercial facilities at the upper end of the study area, including the Chrysler automobile and truck assembly plants, the Treecourt Industrial Park, and a variety of wholesale, retail, and manufacturing facilities. Farther downstream, gravel pits, wholesale and retail facilities, and the Union Electric Meramec generating plant are found. Extensive ground surveys were used to identify businesses for further contact in the study area. Altogether, 71 businesses were identified for further contact.

Transportation Interruption

Since delay time and detour kilometers are major components of costs incurred as a result of transportation interruptions, operating and delay costs are given for truck, rail, and towing operations in Tables 1, 2, and 3 (4), respectively. For purposes of illustration, assume that the MO-30 bridge approaches were inundated. Missouri State Highway Department traffic counts for 1973 indicate that 1030 commercial vehicles, including 270 trailer combinations, used this bridge. Total detour kilometers depend on origins and destinations, but a reasonable distance by the I-44 crossing would be 32 km (20 miles). We assume that the length of haul is 80.47 km (50 miles) (longer hauls would likely use the Interstate system).

Estimated delay costs for trailer combinations = 270 vehicles × \$4.18/vehicle-km (\$6.74/vehicle mile) × 32.3 vehicle-km (20 vehicle miles) = \$36 396/day.
For the remaining single-unit trucks the cost = 760 vehicles × \$2.49/vehicle-km (\$4.01/vehicle mile) × 32.3 vehicle-km (20 vehicle miles) = \$60 952/day.

These calculations assume that no deliveries would be canceled and include driver wages, operating costs, maintenance, capital recovery, and terminal labor costs.

Similarly, for travel by individuals for business reasons, we can estimate the losses caused by closure of the MO-30 crossing. The average daily traffic crossing is 20 000 vehicles, and it will be assumed that 10 percent of all traffic is business related. Origin-destination patterns will dictate that 60 percent of the traffic will detour via I-44 and 40 percent via I-55. Estimated detour distances are 16 and 24 km (10 and 15 miles), respectively, for I-44 and I-55. Out-of-pocket operating costs for intermediate-sized automobiles are 0.2 cents/km

Figure 4. Methodology for estimating secondary transportation-related flood losses to commercial and industrial firms.

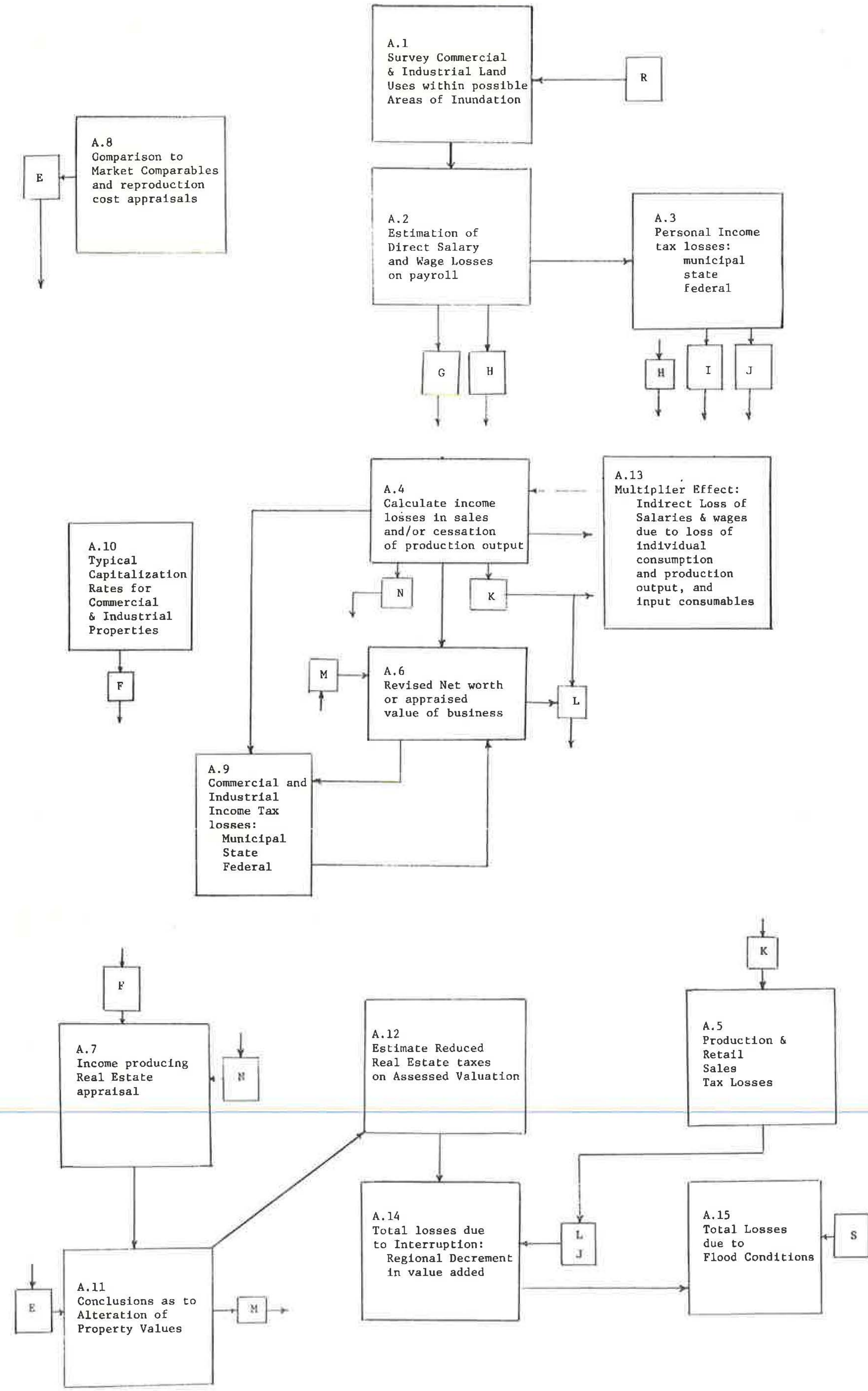


Figure 4. Continued.

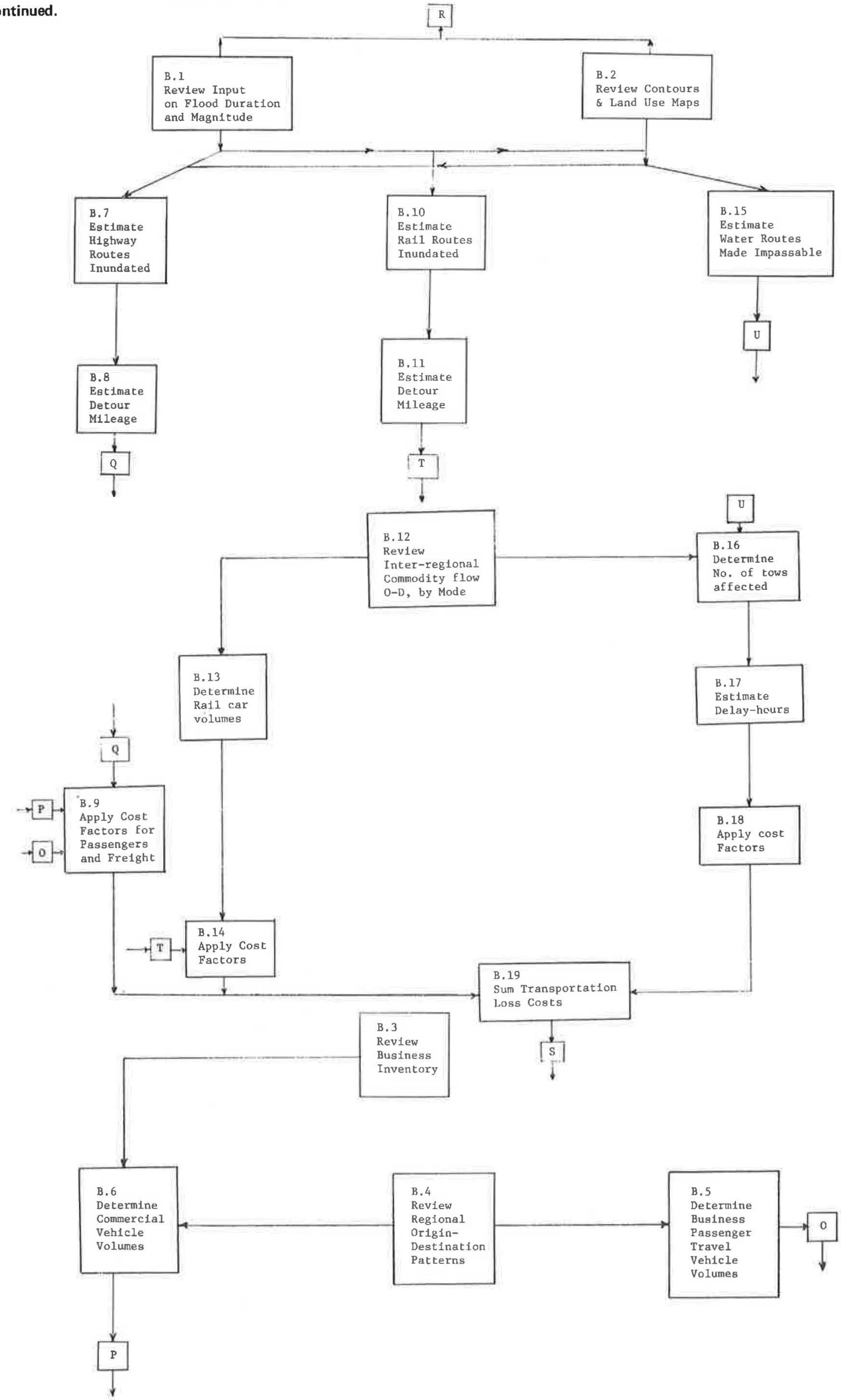


Table 1. Truck costs—1977.

Length of Haul (km)	Cost	Tractor-Semitrailer[a] Dollars per Vehicle Kilometer	Tractor-Semitrailer[a] Cents per Ton-Kilometer	Single-Unit Truck[b] Dollars per Vehicle Kilometer	Single-Unit Truck[b] Cents per Ton-Kilometer
81	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	3.67	34.52	2.06	34.59
	Total	4.18	39.39	2.49	41.65
161	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	1.84	17.26	1.03	17.26
	Total	2.35	22.13	1.46	24.32
323	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	0.92	8.63	0.51	8.63
	Total	1.43	13.49	0.94	15.69
645	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	0.46	4.32	0.26	4.38
	Total	0.97	9.18	0.69	11.44
1290	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	0.23	2.12	0.82	2.19
	Total	0.74	6.99	1.25	9.25
1613	Wages	0.17	1.64	0.14	2.40
	Operating	0.19	1.78	0.16	2.53
	Maintenance	0.08	0.75	0.07	1.16
	Capital[c]	0.07	0.69	0.06	0.96
	Load and unload	0.19	1.78	0.10	1.78
	Total	0.70	6.64	0.53	8.84

Notes: 1 km = 0.62 mile; 1 t·km = 0.685 ton-mile; 1 kg = 2.204 lb.
Computations are based on data from a 1975 cost study by the Transportation Regulatory Board of the Iowa Department of Transportation and 1975 data of the University of Minnesota (1).

[a] 17 242-kg payload.
[b] 12 250-kg payload.
[c] Capital costs reflect equipment depreciation and interest costs based on annual equivalent costs at 11 percent interest and a seven-year life expectancy.

Table 2. Rail costs—1974.

Length of Haul (km)	Conventional Train[a,b] Dollars per Train Kilometer	Conventional Train[a,b] Cents per Ton-Kilometer	Unit Train[c,d] Dollars per Train Kilometer	Unit Train[c,d] Cents per Ton-Kilometer
161	106.64	4.62	23.81	1.03
322	64.48	2.76	18.25	0.79
806	39.06	1.49	14.76	0.65
1613	30.38	1.23	14.28	0.62
3226	26.04	1.10	13.81	0.57

Note: 1 km = 0.62 mile; 1 t·km = 0.685 ton-mile; 1 t = 1.1 tons; 1 kW = 1.34 hp.

[a] Data from the Interstate Commerce Commission (2).
[b] Assumes 64-car train made up of a mixture of cars that average 36 t of cargo per car, average conditions, and three 1493-kW locomotives.
[c] Data from the U.S. Railway Association (3).
[d] Assumes 50-car train with four 1493-kW locomotives.

(2.8 cents/mile) (4). Therefore, detour costs are as follows:

20 000 vehicles × 10 percent × business travel = 2000 vehicles.
0.6 (for I-44) × 2000 vehicles × 16 km (10 miles) × 0.0174 cents/km (0.028 cents/mile) = $336/day for diversions to I-44.
0.4 (for I-55) × 2000 vehicles × 24 km (15 miles) × 0.0174 cents/km (0.028 cents/mile) = $358/day for diversions to I-55.
$336 ÷ $358 = $694/day diversion cost.

For the rail mode, we adopt assumptions similar to those for the truck example. Assume an 805-km (500-mile) length of haul and conventional train operations. If the Missouri-Pacific (MOPAC) rail crossing at the confluence of the Meramec and Mississippi Rivers were inundated and four daily MOPAC trains were detoured only 16 km (10 miles) in southern Missouri to cross over the MOPAC trackage on the Illinois side, then the costs are $39.15/train-km ($63/train-mile) × 16 km (10 miles) × 4 trains = $2520/day.

Business Interruption

In the application of the business interruption portion of the methodology, some multiplier effects in task A.13 are excluded. The data collected were used in conjunction with other financial data sources to develop estimates of loss related to business interruption by SIC codes. The tabulations of loss presented here represent an approximate 20 percent response to the survey form and to follow-up phone calls.

To illustrate the working methodology shown in Figure 4, data and related computations from an electrical

Table 3. Estimated operating costs of towboats on the Mississippi River system—1976.

Item	Operating Cost by Power Range ($)				
	1343-1642 kW	2090-2537 kW	2985-3284 kW	3731-4478 kW	4552-5224 kW
Investment (average new cost)	1 000 000	1 700 000	2 200 000	2 600 000	3 100 000
Fixed costs					
Return on investment	177 500	199 700	258 400	305 400	364 100
Administration and supervision	55 700	80 500	94 500	117 200	130 000
Subtotal	173 200	280 200	352 900	422 600	494 100
Operating costs					
Wages and fringe benefits	250 000	325 000	325 000	350 000	350 000
Fuel	180 000	300 000	400 000	564 000	666 000
Maintenance and repairs	45 000	60 000	80 000	95 000	105 000
Supplies	25 000	34 000	38 000	42 000	44 000
Subsistence	20 000	28 000	28 000	31 000	31 000
Insurance	30 000	50 000	65 000	80 000	93 000
Other	7 000	8 000	9 000	10 000	11 000
Subtotal	557 000	805 000	945 000	1 172 000	1 300 000
Total annual costs	730 000	1 085 200	1 297 900	1 594 600	1 809 200
Hourly operating costs	88	131	157	193	217

Note: 1 kW = 1.34 hp.

Table 4. Business interruption losses for one-week period.

SIC Code	Wage Loss ($)	Income Tax Loss ($): Personal State	Personal Federal	Corporate State	Corporate Federal	Decrement in Property Value ($)
3079	32 307	1938	8 075	624	5 736	96 000
3811	59 340	3560	14 835	572	23 896	135 000
4214	15 384	923	3 845	25	100	3 980
5085(2)	10 500	630	2 620	125	855	19 450
5111	5 000	300	1 250	50	215	7 925
5139	6 615	395	1 650	995	7 910	23 400
5943	15 380	923	3 845	148	1 160	22 800
Total	144 526	8669	36 120	2539	39 872	308 555

instrument company (SIC 3811) are used. A summary of these data is given in Table 4. If it is assumed that business is interrupted for a period of one week, the approximately 230 hourly employees would lose almost $258 each, excluding social security taxes. State income tax loss on these wages would be $3560 at an assumed marginal tax rate of 6 percent. Federal income tax loss would be $14 835 at an assumed marginal rate of 25 percent.

Losses to the employer can be estimated as follows. Again, assume a one-week shutdown and further assume that production and sales are not recovered for the week. The losses in Missouri state and federal corporate income tax would be $572 and $23 896, respectively. Based on statement studies for SIC 3811 businesses (5), salaries and wages typically account for 26 percent of net sales revenue. By using this and information on salaries and wages, the net sales of the company can be estimated to be approximately $16 million. Further research from the above sources indicates that net profits are approximately 5.7 percent of net sales; thus, annual net profits are $900 000, and a one-week loss in profits would amount to $17 500.

In a related impact, it is possible to appraise the loss in property value for this business location that results from interruption by flooding. Using a realistic overall market capitalization rate of 13 percent for the area and the income-appraisal approach of the National Association of Independent Fee Appraisers (6) gives

$$V = I/R \qquad (1)$$

where

V = value of the property,
R = overall market capitalization rate, and
I = net annual income.

The one-week loss in net income can be substituted into the equation, and the reduction in appraised property value can be derived as $135 000. The alteration in property value should be compared with actual sales prices of like or comparable land uses in the study area to yield an effective check on the effect of loss of income on property values. Further, such reduction in property value presumes the interruption would occur annually. Given the infrequent reassessment of real estate value in Missouri, it is unlikely that there would be a loss of real estate taxes related to sporadic or annual increments in property value.

If annual reassessment were to occur, the loss in property taxes based on the above example could be calculated as follows. The property tax rate on the example property is $7.36 per $100 assessed valuation. By law in Missouri, property is assessed at one-third of market value. The loss would then be $135 000 × 0.33 × $0.0781 = $3479 for the one-week interruption. If the assessed valuation percentage were one-fifth or one-half, the corresponding losses would be $2109 and $5272, respectively. In addition, in a related computational aspect of Figure 4, interviews with an experienced corporate tax accountant indicate that the altered net worth of a business attributable to interruption cannot be predicted except on a detailed case-by-case basis.

The losses shown in Figure 4 can be estimated for all businesses in a flood area by SIC code by using the assumptions and calculations carried out above for the one company. This was done for the businesses that responded to the field survey (Table 4). In these calculations, tax items that were available directly from the firm, such as federal income tax, were used; otherwise, such inputs were estimated on the basis of net profits (as previously illustrated) by using annual statement studies. Retail sales tax losses, as described in the original methodology in Figure 4, are not applicable to most of these firms because of their status as wholesalers. (Note that these figures do not include any of the large industrial plants, such as Chrysler, because of the lack of timely response. It is likely that the figures for Chrysler alone might exceed the total for all others in the study area.)

The results of application of the methodology reveal several appropriate conclusions. First, the amount of new data required of the businesses surveyed is not great or time consuming to assemble. The amount of additional financial information necessary for computing losses caused by business interruption is not large. The calculations involved in an application are quite simple and cheap to use and make use of specific software developed for this study. Finally, the use of the SIC code allows a reasonably refined and classified set of secondary losses to be estimated.

CONCLUSIONS

The results of the development and case study application of the methodology that were carried out in this research support several relevant conclusions and define further research needs. Estimation of nonphysical damage losses caused by flood conditions is a multifaceted and complex problem. It requires knowledge of the transportation function of commercial and industrial firms as well as the composition of the transportation network itself. In addition, knowledge of public- and private-sector accounting and real estate appraisal is required. The methodology developed here synthesizes these various components into a technique that requires some collection of field data and the use of previously compiled financial relations and network travel data. With some additional refinement, the technique could also take into account the effect of the documented losses on the rest of the economy of a region. This could be accomplished by using basic-nonbasic multipliers or typical regional input-output types of economic linkages. This is an appropriate subject for further research and expansion of computational capability.

The results provide the means for developing reasonably quick estimates of the losses that result from flood conditions. Application of the approach to other sites can be carried out by using the existing technique and existing financial and accounting information inputs. The computer software and user-related materials provide a capability for generalization and ease of use at other sites.

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Waterway User Charges: Some Likely Impacts in the Tennessee Area

Kenneth J. Burns and George D. Mickle, Memphis State University, Memphis, Tennessee

Research whose purpose was to assess potential waterway user charges and their impacts and to provide the basis for the establishment of a state position is reported. The research was intended to serve the function of an informational report and not to provide hard recommendations either for or against a user charge. Most of the information was gathered through secondary sources published by water carrier associations and various federal agencies. Data were also collected, by means of survey and sampling techniques, from such primary sources as waterway carriers and industrial shippers. An analysis of the financial profile of the towing industry suggests that any user charge levied on towing firms will ultimately be passed on to the consumer. Smaller firms will probably suffer most since they operate with smaller margins and high turnover. Reduction in overall industry market share of national commodity transports will remove some of the economies associated with large-volume movements and eventually affect the profitability of larger towing firms. A segment toll represents the greater impact in terms of towing industry operating costs, shipping rates, state waterway traffic volume, employment, and electrical consumer utility costs. A $0.01/L ($0.04/gal) fuel tax represents the smallest impact. In light of the lack of complete empirical evidence, any cost-recovery scheme should be phased in on a gradual basis so as to allow for a cautious monitoring of both positive and negative impacts.

The state of Tennessee, with its access to three of the nation's major navigable waterways, has found its river systems to be a great asset in attracting basic industries Recently, developments in government policy have focused attention on the "free use" of U.S. inland waterways, and this has culuminated in various proposals for imposing a user charge on the nation's towing industry. The immediate concern of the state of Tennessee is that such a development may reduce the inherent advantages of a river transport system and thus destroy some of the economic vitality and job opportunities provided by the state's river system.

USER CHARGE OPTIONS

The four likely forms of user charge are (a) fuel taxes, (b) lockage fees, (c) segment tolls, and (d) licensing of floating equipment. Fuel tax cost-recovery schemes are analyzed at various levels that range approximately from $0.01 to $0.11/L ($0.04 to $0.40/gal). The magnitude of the lockage-fee method of collection was derived for each specific lock-and-dam facility based on the determination of an "imputed" value that commercial operators place on lockages by taking into consideration