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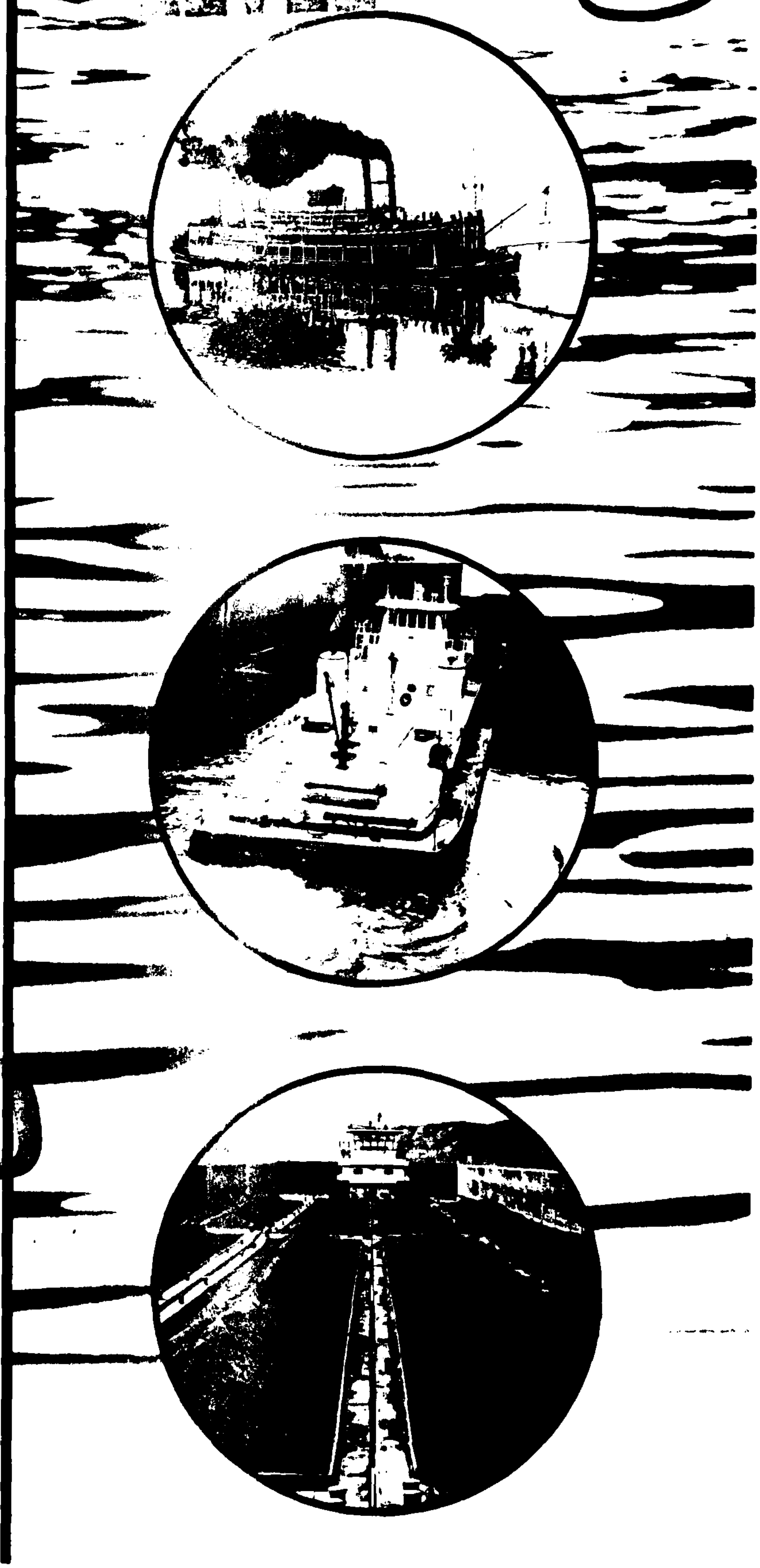

Projections Of Demand For Waterborne Transportation

Ohio River Basin
1980 - 2040

Volume 14

Rubber, Plastics, Nonmetallic Mineral Products, Nec.

U. S. Army Corps of Engineers
Ohio River Division
Cincinnati, Ohio

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

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(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 14 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title	
1	Study summary	
2	Methodology	
3	Group I:	Coal and coke
4	Group II:	Petroleum fuels
5	Group III:	Crude Petrol.
6	Group IV:	Aggregates
7	Group V:	Grains
8	Group VI:	Chemicals and chemical fertilizers
9	Group VII:	Ores and Minerals
10	Group VIII:	Iron ore, steel and iron
11	Group IX:	Feed and food products, nec.
12	Group X:	Wood and paper products
13	Group XI:	Petroleum products, nec.
14	Group XII:	Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII:	Nonferrous, metals and alloys, nec.
16	Group XIV:	Manufactured products, nec.
17	Group XV:	Other, nec.

Additionally, an Executive Summary is available as a separate document.

GROUP XII. RUBBER, PLASTIC, NONMETALLIC MINERAL PRODUCTS, NEC.

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040.

Prepared for

U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT

Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

DECEMBER 1980

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PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

Subject Title	Number of Pages	Volume Number
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
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Additionally, an Executive Summary is available as a separate document.

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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION
OHIO RIVER BASIN
1980, 1990, 2000, 2020, 2040

Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by
Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

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I. INTRODUCTION

Group XII, rubber, plastic and nonmetallic mineral products, nec., accounted for 0.8 percent of the waterborne traffic in the Ohio River System (ORS) during the period 1969-76. The major portion of Group XII movements has been the transport of nonmetallic mineral products, specifically cement and lime, with very little movement of rubber and plastic products. Cement and lime are both used in the construction industry, although lime is used predominantly for chemical and industrial purposes.

Although consumption and production characteristics for nonmetallic mineral products resemble those for aggregates, the two differ in terms of quality and supply. The movement of aggregates in the ORS is predominantly local, illustrating the abundance of supply near points of consumption. The movements of nonmetallic mineral products, however, include balanced tonnages of inbound, outbound, and local shipments.

The areas within the Ohio River Basin (ORB) for which projections of Group XII consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group XII are those U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) and area segments (aggregations of counties within a BEA) which are origins or destinations of Group XII waterborne movements. A map showing Group XII PSAs is presented in the appendix to this report.

In addition to the PSAs, external areas that are linked to the ORB through waterborne commerce have been identified. Areas (BEAs) outside the ORB which are destinations of Group XII movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB which are origins of Group XII waterborne movements destined to the ORB are designated as Secondary Production Areas (SPAs).

A. Description of Group XII

The individual products included in Group XII are:

Waterborne Commerce Statistics Code (WCSC)	Commodity/Product
3011	Rubber and miscellaneous plastics products
3111	Leather and leather products
3211	Glass and glass products
3241	Building cement
3251	Structural clay products, including refractories
3271	Lime
3281	Cut stone and stone products
3291	Miscellaneous nonmetallic mineral products.

Table 1 presents the waterborne movements in the ORS of Group XII products, by product, between 1969 and 1976. The majority of the movements were shipments of building cement and lime, which together accounted for 98.0 percent of Group XII movements in 1976. Rubber, plastic and miscellaneous nonmetallic mineral products generated only random and small movements in the 1969-76 period. Accordingly, analyses and projections of Group XII production, consumption and transportation flows are based entirely on analysis and projections for cement and lime.

A-1. Cement

Building, or hydraulic, cement is the major binding agent used in concrete construction. Approximately 95 percent of building cement is portland cement. Portland cement is manufactured by heating a proportional mixture of calcium silicates and other raw materials in a kiln until a partially fused material is produced. Producers of ready-mix concrete are the major consumers of cement,

Table 1 . Ohio River System: Waterborne Shipments of Rubber, Plastic, Nonmetallic Mineral Products by Commodity Inbound, Outbound, and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

Product and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total[a]	1,317.8	1,358.1	1,486.8	1,771.2	1,456.1	1,322.1	1,070.8	1,471.3	1.6
Inbound	502.0	412.1	438.6	552.1	417.3	528.0	460.8	627.1	3.2
Outbound	165.8	225.6	249.4	222.0	332.3	273.2	219.0	383.1	12.7
Local	649.9	720.5	798.8	997.1	706.5	521.0	391.0	461.1	(4.8)
Rubber, plastics products	0.1	--	0.1	--	0.1	--	0.4	1.1	40.9
Inbound	--	--	0.1	--	--	--	0.4	1.1	b
Outbound	0.1	--	c	--	0.1	--	--	--	b
Local	--	--	--	--	--	--	--	--	--
Glass, glass products	--	--	--	0.3	--	0.4	--	--	--
Inbound	--	--	--	0.3	--	--	--	--	--
Outbound	--	--	--	--	--	0.4	--	--	--
Local	--	--	--	--	--	--	--	--	--
Building cement	975.0	927.9	1,031.2	1,283.1	1,143.4	973.9	807.9	944.9	(0.5)
Inbound	387.3	329.6	328.0	361.0	350.5	367.0	329.5	416.9	1.1
Outbound	146.3	147.4	184.3	184.7	226.7	156.3	121.9	125.0	(2.2)
Local	441.4	450.9	518.9	737.4	566.2	450.6	356.5	403.0	(1.3)
Structural clay products	--	16.8	13.1	17.7	8.8	6.0	22.1	6.7	b
Inbound	--	--	--	--	--	--	--	1.1	b
Outbound	--	12.2	8.7	17.0	8.8	6.0	22.1	5.6	b
Local	--	4.6	4.4	0.7	--	--	--	--	--

(Continued)

Table 1. (Continued)

Product and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Lime	278.6	388.3	377.3	452.7	292.2	331.7	233.0	496.7	8.6
Inbound	114.7	82.5	104.4	190.8	66.4	161.0	130.9	204.7	8.6
Outbound	19.4	65.4	56.0	19.8	96.4	108.4	72.2	252.5	44.3
Local	144.5	240.4	216.9	242.1	129.4	62.3	29.9	39.5	(16.9)
Cut stone and stone products	--	--	--	--	--	--	--	13.0	b
Inbound	--	--	--	--	--	--	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	13.0	b
Nonmetallic mineral products	64.0	25.1	65.1	17.4	11.5	10.2	7.4	8.8	(24.7)
Inbound	--	--	6.2	--	0.3	--	--	3.3	b
Outbound	--	0.5	0.3	0.4	0.3	2.2	2.8	--	b
Local	64.0	24.6	58.6	17.0	10.9	8.0	4.6	5.5	(29.6)

Note: Individual items may not add to totals due to rounding.
a. Excludes waterborne commodity code no. 3111 (leather and leather products) for which no movements have been reported.
b. No movements reported in 1969.
c. Less than 50 tons.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

receiving approximately 66 percent of total portland cement production.[1] Most of the remaining production is used by concrete product producers, and highway and other contractors.

A-2. Lime

Lime, a basic chemical, is produced through heating calcites (such as limestone) or dolomite at high temperatures. Lime has a variety of uses, including chemical production, construction, steel production, water purification and air emission control. Raw material costs for lime production are relatively low. However, production requires more energy input per ton than is required for most industrial materials. Location of kilns is greatly influenced by the availability and cost of energy, the location of feedstock and output markets, and the cost of transportation to markets, given the existing transportation network.

B. Existing Waterway Flows

Between 1969 and 1976, total waterborne shipments of Group XII products increased from 1,317.8 thousand tons to 1,471.3 thousand tons, an average annual increase of 1.6 percent (Table 1). During that period, local movements declined, while outbound shipments increased significantly. Most of this increase was in the outbound movements of lime. However, in 1976 only 1.4 percent of total ORS outbound shipments were shipments of Group XII products (Table 2).

Major outbound shipping areas are BEA 54 (Louisville) and BEA 115 (Paducah). Of the 383.1 thousand tons shipped from the ORS in 1976, 93.3 percent was shipped from BEA 115, near the mouths of the Ohio and Cumberland Rivers (Table 3). Much of this was lime shipped from the Cumberland River to points in BEAs 46 (Memphis) and 133 (Monroe, Louisiana). BEA 54 shipped 17.8 thousand tons of lime outside the ORB to BEAs 133 (Monroe) and 135 (Jackson).

Major inbound shipments were movements of cement to BEAs 49 (Nashville) and 62 (Cincinnati), and of lime to BEA 68 (Cleveland). These shipments originated in BEAs 114 (St. Louis) and 115 (Paducah), points on the Mississippi River.

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1. U.S. Department of the Interior, Bureau of Mines, "Cement," Mineral Facts and Problems, 1975 ed. (Washington, D.C.: GPO, 1976).

Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Rubber, Plastic, and Nonmetallic Minerals Products, Nec., 1976

(Thousands of tons unless otherwise specified)

	Total	Inbound	Outbound	Local
All commodities	200,770.5	29,439.5	26,854.0	144,477.0
Rubber, plastic, nonmetallic mineral products, nec.	1,471.3	627.1	383.1	461.1
As a percentage of all commodities	0.7	2.1	1.4	0.3

Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, supplied by U.S. Army Corps of Engineers.

Table 3. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group 12: Rubber, Plastic, Nonmetallic Mineral Products, Nec.

(Thousands of tons)

Origin	Destination												
	Total	ORB BEAs	Bea 47	BEA 49	BEA 52	BEA 54	BEA 55	BEA 62	BEA 64	BEA 65	BEA 69	BEA 68	BEA 115
TOTAL	1,471.3	1,088.2	15.8	231.6	90.0	27.0	169.5	186.9	14.1	37.8	85.2	153.5	76.8
ORB BEAs	844.2	461.1	15.8	68.0	90.0	27.0	161.0	7.8	13.0	37.8	29.6	3.3	7.8
BEA 47	3.3	3.3	3.3	--	--	--	--	--	--	--	--	--	--
BEA 50	4.5	4.5	4.5	--	--	--	--	--	--	--	--	--	--
BEA 52	32.2	32.2	--	--	21.0	--	--	5.6	--	--	--	--	5.6
BEA 54	112.0	94.2	--	--	--	--	92.0	--	--	--	--	--	2.2
BEA 55	4.4	2.2	--	--	--	--	--	2.2	--	--	--	--	--
BEA 62	29.6	29.6	--	--	--	--	--	--	--	--	28.5	11.1	--
BEA 66	107.9	107.9	--	--	69.0	--	--	--	--	37.8	1.1	--	--
BEA 68	7.8	2.2	--	--	--	--	--	--	--	--	--	2.2	--
BEA 115	542.5	185.0	8.0	68.0	--	27.0	69.0	--	13.0	--	--	--	--
Non-ORB BEAs	627.1	627.1	--	163.6	--	--	8.5	179.1	1.1	--	55.6	150.2	69.0
BEA 114	349.0	349.0	--	163.6	--	--	8.5	175.8	--	--	1.1	--	--
BEA 115[a]	273.7	273.7	--	--	--	--	--	--	1.1	--	54.5	149.1	69.0
BEA 137	3.3	3.3	--	--	--	--	--	3.3	--	--	--	--	--
BEA 141	1.1	1.1	--	--	--	--	--	--	--	--	--	1.1	--

(Continued)

Table 3. (Continued)

Origin	Destination						
	Non-ORB BEAs	BEA 46	BEA 77	BEA 78	BEA 133	BEA 134	BEA 135
TOTAL	383.1	161.6	4.5	10.1	14.4	131.3	61.2
ORB BEAs	383.1	161.6	4.5	10.1	14.4	131.3	61.2
BEA 47	--	--	--	--	--	--	--
BEA 50	--	--	--	--	--	--	--
BEA 52	--	--	--	--	--	--	--
BEA 54	17.8	--	--	--	12.2	--	5.6
BEA 55	2.2	--	--	--	2.2	--	--
BEA 62	--	--	--	--	--	--	--
BEA 66	--	--	--	--	--	--	--
BEA 68	5.6	--	4.5	1.1	--	--	--
BEA 115	357.5	161.6	--	9.0	--	131.3	55.6
Non-ORB BEAs							
BEA 114							
BEA 115[a]							
BEA 137							
BEA 141	* * Traffic external to Ohio River System * *						

a. Consist of counties external to Ohio River Basin.
Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

C. Summary of Study Findings

Consumption of portland cement and lime in the areas served by the ORS declined during the period 1969 to 1976, from 7,711.5 thousand tons to 7,313.9 thousand tons. Consumption is projected to increase at an average annual rate of 4.1 percent through the year 2000, and at an average annual rate of 0.9 percent during the period 2000-2040.

Production of portland cement and lime in the PSAs increased from 4,048.0 thousand tons in 1969 to 4,215.0 thousand tons in 1976. Production is projected to increase at an average annual rate of 3.8 percent between 1974-76 and 2000. During the period 2000-2040, production is projected to increase 0.6 percent per year.

Gross waterborne shipments of Group XII products in the Ohio River System were projected to increase at an average annual rate of 4.9 percent during the period 1976-2000, and at an average annual rate of 1.1 percent during the period 2000-2040.

II. MARKET DEMAND ANALYSIS

Consumption of lime and cement in the areas served by the ORS declined during the period 1969 to 1976, from 7,711.5 thousand tons to 7,313.9 thousand tons. Consumption is projected to increase to 19,942.2 thousand tons by the year 2000, and to 28,511.0 thousand tons by the year 2040. Much of this increased consumption will be lime used in flue gas desulfurization.

A. Market Areas

In addition to local demand for Group XII commodities produced in the PSAs, demand also is generated in Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs that are the destinations of waterborne rubber, plastic, nonmetallic mineral products, nec., movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

This study has identified 12 BEAs and BEA segments in the ORB that either have been or will be the ultimate origins or destinations for waterborne rubber, plastic, nonmetallic mineral products, nec., movements. Appendix Table A-1 presents the BEAs and BEA segments which constitute the PSAs for Group XII. The consumption of the commodity group has been analyzed and projected for these areas.

A-2. Secondary Consumption Areas (SCAs)

BEAs outside the Ohio River Basin which are destinations of waterborne shipments from the ORB were not segmented. The major SCA in 1976 was BEA 46 (Memphis), which received 42 percent of the

383.1 thousand tons shipped by water from the ORB. Other SCAs were BEAs 77 (Chicago), 78 (Peoria), 133 (Monroe), 134 (Greenville), and 135 (Jackson).

B. Product Uses

Approximately 95 percent of U.S. cement production is portland cement, which is used for general construction. The remaining 5 percent is masonry cement used for stucco and mortar. Producers of ready-mix concrete consume two-thirds of portland cement production. The remainder is used by concrete product manufacturers, highway contractors, and other dealers and manufacturers.

Lime is used by the chemical industry for the production of alkalies, by the construction industry for plaster and mortar, by the steel industry, and in agriculture. In 1973, an estimated 92 percent of U.S. lime consumption was for chemical and industrial purposes.[1] The steel industry is the primary industrial user, where lime is utilized for open-hearth steel furnaces. A new major development is the use of lime and limestone in flue gas desulfurization processes. Lime scrubbers for power plants and other industrial plants have also created new demand for lime. However, other desulfurization methods exist and are competitive with lime/limestone processes.

C. Consumption Characteristics

Cement and lime are consumed throughout the PSAs. Demand for cement is linked to construction activity -- specifically, public works and residential, industrial and other private construction projects -- which varies with economic conditions, population shifts and government policy. Market areas for cement and lime are regional, with cement plants usually serving a market area within a 200-mile radius of the plant. Plants on waterways, however, have served customers as far as 1,000 miles from plant sites.

Most of the demand for lime is derived from the demand for specific chemical products and steel. Consumption of lime in the PSAs reflects the production activity of the chemical and steel industry. Approximately one-third of lime production is for captive use, mostly by chemical and steel producers.

Environmental controls have had two effects on increasing the consumption of lime. First, several plants in the United States

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1. U.S. Department of the Interior, Bureau of Mines, Mineral Facts and Problems, 1975 ed. (Washington, D.C.: GPO, 1976).

producing synthetic soda ash have been closed due to pollution control problems and competition from natural soda ash producers. Soda ash requires 0.7 tons of lime per ton of soda ash produced by Solvay process plants. Second, environmental concerns have encouraged the growth of pollution control processes that require lime.[1]

D. Existing Aggregate Demand

Consumption of cement and lime in the PSAs declined in the period 1969-76, from 7,711.5 thousand tons to 7,313.9 thousand tons (Table 4). This decline reflects decreases in cement consumption which had occurred in the years 1975 and 1976.

Major consuming PSAs were BEAs 66 (Pittsburgh), 62 (Cincinnati) and 52 (Huntington), where significant quantities of lime were consumed by the chemical and steel industries.

E. Forecasting Procedures and Assumptions

Projections of cement consumption in the PSAs are based on Bureau of Mines projections of national cement consumption in the year 2000. This forecast was based on analysis of sociological, economic and technological factors, and regression analyses of historical time series data compared with projections of various economic indicators. This national projection, developed in 1978, is the most recent projection of cement consumption available from a recognized authority. The projection was adjusted by using population projections of the 1972 OBERS Projections,[2] prepared for the U.S. Water Resources Council, to obtain cement consumption projections by BEA. Per capita consumption in each BEA was assumed to be the same as the national per capita consumption in 2000, thereafter increasing slowly during the period 2000-2040.

Lime consumption was projected using steel production projections by type of furnace, provided by the Iron Ore, Steel and Iron (Group VIII) Report of this study, and from projections of chemical production provided by the Chemicals and Chemical Fertilizers (Group VI) Report. In addition, Environmental Protection Agency (EPA) estimates of lime required for desulfurization purposes were used. Specific locational information was provided by these EPA estimates.

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1. "Key Chemicals: The Basic Products of the Chemical Industry," Chemical and Engineering News, 9 January 1978.
2. U.S. Water Resources Council, OBERS Projections, Series E, 1972 ed. (Washington, D.C.: GPO, 1974) Vols. I and II.

Table 4. United States and Ohio River Basin: Consumption of Lime and Portland Cement, by BEAs or BEA Segments,[a] Estimated 1969-76

(Thousands of tons)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States	95,487.0	91,327.0	98,677.0	103,244.0	106,407.0	102,904.0	88,051.0	93,121.0
Primary Study Areas[b]	7,711.5	7,170.7	7,475.2	7,624.4	8,118.7	7,890.1	6,607.5	7,313.9
BEA 47: Huntsville, AL	395.2	362.3	400.3	418.6	441.4	423.7	367.8	403.9
BEA 49: Nashville, TN	491.6	488.1	545.1	566.9	576.0	609.8	472.2	481.8
BEA 50: Knoxville, TN	256.3	258.0	286.6	296.4	320.5	304.8	248.7	247.7
BEA 52: Huntington, WV	810.3	779.3	851.9	869.7	914.1	892.5	751.3	881.8
BEA 54: Louisville, KY	621.2	581.7	607.4	611.4	621.4	584.6	539.1	642.0
BEA 55: Evansville, IN	279.7	263.8	272.6	274.1	277.3	269.3	237.9	255.0
BEA 62: Cincinnati, OH	1,217.9	1,112.3	1,137.6	1,150.8	1,233.7	1,148.5	980.6	1,135.3
BEA 64: Columbus, OH	574.1	553.1	590.6	550.9	564.0	558.2	488.3	494.7
BEA 65: Clarksburg	68.6	68.8	92.6	81.9	101.5	98.3	82.5	84.2
BEA 66: Pittsburgh, PA	2,853.8	2,578.9	2,521.5	2,634.4	2,887.0	2,836.8	2,294.6	2,533.2
BEA 68: Cleveland, OH	70.7	60.0	62.8	63.8	72.6	63.5	54.7	54.5
BEA 115: Paducah, KY	72.1	64.4	106.2	105.5	109.2	100.1	89.8	99.8

Note: Consumption by BEAs and BEA segments of portland cement were derived from state portland cement consumption distributed among BEAs and BEA segments on the basis of the 1969-76 distribution of population of counties. Consumption of lime by the steel industry was derived from the usage of lime per ton of steel produced by various furnace types and estimates of steel production by BEA and BEA segment. Consumption of lime by the chemical industry obtained from state consumption by the chemical industry allocated among BEAs and BEA segments on the basis of the distribution of chemical production.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
b. Columns may not add to totals due to rounding.

Source: Estimated from U.S. Department of the Interior, Bureau of Mines: "Cement" and "Lime," Minerals Yearbook, 1969-76 eds.; from annual county population statistics provided by U.S. Department of Commerce, Bureau of Economic Analysis, 1969-76; from American Iron and Steel Institute, Annual Statistical Report, 1969-76; and from Iron Ore, Steel and Iron (Group VIII) Report and Chemicals and Chemical Fertilizers (Group VI) Report.

F. Probable Future Demand

Consumption of lime and cement in the PSAs is projected to increase at an average annual rate of 4.1 percent during the period 1974-76 to 2000 (Table 5). Much of this increased consumption will result from lime consumed in lime and limestone flue gas desulfurization (FGD) installation processes. During the period 2000-2040, lime and cement consumption in the PSAs is projected to increase at an average annual rate of 0.9 percent.

BEA 54 (Louisville) is projected to be the leading PSA consumer. This will result from increased use of FGD processes in the region, as well as population increases which will boost the demand for cement.

Table 5. Ohio River Basin: Consumption of Lime and Portland Cement, by BEAs or BEA Segments,[a] Estimated Average 1974-76, and Projected 1980-2040

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated average 1974-76	Projected 1980	Projected 1990	Projected 2000	Projected 2020	Projected 2040	Average annual percentage change 1974-76—2000	Average annual percentage change 2000-2040
Primary Study Areas	7,270.7	11,429.5	16,677.5	19,942.2	25,044.2	28,511.0	4.1	0.9
BEA 47: Huntsville, AL	398.5	471.4	712.4	974.8	1,588.0	2,075.3	3.6	1.9
BEA 49: Nashville, TN	521.3	558.3	789.4	1,031.0	1,229.7	1,345.9	2.8	0.7
BEA 50: Knoxville, TN	267.1	285.0	376.7	464.2	521.1	557.7	2.2	0.5
BEA 52: Huntington, WV	841.9	1,060.1	1,255.0	1,513.1	2,002.4	2,345.9	2.4	1.1
BEA 54: Louisville, KY	588.6	2,890.6	4,801.4	5,195.5	5,974.6	6,408.6	9.1	0.5
BEA 55: Evansville, IN	254.1	305.9	410.0	529.8	765.6	935.0	3.0	1.4
BEA 62: Cincinnati, OH	1,088.1	1,428.0	2,174.5	2,853.7	4,165.5	5,101.9	3.9	1.5
BEA 64: Columbus, OH	513.7	804.6	1,237.9	1,623.1	2,554.6	3,223.4	4.7	1.7
BEA 65: Clarksburg, WV	88.3	95.5	120.3	143.7	157.0	166.7	2.0	0.4
BEA 66: Pittsburgh, PA	2,554.9	3,348.3	4,507.0	5,241.9	5,634.0	5,843.9	2.9	0.3
BEA 68: Cleveland, OH	57.6	64.0	88.7	115.7	129.9	138.2	2.8	0.5
BEA 115: Paducah, KY	96.6	118.0	204.2	255.7	321.8	368.8	4.0	0.9

Note: Projected consumption of portland cement was derived from estimated state per capita consumption in future years and projected county population. Projected consumption of lime by the steel industry derived from lime usage per ton of steel produced by furnace type and projections of steel production by BEA and BEA segment. Projected consumption of lime by the chemical industry was estimated from RRNA projection of production by the chemical industry. Projected consumption of lime by desulphurization use estimated for planned lime/limestone flue gas desulphurization (FGD) installations processes.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Estimated from U.S. Environmental Protection Agency, Flue Gas Desulphurization in Power Plants Status Report, April 1977; from U.S. Water Resources Council, 1972 OBERS Projection, Regional Economic Activity in the U.S.; from American Iron and Steel Institute, Annual Statistical Report, 1976; and from the Iron Ore, Steel and Iron (Group VIII) Report and Chemicals and Chemical Fertilizers (Group VI) Report.

III. COMMODITY RESOURCE INVENTORY

Production of portland cement and lime in the PSAs increased from 4,048.0 thousand tons in 1969 to 4,215.0 thousand tons in 1976. Production is projected to increase at an average annual rate of 3.8 percent between 1974-76 and 2000. During the period 2000-2040, production is projected to increase 0.6 percent per year.

A. Production Areas

The production of Group XII products in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs which are the origins of Group XII waterborne movements destined to the Ohio River Basin.

Only nine of the 12 PSAs, defined earlier, have significant levels of lime and cement production. Of these PSAs, BEAs 66 (Pittsburgh), 54 (Louisville), and 115 (Paducah) are the major producers.

The major SPA is BEA 114 (St. Louis), which shipped 349.0 thousand tons to the Ohio River System in 1976 from points on the upper Mississippi River. Other SPAs are BEAs 115 (Paducah),[1] 137 (Mobile), and 141 (Houston).

B. Production Characteristics

In 1977, there were 169 cement plants located throughout the United States and Puerto Rico. The industry is not highly concentrated, with 29 companies operating between two and 13 plants and no single firm accounting for more than 7 percent of total production.[2]

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1. Includes counties of BEA 115 which are origins of waterborne movements shipped from points on the Mississippi River.
2. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles: Cement; MCP 26 (Washington, D.C.: Bureau of Mines, 1978).

There are approximately 175 lime plants operating in the United States. Almost one-third of their production is captive, i.e., used by producers. The lime industry is more concentrated than the cement industry in that the ten leading lime manufacturers account for 40 percent of total domestic lime production.[1]

The cement industry has access to abundant supplies of raw materials. Many companies report reserves sufficient to meet the demands of 100 years at present capacity. A serious problem for the cement industry, however, is energy. A high percentage of manufacturing costs is associated with the development of alternative energy sources and processes in order to increase energy efficiency. Efforts have been successful, but have not eliminated the industry's concerns with respect to the increasing cost of energy.

Lime is manufactured from a variety of calcareous materials which are plentiful throughout the world. However, the manufacture of lime, like cement, requires considerable amounts of energy. At present, coal and natural gas are the energy sources used to convert limestone to quicklime.

Both the cement and lime industries have had to modify operations to comply with EPA regulations. The Environmental Noise Control Act of 1972 has had direct impact on the cement industry, and both industries are affected by air and water quality restrictions.

C. Existing Production Levels

During the period 1969-76, production of cement and lime in the PSAs varied from 3.6 to 4.5 million tons, with the lowest levels occurring in 1970 and 1975 and a peak of 4,491.0 thousand tons in 1973 (Table 6). This pattern conformed to variations in national production during the period.

BEA 66 (Pittsburgh) was the leading PSA producer of lime and cement in 1976 with a yield of 29 percent of total production in the PSAs.

BEA 62 (Cincinnati) is the site of two lime plants which began operations during the study period: the Black River Mine, in Pendleton County, Kentucky, and Dravo Corporation's lime plant, in

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1. U.S. Department of the Interior, Bureau of Mines, Mineral Yearbook, 1975 ed. (Washington, D.C.: GPO, 1977) Vol. I.

Table 6. United States and Ohio River Basin: Production of Portland Cement and Lime, by BEAs or BEA Segments[a], Estimated 1969-76

(Thousands of tons)

BEA and BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States	95,400.0	91,200.0	98,500.0	103,000.0	106,100.0	102,500.0	87,800.0	92,800.0
Primary Study Areas	4,048.0	3,607.0	3,979.0	4,232.0	4,491.0	4,400.0	3,794.0	4,215.0
BEA 47: Huntsville, AL	191.0	185.0	186.0	197.0	182.0	179.0	138.0	148.0
BEA 49: Nashville, TN	191.0	185.0	186.0	197.0	182.0	179.0	138.0	148.0
BEA 50: Knoxville, TN	591.0	575.0	582.0	612.0	566.0	554.0	427.0	457.0
BEA 52: Huntington, WV	368.0	298.0	375.0	385.0	415.0	389.0	306.0	292.0
BEA 54: Louisville, KY	799.0	698.0	738.0	769.0	853.0	801.0	688.0	758.0
BEA 62: Cincinatti, OH	.0	.0	83.0	167.0	250.0	333.0	417.0	500.0
BEA 66: Pittsburgh, PA	1,278.0	1,140.0	1,257.0	1,323.0	1,465.0	1,364.0	1,120.0	1,213.0
BEA 115: Paducah, KY	630.0	526.0	572.0	582.0	578.0	601.0	560.0	699.0

Note: Estimates of annual state production of lime and portland cement were obtained from Minerals Yearbook. Production of portland cement allocated to BEAs and BEA segments according to the distribution of production capacity. Production of limestone allocated to BEAs and BEA segments from capacity estimates of larger plants obtained from industry experts and from number of small plants located in each BEA and BEA segment obtained from Bureau of Mines.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of the Interior, Bureau of Mines, Area Reports: Domestic, Vol. II of Minerals Yearbook, 1969-76 eds.; Portland Cement Association, Portland Cement Plants by Producing Capacity, December 31, 1975 and unpublished data provided by the Bureau of Mines and other industry experts.

Maysville, Kentucky. These were the only new plants identified during the study.

BEAs 54 (Louisville) and 115 (Paducah) are major producing PSAs. Both have large portland cement plants.

D. Forecasting Procedures and Assumptions

Projections of lime and cement production are based on projections of consumption in the PSAs. The production of cement by PSA was assumed to grow at the same rate as demand in the PSAs as a whole. The year 1976 was used as the base. An exception to this procedure occurs in BEA 62, where the two new lime plants are located. These plants are assumed to reach levels close to planned capacity by 1980. After 1980, production in these BEAs is assumed to increase at the same rate as lime consumption in the PSAs as a whole. This procedure is based on the regional nature of the lime and cement markets. The availability of water transportation to the major producers provides access to all market areas served by the Ohio River System. An increase in consumption in a PSA will impact production levels throughout the area.

E. Probable Future Production Levels

Production of lime and cement in the PSAs is projected to increase an average of 3.8 percent between 1974-76 and 2000, from 4,134.0 thousand tons to 10,520.0 thousand tons (Table 7). During the period 2000-2040, the average annual rate of increase will be 0.6 percent.

BEA 62 (Cincinnati), the location of the new lime plants, will be the major producing PSA. BEA 66 (Pittsburgh) will continue to contribute approximately 25 to 28 percent of the total PSA production. BEAs 54 (Louisville) and 115 (Paducah) will also continue to be major cement producers.

Table 7. Ohio River Basin: Production of Portland Cement and Lime, by BEAs or BEA Segments[a], Estimated Average 1974-76 and Projected 1980-2040

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated average 1974-76	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1974-76—2000	2000-2040
Primary Study Areas	4,134.0	6,047.0	8,562.0	10,520.0	12,428.0	13,545.0	3.8	0.6
BEA 47: Huntsville, AL	155.0	171.0	234.0	296.0	326.0	342.0	2.6	0.4
BEA 49: Nashville, TN	155.0	171.0	234.0	296.0	326.0	342.0	2.6	0.4
BEA 50: Knoxville, TN	479.0	551.0	764.0	956.0	1,078.0	1,145.0	2.8	0.5
BEA 52: Huntington, WV	329.0	337.0	462.0	584.0	642.0	673.0	2.3	0.4
BEA 54: Louisville, KY	749.0	874.0	1,199.0	1,515.0	1,667.0	1,749.0	2.9	0.4
BEA 62: Cincinnati, OH	417.0	1,600.0	2,404.0	2,604.0	3,754.0	4,346.0	7.9	1.1
BEA 66: Pittsburgh, PA	1,230.0	1,537.0	2,159.0	2,672.0	3,098.0	3,336.0	3.2	0.6
BEA 115: Paducah, KY	620.0	806.0	1,106.0	1,397.0	1,537.0	1,612.0	3.3	0.4

Note: Portland cement production for each producing BEA and BEA segment was assumed to increase at the same rate as projected consumption of portland cement for the Basin as a whole. Lime production for each producing BEA and BEA segment (except BEA 62) is assumed to increase at the same rate as projected lime consumption for the Basin as a whole. Production of lime in BEA 62, where two new large plants have been installed during the study period, is expected to attain a level close to planned capacity by 1980, then increase at the same rate as projected lime consumption for the Basin as a whole.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Estimated from Table 6, adjusted on the basis of unpublished data from the U.S. Department of the Interior, Bureau of Mines.

IV. TRANSPORTATION CHARACTERISTICS

In 1972, 15.1 percent of cement shipments in the United States of over 25 miles was shipped by rail, 15.9 percent by water, and the rest by motor carrier and private truck.[1] The average haul for rail movements was 201 miles; for truck shipments, 77 miles; and for water, 195 miles.

Between 2 and 4 percent of national lime production was moved by water during the past decade.[2] Both rail and truck transportation were used extensively to transport lime.[3]

A. Existing and Historical Modal Split

In 1976, truck was the primary means of providing the PSAs with lime and cement not furnished by local producers. Net truck receipts totalled 2,197.4 thousand tons, or 71 percent of the net requirements of all the PSAs (Table 8).

Major suppliers of materials were BEAs 115 (Paducah), 50 (Knoxville) and 54 (Louisville). These BEAs reported net outbound shipments by all three major modes. Major net receivers were BEAs 66 (Pittsburgh) and 62 (Cincinnati). Both BEAs reported net inbound shipments by all three modes.

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1. U.S. Department of Commerce, Bureau of the Census, Census of Transportation, 1972 ed. (Washington, D.C.: GPO, 1976) Vol. III.
2. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.) Vol. V.
3. U.S. Department of Commerce, Bureau of the Census, Census of Transportation, 1972 ed. (Washington, D.C.: GPO, 1976) Vol. III.

Table 8. Ohio River Basin: Production, Consumption and Shipments, by Mode of Transportation of Rubber, Plastic, Nonmetallic Mineral Products, Nec.,[a] by BEAs or BEA Segments,[b] Estimated 1976

(Thousands of tons)

BEA and BEA segment	Pro-duction	Con-sumption	Shipments (receipts) Total net	Water Net	Water In-bound	Water Out-bound	Water Local	Rail[c] Net	Rail[c] In-bound	Rail[c] Out-bound	Rail[c] Local	Net truck
Primary Study Areas	4,215.0	7,313.9	(3,098.9)	(244.0)	627.1[d]	383.1[d]	461.1[d]	(657.5)	1,667.5[d]	1,010.0[d]	264.7[d]	(2,197.4)
BEA 47: Huntsville, AL	148.0	403.9	(255.9)	(12.5)	12.5	--	3.3	(20.8)	63.1	42.3	--	(222.6)
BEA 4[illegible]: Nashville, TN	148.0	481.8	(333.8)	(231.6)	231.6	--	--	(85.4)	151.0	65.6	--	(16.8)
BEA 50: Knoxville, TN	457.0	247.7	209.3	4.5	--	4.5	--	3.1	79.1	82.2	7.6	201.7
BEA 52: Huntington, WV	292.0	881.8	(589.8)	(57.8)	69.0	11.2	21.0	(135.6)	211.1	75.5	--	(396.4)
BEA 54: Louisville, KY	758.0	642.0	116.0	85.0	27.0	112.0	--	26.0	188.0	214.0	6.6	5.0
BEA 55: Evansville, IN	--	255.0	(255.0)	(165.1)	169.5	4.4	--	(14.2)	52.5	38.3	--	(75.7)
BEA 62: Cincinnati, OH	500.0	1,135.3	(635.3)	(157.3)	186.9	29.6	--	(219.2)	272.6	53.4	64.3	(258.8)
BEA 64: Columbus, OH	--	494.7	(494.7)	(14.1)	14.1	--	--	68.3	40.8	109.1	--	(548.9)
BEA 65: Clarksburg, WV	--	84.2	(84.2)	(37.8)	37.8	--	--	--	--	--	--	(46.4)
BEA 66: Pittsburgh, PA	1,213.0	2,533.2	(1,320.2)	22.7	84.1	106.8	1.1	(333.1)	643.6	310.5	14.6	(1,009.8)
BEA 68: Cleveland, OH	--	54.5	(54.5)	(45.7)	151.3	5.6	2.2	7.4	47.4	54.8	--	83.8
BEA 115: Paducah, KY	699.0	99.8	599.2	465.7	76.8	542.5	--	46.0	47.8	93.8	--	87.5

Note: Gross and net waterborne and net rail shipments (receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting production from consumption. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. Includes portland cement and lime only.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Rail movements of portland cement and lime were estimated from rail movements of rubber, plastic, nonmetallic mineral products, nec., using 1972 ratio of portland cement and lime rail shipments to total rubber, plastic, nonmetallic mineral products, nec., rail shipments to, from, and within the Ohio River Basin.

d. Primary Study Areas shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs or BEA segments.

Source: Production and consumption from Table 4 and 6. Water and rail shipments compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by U.S. Army Corps of Engineers.

B. Intermodal Characteristics

Few waterborne cement shipments are directly received by consumers. Rather, waterside cement plants often serve waterside distribution centers some distance away. Large bulk shipments are moved by barge or rail from plant to terminal. Then, they are either combined with aggregates for ready-mix concrete or are sent directly to consumers by truck.

Almost one-third of lime production is captive. This production usually occurs near the point of consumption and few intermodal transfers occur. The remaining production is sent to distribution points or to industrial users who often have direct access to water and/or rail transportation.

Shipments of cement and lime from plant to distribution centers and directly to ultimate consumers are observed on the waterway.

Information regarding intermodal transfers from barge to rail, or rail to barge, is not available. Because regional markets limit the distances of shipments, possible freight cost savings do not generally justify transfer and handling costs associated with intermodal transfers. Although lime terminals, which may have received lime by rail or barge, then use barge, rail, and/or truck to reach the consumer, these flows are not considered as intermodal transfers.

C. Factors Affecting Modal Choice

Transportation is a significant factor in the delivered cost of cement. Cement has a low price relative to weight; therefore, barge is the preferred mode of transport when both origins and destinations are served by water. Barge cost for cement ranges from 0.3 to 0.5 cents per ton-mile, versus 1.5 to 2.0 cents per ton-mile for rail, and more than 6.0 cents per ton-mile for truck.[1] A similar freight cost structure exists for lime. However, when delivery is required within a short span of time, rail or truck is the major means of shipment.

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1. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles: Cement; MCP 26 (Washington, D.C.: Bureau of Mines, 1978).

D. Forecasting Procedures and Assumptions

Initial projections of waterborne commerce were developed from preliminary information provided by the Corps of Engineers. These initial projections were derived by the following procedures.

Waterborne receipts (inbound plus local movements), by PSA, have been projected to increase at the same rate as projected PSA consumption, except in BEAs 54, 64 and 66. These BEAs were projected to receive additional receipts from BEA 62 starting in 1980. Two large new plants commenced operations in BEA 62 during the study period and are assumed to be operating close to capacity by 1980.

Waterborne shipments (outbound plus local movements) by PSA have been projected to increase at the same rate as projected PSA production, except in BEA 62 where the two new plants are located. Shipments from the ORB to points outside the ORB (outbound), by BEA, have been projected to increase at the same rate as projected production in the area served by the Ohio River System. Local ORS shipments are equal to total waterborne shipments for the ORS minus outbound shipments. Inbound shipments are equal to total waterborne receipts for the PSAs minus local shipments. Inbound shipments have been distributed among the Secondary Production Areas (SPAs) on the basis of the 1976 distribution of inbound shipments.

These projections of waterborne shipments and receipts, by BEA, have been distributed among BEA-to-BEA links using the historical distribution of shipments among BEA receivers, adjusted for projected changes in BEA shipments and receipts. The specific knowledge acquired by commodity specialists during the course of this study was also used.

As more complete information was made available by the Corps of Engineers, initial projections of BEA-to-BEA waterborne traffic were adjusted.[1]

E. Probable Future Modal Split

A summary of the probable future modal split of Group XII product shipments in the area served by the ORS for the 1976 base year and for all the projection years is presented in Table 9.

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1. A description of the manner in which the initial projections were adjusted is contained in the Methodology Report.

Net truck receipts will continue to account for the largest portion of total net receipts. With respect to water movements, net water receipts are projected to increase at slightly higher rates than net rail or truck receipts. This increase will occur because of a small shift in the distribution of ORB water shipments from port equivalents (PEs) outside the ORS to PEs located within the ORS.

F. Probable Future Waterway Flows

Detailed BEA-to-BEA waterborne traffic projections are presented in Table 10. Growth indices derived from the traffic projections are presented in Table 11.

The average annual growth rate of gross waterborne shipments is projected to be 4.9 percent between 1976 and 2000, and 1.1 percent between 2000 and 2040 (Table 9).

Local waterborne shipments will increase most rapidly during the period 1976-2000. The major reason for this growth is that the new lime plants in BEA 62 will be sending much of their waterborne shipments to PSAs within the ORB.

Table 9. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Rubber, Plastic, Nonmetallic Mineral Products, Nec., Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

	Estimated	Projected					Average annual percentage change	
	1976	1980	1990	2000	2020	2040	1976-2000	2000-2040
Production[a]	4,215.0	6,047.0	8,562.0	10,520.0	12,428.0	13,545.0	3.9	0.6
Consumption[a]	7,313.9	11,429.7	16,677.5	19,942.2	25,044.2	28,511.3	4.3	0.9
Net shipments (receipts)	(3,098.9)	(5,382.7)	(8,115.5)	(9,422.2)	(12,616.2)	(14,966.3)	4.7	1.2
Net waterborne	(244.0)	(500.8)	(832.2)	(1,041.0)	(1,842.4)	(2,469.5)	6.2	2.2
Net rail	(657.5)	(2,075.1)	(3,403.5)	(3,641.5)	(4,262.4)	(4,662.8)	7.4	0.6
Net truck	(2,197.4)	(2,806.8)	(3,879.8)	(4,739.7)	(6,511.4)	(7,834.0)	3.3	1.3
Gross waterborne shipments:								
Outbound	383.1	518.1	735.4	917.2	1,037.9	1,106.0	3.7	0.5
Inbound	627.1	1,018.9	1,567.6	1,958.2	2,880.3	3,575.5	4.9	1.5
Local	461.1	1,036.0	1,677.5	1,713.3	2,113.7	2,338.6	5.6	0.8
Total	1,471.3	2,573.0	3,980.5	4,588.7	6,031.9	7,020.1	4.9	1.1

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Waterborne shipments and receipts were first projected on the basis of preliminary information provided by the Corps of Engineers. Waterborne receipts (inbound plus local) by BEA and BEA segment were assumed to increase at the same rate as consumption by BEA. Waterborne shipments (outbound plus local) by BEA and BEA segment were assumed to increase at the same rate as production by BEA. Total waterborne outbound shipments were assumed to increase at the same rate as production in the ORB. Local shipments are the residual of total water shipments less outbound. Inbound shipments are the residual of total water receipts less local shipments. As more complete information regarding 1976 waterborne traffic was made available, BEA-to-BEA traffic projections were revised, and projected to increase/decrease at the same rate as projected earlier. Net truck and net rail shipments by BEA and BEA segment were assumed to have the same relationship to one another that existed in 1976.

a. Includes portland cement and lime only.

Source: Table 5, 7, and 8; Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

Table 10. Ohio River System: BEA-TO-BEA Waterborne Traffic of Rubber, Plastic, Nonmetallic Minerals, Nec., Actual 1976 and Projected 1976-2040, Selected Years

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS					
			1976	1980	1990	2000	2020	2040
047	047	12	33	38	51	65	72	76
050	047	12	45	55	76	95	108	115
052	052	12	210	237	244	253	263	279
052	062	12	56	70	99	118	124	135
052	115	12	56	66	196	330	388	399
054	055	12	920	1084	1439	1859	1983	2041
054	115	12	22	22	32	41	42	43
054	133	12	122	141	198	235	276	300
054	135	12	56	65	91	113	132	144
055	062	12	22	46	65	80	96	105
055	133	12	22	31	44	54	64	69
062	047	12	0	0	0	0	600	1300
062	052	12	0	0	0	0	250	500
062	054	12	0	2314	3763	4570	4943	5153
062	055	12	0	10	15	18	20	31
062	064	12	0	939	1303	1358	2356	2941
062	066	12	285	1965	2716	3104	3912	3947
062	068	12	11	38	79	118	157	196
066	052	12	690	836	[illegible]	1261	1472	1524
066	065	12	378	429	541	646	705	748
066	066	12	11	32	85	134	164	166
068	063	12	22	46	65	80	96	105
068	077	12	45	64	90	111	131	143
068	078	12	11	16	22	27	32	35
114	049	12	1636	2004	3092	4201	5111	5629
114	054	12	0	1429	2211	2256	3818	4707
114	055	12	85	330	670	846	2718	4208
114	062	12	1758	2224	3391	4469	6612	8141
114	066	12	11	11	17	20	24	35
115	046	12	1616	1734	2466	3175	3293	3360
115	047	12	80	93	142	197	244	251
115	049	12	680	690	742	823	899	949
115	054	12	270	366	392	404	447	490
115	055	12	690	713	847	1107	1232	1272
115	064	12	130	271	386	472	564	620
115	078	12	90	128	181	221	258	279
115	134	12	1313	1942	2749	3403	4010	4362
115	135	12	556	1060	1513	1833	2183	2368
137	062	12	33	52	77	96	130	162
141	068	12	11	17	26	32	45	55
915	054	12	0	102	154	203	329	471
915	064	12	11	17	26	32	43	54
915	066	12	545	851	1272	1583	2142	2683
915	068	12	1491	2327	3480	4330	5861	7340
915	115	12	690	825	1260	1514	1970	2270
		TOTAL	14713	25730	37339	45887	60319	70201

Note: BEA 915 refers to counties of BEA 115 which are origins of waterborne movements shipped from points on the Mississippi River.
Source: Robert R. Nathan Associates, Inc.

Table 11. Ohio River System: Growth Rates of Rubber, Plastic, Nonmetallic Mineral Products, Nec., Waterborne Commerce, BEA to BEA, Projected 1976-2040, Selected Years

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
047047	12	33	1000	1147	1559	1971	2176	2294
050047	12	45	1000	1212	1697	2121	2394	2545
052052	12	210	1000	1129	1164	1207	1254	1328
052062	12	56	1000	1255	1766	2106	2213	2404
052115	12	56	1000	1174	3500	5891	6935	7130
054055	12	920	1000	1178	1564	2021	2155	2219
054115	12	22	1000	1000	1467	1844	1911	1956
054133	12	122	1000	1154	1622	1923	2259	2455
054135	12	56	1000	1155	1621	2019	2359	2573
055062	12	22	1000	2084	2970	3629	4342	4766
055133	12	22	1000	1415	2000	2459	2895	3149
062047	12	600	0	0	0	0	1000	2167
062052	12	250	0	0	0	0	1000	2000
062054	12	2314	0	1000	1626	1975	2136	2227
062055	12	10	0	1000	1500	1800	2000	3100
062064	12	939	0	1000	1388	1446	2509	3132
062066	12	285	1000	6894	9531	10890	13727	13849
062068	12	11	1000	3429	7143	10714	14286	17857
066052	12	690	1000	1211	1494	1827	2134	2208
066065	12	378	1000	1136	1431	1708	1864	1979
066066	12	11	1000	2944	7722	12167	14944	15111
068068	12	22	1000	2084	2970	3629	4342	4766
068077	12	45	1000	1412	2000	2471	2912	3176
068078	12	11	1000	1415	2000	2459	2895	3149
114049	12	1636	1000	1225	1890	2568	3124	3441
114054	12	1429	0	1000	1547	1579	2672	3294
114055	12	85	1000	3881	7881	9952	31976	49500
114062	12	1758	1000	1265	1929	2542	3761	4631
114066	12	11	1000	1034	1577	1813	2224	3210
115046	12	1616	1000	1073	1526	1965	2038	2079
115047	12	80	1000	1164	1780	2459	3052	3132
115049	12	680	1000	1015	1091	1211	1322	1395
115054	12	270	1000	1354	1451	1496	1657	1813
115055	12	690	1000	1033	1227	1604	1786	1843
115064	12	130	1000	2084	2970	3629	4342	4766
115078	12	90	1000	1427	2011	2461	2865	3101

(Continued)

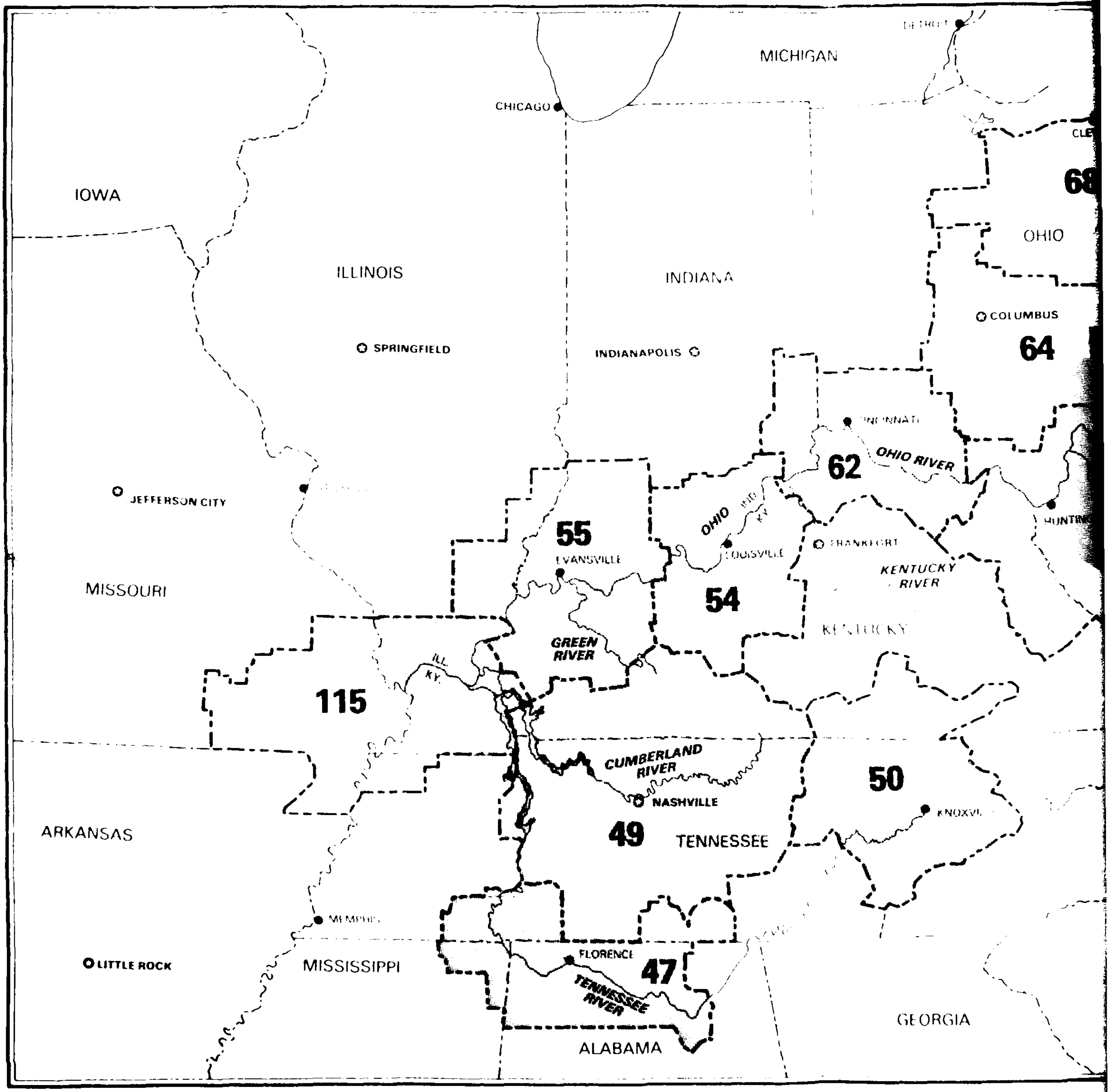
Table 11 (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
115134	12	1313	1000	1479	2094	2592	3054	3322
115135	12	556	1000	1907	2722	3296	3926	4259
137062	12	33	1000	1561	2334	2904	3931	4923
141068	12	11	1000	1556	2333	2889	4111	5000
915054[d]	12	102	0	1000	1510	1990	3225	4618
915064[d]	12	11	1000	1561	2334	2904	3931	4923
915066[d]	12	545	1000	1561	2334	2904	3931	4923
915068[d]	12	1491	1000	1561	2334	2904	3931	4923
915115[d]	12	690	1000	1195	1826	2194	2855	3290

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.
b. Hundreds of tons.
c. Growth rates are reported such that 1000 equals the index value reported in the third column.
d. BEA 915 refers to counties of BEA 115 which are origins of waterborne movements which are shipped from points on the Mississippi River.
Source: Robert R. Nathan Associates, Inc.

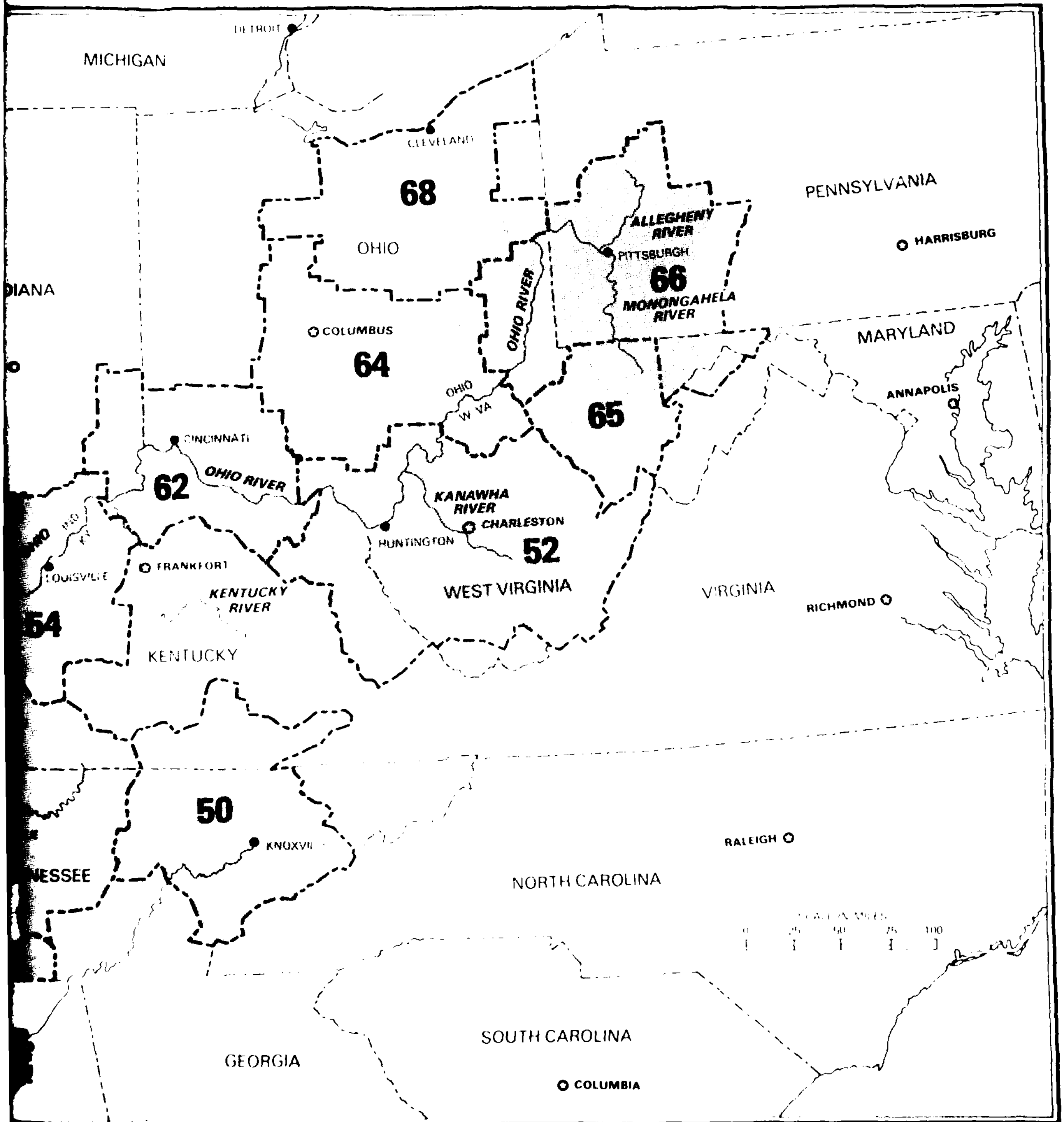
V. APPENDIX

MAP A-1. OHIO RIVER BASIN: PRIMA[illegible] STUDY AREAS FOR RUBBER, P[illegible]
NONMETALLIC MINERAL PRODUC[illegible] [illegible] (PEAs AND BEA SEGME[illegible]



SOURCE: Robert R. Nathan Associates, Inc.

ER BASIN: PRIMARY STUDY AREAS FOR RUBBER, PLASTIC, AND
MINERAL PRODUCTS, NEC. (BEAs AND BEA SEGMENTS)



Primary Study Areas

Table A-1. Ohio River Basin: Primary Study Areas for Rubber, Plastic, Nonmetallic Mineral Products, Nec.
(BEAs and BEA *segments*)

BEA 47: Huntsville, AL
Colbert, AL
Franklin, AL
Lauderdale, AL
Lawrence, AL
Limestone, AL
Madison, AL
Marshall, AL
Morgan, AL
Alcorn, MS
Tishomingo, MS
Franklin, TN
Hardin, TN
Lincoln, TN
McNairy, TN
Wayne, TN

BEA 49 (segment): Nashville, TN
Allen, KY
Barren, KY
Butler, KY
Christian, KY
Clinton, KY
Cumberland KY
Edmonson, KY
Logan, KY
Metcalfe, KY
Monroe, KY
Simpson, KY
Todd, KY
Trigg, KY
Warren, KY
Benton, TN
Cannon, TN
Cheatham, TN
Clay, TN
Coffee, TN
Davidson, TN
DeKalb, TN
Dickson, TN
Giles, TN
Hickman, TN
Houston, TN
Humphreys, TN
Jackson, TN
Lawrence, TN
Lewis, TN
Macon, TN
Maury, TN
Montgomery, TN
Overton, TN
Perry, TN
Pickett, TN
Putnam, TN
Robertson, TN
Rutherford, TN
Smith, TN
Stewart, TN
Trousdale, TN
Van Buren, TN
Warren, TN
White, TN
Williamson, TN
Wilson, TN

BEA 50 (segment): Knoxville, TN
Anderson, TN
Blount, TN
Campbell, TN
Cumberland, TN
Fentress, TN
Grainger, TN
Jefferson, TN
Knox, TN
Loudon, TN
Monroe, TN
Morgan, TN
Roane, TN
Scott, TN
Sevier, TN
Union, TN

BEA 52 (segment): Huntington, WV
Boyd, KY
Carter, KY
Elliot, KY
Greenup, KY
Lawrence, KY
Rowan, KY
Gallia, OH
Lawrence, OH
Meigs, OH
Scioto, OH
Boone, WV
Cabell, WV
Clay, WV
Fayette, WV
Greenbrier, WV
Jackson, WV
Kanawha, WV
Lincoln, WV
Mason, WV
Nicholas, WV
Putnam, WV
Raleigh, WV
Roane, WV
Sumners, WV
Wayne, WV

BEA 54 (segment): Lousiville, KY
Clark, IN
Crawford, IN
Floyd, IN
Harrison, IN
Jefferson, IN
Orange, IN
Scott, IN
Washington, IN
Breckenridge, KY
Bullitt, KY
Grayson, KY
Hardin, KY
Henry, KY
Jefferson, KY
Meade, KY
Nelson, KY
Oldham, KY
Shelby, KY
Trimble, KY
Washington, KY

BEA 55 (segment): Evansville, IN
Caldwell, KY
Crittenden, KY
Daviess, KY
Hancock, KY
Henderson, KY
Hopkins, KY
McLean, KY
Muhlenberg, KY
Ohio, KY
Union, KY
Webster, KY
Edwards, IL
Gallatin, IL
Hamilton, IL
Saline, IL
Wabash, IL
White, IL
Dubois, IN
Gibson, IN
Perry, IN
Pike, IN
Posey, IN
Spencer, IN
Vanderburgh, IN

BEA 62 (segment): Cincinnati, OH
Dearborn, IN
Franklin, IN
Ohio, IN
Ripley, IN
Switzerland, IN
Boone, KY
Bracken, KY
Campbell, KY
Carroll, KY
Fleming, KY
Gallatin, KY
Grant, KY
Kenton, KY
Lewis, KY
Mason, KY
Owen, KY
Pendleton, KY
Robertson, KY
Adams, OH
Butler, OH
Brown, OH
Clermont, OH
Clinton, OH
Hamilton, OH
Highland, OH
Warren, OH

(Continued)

Table A-1. (Continued)

BEA 64 (segment): Columbus, OH
- Athens, OH
- Guernsey, OH
- Jackson, OH
- Morgan, OH
- Noble, OH
- Pike, OH
- Vinton, OH
- Washington, OH
- Pleasants, WV
- Ritchie, WV
- Wirt, WV
- Wood, WV

BEA 65 (segment): Clarksburg, WV
- Barbour, WV
- Doddridge, WV
- Harrison, WV
- Lewis, WV
- Marion, WV
- Monongalia, WV
- Preston, WV
- Taylor, WV
- Upshur, WV

BEA 66 (segment): Pittsburgh, PA
- Garrett, MD
- Belmont, OH
- Harrison, OH
- Jefferson, OH
- Monroe, OH
- Allegheny, PA
- Armstrong, PA
- Beaver, PA
- Butler, PA
- Clarion, PA
- Fayette, PA
- Greene, PA
- Indiana, PA
- Washington, PA
- Westmoreland, PA
- Brooke, WV
- Hancock, WV
- Marshall, WV
- Ohio, WV
- Tyler, WV
- Wetzel, WV

BEA 68 (segment): Cleveland, OH
- Carroll, OH
- Columbian, OH

BEA 115 (segment): Paducah, KY
- Hardin, IL
- Johnson, IL
- Massac, IL
- Pope, IL
- Pulaski, IL
- Union, IL
- Ballard, KY
- Calloway, KY
- Graves, KY
- Livingston, KY
- Lyon, KY
- Marshall, KY
- McCracken, KY

Source: Robert R. Nathan Associates, Inc.

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