US Army Corps
of Engineers
Rock Island District

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UMR-IWW System Navigation Study

Waterway Traffic Forecasts for the Upper Mississippi River Basin

Volume I: Summary
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LIST OF EXHIBITS

[Webmaster's Note: Exhibits not hotlinked or provided in this HTML version of the document are graphs. At some point, images may be provided for those exhibits.]

I. INTRODUCTION

The U.S. Army Corps of Engineers is currently conducting the Upper Mississippi River-Illinois Waterway (UMR-IWW) Navigation Study to investigate the feasibility of navigation improvements on these river systems for the planning period of years 2000 to 2050. This six year study is being jointly conducted by three Corps Districts: St. Louis, Rock Island, and St. Paul, with oversight by North Central and Lower Mississippi Valley Divisions. The study also involves two research labs (Construction Engineering, CERL, and Waterways Experiment Station, WES), as well as other Federal agencies and five Upper Midwest states (Minnesota, Wisconsin, Iowa, Illinois, and Missouri) There are five work groups that together comprise the study team: Study Management, Engineering, Economic, Environmental, and Public Involvement.

Under the study, the Rock Island, St. Louis, and St. Paul districts of the U.S. Army Corps of Engineers are investigating the feasibility of navigation improvements to eight locks and 348 miles of the Illinois Waterway and 29 locks and 854 miles of the Upper Mississippi River. The study will determine location and appropriate sequencing of any needed navigation improvements on the two rivers and prioritize these capital investments for the first half of the next century. This study will also include a system-wide environmental assessment leading to the completion of a system Environmental Impact Statement (EIS).

Commercial navigation on the Upper Mississippi River-Illinois Waterway (UMR-IWW) System plays a vital role in our national economy. The importance of the UMR-IWW as a shipping artery is reflected in the continual increase in tonnage shipped on the system, from 27 million tons in 1960 to 91 million tons in 1990. At present there are more than two hundred terminals on the Upper Mississippi River and Illinois Waterway that ship and receive numerous commodities, including grain, chemicals, petroleum products, coal, cement, non-metallic minerals, metallic and paper products, and scrap. With the present high rate of lock utilization, increased traffic on the current navigation system is expected to create excessive congestion and delays, safety problems, and possible adverse environmental affects.

Lockage delays on the waterways occur because of the increased amount of tonnage being shipped. Built in the 1930s, the system was originally designed to handle tow sizes (tow boat plus barges) of up to 600-feet long (except at Locks 19, 26, and 27 on the Mississippi River). Present-day tows routinely push fifteen barges with a length up to 1,200 feet long. These large tows require double lockages -- a costly and time-consuming process.

The 1988 Inland Waterway Review identified five locks on the Mississippi River (locks 20, 21,22, 24 and 25) and three of the eight locks on the Illinois Waterway (La Grange, Peoria, and Marseilles locks) as being among the 17 locks in the country with the highest average delays, total delays, highest total barge transit processing and lockage times, and highest rate of lock utilization.

In 1992, tows at Locks 20-25 were delayed a total of 87,000 hours at a cost of $35 million while waiting to be locked through. Lock 22 was the most congested lock in the study area. The average delay for the 3,306 tows that used the lock in 1992 was seven hours. Assuming a cost of $400 per hour (industry figures), this delay cost $2,800 per tow processed at Lock 22. In addition, 80 percent of these tows had to double lock; a process that added an additional hour to each lockage. During the period 1988-1992, river traffic grew an average of 4 percent per year. If this rate continues, delays at Lock 22 will increase to about 56 hours per tow by the year 2000. All other locks on the waterways will also experience increased delays as a result of this traffic growth.

To deal with these issues, the Corps is considering small-scale and large-scale enhancements to the system over a fifty-year period (2000-2050). While the large-scale enhancement alternatives include extension of existing locks and construction of new locks on existing dams, the study is not considering any new dams along these waterways. In addition, there is no predetermined large-scale capacity expansion planned for these waterways.

It is within this context that JFA has conducted the research described herein. Our role was to develop waterway traffic forecasts to 2050 for the Upper Mississippi River System. These forecasts will be used in a benefit-cost assessment the Corps is undertaking. Separate forecasts were developed for various commodity groups for the two main segments of the system: the Mississippi River from the Twin Cities to the mouth of the Missouri River and the Illinois Waterway. A forecast for traffic between the mouth of the Missouri and the mouth of the Ohio was not made because there are no constraints to the navigation system within this reach of the river. The forecasts are presented in eight separate reports identified below:

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Volume II       Grain and Soybeans
Volume III      Agricultural Chemicals
Volume IV       Prepared Animal Feeds
Volume V        Coal
Volume VI       Industrial Chemicals
Volume VII      Petroleum Products
Volume VIII     Construction Materials
Volume IX       Steel and Steel Sector Raw Materials
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Each report analyzes production, consumption and modal split trends relevant to the traffic levels on the river system and develops waterway traffic forecasts based upon the analyses.

Assistance in developing the reports was provided by the Criton Corporation and Sparks Companies, Inc. (SCI). Criton was responsible for producing the reports for coal, agricultural chemicals, construction materials, and steel and steel sector raw materials. SCI provided the production and consumption forecasts that were used to develop the waterway traffic projections for grain and soybeans.

The purpose of this report is to summarize the eight separate commodity reports. Section II provides historical waterway traffic data on the principal commodity groups back to 1972. The commodity groups listed above now account for 93 percent of the traffic on the Upper Mississippi and 96 percent on the Illinois Waterway. Section III presents economic profiles for each state in the Study Area (Illinois, Iowa, Minnesota, Missouri, Wisconsin) and reviews production and consumption trends for each of the product groups. Section IV describes the modal split assumptions under which the forecasts are made. Section V reviews the waterway traffic forecasting methodologies and presents the total traffic forecasts.

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II. REVIEW OF HISTORICAL WATER TRAFFIC BY RIVER SEGMENT AND COMMODITY

Average growth rates for the 20-year historical period (1972-92) and for the recent decade (1982- 92), for the commodity groups on the Upper Mississippi (Twin Cities to the mouth of the Missouri) and the Illinois Waterway are presented in Exhibit 1.

Exhibit 1 -- Average Annual Growth Rates Waterway Traffic

	Upper Mississippi		**Illinois Waterway**	
	1972-92	**1982-92**	**1972-92**	**1982-92**
Corn	3.55	1.17	1.09	-2.20
Soybeans	3.37	-0.13	2.45	-0.5
Wheat	0.09	-6.66	1.61	-4.23
Agricultural Chemicals	4.86	6.40	2.75	5.04
Prepared Animal Feeds	6.49	7.75	41.35	7.79
Coal and Coke	0.73	2.12	-0.10	4.15
Industrial Chemicals	0.66	3.42	1.74	5.71
Petroleum Products	-1.09	-0.38	-1.09	-0.41
Construction Materials	0.10	4.85	-1.79	-1.97
Iron and Steel	2.40	5.28	1.88	5.09
Total	2.04	1.52	0.61	0.64
Source: Derived from data in Exhibits 2 and 5.				

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The commodity traffic is subject to considerable variation over time for individual commodity groups but the aggregate tonnage is fairly stable and displays growth trends. For the Upper Mississippi River the overall aggregate trend over the past 20 years had an average annual growth rate at around 2 percent but was significantly lower (1.5 percent annual growth) over the past decade. This aggregate growth trend is lower on the Illinois Waterway but is fairly stable over the past 20 years. Grain, soybeans, and the related fertilizer input generally account for between 45-55 percent of the total traffic on the Upper Mississippi, and animal feed has added another 5 percent in recent years. The other traffic has displayed remarkable stability over time with the exception of petroleum products which have declined (been cut by one-half) in the last few years.

The traffic on the Illinois Waterway is about one-half that of the Upper Mississippi. Grain, soybeans, animal feed and fertilizer account for a steady 40-45 percent of the traffic. The coal and coke group and iron and steel (and related ores) both account for higher percentages of total traffic than on the Upper Mississippi. The other commodity groups account for a stable percentage of total traffic over time. The growth rate in the Illinois Waterway traffic has been less than one-half that of the Upper Mississippi River over the past 10 years.

Both of the waterways assure steady growth trends into the distant future and support regular improvement in the waterway transportation system into the distant future. The detail of this traffic since 1972 is detailed in Exhibits 2 - 7.

Exhibit 2 -- Mississippi River Waterway Traffic By Commodity Twin Cities To Mouth of Missouri River - Thousands of Tons

Exhibit 3 -- Mississippi River Waterway Traffic By Commodity Twin Cities To Mouth of Missouri River - Percent of Total Traffic

Exhibit 4 -- Mississippi River Waterway Traffic By Commodity Twin Cities To Mouth Of Missouri River - Annual Growth Rate

Exhibit 5 -- Illinois Waterway Traffic By Commodity - Thousands of Tons

Exhibit 6 -- Illinois Waterway Traffic By Commodity - Percent of Total Traffic

Exhibit 7 -- Illinois Waterway Traffic by Commodity - Annual Growth Rate

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III. REVIEW OF PRODUCTION AND CONSUMPTION OF WATERBORNE COMMODITIES

This section reviews the geographic production and consumption trends which affect the levels of traffic that move on the Upper Mississippi River System. The first part provides broad industry profiles and population data for each state in the Study Area. These measures provide rough gages of the Study Area’s economic activity, which drives the movement of goods on the waterways. The second part presents a geographic overview of the production and consumption trends by commodity and is not limited to the Study Area. As such, it includes changes in supply and demand outside of the Study Area but which impact the volume of traffic on the river system.

A. STATE/REGIONAL PROFILES

The inland waterway system has contributed to U.S. economic development and is a valuable natural resource. This national resource has shaped the comparative advantages of the U.S. in supplying raw materials and intermediate manufactured goods to other nations in exchange for more labor intensive final products. The Mississippi River and the Ohio River systems and their tributaries define the major part of this economical transportation system.

Economic profiles for the Upper Mississippi River Basin (UMRB) and the Ohio River Basin (ORB) are depicted in Exhibit 8. This tabulation summarizes the Gross State Product (GSP) by industry in each area. GSP measures the value added produced by each industry group in the area. In the U.S. these measures sum to the Gross Domestic Product (GDP). Thus, GSP is a good measure of economic activity by industry that helps determine the importance of an industry both to a geographic area and to the total U.S. economy.

In Exhibit 8, it can be seen that the UMRB represented 11.5% of the total U.S. GSP in 1992. Similarly, the ORB represents 15.5% of total U.S. economic output. Industries which are especially prone to use water transport (the basic bulky raw material, or semi-manufactured products), are delineated separately in the tabulation. Each industry with a higher percentage of U.S. value added than the regional total share (above 11.5% for UMRB and 15.5% for the ORB) indicate the tendency of these industries to concentrate in the region. Thus, production of grain, fabricated metal products, and paper and allied products accounted for concentration in the UMRB region. The concentration of heavy industries in the ORB region included stone, clay and glass; primary metals; fabricated metals; paper and allied products and chemicals. The percentages of U.S. production accounted for since 1980 are very stable for each area with only a slight decline since 1980.

Exhibit 8 -- Gross State Product By Region and Industry

The concentration of grain production in the UMRB is due primarily to the soil and climatic conditions of the area and only partly due to the access to the inland river system. However, concentrations in Illinois in semi-manufacturing of bulk materials, and less so in Missouri, is favored by access to the river system. The heavy concentration in raw materials and bulk manufacturing in the ORB is favored to a large extent by access to the river system. The development based on natural resources in this area has the transportation advantage over areas lacking ready access to less expensive transportation in other resource-endowed areas in the U.S., Canada and other continents in the world.

B. COMMODITY REVIEW

Salient information on each commodity group is summarized in the following sections:

1. Grain and Soybeans

The Study Area is very fertile for grain crops and is the leading supplier in the U.S. for both corn and soybeans, accounting for about 50 percent of U.S. production for each. The U.S. is a leading supplier of both corn and soybeans, accounting for around 40 percent of world production for corn and over 50 percent of soybean production. The yield per acre in the U.S. for corn is about double the world average, and Iowa and Illinois are above average for the total U.S. Yields per acre for soybeans in the U.S. are significantly above world average and Iowa and Illinois are above the total U.S. average. The ranking of the U.S. with other countries in world production of corn and soybeans in recent years, and projected to 2000, is shown in Exhibit 9.

The efficiency in U.S. grain production has led to the "Leontief Paradox" which points out that the U.S. has a comparative advantage in worldwide grain production in spite of its high ranking as an industrial economy. The rapid mechanization of agriculture and scientific advances in the U.S. in post World War II has led to strong gains in productivity and the outstanding U.S. worldwide role in grain trade. The prognosis for this trade opportunity over the next half century is supported with confidence.

Since almost all of the grain traffic on the Upper Mississippi River originates in the Study Area and moves to Louisiana ports for export, this export trade supports most of the Upper Mississippi River grain traffic.

Exhibit 9 -- World Production: Corn and Soybeans 1987-93; Projected 2000

The location of the Study Area with close access to the Upper Mississippi for export trade provides confidence in the forecasts for barge traffic. Grain, prepared animal feed, and agricultural chemicals are safely projected to increase their share of traffic to about two-thirds of total traffic over the next 50 years.

2. Agricultural Chemicals

The movement of agricultural chemicals on the Upper Mississippi River system is directly correlated with the agricultural production in the Study Area. Almost all of the traffic moves into the system from below St. Louis. Two broad factors influence the region's demand for agricultural chemicals: the amount of planted acreage and fertilizer application rates per acre. In regard to the amount of planted acreage, we assumed that it would grow at the same rate that SCI projected for harvested acreage. According to SCI's forecasts, harvested acreage for the Study Area should increase by an average annual rate of 0.19% (See Appendix B in Volume II). The growth rate is small due to the fact that current acreage levels are relatively high (because of relaxations in the ARP) and there is an upper limit on the amount of land that can be used for farming. Although the growth rate is very small, by 2025 total acreage should exceed the high acreage levels seen in the early 80s before the government set-aside programs were implemented. By 2050, acreage levels are expected to approach the upper bound on the amount of land that can be used for farming. SCI's forecast that acreage will slightly grow rather than fall is based on two assumptions: that world demand for grain will continue to be strong and that the passage of the recent Farm Bill will allow U.S. farmers to remain competitive in world grain markets.

Annual fertilizer application rates depend upon a number of factors including soil quality and how the fertilizer is applied. Fertilizer complements other nutrients in the soil. Given a certain mix and quantity of those nutrients, farmers attempt to use the optimum amount of fertilizer needed to maximize their harvest. Not using enough fertilizer can result in low yields; using too much fertilizer can result in low yields as well and can also cost more than the marginal product that results. Fertilizer application rates are also affected by how often fertilizer has to be applied and whether it has to be applied uniformly over an entire field or can be applied selectively across different areas of a field. Over the last ten years, farmers have become more efficient in their use of fertilizer, using it less frequently and applying it more selectively.

The main conclusion that can be drawn from these two broad factors is that fertilizer demand will not increase at the same rate as grain production. In other words, more grain production does not necessarily imply a need for more fertilizer. Rather, gains in grain production will likely be met through technological innovations (e.g., breeding selection). Given a certain level of nutrients in the soil, such innovations will increase yields per plant and will allow for larger plant populations per acre without sacrificing yields.

3. Prepared Animal Feeds

Prepared animal feedstock are manufactured at over 2,000 establishments in the country located in most states. Most of this feed is based on grain and oil seeds supplemented by other nutrient inputs. Most of the feed goes to hogs, cattle, and poultry. The widespread location of the manufacturers and the consumption locations offers little opportunity for domestic transportation on the waterways. Similar to unprocessed grain shipments on the waterway, most of the traffic on the Upper Mississippi originates in the Study Area and is exported through Louisiana ports.

Prepared animal feed exports consist primarily of two commodities: soybean meal and corn gluten feed. Soybean meal production levels are determined by domestic and foreign demand for high protein feedstock. High protein animal feedstock are utilized predominantly by the poultry and hog sectors. The US exports both raw soybeans and soybean meal to help foreign demand sources meet their high protein requirements. Many countries prefer to import raw soybeans and then process the beans themselves; however, they resort to importing meal when the profit margins on crushing the beans become too low. As a result, one would suspect an inverse relationship between U.S. raw soybean exports and US meal production levels. Such a relationship is not evident in a two dimensional graph since US and foreign crops sizes have relatively larger impacts on US soybean export levels. Illinois, Iowa, Minnesota and Missouri produce about 50 percent of the U.S. crushed soybeans for meal.

Forecasts of U.S. soybean meal production are based upon SCI's long term projections of the U.S. soybean crush (presented in Appendix A in Volume II). By 2050, production is expected to approach 55 million tons, over 75% higher than the production levels seen in the early 90s. U.S. soybean meal consumption forecasts are based on anticipated needs for high protein animal feed by the livestock and poultry sectors (which is a function of per capita meat consumption and U.S. meat exports). The forecasts indicate that U.S. soybean meal consumption will increase by just over a 60% between the early 90s and 2050. Since soybean meal is not stored in inventory, the difference between the production and consumption forecasts is assumed to enter the export market. The result of these calculations predict that U.S. soybean meal exports will increase to just over 14 million tons in 2050, over a 130% increase from the volumes observed in the early 90s.

To ensure cost-effective growth and maturity of their livestock and poultry, farmers frequently attempt to find the optimal amounts of starch and protein that their animals need. As starches, feed corn and corn gluten feed can to some extent be substituted with each other. However, US farmers generally don't like to use corn gluten feed and have almost exclusively opted to use feed corn; they don't like it because it requires special storage and handling procedures.

In Europe, corn gluten feed is used in compound feedstock. Feed rationing practiced in Europe is more strict than it is in the US and European farmers utilize relatively more compound feed compared to their US counterparts. In addition, corn price supports in Europe have made corn gluten feed an attractive alternative to feed corn in Europe. For these, reasons, almost all of the corn gluten feed produced in the US has historically been exported to Europe. Between 1990 and 1994, Europe received 99.6 percent of all US corn gluten feed exports. 98.6 percent of those exports move through Louisiana ports. This situation is likely to change in the foreseeable future as Europe begins to reduce its price supports on corn in response to GATT. European demand for corn is likely to fall, lowering its price in the U.S. and making it relatively more attractive to U.S. farmers. Since gluten feed is a byproduct of the corn wet milling process, consumer demand for corn sweeteners, starches, and ethanol determine how much gluten feed will be produced. Exactly how this supply is going to be consumed in the U.S. is not certain. Some analysts are predicting that it will be used primarily by livestock and poultry operations that are located close to wet milling facilities; as a result, it may not continue to be a large source of river traffic.

4. Coal

The source of most of the coal consumed in the Study Area comes from outside the area although Illinois provides a significant share of the supply. Most of the coal traveling on the waterway segments in the area originates from the Illinois Basin (southern Illinois, southwestern Indiana and western Kentucky), the Powder River Basin and Central Appalachia. Since supply/user O-D patterns involve some matching of low-sulfur content with user needs (requiring less scrubbing in the high use of coal for power plants) much of the coal supply has limited direct access to the river system and all rail or rail/water intermodal is involved in the transport. The Study Area's use of coal supplied by river transport is largely for electric utility plants plus limited use in cement, steel, food and corn processing and other industrial uses. Most of this consumption takes place in Illinois with smaller uses in Iowa and Missouri. Riverborne receipts for use in the Study Area amount to only about 10 percent of the total receipts which are mostly supplied by direct rail. The large amount of "through" traffic on the Upper Mississippi River segment is accounted for by traffic originating on the Ohio River that traverses the segment, between Cairo and St. Louis, on its way to the Illinois Waterway.

5. Industrial Chemicals

The Study Area produces about 3 percent of the U.S. production of industrial chemicals with the major production in Illinois and Missouri. The diverse nature of the industrial chemicals transported on the Upper Mississippi River precluded a detailed investigation of the supply and demand aspects for each of the fifteen chemical commodity groups. The commodities produced by the chemicals industry are used in a variety of industrial production stages and in many different industries. It is difficult, therefore, to both characterize the determinants of growth in the industry and specifically isolate specific sectors of the economy that are critical to its vitality. In addition, individual industrial chemicals commodity groups such as "metallic salts" and "other hydrocarbons" are rubrics for over thirty different types of chemicals products making it even more difficult to characterize the supply and demand relationships for these groups. Two industrial chemicals product groups that each accounted for more than 20 percent of the industry chemicals traffic on the Upper Mississippi River, and are characterized by more easily identifiable supply and demand relationships, included alcohol and sodium hydroxide. Alcohols and sodium hydroxide accounted for over 42 percent of the industrial chemicals transported on the Upper Mississippi River and the Illinois Waterway in 1992.

Ethanol is produced from corn and accounts for most the alcohol production transported on the Upper Mississippi River and the Illinois Waterway. Ethanol is principally consumed as fuel for transportation mixed in low proportion with gasoline and subsidized by the Federal government. This ethanol is consumed primarily by the corn producing states in the Study Area and other major corn producers in the Midwest. The future demand for ethanol is uncertain since it competes with MTBE as a blend with gasoline to oxygenate fuels for vehicle use as mandated by clean air standards. This competition depends on subsidization of widespread ethanol use which is more expensive to produce and distribute to markets outside the Midwest.

Sodium hydroxide (caustic soda) is mostly produced outside the Study Area where salt is extracted economically. Louisiana is a major producer and contributes substantially to the barge traffic entering the Study Area. Principal users are petroleum refiners, industrial organic chemicals producers, and pulp, paper and paperboard producers. The consumers are largely in Illinois and Missouri, with smaller consumption in Wisconsin associated with pulp and paper production.

6. Petroleum Products

The Study Area has about nine percent of the U.S. capacity for production of petroleum products, seven percent of which is accounted for by Illinois (Illinois accounted for around 5.2 percent of total value added by refining output in the U.S. in 1992). The Study Area consumed about 9.4 percent of petroleum products in 1992, of which Illinois accounted for about 3.4 percent. The Study Area’s share of U.S. consumption has declined by 21% since 1970. About two-thirds of this decline is explained by a decline in the share of U.S. population in the Study Area -- from 13.2 to 11.4 percent from 1970 to 1992. The remaining decline is explained by a shift to electricity, thus reflecting a substitution of coal for petroleum products in residential, commercial and industrial uses (representing about 35 percent of total consumption in the U.S. whereas transportation accounts for 65 percent of the uses in the U.S.). The substitution of ethanol in gasoline would also have some effect on the reduced share of U.S. petroleum product consumption.

7. Construction Materials

In recent years, the five states in the Upper Mississippi Basin have consumed over ten million tons of cement annually, with the most recent peak occurring in 1994 when cement receipts reached approximately 12 million tons. Within the study region, Illinois represents the largest market, with annual consumption averaging 3.6 million tons over the 1990 to 1995 period. Missouri ranks second among consuming states in the study region with consumption averaging above 2.1 million tons over the

1990-1995 period.

Presently, only three states in the study region have indigenous cement production capacity: Missouri, Iowa, and Illinois. Both Minnesota and Wisconsin must import cement either from other states or from offshore sources to meet their cement demands. Of the three states which have indigenous cement production, Missouri has the largest production base, with Illinois and Iowa shipping roughly equivalent volumes. Given the relatively high cement production levels in Missouri and the relatively low consumption levels in Iowa, each of these states is a net exporter of cement. Illinois, on the other hand, is a net importer of cement.

Cement, unlike most dry bulk commodities, generally requires specialized handling equipment because it is an extremely fine powder. As a result, the cement industry has developed customized equipment to transport and handle its product. This equipment includes dedicated cement barges equipped with pneumatic unloading equipment as well as specifically equipped cement distribution terminals. To a large extent current cement distribution patterns are governed by the company specific cement distribution networks that have developed. For example, each of the major river-served cement production facilities has a network of river served cement terminals to which it ships cement. The upper Mississippi River and the Illinois Waterway are home to 14 separate cement distribution terminals which are concentrated in major metropolitan areas within the region.

Minnesota and Wisconsin share several cement market related characteristics which make these states unique from the other states in the Upper Mississippi study region. Most notable is that neither state has indigenous cement production. As a result, all cement consumed in these states is shipped from outside sources. Additionally, in both Minnesota and Wisconsin, cement is shipped into the states by three major modes: barge via the upper Mississippi, lake vessel, and overland rail and truck routes from nearby cement producing states.

The Missouri/Iowa market segment is distinct from the Minnesota/Wisconsin market segment in that both Missouri and Iowa have indigenous cement production and both states are net exporters of cement. Producers in these states supply not only their own local markets, but also ship cement by barge to the Chicago market, as well as the St. Louis market.

Illinois represents essentially two distinct cement markets: the Chicago metropolitan area and the remainder of the state. The Chicago area has no local cement production facilities and as a result must import 100 percent of its cement needs from outside producers. The remainder of the state, meanwhile, is much like Iowa and Missouri, because it is a net exporter of cement. Like Minnesota and Wisconsin, Illinois also receives a considerable share of its cement needs by lake vessel. It also receives cement by barge via the Illinois Waterway. Both lake and barge shipments are consumed almost exclusively in the Chicago metropolitan area.

Sand, gravel, and crushed stone are found in relative abundance throughout the upper Mississippi study region. Riverborne crushed stone traffic is extremely small when compared with riverborne sand and gravel traffic. Sales of this material has posted impressive increases in the region, rising from 75 to 85 million tons per year during the early 1980s to over 130 million tons in 1994.

Within the five state study region, Illinois represents the largest market, accounting for approximately 31 percent of 1994 sand and gravel sales in the five-state study area. Minnesota and Wisconsin also have large markets, with each accounting for 24 percent of 1994 sales in the five-state region.

Since sand and gravel is a very low value commodity and found in abundant quantities through the region, practically all of the sand and gravel sold in each of the five states was produced in those states.

While total sand and gravel production and sales in the upper Mississippi study region is quite large, the proportion that moves by barge is extremely small. While state or region-level data regarding the modal distribution of sand and gravel traffic is not available, the U.S. Bureau of Mines estimates that 73 percent of all U.S. sand and gravel production moves by truck, four percent moves by water and 1.1 percent moves by rail. The remaining 21.6 percent is used on- site for other industrial or construction purposes.

8. Steel and Steel Sector Raw Materials

Areas served by the Upper Mississippi Basin waterways are home to the single highest concentration of raw steel production capacity in the United States. At the present time, this region has nearly 28 million tons of annual raw steel production capacity, representing approximately 25 percent of total U.S. raw steel production capacity. The vast majority of this steel production capacity is located in the Chicago metropolitan area, which includes sections of northern Indiana which border Lake Michigan. Steel production capacity in the Chicago metropolitan area alone, which is in close proximity to the Illinois Waterway, totals over 20 million tons. Approximately three million additional tons of production capacity is just outside the Chicago area near the Illinois River.

There are essentially two types of steelmaking techniques: fully integrated steel producers using basic oxygen furnaces (BOF) and steel mini mills using electric arc furnace (EAF) technology. The distinction between the two steelmaking processes is critical since it largely determines the type of raw materials used in the steelmaking process. The integrated steel production process involves using iron ore and coke in a blast furnace to produce either molten iron or pig iron. After this process, the output from the blast furnace is fed into the BOF to produce raw steel. In addition to molten iron, however, integrated steelmakers also feed considerable quantities of high-quality scrap steel, pig iron, or scrap substitutes such as direct reduced iron into the BOF.

Electric arc furnace operators, meanwhile, bypass the coking and blast furnace steps by feeding scrap steel directly into the electric arc furnace. When scrap supplies are tight and prices high, however, mini mill operators often will rely on scrap substitutes such as pig iron or direct reduced iron as raw material feedstocks.

Presently, the vast majority (82 percent) of the steelmaking capacity along the Illinois Waterway represents production from integrated steelmakers using basic oxygen furnaces. Practically all of the iron ore used at these facilities is delivered by lake vessel from Minnesota’s iron ore range. All of the steel production capacity along the upper Mississippi River above the Missouri River, meanwhile, is handled by electric arc furnaces. One major integrated steel producer, National Steel, has production facilities on the upper Mississippi below the Melvin Price lock and dam in Granite City, IL.

Since such a large percentage of U.S. steel production capacity is located within the upper Mississippi/Illinois Waterway study area, the markets served by these producers are national in scope. Consequently, steel production and traffic levels from these area producers are heavily influenced by overall U.S. steel demand patterns.

One issue not addressed thus far in the report is the potential impact of an expansion of U.S. mini mill capacity on Illinois Waterway and Upper Mississippi River steel sector traffic. In response to recent booming demand for steel in the U.S. and rising prices, the U.S. steel industry currently is experiencing a major capacity expansion. Overall, Criton estimates that at least 15 million tons of new steelmaking capacity will be added throughout the U.S. during the 1995 to 2000 period. All of this new capacity represents new electric arc furnaces being built by both established and start-up mini mill operators. Much of this capacity is being built in areas away from traditional steelmaking centers such as Chicago, Cleveland and Pittsburgh. A significant proportion of these mini mills are being built along the inland river system.

While it is possible that competition from these new steel mills could impact Illinois Waterway and upper Mississippi steel traffic, the overall impact of these developments should be negligible due to several factors. First, as stated earlier in this report, U.S. steel imports have ranged between 15 and 30 million tons during the 1990 to 1995 period. It is generally expected that the increase in U.S. steel production capacity will first and foremost displace U.S. steel imports. Second, steel industry analysts indicated that the relevant steel producers within the Study Area are among the most healthy in the U.S. steel industry. While the increase in U.S. steel production capacity will no-doubt affect prices, it should not impact the overall financial viability of most of the steelmakers in the Study Area. In addition, as steel prices fall, U.S. steelmakers will face great pressure to reduce costs. Because of the capital intensive nature of the industry, especially in the integrated steel sector, the most effective method of reducing unit costs is to maximize output. In fact, U.S. steel exports should increase as production capacity grows. Finally, while most mini mills are being built outside of the Study Area, additional capacity also is being added within the Study Area. The most notable among these capacity additions are IPSCO steel’s new 1.25 million tons-per-year mini mill currently under construction in Montpelier, IA and Beta Steel’s new one million ton-per-year mini mill which was recently completed in Portage, IN.

C. INDUSTRY FORECASTS BY REGION AND STATE

Projections of population and GSP for the Study Area are shown in Exhibit 10. A small drop in the population share of the U.S. is accompanied by a similar decline in the GSP share. A close correlation between the population and GSP shares are noted.

The purpose of this section is to explain why the transport of bulk cargo on the inland waterway systems is important to economic development in the study area and the continued reliance on the traffic projections to support waterway maintenance and future expansion capacity.

GSP forecasts of bulk products produced in the Study Area and in the Ohio River Basin are provided in Exhibit 11. The tabulation portrays the concentration of bulk production in the states bordering on the most important inland waterway systems in the U.S. -- the UMB and the ORB. The last line in the exhibit shows that each area is projected to represent 8.4 percent and 10.0 percent respectively of bulk product output in 2045 compared with 7.1 percent in the U.S. total. The bulk products share of projected total GSP declined less in the Study Area and ORB than in the U.S. Total GSP is projected to grow at about the same rate in both the Study Area and the ORB as well as in the total U.S.

Growth is projected highest for paper and allied products in the Study Area followed by chemicals, petroleum products and mining. Paper and allied products also lead in ORB projected growth followed by chemicals and farm products). Other bulk products are projected to grow about the same in the Study Area, the ORB and the total U.S. except that primary metals is projected to grow less in the ORB and in the total U.S. The growth in the bulk products in both the Study Area and the Ohio River Basin provides a rough measure of the potential for growth in traffic on the river systems and how traffic on each system contributes to some extent to traffic on the other system. The historical and projected economic activity, measured in GSP, for bulk products in the Study

Exhibit 10 -- Population and GSP Forecasts

Exhibit 11 -- GSP Bulk Products - Forecasts Study Area and U.S. Total

Area and the U.S. are summarized in the following table. The detail for this summary is presented for reference purposes in Exhibits 12-18.

Gross State Products (billions of 1987 dollars)

	Study Area		Total U.S.	
	Bulk Products	**Total GSP**	**Bulk Products**	**Total GSP**
1980	46.4	456	362	3697
1992	55.4	577	447	5001
2045	105.7	1264	809	11445
Annual Growth Rate (Percent)				
1980-1992	1.56	1.98	1.77	2.55
1992-2045	1.21	1.49	1.13	1.57

Exhibit 12 -- Gross State Product: United States

Exhibit 13 -- Gross State Product: Study Area

Exhibit 14 -- Gross State Product: Illinois

Exhibit 15 -- Gross State Product: Missouri

Exhibit 16 -- Gross State Product: Iowa

Exhibit 17 -- Gross State Product: Minnesota

Exhibit 18 -- Gross State Product: Wisconsin

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IV. MODE SPLIT ISSUES

The competition among modes is principally between rail and barge although trucking enters to some extent in the decisions involved between choosing truck/rail intermodal versus truck/barge intermodal. However, sole trucking is favored as the mode for shorter distances of haul between origin and destination. In addition, competition between barge and pipelines is important in evaluating petroleum products.

In the methodology for the projections, it is assumed that the competitive factors between rail and barge remain constant, in terms of relative prices and level and quality of transportation service, by specific origin and destination pairs. However, projected shifts in supply origins and demand destinations do affect the overall mode split and the traffic levels expected on the river segments. For example, shifts in projected grain exports to or from Northwest ports versus the Louisiana ports (depending on the foreign country destinations) could affect the overall modal split and barge traffic level as discussed at length in Volume II. Shifts in domestic O-D pairs also affect the barge traffic as discussed in some detail in each of the separate reports. For example, we have seen that coal users in the Study Area are increasingly turning to low sulphur Powder River Basin coal, which moves into the area by rail and comes at the expense of higher sulphur coal mined in the Illinois Basin. This O-D shift does affect the volume of coal traffic on the Upper Mississippi River system even though the mode split is held constant on each O-D pair.

The constant mode split assumption has impact on how the waterway traffic forecasts should be interpreted. The forecasts represent our estimates of traffic levels that we would expect under the hypothetical scenario that the current transportation environment (e.g., relative price, relative capacity, etc.) will not change. In reality, these conditions have been changing and will continue to change. However, the purpose of this effort was not to predict actual traffic levels; rather, we attempted to develop a set of forecasts that could be used by the Corps to conduct a benefits-cost assessment of potential capital improvements to the locks on the Upper Mississippi River system. The forecasts we have developed meet the criteria needed for inclusion in such an evaluation. Actual traffic levels will vary and could see stronger growth or slower growth depending on whether the improvements are undertaken to reduce delay times. Rail cost reductions and/or capacity improvements could also affect actual traffic levels.

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V. WATERWAY TRAFFIC FORECASTS

This section presents forecasts of waterway traffic to 2050 for the two main segments of the Upper Mississippi River system: the Upper Mississippi River from the Twin Cities to the mouth of the Missouri River, and the Illinois Waterway. The results are presented as well as the methodologies used to develop the forecasts.

A. REVIEW OF METHODOLOGIES USED IN REPORTS

Approaches to projecting the traffic growth rates for each commodity group are briefly described below. The procedures vary depending on the characteristics of the commodities, supply and demand locations, technological development and modal competition. Important assumptions made in the forecasts are stated for each commodity group.

1. Grain and Soybeans

Important Assumptions

- A full production scenario is assumed. In other words, it is assumed that the total land available for crop production will be fully utilized.
- It is believed that annual yield increases in the future will follow a linear trend similar to the one witnessed during the last twenty-five years.
- Forecasts of domestic consumption are based on the assumption that long-term growth in the needs of the food and feed sectors will be similar to the observed growth in domestic use during the 1974 to 1994 time period.
- The export forecasts are based on the additional assumption that US consumers are economically able to out bid non-U.S. consumers for US grain and oilseeds.
- It is assumed that all of the surplus grain produced in the US will be exported.
- It is assumed that future port shares will not vary significantly from recent historical patterns.

The waterway traffic forecasts of grain are derived primarily from forecasts of US exports. The main ingredients in the export forecasts are projections of US production and US domestic consumption.

A full production scenario is assumed. In other words, it is assumed that the total land available for crop production will be fully utilized. There is a finite number of acres that can be utilized for crops, thus there is an upper limit on area. The high area levels of the late 1970s and early 1980's were used to represent an upper extreme or limit for total crop area. During this time period the level of land withheld from production was negligible and cultivated area represents a full production scenario. In all cases, the forecasts of harvested crop areas approach or exceed those 1970's-80's boundaries by the year 2000 and remain at or near the limit for the duration of the forecast. However, there are some restrictions on acreage that are not sensitive to prices. The outlook assumes that some form of land retirement will prevail throughout the forecast horizon and that a certain percentage of the CRP land will be held out of production on a permanent basis as it represents wetlands and other highly erodible land that is not suitable for crop production.

This assumption of a full production scenario is the major assumption used to develop the forecasts. It is based upon other assumptions about world demand and the US' ability to compete in world corn and soybean markets. Strong growth in world demand for grain is projected and commodity prices are assumed to rise over the forecast horizon. It is assumed that the US will expand production to meet this additional demand. We anticipate that US producers will continue to be among the world's low cost producers [see footnote 1 at end of docement] and will remain competitive in world markets. In other words, foreign supply is expected to increase but it will not be able to offset US production. The US has a notable comparative advantage as a grain producer because of its low per unit cost of production, its efficient marketing system, and its highly developed transportation network.

The expectation that US producers will be able to compete in world markets also depends upon two additional assumptions. First, it is expected that US producers will be free to produce those crops they choose to produce. This assumption is valid if US commodity policy retains the general characteristics of the 1996 FAIR Act. We believe this is a valid long range assumption though it may be violated in the short run. While there may be instances of increased intervention on a limited basis from time to time, we do not anticipate that either the U.S. or other countries will return to the level of intervention and regulation witnessed during the mid to late 1980's. For most countries, it will not be economically or politically feasible to return to similar high levels of monetary support. Second, it is assumed that trade barriers will not prevent deficit producing countries from satisfying their needs from low cost suppliers. This assumption is believed to be warranted given the shift toward more liberalized trade that has occurred over the past 3 to 5 years. The recent GATT settlement (activated January 1, 1995, following nearly 10 years of negotiations) stops the trend toward trade distorting practices that have been present for decades and which included import barriers, export subsidies, and the establishment of geographical trade groups (EEC/EC/EU, NAFTA, Mercosur, etc.); and prescribes the early steps toward freer trade. This reversal significantly favors world producers who are "competitive low- cost producers" to the detriment of those who are "high-cost producers" who have been protected/subsidized in the past. The forecast incorporates the GATT regulations governing subsidized exports that were agreed upon by most major exporters. These regulations will impact trade until 2001 and are likely to extend well beyond as the global evolution toward "free trade" is expected to be sustained. The forecast also considers the impact on trade of the various import tariffs reductions for grain and oilseeds and the minimum access provisions that will be implemented over the next 5 to 6 years as a direct result of the GATT agreement.

Yields, the other major component of the production forecast, were projected on the basis of linear long-term trends with a twenty-five year period (1970-1994) as the base. It is believed that the adoption of new technology (application of fertilizers, cultivation practices, machinery, genetics and biotechnology) in the future will follow a pattern similar to the one witnessed during the last twenty-five years. If the forecast errs, it likely will be on the low side as there has been some speculation that we are on the brink of a new technological revolution that could accelerate annual yield increases. Nonetheless, the crop yield forecasts contained in this study represent an accurate and best assessment of yield trends and technology incorporation that will prevail during the coming fifty year time period.

Forecasts of domestic consumption are based on the assumption that long-term growth in the needs of the food and feed sectors will be similar to the observed growth in domestic use during the 1974 to 1994 time period.

The export forecasts are also based on the additional assumption that US consumers are economically able to out bid non-U.S. consumers for US grain and oilseeds. This assumption has been valid for many years. Growth in foreign food demand will be largely income based; but it is still highly unlikely, even with the relatively higher growth in foreign income, that foreign consumers will be able to bid demand away from U.S. domestic users of grain.

The final assumption used to develop the waterway traffic projections pertains to how total US exports were allocated to major US ports. Average historical port shares were used to make these allocations. For the most part, there is little evidence that would suggest that future exports by port will vary significantly from historic patterns. While it may be argued that destination is an important consideration for determining port of shipment, history would indicate that the location/source of the grain to be shipped has played a more important role in determining the port of export. The forecast assumes that port facilities will be adjusted to accommodate the increased level of shipments expected over the next 55 years.

Almost all of the grain traffic on the Upper Mississippi River originates in the Study Area and moves to Louisiana ports. For this reason, SCI's export projections for the Mississippi River were used to drive the waterway traffic projections. The Mississippi River export projections were allocated to the study area based upon the Study Area's historical share of Mississippi River exports and the historical mode split from the Study Area to Louisiana port areas. This tonnage was then adjusted upward slightly for non-export shipments.

Historical BEA shares of the study area's waterborne shipments were used to allocate total tonnage originating in the study area to origin BEAs. We considered adjusting the historical BEA shares for projected changes in relative production (at the state level). However, analysis of the historical data revealed that there is no evident relationship between a state's production share and its share of waterborne shipments. Some relationships (not necessarily strong) were found between a state's waterborne shipments and its domestic consumption or surplus (production plus change in stocks minus domestic consumption); however, our domestic consumption estimates by state are not very precise and we did not feel that we could adequately forecast domestic consumption for each state.

Through traffic estimates for each BEA were estimated by assuming that all traffic originating in the study area moves downstream and out of the study area. This is a reasonable assumption given that less than 1% of the study area's grain shipments are internal and that the amount of grain received in the study area from other states is negligible.

The same methodology was applied generally to forecasts of animal feeds, closely related to grain logistics and for which waterway traffic also depended largely on export demand tied to shipments down river to Louisiana.

2. Agricultural Chemicals

Important Assumptions

- It was assumed that fertilizer application rates in the future would be similar to those witnessed during the last six years. In other words, we do not believe there will be any significant technologies developed that will warrant an increase or decrease in the application of fertilizer per acre planted.
- Forecasts of harvested acreage developed by SCI were accepted as the best possible estimates of future land use. A slight adjustment was made to the forecasts to convert them to estimates of planted acreage: it was assumed that recent historical ratios between planted acreage and harvested acreage would hold in the future.
- Separate forecasts were developed for each of the three major fertilizer types: nitrogen, phosphate, and potash. For each major nutrient, three separate waterway traffic forecasts are presented: Base, High, and Low. Each forecast was developed using the "Base", "High" and "Low" fertilizer demand forecasts generated from the corresponding SCI crop acreage forecasts. (Fertilizer usage is a function of acreage, and not grain yields per acre--hence slow growth in fertilizer use is projected since acreage increases are limited).
- Among the major fertilizers moving on the Upper Mississippi River, Criton does not anticipate any significant changes in riverborne traffic with the exception of the nitrogen fertilizer sector. After an exceptional 1994 season and a marginal 1995 season, nitrogen fertilizer shipments should return to more "normal" levels by 1996 or 1997. Nitrogen fertilizer shipments are expected to begin falling in 1998, however, due to the completion of COGA's new one million ton-per-year urea plant currently under development near Girard, IL. The full impact of the COGA project on riverborne shipments should be realized by 2000.
- Riverborne shipments of phosphate and potash fertilizers are not expected to be influenced by new local production facilities. As a result, while no significant long-term decrease in traffic is expected in riverborne phosphate and potash fertilizers, traffic growth in these commodities is expected to be extremely limited.

3. Prepared Animal Feeds

Important Assumptions

- It was assumed that future riverway traffic of prepared animal feeds would continue to be dominated by movements to U.S. export markets.
- Prepared animal feed exports were assumed to be the residual production of animal feed over U.S. demand.
- It was assumed that European levies on corn would be gradually phased out, significantly reducing European demand for U.S. corn gluten feed.
- It was assumed, that increased output of corn gluten feed, a by-product of projected increases in corn wet millings, would be consumed close to wet milling locations and would not move on the river.
- Shipments of prepared animal feeds on the Upper Mississippi River almost all represented export through New Orleans. Exports of prepared animal feed from grain primarily included corn gluten and soybean meal. SCI forecasted soybean crushing which correlates closely with soybean meal production. Corn gluten is a by-product of the wet milling process for producing sweeteners, starches and ethanol. The production of corn gluten was derived from the forecasted demand for these products. Domestic consumption of both soybean meal and corn gluten were forecasted and subtracted from production to derive U.S. exports as a residual. The historical share of these exports from the study area were assumed to remain constant and thus was the basis for the forecast of the tonnage of prepared animal feed on the Upper Mississippi River.

4. Coal

Important Assumptions

- New electric utility plants will obtain coal largely from the Powder River Basin (for which short barge hauls in the Study Area are not economical).
- It is not assumed that any technology for superconductivity of electricity transmission will be developed by 2050 which could lead to mine-mouth generation and little transport of coal to power plants.
- Consumption of metallurgical coal will decrease since: 1) new steel plants will be largely mini-mills (using electric-arc furnaces that do not require coke), 2) new technology will result in displacing much coke consumed in blast furnaces by substitution of natural gas or pulverized coal injection (PCI--which is not practicable for barge delivery).
- Deregulation of electric generation will increase competition and greater use of low- cost gas as fuel for generation plants. Industrial use of steam coal will grow only moderately due to low cost competition from natural gas.

To derive coal traffic forecasts for the waterways of the upper Mississippi River Basin, Criton evaluated current and prospective supply and demand conditions for each of the major coal using sectors contributing traffic to the upper Mississippi River Basin. These include the domestic utility sector, domestic metallurgical coal sector, the domestic industrial coal sector, the export coal sector, and the regional petroleum coke industry. Criton developed riverborne coal forecasts for each individual sector, relying on a specific and unique set of assumptions for each. For reasons explained in the separate report (Vol. V), Criton does not expect increased coal usage by utilities in the future. The Department of Energy's forecasts of metallurgical coal to 2010 was extended to show a continued forecasted decline in this coal. Industrial coal use was forecasted to increase at one percent per annum. For both the upper Mississippi and Illinois Waterway forecasts, the upper and lower confidence bounds are not symmetric around the base case forecast. This is due to the fact that under higher generation growth scenarios, total riverborne coal traffic will be capped as coal-fired generating capacity reaches is full practical capacity.

a) Electric Utilities

Electric utilities accounted for about 70 percent of coal/coke use in the Study Area with the remainder used primarily by industrial plants.

The NERC forecasts were utilized to generate riverborne coal demand forecasts through 2004 by escalating/de-escalating the projected coal consumption of each power plant in the target region by the forecast change in coal-fired generation for the appropriate NERC Region. Projected coal generation for the remainder of the study period were forecast by extrapolating the annual average change in coal-fired generation for the last five years of the NERC forecast.

Once plant and utility-specific demand forecasts were developed, it was necessary to adjust these forecasts to account for recent and pending shifts in coal origination and delivery patterns. Specifically, Criton adjusted riverborne tonnage to several utility plants that had switched or were planning to switch their coal sourcing and modal delivery patterns since the 1992-1994 period.

b) Metallurgical Coal

Prospects for the U.S. steel industry remain bright, but the future of the metallurgical coal sector is not as certain. Integrated steel producers who rely on metallurgical coal to produce coke should be able to maintain and potentially increase their domestic steel sales through 2000 by displacing imports. These same producers also are beginning to export considerable quantities of steel.

Over the longer term, however, technological advances in the U.S. steel sector should begin cutting demand for metallurgical coal. For example, there is presently approximately 20 million tons of new steelmaking capacity planned for the U.S. All of this capacity, however, will rely on electric-arc furnace technology, which relies on scrap steel and scrap substitutes such as direct- reduced iron as their primary raw material feed stock. No coke is utilized in this process. As these mills become operational later in this decade, the proportion of steel produced by traditional integrated steelmaking operations should decline. Metallurgical coal has properties suitable for producing coke with firm charred cores when heated to 15000F. Most eastern bituminous coal is suitable for this purpose unless it has excessive ash or sulfur content (in which case it is only used as steam coal).

In addition, integrated steel producers have been experimenting with alternate technologies which displaces coke in the production process. The most significant is pulverized coal injection (PCI). PCI technology involves injecting pulverized coal directly into the blast furnace instead of coke. This development is significant because it allows steelmakers to use traditional steam quality coal in the process, eliminating the need for significant quantities of coal with good coking qualities. In addition, integrated steel makers also have been experimenting with natural gas in their blast furnaces instead of coke.

Given these circumstances -- the increased prevalence of electric-arc mini mills, and the use of PCI and natural gas in blast furnaces -- the long-term future of metallurgical coal demand appears bleak.

To estimate prospective demand for metallurgical coal on the waterways Upper Mississippi River Basin, Criton relied upon long-term forecasts of metallurgical coal demand generated by the U.S. Department of Energy for the East North Central Census Division. Criton assumed that riverborne shipments would increase or decrease at the same rate as the overall demand forecast by the Dept. of Energy.

c) Industrial Uses of Coal

Industrial coal use in the U.S. has been relatively flat for the past several years. Its growth has been constrained by relatively cheap natural gas prices and the perception that natural gas-fired boilers carry considerably less environmental baggage than comparable coal-fired boilers. In the upper Mississippi Basin, the majority of the riverborne coal consumed in the region is used to either manufacture cement or to fuel corn processing plants producing either ethanol or high- fructose corn syrup.

While total U.S. industrial coal use has been relatively flat, industrial coal use has experienced significant growth in the midwestern U.S., especially Iowa. This growth has been fueled by a major expansion in the corn processing industry. Industrial coal growth in Iowa has been especially strong, growing from 1.9 million tons in 1991 to 2.8 million tons in 1994 according to U.S. Dept. of Energy figures.

Industrial coal demand on the upper Mississippi between the Missouri and Ohio Rivers and also on the Illinois Waterway were assumed to grow at a one percent annual rate through the entire forecast period.

d) Deliveries of Coal/Coke Outside the Study Area

About 50 percent of the coal moving on the waterways of the Upper Mississippi River Basin was delivered outside the Study Area. About 80 percent of this was delivered to electric utilities down-river

(Missouri, Louisiana and Florida); the remaining 20 percent was exported to Spain and some unidentified users of coke.

5. Industrial Chemicals

Important Assumptions

- Barge shares of industrial chemicals shipped (which are low) declined considerably over the past decade and it was assumed that the shares would remain constant at recent levels over the projection period.
- Traffic of industrial chemicals (in aggregate) destinating in a state located in the study area was assumed to be a function of the state's industry growth and intermediate demand for industrial chemicals. Originating traffic levels in a study area state were assumed to be related to growth in the state's chemical industry.
- The volumes of traffic originating and destinating in a study area state were assumed to be related to economic activity in the total state.
- It was assumed that changes in state-to-state O-Ds of destinating traffic were a result of relative changes in chemical industry growth in origin states. Changes in state-to- state O-Ds of traffic originating in study area states were assumed to be a function of relative changes in intermediate demand for industrial chemicals in destinating states.
- It was assumed that national input-output coefficients, used to calculate intermediate demand, were valid at the state level and would hold in the future.
- OBERs GSP projections were accepted as the best long-range estimates of future industry growth.

Destinating traffic was assumed to be driven by intermediate demand. Give this assumption, our goal was to take into account differences in projected growth rates across industries that exhibit different levels of demand (per unit of output) for industrial chemicals.

Rough estimates of intermediate demand were developed for the base period by multiplying an input-output coefficient by GSP for the corresponding industry. Industry shares of intermediate demand were then calculated and used to allocate total destinating tonnage (rail plus barge) to consuming industries. In the next step, each industry's assigned tonnage was divided by industry GSP to produce a tonnage/GSP ratio.

These tonnage/GSP ratios were computed for each year in the base period. We then examined the historical trends in these ratios and used regression analyses and other procedures to forecast them out into the future. Taking the product of the forecasted tonnage/GSP ratios and the OBERs industry GSP projections yielded forecasts of the total tonnage consumed by each industry in the state. The industry forecasts were summed to estimate the total amount of tonnage (barge plus rail) destinating in the state.

The total tonnage figures were then allocated to state origins. Base year origin shares were based upon actual commodity flow data (rail and barge). The shares were then adjusted according to expected changes in relative supply. We used OBERs GSP projections for the chemicals industry to make these adjustments. State level shares of U.S. chemical industry GSP were calculated for both the base year as well as each forecast year. Changes in the GSP shares were applied to the base year origin shares to make the adjustment for relative changes in supply. State-to-state commodity flows were produced by multiplying the new origin shares by the total tonnage destinating in the state.

A similar procedure was applied to develop the same forecasts for industrial chemical shipments originating in the Study Area.

6. Petroleum Products

Important Assumptions

- In terms of traffic originating in the study area, it was assumed that all future waterway traffic would originate either in Illinois or Minnesota. This assumption was made because there are currently no petroleum refineries in the other three states and we do not anticipate the construction of any in the foreseeable future.
- It was assumed that future barge shipments originating in Illinois would decline as a result of increase pipeline usage. It was assumed that traffic originating in Minnesota would fall as Minnesota's increased consumption of petroleum products started to compete with the state's shipments.
- Traffic destinating in Illinois was assumed to be positively related to its consumption of petroleum products, reflecting growing demand for those petroleum products that are not likely to move by pipeline. Traffic destinating in Missouri was assumed to be a negative function of its petroleum product consumption, indicative of relatively stronger growth in demand for those products which move by pipe and/or increased usage of pipelines in general. Future traffic destinating in Iowa was assumed to follow recent historical patterns. Traffic destinating in Minnesota was assumed to be negatively related to the state's net demand for petroleum products.

The waterway traffic forecasts for petroleum products are based on historical relationships between waterway traffic levels and proxies for supply and/or demand. Most petroleum products are transported by pipeline; however, there is no good source of pipeline data that we could forecast and compare with the water traffic. As a result, we had to forecast barge traffic directly as a function of the supply and demand proxies.

For each state in the Study Area, forecasts were developed both for originating traffic and for destinating traffic. In terms of originating traffic, it was assumed that all of the barge tons of petroleum products originated either in Illinois or Minnesota. This assumption was made because there are no petroleum refineries in the other three states. In addition, our historical barge flows are on a BEA-to-BEA origin-destination basis. Some of the BEAs overlap state boundaries and it was necessary to assign BEA originating traffic to originating states so that the traffic could be tied to state level variables.

7. Construction Materials

Important Assumptions

- It was assumed that riverborne traffic for cement would increase as before with forecasts of Gross State Product: Construction (made by the U.S. Department of Commerce for each state in the Study Area).
- Similar statistical analysis on the riverborne traffic of sand, gravel and other construction aggregates was also applied in forecasting the other construction materials based on forecasted construction activity.

The primary underlying factor in Criton's riverborne cement forecast is overall cement demand in the five-state Upper Mississippi Study Region. Cement demand forecasts were developed for each of the five states in the study region. These forecasts were based upon forecasts for "Gross State Product: Construction" prepared by the U.S. Dept. of Commerce, Bureau of Economic Analysis (BEA). High and low uncertainty bands for the Gross State Product forecasts were developed by JFA.

To determine the relationship between Gross State Product and state-level cement demand, Criton compared these data using ordinary least squares regression techniques. In general, Criton found strong and statistically significant relationships between historic state construction sector GSP (independent variable) and state-wide cement consumption (dependent variable). The only state for which these relationships were not particularly strong was Iowa. Criton could find no explanation for this variance in results. However, given the positive results generated by the remaining four states, it was decided to use the results of the regression analyses to project state-level cement demand levels. Using the regression results, total cement demand forecasts were developed for each of the five states in the upper Mississippi study region based on the GSP construction forecasts.

To develop a comprehensive forecast for riverborne sand, gravel and stone, it was first necessary to develop several separate forecasts for specific markets and river segments. The most important forecasts, in terms of volume, were those for riverborne sand and gravel moving into the Minnesota and Illinois markets.

To forecast riverborne shipments of sand and gravel on the Upper Mississippi, Criton evaluated the statistical relationship between total Minnesota sand and gravel demand to riverborne shipments of sand and gravel into the Minnesota market. This relationship was estimated by several functions which are described in detail in the separate report (Vol. VIII). Similar procedures were followed as for cement in estimating the confidence bands.

8. Steel and Steel Sector Raw Materials

<u>Important Assumptions</u>

- It was assumed that waterborne traffic in steel products, and inputs to steel plants, would be tied closely to historical trends in steel demand in the U.S. based on regression analyses of steel demand and population trends.
- It was assumed that traffic on steel plant raw material inputs would shift toward a higher percentage of scrap, reducing inputs of iron ore and coke which are not inputs to mini-mills using electric-arc furnaces in smelting scrap.

The upper Mississippi and Illinois Waterways serve the largest concentration of raw steel production capacity in the U.S. As a result, the markets these steelmakers serve is national in scope. Consequently, it was assumed that riverborne traffic levels for steel-sector raw materials would be closely tied to overall U.S. steel demand conditions.

Since the vast majority of steel and steel-sector raw materials moving on the upper Mississippi River above the Missouri River represents traffic moving into and out of the Illinois Waterway, waterway traffic forecasts were first developed for the Illinois Waterway. Upper Mississippi waterway traffic forecasts were then largely developed using the results of the Illinois Waterway traffic forecasts.

For the Illinois Waterway, two separate forecasts were prepared: one for raw materials and the other for steel (which includes finished and semi-finished steels). It was considered appropriate to group these commodities, especially in the raw materials segment, since pig iron, scrap steel, and direct reduced iron (included in iron ore) are generally substitute commodities.

In comparing macro U.S. steel demand data to riverborne traffic levels of steel and steel sector raw materials, fairly strong correlations between the data were found to exist. As expected, Illinois waterway traffic for both steel and its raw materials were positively correlated with overall U.S. steel demand. The results of these regression analyses are summarized in the separate report (Vol. IX). These regression results were used to generate the Illinois Waterway steel and steel-sector raw materials forecasts.

While approximately 85 percent of Upper Mississippi steel traffic represents steel-sector materials moving onto or off of the Illinois Waterway, it was nonetheless necessary to forecast traffic levels for the remaining 15 percent of the waterway's steel sector tonnage which is considered local in nature. As with the Illinois Waterway, local Upper Mississippi steel and steel-sector raw materials traffic is positively correlated with overall U.S. steel demand.

Since Criton's forecast model specified that overall upper Mississippi and Illinois Waterway steel sector traffic is largely dependent on overall U.S. steel demand, it was necessary to generate long-term forecasts of U.S. steel demand. This process was accomplished by evaluating historical per capita U.S. steel consumption. In general, per capita U.S. steel consumption has experienced a significant decline since the early 1970s, falling from 522 KG in 1973 to approximately 352 KG in 1990. Much of this decline has been due to a major shift away from steel to lighter weight materials such as aluminum, plastics, and composite materials in many former steel-dominated sectors such as the beverage can industry, the railcar manufacturing industry, and the automobile industry.

It was assumed that the trend decline would continue through the forecast period with the decline in per capita steel consumption slowing. Future per capita steel consumption levels were estimated using a function based on the historical decline.

To determine total U.S. forecast steel consumption, the results of each per capita steel forecast was multiplied by the total U.S. population as forecast by the Census Bureau.

B. TOTAL TRAFFIC FORECASTS

The waterway traffic tonnage forecasts are presented in detail by product group separately for the Upper Mississippi River and the Illinois Waterway (Exhibits 19 and 20). [see fotnote 2 at end of document] The forecasts are presented in five-year intervals between 2000 and 2050 and the 1991-93 actual average is shown for comparison purposes. Average annual growth rates between the projected five-year intervals are shown (between the 1991-93 average tonnage and year 2000, eight years are covered in the first period). [see footnote 3 at end of document] Projected changes in the percentage distribution of the tonnage among the product groups are also calculated.

The share of corn in waterway traffic, and the share of industrial chemicals, is projected to increase, with decreases in the shares of agricultural chemicals (fertilizers), coal and coke and petroleum products. These changes in shares are very similar in the projections for each waterway.

The aggregate traffic on the Upper Mississippi River is forecasted to increase slightly over 90 percent from 1991-93 to 2050. The comparable increase forecasted for the Illinois Waterway is slightly less, about 86 percent. These forecasts, along with historical tonnage (from 1960) are graphed in Exhibits 21-23. The confidence bands for the projections are included in the graphs.

Projected annual growth rates are illustrated in Exhibits 24-25. Exhibit 24 shows a continuation of a declining historical trend in annual growth rates for the Upper Mississippi River between the Twin Cities and the mouth of the Missouri River. It is not possible to glean any obvious historical trends from Exhibit 25. However, the average projected growth rate for the Illinois Waterway falls almost in the middle of the historical range: a half of a percentage point less than the mean growth rate from 1965-1994.

Uncertainty bands for the total traffic forecasts were developed using a random walk procedure. For each river segment, we first created a vector of twenty-five observed historical growth rates in total traffic. Multiplying the base year traffic level by each of the twenty-five growth rates in this vector yielded a distribution of twenty-five traffic estimates for the first forecast year. The variation in this

Exhibit 19 -- Waterway Traffic Forecasts: Twin Cities To Mouth of Missouri River

Exhibit 20 -- Waterway Traffic Forecasts: Illinois Waterway

Exhibit 21 -- Upper Mississippi River Basin Waterway Traffic Forecast - Twin Cities to St. Louis

Exhibit 22 -- Upper Mississippi River Basin Waterway Traffic Forecast - Illinois River

Exhibit 23 -- Total Waterway Traffic Projections

Exhibit 24 -- Total Waterway Traffic: Twin Cities to St. Louis Annual Growth Rate: 1965 - 2050

Exhibit 25 -- Total Waterway Traffic: Illinois Waterway Annual Growth Rate: 1965 - 2050

distribution was then used to estimate the high and low uncertainty bands for that year. The difference between the mean and the 95% confidence level was calculated as a percentage of the mean and then applied to the actual waterway traffic forecasts (developed by summing up the individual commodity forecasts) to estimate the bands.

Confidence bands for successive forecast years were estimated in a similar manner. Probability distributions needed to calculate the variance for these years were developed by multiplying the twenty-five historical growth rates by each point in the preceding year's distribution. For example, the distribution associated with the second forecast year contained 625 (25 X 25) traffic estimates; these were calculated by taking the product of the twenty-five historical growth rates and the twenty-five traffic estimates in the first forecast year distribution. The third forecast year distribution contained 15,625 traffic estimates (25 X 625). For each forecast year, the variation in its respective distribution, calculated as a percentage of the mean, was then applied to the actual waterway traffic forecasts to produce the confidence bands.

The historical growth rates are based on Waterborne Commerce Statistics Center data from 1960 to 1994. To make the problem tractable, we calculated the growth rates using ten year intervals, producing twenty-five observations for the 1960-1994 historical period. Because ten year increments were used, 1990 was selected as the base year (average of 1989-1991) and bands were estimated with the procedure every ten years out to 2050. With twenty-five possible changes and six forecast years (2000, 2010, 2020, 2030, 2040, 2050), it can be seen that the distribution for 2050 contained over 200 million point estimates (25 raised to the 6th power).

Exhibit 26 presents a hypothetical example of the procedure used to estimate the uncertainty bands. The example assumes a base year traffic level of forty million tons and utilizes five historical growth rates. Bands for the first two forecast years are presented.

Exhibits 27 and 28 contrast our base forecasts and confidence bands with an alternative scenario based upon relatively higher growth in corn and soybean traffic. Some analysts are optimistic about future growth in yields and think that average annual changes in yields are going to increase. Historical data on corn yields don't point to such increases; however, recent data on soybeans do suggest the possibility. As some analysts indicate, projections of yields based upon historical trends may be inaccurate because of new innovations which are in the final stages of development and may soon enter the market. Comparisons have been made between these new technologies and the introduction of hybrid corn in the early 50s which accelerated yield increases. Nonetheless, it would be extremely difficult to incorporate such claims in the yield forecasts. It would be necessary to substantiate exactly how much greater the yield increases would be and why the new technologies are going to lead to larger increases than previous technologies recently introduced. While many analysts believe that yield increases are going to accelerate over the next several years, there is some debate about the potential yield levels that could be attained. Also, it is unlikely that such yield increases could be sustained over a fifty year period. New technologies typically bring high returns

Exhibit 26 Development of Uncertainty Bands Example

Exhibit 27 Upper Mississippi River Total Waterway Traffic Forecast

Exhibit 28 Upper Mississippi River Total Waterway Traffic Forecast

in the early years of adoption; but these diminish in later years as the market becomes saturated and the maximum potential of the technology is approached.

With these thoughts in mind, we developed a set of alternative grain forecasts based upon different assumptions about future yields for corn and soybeans. Given our methodology, the increase in yields give rise to relatively higher U.S. grain exports and larger volumes of corn and soybean traffic on the Upper Mississippi River and Illinois Waterway.

Alternative forecasts for corn yields were developed by estimating a linear trend with a fifty year period (1945-1994) rather than a twenty-five year period (1970-1994) as the base. The decision not to use a non-linear curve for the alternative yield forecast was based on the assumption that the long-term growth in yields will accelerate and decelerate around a linear curve. The trend estimated with the longer period has a steeper slope than that estimated with the shorter period; corn yields are forecast to increase by 2.15 bushels per acre in contrast to 1.8 bushels per acre. The alternative yield forecast for corn in 2050 is 235 bushels per acre, compared with 219 bushels per acre estimated using the shorter period. The relatively higher yields result in 2050 export estimates of 5.7 billions bushels, approximately 2.5 times current export levels and 18% higher than the 2050 base export projections.

An alternative forecast for soybean yields was developed by allowing soybean yields to increase by 0.7 bushels each year between now and 2005. This growth was then gradually reduced until it reached 0.49 bushels in 2012, where it was held constant for the remainder of the forecast horizon. Base yield forecasts are based on the assumption that yields will increase linearly by 0.48 bushels per year. Since 1983, soybean yields have increased by an average of 0.67 bushels as farmers have begun to experiment with new planting practices. Such practices have not been adopted by all farmers. Some analysts indicate that it may take another five to ten years before all farmers have adopted the practices and their impact on growth starts to diminish. Using the alternative yield forecasts, soybean exports in 2050 are projected to be 1.76 billion bushels. This is a little over 2 times current export levels and 26% higher than the base export forecasts.

For both corn and soybeans, the alternative traffic forecasts based upon these high growth scenarios fall within the respective confidence intervals presented in the grain report. As can be seen in Exhibits 27 and 28, the total traffic forecasts based upon the high corn AND a high soybean scenarios also fall within the total traffic confidence intervals. It should be noted that the alternative total traffic forecasts were developed using the base forecasts for all commodities except corn and soybeans. In addition, they represent the summation of the average trends of these commodities and for grain assume normal weather conditions.

The examples of methodologies presented above point up some of the problems inherent in long- term projections. The methodologies used depend both upon historical data as well as knowledge about future short-term conditions (e.g, that a new corn processing plant will be constructed in a certain location within the next five years). However, both of these factors can quickly become outdated over a forecast period that spans more than fifty years. Consider the following example which illustrates these inherent problems. In 1879, California and New York together produced over half of the barley grown in the United States. In 1950, California was still a leading barley producer and accounted for 20% of the U.S. barley production. Today, California produces less than 3% of the U.S. barley harvest. In the early 1900s, with twenty-five years of strength in the barley market and no reason to believe that would change in the foreseeable future: what analyst would have predicted that California's production share would drop so significantly?

In making the current forecasts, we can list possible sources of uncertainty that could affect the traffic levels on the river. For example, the grain traffic will be impacted by factors that affect its production, consumption, and transportation. Production can be influenced by government programs (we've seen several changes in government policy over the last two decades that have impacted how much land is used by farmers), changes in yield trends, relative price changes due to shifts in demand and/or competition from foreign producers (could the Former Soviet Union become a major grain competitor in fifty years?). Production shifts could also occur as a result of changes in factor input costs (e.g., water) or genetic engineering developments which could make certain crops more amenable to differing climates (e.g., making corn more resistant to drought and allowing it to be grown further west). Domestic consumption could be reduced by the elimination of the sugar quotas and/or the ethanol subsidies, and possibly elevating U.S. corn export. Factors which could affect grain transportation include port improvements that would permit the handling of larger ocean going vessels.

Of course, there is no way to enumerate all of the sources of uncertainty. Many of the sources are unknown and, as can be seen, there are a multitude of possibilities for each commodity. However, it should be noted that there is probably less risk associated with the aggregate forecasts than there is for the individual commodity groups. Some commodities are subject to decline, whereas others will be subject to expand; as a result, the aggregation of the commodities provides some stability in the forecasts.

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Notes:

1. It is assumed that US storage and transportation infrastructure that supports agricultural production will respond to growing demands and will not hamper it growth.

2. The 1991-93 average traffic for some of the product groups differ slightly from historical volume shown in Exhibit 2-6. This was due to slight differences in definitions used in the analysis from product groups in the Waterborne Commerce statistics.

3. For some commodities such as grain, 1993 traffic levels were significantly below trend due to the

1993 flood. As a result, growth rates between 1991-1993 and 2000 could be biased slightly upward. However, this has no bearing on the actual traffic forecasts since the growth rates were backed out from the projected traffic volumes.

End of Waterway Traffic Forecasts for the Upper Mississippi River Basin

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