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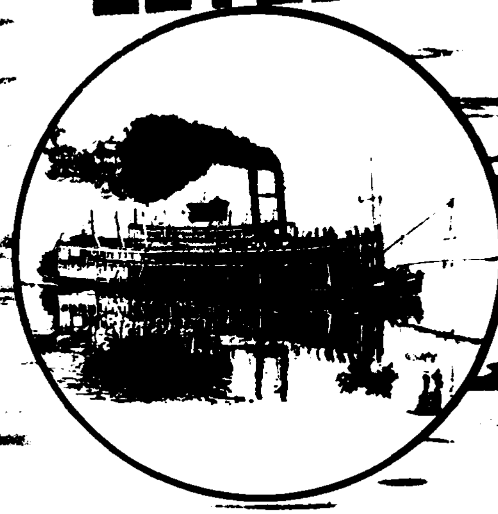

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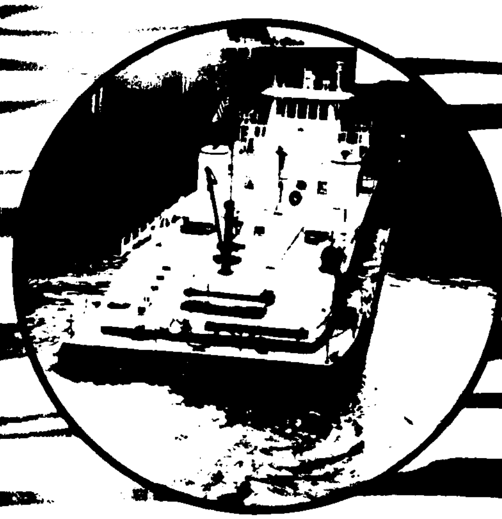

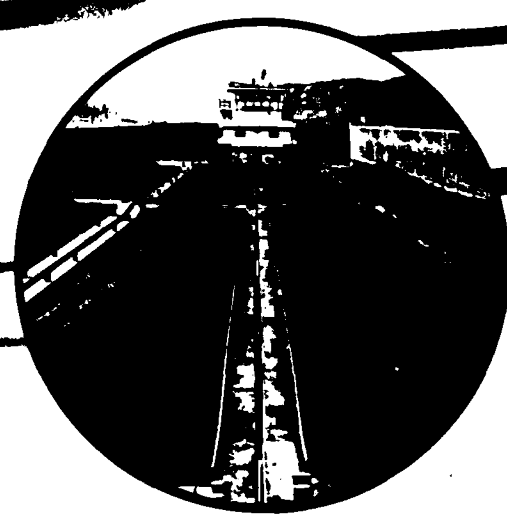

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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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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 6 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.

9 Final Rept.

GROUP IV. AGGREGATES.

6 PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER BASIN, 1980, 1990, 2000, 2020, 2040. Volume 6.

Prepared for

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

15 Contract No. DACW69-78-C-0136

by

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

11 DECEMBER 1980

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"...one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

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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
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

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 IV: Aggregates

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 IV, aggregates, is comprised of construction and industrial materials, including sand and gravel, building stone, and flux. During the 1969-76 period, this group contributed 13.2 percent of total Ohio River System (ORS) waterborne traffic, most of which was local movements. Although Group IV accounts for only small portions of Ohio River Basin (ORB) inbound and outbound waterway movements, aggregates contributed 17.2 percent of local traffic in the ORS waterway 1969 and 1976.

The areas within the Ohio River Basin for which projections of Group IV consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group IV 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 IV waterborne movements. A map showing Group IV PSAs is presented in the appendix to this report.

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

A. Description of Commodity Group

The individual commodities and products included in Group IV are:

Waterborne Commerce Statistics Code (WCSC)	Commodity/Product
0931	Marine shells, unmanufactured

1411	Limestone flux and calcareous stone
1412	Building stone, unworked
1442	Sand, gravel, and crushed rock.

Of the four classifications, significant waterborne commerce has been reported for only two categories: limestone flux (WCSC 1411) and sand, gravel and crushed rock (WCSC 1442). Of the 25,152.3 thousand tons of aggregates shipped in the ORS in 1976, nearly 24,000 thousand tons were sand, gravel and crushed rock; the rest of Group IV shipments were movements of limestone flux (Table 1).

The movement of marine shells and building stone in the Ohio River System has been insignificant. Small quantities of building stone were shipped in 1969, 1970, 1972 and 1976. Marine shells are recorded for only one year during 1969-76, in 1972, when 4,000 tons of shells were shipped from the Gulf Intercoastal Waterway to Cincinnati.

Virtually all shell production is in coastal areas. Shells are very rich in calcium carbonate. However, there is no process or end-product for which other aggregates cannot be substituted for shells. It is unlikely that they will be consumed in significant quantities or constitute a normal part of commodity traffic in the Ohio River System in the foreseeable future.

Use of dimension, or building stone, in construction has decreased greatly since World War II. It has been replaced by more cost-effective materials, such as pre-fabricated or molded concrete, glass, aluminum, etc. From 1964 to 1973, U.S. production and consumption fell from 2.5 million to 1.6 million tons, a decline of 38 percent. In 1977, production fell further to 1.4 million tons. It is safe to assume that dimension stone will constitute an insignificant part of future river traffic.

The term aggregate is generally applied to construction material. The material is defined according to its size as well as its chemical and other physical properties. Strictly speaking, flux, lime rock and other industrial Group IV materials are not aggregates; however, they may be used as such. Crushed rock often substitutes for gravel in concrete, base, and other applications.

Table 1. Ohio River System: Waterborne Shipments of Aggregates by Commodity, Inbound, Outbound, and Local, 1969-76

(Thousands of tons unless otherwise specified)

Commodity and type of movement	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total	23,003.6	21,583.1	24,073.1	22,618.1	23,679.4	23,110.5	18,972.3	25,152.3	1.3
Inbound	19.1	114.0	9.5	5.5	63.5	115.9	93.8	70.1	20.4
Outbound	474.9	1,126.9	1,290.7	1,172.4	853.9	1,738.2	1,228.7	1,265.4	15.0
Local	22,509.6	20,342.2	22,772.8	21,440.3	22,762.0	21,256.4	17,649.8	23,816.8	0.8
Limestone flux	1,554.4	1,848.6	1,704.8	1,378.7	1,801.5	2,366.9	1,774.7	1,144.7	(4.3)
Inbound	15.4	--	--	--	51.0	112.8	82.2	66.8	23.3
Outbound	--	--	5.0	1.4	--	31.4	1.5	3.3	a
Local	1,539.0	1,848.6	1,699.8	1,377.3	1,750.5	2,222.7	1,691.0	1,074.6	(5.0)
Sand, gravel, crushed rock	21,405.3	19,727.2	22,368.2	21,230.4	21,877.8	20,743.5	17,197.7	23,978.1	1.6
Inbound	3.7	114.0	9.5	1.4	12.5	3.1	11.6	3.3	(1.6)
Outbound	474.9	1,126.9	1,285.7	1,171.1	853.9	1,706.7	1,227.2	1,262.1	15.0
Local	20,926.6	18,486.3	21,073.0	20,057.9	21,011.5	19,033.7	15,958.9	22,712.7	1.2
Building stone, unworked	44.0	7.3	--	5.1	--	--	--	30.0	(5.3)
Inbound	--	--	--	--	--	--	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	44.0	7.3	--	5.1	--	--	--	30.0	(5.3)
Marine shell, unmanufactured	--	--	--	4.0	--	--	--	--	--
Inbound	--	--	--	4.0	--	--	--	--	--
Outbound	--	--	--	--	--	--	--	--	--
Local	--	--	--	--	--	--	--	--	--

Note: Individual items may not add to totals due to rounding.
a. No tonnage reported in 1976.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

For the purposes of this study, the term aggregate consists of all sand, gravel and crushed rock.

The major distinction among uses of sand, gravel, and crushed rock is between construction aggregate and crushed rock for industrial purposes.

A-1. Construction aggregate

In 1976, 96.8 percent of U.S. sand and gravel production was used for construction purposes. More than 75 percent of U.S. crushed rock production was used in construction. About 87 percent of total U.S. sand, gravel and crushed rock production was construction aggregate. Construction use of aggregate is distinctive in that considerable substitution among similar materials is possible. For example, crushed stone may take the place of gravel in construction, and vice versa, and artificial sand, manufactured from limestone, can substitute for natural sand.

A-2. Industrial aggregate

Crushed rock, particularly limestone, is used in many industrial processes. The most important use is as feed for cement manufacture. Lime rock, as used for lime production, and flux, as used for iron and steel production, are also important examples of aggregate for industrial usage. More than 12 percent of the national production of aggregates in 1976 was used for industrial purposes.

For industrial uses, chemical and physical properties, as well as dimension specifications of aggregate materials, are important. Substitution among various kinds of material is generally not possible.

B. Existing Waterway Traffic Flows

Total waterborne traffic of aggregates in the ORS increased from 23,003.6 thousand tons in 1969 to 25,152.3 thousand tons in 1976 (Table 1). This traffic can be categorized into three types of traffic: ORS outbound, ORS inbound, and ORS local. The term ORS outbound traffic refers to shipments from points in the ORS to points outside the System. ORS inbound movements are shipments from points outside the ORS to the ORS, and ORS local movements are shipments to and from points within the ORS. Local traffic was the predominant aggregate movement from 1969-76.

Group IV constitutes a major portion of waterway traffic in the Ohio River System, as illustrated in Table 2. In 1976, only 0.2 percent of inbound shipments into the Ohio River System were aggregates, but total aggregate shipments constituted 12.5 percent of the total tonnage transported in the system. The portion of ORS traffic contributed by aggregates is even larger when examining local shipments only. Of all local waterborne shipments in the ORS, 16.5 percent were movements of aggregates.

The 1976 allocation of traffic to origins and destinations, by BEA, is presented in Table 3.

B-1. Local traffic

Much of the aggregate traffic occurred between origins and destinations within the same BEA. Of the 20 BEA origin/destination links with the most 1976 aggregate traffic, eight were intra-BEA (to and from points within one BEA) accounting for more than 60 percent of total aggregate traffic (Table 4). Of the remaining 12 links, all but two links were within the ORS. This is due to the short haul nature of aggregate movements. Aggregates are available throughout much of the area served by the ORS. For that reason, and because they are low cost materials, they are not likely to be transported over long distances. Long haul movements generally occur only when demand requires aggregates with specific characteristics.

B-2. Inbound traffic

Inbound waterway movements of aggregates are sporadic and usually involve small tonnages. From 1969 to 1976, inbound traffic ranged from 5.5 thousand tons in 1972 to 115.9 thousand tons in 1974 (Table 1). At no time from 1969 to 1976 did inbound traffic account for as much as 1 percent of total aggregates traffic.

B-3. Outbound traffic

The PSAs regularly export aggregates to various points along the Mississippi River. During the 1969-76 period, outbound waterborne traffic ranged from 474.9 thousand tons in 1969 to 1,738.2 thousand tons in 1974. This traffic consisted mostly of sand, gravel and crushed rock shipped for use in construction.

In 1976, the largest outbound shipment was from BEA 115 (Paducah) to BEA 46 (Memphis), a shipment of 539.0 thousand tons (Table 3). Another major shipment was 473.1 thousand tons from BEA 115 to BEA 138 (New Orleans).

Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Aggregates, 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
Aggregates	25,152.3	70.1	1,265.4	23,816.8
As a percentage of all commodities	12.5	0.2	4.7	16.5

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 IV: Aggregates

(Thousands of tons)

Origin	Total	ORB BEAs	BEA 47	BEA 48	BEA 49	BEA 50	BEA 52	BEA 53	BEA 54	BEA 55	BEA 62	BEA 64	BEA 66	BEA 68	BEA 115
			Destination												
TOTAL	25,152.3	23,886.9	291.6	1,275.3	2,623.2	126.8	3,557.8	539.0	2,620.8	1,645.7	2,194.6	1,458.2	5,805.2	161.4	1,587.3
ORB BEAs	25,082.2	23,816.8	291.6	1,275.3	2,623.2	126.8	3,557.8	539.0	2,620.8	1,644.6	2,192.4	1,453.7	5,805.2	99.1	1,587.3
BEA 47	145.8	145.8	135.8	10.0	--	--	--	--	--	--	--	--	--	--	--
BEA 48	1,345.4	1,345.4	67.9	1,265.3	--	12.2	--	--	--	--	--	--	--	--	--
BEA 49	1,268.6	1,268.6	87.9	--	1,180.7	--	--	--	--	--	--	--	--	--	--
BEA 50	114.6	114.6	--	--	--	114.6	--	--	--	--	--	--	--	--	--
BEA 52	1,970.8	1,970.8	--	--	--	--	1,919.5	--	--	--	--	46.8	4.5	--	--
BEA 54	4,615.0	4,608.3	--	--	--	--	749.5	539.0	2,495.8	367.0	4,060.0	51.0	--	--	--
BEA 55	1,999.4	1,980.5	--	--	--	--	47.9	--	--	1,275.6	--	--	--	--	657.0
BEA 62	2,439.7	2,439.7	--	--	--	--	627.6	--	-	2.0	1,661.4	30.9	110.0	7.8	--
BEA 64	208.1	208.1	--	--	--	--	1.1	--	--	--	--	176.2	28.8	--	--
BEA 65	672.2	672.2	--	--	--	--	--	--	--	--	--	--	672.2	--	--
BEA 66	6,223.5	6,223.5	--	--	--	--	212.2	--	125.0	--	125.0	1,146.8	4,523.2	91.3	--
BEA 68	466.5	466.5	--	--	--	--	--	--	--	--	--	--	466.5	--	--
BEA 115	3,612.6	2,372.8	--	--	1,442.5	--	--	--	--	--	--	--	--	--	930.3
Non-ORB BEAs	70.1	70.1	--	--	--	--	--	--	--	1.1	2.2	4.5	--	62.3	--
BEA 115[a]	66.8	66.8	--	--	--	--	--	--	--	--	--	4.5	--	62.3	--
BEA 117	1.1	1.1	--	--	--	--	--	--	--	1.1	--	--	--	--	--
BEA 138	2.2	2.2	--	--	--	--	--	--	--	--	2.2	--	--	--	--

(Continued)

Table 3. (Continued)

Origin	Destination										
	Non-ORB	BEA 46	BEA 77	BEA 115[a]	BEA 133	BEA 134	BEA 135	BEA 138	BEA 139	BEA 140	BEA 141
TOTAL	1,265.4	449.5	18.9	5.6	2.2	238.2	42.3	473.1	5.6	24.4	5.6
ORB BEAs	1,265.4	449.5	18.9	5.6	2.2	238.2	42.3	473.1	5.6	24.4	5.6
BEA 47	--	--	--	--	--	--	--	--	--	--	--
BEA 48	--	--	--	--	--	--	--	--	--	--	--
BEA 49	--	--	--	--	--	--	--	--	--	--	--
BEA 50	--	--	--	--	--	--	--	--	--	--	--
BEA 52	6.7	--	--	--	--	--	6.7	--	--	--	--
BEA 54	18.9	--	18.9	--	--	--	--	--	--	--	--
BEA 55	--	--	--	--	--	--	--	--	--	--	--
BEA 62	--	--	--	--	--	--	--	--	--	--	--
BEA 64	--	--	--	--	--	--	--	--	--	--	--
BEA 65	--	--	--	--	--	--	--	--	--	--	--
BEA 66	--	--	--	--	--	--	--	--	--	--	--
BEA 68	--	--	--	--	--	--	--	--	--	--	--
BEA 115	1,239.8	449.5	--	5.6	2.2	238.2	35.6	473.1	5.6	24.4	5.6
Non-ORB BEAs											
BEA 115[a]	**Traffic external to Ohio River System**										
BEA 117											
BEA 138											

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

Table 4. Ohio River System: Summary of BEA to BEA Linkages of Waterborne Aggregates Traffic, 1976

Rank by order of size of link[a]	BEA origin	BEA destination	Thousands of tons	Percent of totals traffic	Description of Link[b]
1	66 (Pittsburgh, PA)	66 (Pittsburgh, PA)	4,523.2	18.0	Intra - BEA
2	54 (Louisville, KY)	54 (Louisville, KY)	2,495.8	9.9	Intra - BEA
3	52 (Huntington, WV)	52 (Huntington, WV)	1,919.5	7.6	Intra - BEA
4	62 (Cincinnati, OH)	62 (Cincinnati, OH)	1,661.4	6.6	Intra - BEA
5	115 (Paducah, KY)	49 (Nashville, TN)	1,442.5	5.7	Inter - BEA
6	55 (Evansville, IN)	55 (Evansville, IN)	1,275.6	5.1	Intra - BEA
7	48 (Chattanooga, IN)	48 (Chattanooga, IN)	1,265.3	5.0	Intra - BEA
8	49 (Nashville, TN)	49 (Nashville, TN)	1,180.7	4.7	Intra - BEA
9	66 (Pittsburgh, PA)	64 (Columbus, OH)	1,146.8	4.6	Inter - BEA
10	115 (Paducah, KY)	115 (Paducah, KY)	930.3	3.7	Intra - BEA
11	54 (Louisville, KY)	52 (Huntington, WV)	749.5	3.0	Inter - BEA
12	65 (Clarksburgh, WV)	66 (Pittsburgh, PA)	672.2	2.7	Inter - BEA
13	55 (Evansville, IN)	115 (Paducah, KY)	657.0	2.6	Inter - BEA
14	62 (Cincinnati, OH)	52 (Huntington, WV)	627.6	2.5	Inter - BEA
15	54 (Louisville, KY)	53 (Lexington, KY)	539.0	2.1	Inter - BEA
16	115 (Paducah, KY)	138 (New Orleans, LA)	473.1	1.9	Inter - BEA
17	68 (Cleveland, OH)	66 (Pittsburgh, PA)	466.5	1.9	Inter - BEA
18	115 (Paducah, KY)	46 (Memphis, TN)	449.5	1.8	Inter - BEA
19	54 (Louisville, KY)	62 (Cincinnati, OH)	406.0	1.6	Inter - BEA
20	54 (Louisville, KY)	55 (Evansville, IN)	367.0	1.5	Inter - BEA
Other shipments (under 250,000 tons)			1,903.8	7.6	
Total all traffic			25,152.3	100.0	
Inter - BEA			9,900.5	39.4	
Intra - BEA			15,251.8	60.6	

Note: Columns may not add to totals due to rounding.
a. Ranking determined only for shipments over 250.0 thousand tons.
b. Intra - BEA links are shipments entirely within one BEA.
Source: Table compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, supplied by U.S. Army Corps of Engineers.

The longest shipment, albeit a small one (5.6 thousand tons), was from BEA 115 (Paducah) to BEA 141 (Houston, TX).

Approximately 40 percent of 1976 oubound shipments reached Gulf Coast BEAs. Nearly all the remaining outbound shipments were to points along the Mississippi River.

B-4. Highlights of Waterborne Commerce

Table 4 ranks the 20 major waterborne links by BEA segment in 1976. These links accounted for 92.4 percent of total ORB traffic of aggregates. In total, there were 57 waterborne BEA to BEA links in 1976.

BEA 66 (Pittsburgh) has the largest population of the Primary Study Areas. It is also the most heavily industrialized PSA. With its large aggregates demand and nearby supplies, it is not surprising that the largest movements are to and from points in BEA 66.

Louisville (in BEA 54) is a growing city with substantial reserves. The second major origin/destination link was between points in BEA 54.

The longest major haul for aggregates within the ORS is up the Kanawha River from Cincinnati, to Charleston, WV, a haul of approximately 325 miles.

a. Shipments

The distribution of shipments among suppliers changes over time, depending on the supply of material. Where adequate reserves exist, the distribution generally remains stable over time. Where reserves are scarce, small or marginal quality deposits are exploited. In these areas, the distribution of source port equivalents (PEs) can change from one year to the next.

BEA 54 (Louisville) was the most important shipping PSA in 1976. The major area supplying material in the BEA was near the McAlpine Lock and Dam. This area is a source of dredged material supplying virtually all of Louisville's needs and much of Frankfort's demand. It is a major shipping area in the ORS, and the supply pattern within the BEA has been stable for many years.

BEA 66 (Pittsburgh) was also an important shipping PSA for aggregates in 1976. This BEA drew on seven PEs in that year, the main shipping PE being Pike Island Lock & Dam Pool. Exploitable waterside and waterway deposits are relatively scarce around Pittsburgh, and the supply pattern changed during 1969-76 as some deposits played out and others were opened up. Indeed, in the early years of the study period, BEA 66 was the origin of the largest shipments in the ORS.

BEA 115 (Paducah), at the mouth of the Ohio River, is one of major BEAs producing aggregates for other BEAs. This is a result of readily exploitable reserves in the BEA and the lack of a nearby metropolian market.

b. Receipts

The distribution of BEA receipts among receiving points has been quite stable and is determined by the locations of cities and industrial users. Otherwise, the pattern of receipts fluctuates mainly according to variations in local economies. Only occasionally does some large project generate receipts in a non-urban area.

Not surprisingly, BEA 66 (Pittsburgh) was the most important receiving PSA of waterborne aggregates in 1976. This was because this BEA has the largest population and greatest concentration of industry in the Ohio River Basin. The extent of waterborne commerce in this area is illustrated by the fact that 21 PEs, along all three of the waterways in the BEA, received materials in 1976.

BEA 52 (Huntington) also received large amounts of aggregates in 1976. Reserves of aggregates are present in many areas of BEA 52, but the characteristics of the material limits its use in the area. Over half of BEA 52's receipts went up the Kanawha to Charleston; much of this came from downstream of Cincinnati. About a third was unloaded in the vicinty of Huntington, W.Va.

Other important PSAs in 1976 were BEA 49 (Nashville) and BEA 54 (Louisville). BEA 49 received material from BEA 115 (Paducah) as well as locally. All shipments were received at three PEs in BEA 49. BEA 54 receipts derived largely from short-haul traffic between the McAlpine area and Louisville.

C. Summary of Study Findings

During the period 1969-76, aggregates in the PSAs were produced at levels almost equal to those of consumption. This is a reflection of a major characteristic of Group IV: production supplies local demand. This is not expected to change in the future. Both production and consumption are projected to increase at average annual rates of 1.2 percent during the period 1976-2000 and at annual rates of 0.6 percent during the period 2000-2040.

Gross waterborne shipments of aggregates in the ORS are projected to increase at an average annual rate of 0.9 percent until the year 2000. During the period 2000-2040, the average annual growth rate is projected to be 0.6 percent.

II. MARKET DEMAND ANALYSIS

Consumption of aggregates in the area served by the ORS was stable during the 1969-76 period, with a low of 116.4 million tons in 1970 and a high of 152.9 million tons in 1973. Most consumption occurred in construction uses. Industrial consumption of lime flux in the steel industry and crushed rock consumption in the cement industry were also notable.

A. Market Areas

In addition to local demand for Group IV commodities produced in the PSAs, demand also is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs which are the destinations of waterborne aggregate movements originating in the Ohio River Basin.

A-1. Primary Study Areas

This study has identified 14 BEAs and BEA segments in the ORB which have been or will be future origins or destinations for waterborne aggregates.[1] Appendix Table A-1 presents the BEAs and BEA segments which constitute the PSAs for aggregates and for which aggregate consumption has been analyzed and projected. With the exception of BEA 46 (Memphis) which includes counties that border the Tennessee River, every waterside BEA segment in the ORB is a PSA. This use of waterway throughout the ORB results from the widespread consumption and production of aggregates as well as the physical characteristics of the commodity. Most consumption of waterborne aggregates in the ORB occurs within 30 miles of the waterway.

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1. The procedures for definition of the ORS hinterland are described in Methodology Volume.

When used as a base or fill in construction, aggregate is a final good (that is, it is used in the form in which it is produced). It is consumed virtually everywhere. When used in bituminous aggregate or concrete construction, aggregate is an intermediate good. The material is an input in the production of final goods. This consumption may occur on site (i.e., the concrete or blacktop is mixed on location) or in central locations, as in the case of large urban ready-mix producers. Such intermediate consumption usually occurs near the product's end-use. For example, only about one eighth of one percent of wet ready-mix concrete travelled more than twenty five miles in 1972.[1]

BEA 49 (Nashville) is large geographically. Its consumption rose steadily during 1969-76. In 1976, boosted by the construction of a nuclear power plant, it displaced BEA 66 (Pittsburgh) as the largest consumer of construction aggregate. BEA 62 (Cincinnati) was consistently the third largest consumer of construction aggregate during 1969-76, and BEA 54 (Louisville) was fourth in use of construction material.

BEA 66 (Pittsburgh) was the largest consumer of construction aggregate during most of 1969-76 despite a local economic downturn and a halt in highway construction in Pennsylvania. Pittsburgh is the largest city in the PSAs.

The market areas for crushed stone for industrial material are determined by the locations of iron, steel, lime and cement plants. Although the levels of industrial aggregate consumption in BEA 66 (Pittsburgh) declined during 1969-76, the BEA consumed the most crushed rock for industrial purposes. The concentration of industry in the BEA assures that industrial consumption will always be important. Demand for flux by the iron and steel industry generated well over half the demand for industrial aggregate.

BEAs 49 (Nashville), 52 (Huntington), 54 (Louisville), and 115 (Paducah) each consumed more than one million tons of aggregate for industrial purposes annually during 1969-76, and BEA 62 (Cincinnati), as a result of increases in lime production, consumed more than one million tons of this material annually from 1972 to 1976.

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1. U.S. Department of Commerce, Bureau of the Census, Commodity Transportation Survey, Volume III of Census of Transportation, 1972 ed., (Washington, D.C.: GPO, 1976).

A-2. Secondary Consumption Areas

Secondary Consumption Areas (SCAs) are areas outside the ORB which satisfy a part of their demand with shipments from the ORB. Since most aggregates produced in the area served by the ORS are consumed in the region, SCAs do not receive substantial amounts of PSA production.

During 1969-76, there were two major areas outside of the ORB which received ORB aggregates via the waterways: BEAs along the lower Mississippi River and BEAs on the Gulf Coast. Most waterborne ORB aggregates received along the lower Mississippi River were consumed in BEA 46 (Memphis). Material moving to the Gulf Coast was consumed mostly in BEA 138 (New Orleans). Small waterborne shipments from the ORB reached northern Louisiana, the Vicksburg area, the Yazoo River, western Louisiana, eastern Texas, and Chicago.

In addition to areas outside the ORB which were served by the waterway, the PSAs provide aggregates to other areas by rail. BEA 114 (St. Louis), BEA 68 (Cleveland),[1] BEA 52 (Huntington)[1] and BEAs in the Carolinas all received more than one million tons of PSA aggregate production by rail in 1976. In addition, there were many other BEAs receiving smaller amounts by rail.

The Tennessee-Tombigbee Waterway, passing through BEA 45 (Birmingham), may soon join the Tennessee and Tombigbee Rivers. Very little good quality aggregate is produced or is likely to be produced along the route of the new waterway. Upon completion of the canal, the area which it serves will probably become a Secondary Consumption Area for ORB waterborne aggregates. It may be cheaper to supply the Tenn-Tom area via the Ohio River System than to truck or rail material produced inland, or to transport the material in small amounts up the Tombigbee itself. No attempt was made to project the amount of traffic which will be induced by the Tennessee-Tombigbee construction project.

B. Commodity Uses

The two main uses of aggregate are construction use and industrial use. Each of these uses is discussed in detail below.

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1. Excludes segments of these BEAs defined as PSAs.

B-1. Construction Aggregates

Virtually all sand and gravel produced is used in construction. In the past ten years, 83 to 87 percent of U.S. crushed rock production and 95 to 97 percent of U.S. sand and gravel production have gone to the construction industry. The percentage of all aggregate production going to construction increased from 85 percent in 1950 to 92 percent in 1976.

Table 5 presents national data on construction sand and gravel, by use, in 1976. The most important use is in concrete, which consumed about one-third of production. More than half of national production is mixed with cement or bituminous-type material to form durable pavement or structures. These uses usually require what is known as specification material; that is, chemically inert substances conforming to certain size and density requirements. Fill is most often run of the bank and is, therefore, unprocessed material. It is almost never shipped long distances.

Sand and gravel dredged from rivers are considered to be among the highest quality construction aggregates. The resulting concrete has better non-skid properties than a mix composed largely of limestone. Its brownish tint is considered more attractive than the greyish hue of substitute mixes. Furthermore, there is some concern that, for chemical reasons, concrete made with crushed limestone may not prove as strong and durable in the long run. River gravel is clean, hard, well-polished and generally inert.

Most U.S. crushed rock production is used in construction. Table 6 presents national data on crushed stone production, by use, in 1976. More than 35 percent of national production was used as road base, roadstone and for similar uses. More than 28 percent was mixed with cement, bituminous, or asphalt for concrete or pavement material. Uses requiring material with large size specifications, particularly rip-rap and railroad ballast, were also important.

Crushed rock is particularly well-suited to roadbeds because it is angular. It can easily be produced to specifications rather than sifted and blended from deposits which may be quite far apart. It is also well-suited to bituminous paving. Along the ORS, some producers are crushing gravel to meet specifications for uses often filled by crushed rock.

Table 5. United States: Construction Sand and Gravel Sold or Used, by Major Use, 1976

Category of use	Thousand of tons	Percent of total
Concrete aggregate	279,088	32.6
Concrete products (blocks, etc.)	78,059	9.1
Asphalt, bituminous aggregate	127,576	14.9
Roadbase and coverings	208,563	24.4
Fill	136,854	16.0
Other	25,102	2.9
Total[a]	842,242	100.0

a. Data may not add to totals due to rounding.
Source: U.S. Department of the Interior, Bureau of Mines, "Sand and Gravel," Minerals Yearbook, 1976 ed.

Table 6. United States: Crushed Rock Sold or Used, by Use, 1976

Category of use	Thousands of tons	Percent of total
Roadbase	191,160	21.2
Other aggregate, roadstone	131,170	14.6
Concrete aggregate	116,000	12.9
Bituminous aggregate	86,639	9.6
Surface treatment aggregate	54,708	6.1
Macadam aggregate	27,556	3.1
Rip-rap	27,076	3.0
Railroad ballast	23,204	2.6
Other construction uses	19,150	2.1
Construction material	676,663	75.2
Cement	99,208	11.0
Agstone	39,995	4.4
Lime	37,756	4.2
Flux	23,767	2.6
Other	22,874	2.5
Industrial material	223,600	24.8
Total[a]	900,260	100.0

a. Data may not add to totals due to rounding.
Source: U.S. Department of the Interior, Bureau of Mines, "Stone," _Minerals Yearbook_, 1976 ed.

B-2. Industrial Aggregate

Virtually all aggregate-type material used in industry is crushed rock. Cement manufacture is the most important use, requiring nearly 100 million tons of crushed rock in 1976. Inclusion of iron ore, slag, alumina, clays and other aggregate-related materials required in cement production would increase this figure by at least 20 percent. Cement requires low magnesium calcareous stone.

Lime manufacture was another important use in 1976, requiring nearly 38 million tons of crushed rock. Flux for iron and steel production accounted for nearly 24 million tons.

Sand is used in a variety of activities including molding, glass, blasting, grinding and polishing, furnaces, filtration, hydrafac (oil), chemicals, pottery and others. About 5 to 6 percent of sand production goes towards these industrial uses.

Most non-construction gravel production is for metallurgical uses. Less than 1 percent of gravel production goes to industrial uses.

C. Consumption Characteristics

The distinction between construction and industrial applications of aggregate affects all aspects of consumption.

C-1. Construction Aggregates

Projections of construction demand for aggregates require analysis of major factors influencing demand. These factors can be categorized according to the economic, technological, and institutional characteristics of aggregate consumption.

a. Economic Characteristics

Demand for construction aggregates is a function of construction demand, which consists primarily of public works and commercial construction. The former is largely determined by government policies and programs, including, among others, highway construction and maintenance. The latter may be subdivided into two subcomponents: residential construction and industrial construction.

Industry sources estimate that more than half of aggregate used for roads is for maintenance. This demand is fairly stable. The demand for aggregates for road construction is declining. There is little doubt that the post-war highway building boom is over. In recent years, there has been a virtual stand-still in highway construction in the Ohio River Basin. The amount of construction aggregate requiring construction is significant, if undeterminable.

Both commercial and public demand for aggregate may be linked to economic growth and population trends. Aggregate consumption, with respect to population, is constant across the country. Aggregates tend to move to urban centers, and the amounts moving to these centers are largely a function of urban populations, regardless of intended aggregate use.

b. Technological Characteristics

Size and density are generally the only necessary specifications for construction aggregate. Chemical properties can be important, and no material which may impede the setting of concrete or which may interact chemically with cement to cause deterioration is acceptable. For example, gravel deposits containing lignite cannot be used.

Roadbed or railroad bed material often must be large in size. For concrete, various ratios of sand to gravel and stone must be maintained. Certain applications require either angular, or smooth, rounded materials. These are the kinds of requirements which separate specification material from run of the bank material. Virtually all waterborne commerce is in specification material, as there is rarely any reason to incur transportation costs to obtain run of the bank aggregate.

For construction, crushed rock and gravel are often near perfect substitutes. Usually natural gravel is preferred for the sake of appearance, or for non-skid properties. However, in terms of strength there is little difference.

Artificial sand, manufactured from limestone, can be used in lieu of natural sand. It is, however, inferior to the natural sand; it is considered quite unattractive, and it adversely affects the non-skid properties of pavement. Furthermore, it is abrasive and thus very hard on equipment. For example, high-rise buildings are often built by pumping wet concrete though pipes to upper levels; and concrete made from artificial sand cannot be poured in this fashion because it wears out pumps and pipes.

c. Institutional Characteristics

Demand for construction aggregate is centered in urban areas where large numbers of consumers are clustered together. Very often a few suppliers supply most of the aggregate required by a number of cities.

Aggregate operations tend to be vertically integrated. An operator often will produce, transport and sell the material. Generally, operators also sell ready-mixed concrete, and they may be construction contractors as well.

A large percentage of total final consumption is small lot use by many dispersed customers. Examples are residental home construction, and both commercial and public maintenance.

Individual consumers are well-integrated into this system. With a phone call, a truck load of base or a mixer of concrete can be ordered for immediate delivery. The operator serving an area delivers the aggregate he produced downstream, processed, transported and stored until needed.

C-2. Industrial Materials

Aggregates have a number of industrial uses, and the kinds of material required vary. However, most industrial users require crushed stone.

a. Economic Characteristics

Aggregate required by industry is in the form of intermediate goods that are used to produce finished products. Unlike construction aggregate, consumption is not dispersed. Since large quantity shipments are common, transportation is usually by barge or rail.

b. Technological Characteristics

Industrial aggregate must meet specific requirements of users. It must be of narrowly specified dimension and conform to relatively rigid chemical and physical specifications.

Cement, in particular, requires a specific mix of material. Nationally, 66 percent of cement raw material input is calcareous and about 9 percent is ferrous siliceous or other material.[1]

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1. U.S. Department of the Interior, Bureau of Mines, "Cement" and "Lime," Minerals Yearbook, 1976 ed. (Washington, D.C.: GPO, 1979).

c. Institutional Characteristics

Industrial users of aggregate often have captive sources of aggregate. For example, Flintkote, in western Kentucky, owns a stone quarry which supplies feed for its cement plant. The plant and quarry are linked by company-owned barges. Black River Mine, in eastern Kentucky, is a joint venture limestone mine owned by steel producers. Dravo mines limestone in Maysville, Kentucky to produce lime. Because steady consumers regularly get large supplies over long periods of time from specific suppliers, large quantity movements are generated. Rail and water links often are used for these large regular shipments.

D. Existing Aggregate Demand

Nationally, crushed rock consumption exceeded sand and gravel consumption by the early 1970s. It rose from about 30 percent of total aggregate consumption in the early 1950s to well over 50 percent in the 1970s. About 4.8 percent of aggregate demand in 1976 was satisfied by 81.4 million tons of clay, gypsum and slag. Although decreasing as a percentage of aggregates used, these alternate materials have been slowly but steadily rising in use since World War II.

During the 1969-76 period, consumption of aggregates in the PSAs grew from 122.3 million tons in 1969 to 132.3 million tons in 1976, an average annual increase of about 1.3 percent. However, annual consumption fluctuated during this period, reaching a low of 116.4 million tons in 1970 and a high of 152.9 million tons in 1973 (Table 7). Most of this fluctuation was due to changes in the amount of construction aggregate demand which resulted from population shifts and changes in national per capita use of aggregate.

Of the 132.3 million tons of aggregates consumed in the PSAs in 1976, more than 89 percent was consumed in construction uses. Consumption of construction aggregates occurred mostly in BEA 66 (Pittsburgh), BEA 49 (Nashville), BEA 62 (Cincinnati), and BEA 54 (Louisville).

The bulk of industrial aggregates was used for cement manufacture. However, more than 4.0 million tons were used for the manufacture of pig iron. This consumption occurred mostly in BEA 66 (Pittsburgh).

Table 7. Ohio River Basin: Consumption of Aggregates, by BEA or BEA Segments, Estimated 1969-76

(Thousands of tons)

BEA or BEA Segment		1969	1970	1971	1972	1973	1974	1975	1976
Primary Study Area		122,292.2	116,350.8	119,068.4	126,646.8	152,898.0	137,926.3	127,829.3	132,319.2
BEA 47:	Huntsville, AL	4,868.8	4,692.0	4,490.2	4,746.6	5,522.6	6,200.2	5,506.4	6,021.4
BEA 48:	Chattanooga, TN	8,355.6	7,466.0	6,879.0	7,852.8	11,211.8	9,127.2	9,841.6	7,992.6
BEA 49:	Nashville, TN	13,677.8	14,414.0	13,993.8	15,955.6	18,898.6	17,982.2	17,195.4	20,777.4
BEA 50:	Knoxville, TN	7,178.3	7,622.3	7,395.1	8,455.0	9,757.1	9,361.0	8,858.1	8,852.9
BEA 52:	Huntington, WV	8,489.4	7,918.5	9,246.3	9,305.4	10,968.0	10,246.0	9,804.3	9,286.1
BEA 53:	Lexington, KY	6,264.0	6,061.0	5,160.0	6,542.0	7,691.0	6,903.0	6,557.0	6,861.0
BEA 54:	Louisville, KY	14,569.2	13,863.4	14,118.4	14,760.2	18,354.4	15,350.8	14,181.4	14,874.4
BEA 55:	Evansville, IN	6,915.9	6,608.8	6,799.9	7,109.8	9,970.8	7,472.5	6,778.7	7,140.8
BEA 62:	Cincinnati, OH	17,297.0	15,581.3	15,615.2	16,573.6	19,561.7	17,006.2	15,649.1	15,897.2
BEA 64:	Columbus, OH	2,447.0	2,253.0	2,411.0	2,494.0	2,913.0	2,612.0	2,448.0	2,330.0
BEA 65:	Clarksburg, WV	1,278.0	1,263.0	1,663.0	1,629.0	2,010.0	1,943.0	1,943.0	1,743.0
BEA 66:	Pittsburgh, PA	26,087.2	24,141.7	25,573.9	26,402.2	30,597.6	28,660.4	24,289.3	25,508.2
BEA 68:	Cleveland, OH	1,416.0	1,273.0	1,366.0	1,415.0	1,661.0	1,503.0	1,404.0	1,346.0
BEA 115:	Paducah, KY	3,448.0	3,192.8	3,356.6	3,405.6	3,780.4	3,558.8	3,373.0	3,688.2

Note: Total state consumption of aggregates by state was assumed equal to state production of sand, gravel and crushed rock, plus consumption of specified material used in the construction of nuclear plants. State production data were obtained from Mineral Yearbook and available estimates of aggregates produced and consumed on site, which were excluded from Bureau of Mines data. Aggregates used for construction purposes were estimated at a state level by subtraction of industrially used aggregates from state consumption totals. Aggregates used in construction (other than nuclear plant construction) were distributed to BEA segments on the basis of population. Aggregates used in nuclear plant construction were estimated by BEA segment from Construction Status Report; Capital and Cost; Boiling Water Reactor Plants; Capital Cost: Pressurized Water Reactor Plant. Characteristics of consumption for ORB nuclear plants assumed to be the same as for the typical plants described in those sources. This consumption was assumed to occur in first 10 percent of construction period. Estimates of industrial consumption of aggregates by state and by BEA segment were obtained from Mineral Yearbook and from estimates of consumption in the manufacture of steel, lime and cement. Production of steel, lime and cement were obtained from RRNA estimates of these commodities (Groups VIII and XII). The aggregates requirements for this production were obtained from American Iron and Steel Institute, Annual Statistical Report, and the Bureau of Mines.

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

Source: Estimated by RRNA from U.S. Department of the Interior, Bureau of Mines, Area Reports, Vol. II of Minerals Yearbook, 1969-76 eds.; U.S. Department of Energy, Energy Information Agency, Nuclear Analysis Division, Construction Status Report, November 30, 1978 and Nuclear Regulatory Commission, Capital Cost: Boiling Water Reactor Plants and Capital Cost: Pressurized Water Reactor Plant. Population data supplied by U.S. Department of Commerce, Bureau of Economic Analysis. Conversion factors for industrial consumption from American Iron and Steel Institute, Annual Statistical Report, 1969-76, and U.S. Department of the Interior, Bureau of Mines, Mineral Facts and Problems, 1975, and unpublished information from the Bureau of Mines. Cement and lime and iron and steel production estimates from Group XII and Group VIII sections of this study.

E. Forecasting Procedures and Assumptions

The assumptions on which projections of future consumption of aggregates in the PSAs were based are essentially the same as the assumptions made to estimate historical consumption. Demand for aggregates was assumed to parallel aggregate production in the areas.

E-1. Forecasting Construction Aggregate Consumption

The U.S. Bureau of Mines is the principal source for information regarding the reserves, production and consumption of mineral commodities. Data for nonfuel minerals are collected through 160 statistical surveys from approximately 60,000 firms and individuals. Bureau of Mines compilations of detailed information on aggregates (such as end-use and geographic region information) have been used in the projection of construction and industrial demand.

The Bureau of Mines provides individual projections for the demand for sand and gravel and for crushed stone. The analysis and projections also include consideration of these commodities together. The Bureau of Mines begins with statistical regressions. Projections are then developed with consideration given to current and anticipated developments which might have an impact on demand. These developments may include environmental restrictions, new technical innovations and competitive trends.

Three sets of projections to the year 2000 were provided for sand and gravel by the Bureau of Mines, using data through the year 1976. The high forecast was based on a 20-year trend, while the low forecast was based on a 15-year trend. The most probable projection, 1,150 million tons,[1] was obtained using a midrange trend line. Demand in construction use was projected to equal 97 percent of total demand for sand and gravel, which is close to the percentage distribution in 1976.

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1. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles: Sand and Gravel, MCP 23 (Washington, D.C.: Bureau of Mines, 1978).

The most probable projection of construction demand for crushed stone in the year 2000 is 1,365 million tons[1], approximately 85 percent of total forecast for crushed stone. This projection is lower than the statistical projection which did not consider expansion in lightweight aggregates and competition from brick, tile, plastics and metals manufacturers.

National per capita consumption projections, based on Bureau of Mines projections, are reported in Mineral Trends and Forecasts.[2] Per capita consumption estimates for construction usage were derived for the year 2000 using forecasts in Mineral Commodity Profiles, and was equal to 9.5 tons per person. No projections beyond the year 2000 were published; therefore, projections of consumption have been made assuming a gradual decrease in the rate of change after 2000. By the year 2020, it is projected that per capita consumption will be 10.3 tons, based on the assumption that the increase from 2000 to 2020 will be equal to the increase between 1985 to 2000. By the year 2040, it is assumed that per capita national construction consumption of aggregates will to be 10.7 tons, assuming that the increase from 2020 to 2040 will be equal to half the increase projected between 2000 and 2020.

Per capita consumption in the PSAs was assumed to tend towards the national per capita consumption, and that it would equal national per capital consumption by the year 2000. These projections of PSA per capita consumption were used with projections of population growth by BEA to obtain estimates of total construction demand for aggregates by BEA or BEA segment. Population projections by BEA for the period 1980-2020 were obtained from OBERS Projections.[3] Population growth rates by BEA for the period 2020-2040 were assumed to equal half the rates projected for the period 2000-2020.

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1. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles: Stone, MCP 17 (Washington, D.C.: Bureau of Mines, 1978).
2. U.S. Department of the Interior, Bureau of Mines, Mineral Trends and Forecasts, 1979 ed. (Washington, D.C.: Bureau of Mines, 1979).
3. U.S. Water Resources Council, OBERS Projections, Series E, 1972 ed. (Washington, D.C.: GPO, 1974).

E-2. Forecasting Industrial Aggregate Consumption

Four industries account for most of the crushed rock used in industry. They are the cement, lime, pig iron and steel industries.

Projections of the consumption of flux by the iron and steel industry were based on projections of iron and steel production, by PSA and by furnace type. Different types of furnaces use different amounts of flux. Expected changes in furnace types were considered in this forecast. It was assumed that the amount of flux used by the various furnace types will not change in future, an assumption which industry experts support. Thus, a factor specific to each furnace type was applied to project production by type of furnace within each BEA. These factors are national averages obtained from the American Iron and Steel Institute. This calculation furnished the projected consumption of flux by the steel industry for 1980 through 2040.

Similarly, pig iron production was projected by PSA. From national data, the average amount of flux used per ton of pig iron produced was computed. A factor of 0.21307 was derived and applied to projected pig iron production to generate a projection of consumption of flux in pig iron manufacturing.

Projections of cement and lime production by BEA, provided by the Rubber, Plastic and Nonmetallic Minerals, Nec., (Group XII) Report of this study, were used to project industrial consumption of aggregates in the manufacture of cement and lime. For cement, approximately 1.8 tons of feed are used to manufacture one ton of final product. Along the Ohio River, most of this feed is limestone. About 2.0 tons of lime rock must be burned to manufacture a ton of lime. Thus, factors of 1.8 and 2.0 were applied to the cement and lime production projections, respectively.

As stated above, national factors were used as an approximation of the average factors for the PSAs. Within the PSAs, variation may exist with respect to the amount of flux used in steel or pig iron production. Also, variation may exist as to the amount of aggregates required per ton of cement or lime. These variances reflect differences from plant to plant in technology, management and final product. Also, variances may occur in the same plant over time. No attempt was made to account for these differences.

In estimating historical consumption, usage of material in the construction of nuclear power plants was explicitly considered. Adjustments for nuclear power plant construction were made to enhance estimates of total aggregate demand. They were based on data provided by the U.S. Department of Energy. Information regarding requirements for aggregates in the construction of other power plants and other major projects would also have enhanced the accuracy of historical consumption estimates. However, such information was not readily available.

Even though future construction dates of planned nuclear installations can be determined, this form of demand was not explicitly considered for two reasons: first, these construction schedules are unlikely to remain unchanged as national policies in regard to nuclear energy change; second, demand in intervening years (for example, 1984 or 1992) is projected by interpolating between 1980 and 1990, or 1990 and 2000, etc. An upward "bump" projected in 1990 would cause an upward bias in the projections for 1981 to 1989 and for 1991 to 1999 for individual BEAs as well as for the entire study area.

F. <u>Probable Future Demand</u>

Demand for aggregates in the PSAs is projected to increase from an average of 132.7 million tons in 1974-76 to 229.9 million tons in 2040 (Table 8). During the period 1974-2000, consumption is projected to increase at an average rate of 1.2 percent per year. For the period 2000-2040, consumption is projected to increase at approximately 0.6 percent annually. The slower growth rate reflects an anticipated leveling of per capita consumption rates and a slower rate of growth in population.

BEAs 66 (Pittsburgh), 62 (Cincinnati), 54 (Louisville), and 49 (Nashville) will continue to be the primary consumers of aggregates. The fastest growing BEAs are expected to be BEA 64 (Columbus) and BEA 47 (Huntsville). In BEA 62, a portion of the increase is expected to result from increased cement production. This increase, in turn, is expected to result from a high growth in population and changes in per capita consumption in the BEA.

Table 8. Ohio River Basin: Consumption of Aggregates, by BEAs or BEA Segments[a], Estimated Average 1974-76 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated average 1974-76	Projected					Average annual percentage change	
		1980	1990	2000	2020	2040	1974-76-2000	2000-2040
Primary Study Areas	132,691.8	139,680.5	161,785.4	178,855.8	211,523.6	229,685.8	1.2	0.6
BEA 47: Huntsville, AL	5,909.3	6,574.2	8,380.2	10,087.6	13,224.3	14,968.8	2.2	1.0
BEA 48: Chattanooga, TN	8,987.1	8,733.4	10,300.3	11,380.4	13,718.4	15,005.2	0.9	0.7
BEA 49: Nashville, TN	18,651.7	17,719.2	19,174.0	19,606.1	24,609.0	27,354.4	0.2	0.8
BEA 50: Knoxville, TN	9,024.0	9,164.2	9,578.9	9,546.5	10,769.9	11,430.1	0.2	0.5
BEA 52: Huntington, WV	9,778.8	9,776.6	10,708.8	11,408.6	11,582.0	11,655.4	0.6	0.1
BEA 53: Lexington, KY	6,773.7	7,005.1	7,190.3	6,958.9	8,176.8	8,836.9	0.1	0.6
BEA 54: Louisville, KY	14,802.2	15,408.2	17,168.6	18,241.8	23,046.2	25,704.4	0.8	0.9
BEA 55: Evansville, IN	7,130.7	7,383.9	7,741.5	7,849.2	9,239.9	9,998.6	0.4	0.6
BEA 62: Cincinnati, OH	16,184.2	19,306.2	24,203.6	28,354.3	34,632.5	38,318.3	2.3	0.8
BEA 64: Columbus, OH	2,463.4	2,632.9	3,464.7	4,308.8	5,353.4	5,925.9	2.3	0.8
BEA 65: Clarksburg, WV	1,876.4	1,903.4	2,227.6	2,502.3	2,733.2	2,854.9	1.2	0.3
BEA 66: Pittsburgh, PA	26,152.6	28,669.2	34,193.8	40,367.7	45,046.7	47,618.5	1.8	0.4
BEA 68: Cleveland, OH	1,417.7	1,479.3	1,817.1	2,170.5	2,561.5	2,774.6	1.7	0.6
BEA 115: Paducah, KY	3,540.0	3,924.7	5,636.0	6,073.1	6,829.8	7,239.8	2.2	0.4

Note: Consumption of flux by BEA and BEA segment was projected by applying ratio of flux per ton of iron and steel manufactures to RRNA projection of iron and steel production and furnace type. Consumption of crushed rocks by cement and lime industry by BEA segment was obtained by applying a factor of 1.8 and 2.0 respectively to RRNA projections of cement and lime production. Projected consumption of construction aggregates was obtained by projecting per capita consumption of aggregates by BEA segment and applied to projected population by BEA segment.

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

Source: Table 1; American Iron and Steel Institute: Annual Statistical Report, 1969-79 eds.; U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profile, "Stone," July 1978 and "Sand and Gravel," September 1978; Mineral Trends and Forecasts, 1979 ed. Mineral Facts and Problems, 1975 ed., and Mineral Yearbook, "Sand and Gravel," "Stone," 1972 ed.; U.S. Water Resources Council, OBERS Projections, Regional Activity in the U.S., Series E, 1972 ed., and unpublished data on tapes. Cement and lime and iron and steel projections from Group XII and Group VIII sections of this study.

III. COMMODITY RESOURCES INVENTORY

During the period 1969-76, production of aggregates in the Primary Study Areas increased from 122.4 million tons to 127.9 million tons. These levels of production reflected the demands for aggregates in the PSAs. The production characteristics of Group IV are such that, with few exceptions, demands are met from nearby sources.

A. Production Areas

The production of Group IV commodities 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 IV waterborne movements destined to the Ohio River Basin.

A-1. Primary Study Areas

The Primary Study Areas for aggregates are presented in Appendix Table A-1. Production of aggregates occurred in every PSA, with virtually all production of waterborne aggregates occurring within a short distance of the waterway, usually within one mile from shore.

Since production is largely a function of local demand, most production points are linked to nearby urban areas. The largest PSA, in terms of production levels, was BEA 66 (Pittsburgh). BEAs 54 (Louisville), 50 (Knoxville), 62 (Cincinnati) and 49 (Nashville) were also major producing areas.

Although most production in the PSAs was consumed locally, several BEAs contributed substantial amounts of aggregates for consumption elsewhere. BEA 54 (Louisville) supplied the largest amount of production for external consumption outside the BEA. Due to the availability of low-cost, high quality stone deposits, and due to the lack of nearby major urban areas, substantial quantities of aggregates were produced in BEA 115 (Paducah) to meet demands considerable distances away. BEAs 47 (Huntsville), 50 (Knoxville), and 65 (Clarksburg) are also major suppliers of aggregates in the PSAs.

A-2. Secondary Production Areas (SPAs)

Production of aggregate is widespread throughout the country. However, many regions rely on outside areas for some of their supplies. This is particularly true of high-specification material. Some areas outside the PSAs supply certain grades of industrial material to various PSAs. More than 9 million tons of material were shipped into the PSAs in 1976, most of which was shipped by rail. More than a million tons came from central Pennsylvania, about 2.3 million tons from Virginia, and about three quarters of a million tons came from the Carolinas and Georgia. Michigan supplied about 400,000 tons.

In 1976, inbound waterborne shipments to the Ohio River Basin were insignificant. Not one Secondary Production Area served as a major supplier for any PSA.

B. Production Characteristics

The method for production depends in part on the nature of the raw material and in part on economic factors. Materials suitable or adaptable to aggregate use are ubiquitous and practically inexhaustible, although local shortages for certain specific types of material may occur. Accordingly, the major cost to the consumer is typically transportation cost. The short-haul nature of movements greatly impacts on production and distribution patterns.

On the whole, production equals demand. There is little stockpiling; producers tend to vary their rates of production to meet current demand. This is due to the product being processed and blended to meet the consumer's requirements, and to the lack of economic incentives to generate and hold inventories. It has been said of the industry that the deposits themselves may be viewed as stockpiles of semi-finished product.

Production and supply in a region will nearly always be determined by the region's demand. The closer a supplier is located to the consumer, the greater the supplier's competitive advantage in terms of transportation costs. In a highly competitive industry where transportation is a major factor, location of supply will be as close to consumers as possible.

Most sand and gravel deposits in the PSAs are of high quality. Thus, little processing is required, and the deposits are suitable for a wide range of uses. They are also conveniently located for water transport. North of and on the Ohio River, deposits are scattered throughout Illinois, Indiana and Ohio in such a way that few areas in those states are distant from workable deposits. Furthermore, most of the Basin's population is located in counties on and north of the Ohio River. Thus, both supply and demand are principally on the Ohio River and its northern tributaries. It is not surprising, therefore, to note that the southern tributaries carry relatively small percentages of waterborne aggregates traffic.

Production economies of scale generally require large deposits to justify large capital expenditures. Such large deposits of sand and gravel are found on and north of the Ohio River. Limestone deposits are located in many areas of the PSAs. Furthermore, transport economies of scale require centralized clusters of consumers (i.e., population centers) in order to render large lot transport from the point of production to points of distribution economically feasible, and this necessity is also met in the region.

B-1. Methods of Production

Dredging is an important method of sand and gravel production along waterways. However, the importance of dredging is diminishing as good waterway deposits become harder to find. Furthermore, environmentally inspired restrictions are hampering investment in new dredges, and waterside pits are providing a higher proportion of PSA sand and gravel.

Quarries supply most crushed rock. They too are coming under increasing pressure due to environmental restrictions on dust, noise, and land use. Therefore, underground mines are an increasingly important source of crushed rock.

Sand and gravel generally must be washed for use as an input for concrete and for some other uses. Considerable quantities of water are required, and effluent disposal is a problem. About 460 gallons of water are required, on the average, to process a ton of sand and gravel, and a third of a ton of waste is generated.[1] These considerations encourage operators to locate near rivers and other water sources.

Deposits vary in terms of quality and size of material as well as in their ratios of sand to gravel. Thus, aggregates must be sorted according to size; then mixed, according to specifications.

Exploitable rock deposits are solid stratums of stone, the thicker the better, with little overburden. The stone is usually loosened initially by explosives. For most crushed rock production, operators use a concussive or blast to break up the material, after which some mechanical crushing and processing occurs. The material is then sorted according to size. Stone is sometimes mined selectively for chemical characteristics.

Rip-rap, derrick stone and other large size special grade rock require specialized production techniques, including blasting. Often the large-size product must be moved piece by piece rather than by conveyor belt.

B-2. Institutional Factors

Production of aggregates is highly centralized and vertically integrated. Marketing of the product is most often done by the producers. Much production is used by the producers themselves; for example, as input into ready mix concrete. This is particularly true of industrial aggregates.

Dredgers are required to obtain permits for their operations. Thus, public policies affect the latitude of operations. Indeed, all aggregate operators are increasingly subject to the institutional constraints of public policy.

C. Feedstocks and Raw Materials

Natural deposits of sand and gravel exist in substantial quantities along and in the Ohio River. These deposits are glacial in origin and pure sand deposits are abundant between the Ohio

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1. U.S. Department of the Interior, Bureau of Mines, "Sand and Gravel," Minerals Yearbook, 1976 ed. (Washington, D.C.: GPO, 1979).

River and the Great Lakes. Gravel and mixed deposits are conveniently located in river valleys or in the riverbed itself. They are found throughout the northern and central part of the ORB. Such deposits are rare south of the Ohio River, however. The limited glacial deposits in southern regions of the area served by the ORS result in aggregate movements to these deficit areas.

Where they are found, glacial deposits of sand and gravel are common and evenly scattered. However, the raw materials are of various types, quantities, qualities and blends. They also vary in depth of deposition and, consequently, in economic feasibility of exploitation.

There is some concern about sand and gravel reserves for the long term. Uncertainty of supply results from environmental objections to dredging, particularly in shallow waters.

The only tributaries of the Ohio River producing substantial quantities of sand and gravel are the Tennessee and Allegheny Rivers. It is expected that Allegheny River production will be insignificant by 1990. Operators are already reworking old deposits. Most potential Allegheny reserves are in shallow water and are restricted due to environmental regulations. Sand is already in short supply in the upper Tennessee River.

There are many waterside and waterway sand and gravel deposits on the Ohio River where it forms the boundary between the states of Ohio and West Virginia. Some of these, particularly those upstream, are quite small and will soon be depleted.

Presently existing waterside reserves at Markland Pool, west of Cincinnati, are sufficient to last at least twenty years.

The McAlpine area, in BEA 54 (Louisville), one of the most productive areas in the PSAs in recent years, has plenty of suitable material left for dredging. Similarly, Cannelton Pool, in BEA 55 (Evansville), has substantial reserves remaining.

Near the mouth of the Ohio, and where the Ohio River borders Illinois, dredging operations are still viable and will be for some time.

There is still a lot of material in the waterways, but these reserves cannot be regarded as inexhaustible. The quality of dredged material has declined over the years as well. Environmental opposition to dredging operations already limits operations.

Dredging, as a procedure for accumulating material, will surely diminish in importance in the future.

Crushed stone moves down the Monongahela River in substantial quantities and will continue to do so in the future. In general, however, easily exploitable deposits of good stone are not found along the waterways in the upper Ohio River Basin.

Massive reserves of limestone are found along the waterways throughout most of Kentucky and in parts of Tennessee. In eastern Kentucky, two large deposits were opened up during 1969-76, mainly to provide lime rock for two new lime plants. The area has abundant exploitable deposits. Several limestone operations produce and ship large amounts of stone by water. There are sufficient reserves to allow production increases. Limestone reserves are also found in many areas adjacent to the Tennessee River.

D. Existing Production Levels

The production of aggregates increased in the PSAs at an average rate of 0.6 percent per year during 1969-76. There was a great amount of fluctuation in production, with a low of 114.8 million tons in 1971 and a high of 146.7 million tons in 1973 (Table 9). Most production was used to satisfy local demand for construction aggregate. BEA 50 (Knoxville), BEA 54 (Louisville) and BEA 115 (Paducah) were major suppliers to consumption areas elsewhere in and outside the Basin.

Several trends are affecting the production of aggregates in the Ohio River Basin. Waterway deposits suitable for dredging are being exhausted in many areas. This is particularly true of the upper Ohio and Allegheny Rivers. Environmental restrictions, both existing and potential, are discouraging and preventing operators from expanding dredging operations even where adequate reserves of material exist. Crushed rock is being substituted increasingly for gravel. Artificial sand, manufactured from limestone, is similarly taking the place of sand in some areas. The degree of substitution depends on physical characteristics and uses of the materials. Thus, in areas where limestone and other rock are plentiful, production is growing rapidly. In other areas, ones which once satisfied local demand with natural sand and gravel, production is decreasing.

The production in BEAs upstream of Cincinnati decreased during 1969-76. One major reason for production decreases was a decline in the level of demand. Apart from BEA 65 (Clarksburg) and BEA 53

Table 9. Ohio River Basin: Production of Aggregates, by BEAs or BEA Segments[a], Estimated 1969-76

(Thousands of tons)

BEA or BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
Primary Study Areas	122,448.1	114,780.1	115,710.7	121,151.5	146,659.8	132,657.5	123,265.8	127,935.4
BEA 47: Huntsville, AL	4,560.5	4,327.2	4,420.1	4,681.2	6,071.7	5,863.5	5,793.5	6,373.6
BEA 48: Chattanooga, TN	8,429.3	7,472.2	7,116.2	7,015.0	8,447.6	7,601.3	7,013.8	7,238.7
BEA 49: Nashville, TN	13,101.4	12,889.8	13,596.0	14,881.8	19,124.4	18,293.5	17,935.2	19,571.3
BEA 50: Knoxville, TN	7,123.7	7,437.8	8,250.2	9,434.2	11,542.1	10,546.3	9,885.9	10,360.0
BEA 52: Huntington, WV	7,877.3	6,795.0	6,259.9	5,940.5	7,377.0	6,858.4	6,533.1	6,954.4
BEA 53: Lexington, KY	6,207.6	5,899.7	6,017.0	6,384.2	7,641.0	6,831.9	6,274.2	6,433.3
BEA 54: Louisville, KY	16,380.2	15,724.9	16,222.6	17,371.1	20,825.7	18,651.6	17,146.3	17,618.8
BEA 55: Evansville, IN	5,500.7	5,279.9	5,438.4	5,827.4	7,230.3	6,685.9	6,360.5	6,744.1
BEA 62: Cincinnati, OH	17,580.2	16,390.5	16,442.5	17,116.9	20,107.2	17,643.4	15,889.0	15,972.6
BEA 64: Columbus, OH	1,962.9	2,295.6	2,777.1	3,392.1	3,387.8	2,401.1	1,639.4	1,061.5
BEA 65: Clarksburg, WV	1,812.1	1,790.6	1,886.1	2,074.6	2,551.9	2,347.6	2,268.1	2,415.2
BEA 66: Pittsburgh, PA	25,630.2	21,842.6	19,821.3	18,428.5	22,438.9	20,389.4	19,044.5	19,858.4
BEA 68: Cleveland, OH	1,406.5	1,687.3	2,082.8	2,567.2	2,801.2	2,255.2	1,836.7	1,641.5
BEA 115: Paducah, KY	4,875.5	4,947.0	5,380.5	6,036.8	7,113.0	6,261.4	5,645.6	5,692.0

Note: Production by BEAs and BEA segments for 1969, 1972 and 1976 based on RRNA consumption estimates adjusted for inter-BEA rail and water shipments. Production for the entire ORB for other years was determined using linear extrapolations of the ratio of ORB production to consumption obtained for 1969, 1972, and 1976. Production was allocated to BEAs and BEA segments using linear extrapolations of the BEA or BEA segment share of the ORB production. Columns may not equal totals due to rounding.

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

Source: Table 7, Waterborne Commerce by Port Equivalents, 1969-76, and ICC Railroad Waybill Sample, 1969, 1972, 1976, supplied by U.S. Army Corps of Engineers.

(Lexington), every PSA from Cincinnati upstream consumed less aggregate in 1976 than in 1969. The most vivid example is BEA 66 (Pittsburgh). Its percentage of total PSA production fell from 20.9 percent in 1969 to 15.5 percent in 1976. This was due primarily to a weak local economy and a leveling off in population growth. A decrease in highway construction and maintenance by the Pennsylvania state government and local governments, during the mid-1970s contributed to the decline.

Another reason for production decreases was that good quality aggregate is increasingly scarce in the upper Ohio River Basin. Net inbound shipments into the area have increased. During the study period, dredging and waterside operations near Pittsburgh exhausted deposits and were forced to move further downstream. Similarly, Charleston, in BEA 52, began to consume material from sources downstream of Cincinnati.

In the PSAs downstream of Cincinnati, with the exception of BEA 48 (Chattanooga), levels of production increased. The upper Tennessee River area is critically short of good quality sand.

E. Forecasting Procedures and Assumptions

Projections of production for each PSA were made on the basis of projections of aggregates consumption (Table 8) and net shipments. This was done since, for reasons stated earlier, production in a region is mostly determined by the region's demand. However, certain shipment patterns exist which reflect the availability of required material and institutional factors. Production is equal to consumption plus net shipments (outbound minus inbound).

In projecting net shipments, it was assumed that, for all practical purposes, truck movements of aggregates are local movements within BEAs. This simplifying assumption is supported by field observations indicating that truck movements generally are less than thirty miles and are the main mode of transport for local distribution. Thus, inter-BEA shipments move almost entirely by water or rail.

The net water shipments for each BEA were determined as follows:

a. Total waterborne receipts were projected for the PSAs on the basis of the relationship between receipts and consumption during 1969-76.

b. Total waterborne shipments were projected for the PSAs on the basis of historical (1969-76) trends and field information gathered during the course of this study.

c. Projected total waterborne receipts and shipments of aggregates were distributed to individual BEAs according to the distribution of estimated material reserves among BEAs, historical distribution of receipts and shipments, and field information gathered during the course of this study. Shippers and receivers of aggregates located throughout the PSAs were interviewed either in person or through phone conversations. In addition, authorities, with positions in state or national government, were interviewed. These interviews provided data regarding the existence and nature of reserves, as well as expectations regarding future patterns of waterborne traffic.

d. Projected net waterborne shipments of aggregates by BEA were determined by subtracting projected receipts by BEA from projected shipments by BEA.

Projected net rail shipments of aggregates for each BEA were based on the relationship, in percentage terms, between BEA net rail shipments and consumption in 1976.

Projected total net aggregate shipments for each BEA were determined by summing projected net water and rail shipments.

Projected production for each BEA is the summation of projected total net shipments (outbound less inbound) and projected consumption for each BEA. This follows from the assumption that production less outbound shipments equals consumption less inbound shipments.

F. Probable Future Production Levels

Production of aggregates in the Primary Study Areas is expected to increase from an average of 128.0 million tons during the 1974-76 period to 172.2 million tons in the year 2000, an average increase of approximately 1.2 percent per year. During the period 2000 to 2040, production is projected to increase at an average annual rate of 0.6 percent per year (Table 10). These increases reflect changes in total PSA consumption which is projected to increase at the same rates.

Table 10. Ohio River Basin: Production of Aggregates, by BEAs or BEA Segments[a], Estimated Average 1974-76, and Projected 1980-2040, Selected Years

(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 1976-2000	Average annual percentage change 2000-2040
Primary Study Areas		127,955.1	135,611.3	156,594.5	172,248.3	204,570.7	222,546.3	1.2	0.6
BEA 47:	Huntsville, AL	6,010.2	6,928.0	8,795.8	10,575.5	13,845.5	15,663.2	2.3	1.0
BEA 48:	Chattanooga, TN	7,284.8	7,909.8	9,175.0	10,004.3	11,997.3	13,093.8	1.3	0.7
BEA 49:	Nashville, TN	18,600.0	17,036.8	18,618.1	19,217.0	23,960.6	26,562.4	0.1	0.8
BEA 50:	Knoxville, TN	10,264.1	10,712.6	11,212.1	11,187.7	12,625.8	13,402.1	0.4	0.5
BEA 52:	Huntington, WV	6,782.0	7,677.7	8,834.2	9,761.2	10,347.1	10,664.7	1.5	0.2
BEA 53:	Lexington, KY	6,515.1	6,576.0	6,789.4	6,605.2	7,751.9	8,373.1	0.1	0.6
BEA 54:	Louisville, KY	17,805.6	18,543.3	20,761.2	22,126.1	27,433.9	30,368.8	0.9	0.8
BEA 55:	Evansville, IN	6,596.8	6,839.4	8,423.1	9,270.2	10,902.5	11,799.0	1.4	0.6
BEA 62:	Cincinnati, OH	16,501.7	18,820.2	23,374.3	27,374.3	33,262.9	36,702.8	2.1	0.7
BEA 64:	Columbus, OH	1,700.7	1,229.9	1,783.9	2,316.9	2,809.3	3,076.5	1.2	0.7
BEA 65:	Clarksburg, WV	2,352.6	2,717.9	3,413.4	3,889.3	4,373.5	4,636.1	2.0	0.4
BEA 66:	Pittsburgh, PA	19,764.1	21,823.1	24,006.3	27,284.2	30,588.8	32,411.0	1.3	0.4
BEA 68:	Cleveland, OH	1,911.1	1,804.9	2,163.5	2,514.3	2,964.3	3,210.6	1.1	0.6
BEA 115:	Paducah, KY	5,866.3	6,991.0	9,168.2	10,122.1	11,707.3	12,582.2	2.2	0.6

Note: Production assumed to be equal to consumption plus net shipment. Total Primary Study Area waterborne receipts were projected as a proportion of total PSA projected consumption. Projection of outbound traffic is based partly on historical pattern and partly on field information. Projection of inbound traffic is based on historical pattern. Primary Study Area shipments were allocated among BEAs and BEA segments according to their probable potential reserves of material. Projections of net rail shipments were assumed to be equal to a constant proportion of total consumption.

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

Source: Tables 8 and 11, RRNA estimates of net shipments by BEA and BEA segments, as noted above.

The major producing BEAs will continue to be BEA 66 (Pittsburgh), BEA 49 (Nashville), BEA 54 (Louisville) and BEA 62 (Cincinnati). However, the rankings of these four PSAs will change overtime. Production in Pittsburgh, the major producer of aggregates of the PSAs in the 1974-76 period, will drop below production in Louisville and Cincinnati. This will result from the continued depletion of suitable aggregate reserves in the Pittsburgh area, combined with substantial increases in demand in PSAs supplied by Louisville and Cincinnati, both of which have suitable reserves.

The highest rate of increase in production will occur in BEA 47 (Huntsville), which will have substantial growth in consumption of aggregates during the projection period.

IV. TRANSPORTATION CHARACTERISTICS

The modal split for aggregates in the area served by the ORS differs greatly from the nation as a whole. In 1976, more than 16 percent of the PSAs' production was shipped by water, versus 6.5 percent of national production.[1] The availability of water transport near production and consumption centers is the obvious reason for this higher use of water transport in the area.

In the mid-1950s, 55 to 58 percent of U.S. aggregate production moved by road to consumers; about 14 percent by rail; and, 7 percent by water. By the early to mid-1970s, 76 to 85 percent of aggregates was shipped by truck, 7 to 8 percent by rail and 5 to 6.5 percent by water.[2]

It is expected that the average haul for aggregate shipments will increase over time, both nationally and in the PSAs. This has been the case since World War II.

A. Existing Modal Split

Table 11 presents estimates of the total aggregate commerce moving by truck, rail, and water in the PSAs, by BEA and BEA segment, in 1976. BEA 115 (Paducah) shipped over one third of its

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1. Estimated from U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, 1976 ed. (Washington, D.C.: GPO, 1979) and U.S. Army Corps of Engineers, Waterborne Commerce of The United States, 1976 ed. (New Orleans; COE, n.d.) Vol. V.

2. U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1955-75 eds. (Washington, D.C.: GPO, 1957-77). Mode of annual average production percentages do not total 100 percent due to "Unspecified," "Other," and "Used at site" categories.

Table 11. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Aggregates by BEAs or BEA Segments[a], 1976

(Thousands of tons)

BEA or BEA segment	Production	Consumption	Shipments (receipts)								
			Total net	Water				Rail			
				Net	Inbound	Outbound	Local	Net	Inbound	Outbound	Local
Primary study areas	127,935.4	132,319.2	(4,383.8)	1,195.3	70.1	1,265.4	23,816.8	(5,579.1)	9,419.6	3,840.5	3,544.2
BEA 47: Huntsville, AL	6,373.6	6,021.4	352.2	(145.8)	155.8	10.0	135.8	498.0	177.2	675.2	61.2
BEA 48: Chattanooga, TN	7,238.7	7,992.6	(753.9)	70.1	10.0	80.1	1,265.3	(824.0)	841.0	17.0	--
BEA 49: Nashville, TN	19,571.3	20,777.4	(1,206.1)	(1,354.6)	1,442.5	87.9	1,180.7	148.5	388.9	537.4	416.8
BEA 50: Knoxville, TN	10,360.0	8,852.9	1,507.1	(12.2)	12.2	--	114.6	1,519.3	90.9	1,610.2	13.9
BEA 52: Huntington, WV	6,954.4	9,286.1	(2,331.7)	(1,587.0)	1,638.3	51.3	1,919.5	(744.7)	1,375.1	630.4	690.2
BEA 53: Lexington, KY	6,433.3	6,861.0	(427.7)	(539.0)	539.0	--	--	111.3	62.5	173.8	187.6
BEA 54: Louisville, KY	17,618.8	14,874.4	2,744.4	1,994.2	125.0	2,119.2	2,495.8	750.2	167.4	917.6	--
BEA 55: Evansville, IN	6,744.1	7,140.8	(396.7)	353.7	370.1	723.8	1,275.6	(750.4)	813.2	62.8	9.6
BEA 62: Cincinnati, OH	15,972.6	15,897.2	75.4	245.1	533.2	778.3	1,661.4	(169.7)	611.9	442.2	284.0
BEA 64: Columbus, OH	1,061.5	2,330.0	(1,268.5)	(1,250.1)	1,280.0	29.9	178.2	(18.4)	117.4	99.0	--
BEA 65: Clarksburg, WV	2,415.2	1,743.0	672.2	672.2	--	672.2	--	--	--	--	--
BEA 66: Pittsburgh, PA	19,858.4	25,508.2	(5,649.8)	418.3	1,282.0	1,700.3	4,523.2	(6,068.1)	6,345.1	277.0	72.7
BEA 68: Cleveland, OH	1,641.5	1,346.0	295.5	305.1	161.4	466.5	--	(9.6)	9.6	--	--
BEA 115: Paducah, KY	5,692.0	3,688.2	2,003.8	2,025.3	657.0	2,682.3	930.3	(21.5)	227.5	206.0	--

Note: Gross and net waterborne and rail shipments (receipts) were determined for 1976 from U.S. Corps of Engineers Waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net truck shipments (receipts) were assumed to equal zero; that is, inter-BEA truck shipments were equal to inter-BEA truck receipts.

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

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

Source: Estimated production and consumption from Tables 7 and 9. Water and rail shipments (receipts) compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

aggregate production by water in 1976. Most of this was outbound traffic. BEA 52 (Huntington) received substantial water and rail inbound shipments in addition to significant local traffic. Most of this traffic satisfied the needs of Charleston and Huntington. BEA 66 (Pittsburgh) imported more aggregates by rail than any other PSA. Much of its requirement is for special grades of crushed rock for industrial purposes. BEAs 54 (Louisville) and 115 (Paducah) used the waterways extensively but not railroads. Most PSAs utilize water more extensively than rail.

B. Intramodal Characteristics

Economic considerations dictate which mode of transport will be employed to move aggregate from the point of production to the point of consumption. The major considerations are: cost, availability of various modes, type of extraction, and flexibility of various modes. The time required for transport is not a prime consideration for the transport of aggregates. Consumers can easily forecast their needs, the product does not deteriorate over time, and it is easily stored.

B-1. Truck

Truck shipments dominate local transport, although short hauls by water are significant. The reasons are obvious. Most aggregates are not consumed directly along rail and water systems. However, they are frequently converted to a finished or semi-finished form at the water side or rail system and then transshipped to points of ultimate destination. Since production of aggregates is fairly widespread throughout the area served by the ORS, aggregates are usually produced within the BEA of consumption and moved to specific points of consumption by truck.

Furthermore, construction material usually is consumed in relatively small lots. Trucks are much better suited to the distribution of aggregates in small quantities.

Operators producing near urban areas often utilize trucks to bring their product to central locations for redistribution or to deliver directly to customers. Operators who haul aggregate long distances by barge or rail often distribute the product to the ultimate consumer by truck. Aggregates almost never move from one urban center to another by truck.

B-2. Rail

For most of the country, rail is the most important method used to ship aggregates long distances. Rail is particularly suited to moving industrial aggregates. Most industrial plants require regular shipments unhampered by weather conditions and do have rail access. Furthermore, industrial users generally require high specification material that has a relatively high value per ton and is, therefore, less sensitive to transportation costs.

Of total PSA rail traffic of aggregates in 1976, 22.8 percent was outbound, 56.1 percent was inbound, and 21.1 percent was within the PSAs.

B-3. Water

Water is suited for moving aggregate for all purposes. However, water transport is available only to areas bordering navigable waterways. Much PSA aggregate is produced by dredges. This material invariably moves by barge.

C. Factors Affecting Modal Choice

Water is the cheapest mode for the movement of aggregates. Rail is somewhat more expensive, but truck is considerably more expensive than either other mode. Both water and rail require large tonnage shipments to realize economies of scale. Therefore, small shipments are almost always moved by truck.

It is generally less expensive to load barges than trains, and both trains and barges tend to be less expensive to load than trucks. Therefore, if both the aggregate producer and consumer have rail or barge loading facilities, the product will almost surely be moved by one of these modes.

Although weather can impede river traffic during the winter, construction often slows during that season, so this is not a serious problem for many users.

Other than the redistribution of waterborne aggregates by trucks, the transshipment of aggregates is quite rare. This is largely due to the fact that competition does not allow for high transshipment costs. Even a 10 cent per ton transshipment cost would represent a 5 percent increase in aggregates cost to the consumer. Furthermore, ten cents can move a ton of aggregates nearly twenty miles by water.

D. Forecasting Procedures and Assumptions

Projections of Group IV waterborne flows in the ORS were based on historical trends which are adjusted to reflect the observations of industrial shippers and receivers and on analysis of consumption and production relationships. Total waterborne receipts of aggregates for the PSAs were projected as a slowly declining percentage of the projected consumption of aggregates. These projections were explained earlier in Chapter III of this report. The receipts were distributed among BEAs based on changes in projected consumption and on the historical distribution of receipts by BEA. Outbound shipments were estimated to grow at the same rate as PSA receipts, except in BEAs 137, 139, 140, and 141 in 1980. Projections of 1980 receipts for these BEAs were based on information received from shippers and receivers. After 1980, shipments to these BEAs were projected to increase at the same rate as other outbound shipments. PSA receipts and outbound shipments were equal to gross shipments. These shipments were distributed among origin BEAs based on historical information, expected production shifts among the PSAs, and interviews with industrial shippers, receivers, and with the Bureau of Mines.

BEA-to-BEA flows were projected on the premises that, as consumption of aggregates grows in the PSAs, the tonnage moving on ORS waterways will grow and that aggregate shipments will tend to move farther and farther as time progresses.

As cities grow, nearby reserves become exhausted. Land with potential reserves is developed for other purposes. Also, land prices near expanding cities increase. Thus, the cost of site development is increased. Points of production became more distant from points of consumption. While tonnage shipped is projected to increase steadily, ton-miles of traffic are expected to increase a great deal.

Limestone quarries and mines often are well-situated to take advantage of economies of scale from large operations. They are less vulnerable to environmental restrictions. Such massive reserves of suitable stone are located in Kentucky and parts of Tennessee.

With more supply then ever originating from the downstream portion of the System, with urban-based demand steadily growing, and with an increase in distance of the average haul, it is expected that the tendency for aggregates to move upstream within the ORS will increase. Traffic will be less localized than in the past.

E. Probable Future Waterway Traffic Flows

The average annual growth rates of gross waterborne aggregate shipments in the ORS are projected to be 0.9 percent between 1976 and 2000, and 0.6 percent between 2000 and 2040 (Table 12). Since sand and gravel will remain relatively abundant in the PSAs, the proportion of traffic inbound to the system will remain small. There will not be requirements for substantial inbound shipments. There may be a shortage in natural sand in some areas, however, so sand will have to be shipped into and within the ORS. There will be an increase in the proportion of traffic outbound from the system. In 1976, about 5.0 percent of waterborne traffic was outbound. By 2040, 8.8 percent of waterborne traffic is projected to be outbound.

BEA-to-BEA waterborne traffic projections are presented in Table 13. Growth indices derived from the traffic projections are presented in Table 14.

F. Highlights of Projected Waterborne Commerce

Both lower Ohio River Basin operators and coastal operators have indicated that large amounts of limestone will be moving out of the ORS down the Mississippi River. This increase will occur by 1980/81. The major destinations are expected to be BEAs 137 (Mobile), 139 (Lake Charles), 140 (Beaumont), and 141 (Houston).

Areas in the upper part of the Ohio River Basin will become increasingly dependent on downstream sources for aggregates. The beginning of this trend was observed in the historical waterborne data. Dredging on the Allegheny will become insignificant; thus flows will be shut off down as far as Pittsburgh. Operators are already re-working old deposits. Presently existing environmental restrictions already have closed off most potential supplies in this shallow river.

Crushed rock flows coming down the Monongahela River will increase steadily but not dramatically. Therefore, the Pittsburgh market will reach farther downstream along the Ohio for supplies and will compete with Charleston. At present, Hannibal Pool represents a border of a relatively self-contained waterborne aggregates market area centered around Pittsburgh. As Pittsburgh relies increasingly on sources further downstream, this cut-off point will blur and vanish.

Table 12. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Aggregates, 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	127,935.4	135,611.3	156,594.4	172,248.3	204,570.7	222,546.3	1.3	0.6
Consumption	132,319.2	139,680.5	161,785.4	178,855.8	211,523.6	229,685.8	1.3	0.6
Net shipments (receipts)	(4,383.8)	(4,069.2)	(5,191.0)	(6,607.5)	(6,952.9)	(7,139.5)	1.7	0.2
Net waterborne	1,195.3	2,338.2	2,552.7	2,650.6	3,134.4	3,403.7	3.4	0.6
Net rail	(5,579.1)	(6,407.4)	(7,743.7)	(9,258.1)	(10,087.3)	(10,543.2)	2.1	0.3
Gross waterborne shipments:								
Outbound	1,265.4	2,412.2	2,638.4	2,745.3	3,246.4	3,525.4	3.3	0.6
Inbound	70.1	74.0	85.7	94.7	112.0	121.7	1.3	0.6
Local	23,816.8	25,067.8	27,416.1	28,523.7	33,733.8	36,628.9	0.8	0.6
Total	25,152.3	27,554.0	30,140.2	31,363.7	37,092.2	40,276.0	0.9	0.6

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for PSAs was estimated from projections of modal split for each BEA and BEA segment. Net rail shipments by BEA and BEA segment were projected to be a constant proportion of consumption by BEA and BEA segment. ORS waterborne receipts (inbound plus local traffic) were assumed to be a slowly declining proportion of total PSAs consumption. Receipts were allocated to each BEA as indicated by data, analyses, and conversations with industrial authorities. Outbound shipments by BEA were projected to grow at the same rate as ORS receipts except when analyses indicated otherwise.

Source: Tables 8, 10, and 11; Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

Table 13. Ohio River System: BEA-to-BEA Waterborne Traffic of Aggregates Actual 1976 and Projected 1980-2040, Selected Years

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
047	047	04	1356	1156	944	706	835	906
047	048	04	100	86	0	0	0	0
048	047	04	679	711	940	1034	1410	1505
048	048	04	12653	13653	13425	12387	14462	15728
048	050	04	122	143	59	50	61	68
049	047	04	879	1274	1835	2368	3229	3837
049	049	04	11807	12693	13413	13472	15503	16494
050	048	04	0	0	0	119	208	251
050	050	04	1146	1052	1149	1076	1207	1286
052	052	04	19195	22957	23322	23380	24435	25107
052	054	04	468	606	3515	3924	5304	5955
052	066	04	45	213	603	2668	5724	7434
054	052	04	7495	7900	8387	7705	7802	7622
054	053	04	5390	5428	5174	4668	5573	6075
054	054	04	24958	25083	25233	25058	31297	34841
054	055	04	3670	4196	2173	2041	2455	2653
054	062	04	4060	7004	7085	8522	10662	12143
054	064	04	510	592	1011	1845	2024	2267
054	066	04	0	100	5856	7178	7617	7620
054	135	04	67	42	52	51	69	74
055	052	04	479	1027	1555	1734	1754	1947
055	055	04	12756	11544	11506	10626	13190	14593
055	064	04	0	0	0	4100	5219	5740
055	066	04	0	0	8519	14915	14907	14992
055	077	04	169	199	218	227	268	291
055	115	04	6579	6320	9507	6294	9481	11110
062	052	04	6276	5052	4330	4481	4531	4381
062	055	04	20	24	0	0	0	0
062	062	04	16614	16880	19173	20076	24735	27463
062	064	04	309	323	522	634	814	917
062	066	04	1190	1140	1536	1319	1238	1263
062	068	04	78	72	162	138	163	172
064	052	04	11	0	0	0	0	0
064	064	04	1782	2007	3200	3335	4065	4414
064	066	04	288	421	133	100	0	0
065	066	04	6722	8147	11558	13867	16402	17813
066	052	04	2122	0	0	0	0	0
066	054	04	1250	1181	865	701	2258	3068

(Continued)

Table 13. (Continued)

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
066	062	04	1250	0	0	0	0	0
066	064	04	11468	12695	11617	9174	11651	13142
066	066	04	45232	49212	37181	32567	36231	38221
066	068	04	913	996	1078	1182	1437	1578
068	066	04	4665	5113	5589	5817	6876	7469
115	046	04	4495	4733	5174	5385	6365	6913
115	047	04	0	0	0	62	86	94
115	048	04	0	0	1633	2993	4331	4966
115	049	04	14425	9362	8770	7660	11468	13715
115	050	04	0	100	48	40	71	79
115	054	04	0	498	1606	1662	1698	1702
115	055	04	0	1000	2660	2759	2819	2895
115	062	04	0	2374	4333	4791	6047	6619
115	115	04	9303	10336	12717	16010	16038	16141
115	133	04	22	23	25	26	31	34
115	134	04	2382	2506	2742	2854	3373	3664
115	135	04	356	403	435	456	531	577
115	137	04	0	1800	1967	2048	2423	2630
115	138	04	4731	4982	5459	5668	6704	7281
115	139	04	56	3659	4003	4165	4926	5349
115	140	04	244	2657	2907	3025	3578	3885
115	141	04	56	3059	3346	3481	4117	4470
115	915	04	56	59	65	67	79	86
117	055	04	11	12	14	15	18	19
138	062	04	22	23	27	30	35	38
915	064	04	45	24	0	0	0	0
915	068	04	623	681	816	902	1067	1160
		TOTAL	251523	275540	301402	313637	370922	402760

Note: BEA 915 refers to counties of BEA 115 which are origins and destinations of waterborne movements shipped from and to points on the Mississippi River.

Source: Robert R. Nathan Associates, Inc.

Table 14. Ohio River System: Growth Rates of Aggregates 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	04	1358	1000	851	695	520	615	667
047048	04	100	1000	860	0	0	0	0
048047	04	679	1000	1047	1384	1523	2077	2216
048048	04	12653	1000	1079	1061	979	1143	1243
048050	04	122	1000	1172	484	410	500	557
049047	04	879	1000	1449	2088	2694	3673	4365
049049	04	11807	1000	1075	1136	1141	1313	1397
050048	04	119	0	0	0	1000	1748	2109
050050	04	1146	1000	918	1003	941	1053	1122
052052	04	19195	1000	1196	1215	1218	1273	1308
052064	04	468	1000	1295	7511	8385	11333	12724
052066	04	218	206	1000	2766	12239	26257	34101
054052	04	7495	1000	1054	1119	1028	1041	1017
054053	04	5390	1000	1007	960	866	1034	1127
054054	04	24958	1000	1005	1011	1004	1254	1396
054055	04	3670	1000	1144	592	556	669	723
054062	04	4060	1000	1725	1745	2099	2626	2991
054064	04	510	1000	1161	1982	3618	3969	4445
054066	04	100	0	1000	58560	71780	76170	76200
054135	04	67	1000	627	776	761	1030	1104
055052	04	479	1000	2144	3246	3620	3662	4065
055055	04	12756	1000	905	902	833	1034	1144
055064	04	4100	0	0	0	1000	1273	1400
055066	04	8518	0	0	1000	1751	1750	1760
055077	04	189	1000	1053	1152	1201	1418	1540
055115	04	6579	1000	962	1447	958	1443	1591
062052	04	6276	1000	805	690	714	722	698
062055	04	20	1000	1200	0	0	0	0
062062	04	16614	1000	1016	1154	1208	1490	1653
062064	04	309	1000	1045	1689	2052	2634	2968
062066	04	1100	1000	1036	1396	1199	1125	1148
062068	04	78	1000	923	1308	1769	2090	2205
064052	04	11	1000	0	0	0	0	0
064064	04	1782	1000	1126	1796	1873	2281	2477
064066	04	288	1000	1462	462	347	0	0
065066	04	6722	1000	1212	1764	2063	2440	2650
066052	04	2122	1000	0	0	0	0	0
066054	04	1250	1000	945	692	561	1806	2454
066062	04	1250	1000	0	0	0	0	0
066064	04	11468	1000	1107	1013	800	1016	1146
066066	04	45232	1000	1088	822	720	801	845
066063	04	913	1000	1091	1181	1295	1574	1728

(Continued)

Table 14. (Continued)

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
068066	04	4665	1000	1096	1198	1247	1474	1601
115046	04	4495	1000	1053	1151	1198	1416	1538
115047	04	62	0	0	0	1000	1337	1516
115048	04	1633	0	0	1000	1833	2652	3041
115049	04	14425	1000	649	608	531	795	951
115050	04	100	0	1000	480	400	710	790
115054	04	498	0	1000	3225	3337	3410	3418
115055	04	1000	0	1000	2660	2759	2819	2895
115062	04	2374	0	1000	1825	2018	2547	2788
115115	04	9303	1000	1111	1367	1721	1724	1735
115133	04	22	1000	1045	1136	1182	1409	1545
115134	04	2382	1000	1052	1151	1198	1416	1538
115135	04	356	1000	1132	1222	1281	1492	1621
115137	04	1800	0	1000	1093	1138	1346	1461
115138	04	4731	1000	1053	1152	1198	1417	1539
115139	04	56	1000	65339	71482	74375	87964	95518
115140	04	244	1000	10889	11914	12398	14664	15922
115141	04	56	1000	54625	59750	62161	73519	79821
115915[d]	04	56	1000	1054	1161	1196	1411	1536
117055	04	11	1000	1091	1273	1364	1636	1727
138062	04	22	1000	1045	1227	1364	1591	1727
915064[d]	04	45	1000	533	0	0	0	0
915068[d]	04	623	1000	1093	1310	1448	1713	1862

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 and destinations of waterborne movements which are shipped from and to the points on the Mississippi River.

Source: Robert R. Nathan Associates, Inc.

Charleston, in BEA 52, will depend more than ever on downstream sources. At present, the city receives some supplies from up the Ohio River, but these will probably be diverted towards Pittsburgh.

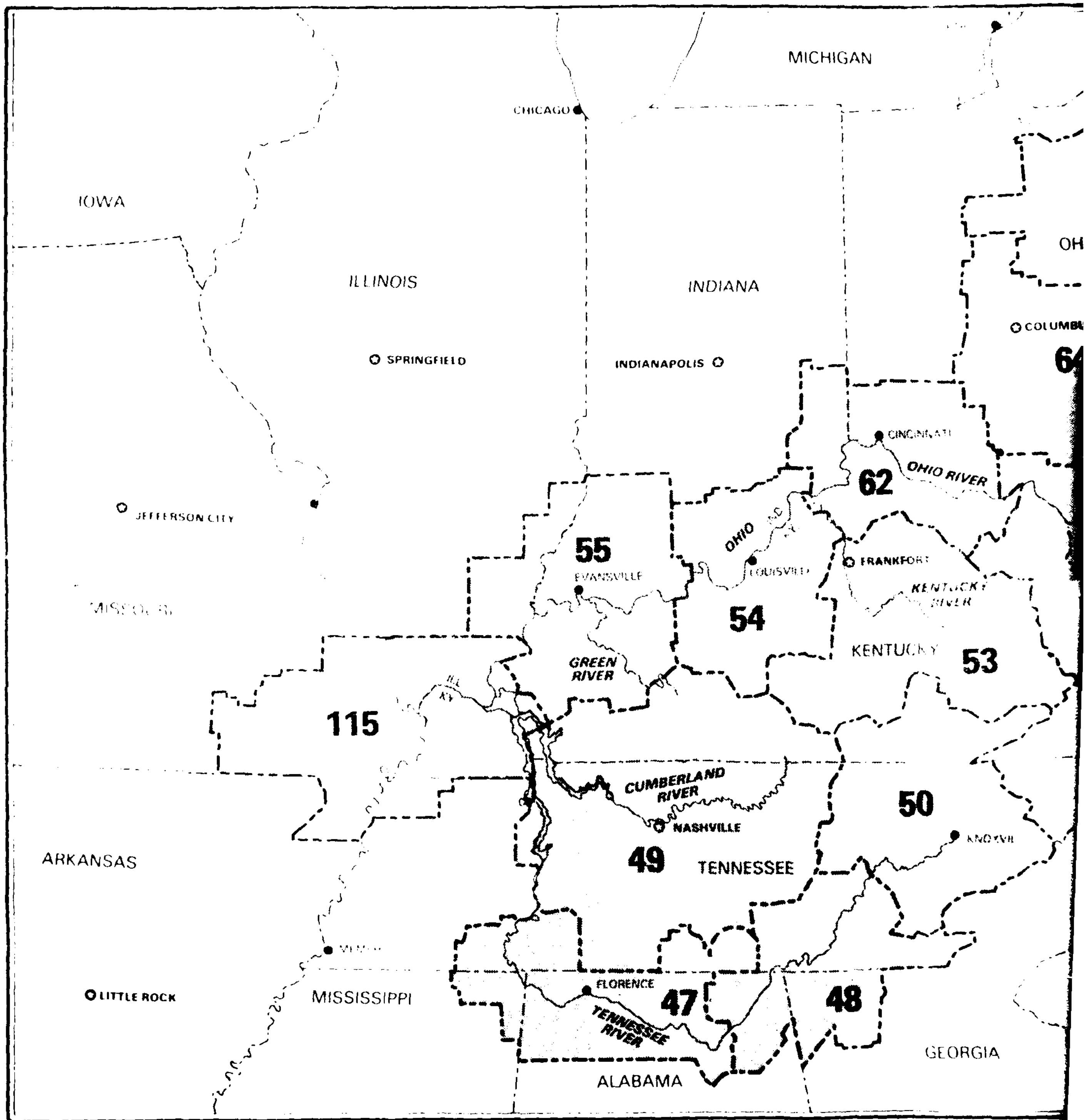
BEA 54 (Louisville) is presently supplied entirely by short hauls downstream from McAlpine Pool. BEA 55 (Evansville) is similarly served by hauls downstream, mainly from nearby Cannelton Pool. The traffic is localized along the Ohio in western Indiana, with almost no through-bound shipments. This situation will change. The steadily evolving supply/demand balance will pull material upstream, and longer hauls will appear.

Meeting this increasing demand upstream, shipments of stone from western Kentucky are expected to increase substantially. Most of this increase is expected to occur in BEA 115 (Paducah) in the general area where the Tennessee, Cumberland and Ohio River meet. Potential reserves reportedly exist nearby in parts of BEAs 46 (Memphis), 49 (Nashville), and 55 (Evansville). However, BEA 115 is the most centrally located in terms of waterway shipments. These sources will also serve markets along the Cumberland and Tennessee Rivers.

The PSAs historically have exported material to the lower Mississippi, New Orleans, and western Louisiana. These movements will continue in the future. In that part of the country, dredged marine shell has long been a source of calcareous material. However, Lake Pontchartrain, which was once a major source, is reportedly playing out. Most shell deposits are found in shallow coastal waters and are likely to be unexploitable due to environmental restrictions.

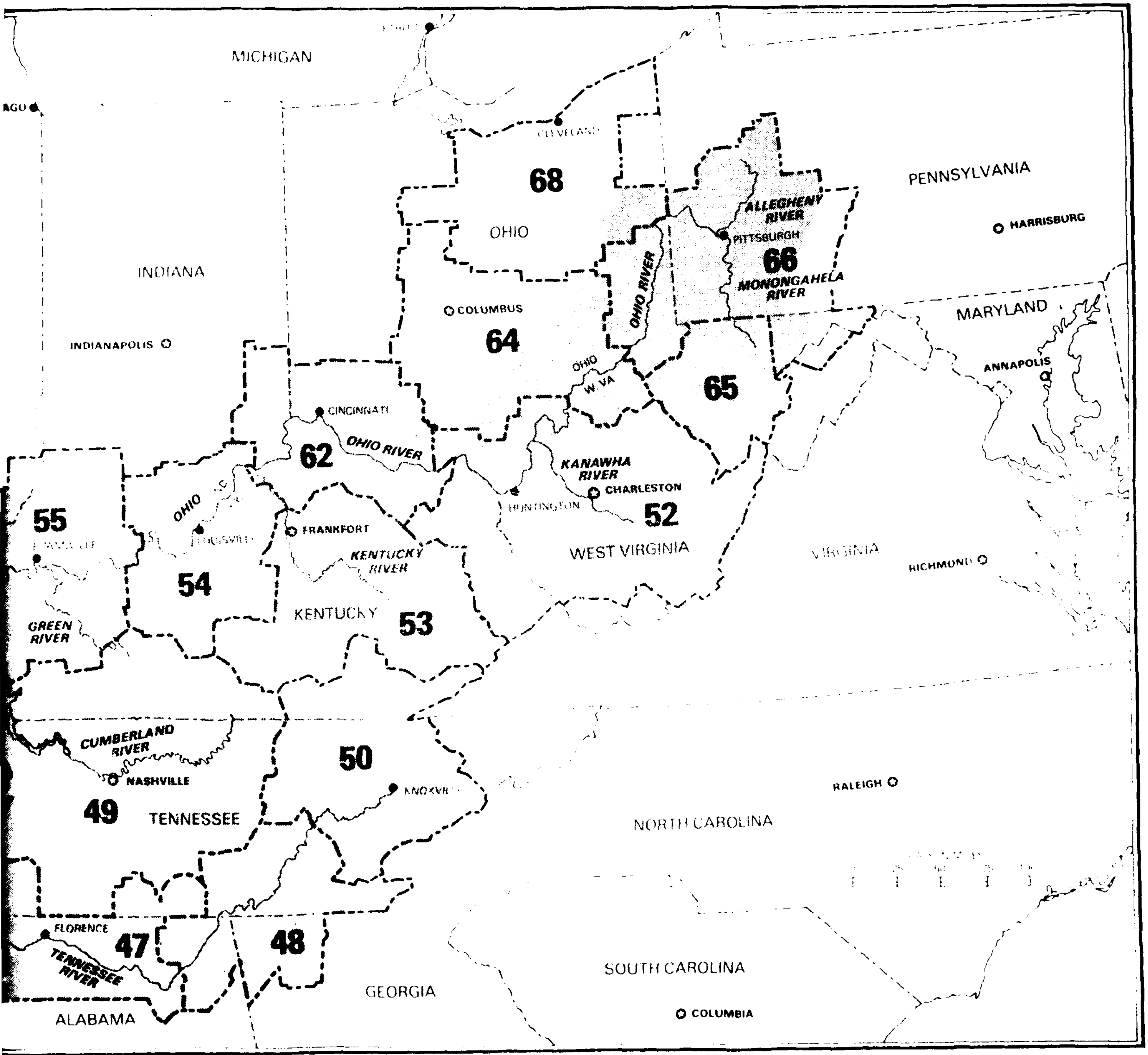
V. APPENDIX

MAP A-1. OHIO RIVER BASIN: PRIM[illegible] STUDY AREAS FOR
(BEAS AND BEA [illegible]MENTS)



SOURCE: Robert R. Nathan Associates, Inc.

MAP [illegible] OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR AGGREGATES (BEAs AND BEA SEGMENTS)



Primary Study Areas

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Table A-1. Ohio River Basin: Primary Study Areas for Aggregates

(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 48 (segment): Chattanooga, TN
DeKalb, AL
Jackson, AL
Catoosa, GA
Chattooga, GA
Dade, GA
Walker, GA
Whitfield, GA
Bledsoe, TN
Bradley, TN
Grundy, TN
Hamilton, TN
Marion, TN
McMinn, TN
Meigs, TN
Polk, TN
Rhea, TN
Sequatchie, 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
Sumner, 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
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
Galia, OH
Lawrence, OH
Meigs, OH
Scioto, OH
Boone, WV

(Continued)

Table A-1. (Continued)

Cabell, WV
Clay, WV
Fayette, WV
Greenbrier, WV
Jackson, WV
Kanawha, WV
Lincoln, WV
Mason, WV
Nicholas, WV
Putnam, WV
Raleigh, WV
Roane, WV
Summers, WV
Wayne, WV

BEA 53 (segment): Lexington, KY
Anderson, KY
Bath, KY
Bourbon, KY
Boyle, KY
Breathitt, KY
Clark, KY
Estill, KY
Fayette, KY
Franklin, KY
Garrard, KY
Harrison, KY
Jackson, KY
Jessamine, KY
Lee, KY
Lincoln, KY
Madison, KY
Menifee, KY
Mercer, KY
Montgomery, KY
Nicholas, KY
Owsley, KY
Powell, KY
Scott, KY
Wolfe, KY
Woodford, KY

BEA 54 (segment): Louisville, 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
Oldham, KY
Shelby, KY
Spencer, 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
Warrick, 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

BEA 64 (segment): Columbus, OH
Athens, OH
Guernsey, OH
Hocking, OH

Table A-1. (Continued)

Wood, WV
Jackson, OH
Morgan, OH
Noble, OH
Pike, OH
Vinton, OH
Washington, OH
Pleasants, WV
Ritchie, WV
Wirt, 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
Columbiana, 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, LY
Marshall, KY
McCracken, KY

Source: Robert R. Nathan Associates, Inc.

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