Waterway Traffic Forecasts for the Upper Mississippi River Basin

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I. Introduction

The Criton Corporation has developed this analysis to evaluate past, present and prospective supply and demand relationships relating to basin nonferrous construction materials in geographic regions served by the Upper Mississippi River Basin waterway transportation network. These analyses were undertaken to develop insight into the major determinants of riverborne shipments of sand, gravel, stone and cement along the targeted waterways. These analyses were then used to derive relevant demand estimates for these commodities, which in turn were used to generate riverborne traffic forecasts through 2050 for the Upper Mississippi River Basin waterways. Specifically, traffic levels were forecast for the Upper Mississippi River between Minneapolis/St. Paul and the mouth of the Missouri River and the entire length of the Illinois Waterway.

This report is divided into two parts. Part I focuses on the cement industry while Part II evaluates the sand, gravel, and stone sectors. Data developed in Part I of this report was used extesively to generate commodity demand and riverborne traffic forecasts in Part II of this report.

Part I. Cement

I. Introduction

The cement industry is a significant contributor to riverborne traffic on the upper Mississippi and Illinois Waterways. Part I of this report focuses on historic, current and prospective cement supply/demand issues in the five state Upper Mississippi River Basin study region and their consequences on prospective riverborne cement traffic. This part of the report is divided into four major sections including this introduction. Section II reviews historic cement production and consumption patterns in the Upper Mississippi study region. The section also summarizes recent riverborne shipments of cement into and out of the region, and identifies major factors which likely will affect future cement supply and demand as well as how those factors likely will influence riverborne cement traffic levels. Section III discusses the methodology and major assumptions used to generate prospective cement demand levels as well as prospective riverborne traffic levels. The final section presents Criton's forecast for riverborne cement shipments through 2050 given the assumptions and methodologies discussed in the previous sections.

II. Cement Consumption, Production, and Riverborne Traffic.

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 (Table I.1). Within the study region, Illinois represents the largest cement 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.

Table I.1. Annual Receipts of Portland Cement by all modes by State (000s of Tons)

	Illinois	Iowa	Minnesota	Missouri	Wisconsin	Total
1980	2664	1294	1447	1430	1544	8379
1981	2323	1147	1238	1426	1331	7465
1982	2309	1158	1112	1249	1048	6876
1983	2231	1147	1124	1383	1247	7132
1984	2614	1204	1173	1650	1418	8059
1985	2724	1078	1419	1735	1240	8196
1986	3314	1046	1464	2221	1475	9520
1987	3535	1199	1582	2091	1587	9994
1988	3572	1225	1464	2165	1635	10061
1989	3680	1262	1588	1971	1752	10253
1990	3641	1362	1630	1949	1793	10375
1991	3350	1308	1313	1596	1747	9314
1992	3671	1540	1574	2164	1971	10920
1993	3503	1441	1530	2074	1996	10544
1994	3959	1670	1673	2629	2082	12013
1995	3640	1575	1740	2462	2026	11443

Source: U.S. Bureau of Mines, Minerals Yearbook, 1982-1994

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 (see Table I.2). 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. At a regional level, overall cement supply and demand are essentially in balance during periods of moderate demand. When cement demand is relatively strong, however, the five state upper Mississippi region is a net importer. This was especially true in 1994 when the region was a net importer of approximately 1.4 million tons of cement.

Table I.2. Annual Shipments of Portland Cement by State (000s of Tons)

	Illinois	Iowa	Minnesota	Missouri	Wisconsin	Total
1981	1574	1779	-	3732	-	7085
1982	1757	1622	-	3205	-	6584
1983	1857	1644	-	3499	-	7000
1984	1997	1730	-	3981	-	7708
1985	2101	1618	-	3669	-	7388
1986	2118	1819	-	4642	-	8579
1987	2119	2139	-	5110	-	9368
1988	2307	2029	-	4679	-	9015
1989	2700	2072	-	4922	-	9694
1990	2662	2525	-	4481	-	9668
1991	2668	2477	-	4100	-	9245
1992	2860	2824	-	4725	-	10409
1993	2856	2231	-	4710	-	9797
1994	2781	2249	-	5570	-	10600
1995	2466	2674	-	4148	-	9288

Source: U.S. Bureau of Mines, Minerals Yearbook, 1982-1994

Missouri currently is home to five major cement manufacturing facilities (see Table I.3). These facilities have an aggregate rated annual capacity of approximately 4.4 million tons of clinker[1] per year. Actual production of finished cement, however, can exceed these volumes because aggregate Missouri grinding capacity totals over 4.6 million tons. In situations where indigenous clinker production falls short of demand, these facilities often purchase clinker on the open market to satisfy the local clinker shortfall. Each of Missouri's five cement production facilities is located along a navigable waterway. Only three (Continental's Hannibal plant, Holnam's Clarksville, plant, and River Cement's Festus) plants are located along the relevant upper Mississippi study segments. All three plants rely heavily on the inland river system to move their product to market, with each

[1] Clinker is an intermediate product is the cement production process. Clinker is produced by heating limestone and other minerals to high temperatures in large kilns. This material is ground to produce cement.

plant shipping over 80 percent of its annual production by barge. The remaining two cement plants generally do not ship cement into or through the relevant study area.

Iowa, meanwhile, is home to three fully integrated cement plants as well as a fourth facility which only has grinding capacity. Combined, these facilities have an annual clinker production capacity of approximately 2.4 million tons. Aggregate grinding capacity for the Iowa plants totals approximately 2.8 million tons. Only one of Iowa's four cement facilities has barge access: Lafarge's Buffalo plant. In general, this plant ships between 30 and 40 percent of its annual production by barge primarily to the Minnesota cement market.

Illinois also has four cement production facilities within its borders with an aggregate annual clinker capacity of approximately 2.5 million tons. Illinois' aggregate grinding capacity totals over three million tons per year. Only one of Illinois' four plants ships by barge: Lafarge's Joppa plant. This plant, however, is located on the Ohio River and is primarily dedicated to shipping its production to markets in the Ohio River and Lower Mississippi River Valleys. The remaining three plants primarily feed local cement needs, especially in the Chicago metropolitan area. Cement from these inland facilities also is shipped into the Wisconsin market by rail or truck.

Table I.3.
Primary Portland Cement Production Facilities
in the Upper Mississippi Study Region: 1995

State / Plant	Location	Grinding Cap. (000s)	Kiln Cap. (000s)	Remarks
Missouri				
Continental Cement	Hannibal	680	544	85% shipped by barge
Holnam, Inc.	Clarksville	1270	1179	80% shipped by barge
LaFarge Corp.	Sugar Creek	458	478	Located on MO River
Lone Star Indust.	Cape Girardeau	1088	1092	Located on Lower Miss
River Cement Co.	Festus	1134	1074	90% shipped by barge
		4630	**4357**	
Iowa				
Holnam, Inc.	Mason City	816	835	Serves inland markets
Lafarge Corp.	Buffalo	893	843	30-40% by barge
Lehigh Portland Cem.	Mason City	800	725	Serves inland markets
Monarch Cement	Des Moines	304	0	Serves inland markets
		2813	**2403**	
Illinois				
Centex	LaSalle	512	453	Serves inland markets
Dixon-Marquette	Dixon	600	474	Serves inland markets
Lafarge Corp.	Joppa	1361	1076	Located on Ohio River
Lone Star Indust.	Oglesby	544	522	Serves inland markets
		3017	**2525**	

Source: Portland Cement Association, U.S. and Canadian Portland Cement Industry: Plant Information Summary, 1995.

Cement Distribution Dynamics

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 specially 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 (see Table I.4).

Table I.4.
River-Served Cement Terminals on the Upper Mississippi and Illinois River Systems

Lafarge	Holnam	River Cement	Continental Cement
Minneapolis, MN	Minneapolis, MN	St. Louis, MO	Quad Cities, IA
St. Paul, MN (2)	LaCrosse, WI		St. Louis, MO
Winona, MN	Chicago, IL (3)		
Chicago, IL (2)	Lemont, IL		

Source: Criton Corp. River Transport News, June 20, 1994.

In general, cement terminals are matched with cement production facilities. For example, most of the cement moving to Lafarge's Minnesota terminals originates at Lafarge's Buffalo, IA cement plant. Meanwhile, cement moving to Lafarge's Chicago area terminals generally originates at the company's Joppa, IL cement plant. Holnam, meanwhile, generally ships cement from its Clarksville, MO cement plant to all of its upper Mississippi and Illinois waterway cement terminals. River Cement, meanwhile, generally ships cement to its St. Louis terminal from its Festus, MO cement plant, while Continental Cement supplies its three upper Mississippi/Illinois Waterway terminals from its Hannibal, MO cement plant. In periods of high cement demand, however, all of these cement producers supplement their domestic shipments with imports via the lower Mississippi River. This was especially apparent in 1994 and 1995 as these producers diverted cement from their river-served plants to inland markets and used imported barge-delivered cement to back-fill the shortfall at their barge-served terminals.

Given the relatively high volume of cement industry related production and distribution facilities located on the upper Mississippi and Illinois Waterways, it is not surprising that a considerable volume of cement moves by barge on these waterways. During the 1990 to 1994 period, the upper Mississippi River between the Twin Cities and the mouth of the Missouri River handled an average of 1.8 million tons of cement annually with shipments reaching an all-time high in 1994 at 2.2 million tons (see Table I.5). Cement traffic on the Illinois Waterway, meanwhile, averaged nearly 800,000 tons. Practically all of this tonnage represents inbound shipments moving to the Chicago metropolitan area cement market.

Table I.5.
Cement Traffic on the Upper Mississippi and Illinois Waterways: 1990-1994
(000s of Tons)

Upper Mississippi: Twin Cities to Mouth of Missouri River

Year	Inbound	Outbound	Through	Intra	Total
1990	134	1,164	163	495	1957
1991	154	911	34	492	1591
1992	176	956	114	628	1835
1993	141	981	36	378	1536
1994	480	1046	204	484	2214

Illinois Waterway

Year	Inbound	Outbound	Through	Intra	Total
1990	774	-	278	-	1051
1991	565	-	155	-	719
1992	593	-	164	3	760
1993	486	-	11	-	580
1994	632	1	171	1	806

Source: Waterborne Commerce of the United States: 1990-1994

Riverborne cement volumes vary with overall cement demand. Traffic levels, however, also are influenced by changes in industry corporate structure which result in changing distribution patterns. For example, lower overall cement demand in 1991 versus 1990 resulted in substantial reductions in riverborne cement shipments in 1991. The decrease in percentage terms, however, was substantially more severe on the Illinois Waterway than on the upper Mississippi. Much of the disproportionate decrease was due to Lafarge Corporation's acquisition of Davenport Portland Cement's assets in 1991. Davenport historically had shipped a portion of its Buffalo, IA cement production to the Chicago metropolitan market. After Lafarge acquired Davenport, however, Lafarge displaced shipments into Chicago formerly moving from Iowa with cement produced at the company's Alpena, MI cement factory which was delivered to the Chicago market by lake vessel.

Cement Market Segments

For analytical purposes, Criton has segmented the upper Mississippi cement market into three geographic market segments each with unique cement production and distribution features. The dynamics of each segment are discussed below.

Minnesota/Wisconsin

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.

Land-based modes accounted for approximately half of the volume of cement moving into the Minnesota/Wisconsin market (see Table I.6). The overall market share of land-based modes, however, tends to fall during periods when overall cement demand rises. This likely is due to cement producers using waterborne deliveries to backfill markets where shipments of rail or truck delivered cement are constrained due to higher demand in closer local markets. The barge industry's share of deliveries generally has hovered between 15 and 20 percent (discounting the flood disrupted 1993 season). The Lakes share of shipments into this region, however, has grown from approximately 30 percent early in the decade to 40 percent in 1994.

Table I.6.
Cement Distribution into the Minnesota/Wisconsin Market by Mode of Transport: 1990-1994

(000s of Tons)

Year	Lakes	Barge	Other	Total
1990	1021	532	1870	3423
1991	991	553	1516	3060
1992	1059	630	1856	3545
1993	1371	439	1716	3526
1994	1501	663	1591	3755

(Modal Share %)

Year	Lakes	Barge	Other	Total
1990	29.8	15.5	54.6	100.0
1991	32.4	18.1	49.5	100.0
1992	29.9	17.8	52.4	100.0
1993	38.9	12.5	48.7	100.0
1994	40.0	17.7	42.4	100.0

Sources: Waterborne Commerce of the United States; Criton Corporation

Missouri/Iowa

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. Cement producers in western Iowa also ship cement by rail and truck into the western Minnesota market. As discussed later in this report, the volume of cement these producers ship by barge generally is inversely related to cement demand in their local rail or truck-served markets. As local demand surges, these producers meet this demand by shifting increased volumes of cement from their river-served plants into inland markets. They then use imports to backfill volumes diverted from their traditional river-served terminal markets. Presently, only very small volumes of cement move by barge into Iowa, primarily through Continental Cement's Quad Cities, IA, terminal. Riverborne cement receipts in Missouri focus exclusively in the St. Louis area.

Illinois

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 the region 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.

The modal distribution patterns for Illinois mirror those for the other four states in the study region: As cement demand rises, the proportion that is delivered by waterborne modes also rises when local land-based cement plants cannot increase production to sufficient levels to meet demand. Overall, the share of land-based modes in the Illinois cement market gradually fell from approximately 32 percent early in the decade to approximately 27 percent in 1994 (see Table I.7). The barge share of deliveries has remained near 38 percent through most of the 1990-1994 period following a four percent market share decline between 1990 and 1991 due to Lafarge's acquisition of Davenport Portland Cement and its shift from barge to lake deliveries into the Chicago market.

Table I.7.
Cement Distribution into the Illinois Market by Mode of Transport: 1990-1994

Thousand of Tons

Year	Barge	Lakes	Other	Total
1990	986	563	748	2297
1991	691	534	577	1802
1992	747	621	633	2001
1993	577	839	582	1998
1994	785	729	563	2077

Percentage Market Share

Year	Barge	Lakes	Other	Total
1990	42.9	24.5	32.6	100.0
1991	38.3	29.6	32.0	100.0
1992	37.3	31.0	31.6	100.0
1993	28.9	42.0	29.1	100.0
1994	37.8	35.1	27.1	100.0

Source: Waterborne Commerce of the United States; Criton Corporation

III. Cement Forecast Methodology and Assumptions

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.

BEA used a two-step process to develop its forecasts of construction GSP. First, employment forecasts were developed using a process that involved making projections on population, labor force participation rates, unemployment rates, and location quotients. Second, BEA forecasted GSP per employee (i.e., productivity) by analyzing historical trends. These two series were then multiplied together to produce the GSP projections.

JFA developed uncertainty bands for these projections using a Monte Carlo simulation. This exercise proceeded as follows. First, regression analysis was used to estimate trends for both the employment and productivity series for each state. Since the dependent variables in these regressions were specified as a function only of time, it was possible to estimate the standard error associated with each forecast year point estimate. Assuming that the forecasts were normally distributed, we then introduced each point estimate and its concomitant standard error into a random number generator to produce 5000 random numbers for each series and forecast year. The two series (Employment and GSP/Employee) were then multiplied by each other, yielding 5000 GSP estimates for each forecast year. Finally, the values associated with the 95 percent confidence levels for each of these GSP distributions was used to define the uncertainty bands.

Most of the uncertainty bands are quite wide as the standard errors of the regressions were large. There are a couple of reasons for this. First, both employment and GSP/employee were specified only as a function of time. Since there are many variables that can explain the observed values of these series, the fit of the regressions were not very tight and wide standard errors ensued. Of course, other variables, such as population, could have been used as explanatory variables in the regressions; however, the projected values of these variables would have included variance which would have been incorporated into the GSP uncertainty bands. How the equations were specified also affected the size of the standard errors. When thinking about which equation to specify, it is possible to look either for one that reflects the trend in the historical data or for one that has the tightest fit. These two considerations are not always consistent with each other. In making this decision, we chose to use equations that were thought to reflect the trend in historical data, since the goal was to develop bands around a projected trend. As a result, it was sometimes necessary to sacrifice "goodness of fit."

Care should be taken in interpreting these bands since they were developed for years outside of the base period and therefore do not represent actual confidence intervals. The bands themselves are estimates which depend upon the accuracy of the trend forecasts. Significant changes in the trend, which are possible given the length of the forecast period, could result in more than five percent of the future observations falling outside of the bands.

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 (see Table I.8.). 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 summarized in Table I.8 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 contained in Appendix A. The base case results of this forecast are presented in Table I.9. The "high" and "low" confidence bounds are contained in Appendix B

Table I.8
Regression Results for Analysis of Relationship Between State Construction GSP and Cement Demand

State	Intercept	Coefficient	R-Square
Minnesota	85	0.384	0.82
Wisconsin	-51	0.531	0.89
Illinois	-1943	0.532	0.91
Iowa	546	0.436	0.36
Missouri	-954	0.734	0.81

Table I.9. Projected Cement Demand by State
Base Case
(000s of Tons)

Year	Illinois	Iowa	Minnesota	Missouri	Wisconsin
2000	3,974	1,418	1,706	2,131	2,299
2001	4,022	1,425	1,720	2,156	2,322
2002	4,071	1,431	1,734	2,182	2,345
2003	4,120	1,438	1,749	2,208	2,368
2004	4,170	1,445	1,764	2,234	2,392
2005	4,220	1,452	1,778	2,260	2,416
2006	4,271	1,459	1,792	2,286	2,439
2007	4,322	1,466	1,806	2,311	2,461
2008	4,373	1,473	1,820	2,337	2,485
2009	4,425	1,480	1,834	2,363	2,508
2010	4,457	1,486	1,848	2,389	2,531
2011	4,495	1,491	1,859	2,409	2,550
2012	4,532	1,496	1,870	2,429	2,569
2013	4,570	1,501	1,881	2,449	2,588
2014	4,608	1,506	1,892	2,470	2,608
2015	4,646	1,512	1,903	2,490	2,627
2016	4,679	1,516	1,912	2,507	2,643
2017	4,712	1,520	1,922	2,525	2,660
2018	4,745	1,525	1,931	2,542	2,677
2019	4,778	1,529	1,941	2,560	2,694
2020	4,811	1,533	1,950	2,578	2,711
2021	4,844	1,538	1,960	2,596	2,728
2022	4,878	1,542	1,970	2,614	2,745
2023	4,911	1,547	1,980	2,632	2,762
2024	4,945	1,551	1,989	2,650	2,779
2025	4,979	1,556	1,999	2,668	2,797
2030	5,324	1,605	2,097	2,852	2,953
2035	5,686	1,656	2,200	3,046	3,117
2040	6,065	1,711	2,308	3,249	3,290
2045	6,464	1,768	2,421	3,463	3,473
2050	6,883	1,827	2,541	3,687	3,665

To develop barge traffic forecasts for cement, it was first necessary to make several critical assumptions. The most critical assumption dealt with prospective supply. In the past several years, cement demand in the five-state Upper Mississippi region has grown at a faster pace than supply. As a result, the region has become a net importer of cement in recent years. Much of the imports are moving via lake vessel or barge via the lower Mississippi River.

Discussions with most major cement producers in the region indicate that it is extremely unlikely that any new greenfield-site production capacity will be added in the region. Most cited the extremely rigorous and time consuming environmental permitting process as the primary reason behind the expected dearth in prospective new production capacity. To the extent new cement plants are built in the U.S., they likely will be built in coastal areas, which allows the producer to reach a much broader market thereby decreasing the likelihood that the plant will be stuck with excess inventories if demand softens in any particularly market. To the extent new plants are built in non-coastal regions, these likely will be built at sites already permitted with existing production facilities. The new plants essentially will be built to replace production units which will be retired due to age or efficiency concerns.

In addition, the cement industry has been undergoing a major consolidation. Much of the U.S. and upper Mississippi cement market has been captured by major international firms. Since these firms have both international and local cement manufacturing and distribution facilities, it was assumed that they will focus their new production efforts in those areas which have the lowest cost and greatest market access. Such areas include the Caribbean Basin, South America, and Western Europe, especially Spain and France. Given the international focus of these firms, they likely will rely on offshore supplies to fill the growing gap between domestic demand and domestic production. This trend is exemplified by the fact that Holnam currently is developing a dedicated cement terminal on the lower Mississippi in Louisiana to handle imported cement shipments. Lafarge Corporation, meanwhile, assisted an independent lower Mississippi stevedore to secure and refurbish a floating cement pump designed to transfer cement from vessel to barge in a safe, environmentally friendly manner.

Given these developments, Criton assumes that there will be no additional greenfield cement capacity built in the Upper Mississippi Study region. Additional capacity, to the extent it develops, will result from efficiency improvements and equipment retrofits at existing plant sites. It is not believed that these measures alone will be sufficient to totally meet prospective demand.

The primary implication of this assumption is that outbound cement shipments from the three river-served cement plants discussed above will decline once regional cement demand reaches a certain level. It is assumed that cement from these facilities will move in increased volumes to inland markets in central and western Iowa and Missouri to supplement production shortfalls in these regions. The cement producers will then turn to offshore supplies and import cement and move it via barge to those terminals which formerly received most of their cement from the three U.S. river-served plants located on the upper Mississippi River. As a result, as regional cement demand increases, inbound barge receipts should increase at a higher pace than overall demand, while outbound barge shipments should increase at a slower pace and eventually decline as they are increasingly displaced by imports.

Riverborne Receipts: Minnesota and Wisconsin

In developing a riverborne cement forecast, Criton developed separate forecasts for individual market segments. These include inbound barge receipts for the Minnesota/Wisconsin market, inbound barge receipts for the Iowa/Missouri market and inbound barge receipts for the Chicago market. Criton also developed a separate forecast for outbound shipments for the Iowa/Missouri market. These were then analyzed to develop "through" forecasts for the upper Mississippi. All of these forecasts are derived from the state-level cement demand forecasts summarized in Table 10 and Appendix B.

To forecast barge shipments to the Minnesota/Wisconsin market, Criton evaluated the relationship between overall demand and the modal distribution of these shipments. A statistical analysis of these relationships revealed that on average as cement demand in the region increased, the proportion of cement delivered into these markets by rail and truck declined (see Table I.6). Statistically, the relationship between the proportion of cement delivered into the Minnesota/Wisconsin market by rail or truck can be estimated by the function:

$$Yo = 77.78 - 0.00816(Xo) \qquad (A)$$

where Yo equals the share of Minnesota and Wisconsin cement demand delivered by rail or truck and Xo represents total Minnesota/Wisconsin cement demand. It is apparent from this function that as regional cement demand increases, the share of cement delivered by rail or truck decreases. This is consistent with our assumption regarding constrained regional production.

The estimates of rail/truck modal share at various demand levels were used to estimate total volumes of rail/tuck deliveries of cement to the Minnesota/Wisconsin market. These volumes were then subtracted from total demand for these states to determine how much volume would be needed to be delivered by barge or lake vessel. Based on a review of historical market shares of waterborne deliveries to the Minnesota and Wisconsin markets, it was assumed that 34 percent of the non-rail/truck shipments would be delivered by barge while the remaining 66 percent would arrive by lake vessel. An illustration of this methodology for the forecast years 2000 to 2009 is summarized in Table I.10.

Table I.10.
Derivation of Minnesota/Wisconsin Cement Barge Demand Forecast

	(1)	(2)	(3)	(4)	(5)	(6)
	MN/WI	Rail/Truck				
	Demand	Share	Volume	Remainder	Barge	Lakes
Deriv.	Given	Eq. (A)	(1)x(2)	(1)-(3)	(4)x0.34	(4)x0.66
2000	4005	45.10%	1806	2198	747	1451
2001	4042	44.80%	1811	2231	759	1473
2002	4079	44.49%	1815	2264	770	1495
2003	4117	44.18%	1819	2298	781	1517
2004	4156	43.87%	1823	2332	793	1539
2005	4194	43.56%	1827	2367	805	1562
2006	4231	43.26%	1830	2400	816	1584
2007	4267	42.96%	1833	2434	828	1606
2008	4304	42.66%	1836	2468	839	1629
2009	4342	42.35%	1839	2503	851	1652

Riverborne Receipts: Illinois

The same methodology used to develop the Minnesota/Wisconsin barge demand forecast also was used to estimate riverborne cement shipments on the Illinois Waterway using Illinois and Chicago-area cement demand data. As in the case of Minnesota/Wisconsin, the proportion of regional demand met by rail or truck deliveries falls as demand increases. This relationship has been estimated by the function:

$$Yc = 59.58 - 0.01504(Xc) \qquad (B)$$

Where Yc equals the proportion of Chicago's cement demand delivered by rail or truck while Xc equals overall Chicago cement demand. Table I.11 illustrates the full methodology used to derive the Chicago barged cement demand forecast.

Table I.11.
Derivation of Illinois Waterway (Chicago) Cement Barge Demand Forecast

	(1)	(2)	(3)	(4)	(5)	(6)
	Chicago	Rail/Truck				
	Demand	Share	Volume	Remainder	Barge	Lakes
Deriv.	Given	Eq. (B)	(1)x(2)	(1)-(3)	(4)x0.53	(4)x0.47
2000	2035	28.98%	590	1445	766	679
2001	2060	28.60%	589	1471	779	691
2002	2085	28.23%	588	1496	793	703
2003	2110	27.85%	588	1522	807	716
2004	2135	27.46%	586	1549	821	728
2005	2161	27.08%	585	1576	835	741
2006	2187	26.69%	584	1603	850	754
2007	2213	26.30%	582	1631	864	767
2008	2239	25.90%	580	1659	879	780
2009	2265	25.50%	578	1688	895	793

Riverborne Receipts: Iowa/Missouri

While the riverborne receipts of cement in the Iowa/Missouri market are relatively small when compared to the overall market, this segment will gain in importance as cement demand in these two states grows. In particular, inbound shipments into this market should grow for two reasons: 1) increased receipts of clinkers to supplement local production and 2) the use of imports to backfill growing river markets as more and more local production is diverted to inland markets. Historical data support these observations. Riverborne receipts of cement in this market grow relatively rapidly as overall regional demand grows. This relationship can be estimated by the function:

$$Yi = -378.6 + 0.153662(Xi) \qquad \text{(C)}$$

where Yi equals barged receipts of cement in the Iowa/Missouri market while Xi equals total cement demand in Iowa and Missouri.

"Outbound" Shipments: Upper Miss from Twin Cities to Missouri River

While riverborne receipts of cement are grow at a faster rate than overall demand because of constrained domestic supplies, the opposite relationship holds for "outbound" barge shipments from origins on the Upper Mississippi between the Twin Cities and the mouth of the Missouri River. Historically, the ratio of "Outbound" upper Mississippi barge shipments to total Iowa and Missouri cement demand fell as cement demand increased. This is not surprising since it supports the theory that cement producers divert increased volumes of cement from their river-served plants to inland markets as demand in those markets grows, relying on imported materials to meet the shortfall at their barge-served terminals. This relationship between overall demand and outbound shipments can be estimated using the function:

$$Yd = .46 - 0.00005163\ (Xd) \qquad \text{(D)}$$

where Yd equals the ratio of "outbound" riverborne cement shipments from Iowa and Missouri to total cement demand in those states. Xd, meanwhile, equals total cement demand in Iowa and Missouri. An example for how this data was used to derive "outbound" traffic estimates is summarized in Table I.12.

Table I,12.
Derivation of Upper Miss "Outbound" and "Through" Traffic

	(1) IA/MO Demand	(2) Yd	(3) Outbound Barge Total	(4) Outbound Barge Chicago	(5) Outbound Barge St. Louis	(6) Other	(7) Chicago Demand	(8) UMiss Through
Deriv.	Given	Eq (D)	(1)x(2)	(3)x.66	(3)x.152	(3)x.188	Table 12	(7)-(4)
2000	3549	27.65%	981	648	149	184	766	118
2001	3581	27.48%	984	650	150	185	779	130
2002	3614	27.31%	987	651	150	186	793	142
2003	3646	27.14%	990	653	150	186	807	154
2004	3680	26.97%	992	655	151	187	821	166
2005	3713	26.80%	995	657	151	187	835	178
2006	3745	26.64%	997	658	152	188	850	191
2007	3777	26.47%	1000	660	152	188	864	205
2008	3810	26.30%	1002	661	152	188	879	218
2009	3842	26.13%	1004	663	153	189	895	232

Once the "outbound" estimates were derived (Column 3), the outbound volumes were then split into three separate groupings according to their historic market shares. It was assumed that 66 percent of Upper Mississippi outbound traffic would move into the Chicago market. It also was assumed the approximately 15 percent would move into the St. Louis market and approximately 19 percent would move to other markets. With this information, it was possible to estimate "through" volumes moving via the upper Mississippi on their way from points south onto the Illinois waterway. These "through" volumes were assumed to represent all barge deliveries into the Chicago market that were not met with shipments from upper Mississippi origins. In Table I.12, this is represented by Column 8, which equals Column 4 subtracted from Column 7.

IV. Riverborne Cement Traffic Forecasts for the Upper Mississippi and Illinois Waterways.

The aggregate results of the preceding analyses for the upper Mississippi River from the Twin Cities to the Mouth of the Missouri River are summarized in Table I.13. Projected upper Mississippi riverborne cement shipments under the base cement demand forecast are expected to exceed four million tons by 2050. Shipments in all categories grows through the early years of the forecast. Growth is especially brisk in "Inbound/Intra" shipments as well as "Through" shipments, reflecting the need to rely increasingly on waterborne cement deliveries in these markets. "Outbound" cement traffic also is projected to grow through 2029, but its rate of growth is substantially below the increases forecast for "Inbound/Intra" shipments and "Through" shipments. "Outbound" shipments are then projected to decline beginning in 2029.

As expected, riverborne cement shipments grow at a much faster pace in the high demand growth scenario. The decline in "Outbound" shipments, meanwhile, occurs at a much earlier date than in the base case, representing only 13 percent of waterway cement traffic by 2050.

Riverborne cement traffic projections for the Illinois Waterway are presented in Table I.14. The vast majority of this traffic represents cement moving into the upper reaches of the Illinois Waterway to meet demand in the metropolitan Chicago area market.

Table I.13. Projected Riverborne Shipments of Cement and Concrete: Upper Mississippi Twin Cities to Missouri River

	Low				Base				High			
	In/Intra	Outbound	Through	Total	In/Intra	Outbound	Through	Total	In/Intra	Outbound	Through	Total
2000	681	934	0	1614	914	981	118	2014	1168	1011	320	2499
2001	688	936	0	1624	930	984	130	2044	1194	1013	343	2549
2002	696	939	0	1634	947	987	142	2075	1220	1015	366	2601
2003	703	941	0	1644	963	990	154	2106	1247	1017	390	2654
2004	711	943	0	1654	980	992	166	2138	1275	1019	414	2708
2005	718	946	0	1664	997	995	178	2170	1303	1020	440	2763
2006	726	948	0	1674	1013	997	191	2202	1330	1021	462	2813
2007	733	950	0	1683	1029	1000	205	2234	1357	1022	485	2863
2008	740	953	0	1693	1046	1002	218	2266	1384	1023	508	2915
2009	748	955	0	1703	1063	1004	232	2299	1412	1023	532	2967
2010	755	957	0	1712	1080	1006	240	2326	1440	1023	557	3020
2011	760	958	0	1719	1093	1008	250	2351	1464	1023	576	3063
2012	765	960	0	1725	1107	1009	261	2376	1487	1023	595	3106
2013	770	961	1	1732	1120	1010	271	2402	1511	1023	616	3150
2014	775	962	4	1742	1134	1012	282	2427	1536	1022	636	3194
2015	780	964	8	1752	1148	1013	293	2453	1561	1022	657	3239
2016	784	965	12	1760	1160	1014	302	2475	1582	1021	674	3277
2017	788	966	16	1769	1171	1015	311	2497	1604	1020	692	3316
2018	791	967	19	1777	1184	1016	321	2520	1626	1019	710	3355
2019	795	968	23	1786	1196	1016	330	2543	1648	1018	728	3394
2020	799	969	27	1795	1208	1017	340	2565	1670	1017	747	3434
2021	803	970	31	1803	1220	1018	350	2588	1693	1016	766	3474
2022	807	970	34	1812	1233	1019	360	2612	1716	1014	785	3515
2023	811	971	38	1821	1245	1019	370	2635	1739	1013	805	3556
2024	815	972	42	1830	1258	1020	380	2659	1763	1011	824	3598
2025	819	973	46	1839	1271	1021	391	2682	1787	1009	845	3640
2030	885	988	101	1973	1395	1023	501	2920	1982	987	1030	4000
2035	954	1000	162	2117	1530	1020	626	3176	2198	953	1242	4394
2040	1027	1010	231	2269	1676	1010	768	3454	2436	905	1484	4825
2045	1105	1018	308	2431	1834	992	928	3754	2698	841	1676	5215
2050	1188	1022	393	2603	2006	965	1108	4079	2987	758	1882	5627

Table I.14. Projected Riverborne Shipments of Cement: Illinois Waterway			
	Low	Base	High
2000	569	766	987
2001	573	779	1011
2002	578	793	1036
2003	583	807	1061
2004	587	821	1087
2005	592	835	1113
2006	598	850	1136
2007	603	864	1159
2008	609	879	1183
2009	615	895	1207
2010	621	904	1232
2011	626	915	1251
2012	630	927	1271
2013	635	938	1291
2014	640	949	1311
2015	644	961	1331
2016	649	971	1348
2017	653	981	1365
2018	657	991	1383
2019	662	1001	1400
2020	666	1012	1418
2021	671	1022	1436
2022	675	1032	1454
2023	679	1043	1473
2024	684	1054	1492
2025	688	1064	1511
2026	701	1086	1543
2027	714	1108	1577
2028	726	1130	1611
2029	740	1153	1646
2030	753	1177	1682
2031	766	1200	1718
2032	780	1224	1755
2033	794	1249	1793
2034	808	1274	1832
2035	822	1299	1872
2040	898	1434	2082
2045	980	1583	2231
2050	1068	1745	2382

Part II. Sand, Gravel & Stone

I. Introduction

Because sand, gravel and crushed stone (primarily limestone) are found in significant quantities throughout the uppert Mississippi River basin, significant quantities of these materials are transported by barge along the upper Mississippi and Illinois Rivers. Part II of this report focuses on historic, current and prospective sand/gravel/stone supply/demand issues in the five state Upper Mississippi River Basin study region and their consequences on prospective riverborne traffic for these materials. This part of the report is divided into four major sections including this introduction. Section II reviews historic sand and gravel production and consumption patterns in the Upper Mississippi study region. The section also summarizes historic riverborne shipments of sand/gravel/stone shipments into and out of the region, and identifies major factors that likely will affect future sand, gravel and stone supply and demand as well as how those factors likely will influence riverborne traffic levels for these commodities. Section III discusses the methodology and major assumptions used to generate prospective demand levels as well as prospective riverborne traffic levels for the sand/gravel/stone sector. The final section presents Criton's forecast for riverborne sand/gravel/stone shipments through 2050 given the assumptions and methodologies discussed in the previous sections.

II. Sand and Gravel Production, Consumption, and Riverborne Traffic

Sand, gravel, and crushed stone are found in relative abundance throughout the upper Mississippi study region (As discussed later in this report, riverborne crushed stone traffic is extremely small when compared with riverborne sand and gravel traffic. Because of this, the vast majority of this section of the report focuses on the sand and gravel industry.) 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 (see Table II.1)

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 throughout the region, practically all of the sand and gravel sold in each of the five states was produced in those states.

Table II.1.
Construction Sand and Gravel Sold in Five-State Study Region by State (000s of Tons)

	Illinois	Iowa	Minnesota	Missouri	Wisconsin	Total
1981	25,150	10,330	23,950	7,500	18,210	85,140
1982	24,557	10,064	20,276	6,359	14,515	75,771
1983	21,100	11,800	24,600	7,700	14,200	79,400
1984	25,969	13,882	22,612	7,967	17,785	88,215
1985	26,600	12,000	25,000	7,500	16,000	87,100
1986	27,867	14,511	24,055	9,746	24,913	101,092
1987	28,300	19,000	25,200	10,900	23,900	107,300
1988	30,098	11,880	33,769	11,217	25,048	112,012
1989	33,000	12,800	33,700	10,000	21,700	111,200
1990	32,380	14,953	33,869	9,243	29,572	120,017
1991	26,300	17,400	24,500	7,400	29,600	105,200
1992	35,695	16,825	37,604	9,024	29,109	128,257
1993	38,019	18,293	33,611	7,053	30,415	127,391
1994	41,764	16,860	32,509	10,756	32,178	134,067

Source: U.S. Bureau of Mines, Minerals Yearbook, 1982-1994

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.

Despite the close proximity of waterway navigation in the five-state study region, the proportion of regional sand and gravel production moving by barge is less than three percent. For the upper Mississippi between the Twin Cities and the mouth of the Missouri River, sand, gravel and stone traffic totaled between 2.8 and 3.5 million tons per year during the 1990 to 1994 period (see Table II.2). Sand and gravel accounted for 90 percent of this tonnage while crushed stone constituted the remainder.

Sand and gravel moving on the Illinois River, meanwhile, totaled between 1.3 and 2.5 million tons per year over the same five-year period. Crushed stone shipments were negligible during the 1990 to 1994 period.

Table II.2.
Sand/Gravel/Stone Traffic on the Upper Mississippi and Illinois Rivers: 1990-1994
(000s of Tons)

Upper Mississippi: Twin Cities to Mouth of Missouri River

Year	Inbound	Outbound	Through	Intra	Total
1990	234	146	177	2851	3390
1991	166	132	179	2469	3001
1992	131	268	255	2812	3466
1993	76	220	263	2313	2884
1994	140	375	325	2575	3412

Illinois River

Year	Inbound	Outbound	Through	Intra	Total
1990	470	1146	60	5	1681
1991	441	747	114	16	1317
1992	499	725	127	3	1354
1993	528	790	117	3	1438
1994	692	1615	178	12	2497

Source: Waterborne Commerce of the United States: 1990-1994

Upper Mississippi River Sand and Gravel Markets

In general, the riverborne market for sand and gravel on the upper Mississippi River between the Twin Cities and the mouth of the Missouri River is concentrated into two distinct and fairly concentrated geographic markets. Because sand and gravel are relatively low value commodities and generally found in abundant quantities throughout the region, these materials generally travel only very short distances by barge within these two regional river sand and gravel markets.

The largest riverborne sand and gravel market is located along the upper Mississippi River in southern Minnesota. In recent years, approximately 70 percent of all sand and gravel moving on the Upper Mississippi River above the mouth of the Missouri River represents sand and gravel mined in southern Minnesota and the Minneapolis/St. Paul area moving short distances by barge within this region. The second largest market segment represents sand and gravel mined in Rock Island and Jo Daviess Counties in northwestern Illinois. A small portion of riverborne sand and gravel mined in this general area also originates in Clinton County, Iowa. Combined, these markets, which primarily supply sand and gravel users in Illinois, account for 20 percent of total Upper Mississippi sand and gravel shipments. The remaining 10 percent of the Upper Mississippi sand and gravel traffic is believed to be moving into Iowa and Missouri.

Illinois River Sand and Gravel Markets

The vast majority of the sand and gravel shipped on the Illinois River originates at the northern end of the waterway between Hennepin, IL and Chicago with nearly all of this traffic moving into and out of the Chicago metropolitan area. Most of this sand and gravel stays within this localized area, although 200,000 to 300,000 tons does move from the Chicago are to Peoria. A relatively small volume of sand and gravel also moves from the upper Mississippi to the southern segment of the Illinois River.

III. Sand/Gravel/Stone Forecast Methodology and Assumptions.

The primary underlying variables driving Criton's riverborne sand/gravel/stone forecasts are total demand for sand and gravel for the two states accounting for practically all of the riverborne shipments of sand/gravel/stone in the five-state study region: Minnesota and Illinois. Total sand and gravel demand forecasts were developed for each of these states.

The U.S. Bureau of Mines estimates that over 40% of all U.S. sand and gravel is used to produce concrete or cement products such as pipe. The second largest use (28%) represents sand and gravel used for road base and road stabilization. The remainder is used for asphaltic concrete aggregates, fill material, and miscellaneous uses. Since such a large percentage of sand and gravel use is devoted to uses in concrete applications and much of the remaining uses are complementary to concrete applications, it was assumed that state-level sand and gravel demand would be most heavily influenced by demand for cement.

To determine the relationship between state-level cement demand and state-level demand for sand and gravel, Criton compared these data using ordinary least squares regression techniques. In general, the regression analyses yielded significant and fairly strong statistical relationships between cement demand (independent variable) and sand/gravel demand (dependent variable). The results of these analyses are summarized in Table II.3.

Table II.3
Regression Results of Analysis of Relationship Between State Cement Demand and State Sand/Gravel Demand

State	Intercept	Coefficient	R-Square
Illinois	11098	5.478	0.83
Minnesota	729	18.77	0.54

Using the regression results summarized in Table II.3, state-level sand/gravel demand forecasts for Illinois and Minnesota were generated through the year 2050. Data for future cement demand levels were obtained from Part I of this report (Table I.10). The resulting forecast for total state-level sand and gravel demand is summarized in Table II.4.

Table II.4. Projected Demand for Sand & Gravel (000s of Tons)		
Year	Illinois	Minnesota
2000	32,867	32,744
2001	33,133	33,010
2002	33,401	33,280
2003	33,671	33,551
2004	33,943	33,825
2005	34,218	34,102
2006	34,494	34,358
2007	34,774	34,617
2008	35,055	34,878
2009	35,339	35,141
2010	35,516	35,406
2011	35,721	35,610
2012	35,928	35,815
2013	36,135	36,021
2014	36,343	36,229
2015	36,553	36,438
2016	36,732	36,615
2017	36,911	36,792
2018	37,091	36,971
2019	37,272	37,151
2020	37,454	37,332
2025	38,376	38,249
2030	40,264	40,084
2035	42,246	42,014
2040	44,327	44,041
2045	46,511	46,173
2050	48,803	48,413

IV. Riverborne Traffic 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 the function:

$$Ya = 1093 + 0.029102(Xa)$$

where Ya equals riverborne sand and gravel traffic in the Minnesota region and Xa represents total Minnesota sand and gravel demand. The resulting forecast is summarized in Table II.5.

Criton's forecast for riverborne sand and gravel moving on the Upper Mississippi into the Illinois market, meanwhile, is based on a strong statistical relationship between total Illinois sand and gravel demand and riverborne shipments moving into these markets. This relationship can be estimated with the following function:

$$Yb = 92 + 0.01519(Xb)$$

where Yb represents upper Mississippi sand and gravel traffic moving into local Illinois markets and Xb represents total Illinois sand and gravel demand. The resulting forecast is summarized in Table II.5. Forecasts for the remaining 10 percent of the upper Mississippi's "inbound" and "intra" traffic was generated using a weighted average of the Minnesota and Illinois upper Mississippi sand and gravel traffic forecasts. This forecast also is summarized in Table II.5.

Though non-local "through" and "outbound" traffic on the Upper Mississippi River is extremely small relative to local Minnesota and Illinois demand, forecasts also were developed for these market segments. Since most through traffic represents sand and gravel moving to or from sources on the Illinois River, it was assumed that there would be a correlation between total sand and gravel traffic on the Illinois River and "through" traffic on the upper Mississippi. This relationship was found to exist and was estimated using the following function:

$$Yc = 30.37 + 0.00633(Xc)$$

where Yc represents Upper Mississippi sand and gravel "through" traffic and Xc represents total Illinois River sand and gravel traffic (the forecast for Illinois River sand and gravel traffic is discussed later in this report).

Sand and gravel moving "outbound" from the upper Mississippi generally moves to points on the southern section of the Illinois River. As a result, it was assumed that most significant variable affecting "outbound" upper Mississippi sand and gravel would be total Illinois sand and gravel demand. This relationship was found to be statistically significant and was estimated using the following function:

$$Yd = -289.7 + 0.0149(Xd)$$

where Yd represent total Upper Mississippi "outbound" sand and gravel traffic while Xd represents total Illinois sand and gravel demand. Again, these results are summarized in Table II.5.

While crushed stone represents a tiny fraction of upper Mississippi traffic when compared to the sand and gravel sector, volumes of crushed stone are none-the-less significant. Practically all of the crushed stone moving on the upper Mississippi River above the mouth of the Missouri River is quarried in Illinois. As such, it was thought that upper Mississippi crushed stone traffic would be statistically related to total Illinois sand and gravel demand. A strong correlation was found between these two variables which was estimated using the function:

$$Ye = 60.74 + 0.007317(Xe)$$

where Ye represents Upper Mississippi crushed stone traffic while Xe represent Illinois sand and gravel demand. The results of this forecast also are summarized in Table II.5.

Table II.5. Upper Mississippi Traffic Forecast: Sand/Gravel/Stone (000s of Tons)

	Sand/Gravel								
	In/Intra							Total	Grand
Year	Minn	Illinois	Other	Total	Through	Outbound	Total	Stone	Total
2000	2046	591	237	2875	239	199	3312	301	3614
2001	2054	595	238	2888	240	203	3331	303	3634
2002	2062	599	240	2901	242	207	3350	305	3655
2003	2070	603	241	2914	244	211	3368	307	3676
2004	2078	608	242	2927	245	215	3387	309	3697
2005	2086	612	243	2940	247	219	3407	311	3718
2006	2093	616	244	2953	249	223	3425	313	3738
2007	2101	620	245	2966	251	227	3444	315	3759
2008	2108	625	246	2979	252	232	3463	317	3780
2009	2116	629	247	2992	254	236	3482	319	3801
2010	2124	632	248	3003	255	238	3497	321	3818
2011	2130	635	249	3013	257	241	3511	322	3833
2012	2136	638	250	3023	258	244	3526	324	3849
2013	2142	641	250	3033	259	248	3540	325	3865
2014	2148	644	251	3043	261	251	3554	327	3881
2015	2154	647	252	3053	262	254	3569	328	3897
2016	2159	650	253	3062	263	256	3581	330	3911
2017	2164	653	254	3070	264	259	3594	331	3924
2018	2169	655	254	3079	265	262	3606	332	3938
2019	2175	658	255	3088	266	264	3619	333	3952
2020	2180	661	256	3096	268	267	3631	335	3966
2025	2207	675	259	3141	273	281	3695	342	4037
2030	2260	704	267	3230	285	309	3825	355	4180
2035	2316	734	274	3324	298	338	3961	370	4331
2040	2375	765	283	3423	311	369	4104	385	4489
2045	2437	799	291	3527	325	402	4254	401	4655
2050	2502	833	300	3636	340	436	4411	418	4829

Traffic levels on the Illinois River, meanwhile, generally were expected to be strongly correlated with total demand for sand and gravel in the state of Illinois (the volume of crushed stone moving on the Illinois River is negligible). This relationship can be expressed by the function:

$$Yf = -193 + 0.0505(Xf)$$

where Yf equals total Illinois River sand and gravel traffic while Xf equal total Illinois sand and gravel demand. The resulting forecast for Illinois River sand, gravel and stone traffic is summarized in Table II.6.

Table II.6. Projected Riverborne Sand/Gravel Stone Traffic: Illinois River (000s of Tons)

Year	Grand Total
2000	1468
2001	1481
2002	1495
2003	1508
2004	1522
2005	1536
2006	1550
2007	1564
2008	1578
2009	1593
2010	1602
2011	1612
2012	1622
2013	1633
2014	1643
2015	1654
2016	1663
2017	1672
2018	1681
2019	1690
2020	1700
2025	1746
2030	1842
2035	1942
2040	2047
2045	2157
2050	2273

Appendix A

Forecast Gross State Product: Construction

Appendix A: Forecast Gross State Product: Construction (Millions)

	Illinois			Iowa			Minnesota			Missouri			Wisconsin		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
2000	9,703	11,129	12,556	1,765	2,000	2,235	3,830	4,216	4,601	3,779	4,204	4,629	3,537	4,387	5,238
2001	9,738	11,220	12,702	1,771	2,016	2,261	3,856	4,252	4,649	3,800	4,239	4,677	3,551	4,430	5,310
2002	9,773	11,313	12,850	1,778	2,032	2,286	3,881	4,290	4,698	3,822	4,274	4,726	3,564	4,474	5,382
2003	9,809	11,405	13,000	1,784	2,048	2,312	3,907	4,327	4,747	3,843	4,309	4,775	3,579	4,517	5,456
2004	9,845	11,499	13,151	1,790	2,064	2,339	3,933	4,365	4,797	3,865	4,345	4,824	3,593	4,562	5,530
2005	9,881	11,593	13,305	1,796	2,080	2,365	3,960	4,404	4,848	3,886	4,381	4,875	3,607	4,606	5,605
2006	9,924	11,688	13,437	1,804	2,095	2,387	3,981	4,439	4,898	3,906	4,415	4,924	3,623	4,648	5,674
2007	9,967	11,784	13,571	1,813	2,111	2,409	4,002	4,475	4,948	3,926	4,450	4,973	3,639	4,691	5,743
2008	10,010	11,881	13,706	1,821	2,126	2,432	4,023	4,511	4,999	3,946	4,485	5,023	3,656	4,734	5,813
2009	10,053	11,978	13,842	1,829	2,142	2,455	4,044	4,548	5,051	3,966	4,520	5,074	3,672	4,778	5,884
2010	10,097	12,039	13,980	1,838	2,158	2,478	4,066	4,584	5,103	3,987	4,556	5,125	3,688	4,822	5,955
2011	10,131	12,109	14,086	1,841	2,169	2,497	4,082	4,613	5,143	4,001	4,583	5,165	3,697	4,857	6,016
2012	10,166	12,180	14,194	1,844	2,181	2,517	4,099	4,641	5,183	4,015	4,610	5,205	3,706	4,892	6,078
2013	10,200	12,251	14,302	1,848	2,192	2,537	4,115	4,670	5,224	4,030	4,638	5,246	3,715	4,928	6,141
2014	10,235	12,323	14,410	1,851	2,204	2,556	4,132	4,698	5,265	4,044	4,666	5,287	3,724	4,964	6,204
2015	10,270	12,395	14,520	1,854	2,216	2,577	4,149	4,727	5,306	4,059	4,694	5,328	3,733	5,000	6,267
2016	10,301	12,456	14,611	1,857	2,225	2,594	4,162	4,752	5,342	4,069	4,717	5,365	3,740	5,031	6,321
2017	10,333	12,518	14,702	1,859	2,235	2,611	4,175	4,777	5,378	4,080	4,741	5,402	3,747	5,062	6,376
2018	10,365	12,580	14,794	1,862	2,245	2,628	4,189	4,801	5,414	4,090	4,765	5,439	3,755	5,093	6,431
2019	10,396	12,642	14,887	1,864	2,255	2,646	4,202	4,826	5,450	4,101	4,789	5,476	3,762	5,125	6,486
2020	10,428	12,704	14,980	1,867	2,265	2,664	4,216	4,851	5,486	4,112	4,813	5,514	3,770	5,156	6,542
2025	10,589	13,021	15,454	1,879	2,316	2,754	4,284	4,978	5,672	4,165	4,936	5,706	3,807	5,317	6,828
2030	11,039	13,669	16,299	1,941	2,429	2,917	4,467	5,233	5,998	4,341	5,187	6,032	3,947	5,608	7,267
2035	11,509	14,350	17,190	2,005	2,548	3,089	4,658	5,500	6,341	4,524	5,451	6,376	4,092	5,915	7,734
2040	11,999	15,064	18,129	2,071	2,672	3,272	4,856	5,781	6,705	4,714	5,728	6,740	4,242	6,238	8,231
2045	12,509	15,814	19,120	2,140	2,803	3,466	5,064	6,076	7,089	4,913	6,019	7,125	4,398	6,579	8,760
2050	13,041	16,601	20,165	2,210	2,939	3,671	5,280	6,387	7,495	5,120	6,325	7,532	4,559	6,939	9,324

Appendix B:

High and Low Cement Demand Forecasts by State

Projected Cement Demand By State Low Case (000s of Tons)					
Year	Illinois	Iowa	Minnesota	Missouri	Wisconsin
2000	3,215	1,315	1,558	1,819	1,843
2001	3,234	1,318	1,568	1,835	1,851
2002	3,253	1,321	1,577	1,850	1,858
2003	3,272	1,323	1,587	1,866	1,866
2004	3,291	1,326	1,597	1,882	1,873
2005	3,310	1,329	1,607	1,898	1,881
2006	3,333	1,332	1,616	1,912	1,889
2007	3,356	1,336	1,624	1,927	1,898
2008	3,379	1,340	1,632	1,942	1,907
2009	3,402	1,343	1,640	1,957	1,916
2010	3,425	1,347	1,648	1,971	1,924
2011	3,443	1,348	1,655	1,982	1,929
2012	3,461	1,350	1,661	1,992	1,934
2013	3,480	1,351	1,667	2,003	1,939
2014	3,498	1,353	1,674	2,014	1,943
2015	3,517	1,354	1,680	2,024	1,948
2016	3,534	1,355	1,685	2,032	1,952
2017	3,550	1,356	1,690	2,040	1,956
2018	3,567	1,357	1,696	2,048	1,960
2019	3,584	1,358	1,701	2,055	1,964
2020	3,601	1,359	1,706	2,063	1,968
2025	3,686	1,365	1,732	2,103	1,988
2030	3,926	1,392	1,803	2,231	2,063
2035	4,175	1,420	1,876	2,365	2,141
2040	4,436	1,449	1,952	2,505	2,221
2045	4,707	1,478	2,032	2,651	2,304
2050	4,990	1,509	2,115	2,803	2,391

Projected Cement Demand By State High Case (000s of Tons)					
Year	Illinois	Iowa	Minnesota	Missouri	Wisconsin
2000	4,732	1,520	1,854	2,443	2,754
2001	4,810	1,531	1,873	2,478	2,793
2002	4,888	1,542	1,891	2,514	2,832
2003	4,968	1,554	1,910	2,550	2,871
2004	5,049	1,565	1,930	2,586	2,911
2005	5,130	1,577	1,949	2,623	2,951
2006	5,201	1,586	1,968	2,659	2,988
2007	5,272	1,596	1,988	2,695	3,025
2008	5,343	1,606	2,007	2,732	3,062
2009	5,416	1,616	2,027	2,769	3,100
2010	5,489	1,626	2,047	2,807	3,138
2011	5,546	1,634	2,063	2,836	3,171
2012	5,603	1,643	2,078	2,866	3,204
2013	5,660	1,652	2,094	2,895	3,238
2014	5,718	1,660	2,109	2,926	3,272
2015	5,776	1,669	2,125	2,956	3,306
2016	5,824	1,676	2,139	2,983	3,335
2017	5,873	1,684	2,153	3,010	3,364
2018	5,922	1,692	2,167	3,037	3,393
2019	5,971	1,699	2,181	3,064	3,423
2020	6,021	1,707	2,195	3,092	3,453
2025	6,273	1,746	2,266	3,233	3,606
2030	6,722	1,817	2,391	3,472	3,841
2035	7,195	1,893	2,523	3,725	4,091
2040	7,695	1,972	2,663	3,992	4,357
2045	8,222	2,057	2,811	4,274	4,641
2050	8,777	2,146	2,967	4,573	4,943