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FOREWORD

This RECORD contains papers that examine inland waterways, a new area for the Transportation Research Board. The papers are provocative and should be of value to transportation planners.

Broemser discusses the significant role that inland waterways play in the domestic transportation system. The influence of federal agencies is examined. The unregulated status of the waterway system and the attempt by Congress to impose user charges on the carriers of bulk commodities are emphasized.

Hull discusses the 4 advantages that water transportation possesses: (a) economy in the use of energy, (b) inherent low cost, (c) capacity for expansion, and (d) capability to increase service without encountering physical constraints.

Karlson discusses the waterway towing industry and provides statistics on tonnage, extent of navigable waterways, the different components of the waterway system, and the difference between foreign and domestic tonnage. Karlson also discusses the difference between East- and West-Coast towing operations and the lighter-aboard-ship and Seabee vessels engaged in foreign commerce.

Significant changes in shipping on the Great Lakes are now under way. These changes involve internal Great Lakes shipping and external shipping among the Great Lakes, lower Saint Lawrence River ports, and overseas ports. Mayer provides a general overview of some recent and prospective changes in Great Lakes shipping that are relevant to policy decisions.

Foster discusses the transportation planning implications resulting from the existence or the construction of a multipurpose water resource project. Multipurpose dams and locks along the Tennessee River are discussed, and their benefits are listed.

Morris discusses the U.S. Army's role in maintaining waterways, the problems it faces, and its efforts toward solving the problems.

Koch briefly describes the characteristics of inland navigation and the purpose of various types of improvements to river navigation. A newly implemented performance-monitoring system of data collection is explained in more detail. He concludes with a description of how waterway operations influence design of future improvements.

Becker, in the last paper, shows the necessity of producing an alternative and practical solution to meet the personnel needs of the inland waterway industry.

ROLE OF WATERWAYS IN THE NATION'S TRANSPORTATION SYSTEM

Gary M. Broemser, U.S. Department of Transportation

The significant role that inland waterways play in the domestic transportation system is discussed. The influence of federal agencies is examined. The unregulated status of the waterway system and the attempt by the U.S. Congress to impose user charges on the carriers of bulk commodities are emphasized.

•THE PUBLIC frequently overlooks inland waterways partly because most waterway freight traffic is bulk rather than final consumer goods and partly because relatively little commercial service on inland waterways moves passengers. Because the public has limited contact with the nation's inland waterway system, except perhaps for recreation, they sometimes find it difficult to understand how significant this mode is to the nation's flow of commerce. Statistics reveal that this is an impressive industry. The United States has over 25,000 miles (40 000 km) of commercially navigable waterways. Fifteen thousand miles (24 000 km) of these are deeper than 9 ft (2.7 m). The inland waterway and Great Lakes systems carry about 16 percent of the nation's total intercity traffic. Approximately 300 billion ton-miles (168 billion metric-ton-km) of freight move on these systems annually. Eighteen hundred different companies operate 21,000 barges and more than 4,000 towboats. Approximately 80,000 persons are employed onshore in jobs directly related to waterway navigation.

The proportion of total intercity traffic carried by the inland waterways in relation to other modes increased from 9.9 percent in 1967 to 10.9 percent in 1971. Of all the major freight modes, only pipelines grew at a faster rate during this period. During the same period, however, ton-mile (metric-ton-kilometer) freight movements on the Great Lakes fell from 6.1 to 5.5 percent of all intercity freight movements.

A few bulk items make up most waterway traffic. Coal and petroleum and their products account for about 58 percent of total traffic. Sand, gravel, and building cement account for 14 percent, and grains and soybeans account for about 6 percent. Almost 90 percent of all inland waterway cargoes consist of bulk items.

Although the number of tows and tugboats in use on the inland waterway system has remained relatively constant over recent years, there has been a large growth in total tugboat horsepower. Other factors, such as better communications, radar, and automatic steering arrangements, also have increased the hours of barge operation. Combined with increases in the quantity and cargo capacity of barges, these factors have helped increase the productivity of the industry. The future technologies of containerization, lighter-aboard ships, and Seabee and shallow-draft oceangoing vessels also are expected to affect the capacity and productivity of the nation's inland waterway system.

FEDERAL INTEREST

Federal interest in the use of the nation's lakes and rivers for public navigation became apparent early in U.S. history. After independence was achieved, the United States was concerned with preserving navigational freedom against restrictions imposed by foreign powers and the individual states. For example, western farmers worried about continued use of the Mississippi River in the face of Spanish control of its mouth. Maryland merchants, too, were concerned about Virginia's ability to restrict ships going to Baltimore because it controlled access to the lower Chesapeake Bay.

Conflicting navigation policies of the individual states helped lead to the Constitutional Convention of 1787. During the drafting of the Constitution, fears of state trade rivalry and discrimination on the nation's waterways played a part in framing the Constitution's commerce clause. Free navigational policies for both the Potomac River and the rivers of the Northwest Territory were major issues at the 1787 convention.

Since then, numerous acts of Congress have reaffirmed the importance of open navigation on American waterways by making interstate rivers "public highways" that are to be available to all citizens "forever free." Most historians view "forever free" as prohibiting private control over inland navigation, but it has often been construed by opponents of cost sharing to mean that all navigation improvements to waterways should be paid for by the taxpayer rather than by the immediate beneficiaries who are the users of these improvements.

Albert Gallatin (1) presented the first American attempt at comprehensive transportation planning in a report to Congress in 1808. His 10-year plan called for constructing a $20-million intracoastal waterway along the Atlantic Ocean with a series of canals and roads to connect the seaboard with the interior. Gallatin's report recognized the importance of transportation to the nation's development and recommended that the government select routes to ensure harmony with the geographic features of the country. Congress, however, left waterway development in the hands of private and state interests until 1824. Then, Congress authorized federal improvement of rivers and harbors to be carried out by the U.S. Army Corps of Engineers.

The individual states engaged in extensive canal building during the first half of the 19th century with a small amount of federal assistance through land grants. During this period, major canals were built in New York, New Jersey, Pennsylvania, Maryland, Virginia, Ohio, Indiana, and Illinois. Canal traffic began to decline after the introduction of railroads and the Panic of 1837.

In 1873 the federal government began assuming responsibility for private and state canals, and in 1879 the Mississippi River Commission was formed primarily to coordinate flood protection measures on the lower Mississippi River. When the federal government took over the bankrupt canals from the states, it continued to collect tolls. In 1882, the Erie Canal, a state agency, stopped assessing tolls because of rail competition, and Congress enacted a toll-free navigation policy for all federally provided inland waterways. This was an attempt to save a declining industry and compete with the rail monopoly. The federal government has been the major force in water development ever since then. Today, several federal agencies have an interest in domestic water transportation.

U.S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers has been responsible for 151 years for planning, constructing, operating, and maintaining improvements on the nation's waterways. Their undertaking is one of the greatest public works programs ever undertaken by any country in the history of the world. From 1824 through 1970, the Corps of Engineers spent more than $3 billion on inland waterway navigation construction. This sum does not include federal appropriations for seacoast harbors or Great Lakes channels and harbors. It also excludes local participation in waterway projects, and this amounts to millions of dollars annually. The Corps of Engineers, moreover, spends $200 million annually on operation and maintenance of inland and Great Lakes navigation waterways.

INTERSTATE COMMERCE COMMISSION

Inland water carrier transportation was brought under Interstate Commerce Commission (ICC) regulation by the Transportation Act of 1940, but certain bulk and liquid commodities were exempted from regulation. As a result, only about 10 percent of commodities transported in vessels on inland channels is regulated currently by ICC. The other 90

percent is either exempt for-hire service or private transportation.

MARITIME ADMINISTRATION

The Maritime Administration of the U.S. Department of Commerce has a congressional mandate to promote all segments of the domestic shipping industry and a merchant marine to serve the industry. It also offers financial assistance to private industry for mortgage and marine insurance and construction-reserve and capital-construction funds. An Office of Domestic Shipping was established in October 1971 to promote all segments of the domestic shipping industry.

U.S. DEPARTMENT OF TRANSPORTATION AND U.S. COAST GUARD

Congress, in the 1966 Department of Transportation Act, gave the U.S. Department of Transportation (DOT) broad responsibility to:

> Provide general leadership in the identification and solution of transportation problems; and to develop and recommend to the President and the Congress for approval of national transportation policies and programs to accomplish these objectives with full and appropriate consideration of the needs of the public, users, carriers, industry, labor, and the national defense.

DOT, the U.S. Coast Guard, and the Saint Lawrence Seaway Development Corporation play an important part in domestic waterway navigation. The Coast Guard is responsible for waterway safety, which includes boating safety, cargo security, and port safety. The Coast Guard also has a significant responsibility to provide extensive navigation aids to facilitate vessel traffic, protect and enhance the marine environment, and enforce antipollution laws. In recent years, the Coast Guard has been spending over $300 million annually on inland and Great Lakes navigation operations.

TRANSPORTATION POLICY

Secretary of Transportation Claude S. Brinegar in May 1974 issued a report setting forth the principles that guide DOT in formulating national transportation policy (2). Several of the policy principles in this report are relevant to this discussion:

> The overriding thrust of Federal policy is to see that the nation has an overall transportation system that reasonably meets its essential needs. To the maximum feasible extent, this system should provide transportation that is efficient, safe, fast, convenient, and limits negative impacts on the environment.
>
> The nation's transportation system should, as much as possible, be provided through the competitive forces of the private sector, or, if the private sector is inappropriate, by the state and local governments. Direct Federal financing of transportation investments or operations should be limited to those few cases where there is a clear and widely accepted requirement for concerted action in areas of high national priority, and where the private sector or state and local governments are obviously incapable of adequately meeting this requirement.
>
> When Federal expenditures are used to finance transportation investments or operations, these expenditures should be recovered from the users and other beneficiaries in a manner that is appropriate to the degree of benefits received, unless widely accepted national policy directs otherwise. The lack of user charges or cost sharing on the inland waterways that have been developed and are maintained with Federal funds is not consistent with this policy.
>
> The economic regulation of interstate transportation needs to be thoroughly reexamined to determine which parts are necessary, as a minimum, to protect the public interest, and those

> which, through the passage of time, have become more of a burden than a help. We believe that a significant streamlining of this regulatory process is in order, directed to greater reliance on the forces of open market competition. A particular effort is needed to eliminate restrictions on intermodal competition.

The policy report concluded as follows:

> We well recognize that many aspects of the above policy statement—especially those that are rooted in the concepts of the desirability of promoting more freedom of choice, greater economic efficiency, and allocation of costs to users—are controversial. Some will praise them; others will damn them. It must be understood that we do not put them forward as final answers (for there are none), but rather as what appear to us to be the proper future directions for the nation as a whole.

HOW TRANSPORTATION POLICIES APPLY TO INLAND WATERWAYS

Congress, in Public Law 91-590, directed DOT to undertake a comprehensive study of the present system of economic regulation of dry-bulk commodity transportation. The conclusions and recommendations of this study that apply these policies are contained in The Barge Mixing Rule Problem (3), which focused on several conditions that the 1940 amendment to the Interstate Commerce Act required be met to exempt dry-bulk-commodity barge movements from ICC regulation.

The study found that there have been vast technological and scale changes in both the barge industry and the shippers using it since enactment of regulation in 1940. The legal constraints of the 1940 act are no longer compatible with the operating conditions and practices of a modern barge industry. The custom-of-the-trade provision, which stipulated that only those dry commodities being carried in bulk on or before June 1, 1939, were to be exempt from regulation, is relatively unimportant to total dry-bulk barge trade. The 3-commodity restriction, which stipulated that no more than 3 exempt commodities could be carried in 1 tow, and the no-mixing rule, which held that exempt dry-bulk commodities could not be mixed with regulated cargo in the same tow and retain exempt status, would not serve any relevant or beneficial purpose for the water carrier industry or the shipping and consuming public. Effective application and enforcement of these restrictions on the exemption at this late date would severely hamper transportation flexibility, raise shippers' costs, and create operational difficulties in water transportation of dry-bulk commodities. Congress agreed with the DOT finding and enacted Public Law 93-201, which extended the exemption of dry-bulk commodities.

The inland water carrier industry is a prime example of how effective competition and efficient transportation can exist in a relatively unregulated environment. When one compares the various other modes, all of which have substantially more economic regulation, one concludes that the economic strength and efficiency of the water carrier industry are a tribute to both the industry and the American system of free competition.

COST SHARING

Cost sharing is a major issue facing waterway navigation today. The estimated fiscal year 1972 federal expenditures for commercial navigation and recreational boating are $266 million for new construction and $596 million for operation and maintenance, which totals $862 million.

In the early days of the United States, government development of waterway navigation paid great benefits in the development of the national economy. After the federal government took over bankrupt canals from the states, toll collection was halted and

Congress enacted a toll-free navigation policy for all federally provided inland waterways. The federal policy of public financing of waterway development made sense at the time because it was designed to save a declining industry and provide competition to existing rail monopolies.

Since World War II, however, there has been a reversal in the productivity of the barge industry. During the postwar period, the volume of traffic on major inland waterway routes rose by more than 300 percent. Technological advances and reductions in staff requirements continue today. Because of this increase in productivity, barge rates have remained low.

The average cost to the carrier until 1974 was approximately 0.3 cent/ton-mile (0.5 cent/metric ton-km) of freight, which compares favorably with rates in effect almost 20 years ago. Recently, inflation and increasing fuel costs have caused an increase in this figure to almost 0.5 cent/ton-mile (0.9 cent/metric ton-km).

It appears that most, if not all, high-priority opportunities for developing our rivers and coastal areas already have been exploited. The capacity of the present system, except for a few bottlenecks, is many times its present level of use. The inland waterway transportation system is, today, a mature industry. It no longer demands full federal subsidy. DOT, with its responsibilities for all modes, believes in evenhanded, across-the-board, federal treatment. At present, both pipelines and railroads pay all costs of constructing and operating their modes. Most of the other modes also contribute through user charges to the costs of federally constructed modes.

The Federal-Aid Highway Act of 1956 specified that a study be carried out to aid Congress in setting highway user charges. The Airport and Airway Development Act of 1970 extended cost sharing to this mode. Internal waterways, ocean shipping, and port facilities seem to be the only exceptions to a definitely accepted policy of imposed user charges.

Every U.S. president since 1940 has proposed cost sharing for inland waterway navigation because each has recognized the arguments of equity and efficiency. In a pre-Thanksgiving speech to Congress in 1974, President Ford called for a tax plan under which users would be required to pay the full costs of operating and maintaining 20 major segments of the inland waterway system. The Ford proposal would subject cargo-carrying vessels using the waterways to user charges based on ton-miles (metric-ton-kilometers) of freight transport. A separate schedule of lockage fees was proposed for other vessels. Legislation to carry out these proposals was sent to Congress.

SUMMARY

In summary, the inland waterway industry is extremely important in the national transportation system, and it has demonstrated that effective competition and efficient transportation can exist in a relatively unregulated environment.

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2. C. S. Brinegar. A Progress Report on National Transportation Policy. U.S. Department of Transportation, May 1974.
3. The Barge Mixing Rule Problem. U.S. Department of Transportation, Vols. 1 and 2.

ECONOMIC POLICY OF WATERWAY TRANSPORTATION

William J. Hull, Ashland Oil, Inc.

Four advantages that water transportation possesses are discussed: (a) the extremely efficient use of energy per ton-mile (metric-ton-kilometer) of freight moved by water, (b) the ability of water transportation to control operating costs through technological advances in power and design to the extent that the average water transportation rates of today for bulk cargoes are lower than the ceiling rates of World War II, (c) the expanded capacity of water transportation that means low capital costs, and (d) the increased service that water transportation can provide without physical constraints.

•THE foundations of national waterways policy laid in the early years of the United States are clear. They were set forth in the Northwest Ordinance of 1787, which guaranteed the freedom of the navigable waters leading into the Mississippi and the Saint Lawrence Rivers from any taxes, imports, or duties, and in the assumption by Congress in 1824 of responsibility for river improvements. The Rivers and Harbors Act of 1882 marked a significant milestone in the development of the nation's waterways, for it was the first act of Congress that combined appropriations for developing the nation's waterways with a reaffirmation of the policy of freedom from tolls or other user charges. The objective of regulation of transportation as set forth in the Transportation Act of 1940 is the development, coordination, and preservation "of a national transportation system by water, highway and rail, as well as other means adequate to meet the needs of the commerce of the United States, of the Postal Service and the National Defense." More recently, in the Water Resources Planning Act of 1965, Congress declared,

> In order to meet the rapidly expanding needs for water throughout the Nation, it is hereby declared to be the policy of Congress to encourage the conservation, development and utilization of water and related land resources of the United States on a comprehensive and coordinated basis.

The intent of Congress in enacting this legislation was succinctly expressed in the Report of the House Committee on Interior and Insular Affairs on HR 1111, which with amendments became the Water Resources Planning Act of 1965. Some relevant comments of the committee are as follows:

> Thus, we must plan to use our Nation's water supplies to provide maximum benefits to all purposes . . . controlling floods and preventing pollution, providing water for irrigation, assisting navigation, providing hydroelectric power and energy and providing outdoor recreation opportunities and fish and wildlife conservation and enhancement.

Over the years, Congress has repeatedly reaffirmed its opposition to waterway tolls and operating charges. It has maintained its commitment to improving and maintaining the navigable waterways by authorizing projects and appropriating funds for construction and maintenance because it believed that such improvements benefit the national economy and advance basic objectives of national policy. These objectives have included unifying the country, defeating sectionalism and its internal trade barriers and

discriminatory impositions on commerce, furthering westward expansion, and providing low-cost transportation adequate to the needs of a growing economy to restrain the rates charged by competing overland transport modes. These rates were so exorbitant that they obstructed regional economic development.

In later years, this policy has been effectively applied to aid the economies of underdeveloped regions of the country through navigation improvements that provide market outlets and access to new materials, to assist farm economies through cheaper distribution, and to stimulate industrial expansion and broadened employment opportunities, which is particularly effective in depressed area rehabilitation. No economic policy is more deeply embedded in the fabric of our national life, and it has been a brilliant success. Programs implementing these policies have strengthened the national defense by facilitating dispersion of industry. They have stimulated economic growth as evidenced by the investment of $42.8 billion in new and expanded plant facilities in the counties bordering the Ohio River and its navigable tributaries from 1950 through 1972. They have released resources that had been locked in by the high charges imposed by other modes of transportation. They have cut costs, stabilized the economy, and held back the forces of inflation, and through rehabilitation of depressed areas they have reduced population pressures on overcrowded metropolitan areas. Under the enlightened policies and programs of the past, the water transportation industry has been able to do an exemplary job of public service, and the carriers continue to put technological innovations into effect. The industry is intensely competitive, so the benefits of new technology are passed directly to the shipping public in improved service.

From 1964 to 1974, the ton-miles (metric-ton-kilometers) carried in domestic commerce by water increased by 19.6 percent; the ton-miles (metric-ton-kilometers) carried by shallow-draft water carriers increased by 68.6 percent.

Water carriage is a mainstay of U.S. energy supply. Any comprehensive energy policy requires major strengthening of this mode's inherent advantages for energy transportation. In 1973, 57.5 percent of the ton-miles (metric-ton-kilometers) of freight carried by water consisted of fuels, and 7.7 percent consisted of chemicals, much of which were products of the petroleum industry.

Rate increases in water transportation have been restrained compared to those for other modes. From 1967 to 1973, the average revenue of U.S. class I railroads increased from 12.7 to 16.2 mills/ton-mile (22.6 to 28.8 mills/metric-ton-km). Water carrier charges increased by less than 1 mill/ton-mile (1.78 mills/metric-ton-km) in 1973. The additional increase of 1 mill/ton-mile (1.78 mills/metric-ton-km) for the first 6 months of 1974 over the cost per ton-mile (metric-ton-kilometer) for the same period in 1973 can be attributed principally to drastic increases in fuel costs.

The U.S. Department of Transportation (DOT) projects an increase of 77.8 percent in ton-miles (metric-ton-kilometers) of domestic commerce to be carried by water from 1970 to 1990.

We have entered a period of energy shortages and high energy costs accompanied by chronic inflation, soaring capital requirements at unprecedented costs, and a serious economic recession. Full development of the potential of U.S. water transportation facilities should have a high priority. Water transportation possesses several advantages that can help preserve our economic well-being and national security.

1. Water transportation is highly efficient in the use of energy, which is important in a time of scarcity and rising fuel costs. William Mooz of the Rand Corporation has stated that it takes only 500 Btu to move 1 ton-mile (950 kJ to move 1 metric-ton-km) of cargo by water. It takes 750 Btu to move 1 ton-mile (1425 kJ to move 1 metric-ton-km) of cargo by rail, 1,850 Btu to move 1 ton-mile (3515 kJ to move 1 metric-ton-km) of cargo by pipeline, 2,400 Btu to move 1 ton-mile (4560 kJ to move 1 metric-ton-km) of cargo by truck, and 6,300 Btu to move 1 ton-mile (11 970 kJ to move 1 metric-ton-km) of cargo by air.

2. Water transportation, through technological advances in power and design, has been able to control operating costs so that, today, average water transportation rates are lower than the ceiling rates of World War II for movements of bulk cargoes, especially petroleum products and coal. This not only favorably influences the cost of

commodities but also eases the burden of huge investments that are required to improve the U.S. energy supply. Congressman Leonor K. Sullivan (1) of Missouri, chairman of the House Committee on Merchant Marine and Fisheries, stated:

> The water transportation industry presently carries some 16 percent of the Nation's freight expressed in terms of ton miles of cargo transported. It performs this feat at a cost of less than 2 percent of the Nation's freight bill. For this reason alone, it would appear imperative to maintain water transportation at its maximum output to sustain a healthy economy. Examination of the fuel usage of all transportation shows that the energy crisis will be magnified and intensified if water transportation suffers any loss of fuel needed to perform its task.

3. Expanding water transportation capacity entails relatively low capital costs. In 1972 DOT projected a capital expenditure for the railroads for the decade ending in 1980 of $32.30/thousand ton-miles ($57.67/thousand metric-ton-km) of freight estimated for that year (2). This does not consider public funds for railroad rescue and subsidies. The corresponding figure for water carriage is only $6.84/thousand ton-miles ($12.21/thousand metric-ton-km) based on DOT estimates of private investment and a projection of public investment in river and harbor improvements and replacements at the average rate of the period 1970 to 1975. A nearly 5-fold advantage in capital requirements for expansion surely entitles the waterways to high priority in the allocation of funds to meet the nation's expanding transportation requirements.

4. Water transportation can greatly increase service without encountering physical constraints except for a few easily removed bottlenecks or limitations, such as outmoded locks and dams on certain portions of the inland waterways system and disposition of dredged material, which has obstructed dredging on the Great Lakes and important segments of the Mississippi River system. Increasing the minimum stage from 9 to 12 ft (2.7 to 3.6 m) on the Ohio River and other segments of the Western rivers also should be considered. This could greatly enhance the service capabilities, efficiency, and economy of river transportation. Extension of the navigation season would provide an enormous addition to the capacity of the Great Lakes and Saint Lawrence Seaway systems.

The logistics of energy supply are such that our transportation facilities will be called on to move ever larger volumes of energy materials, such as coal and petroleum products, over longer distances. In meeting that urgent need, inland water transportation can perform a distinctive service. The economy of water transportation in the use of energy, its inherent low cost, its capacity for expansion, and its capabilities for efficient carriage of massive cargoes can alleviate scarcities of fuel, farm crops, commercial fertilizers, chemicals, and other commodities basic to economic life that would otherwise result from shortages of freight cars and other bottlenecks in overland transportation. In these ways, water transportation sustains the economic life of countless industrial enterprises threatened with scarcities and rising costs. It thereby reduces serious sacrifices in consumer standards of living and mitigates the dislocations of commerce and industry and resulting unemployment that are consequences of the energy shortage.

The National Commission on Materials Policy in its 1973 report summarized the significance of water transportation to the supply of industrial materials, including energy, in these words:

> Since much of the raw material required by industry is heavy and bulky, water transportation is of unique importance to the Nation's materials system. The most efficient way to move such material to factories and in some instances to transport finished products, is by barge on inland waterways or by deep-draft vessels on the Great Lakes and oceans. No little share of the success of American industry is due to the great system of harbors and waterways available to it.

Despite the outstanding capabilities and inherent advantages of the U.S. waterway system and the clearly stated policy of Congress to encourage waterway development as a federal responsibility, the executive branch of the government has been profoundly negative in recent years. Arthur Maas of Harvard summarized the condition of the U.S. waterway system before a congressional committee in 1974: "The navigation program... has in my view fallen woefully behind national needs in recent years.... It has been in the Executive doghouse." This conclusion is fully supported by the record of federal investments in waterway improvements, which manifests a determined effort to starve out the waterways program. In 1962 federal appropriations for new work on navigation projects amounted to 37 cents/$1,000 of the gross national product (GNP). In 1968 this had fallen to 32 cents, and in 1972 it had fallen to 18 cents in currency of depreciated value.

The effect of this penny-wise and pound-foolish policy is costly to the national economy because it is costly to energy supply, costly to food supply, costly to employment in water-based industries, costly to basic materials, such as chemicals, steel, aluminum, and building materials, and conducive to heightened inflation.

The large public investment already made in enlarged river and harbor carrying capacity is being wasted by continued bottlenecks in the system, such as those on the Mississippi and Illinois Rivers, the Ohio River and its tributaries, and the Gulf Intracoastal Waterway. Something of this loss is measured by a recent announcement by Wayne S. Nichols, Ohio River Division Engineer. Nichols stated that the raising of the pools of the new navigation structures at Newburgh and Uniontown on the Ohio River will reduce costs of commercial navigation by $7 to $9 million/year. If we take an $8 million figure and apply it to the traffic moved through these pools in the latest year reported, we could reduce costs by 1 mill/ton-mile (1.78 mills/metric-ton-km) of cargo transited through just these 2 pools. This represents a saving of 20 to 50 percent in the cost of water transportation. If we could achieve this by relieving the various other bottlenecks on the waterway system, the benefit to the national economy would be enormous. This benefit is being withheld by short-sighted and parsimonious negativism.

The philosophy of parsimony takes its most extreme form in the waterway-user-charge campaign. We have seen the reduction over recent years in federal outlays on waterway construction from 37 cents/$1,000 of GNP to only 18 cents. A waterway-user charge scaled to recover federal costs in their entirety would reduce this to 0. Whatever the government would expend on waterways and harbors it would take back through the user charge. This would be a complete withdrawal from the navigation responsibility the government has carried throughout our history.

In November 1974, the administration submitted a bill to Congress calling for a ton-mile (metric-ton-kilometer) tax that would close numerous branches of the U.S. waterway system to navigation. This would be achieved by taxing each segment of the system at a rate sufficient to recover to the federal government the costs of operation and maintenance for that segment. On some rivers costs would be considerably more than their present level, and industries and shippers simply could not afford any longer to use these waterways. If this tributary traffic is cut off, then the volume of commerce on the main rivers, such as the Illinois, the Mississippi, and the Ohio, would be drastically reduced. Because operation and maintenance costs are largely fixed, the user tax could require rising tax rates per ton-mile (metric-ton-kilometer) to meet the cost-recovery target even on the main rivers, and this would further diminish the volume of commerce. If traffic is eliminated on some waterways and drastically reduced on all waterways, then the benefit-cost test for bottleneck relief would turn negative, and modernization and development of rivers and harbors would be further curtailed.

The philosophy underlying the waterway-user tax proposal reached its logical conclusion in the 1973 report of the National Water Commission. The commission advocated explicit and complete repudiation of all responsibility for future waterway development as a federal cost. They provided instead that federally chartered or nonfederal entities enter into agreement with the government to repay construction cost, including interest, over a specified period of years. This would transfer reponsibility for waterway and harbor development in its entirety to the states, to localities, and to

private interests. The federal government would act only as a kind of clearinghouse or banker. The expenditure of 18 cents/$1,000 for 1972 thus would be entirely eliminated.

Impairment of massive investments that are based on continued availability of low-cost water transportation would follow together with competitive dislocations of far-reaching consequence. It is difficult to conceive that even the most doctrinaire economic theorists could propose such a scheme for congressional consideration without making any serious studies to determine its effects on national and regional economies and allocation of transportation resources. I find it difficult to believe that discouraging use of the most efficient mode of transportation through destructive taxation could be regarded as compatible with the nation's interests.

Another fundamental premise of the water resource policy of the executive branch is that future benefits projected for water projects should be discounted sharply to present worth so that any project that is estimated to increase its benefits over time most likely would be rejected. Application of this policy tends to rule out navigation improvements whose benefits take time to develop and other capital-intensive projects such as major multipurpose reservoirs. Here again the views of the theoretical economists are in sharp conflict with the traditional conception that government bears a special responsibility for the welfare of future generations. Such emphasis on immediate returns and the tendency to take the cash and let the credit go, to use up everything today and go begging for tomorrow's needs, seems to be more primitive than civilized. On what rational considerations shall contemporary citizens be called on to make sacrifices for the benefit of future generations? Robert Heilbroner (3) stated, "There is only one possible answer to the question. It lies in our capacity to form a collective bond of identity with those of future generations."

The rate of increase in applied interest-discount factors for evaluating water projects has been slowed down by congressional action in the Water Resource Development Act of 1973. But the battle is only suspended; final victories are rarely won against the Office of Management and Budget. Continued vigilance by all who are concerned is as necessary as ever.

The great economic issue for water transportation may be reduced to 2 questions. Will the nation adhere to the philosophy of waterways development as a federal responsibility under policies and programs designed to bring the full potential of this great natural resource to bear on the grave problems of food and energy shortages, rising costs, and mounting unemployment that beset us? Or will it yield to the alluring generalities of the economic theorists who would cast the government in the role of a shopkeeper selling water resource services on profitable terms and burying the duties of sovereign responsibility for the national welfare in the printouts of benefit-cost ratios narrowly calculated to obstruct investments in the nation's future?

Certain congressional committees will begin this year a series of hearings leading, I believe, to formulation of a national water policy. Will the end product articulate a defeatist philosophy for America's future? Or will it rather reaffirm the philosophy of security and progress based on the wise use and improvement of our national heritage that has guided the nation to prosperity and leadership of the free world?

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TRANSPORTATION ON INLAND WATERWAYS

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The waterway towing industry is discussed. Statistics on tonnage, extent of navigable waterways, different components of the waterway system, and the difference between foreign and domestic tonnage are provided. The difference between East- and West-Coast towing operations also is discussed, and lighter-aboard-ship and Seabee vessels engaged in foreign commerce are examined briefly.

•THE DIVISION of Inland Waterways in the Office of Domestic Shipping of the Maritime Administration promotes domestic waterborne commerce on the nation's inland waterways. Similar divisions promote waterborne commerce on the Great Lakes and in coastal and noncontiguous ocean trades.

SYSTEM SIZE

If we disregard the Great Lakes, Saint Lawrence Seaway, and coastal routes, the heart of the navigable inland waterways system is the Mississippi River system and its tributaries that pass through Sioux City, Iowa; Minneapolis, Minnesota; Chicago, Illinois; Pittsburgh, Pennsylvania; Knoxville, Tennessee; and New Orleans, Louisiana. This represents about 6,000 miles (9600 km) of commercial waterways with minimum 9-ft (2.7-m) channels. On the Gulf of Mexico is the Gulf Intracoastal Waterway and its tributaries, which represent 2,700 miles (4300 km) of navigable water from Brownsville, Texas, to Saint Marks, Florida. On the Atlantic Ocean the Atlantic Intracoastal Waterway and its tributaries and the New York and New England waterways represent another 4,300 miles (6900 km) of channels. On the West Coast a waterway system extending inland from San Francisco and the Columbia River system in the northwest United States represents another 2,300 miles (3700 km) of waterways. This makes a total of about 15,300 miles (24 480 km) of inland waterway systems that have 9 ft (2.7 m) or more navigable depth. The newest addition to the system—the Tennessee-Tombigbee project—which is primarily in the state of Mississippi, is now under construction.

TONNAGE AND MARKET SHARE

In 1970, 581 million tons (522.9 million metric tons) moved in the nation's foreign waterborne commerce and 950 million tons (855 million metric tons) moved in domestic waterborne commerce. When we consider that U.S. flag vessels move less than 10 percent of U.S. foreign commerce, we can see that the U.S. domestic fleet carries about 30 times more tonnage than ocean-going vessels engaged in international trade do.

A declining trend in market share for both rail and water transportation, an increasing but recently stable trend for truck transportation and a steadily increasing trend for pipeline transportation are evident. Traffic tonnage for all modes of transportation is increasing, but trucks and pipelines are increasing faster than railways or water carriage. Water transportation now makes up about 30 percent of the market.

The 4 main beneficial characteristics of water transportation are flexibility, high capacity, high speed, and low cost. Water transportation, for all practical purposes, competes only with railways and pipelines. The high capacity and low cost of water transportation are its main advantages over railways, its primary competitor. These

advantages are the competitive strengths of this mode. Nondimensional cost-capacity curves for the various modes of transportation also demonstrate the competitive strengths of this mode.

The commodities that are moved by water carriage are primarily liquid and dry bulks: petroleum, chemicals, coal, ore, sand and gravel, and grain products.

Deep-sea, inland-waterway, and Great Lakes components make up domestic water transportation. Inland waterways have about 30 percent of the domestic water transportation market, but they carry about 60 percent of the tonnage. Inland waterways move more tonnage but for shorter average distances than Great Lakes and deep-sea transportation do.

Beginning in 1969 inland waterway tonnage for 19 major commodity groups was slightly over 450 million tons (364.5 million metric tons), which can be expected to grow to almost 870 million tons (783 million metric tons) by the year 2000—an increase of 114 percent. In 1969, all modes transported 837 million tons (753 million metric tons) in the inland waterways trade area, which indicates that water transportation had a 48 percent share of the market. Total transportation will increase by 121 percent by the year 2000; market share for water carriage is expected to decrease slightly from 48 to 46.7 percent. U.S. Department of Transportation projections verify these estimates.

After separately listing the largest U.S. ports in 1970 in terms of foreign commerce tonnage and largest U.S. ports in terms of inland waterways tonnage and then combining and ranking the 2 lists, one finds that in 1970 New York and New Orleans ranked first and second. These 2 ports were ranked this high because of inland waterway tonnage, not foreign commerce tonnage. In fact, Huntington, West Virginia, is a major port in waterborne commerce because of the volume of coal that moves through its terminals.

EAST-COAST AND WEST-COAST TOWING

Specialized towing on the East and West Coasts differs somewhat from that on the Mississippi River system. In the Pacific Northwest the tows are smaller and the barges are much less standardized. Curious-looking, but functional, special-purpose barges are commonplace.

LIGHTER-ABOARD-SHIP AND SEABEE VESSELS

By the end of 1975, 27 lighter-aboard-ship (LASH) and Seabee vessels will be in service. The LASH mother vessel carries 375 ton-lighters that are loaded on board by means of a huge crane on rails that picks up the lighter over the stern and then moves it forward in the vessel to stowage. The Seabee mother vessel carries 1,000 ton-barges that are loaded on board by means of a 2,000-ton (1800-metric-ton) elevator at the vessel's stern. Both the LASH and Seabee systems provide a new type of door-to-door service in which cargo is not rehandled between origin and destination.

INLAND WATERWAY PORTS

When a large tow arrives in New Orleans, it drops off all barges and picks up a northbound tow that has been made up and is ready to go.

The dropped-off barges are unloaded and then moved to a fleeting facility where they are cleaned and held until they are made up for a tow heading back up the river. In any given year, the New Orleans area handles more than 90,000 barges.

Ports and terminals on the inland waterways are different from the familiar seaports along the coasts. Terminal facilities generally are not concentrated at river ports. A river port is a group of separate individual terminals that may stretch for 20 miles (32 km) along the river. Different facilities, such as a grain elevator, a petroleum terminal, an ore-loading facility, a coal transloader, and a multipurpose municipal terminal may make up the group.

INTERNAL AND EXTERNAL SHIPPING ON THE GREAT LAKES

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Significant changes in shipping are now under way on the Great Lakes. These changes involve internal Great Lakes shipping, including both domestic trade and trade between the United States and Canada, and external shipping among the Great Lakes, lower Saint Lawrence River ports, and overseas. This paper provides a general overview of some recent changes and prospective changes in Great Lakes shipping.

•SIGNIFICANT changes in shipping are now under way on the Great Lakes. These changes involve internal Great Lakes shipping, including both domestic trade and trade between the United States and Canada, and external shipping among the Great Lakes, lower Saint Lawrence River ports, and overseas. This paper provides a general overview of some recent changes and prospective changes in Great Lakes shipping that are relevant to policy decisions.

The Great Lakes together constitute the largest body of navigable fresh water in the world. With a relatively small drainage basin of 295,000 $miles^2$ (767 000 km^2), the lakes themselves have a surface area of just under 100,000 $miles^2$ (260 000 km^2). Elevations above sea level range from 246 ft (75 m) for Lake Ontario to 602 ft (183 m) for Lake Superior. The head of the tidewater at Montreal is 1,337 statute miles (2139 km) from the head of the lakes at Duluth; it is 1,244 miles (1990 km) from the head of the lakes at Chicago. Montreal is 800 miles (1280 km) from the Atlantic Ocean south of Newfoundland, and it is 1,000 miles (1600 km) from the Atlantic Ocean north of Newfoundland. Although a significant proportion of the Great Lakes and much of the Great Lakes-Saint Lawrence route involve open-water navigation, the connecting channels between the lakes and much of the Saint Lawrence River, especially above Montreal involve transit through confined channels. These place serious limitations on the dimensions (especially the drafts) of vessels. The seasonality of the interlake and Saint Lawrence operations also imposes further handicaps. The attempts to overcome these limitations are among the most significant current developments.

The Saint Lawrence route between the Great Lakes and overseas was not created when the Saint Lawrence Seaway was opened in 1959. Small canals circumvented the rapids of the Saint Lawrence River in Canada, and the predecessor of the Welland Canal connected Lake Erie and Lake Ontario from the end of the War of 1812. These competed with the Erie Canal, which connected the Great Lakes and the New York tidewater. As early as the middle 1850s, wheat was shipped from the upper Great Lakes to Europe. A series of enlargements of the Saint Lawrence route culminated around the turn of the century in a number of canals along the present Saint Lawrence Seaway route. In 1932 the Welland Ship Canal, with 8 locks, opened up Lake Ontario to the large "upper laker" bulk carriers. That canal, which has since been partially rebuilt, constitutes part of the present seaway. In 1933, the first regularly scheduled cargo liner service connected the Great Lakes with Europe by means of small vessels. Service was interrupted only during World War II. The depths to which the channels were dredged and the dimensions of the locks along the route were more influenced by the characteristics of lake-user bulk vessels than the characteristics of salt-water ships. The standard seaway depth is 27 ft (8.2 m), and most of the major Great Lakes harbors have been dredged to the same depth. This normally permits access and transit by vessels of up to 26.75-ft (8.2-m) draft. Because of these decisions that were made several decades ago, a rapidly decreasing proportion of the world's ocean-going vessels can use the Great Lakes-Saint Lawrence route, and the economies of scale currently realized on most of the principal ocean routes cannot be realized for Great Lakes-overseas movements.

Until 1959, 22 small locks were in the 6 canals that bypass the rapids of the Saint Lawrence River in the 110 miles (176 km) above Montreal. Lake vessels transiting to and from the lower Saint Lawrence River were designed to fit these locks. They were limited to a length of 259 ft (79 m), a beam of 23.5 ft (7.2 m), and a draft of 14 ft (4.3 m). With those dimensions, they could carry up to 3,000 tons (2700 metric tons) of cargo. More than 200 such canallers operated in the Saint Lawrence canals from World War II to the opening of the enlarged seaway in 1959. Virtually all of them were under Canadian registry, and they included both package freighters and bulk carriers. The early, preseaway general-cargo liners that pioneered the Great Lakes-overseas direct trades between 1933 and 1959 were limited to the same dimensions, but, because of their necessarily finer lines as seagoing ships, such salt-water ships could not move more than 1,600 tons (1440 metric tons) on canal draft. They usually added a few thousand tons more cargo in the lower Saint Lawrence area for the ocean voyage. The vessels moved slowly through the canals and channels paralleling the Saint Lawrence above Montreal whether they were lake-user or saltwater ships. They commonly took 3 days between Lake Ontario and tidewater.

After 5 years of construction from 1954 to 1959 the seaway was opened. The Saint Lawrence portion involved the building of 2 dams (a diversion dam at Iroquois and the Moses-Saunders dam) with 2 million kW of electric generating capacity, between Massena, New York, and Cornwall, Ontario. Without the power, the seaway as a navigation project probably would have been economically and politically infeasible because all construction and facilities jointly used for navigation and power are charged against power, rather than navigation. Originally, 29 percent of costs and benefits for navigation was assigned to the United States; the remainder was assigned to Canada. Later, this ratio was changed slightly. Toll revenues are similarly assigned. Two of the 7 locks between Lake Ontario and tidewater and the 10-mile (16-km) Wiley-Dondero Canal are within, and were constructed by, the United States.

Most of the preopening traffic estimates for the seaway were optimistic. During the early 1970s volume reached the projections. But, in 1974, a substantial decline was noted although final figures are not yet available. Throughout the entire 16 years of its operation, the seaway, as anticipated, has been predominantly an artery for bulk traffic rather than for general cargo. Through the Lake Ontario-Montreal section, which is the seaway proper, the predominant downward-bound cargoes are grains. The predominant upward-bound cargoes are iron ore, which are principally from the Quebec-Labrador area. These cargoes are carried in lake-type vessels that are slightly modified for seaway operation with bronze bearings and constant-tension winches. Many of the vessels were built to the maximum dimensions of the Welland and Seaway Locks [730 ft (222 m) long, a 75-ft (22.9-m) beam, and a maximum draft of 26.75 ft (8.2 m)]. Vessels with these dimensions normally can carry about 28,000 tons (25 200 metric tons) of cargo. Because of the higher costs of U.S.-flag operations, the overwhelming proportion of the "maximum lakers" are under Canadian registry, although recent additions have been made to the U.S.-flag fleet.

Many of the lakers carry grain from both Canadian and U.S. lakehead ports to the lower Saint Lawrence for transfer to larger ocean-going vessels. The proportion of lakers to saltwater vessels engaged in seaway grain movement is mostly a function of the worldwide demand for tramp bottoms. When demand is high for ocean-going, dry-cargo ships, such as during a war, a higher proportion of the outbound grain is transshipped in the lower Saint Lawrence, and fewer saltwater vessels are loaded at lake ports.

Except for the unusual circumstances of 1974, when strikes partially crippled the movements, a collision blocked the Welland Canal during peak season, and the recession resulted in lessened industrial activity, it appears that the long-term capacity of the Saint Lawrence Seaway system will be limited not by the ability of the system to attract bulk cargoes but rather by the physical capacity of the system to handle the cargo movement. In the early 1970s, the Lake Ontario-Montreal section handled nearly 60 million tons (54 million metric tons) of cargo/year, which was very close to the early estimates of its capacity. Fortunately, the efficiency of the waterway route has been substantially improved by the trend toward larger vessels that can

handle more tonnage per transit. The maximum laker is now much more typical than the preseaway small canallers, which have virtually disappeared. Also, additional annual capacity has been provided by the lengthening of the navigation season with earlier openings and later closings.

General cargo, which moves in scheduled liners, has been declining after an initial period of expansion. It declined precipitously in 1973 and declined even more in 1974. The number of cargo liner services between the Great Lakes and overseas had reached about 60, but it has declined to about 12 in recent years. No U.S.-flag liners have been engaged in direct Great Lakes-overseas services since the early years following the seaway opening although a number of operators tried it and gave up. A high proportion of the current service is by Soviet, Polish, and Yugoslavian vessels.

In addition to the Saint Lawrence Seaway route, the Great Lakes are connected with salt water by the Illinois Lakes-to-Gulf Waterway, which is part of the Mississippi River system, the dominant inland waterway route of North America. Although internal Great Lakes transportation has remained fairly constant in volume over the past several decades, the Mississippi River system, operated almost entirely with barges and towboats, has witnessed a rapid long-term increase, stimulated by the extensive federal improvements to the waterway system. The 2 inland waterway systems meet at Chicago, which is the only port on both systems. Modern barge navigation to and from the lakes became practicable when improvements on the Illinois Waterway were completed in 1933. The Calumet-Sag route, whose enlargement was authorized in 1946 and begun in 1955, is now nearing completion. It provides a second major connection that serves the Calumet region of metropolitan Chicago, which has one of the world's largest concentrations of heavy industry.

The Port of Chicago has been, for many years, a leading bulk port on both waterway systems. It also has handled the greatest proportion of the Great Lakes-overseas direct general-cargo traffic. It is a fragmented port that involves several local agencies, but it probably will remain the dominant inland port of North America. The development of barge-carrying ships [lighter-aboard-ship (LASH) and Seabee vessels] gives Chicago as well as nearby ports on the Lake Michigan shore the opportunity to develop direct overseas services via the 2 competitive routes. Both can involve transfer at deepwater ports near the sea or direct barge service without break of bulk; the barges are carried across the oceans by LASH or Seabee vessels. Until now, these "kangaroo" services have been used primarily to facilitate turnaround time for the large vessels; the barges normally do not venture far inland although some have reached Chicago, St. Louis, and other ports upriver from New Orleans. The other alternative—use of LASH and Seabee barges through the Great Lakes-Saint Lawrence route to the lower Saint Lawrence River—has not yet been developed. Meanwhile, much bulk traffic is transshipped in the lower Saint Lawrence River. One general-cargo operator uses small ocean-type feeder vessels for container traffic in connection with its larger vessels at Montreal by shuttling the containers between Montreal, Chicago, and other ports on the Saint Lawrence-Great Lakes system.

Although the terminals for general cargo and for bulk traffic are different around the Great Lakes (the former generally is under public ownership and the latter usually is under private ownership), most of the lake ports have both types, and most of the channels serve both types of traffic.

Internal Great Lakes traffic is changing and, with it, vessels and ports are changing. The dominant bulk commodities, however, have not changed significantly for decades. General cargo, or package freight, has, with the exception of a small amount of Canadian domestic traffic, disappeared since World War II. Virtually all internal domestic and U.S.-Canadian international traffic either is associated with heavy industrial development in and near the lakes or involves fossil fuels moving to utility plants along the shores.

Along the shores of Lakes Ontario, Erie, and Michigan, and in the nearby lake hinterlands, are the world's largest concentration of basic iron and steel production and innumerable metal fabricating, machinery, and other establishments that use the output of the iron and steel plants. Geographers have long recognized the lower lakes area as the core region of the United States and Canada. Great Lakes transportation is the vital

link connecting this area with the sources of raw materials such as ore, limestone, and coal. Major changes in the direction and character of movement of these materials have taken place recently. These changes are reflected in the characteristics of the vessels and of the port terminals.

Direct shipments of iron ore from Lake Superior, the principal source for more than a century, began with the opening of the first canal circumventing the rapids of the Saint Marys River, which connected Lake Superior with the lower lakes, in 1855. The subsequent series of enlargements of locks at Sault Sainte Marie (Soo) has been accompanied by larger ships. After the opening of the Welland Canal in 1932, which has locks identical in size to what was then the largest of the Soo locks and the later locks of the Saint Lawrence Seaway, the maximum lakers gained access first to Lake Ontario and later to the lower Saint Lawrence River. The ranges around Lake Superior have been the overwhelmingly dominant source of ore, but with the opening of the seaway the ores of the Quebec-Labrador area have become competitive at the Canadian plants of Lake Ontario, and through the Welland Canal, in the Cleveland-Youngstown-Pittsburgh area. After 1959, the maximum lakers no longer were confined to the area of the Great Lakes proper. They carry grain eastward to the lower Saint Lawrence River and return with ore. Some vessels were designed for ocean service as well as for operations within the lakes, and they commonly engage in worldwide tramping during the closed season on the lakes.

Until recently, nearly all world records for rapid loading of bulk cargoes were held by the upper lake ports. Ports such as Duluth, Two Harbors, and Superior, which are highly mechanized, are links in an integrated chain of transportation involving railroads from the mines to lakehead ports, water movement through the lakes, and either termination at waterfront plants in lower lake ports or further rail movement to nearby inland points such as Pittsburgh and Youngstown. Ton-mile (metric-ton-kilometer) costs of this transportation traditionally have been among the lowest in the world.

Lower lake ports, particularly those along the south shore of Lake Erie, and, to some extent, South Chicago, handle return cargoes of coal; the former handle cargo from the Appalachian region, and the latter handle cargo from central and southern Illinois and western Kentucky. These cargoes are shipped to the thermal electric utilities of the upper lakes including those serving such industrial cities as Detroit, Chicago, and Milwaukee.

Grain movement in the Great Lakes has fluctuated from year to year, but the development of larger canals and locks along the entire Great Lakes-Saint Lawrence system has shifted the movements substantially. Buffalo was, until 1932, the easterly head of lake grain movement, except for the small canallers previously mentioned. After the opening of Lake Ontario to the large upper lakers in that year, the decline of Buffalo as a major flour milling center accelerated. Baltimore, the closest rail-connected U.S. saltwater port, also declined as an exporter of grain. Transfer of grain between lake and canal vessels took place at Prescott, Ontario, and Ogdensburg, New York, which between 1933 and 1959 constituted the lower head of navigation for the lake vessels, and at other ports of the upper Saint Lawrence River and Lake Ontario. In such instances, another transfer of export grain took place between cannallers and ocean-going ships at Montreal or other lower Saint Lawrence ports. With the opening of the enlarged Saint Lawrence Seaway, direct Great Lakes-overseas movement of grain in ocean-going vessels was supplemented by transfer between lakers and ocean ships in Saint Lawrence ports below the canals. The balance between direct Great Lakes-overseas and transfer movements now depends on the relative rates for lakers and saltwater vessels, which in turn are a function of the world tramp market. In the Great Lakes, grain can be handled in either of the 2 principal types of lake vessels: "straight-deckers," which have no unloading equipment on board, and "self-unloaders," which can discharge cargoes independent of shore-based equipment. Several developments of recent years have shifted the character of the typical lake vessel from the straight-decker to the self-unloader.

The development of iron ore concentrates, particularly taconite, is rapidly changing the character of the Great Lakes iron ore traffic. The proportion of concentrate to direct shipping ore (principally hematite) between the upper lakes and lower lake ports,

has made greater efficiency possible through use of self-unloaders in the iron ore trades. Taconite, unlike direct shipping ores, is dehydrated. Formerly, it was not possible to use self-unloaders in the ore trade partly because during cold weather the water content would freeze the ore and partly because of the nonuniform sizes and shapes of the ore. Taconite concentration plants are located in the upper lakes region, and an increasing proportion of the ore moving in the lakes is concentrated. As a result, although the amount of iron involved is increasing year by year, the total volume of ore has remained fairly constant. Currently the proportion of total ore tonnage movement both within the lakes and through the seaway from eastern Canada is about 75 percent taconite and 25 percent direct-shipping ore.

For a number of years, nearly all new bulk carriers on the Great Lakes have been self-unloaders. These can be used for ore, coal, stone, and grain trades. A significant number of the older vessels have been retrofitted as self-unloaders.

A second relatively recent development of great significance is the completion of the Poe Lock at the Soo, which was opened in 1970. In contrast to other parallel locks that limit the dimensions of the vessels operating between Lake Superior and the other lakes to seaway size, the Poe Lock admits vessels up to 1,000 ft (300 m) long and with 105-ft (32-m) beam; such lakers can carry over 56,000 tons (50 400 metric tons) on normal lake draft, which is more than twice as much as any prior lakers. Almost immediately, vessels of these dimensions were under construction and older vessels were enlarged. A new generation of lake ships is under way. Again, however, a portion of the Great Lakes fleet, for the first time since 1932, is unable to operate east of Lake Erie because the vessels exceed the dimensions of the locks in the Welland Ship Canal and the seaway proper.

Two other developments affecting the character of internal Great Lakes traffic are of great significance. One concerns energy. There is an awareness of the environmental impacts of power plants and the fuels that they use. The emphasis on use of low-sulfur coal is rapidly expanding traffic that is the reverse of the previous lake coal movements. Now there is a downward-bound movement of western low-sulfur coal from Lake Superior that is received at the lower lake ports. Unlike the upward-bound movement, which dominated the lake trades for decades, coal now moves in the same direction as ore does. Additional major loading facilities are under construction and planned for lakehead ports. These ports are connected with the western coal fields by unit trains. This greatly reduces the costs of long-haul movement. Unit trains compete with lake shipping by offering low rates for the through movement between mines and consuming plants. Commitments have been made in several instances for long-term investments to handle downward-bound lake coal movements. So this type of movement will increase, but through unit-train movement may, in the long run, restrain competition. To some degree, this is not unlike the movement of petroleum from the refinery district of northwestern Indiana to other Lake Michigan ports such as Milwaukee and Green Bay, Wisconsin, which are now served by pipelines paralleling the lake shore. Unit trains between the Appalachian coalfields and utility plants north of Lake Erie, most notably in the Detroit area, constitute a challenge to short-haul coal movements across western Lake Erie. Levels of all-rail and rail-lake movement are not yet clear. The proliferation of nuclear power plants in the Great Lakes region, now slowed by environmental constraints, the recession, and technological difficulties, will significantly affect the total demand for Great Lakes coal transportation.

The second development affecting Great Lakes shipping is the prospect of continued extension of the navigation season. Overseas shipping is about 1 month longer within the lakes than it was during the early years of the seaway. Internal interlake shipping has been extended in some instances from 8 months to 10 months. Some lakers currently operate into February and resume in March. Substantial additional annual capacity can be generated by continued extension of the season. Whether all-year operation of interlake shipping will be practicable has not yet been determined.

In summary, in internal Great Lakes traffic, new conditions of operation, new types and directions of traffic flow, and fewer but larger and more efficient bulk-carrying vessels represent the current trend and the short- and intermediate-range future prospects.

A major change in character and volume in Great Lakes-overseas direct trades has occurred in the past several years. The volume of general cargo carried by scheduled liner services peaked several years ago at about 5 million tons (4.5 metric tons)/year. There were about 60 regular liner services. Since the seaway opening, radical changes in the technology of both inland and ocean transportation have had almost catastrophic effect on the Great Lakes-overseas general-cargo trades.

In the early years, Great Lakes-overseas movements involved break of bulk at the Great Lakes ports. Within the lakes, turnaround time of break-bulk liners is slow, and the port operations are labor intensive. Load centers developed that involved concentrations of cargoes at fewer but larger and more efficient ports. The smaller Great Lakes ports were bypassed. Great Lakes-overseas vessels were transiting the seaway that were several times larger than their preseaway counterparts. Then, in the late 1960s, containerization became dominant on the major ocean routes, and intermodal transportation rapidly replaced break-bulk movements on many such routes. Modern container ships are far too large to transit the seaway, and operating and fixed costs are so high that they require very fast port turnarounds. Therefore, they must carry concentrations of cargo volume several times greater than that which would justify port calls by conventional break-bulk vessels. The infrastructure of inland transportation, including railroad piggyback and container operations and faster freight trains, the building of the Interstate Highway System, rapid expansion of intercity trucking, and the adoption of new technology at ports for intermodal interchange of containerized cargoes and roll-on-roll-off intermodal movements combined to make the capital investment easier at coastal ports. A modern container ship represents as much as $25,000/day, a container crane may cost up to $2 million, and an efficient berth for a container ship uses 30 to 50 acres (12 to 20 hm^2) of land. Even if all general-cargo Great Lakes-overseas traffic of the recent peak year were concentrated at a single port, it would scarcely justify the huge investment that would be required. Furthermore, the limited navigation season, the hazards of operation in confined channels, the necessarily long turnaround time between entering and leaving the Great Lakes-Saint Lawrence Seaway system, the prospect of pyramiding delays caused by channel blockages and strikes combine to limit the prospects for future general-cargo movement by the Great Lakes-Saint Lawrence Seaway route in competition with load centers at coastal ports.

This pessimistic picture was compounded by a precipitous decline in general-cargo traffic in 1973 and an even greater decline in 1974. In the past year, certain sporadic events led many to believe that the decline was unusual. These events included strikes, the recession, completion of grain movements to the Soviet Union, and the blocking of the Welland Canal at a critical time. In spite of these events, several of the major Great Lakes ports are preparing and developing plans for greatly expanded overseas general-cargo traffic. Cleveland is contemplating a new outer harbor area, Chicago, a container terminal, and Milwaukee, an extensive harbor north of its present port terminals. Meanwhile, in 1974, direct overseas general-cargo traffic is reported to have declined to about half of that in 1973, which was a poor year, at the Port of Chicago. At Milwaukee, the 1974 total overseas tonnage was less than half the volume of the previous year. Thus, the Great Lakes-overseas general-cargo traffic no longer is as vital as it once was, and the optimistic projections of the preseaway years will not be realized in the foreseeable future. This does not mean, however, that overseas trade through the seaway will not continue in substantial volume. The seaway is causing a "handy size" bulk carrier to be produced that will be built to the maximum dimensions admissable in the seaway. Furthermore, some of the Great Lakes ports are in a strategic position to handle specialized cargoes. Major metropolitan industrial areas on the lakes, such as Chicago, Milwaukee, and Cleveland, produce heavy and bulky manufactured products, such as mining and construction machinery and locomotives, that cannot be transported overland because of their bulk or weight. Heavy-lift traffic at such ports represents a movement of considerable consequence that has excellent prospects for the future involving specialized port terminal facilities and, in some cases, specialized vessels. Expansion of container feeder services and LASH and Seabee

barge services between Great Lakes ports and those of the Gulf Coast and the lower Saint Lawrence River also is possible.

All of these prospects are tentative. Their ultimate development will depend on outside forces: the economic, political, social, and military conditions in the Great Lakes region, and the nation, and the world. Projection and, even more, prediction are dangerous.

The intralake operations are the third facet of transportation on the lakes.

The short-haul package freight and passenger steamer within the lakes no longer exists. It disappeared before World War II. However, several ferry services, particularly those across Lake Michigan, remain within the lakes. On Lake Superior, a railroad-car-ferry service was initiated recently connecting the Canadian lakehead port of Thunder Bay with the American lakehead port of Duluth-Superior, providing a link where no parallel railroad exists.

On Lake Michigan, however, the situation is critical. That lake, except for the ferries, is a barrier over 300 miles (480 km) long straddling the main east-west transportation corridor of the nation, and it forces all movement except air transportation around the ends of the lake, especially through the congested Chicago gateway. Three railroads operate car-ferry services across Lake Michigan. Several of their routes were abandoned in recent years, and the remaining ones are greatly curtailed. Most of the vessels were decommissioned or scrapped recently. None are equipped to handle heavy trucking, and most do not conform to contemporary environmental requirements.

The ferries enabled coastal cities, such as Milwaukee and the hinterland northwest of Chicago, to be placed on a rate equal to that of Chicago and thus gain access to the northeastern railroad territory on an equal basis. How long this rate situation could be maintained without the ferries is problematical. Rail, and especially highway, traffic to and from most of Wisconsin and adjacent states is subject to the handicap of circuitous routes around the southern end of the lake, which involves interline instead of single-carrier movement.

Several studies of prospects for a modern and comprehensive service across Lake Michigan to replace the existing deteriorating services are under way. No such service, by itself, could operate profitably, but the economic benefits to the regions on both sides of the lake and the nation as a whole justify some sort of public subsidy for a comprehensive cross-lake service run by fast, efficient, modern vessels equipped for both truck and automobile traffic. A Milwaukee-Muskegon route is favorably located to maximize benefits from such a service and would supply a missing link in the nation's highway network. There are Interstate as well as other federal highway routes extending east and west on both sides of the lake from the prospective terminals; the cost of a ferry service, however organized, would be substantially below the cost per mile (kilometer) of providing a typical highway on land.

Ferry services, unlike the interlake and overseas services, can operate year round. U.S. Coast Guard icebreakers are stationed within the lakes, and plans are under way for smaller craft to keep the harbors, and eventually the connecting channels between the lakes, open the year round. The existing ferries, and those that may be developed in the future, have icebreaking characteristics, and the newest Great Lakes bulk carriers, as well as many of the ships in Great Lakes overseas services, can operate under some ice conditions.

Although the Great Lakes overseas general-cargo services face an uncertain future, certain specialized types of service by salt-water vessels will continue to be important, and even may expand. On the other hand, Great Lakes ports are not now justified in placing heavy investments in facilities for direct overseas general-cargo trades. Interlake movements are changing rapidly in character, direction, and types of vessels. Even though such movements have not grown significantly in total volume for many years, they are carried out more efficiently and more economically than in the past.

MULTIPURPOSE PROJECTS ON THE TENNESSEE RIVER

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The purpose of this paper is to present the transportation planning implications resulting from the existence or construction of a multipurpose water resource project. The series of multipurpose dams and locks along the Tennessee River is discussed, and its benefits are listed.

•THE TENNESSEE River is a part of the Mississippi River system of 10,000 miles (16 000 km) of improved channels that connect 21 states. This system reaches from the Great Lakes to the Gulf Coast. Transmission lines carry power produced by hydroelectric and steam plants to the homes, farms, businesses, and industries in the 201-county Tennessee Valley region. Because steam plants are large, nonconsumptive users of water, their locations are made more economical by multipurpose reservoirs. A series of 9 multipurpose high dams with locks permits navigation on the entire length of the Tennessee River, which is 650 miles (1046 km) long. High dams also provide benefits such as flood control, hydroelectric power, recreational activities, and adequate water supply for homes and industry.

During the winter, Tennessee Valley Authority (TVA) lakes are drawn down to keep heavy winter and spring rains from causing severe flooding. Nearly all of the major floods in the Tennessee Valley have occurred in the winter and spring months. The multipurpose high dams help prevent floods by regulating runoff and flow. This creates usable land. But it also creates difficult policy decisions on allocating the land. TVA policy stipulates that only water-use structures and open nonstructural uses be permitted below the structure profile, which usually approximates the regional flood. Furthermore, only when overriding economic reasons offset the risk are structural uses permitted between the structure profile and the maximum probable flood. These policy decisions have a great effect on transportation planning. For example, if the floodplain below a dam is restricted to nonstructural daytime recreational use, then highway connections will not have to cross connecting rail spurs or carry industrial or commercial traffic.

The key to industrial development in an inland waterway region is not merely the availability of water transportation but also the availability of rail, highway, and deepwater transportation at the same location. At every point on the Tennessee River and its major tributaries where these 3 modes intersect and buildable land is available, waterfront industrial development has taken place. Transportation planners can forecast where rail and highway connections will be needed if the public and key public agencies approve of and support economic growth and if the multipurpose reservoir has a stable buildable shoreline with deep water within reasonable distance. TVA believes that rail and highway transportation should have a proximity of 15 flat miles (24 km); water transportation should have 1 mile (1.6 km) of dredging. If any of these is exceeded, the others are not likely to be needed for a long time under normal circumstances. Availability of a good transportation network and abundant electric power has encouraged industry to locate along the Tennessee River and its tributaries. There are more than 200 plants and terminals that provide more than 41,000 jobs.

Both inland and waterfront industry take advantage of low-cost barge transportation to ship raw materials and finished products to other industrial centers on the inland waterway and to foreign countries. If the hinterland industry produces or receives high-volume nonpackaged material, then public terminals will be needed. Their planning requirements are similar to those for waterfront plants. If the multipurpose

reservoir has unstable banks, requires excessive dredging, or if access channels silt up rapidly, industry will tend to cluster around the public terminal. Such concentrations cause problems and must be well planned for.

Recreation is 1 of the many purposes that only recently could be used as a benefit to justify public investment. All boats have 1 thing in common—they all have to land somewhere. About 22 percent will be concentrated at marinas and commercial docks. Regionwide or even statewide automobile peak-traffic figures related to these concentrations are not meaningful unless they are related to the type of marina and overall pattern of use. Connecting roads and parking areas need to reflect more than this because marinas have a tendency to expand rapidly. TVA deals with this when a permit is issued by setting the maximum water surface area the marina can expect to occupy. If a launching ramp is provided, then these figures have to be multiplied by a sizable factor. Trailer boaters take up a lot of room and have trouble on steep and curving roads. TVA recreation planners prefer to separate the launching ramps from the marinas and provide large parking areas and easy turnarounds to better serve the public.

Swimming areas usually have been located close to urban concentrations unless a large and diverse recreational complex such as a state park was available. Most multipurpose reservoirs have many sites that are physically acceptable for this type of recreation. Coves off the main stream usually are the best locations. In most cases closeness to the existing highway pattern is a location requirement.

Locating camping areas near reservoirs is exceptionally good. TVA has camping areas below dams where certain kinds of fishing are particularly good but the swimming is not. Camping areas also are above dams where swimming, fishing, and boating are good.

Multipurpose reservoirs create changes in residential patterns. Property values are increased. Multipurpose reservoirs do for residential development what interstate access points do for motels and service stations. Unless carefully planned, these reservoirs can create strip and sprawl development just as an unlimited-access highway can.

A new reservoir can change the riverfront of a metropolitan area by affording the opportunity to correct previous development mistakes. A new boundary will exist for usable land, bridges can be raised or relocated, and lateral roads can be replaced. When you see a large city with a beautiful, well-planned waterfront, you usually can conclude that it resulted from the construction of a reservoir.

For a very small incremental investment for dredging to extend the navigation depth and for land acquisition, it was possible to add an industrial park to the Melton Hill Reservoir project. However, in order to justify the increased investment, the builders had to get commitments on rail and highway rights-of-way, funding of rail and highway access, and support of nearby waterfront residential interests. Now 4 blue-chip company plants are there, and a fifth plant is being planned. This 1,000-acre (400-hm^2) project will produce 2,000 high-paying jobs. The project also is compatible with nearby residential land use, a trout fishery, a fish hatchery, and a recreational waterway. It is worth all of the planning effort that was put into it. Multipurpose projects require extra planning, but they offer large returns on the effort.

MAINTAINING THE NATION'S WATERWAYS

John W. Morris, U.S. Army Corps of Engineers

The requirement to dredge navigable waterways to maintain channel depths for shipping has become a problem of great national significance. The ability of the U.S. Army Corps of Engineers to dredge is declining. Unless ways can be found to continue the maintenance of waterways in the face of environmental, legal, and technical constraints, an economic situation that would adversely affect the entire economy will be precipitated. The purpose of this paper is to familiarize the reader with the Army's role in maintaining waterways, the problems it faces, and its efforts toward solving the problems.

•THE REQUIREMENT to dredge the navigable waterways of the United States to maintain channel depths for shipping has become a problem of great national significance. The ability of the U.S. Army Corps of Engineers to dredge is declining. Vital harbors, ports, and inland waterways throughout the nation are adversely affected. In some cases, they face being shut down. Unless the Corps of Engineers can find ways to continue to maintain waterways in the face of environmental, legal, and technical constraints, an economic situation that would adversely affect the economy of the entire country could be precipitated.

BACKGROUND

Waterway System

Since 1824 congressionally directed navigation maintenance responsibilities have constantly increased; today they include 22,000 miles (35 400 km) of inland waterways, 3,000 miles (4800 km) of intracoastal channels, 107 commercial port facilities, and 400 small boat harbors.

Domestic waterborne commerce, including inland barge and Great Lakes traffic, moves almost 16 percent of the nation's ton-miles (metric-ton-kilometers) of intercity cargo.

Inland waterway barge traffic has increased over the past 2 decades at a compound rate of slightly more than 5 percent/year. The amount of tonnage that can be moved in a single tow has increased from 5,000 to 50,000 tons (4500 to 45 000 metric tons)/tow.

Waterway commerce presently totals 1.7 billion tons (0.9 billion metric tons)/year, which is more than 350 billion ton-miles (196 billion metric ton-km), or about 7 tons (6.3 metric tons) per capita. This cargo is carried at an average cost of 3 mills/ton-mile (5 mills/metric ton-km). Energy-producing commodities, predominantly petroleum and coal, make up slightly more than 50 percent of U.S. waterborne freight. The rate of energy use in the United States has outstripped the rate of population growth, gross national product, and most other indicators. Water carriers consume less energy than other carriers do; water carriers use less than 500 Btu/ton-mile (950 kJ/metric-ton-km).

Continued economic and population growth requires continued expansion of ports and associated facilities. In the 27-year period ending in 1972, individual ports in the United States, Puerto Rico, and Canada invested almost $4 billion in marine terminal facilities. The projected annual rate of investment for these purposes for 1973

to 1977 is $341 million. The development of service facilities for offshore oil terminals may add another $500 million to this investment.

The economic effect of a port on the local area and state in which it is located is tremendous. At the Port of New Orleans, for example, the chain of economic events that starts when cargo lands results in the employment of 37,000 people, $7 million in taxes for the city, $19 million in taxes for the state, $256 million in port-related income, for a total economic effect on Louisiana of $1.8 billion a year. The health of the U.S. economy clearly depends on its ability to keep waterways, ports, and harbors open to navigation.

Harbors and channels are subject to natural deposits of material that cause them to shoal and lose depth. To maintain navigation, the Corps of Engineers either has to limit vessel draft or remove the material. Annually, the volume of material removed from U.S. waterways is approximately 300 million yd^3 (228 million m^3). We could give Delaware a new 1-yd-deep (0.9-m-deep) surface in 20 years.

Operation and maintenance costs for navigation in fiscal year 1974 were $270 million. The sum of $155 million (57.5 percent of the costs) was spent for maintenance dredging on federal project channels.

Disposal Locations

Obviously, the material that the Corps of Engineers removes to maintain navigation has to be put somewhere. There are 4 locations where it can be placed:

1. Off channel,
2. Ocean or open water,
3. Diked areas, or
4. Upland.

Off-channel disposal is an inexpensive method that has been used for many years. Materials dredged from the channel are redeposited in open water or on islands adjacent to the channel.

Ocean or open-water disposal of dredged material also has been used for many years. Material contained in hopper dredges is transported to an open-water area and discharged. Approximately 250 million yd^3 (190 million m^3) of dredged material is deposited annually in open water, which represents 70 percent of the annual dredge product.

There are 2 types of diked disposal: (a) diked areas on shore that prevent runoff into the water or (b) diked areas built adjacent to the shore or in the water. The Corps of Engineers normally builds diked disposal areas by diking adjacent to the shoreline. This contains the dredged material and minimizes turbidity in the discharge area.

Upland disposal is controlled almost completely by the availability of areas on which to place the material. Even a small volume of material requires a relatively large disposal area. For example, a small effort such as the river channel at West Haven, Connecticut, involved only 81,000 yd^3 (61 560 m^3), but it required more than 20 acres (8 hm^2). In high-density population areas, a lot that size within economic reach is difficult to find.

Plant Capability

Although nearly 67 percent of Corps dredging is done under contract with private companies, the Corps maintains its own moderate fleet of specialized hydraulic and mechanical dredges, such as pipeline, hopper, dipper, and bucket dredges. All types of Corps plant are available in the private sector except for the hopper dredge.

The plant used most often in major channel work is the pipeline dredge. This dredge sucks the material from the bottom and pumps it through a pipeline to the disposal site. The length of the discharge line varies widely with the size and capacity of the plant.

Approximately 90 percent of this type of dredging is done by contract.

The sea-going hopper dredge, which was developed by the Corps, is a self-contained ship that pumps dredged material into internal hopper bins through suction lines. The dredge then sails into open sea, or other deep water areas, and discharges its cargo. These dredges also can pump the material from the hopper bins to a shore location if one is available.

The mechanical plants—bucket and dipper dredges—are much like land-based shovels and scoops. They are used in confined areas where larger equipment cannot operate and on special tasks that hydraulic equipment cannot handle.

LEGISLATION

Some of the major laws that affect the maintenance effort subject all Corps dredging to public scrutiny. Three will be discussed in detail:

1. Section 404 of the Federal Water Pollution Control Act of 1972 (FWPCA),
2. Section 103 of the Ocean Dumping Act of 1972, and
3. National Environmental Policy Act of 1969 (NEPA).

NEPA requires an environmental impact statement when a major federal action significantly affects the quality of the human environment. On the date of enactment, the Corps had more than 1,200 navigation maintenance projects alone, many of which are of great scope and environmental complexity. The Corps had to consider impact statements on them all.

The Federal Water Pollution Control Act and the Ocean Dumping Act contain sections pertaining to the disposal of dredged material. The first law applies to inland waters, and the second law applies to ocean waters. Although both designate the Corps as the agency responsible for authorizing such discharges, each act gives the Environmental Protection Agency (EPA) a substantial review responsibility for the disposal of dredged material.

Under Section 404 of FWPCA, the Corps does not issue permits to itself, but rather controls its own disposal operations by applying to itself by regulation the same criteria and procedures that are applied to permit applicants. FWPCA requires public notice and involvement. It requires the Corps and EPA to develop disposal guidelines.

If the Corps feels that the public interest demands navigation maintenance, it may request a waiver from EPA and dispose of the normal criteria. The ultimate decision, however, rests with the Environmental Protection Agency.

The requirements of Section 103 of the Ocean Dumping Act are similar to those contained in Section 404 of FWPCA. If no economically feasible method or site is available for disposal other than one that conflicts with EPA criteria or restrictions, the Corps must request a waiver. The waiver request must identify critical need, impact on commerce if dredging is not accomplished, and explain why alternate sites or methods are not feasible. The ultimate decision in these cases also rests with EPA.

BASIC PROBLEM

The basic problem of maintaining and operating U.S. waterways springs from the interrelationship of 3 factors: placement of dredged material, plant capability, and legal constraints.

Placement of Dredged Material

All of the 300 million yd^3 (228 million m^3) dredged annually has to be placed somewhere, and that somewhere is almost always unacceptable to someone. Off-channel discharge, common to inland waterways, is cost effective. It can result in the extension of wetland

areas, the creation of active biotic communities, and the development of attractive recreational sand spits and beaches. But off-channel discharge increases water turbidity at the discharge point, temporarily disrupts the biotic community, and tends to cause shoaling, which can interfere with lateral drainage and natural flows. The Corps knows about the changes in affected biotic communities, but the state of technology does not permit the quantitative evaluation of these changes with any degree of accuracy.

Ocean and other open-water disposal appears to be an environmentally acceptable method of disposal. It avoids disruption of all the natural values in the coastal zone and wetlands. The disruptive influence it has in the discharge area is so small compared with the vast and dynamic influence of the surrounding waters that the net effect should be minimal. However, some of the dredged materials are polluted, and some marine scientists contend that the long-term cumulative effects of ocean disposal could have serious adverse consequences. Again, simply not enough is known about the effects of open-water disposal to determine the degree of risk involved.

Dredged material could be disposed of in very deep water at great distances from the shore, but the costs of long-haul disposal increase drastically with distance.

Diked disposal areas offer major advantages. They can be used as land fills, and, if the elevation of the final lift is carefully controlled, they can be used as wetland areas. Diked disposal areas usually lie along a shoreline or are superimposed on natural wetlands, and they are usually controversial. In addition, they are expensive. For example, the diked disposal program in the Great Lakes will cost an estimated $240 million over the next 10 years. That would pay for open-water disposal in the Great Lakes for the next 25 years.

Upland disposal is an alternative often suggested by those who find disposal in open water or on wetlands unacceptable. Unfortunately, upland disposal also has disadvantages. In addition to its high costs, all upland disposal results in some change in land configuration, some disruption of the predisposal biotic community, and some opposition from landowners, communities, developers, conservationists, and others.

There is no comfortable solution to the disposal problem.

In the upper Mississippi River, where off-channel disposal is used extensively, the disposal problem is in sharp focus. Navigation has extended both the water surface and the surrounding wetlands, and locks and dams have created a highly attractive biological setting. By direction of the U.S. Congress, the Corps of Engineers has maintained navigability of the upper Mississippi River since 1922. But maintenance dredging in the channel, along the natural accretions, has created a series of small islands that act to reduce water surface, narrow existing wetlands, and, in some cases, cause shoaling. This has caused back-channel drainage problems. As a result, Corps disposal techniques have come under sharp criticism.

In San Francisco Bay, constraints against traditional open-water disposal seriously affect maintenance efforts. This was caused when the state adopted suggested EPA guidelines for pollution. These guidelines, for example, provide that dredged material containing levels of heavy metals exceeding those recommended should not be placed in open water. However, the natural state of San Francisco Bay exceeds EPA guidelines for heavy metals. In other words, what is picked up cannot be put back. Added costs associated with the constraints would result in a drastic increase of the unit dredge costs in Oakland Harbor and Mare Island Straits.

Jacksonville Harbor is a place where upland disposal is essential from an economic viewpoint. The harbor and river areas are too shallow to accept dredged material, and the ocean is too far away. In the harbor area itself, disposal sites are available, but, almost without exception, they have been contested. Many Corps proposals are reasonably sound environmentally. They provide beach nourishment; they also provide recreational areas.

Occasionally the Corps has found itself doing such a good job of material placement that disposal sites become preempted. For example, at Cabin John Creek, on the C&O Canal, the Corps used approximately a third of its disposal capacity in 1969. When it returned to use the site again, the pond that had been created in the upper basin had become a popular fishing place that was abundant with wildlife. It is now a valuable natural resource. So it is environmentally unacceptable for the Corps to use its own approved disposal site.

Plant Capability

Corps plant is old; it has been in operation for an average of 35 years. It is expensive to maintain and operate. Contractor plant is in much the same condition. To make matters even more serious, no new plant is coming on line.

Government appropriations committees have for the past 2 years imposed a moratorium on any additions, modifications, or replacement of Corps dredge plant pending a report from the Corps on proportionate plant requirements in the federal and private sectors. Under the moratorium, the Corps of Engineers cannot improve its plant. In the private sector, because the future is uncertain, most commercial dredging firms are unwilling to make any major investments in new dredging equipment.

As a result, the Corps is hard pressed to maintain its channels. In the spring of 1974, for example, as little as 34 ft (10 m) was in the 40-ft (12-m) entrance channel to the Port of New Orleans. This required ships to sail without a full load and resulted in the detaining of $500 million in world commerce imports and exports. To meet this crisis, Corps and contractor plant had to be shifted from the East Coast and the Gulf Coast areas. Now there is a backlog in ports in those areas.

Costs of operating Corps plant are steadily increasing. Even though annual dollar allocations are going up, funds available for expenditure in terms of constant dollars have experienced a net decrease.

In addition to the inefficiencies of aging plant and the higher costs of labor and materials, the Corps also faces the increased costs associated with more expensive disposal methods while using a plant that is not well adapted to those methods.

Legal Constraints

The Corps of Engineers is now publishing regulations that will bring them into full compliance with the administrative requirements of FWPCA and the Ocean Dumping Act. Nevertheless, the Corps of Engineers still faces problems on 2 matters. First, an overwhelming number of impact statements have to be prepared. Second, greater effort and time are now needed to prepare technical and legally sufficient impact statements that will satisfy other federal agencies and private organizations.

When NEPA became law, the Corps of Engineers had several thousand projects and activities across the nation in a variety of stages between planning and operations that were immediately subject to that law. To date, the Corps has written more than 1,500 environmental impact statements. By the end of this year, impact statements are scheduled to be on file to cover all new ongoing construction work. A substantial backlog on certain dredging projects in operation before NEPA still exists. There are environmental assessments for these projects but either no environmental impact statement or no negative determination has yet been filled. Three hundred and six dredging projects are included in the budgeted effort for fiscal year 1975. Of these, 95 dredging projects may have to proceed without either an environmental impact statement or a negative determination. The situation is extremely serious because of the public notice requirements of the applicable laws. When the Corps of Engineers issues public notice of dredging activities not covered by an environmental impact statement or a negative determination, it invites court action by those opposed to the projects.

Other government agencies sometimes add to the burden. The Corps of Engineers faces an apparently insatiable demand for more detailed analyses of additional alternatives covering both specific and cumulative impacts on any proposed work.

Justification does exist for these requirements, but neither the Corps of Engineers nor anyone else now has the kind of information to satisfy such requirements. And, if Corps environmental impact statements are challenged, comments, particularly those from other federal agencies, weaken the legal position of the Corps.

OVERVIEW

I have discussed the U.S. waterway system and demonstrated that navigation must be maintained. I have defined the disposal placement problem and have identified the techniques available to handle dredged material. I have explained that, with old equipment, the Corps has limited ability to do the work that must be done. And I also have delineated the difficult legal constraints within which the Corps of Engineers must work.

Much is being done to solve the problems and much remains to be done by other agencies.

WHAT IS BEING DONE

On dredged material and its placement, the Corps of Engineers is continuing and intensifying a 2-pronged attack initiated several years ago. First, the Corps is looking for new disposal concepts and techniques that will convert dredged material from a vexing problem into a valuable resource. Corps environmental and recreational staffs are working with engineers to develop beneficial ways to use dredged materials. In some areas, new wetlands, water-based recreational areas, nourished beaches, and wildlife habitats have been created, and highly attractive islands have been extended. As other agencies and groups become convinced that dredged material can serve useful environmental purposes, the Corps will have far greater success. Second, the Corps embarked last year on a 5-year, $30 million research program that is being managed at the Waterways Experiment Station in Vicksburg, Mississippi, by the finest staff of experts the Corps can find in government, education, science, and industry. Out of all this, the Corps should learn where dredged material is harmful and where it is not. The Corps should learn what additional costs are justified in the interests of environmental protection. And it should learn enough to answer the kinds of questions to make environmental impact statements technically sufficient to satisfy other agencies and groups.

Since last year, the Corps of Engineers has had under way a comprehensive study of the national dredge plant requirement and the capacity of both federal and private equipment to meet this requirement. The study will be completed in 1975. A determination of the total plant required in both the federal and private sectors should be found. Hopefully, the moratorium on federal plant improvement then will be lifted. When this study is completed, both government and private industry should be able to modernize the national dredge fleet and improve operations.

The Corps of Engineers over the next decade should see an increase in plant capacity and operating efficiency that will allow far greater flexibility in scheduling dredging operations in the interests of environmental quality.

On the time needed to comply with legal requirements and still maintain navigability the Corps of Engineers has taken the position that NEPA was not intended to halt all ongoing major federal actions that might significantly affect the quality of the human environment. But, in its latest regulation, the Corps of Engineers delineated a phased preparation of environmental statements for maintenance and operation projects including those authorized or constructed before 1970. The Corps has gone further in regulations covering its own dredging by providing that no maintenance dredging will take place after January 1, 1976, unless full compliance with the intent of NEPA in the preparation of environmental impact statements has been met. In the interim, the Corps of Engineers will follow a phased approach to preparing necessary statements.

The Corps of Engineers feels that its approach is reasonable, that it will enhance the environment, and that it will cause minimum environmental degradation. But legal actions challenging either the phased approach or the sufficiency of any proposed environmental impact statement probably will not be forestalled. The Corps hopes to minimize these challenges by placing the more controversial navigational maintenance projects high on the list of priorities for the preparation of environmental impact statements. In addition, the Corps will ask other federal agencies, especially the Bureau of Fish and Wildlife Service, to help set these priorities.

WHAT OTHER AGENCIES CAN DO

No new dredging equipment is coming on line that will permit a change in dredging methods. And there is a legal problem that will be uncomfortable for the next few months. The Corps of Engineers needs the help of other federal agencies, the water resource community, and the general public. Federal agencies must be informed on the importance to the national economy of maintaining navigation. An attitude that no dredging should be permitted is simply wrong. Dredging is necessary to maintain navigation. It must be understood that the Corps has very real plant and cost constraints. The Corps of Engineers recognizes that agencies with responsibility for conservation of natural resources cannot and should not relax the standards that they seek to achieve. Nevertheless, the sentiment that the Corps must do something different, but what it does and how much it costs is the problem of the Corps, is not constructive. The Corps of Engineers also needs the active support of the water resource community to help reach the general public to develop a better understanding of the need for dredging and the steps that are being taken to minimize environmental impacts while definitive answers to questions of concern to everyone are sought. The Corps needs continued cooperation from those with whom it works and reasoned judgment from others as it processes environmental impact statements on maintenance dredging projects. The current laws designed to protect the environment are good laws. Representatives of the Secretary of the Army and the Chief of Engineers have publicly pronounced this belief. But, if the Corps cannot continue to maintain U.S. waterways, then the resulting economic disruptions may generate major pressures for legislative relief. The Corps of Engineers seeks balanced actions that consider all sides and reflect decisions that are of the greatest benefit to the most people.

WATERWAYS AS A SYSTEM FOR OPERATIONS AND PLANNING

DuWayne A. Koch, U.S. Army Corps of Engineers

The characteristics of inland navigation and the purpose of various types of improvements to river navigation are described briefly. A newly implemented performance monitoring system of data collection is explained in some detail. How the operation of waterways influences the design of future improvements is also described.

•THE inland navigation system of the United States consists of approximately 25,000 miles (40 000 km) of navigable channels, 15,000 miles (24 000 km) of which are 9 ft (2.7 m) or more in depth. The Mississippi River and its tributaries constitute the majority of this system (Figure 1). About 1,800 firms use these waters as a means of livelihood, and they transport more than 560 million tons (494 million metric tons) of commerce by shallow draft vessels throughout the United States each year. The average distance shipped by water has increased 20-fold over the past 40 years; the maximum tow size has increased from 5,000 tons (4500 metric tons)/tow to approximately 50,000 tons (45 000 metric tons)/tow.

A tow consists of a towboat and a number of barges held together by a series of tightly winched cables. The typical barge measures approximately 35 by 195 ft (10.7 by 59.4 m), has a draft of 9 ft (2.7 m), and can hold between 1,200 and 1,500 tons (1080 and 1350 metric tons) of commerce. This is equivalent to the amount carried by 25 to 30 average rail boxcars. Tows on the Mississippi River with more than 15 barges normally restrict their operation to below St. Louis because of the dams and channel constraints on the upper Mississippi River and most of its navigable tributaries. However, even a 15-barge tow when fully loaded can carry approximately 20,000 tons (18 000 metric tons) of cargo.

The U.S. Army Corps of Engineers has had the responsibility for the development, maintenance, and operation of U.S. inland waterways since about 1824. The job of caretaker to these waterways is not simple. The task of satisfying the demand for all modes of transportation is straining all sectors—rail, barge, truck, and pipeline. In the absence of expanded and more efficient transportation facilities, the cost of all modes must rise. In the long run, the ability to consider one form of transportation over another may be less relevant than the ability to transport at all.

The Corps of Engineers has several ongoing programs by which they hope to maximize the operating efficiency of the waterways and optimize the design and scheduling of future improvements. Using the navigation lock and dam is one of the most common methods by which a waterway may become navigable. The purpose of these structures is to maintain depth that is adequate for commercial tows to navigate. Usually a depth of 9 ft (2.7 m) is ensured. Excess water is released by means of tainter gates in the dam. To permit the tow to pass from one pool on the river to another, locks are built into the navigation dam. After they are placed in operation, a navigation lock and dam are expected to remain in service for 40 or 50 years.

As the costs to construct these projects increase (some cost more than $200 million), the need to operate present facilities as efficiently as possible becomes even more essential. Also delays at a dam cost a shipper about $100/h/tow; on long transits this can add significantly to the cost of a shipment. This cost usually will be passed on to the final consumer of the product. Better operating efficiency means fewer delays, the ability to postpone costly structural improvements, and, in the long run, reduction in the overall cost of transportation.

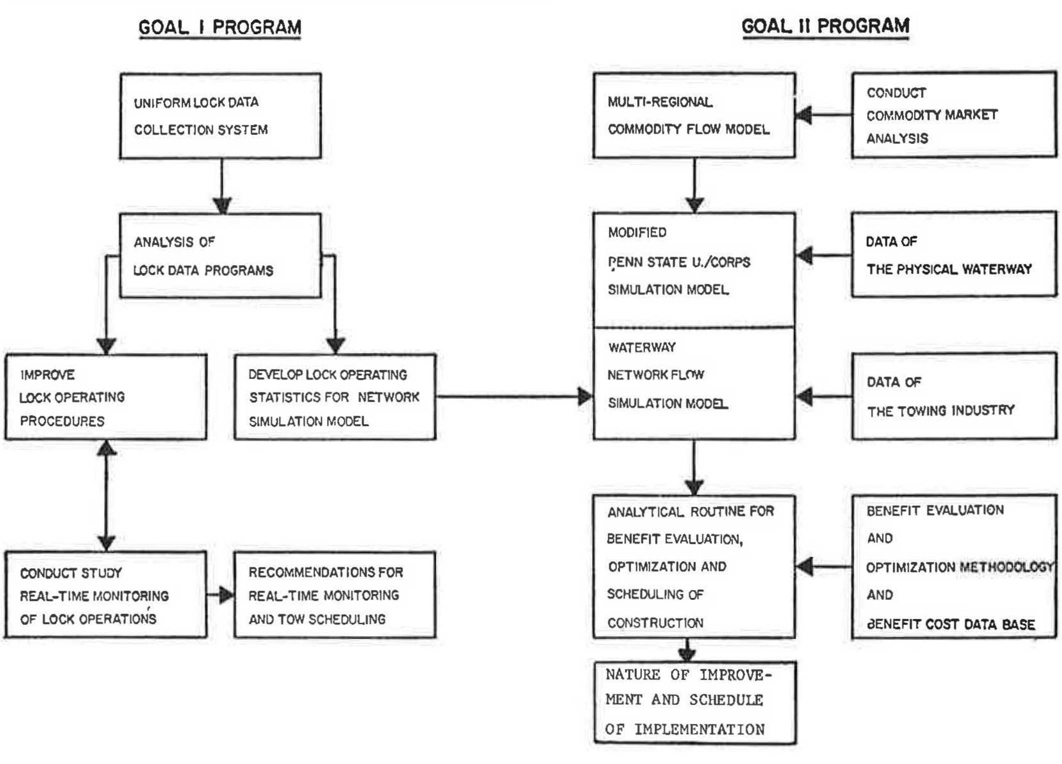
As part of our effort to maximize the operating efficiency of the waterway and optimize the design of future improvements, a new data collection system is being im-

Figure 1. Inland waterways system of the Mississippi River and tributaries.

plemented at each of the 256 locks operated by the Corps of Engineers. Information on the nature of traffic, weather, waterway conditions, delays, and lockage characteristics can for the first time be collected uniformly and compared with operations at other locations. Some of the initial computer programs have already been written and will be in use by the end of April 1975. This performance monitoring system should provide us with much valuable information for the planning of future waterway improvements and more efficient operation of present facilities. For example, monthly statistics by type of commodity on the amount of commerce that passes each lock will be collected. The level of lock use and delays experienced at each lock will be measured. Hourly traffic levels also can be analyzed. The length of time it takes a tow to make a lockage under various operating conditions is of primary interest. An early study will include an analysis of lockage times at various geographic locations to understand why a certain type of lockage at one location takes 30 min and at a different location it takes an hour. Similar studies have been made at single locations, but these studies have never been done nationwide. Where operating improvements can be identified, they will be implemented.

Every user of the inland waterways, including the Corps of Engineers, must operate as responsibly and efficiently as possible. The performance monitoring system will aid in identifying less-than-efficient operations and, hopefully, will lead to their improvement. In addition, the system will indicate which portions of the waterway are most heavily used. A great deal about the nature of future traffic may also be learned. Data from the performance monitoring system will be analyzed and combined with information on various physical characteristics of the waterway. The characteristics of the waterways, bridges, bends, and channels, as well as those of the commodities shipped, can aid in the analysis and projection of future traffic. This, in turn, will influence the design of future navigation improvements and determine when they will be needed.

Figure 2. Overview of inland navigation systems analysis.



For several years now the Corps of Engineers has been active in the development of new methods by which to improve the operating efficiency of the inland waterways of the United States and the planning of future improvements. In addition to the performance monitoring system that I have described briefly, the Corps of Engineers is engaged in a $1 million program that can analyze simultaneously all of the navigation components of the Mississippi River system (Figure 2). This research includes a commodity market analysis of those products that can be moved by barge to better understand the nature of these commodities. The market analysis is an extension of the study done for the Maritime Administration (1) and is intended to supplement a multiregional commodity-flow model of the markets serviced by the inland waterways of the United States. The purpose of this commodity-flow planning tool is to give the Corps of Engineers the ability to evaluate alternate economic plans and estimate the effects of each of the 4 transportation modes (special attention is given to inland navigation). For example, the potential market shifts in supply and demand caused by the development of the coal deposits in the western United States can be evaluated.

A sophisticated computer simulation and optimization model is also being developed to be the central part of the analysis of the inland waterways navigation system. It will take data on commodity flows, characteristics of each transportation mode, and other data on the locks and waterways and evaluate the capability of each mode to meet projected demands. This computer model then will evaluate which alternative waterway improvements are needed and rank them in accordance with their contribution to the navigation system. The Corps of Engineers has been moving toward the capability for total systems analysis for nearly 5 years. Some of this work has been completed successfully; however, in applied research there is always the risk of failure.

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PERSONNEL DEVELOPMENT FOR INLAND WATERWAYS

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The purpose of this paper is to show the necessity of solving the problem of the personnel needs of the inland waterway industry. The only way in which the challenge can be effectively met is optimizing training results through the application of modern techniques, effective administration, unique training aids, and institutional and on-board training.

•HISTORICALLY, turnover has been high for deckhands on riverboats. This has not been the case for those working in the pilothouse. However, to be retained, they have had to learn innumerable techniques. The importance of this training has grown at a rate equaling that of the growth of waterways and the marine transportation industries. A real need exists for a specialized training program geared to provide future qualified personnel for the inland waterway industry.

Safety is a matter of continuing and vital concern to the barge and towing industry. Intensive in-company training and safety programs give crews an opportunity to improve their skills in accident prevention and safety. Traditionally, the inland waterway transportation industry has depended on on-the-job training to fulfill qualified personnel requirements. Skill, experience, and a feel of the river are required to pilot a tow of barges, most of which are longer than the greatest ocean liners, through the inland waters.

The crews of the vessels are the most important part of the advancement of the marine transportation field. Trained and efficient personnel who take professional pride in their jobs and in the industry for which they work are the backbone of the waterway industry. These people have contributed immeasurably to the prosperity of marine business. Continued development of the inland waterway industry largely depends on the competence of its personnel. As navigable waters become congested with a large array of vessels, as cargoes become more hazardous, and as quantities shipped by water increase, the technology of the industry and the skill of the personnel must advance.

Many changes have taken place during the past 160 years of river traffic. Most of them occurred during the modern age of towboating (1925 to the present).

In the beginning of the industry, large crews (40 to 50 people) were needed to run the tows because almost everything was done by hand. Crew size dropped after the Civil War, but the drop was not appreciable because many people still were needed to keep the barges in tow and to load and unload the bulky cargoes. Modern technology, with its bigger and better power units, steel barges, searchlights, steel cables, rudder indicators, and diesel power, started to advance in 1925. At this time crew size began to shrink. The veterans of today were the youths that manned the new and complicated equipment, but they are now retiring and they are leaving the industry with large gaps in personnel.

On-the-job training, despite its disadvantages, has been a most effective training device from the earliest days of marine transportation, and it will continue to play a vital role in the education of waterway personnel. For example, on a steamboat, the pilot, not the captain or mate, navigated the boat. The pilot's knowledge was gained through actual practice and close observation of the river. The pilot's knowledge of the innumerable details of water depth, locations and names of beacons, bars, islands, chutes (narrow channels), projections, landmarks, the shape of every bend, the precise point for making crossings, and many other facts took years to accumulate. Pilots first were trained as steersmen, then they advanced to apprentice, and finally they became pilots.

Apprentice engineers, or strikers, began their training by cleaning and oiling the machinery and tending the boiler. Later they progressed to adjusting and operating the machinery under supervision. Then they became reasonably qualified engineers.

The first licensing system came into effect with the Steamboat Inspection Act of 1852, and qualified pilots and engineers were, after appropriate examination and experience, granted licenses attesting to their proficiency. Pilots applying for a federal pilot's license had to draw from memory every stretch of river for which they desired licensing. Faced with newly imposed standards aimed at increasing engine room safety, the engineers were examined on procedures and methods of operation.

These lengthy apprentice programs and the licensing system provided a satisfactory number of qualified personnel for many years, but the dramatic growth of the waterway industry requires a new and more efficient approach to crew training. Crew members must be more skilled so that they can use the increasingly sophisticated equipment on towboats and safely operate the constantly growing tows. Even if apprentice programs could provide prospective crew members with the necessary knowledge, they could not do it at a rate sufficient to keep up with growing demands.

The Towboat Operator's Licensing Act of 1973 initiated compulsory licensing of operators of uninspected towing vessels. This act provides for an operator's license for 1 or more geographical areas. To be eligible for this license, a crew member must have 1 of the following: (a) at least 3 years of service, including at least 2 years on deck of any vessel 26 ft (7.8 m) or longer, (b) 3 years of service on towing vessels, including at least 1 year of service on deck, or (c) 18 months service on deck on a towing vessel for a license that is endorsed for a limited local area designated by an officer in charge of a U. S. Coast Guard Marine Inspection Office. That is, a deckhand on the inland waterways who serves 30 days on and 30 days off with no break in service will need 4 years to qualify. The U. S. Coast Guard credits 1.5 days for every 1 day on board, because all crew members work 12 h/day. After accumulating the required time on the river, the prospective operator must then pass a physical examination and a very stringent written examination on the many facets of towboat operation. All too often, experienced people encounter severe difficulties in taking the written exam because their training has not included the fine points of information that are necessary to pass.

There are more than 4,200 towboats, 1,800 dry-cargo barges, and 3,420 tank barges in the waterway system. The towboat industry will require more than 600 new operators per year because of retirements, job changes, sickness, deaths, injuries, and promotions. The greatest source of replacements is the vast number of deckhands who generally make up half of the crew. The assumption that a critical pilothouse personnel shortage exists is based on the following:

1. Many deckhands serve on the river intermittently;
2. Numerous deckhands seek shore positions after serving 1 to 2 years on the river; and
3. Deckhands qualified to be pilots must possess the essential aptitude and pass an eye examination and a U. S. Coast Guard written examination.

The attrition rate of deckhands is greater than the number of licensed pilots required for the inland waterway system. The towing companies cannot afford to wait for people to learn by experience alone. The water transportation industry needs people who have learned on the job and have experienced the new and updated methods of operations in classroom settings. How does the industry plan to solve the problem? In 1969, Bill Alexander, U. S. Representative from Arkansas, discussed with prominent industry leaders the need for establishing a training institution that could eventually alleviate this personnel shortage. This discussion led to the founding of the National River Academy of the United States of America (NRA), which trains people for all positions in the inland waterway industry. The NRA is supported by the waterway industry. It serves through 3 types of membership. Owners or operators of waterborne vessels may elect to become regular members; firms, corporations, or persons connected with the industry frequently become associated members; and individuals or nonprofit organizations interested in the industry may join as affiliate members.

The objectives of NRA are

1. To promote the study of the U.S. inland waterway system, its uses, and resources,
2. To attract young people to careers in inland waterway transportation,
3. To provide education and training for all categories of personnel in the industry,
4. To maintain a library and research center, and
5. To assist persons who have completed training at NRA in finding employment.

At present, NRA coordinates programs with industry executives on the safety of personnel and transfer of liquid cargoes and liquefied flammable gases, chemicals, and dangerous cargoes. NRA, in addition to providing a much needed professional education program, can become the focal point of technological advancement for the inland waterway industry. The development of a total environmental simulator is a substantial advancement in providing a labor force that will be prepared to cope with the advancing automation and industrial demand within the rapidly expanding transportation network.

Noble Gordon, Chairman of NRA's Simulator Advisory Committee, has worked diligently toward the development and acquisition of a river pilot simulator, a device that is similar to those now used by the airlines. A simulation of circumstances and events that a pilot actually will experience will be part of the program. The trainee will stand in a typical pilothouse and will see areas similar to test areas projected on screens outside the windows of the pilothouse. The scene will change in response to pilot-controlled changes and external computer-generated changes. The simulator will realistically simulate weather conditions, emergencies, and radio and radar communications. The test areas to be used for training purposes include hazardous locales such as the Berwick Bay bridges, St. Louis harbor, New Orleans harbor, Vicksburg Bridge, Beardstown Bridge, the new bridge at Booth's Point, and Gallipolis Lock.

The most important benefit of a simulator is its ability to take a trainee through a hazardous area over and over again until the person masters it or demonstrates the inability to do so. The ability of the simulator to take a trainee from St. Louis to New Orleans in a matter of hours rather than days also is valuable.

Half of the cadet-pilot program is institutional training and half is on-board experience. Cadets experience training and practical application at the deckhand, wiper-oiler, mate-tankerman, and apprentice-pilot levels. After graduation, the licensed cadet is qualified to serve as a steersman. The cadet will be knowledgeable on the use and procedures of radio telephones; use, limitation, interpretation, care, and adjustment of radar; western and inland rules of the road; the duties and responsibilities expected of deckhands and mates; and the engine room's main and auxiliary units and their cycles, operation procedures, repairs, and emergency procedures. The graduate also will be certified for all necessary grades of liquids and chemicals.

In conclusion, the cadet program supplemented with upgrading courses and use of the simulator makes the occupational outlook for cadet-pilots unlimited.

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