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NATIONAL WATERWAYS STUDY. COMMERCIAL WATER TRANSPORTATION USERS--ETC(U)

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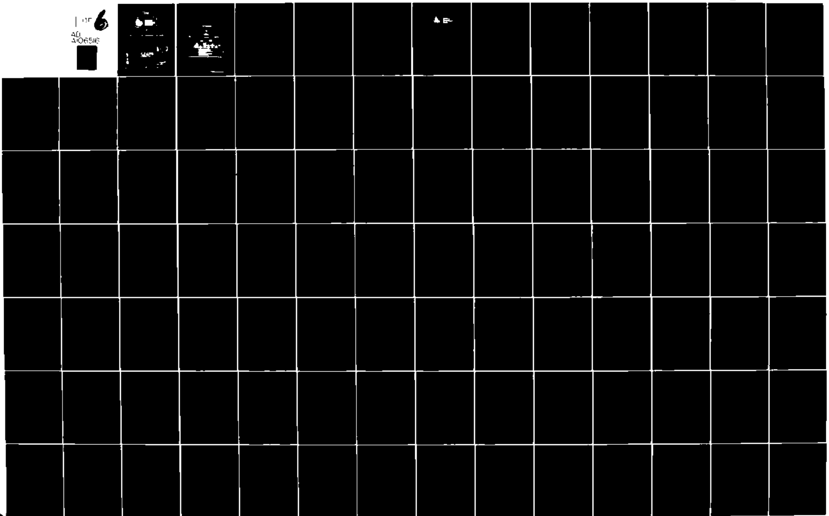

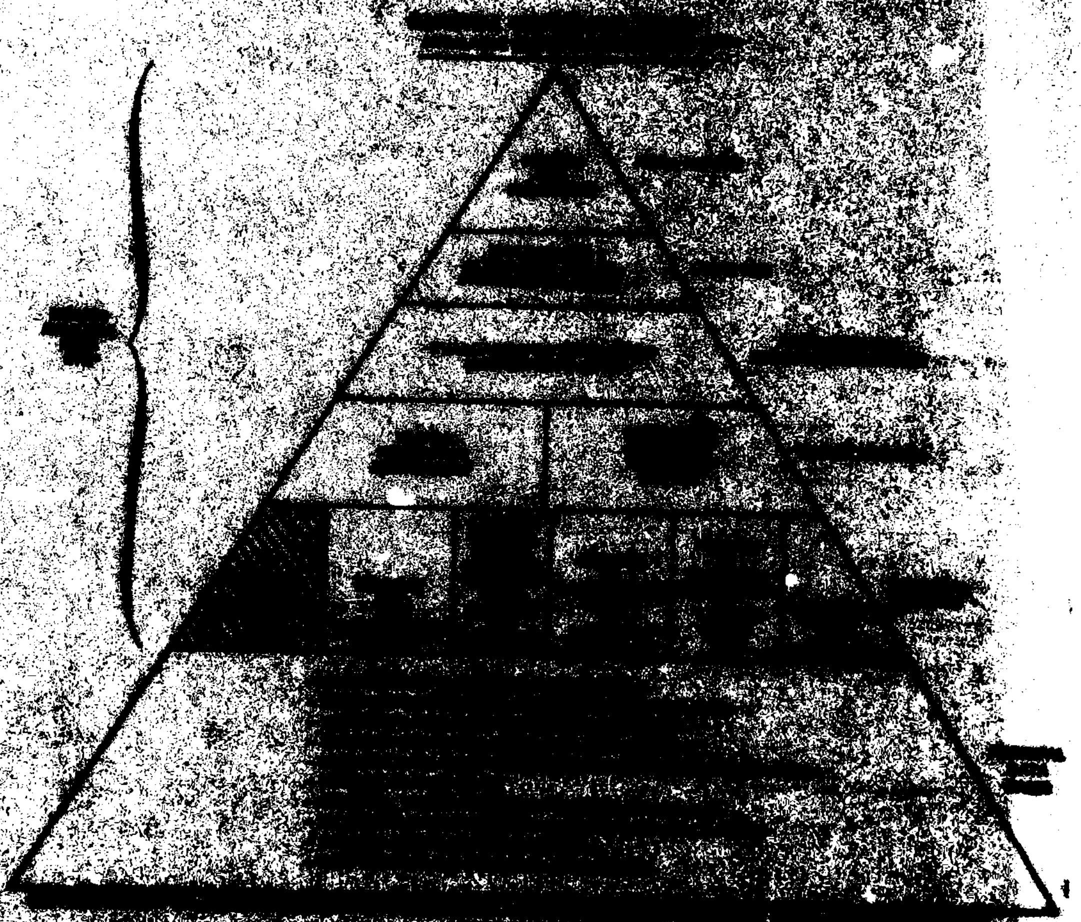

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This report of the National Waterways Study discusses factors which influence the decision of companies to use water transportation. Generally, the decision to use water transportation is a strategic decision to commit a company to a water-based logistics system for a long period of time -- often the economic life of a utility plant or grain-exporting facility. As a result, the decision to use water transportation is integrated with capital, sourcing, and marketing requirements. One of the primary purposes of this report is to identify those industry-wide trends or changes that can be expected to influence the future use of water transportation. Changes in three industries are expected to dominate changes in water transportation use to the year 2000. These industries are: coal, petroleum and petroleum products, and agriculture.

This report also discusses the following industries: fertilizer, steel, chemicals and forest products.

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THIS REPORT IS PART OF THE NATIONAL WATERWAYS STUDY AUTHORIZED BY CONGRESS IN SECTION 158 OF THE WATER RESOURCES DEVELOPMENT ACT OF 1976 (PUBLIC LAW 94-587). THE STUDY WAS CONDUCTED BY THE US ARMY ENGINEER INSTITUTE FOR WATER RESOURCES FOR THE CHIEF OF ENGINEERS ACTING FOR THE SECRETARY OF THE ARMY.

NATIONAL WATERWAYS STUDY

COMMERCIAL WATER TRANSPORTATION USERS

PREFACE

This report is one of eleven technical reports provided to the Corps of Engineers in support of the National Waterways Study by A. T. Kearney, Inc. and its subcontractors. This set of reports contains all significant findings and conclusions from the contractor effort over more than two years.

A. T. Kearney, Inc. (Management Consultants) was the prime contractor to the Institute for Water Resources of the U.S. Army Corps of Engineers for the National Waterways Study. Kearney was supported by two subcontractors: Data Resources, Inc. (economics and forecasting) and Louis Berger & Associates (waterway and environmental engineering).

The purpose of the contractor effort has been to professionally and evenhandedly analyze potential alternative strategies for the management of the nation's waterways through the year 2000. The purpose of the National Waterways Study is to provide the basis for policy recommendations by the Secretary of the Army and for the formulation of national waterways policy by Congress.

This report forms part of the base of technical research conducted for this study. The focus of this report, Commercial Water Transportation Users, is to identify those industry-wide trends or changes that can be expected to influence the future use of water transportation. The results of this analysis were reviewed at public meetings held throughout the country. Comments and suggestions from the public were incorporated.

This is deliverable under Contract DACW 72-79-C-0003. It represents the output to satisfy the requirements for the deliverable in the Statement of Work. This report constitutes the single requirement of this Project Element, completed by A. T. Kearney, Inc. and its primary subcontractors, Data Resources, Inc. and Louis Berger and Associates, Inc. The primary technical work on this report was the responsibility of A. T. Kearney, Inc. This document supercedes all deliverable working papers. This report is the sole official deliverable available for use under this Project Element.

National Waterways Study

FINAL REPORT

COMMERCIAL WATER TRANSPORTATION USERS

UNITED STATES CORPS OF ENGINEERS
COMMERCIAL WATER TRANSPORTATION USERS
TABLE OF CONTENTS

SECTION	TITLE	PAGE
	EXECUTIVE SUMMARY	16
I	INTRODUCTION	20
	Scope	21
	Primary Waterway Industries	22
II	AGRICULTURE	28
	Commodity Characteristics	30
	Markets	35
	Economics of the Industry	47
	Description of Logistics System	48
	Principal Transportation Flows	72
	Factors Influencing Flows in the Future	81
III	FERTILIZER	102
	Commodity Characteristics	102
	Markets	110
	Economics of the Industry	118
	Description of Logistics System	120
	Principal Transportation Flows	127
	Factors Influencing Flows in the Future	130
IV	STEEL	145
	Commodity Characteristics	146
	Markets	154
	Economics of the Industry	162
	Description of Logistics System	164
	Prinicpal Transportation Flows	172
	Factors Influencing Flows in the Future	178
V	PETROLEUM AND PETROLEUM PRODUCTS	191
	Commodity Characteristics	193
	Markets	198
	Economics of the Industry	207
	Description of Logistics System	208
	Prinicpal Transportation Flows	216
	Factors Affecting Flows in the Future	222

TABLE OF CONTENTS (Cont'd)

SECTION	TITLE	PAGE
VI	COAL	230
	Commodity Characteristics	231
	Markets	235
	Economics of the Industry	246
	Description of Logistics System	249
	Principal Transportation Flows	258
	Factors Influencing Flows in the Future	266
VII	CHEMICALS	291
	Commodity Characteristics	293
	Markets	298
	Economics of the Industry	311
	Description of the Logistics System	314
	Principal Transportation Flows	323
	Factors Influencing Flows in the Future	332
VIII	FOREST PRODUCTS	351
	Commodity Characteristics	354
	Markets	356
	Economics of the Industry	367
	Description of Logistics System	370
	Principal Transportation Flows	373
	Factors Influencing Flows in the Future	376
IX	OTHER WATERBORNE COMMODITIES AND NEW WATERBORNE COMMODITY FLOWS	387
	Sand, Gravel, and Crushed Rock	388
	Aluminum Ores and Concentrate	392
	Cement	394
	Marine Shells	397
	Salt	398
	Biomass Derived Liquid Fuels	401
	Composite Materials	403
	Ocean Bed Nodules	405
	Direct Reduced Iron	407
	Summary	410

TABLE OF CONTENTS (Cont'd)

SECTION	TITLE	PAGE
X	SHIPPER CONSTRAINTS TO WATERWAY USE	411
	Introduction	411
	Locks	413
	Seacoast and Great Lakes Port Constraints	420
	Channel Maintenance on Inland Waterways	434
	Terminals and Fleeting	435
	Other Issues	438
	Conclusions	439
XI	POSSIBLE ACTIONS AND RECOMMENDATIONS FOR FURTHER INVESTIGATION	442
	Introduction	442
	Increasing Lock Capacity	443
	Addressing Port Constraints and Concerns	447
	Improving Channel Maintenance	448
	Developing Terminals and Fleeting Areas	449
	Conclusions	450
XII	CONCLUSIONS	452
	Coal	457
	Agriculture	459
	Petroleum	460
	Steel	461
	Chemicals	461
	Fertilizer	462
	Forest Products	463
	FOOTNOTES	464
	BIBLIOGRAPHY	465
	GLOSSARY	469
	APPENDICES	472

LIST OF TABLES

TABLE	TITLE	PAGE
I-1	Principal Commodities in Waterborne Commerce for 1977	22
I-2	NWS Reporting Commodity Groups	23
I-3	Commodities Not Included in Primary Water Industries	25
II-1	1977 Waterborne Shipments of Grains, Oilseeds and Grain Products	29
II-2	United States Wheat Production	31
II-3	Shipments of Corn for Food Use	34
II-4	United States Wheat Use for 1977	36
II-5	Wheat Production by Country	37
II-6	World Production of Principal Foodgrains	38
II-7	Wheat and Equivalent Wheat Flour Exports by Country	39
II-8	United States Corn Use for 1977	40
II-9	Corn Production by Country	43
II-10	United States Soybean Use for 1977	45
II-11	Soybean Production by Country	46
II-12	Principal Rail, Barge, and Truck Movements of Wheat, Corn, Soybeans, and Processed Products	74
II-13	Port Share of Grain and Oilseed Exports	80
III-1	Elements Essential for Plant Growth	103
III-2	Characteristics of Major Nitrogenous Fertilizers	106
III-3	Nitrogen Fertilizer Consumed in the United States for Year Ended June 30, 1978	109
III-4	United States Phosphate Rock Production and Use for 1977	114
III-5	Fixed Nitrogen Production and Use for 1977	116
III-6	United States Potash Production and Use for 1977	117
III-7	Financial Results for Selected Fertilizer Companies	119
III-8	Share of Phosphate Fertilizer Production in Florida	125

LIST OF TABLES (cont'd)

TABLE	TITLE	PAGE
IV-1	1977 Waterborne Flows for the Steel Industry	145
IV-2	United States Production and Consumption of Iron Ore	156
IV-3	United States Lime Production and Consumption	157
IV-4	United States Consumption of Scrap and Pig Iron	158
IV-5	Domestic Use of Coal for Coke Production	159
IV-6	Concentration Ratios for the Steel Industry	163
IV-7	Modal Share of Steel Product Shipments	169
IV-8	United States Imports of Manganese Ore and Ferromanganese	176
IV-9	United States Imports of Steel Products	177
V-1	1977 Waterborne Flows of Petroleum and Products	192
V-2	Yield of Crude Oil Refined by 1978	195
V-3	Petroleum Products and Applications	196
V-4	World Production of Crude Oil	198
V-5	United States Crude Oil Imports for 1977	200
V-6	United States Fossil Fuel Prices	201
V-7	Oil Consumption in Selected Industrial Nations	202
V-8	Annual Crude Oil Production by PADD	203
V-9	Annual Crude Oil Imports by PADD	205
V-10	Annual Crude Oil Refined by PADD	205
V-11	Net Demands (Supplies) of Crude Oil or Equivalents by PADD	206

LIST OF TABLES (cont'd)

TABLE	TITLE	PAGE
VI-1	Typical Coal Characteristics	231
VI-2	Sulfur Content of United States Coal Resources	232
VI-3	Output per Man Day at United States Coal Mines	234
VI-4	United States Coal Production	235
VI-5	Sources of Energy in the United States for 1970 and 1978	237
VI-6	Consumption of Coal for 1971 and 1977	237
VI-7	Generation Mix at Electric Utility Plants for 1977	238
VI-8	United States Exports of Coal for 1977	245
VI-9	1976 Shipments of Coal from the Mine	259
VI-10	Coal's Share of the 1976 Fossil Fuel Market for Steam Electric Utilities	269
VI-11	1977 Coal Shipments by Mode and State of Destination	273
VII-1	1977 Waterborne Shipments of Chemicals and Allied Products	292
VII-2	Physical Characteristics and Hazard Ratings of Major Waterborne Industrial Chemicals	297
VII-3	1977 Production of Ethylene and Derivatives	299
VII-4	1977 Production of Propylene and Derivatives	300
VII-5	1977 Production of Butadiene and Derivatives	301
VII-6	1977 Production of Benzene and Derivatives	303
VII-7	1977 Production of Xylenes and Derivatives	305
VII-8	1977 Production of Methanol and Derivatives	308
VII-9	Revenue to Variable Cost Ratios for 1977 Rail Shipments of Industrial Chemicals	338

LIST OF TABLES (cont'd)

TABLE	TITLE	PAGE
VIII-1	1977 Waterborne Shipments of Forest Products	353
VIII-2	United States Lumber Production	356
VIII-3	United States Lumber Production and Consumption	359
VIII-4	United States Domestic Production of Softwood Plywood	360
VIII-5	Changes in Lumber Consumption Patterns by Region	362
VIII-6	1976 Geographic Location of the United States Paper and Pulp Industry	365
VIII-7	United States Per Capita Consumption of Paper and Paperboard	366
VIII-8	Stumpage Price Comparisons	371
VIII-9	1977 Shipments of Rafted Logs	374
IX-1	Waterborne Shipments of Sand, Gravel, and Crushed Rock for 1977	389
IX-2	United States Production of Sand, Gravel, and Crushed Rock	390
IX-3	Sand, Gravel, and Crushed Rock Shipments by Mode for 1976	391
IX-4	Waterborne Shipments of Cement	395
IX-5	United States Shipments of Portland Cement for 1976	397
IX-6	Waterborne Shipments of Salt and Nonmetallic Minerals for 1977	398
IX-7	Illustrative Chemical Composition of Nodules	406
X-1	Comparison of Average Tow Size and Processing Time by Type of Lockage	414
X-2	Lock Constraints	416
X-3	Bulk Port Constraints	425
X-4	Channel Maintenance Problems	436

LIST OF FIGURES

FIGURE	TITLE	PAGE
II-A	Grain Distribution System	49
II-B	Illinois Truck Rates for Corn	59
II-C	Grain-Gathering Areas for Selected Illinois River Ports	61
III-A	United States Consumption of Nitrogen Nutrients by Fertilizer Type	107
III-B	United States Consumption of Nitrogen Products	111
III-C	Plant Nutrient Consumption	112
III-D	Domestic Distribution System for Phosphate Fertilizers	121
IV-A	The Flow of Ferrous Material through the Economy	151
IV-B	Distribution System for Steel Production Using Basic Oxygen Furnaces	165
VI-A	Prices of Fossil Fuels to Electric Utility Plants	239
VII-A	Production Process of the Chemical Industry	295
IX-A	Primary Aluminum Production	393

LIST OF EXHIBITS

EXHIBIT	TITLE
I-1	National Waterway Study Commodities
II-1	United States Wheat Production by State
II-2	United States Corn Production by State
II-3	United States Soybean Production by State
II-4	United States Domestic Production of Fats and Oils in 1977
II-5	Wheat Flour Milling Capacity by State
II-6	United States Broiler Production in 1977
II-7	Cattle and Calves on Feed
II-8	Number of Milk Cows in 1977
II-9	Pig Crop in 1977
II-10	Number of Wet Corn Processing Plants by State
II-11	Number of Soybean Processing Plants
II-12	Differential Between Gulf Corn Bids and River Bids at Hennepin, IL.
II-13	100 - Car Train Export Rates to East Coast Ports
II-14	Unexpanded One Percent Waybill Sample - Wet Corn Mill Products Shipments for 1977
II-15	Export Bids for No. 1 Heavy Northern Spring Wheat
III-1	Primary Phosphate Reserves
III-2	Fertilizer Use by Major Crops
III-3	Application Rates per Acre on Crops Fertilized
III-4	World Phosphate Rock Production and Reserve Base
III-5	Phosphorous Fertilizer Consumption by State
III-6	World Ammonia Production for 1977
III-7	Nitrogen Fertilizer Consumption by State
III-8	World Potash Production and Reserve Base
III-9	Potassium Fertilizer Consumption by State
III-10	Inland Waterborne Receipts of Nitrogen Fertilizers
III-11	Florida Phosphate Rock Shipments
III-12	Shipments of Phosphate Fertilizers
III-13	Shipments of Ammoniated Phosphates

LIST OF EXHIBITS (cont'd)

EXHIBIT	TITLE
IV-1	Raw Steel Production by Type
IV-2	Net Industry Shipments and Net Imports of Steel Products in 1978
IV-3	World Iron Ore Production and Recoverable Iron Reserves
IV-4	United States Production and Use of Steel Products
IV-5	World Raw Steel Production
IV-6	Selected Financial Data for Nine Steel Companies
IV-7	United States Iron and Steel - Making Facilities
IV-8	Unexpanded One Percent Waybill Sample - Iron and Steel Scrap Shipments for 1977
IV-9	Unexpanded One Percent Waybill Sample - Semi-Finished and Basic Steel Products Shipments for 1977
V-1	United States Production and Consumption of Energy
V-2	United States Crude Oil Production and Proven Reserves
V-3	Petroleum Administration for Defense Districts
V-4	Return on Equity for Selected Oil Companies
VI-1	United States Coal Production and Demonstrated Coal Reserve Base
VI-2	World Coal Production and Reserves
VI-3	Premium Bituminous Coal Reserves Suitable for Coke Production
VI-4	Largest Coal - Producing Companies in the United States for 1978
VI-5	Major Oil and Coal Mergers Since 1976
VI-6	Average Value F.O.B. Mine by State for 1976
VI-7	Regional Reclamation Costs for 1977
VI-8	Financial Performance for Selected Coal Companies
VI-9	1977 Total Coal Flows
VI-10	Future Coal-Burning Units to be Water-Served
VI-11	Nuclear Plants Currently Under Planning for 1980 to 1987 or Construction
VI-12	Active and Semi-Active Coal-Slurry Pipeline Proposals

LIST OF EXHIBITS (cont'd)

EXHIBIT	TITLE
VII-1	Top 50 Chemicals Produced in the United States During 1977
VII-2	Major End Uses of Ethylene
VII-3	Major End Uses of Propylene
VII-4	Major End Uses of Butadiene
VII-5	Major End Uses of Benzene
VII-6	Major End Uses of Xylenes
VII-7	Major End Uses of Methanol
VII-8	Financial Data for Selected Chemical Companies
VII-9	Hazardous Substances Regulated in Section 311 of the Clean Water Act
VII-10	Modal Share of Selected Chemicals for 1972
VIII-1	Estimated United States Consumption of Softwood Lumber by Region of Origin
VIII-2	Lumber Shipments to Selected Market Areas
VIII-3	1978 World Production and Consumption of Paper and Paperboard
VIII-4	World Production and Consumption of Pulp in 1978
VIII-5	Financial Data for Selected Forest Product and Paper Companies
VIII-6	Lumber Shipments Originating in Western States by Rail and Truck
VIII-7	Lumber Shipments Originating in Southern States by Rail and Truck
VIII-8	United States Plywood Shipments by Mode
VIII-9	1972 Shipments of Pulp and Paper by Type of Carrier
VIII-10	Unexpanded One Percent Waybill Sample - - Lumber Shipments for 1977
X-1	Description of Lockage Types

LIST OF APPENDICES

APPENDIX	TITLE
A	National Waterway Study Interviews
B	National Waterway Study Reporting Regions

EXECUTIVE SUMMARY

A number of factors influence the decision of companies to use water transportation. Generally, the decision to use water transportation is a strategic decision to commit a company to a water-based logistics system for a long period of time - often the economic life of a utility plant or grain-exporting facility. As a result, the decision to use water transportation is integrated with capital, sourcing, and marketing requirements.

One of the primary purposes of this report is to identify those industry-wide trends or changes that can be expected to influence the future use of water transportation. Changes in the following three industries are expected to dominate changes in water transportation use to the year 2000:

- Coal.
- Petroleum and petroleum products.
- Agriculture.

Industry-wide trends are discussed for each of these industries.

COAL

Water transportation of coal is expected to increase dramatically through the year 2000 for several reasons:

1. The construction of new coal-fired electric utility and industrial power plants. The largest number of plants are to be constructed along the Ohio River (10 plants) and the Gulf Coast East Region (seven to eight plants) in the next 10 years.

2. The conversion of existing oil or gas-fired electric utility and industrial power plants to coal. Conversions are expected along the Middle Atlantic and North Atlantic Coasts as well as in the West South Central area and the states of Florida and Mississippi.

3. Increased production of synthetic fuels from coal. Synthetic fuels may be produced near chemical plants or refineries located along the Gulf Coast.

4. Increased exports of steam bituminous coal.

5. A possible moratorium or slowdown in the construction of nuclear power plants. A large number of nuclear power plants are planned or under construction in areas served by the Ohio (20 plants), Tennessee (11 plants), and Illinois (seven plants) Rivers.

Although water transportation of coal is expected to increase dramatically by the year 2000, increased competition from coal-slurry pipelines and strengthened railroads can be expected to reduce waterborne coal flows (principally on the Mississippi and along the Gulf Coast) below what they would have otherwise been.

PETROLEUM AND PETROLEUM PRODUCTS

Petroleum and petroleum products are the single largest tonnage moving on the national waterways, but conservation of all forms of energy and substitution of other energy products for petroleum are expected to hold the rate of growth in shipments well below historical levels or to cause an actual decline in shipments.

In addition, the growth in pipeline capacity of existing product pipes running from the Gulf to the East Coast, the possible conversion of a natural gas pipeline running along the Gulf Coast to petroleum products, and the possible construction of new pipelines to handle Alaskan crude oil can be expected to reduce the waterborne share of petroleum and product shipments by the year 2000.

AGRICULTURE

In contrast to coal, there are few industry-wide factors that are expected to change the nature of waterborne grain flows in the future. The United States is expected to continue to have a dominant position in the international sale of corn and soybeans and a major position in the international sale of wheat. No major shifts in United States crop production by region are expected. In addition, grain export activity can be expected to fluctuate with changes in demand, although increased farm storage and price support programs are reducing the fluctuations due solely to supply side factors.

The single most important factor that may change the nature of inland waterborne grain flows in the future is the railroads' ability to compete for grain exports. The long-term impact of both rail mergers and increased contract rates between rail carriers and shippers may well be a higher rail share of grain shipments from midwestern origins to coastal ports. Key factors influencing the railroads' ability to compete are the nature and timing of actions to increase the capacity at Lock and Dam 26. Grain shippers on the Illinois, Upper Mississippi and Lower Upper Mississippi Rivers will be forced to invest much more heavily in rail-based logistics systems if additional capacity above and beyond the single authorized 1,200 feet chamber is not made.

CONSTRAINTS TO PROJECTED TRANSPORTATION USE AND POSSIBLE ACTIONS

Other purposes of this report are to present the principal constraints and concerns as perceived by waterway users to the present or future use of the waterways for transportation and possible actions for addressing these constraints and concerns.

In the opinion of the shippers and carriers interviewed for NWS, inadequate lock capacity was the single most important potential constraint to future traffic growth. Lock and Dam 26, Gallipolis Lock, and the Inner Harbor Navigation Canal Lock were considered to be the key constraining locks at the present time. Shippers favored use of non-structural actions on a system-wide basis and the more timely replacement of aging or inadequate chambers with larger chambers. Schemes for rationing lock capacity were not considered to be practical.

Aside from shortfalls in the capacity of locks, shippers, carriers, and port authorities mentioned lack of suitable land for both terminal development and dredged material disposal at seacoast ports as a potential constraint. Of the ports contacted for NWS, lack of land for dredge disposal is especially serious at the ports of Baltimore, Hampton Roads, Philadelphia, and Mobile. Upgrading existing terminals and constructing new facilities on sites with poorly utilized facilities were two key actions for dealing with the shortage of land at ports. Increased emphasis on the cost of compliance with environmental standards would be a key policy change resulting in the selection of more practical means of dredge disposal.

Increasing channel and port depths were two major actions that all commercial waterway users considered to be most appropriate for a strategy of improving their level of service and reducing their real costs of water transportation. However, when forced to choose, most shippers favored the proper maintenance of channels and the addition of capacity at constraining locks rather than the construction of new waterways.

I - INTRODUCTION

This Section discusses the purpose and scope of this report; the principal waterway industries that account for the overwhelming majority of traffic on the nation's inland waterways, Great Lakes, and coastal waters; and the organization of the remainder of the report.

PURPOSE

The primary purpose of this report is to provide the reader with an understanding of the present and future uses of the national waterways for commercial transportation. The secondary purposes of the report are to provide an understanding of the actual or potential constraints to the use of water transportation; the effects that such constraints have or will have on the primary waterway industries if actions are not taken to address these constraints; and possible actions that might be taken by the Corps, Congress, other government agencies, shippers, and carriers to address constraints to water transportation use.

The findings and conclusions of this review of commercial water transportation users have been used in the NWS to:

1. Refine the forecasting of waterborne commodity flows by identifying key industry trends.

2. Define some of the alternative scenarios of future water transportation use by highlighting key factors or events that could change commodity flows.

3. Identify the principal constraints to waterway transportation.

4. Define the effect of constraints on the logistics patterns and transportation costs of waterway industries.

5. Identify actions that might be taken to address constraints.

SCOPE

The scope of this report is limited to a series of field interviews and a review of existing literature and published data.

Interviews were conducted with 26 shippers, 17 carriers, 14 coastal port authorities, and 10 trade associations. The list of interviews conducted is presented in Appendix A. Since only a few interviews were conducted for each of the primary waterway industries, the companies interviewed were selected after discussions with appropriate trade associations. Shippers were asked to discuss such topics as principal waterway shipments; modal share; industry factors or government policy in the future; constraints to waterway use; possible actions to remove constraints; and investment plans. Since this information is in some cases proprietary, shippers were assured that their comments would be kept confidential. In no circumstances were any comments to be attributed to an individual company nor were company shipment data to be published in lieu of publicly available data on industrial production and shipments.

The list of carriers contacted is presented in Appendix A. Although the primary purpose of these interviews was to provide information for the Overview of Transportation Industry (Report #8 for NWS), information on constraints to water transportation and possible actions to remove such constraints was used in Sections X and XI of this report. Of course, carriers were also assured that their comments were not to be attributed to individual companies.

The list of coastal port authorities contacted is presented in Appendix A. As in the case of carriers, coastal port authorities were asked to identify potential constraints to future port growth and possible actions to remove these constraints. Thus, Sections X and XI were also based in part upon these discussions.

Trade associations identified key industry trends and possible government policy changes that could change waterway commodity flows in the future. In addition, these associations listed their suggestions for shipper interviews.

Aside from the interviews, no original research was conducted for this report. The existing studies and published data used for this report are presented in the bibliography at the end of this report.

PRIMARY WATERWAY INDUSTRIES

Table I-1 presents the principal commodities in foreign and domestic waterborne commerce for 1977.

Table I-1

Principal Commodities in Waterborne Commerce for 1977

Commodity	Millions of Tons	Percent of Total
Petroleum and Products	937	49.1%
Coal and Coke	235	12.3
Iron Ore and Iron and Steel	126	6.6
Grains	118	6.2
Sand, Gravel and Stone	103	5.4
Chemicals	101	5.3
Logs and Lumber	53	2.8
All Other Commodities	235	12.3
TOTAL	1,908	100.0%

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

As can be seen by Table I-1, petroleum and petroleum products accounted for almost half of the waterborne commerce in 1977. Coal and coke, the next largest group of commodities, accounted for just over 12% of the 1977 traffic. The seven bulk commodity groupings listed in Table I-1 accounted for almost 88% of all the domestic and foreign waterborne commerce in 1977. The importance of a small number of key bulk commodities to waterborne commerce cannot be over emphasized.

The waterborne commerce on the nation's inland waterways, Great Lakes, and coastal waters has been classified according to a list of 50 commodities for purposes of forecasting NWS commodity flows to the year 2003. This list of 50 commodities is presented in Exhibit I-1. For purposes of reporting the forecasts of commodity flows to the public (see NWS Report 9: Traffic Forecasts for a presentation and discussion of these forecasts), these 50 commodities have been further classified into 14 groups. Table I-2 presents these 14 commodity groups along with the 1977 estimates of waterborne commerce.

Table I-2

NWS Reporting Commodity Groups and 1977 Waterborne Traffic

Group	Millions of Tons	Percent of Total
Farm Products	158	8.3%
Metallic Ores	115	6.0
Coal	212	11.1
Crude Petroleum	489	25.6
Nonmetallic Minerals	159	8.3
Food and Kindred Products	44	2.3
Lumber and Wood Products	53	2.8
Pulp, Paper and Allied Products	12	0.6
Chemicals	78	4.1
Petroleum and Coal Products	454	23.8
Stone, Clay, Glass, and Concrete Products	16	0.8
Primary Metal Products	50	2.6
Waste and Scrap	22	1.2
Other Commodities	46	2.5
TOTAL	1,908	100.0%

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

Table I-2 presents the 1977 waterborne commerce according to a different classification than in Table I-1, but the totals and appropriate commodity subtotals are comparable with one exception. The "Chemicals" category in Table I-2 is less than the "Chemicals" category in Table I-1, because the former classification excludes phosphate rock and other natural fertilizers from this category.

The discussion of the primary waterway industries is based on seven industries that account for most of the traffic categories in Table I-2. These seven industries are:

- Agriculture.
- Fertilizer.
- Steel.
- Petroleum and petroleum products.
- Coal.
- Chemicals.
- Forest products.

Agriculture includes both "Farm Products" and "Food and Kindred Products." Fertilizer includes phosphate rock, natural fertilizers, and selected chemicals. Steel includes a variety of products listed under "Metallic Ores," "Coal," "Nonmetallic Minerals" (principally limestone), "Primary Metal Products," and "Waste and Scrap" (principally iron and steel scrap). Petroleum and petroleum products include, of course, "Crude Petroleum" and "Petroleum and Coal Products" while coal refers to "Coal" and certain commodities classifed under "Petroleum and Coal Products." Chemicals refers to certain products classifed under "Nonmetallic Minerals" (principally sulfur) as well as "Chemicals and Allied Products." Forest products includes both "Lumber and Wood Products" and "Pulp, Paper and Allied Products."

Although most significant commodities transported by water are included in one of these seven industries, there are seven exceptions. These exceptions and their corresponding 1977 traffic estimates are provided in Table I-3.

Table I-3

Commodities Not Included in Primary Waterway Industries

Commodity	1977 Traffic in Millions of Tons
Sand, Gravel and Crushed Rock	63
Aluminum Ores	17
Cement	13
Marine Shells	12
Machinery and Equipment	7
Salt 1/	5
Motor Vehicles, Parts, and Equipment	5

NOTE: 1/ Salt traffic is understated because internal traffic of salt is included in a general category of nonmetallic minerals to avoid disclosure of individual company operations.

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

A separate discussion of the characteristics of five of these commodities is included in Section IX. Machinery and equipment as well as motor vehicles, parts, and equipment are not discussed any further, since these products are well known to the reader and account for a very small percentage of total waterborne commerce. Each of the seven primary waterway industries are discussed separately in Sections II through VIII.

REPORT ORGANIZATION

This report discusses the various commodities that move in the waterways. This includes Agriculture, Fertilizer, Steel, Petroleum and Petroleum Products, Coal, Chemicals, Forest Products, Other Waterborne Commodities and New Waterborne Commodity Flows.

EXHIBIT I-1

NATIONAL WATERWAYS STUDY COMMODITIES

Commodity	Commodity Classification for Waterborne Commerce
1. Corn	0103
2. Wheat	0107
3. Soybeans	0111
4. Other Farm Products	0102, 0104-0106, 0109, 0112-0191
5. Iron Ore and Concentrates	1011
6. Other Ores	1021, 1051, 1061, 1091
7. Coal and Lignite	1121
8. Crude Petroleum	1131
9. Sand, Gravel and Crushed Rock	1442
10. Limestone	1411
11. Phosphate Rock and Other Natural Fertilizer Materials	1471, 1479
12. Salt	1491
13. Sulfur	1492, 1493
14. Other Nonmetallic Minerals	1412, 1451, 1494, 1499
15. Vegetable Oils	2091
16. Grain Mill Products	2041, 2042, 2049
17. Other Food Products	2011-2039, 2061, 2062, 2081, 2092-2099
18. Logs	2411, 2415
19. Rafted Logs	2412
20. Lumber and Plywood	2421, 2431
21. Other Lumber and Wood Products	2413-2416, 2491
22. Pulp	2611
23. Other Pulp and Paper Products	2621, 2631, 2691
24. Sodium Hydroxide	2810
25. Crude Tar, Oil and Gas Products	2811
26. Alcohols	2813
27. Benzene and Toluene	2817
28. Sulfuric Acid	2818

EXHIBIT I-1

NATIONAL WATERWAYS STUDY COMMODITIES

Commodity	Commodity Classification for Waterborne Commerce
29. Other Chemicals	2812, 2816, 2819-2823, 2831, 2841, 2861, 2876, 2891
30. Nitrogenous Chemical Fertilizer	2871
31. Potassic Chemical Fertilizers	2872
32. Phosphatic Chemical Fertilizers	2873
33. Other Fertilizer Products	2879
34. Gasoline	2911
35. Jet Fuel and Kerosene	2912, 2913
36. Distillate Fuel Oil	2914
37. Residual Fuel Oil	2915
38. Coke	2920
39. Other Petroleum and Coal Product, N.E.C.	2916-2918, 2921, 2951, 2991
40. Cement	3241
41. Other Stone, Clay, and Glass Products	3211, 3251, 3271, 3281, 3291
42. Iron and Steel Primary Forms	3314
43. Steel Mill Products	3315-3317
44. Primary Metals	3311, 3312, 3318, 3319
45. Other Primary Metal Products	3321-3324
46. Metal Scrap	4011, 4012
47. Other Scrap	4022-4029
48. Marine Shells	0931
49. Miscellaneous	0841, 0861, 0911, 0913, 2111-2311, 2511, 2711, 3011, 3111, 3411-3991, 4111, 4112
50. Waterways Improvement Materials	4118

II - AGRICULTURE

This industry is comprised of grain, oilseeds, grain mill products, vegetable oils, and other foods or feeds. Grain is not a homogenous commodity category. It consists of the numerous grain crops that are grown in the United States. The principal grains discussed here include wheat and corn. Oilseeds include soybeans, sunflower seeds, and flaxseeds, but this discussion is limited to soybeans. Grain mill products include such commodities as wheat flour, wet corn milling products, and soybean meal. Vegetable oils include corn oil and soybean oil. These grains products are discussed below. Although other foods and feeds are not discussed, they include such items as sugar and molasses.

Table II-1 presents the waterborne commodity flows for corn, wheat, soybean, wheat flour, and other grain products.

Table II-1

1977 Waterborne Shipments of Grain, Oilseeds and Grain Products[1/]
(Millions of Tons)

Farm Products	Domestic	Foreign	Total
Corn	23.6	44.2	67.8
Wheat	11.8	26.3	38.1
Soybeans	11.7	17.8	29.5
Other Farm Products	2.3	20.2	22.5
Subtotal	49.4	108.5	157.9
Food & Kindred Products			
Grain Mill Products	5.8	7.3	13.1
Vegetable Oils	1.2	2.4	3.6
Prepared Animal Feeds	0.8	1.3	2.1
Wheat Flour	0.2	1.1	1.3
Other Products	7.4	16.1	24.9
Subtotal	15.4	28.7	44.1
TOTAL	64.8	137.2	202.0

NOTE: 1/ Some of the domestic waterborne shipments are counted again as foreign traffic.

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977, 1979.

Corn, wheat, and soybeans accounted for well over half of the water traffic in this commodity group. Water transportation plays a major role in the distribution of grain and oilseeds to export markets. Not only are such exports made from all four coasts (Atlantic, Gulf, Pacific and Great Lakes), but major amounts of corn, wheat, and soybean are originated on the Upper Mississippi, Illinois, and Ohio Rivers for shipment to the Baton Rouge to Gulf area (for a definition of the regions of the national waterways used in the NWS, see Appendix B).

This section is divided into the following subsections:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.
- Description of the Logistics System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

COMMODITY CHARACTERISTICS

(a) Wheat

There are five major strains of wheat grown in the United States. These are hard winter wheat, hard red spring wheat, durum wheat, soft red spring wheat, and white wheat. Table II-1 presents estimates of United States production for the 1976-1978 crop years.

Table II-2

United States Wheat Production 1/
(1976-78 Three Year Average) 2/

Kind	Millions of Bushels
Winter Wheat	1,448
Spring Wheat 3/	428
Durum	116
United States TOTAL	1,992

NOTE: 1/ Preliminary for 1978.

NOTE: 2/ Year begins June 1.

NOTE: 3/ Includes white wheat.

SOURCE: USDA, *Agricultural Statistics*, 1979.

Hard winter wheat is the single most important type of wheat, accounting for over 70% of United States production in recent years. Winter wheat, unlike durum and spring wheat, is sown in the fall, lies fallow during the winter, and is harvested in spring. Hard winter wheat is grown in such states as Kansas, Oklahoma, Nebraska and Texas (see Exhibit II-1 for a listing of the major wheat-producing states). It is a high-protein wheat which is used primarily for bread flour.

Hard red spring wheat is grown in such states as North Dakota and Minnesota. This wheat is used in bakery products. Durum wheat is also grown in the Upper Midwest and is used to make spaghetti, macaroni, and noodles. Soft red spring wheat has a low protein content and is used primarily for pastry, cakes, and general-purpose flour. Soft wheat is grown in such states as Ohio and Illinois. White wheat is also low in protein content and is used for pastry, cakes, and general-purpose flour.

(b) Corn

Most United States corn is a yellow hybrid variety, however there are much smaller quantities of white corn, waxy maize, sweet corn, and popcorn grown in the United States. The yellow corn is produced in such midwestern states as Iowa, Illinois, Indiana, Nebraska, and Minnesota. Exhibit II-2 provides a list of the top 10 corn producing states for the 1976-1978 crop years.

Yellow corn is planted in the spring and harvested either for silage in the late summer or for grain in the early or late fall. When corn is used for silage, the entire plant including stalks and ears is chopped while the plant is still green and stored in covered or pit silos for feed. When corn in used for its grain only, the ears are picked off the plant and the corn is shelled from the ears.

The great majority of farmers raising corn use hybrid seed, because the yield increases obtained from hybrid seed have been significant in the past 20 to 30 years. In addition, corn farmers apply significant amounts of fertilizer per acre to improve their yields. Since 1964, the average yield per harvested acre of corn has increased over 60% to an average yield of just over 100 bushels in the 1978-1979 crop year. This yield increase compares quite favorably with that of wheat (yield per harvested acre of wheat has increased 20% since 1964) and soybeans (yield per harvested acre of soybeans has increased 28% since 1964). The yield increases for wheat and soybeans are lower due in part to less successful hybrid seeds and lower levels of fertilizer applications.

(c) Soybeans

Soybeans are yellow seeds containing high levels of protein and oil. Soybean production is concentrated in three areas: the Midwest (such states as Illinois, Iowa, and Indiana); Southwest (Arkansas and Louisiana); and Southeast (Mississippi and Tennessee). Exhibit II-3 provides a listing of the top soybean producing states for the crop years of 1976-1978.

Soybeans are planted in the spring and harvested in the early fall. In the cornbelt, farmers will determine their planting of soybeans based, in part, upon the price differential between corn and soybeans at planting time. In the Southeast and Southwest, soybeans are planted more or less from one year to the next based on the price differentials among soybeans, corn, cotton, grain sorghum, and peanuts to name a few of the competing crops.

In recent years, there have been significant acreage increases in another oilseed, namely sunflower seeds. Sunflower seeds are grown primarily as an oilseed, however, there are smaller markets for confectionary seeds used as food and bird seed. The principal states raising sunflower seeds are North Dakota (this state accounted for over 60% of United States production in recent years) and Minnesota.

(d) Wheat Flour

Although other grains, such as rye, buckwheat, and oats, are milled into flour, wheat is the principal grain milled in the United States. Wheat flour is finely ground wheat that has been sifted through a sieve (i.e., bolted). Several grades of flour are produced: patent flour (highest grade flour -- free of bran and germ); clean flour (second grade); and red dog flour (low grade residue raised for animal feed). A bushel of wheat (60 lbs.) produces approximately 46 or 47 lbs. of milled flour. The other byproducts of wheat milling include feedstuffs, such as midlings and shorts.

Flour must be kept clean and dry and, as a result, must be transported in a contamination-free manner. Bulk flour is transported in specially designed covered hopper cars or barges that have lined interiors and pneumatic discharge outlets. As a fine powder, flour has an adhesive quality; however, under pressure it exhibits the flow characteristics of a liquid. This makes pneumatic loading and unloading possible.

(e) Corn Milling Products

Corn is milled by both a dry and wet milling process. Wet corn milling employs large quantities of water to separate the components of the kernel. A bushel of corn (56 lbs.) milled by a wet corn process will typically produce 1-1/2 lbs. of oil; 2-1/2 lbs. of 60% protein-gluten meal (a high-protein feedstuff for broilers and hogs), 12-1/2 lbs. of 21% protein-gluten feed (another feedstuff used by domestic and foreign livestock feeders); and 31 lbs. of starch. Starch can in turn be chemically converted into sugars and the dry starch is processed into adhesives called dextrins.

Corn is also used in a dry milling process to produce such foods as breakfast cereals, corn meal, and grits. Another use of corn is in the preparation of alcohol and distilled spirits.

Table II-3 presents estimates of corn shipments for food use by type of processing.

Table II-3

Shipments of Corn for Food Use
(Million Bushels -- Grain Equivalent)

	1978	1977
Wet Corn Milling	207	380
Dry Milling:		
Corn Meal and Flour	37	35
Homing grits	21	10
Breakfast foods	22	25
Alcoholic Beverages:		
Distilled liquors	33	22
Fermented malt liquors	42	57
TOTAL SHIPMENTS	362	529

SOURCE: USDA, Situation Reports, Feed Situation -- 269.

The principal growth of corn products in the past 10 years has been wet corn milling products and the remaining discussion of corn products will be limited to these products.

(f) Soybean Oil and Meal

Soybeans are primarily crushed for oil and meal although a small percentage of soybeans are prepared for food consumption as roasted seeds or bean paste and curd. A bushel of soybeans (60 lbs.) produces approximately 11 lbs. of oil and 47 lbs. of high-protein meal.

Exhibit II-4 presents United States domestic production of fats and oils for the crop-year 1977. Although there are other oilseeds that are processed in a similar fashion, soybeans are the principal oilseed processed in the United States In recent years, almost two-thirds of fats and oils production have been from soybeans.

MARKETS

The principal markets for wheat, corn, and soybeans are discussed below.

(a) Wheat and Wheat Flour

The markets for United States wheat are foreign exports, domestic milling of wheat into flour, and domestic feeding of wheat. Table II-4 provides estimates of wheat use in the United States by these markets for the 1977 crop-year.

Table II-4

United States Wheat Use for 1977 1/

Use	Millions of Bushels	Percent of Total
Domestic Food	586	30%
Domestic Feed	183	9
Seed	80	4
Export	1,124	57
TOTAL	1,973	100%

NOTE: 1/ Crop-year begins June 1.

SOURCE: USDA, Agricultural Statistics, 1979.

The two primary markets for United States wheat are foreign exports and domestic milling. Each of these markets are discussed under separate headings. Although wheat is typically not considered a feed grain, wheat does compete for feed with other grains and, at times, can be fed extensively as part of rations for broilers and cattle. The remaining use of wheat is for seed.

1. Wheat Exports. In recent years, the United States has exported approximately 60% of its crop. In contrast to corn and soybeans, the United States is not the largest producer of wheat. Table II-5 presents average wheat production by country for 1976-1978:

Table II-5

Wheat Production by Country 1/
(1976-78 Three-Year Average) 2/

Country	Millions of Metric Tons	Percent of Total
Russia	101.3	25%
United States	54.2	13
People's Republic of China	42.5	11
India	29.7	7
Canada	21.5	5
France	18.1	5
All Others	139.5	34
TOTAL	406.8	100%

NOTE: 1/ Preliminary for the 1978 crop-year.

NOTE: 2/ Years shown refer to years of harvest in the Northern Hemisphere. Harvests of Northern Hemisphere countries are combined with those of the Southern Hemisphere which immediately follow.

SOURCE: USDA, Agricultural Statistics, 1979.

Russia, not the United States, is the largest producer of wheat. For the past three crop-years, Russia has accounted for one quarter of the world's wheat production. The United States and the People's Republic of China have accounted for another one quarter of the world's wheat production.

Several factors are important for understanding the market for United States wheat exports. First, although Russia is the largest producer of wheat, its yields per hectare are more variable than many other countries. For example, the average yield per hectare for the 1976-1978 wheat harvests was 1.65 metric tons per hectare, but the range of these yields was from 1.49 to 1.83. By contrast, the range in yield's for the United States was 2.04 to 2.13 metric tons per hectare for the same period. Since Russia has been a net importer of wheat in recent years, the variation in yield can dramatically affect its share of world imports. In the crop-year beginning in June 1975, Russia accounted for over one quarter of the world's imports of wheat, but this percentage dropped to 14% in the next crop-year.

Second, wheat is only one of two major food grains produced in the world and it is often used as a substitute for rice when the major rice-producing countries suffer a decline in production. Table II-6 presents world production of rice, wheat, and rye for the 1976-1978 crop-years.

Table II-6

World Production of Principal Food Grains
(1976-1978 Three-Year Average) 1/

	Food Grain	Millions of Metric Tons
	Wheat	406.8
	Rice	363.8
	Rye	26.5
TOTAL		797.1

NOTE: 1/ Each crop has a slightly different crop-year.

SOURCE: USDA, Agricultural Statistics, 1979.

As can be seen, the world production of rice is somewhat less than wheat, but it is nonetheless a significant grain for the feeding of much of the world's population. Wheat is imported as a substitute for rice due in part to the limited international trade in rice as compared to the international trade in wheat. According to USDA, an estimated 8.1 million metric tons of rice were imported on average for the crop-years 1975-1977. In contrast, world imports of wheat and equivalent wheat flour exceed 46.8 million metric tons for the same crop-years.

Third, the United States is the largest wheat exporter in the world, but its share of the wheat export market is less than its shares of the comparable corn and soybean markets. Table II-7 presents average wheat exports by country for the 1975-1977 crop-years.

Table II-7

Wheat and Equivalent Wheat Flour Exports by Country 1/ (1975-77 Three-Year Average)

Country	Millions of Metric Tons	Percent of Total
United States	28	41%
Canada	13	19
Australia	8	12
France	8	12
Argentina	5	7
All Others	6	9
TOTAL	68	100%

NOTE: 1/ Preliminary estimates for 1977.

SOURCE: USDA, Agricultural Statistics, 1979.

The United States had a 41% share of world wheat exports for 1975-77. Other countries competing with the United States for the sale of wheat and wheat flour include Canada, Australia, and France. Principal customers of United States wheat include such countries as Japan, Korea, Brazil, and India.

2. Domestic Milling of Wheat. An estimated 30% of 1977 wheat use in the United States was for domestic milling into flour (see Table II-4). Wheat flour consumption in the United States has been gradually increasing over the past 10 years, but the annual increase has been less than two percent on a compounded basis. Thus, the primary domestic market for wheat is characterized by slow growth.

Wheat milling plants are dispersed throughout the United States. Some 37 states in the continental United States have active milling operations. Exhibit II-5 lists the 10 states with the greatest amount of active mill capacity. Milling operations are located both in wheat-producing areas, such as Kansas and Minnesota, and in major flour-consuming areas, such as New York and California.

(b) Corn and Corn Products

The markets for United States corn are domestic feeding, domestic processing, and foreign exports. Table II-8 presents estimates of corn use in the United States for the 1977 crop-year.

Table II-8

U.S. Corn Use for 1977 1/

Use	Millions of Bushels	Percent of Total
Domestic Feed	3,709	60%
Domestic Food, Alcohol and Seed	551	9
Exports	1,948	31
TOTAL	6,208	100%

NOTE: 1/ Crop-year begin October 1. Preliminary estimates only.

SOURCE: USDA, Agricultural Statistics, 1979.

In sharp contrast to wheat, domestic consumption of corn for feed accounts for 60% corn's use. Exports and domestic food use account for the remaining uses of corn. Each of these markets are discussed below.

1. Domestic Feed. The domestic feed market is the largest market for United States corn. Livestock feeding of corn involves broiler, egg, and other poultry operations; beef cattle operations; dairy cattle operations; and hog operations.

These livestock are fed formulated rations made of feed-grains, such as corn, grain sorghum, oats, barley, and on occasion wheat, and protein sources, such as soybean meal. Rations are formulated for each type of livestock and are varied as the market prices of competing feed grains and protein sources change. Hogs and broilers are typically fed a highly-concentrated ration of corn and soybean meal. Beef cattle can be fed a similar ration or put on grass with a corn and soybean meal supplement. Dairy cattle are fed a grain concentrate of corn and soybean meal and substantial amounts of hay, silage, or similar roughage.

Feeders are continually striving to improve their yields by formulating rations more carefully, adopting new veterinarian techniques, and obtaining better breeding stocks. Despite these actions, meat, dairy, and poultry products are not produced from feedgrains on a pound-for-pound basis. On the contrary, it takes eight or more pounds of feedgrains to add an additional pound of weight to a calf. Thus, as demand for livestock products grow, demand for feedgrains increases somewhat faster.

Domestic use of corn for feed has shown little growth over the past 10 years. From 1968 to 1972, feed use increased from 3.6 to 4.3 billion bushels. In the early 1970's, United States corn exports began to expand rapidly; these stronger export markets and poor harvests in 1970 and 1974 "pulled" feedgrains away from domestic livestock producers. As a result, domestic use of corn for feed actually declined from 4.3 billion bushels in 1972 to 3.2 billion bushels in 1974. Since 1974, feed use has increased to levels of the late 1960's.

The domestic livestock markets are concentrated in different parts of the country. Broiler production is concentrated in the Southwest (Arkansas and Texas), Southeast (Georgia and Alabama), and Middle Atlantic states (Maryland and Delaware). Exhibit II-6 presents the top 10 broiler-producing states in 1977. Beef cattle operations are concentrated in the Midwest (Iowa and Illinois), Southwest (Texas, Kansas, and Colorado), and West (California and Arizona). Exhibit II-7 presents the important cattle-producing states.

Dairy cattle and hog operations are located primarily in the Midwest. Dairy operations in the Northeast and California are exceptions to this statement. Exhibits II-8 and II-9 list the important dairy cattle and hog-producing states.

2. Exports. Over 30% of corn use in 1977 was for exports. Table II-9 presents average corn production by country for 1976 to 1978.

Table II-9

Corn Production by Country 1/
(1976-78 Three-Year Averages) 2/

Country	Millions of Metric Tons	Percent of Total
United States	164.9	47%
People's Republic of China	33.7	10
Brazil	17.2	5
Romania	10.6	3
Soviet Union	10.0	3
All Others	110.8	32
TOTAL	347.2	100%

NOTE: 1/ Preliminary for 1978.

NOTE: 2/ Years shown refer to harvest in the Northern Hemisphere. Harvests of Northern Hemisphere countries are combined with those of the Southern Hemisphere which immediately follow.

SOURCE: USDA, Agricultural Statistics, 1979.

The United States accounts for almost half of the world's production of corn. The country with the next largest production, China, is a distant second to the United States. Since corn is the principal feedgrain produced in the world, the United States has a dominant position in all feedgrain markets.

The United States is the largest exporter of corn. Argentina and South Africa make some export shipments as well. The principal customers for United States corn are those countries seeking to build and maintain their own poultry, cattle, and hog operations. These countries include Japan, West Germany, the Netherlands (for domestic use and transhipment to other European destinations), Italy, and, up until the grain embargo imposed by President Carter, the Soviet Union.

The level of corn exports to selected countries is, of course, influenced by the trade policies of the various United States and foreign countries. The sudden embargo of United States corn exports to Russia is only one example. Western European countries are particularly encouraged to import selected wet corn milling products, such as corn gluten feed, and soybean meal for several reasons. First, local grain prices are higher than they would otherwise be due to the price support programs of these countries. Second, duties or levies are placed on the importing of whole grains from the United States, but grain processed products imported from the United States are not subject to duties or levies.

3. <u>Domestic Food</u>. As noted earlier, wet corn milling accounts for the majority of domestic food use. Wet corn milling plants are located in eight states and, for the most part, these plants are concentrated in the cornbelt states (see Exhibit II-10 for a listing of wet corn processing plants by state). Food products are distributed nationwide from these plants, while feed products are shipped to domestic or export markets.

(c) Soybean and Soybean Products

The markets for United States soybeans are domestic crushing operations and exports. Table II-10 presents estimates of soybean use in the United States for the 1977 crop-year.

Table II-10

U.S. Soybean Use for 1977 1/

Use	Millions of Bushels	Percent of Total
Crushed	926.6	54%
Exports	700.5	41
Seed and Residual	78.5	5
TOTAL	1,703.6	100%

NOTE: 1/ Crop-year begins September 1. Preliminary estimates only.

SOURCE: USDA, Agricultural Statistics, 1979.

An estimated 54% of the beans used in 1977 were processed into oil and meal for domestic markets. As noted earlier, soybean oil is the dominant oil produced in the United States and accounted for almost two-thirds of United States domestic production in 1977 (see Exhibit II-4). Soybean meal is a high-protein feed and is shipped to domestic livestock markets. Since 1968, crushing of soybeans for domestic markets has increased approximately 50% overall or first over five percent on an annual compound basis.

Soybean processing plants are concentrated in three areas: the Midwest, Southwest, and Southeast. Exhibit II-11 presents a partial listing of states with active soybean processing plants. Oil is shipped throughout the United States from these plants while meal is shipped to domestic and foreign livestock markets.

Another 41% of soybean use was for exports. Table II-11 presents average soybean production by country for 1976 to 1978:

Table II-11

Soybean Production by Country 1/
(1976-1978 Three-Year Average) 2/

Country	Millions of Metric Tons	Percent of Total
United States	44.4	63%
Brazil	11.0	16
People's Republic of China	9.5	13
Argentina	1.6	2
All Others	4.1	6
TOTAL	70.6	100%

NOTE: 1/ Preliminary for 1978.

NOTE: 2/ Years shown refer to years of harvest. Southern Hemisphere crops, which are harvested in the early part of the year, are combined with those of the Northern Hemisphere.

SOURCE: USDA, Agricultural Statistics, 1979.

Just as in the case of corn, the United States is the leading producer of soybeans.

The United States is also the largest exporter of soybeans, both in the form of oilseeds and crushed products. Brazil and, to a smaller degree, Argentina are competitors of the United States for these sales. The principal customers for United States soybeans and products are Japan, the Netherlands (both domestic use and transhipment to other Western European countries), Germany, Spain, Italy, and Taiwan.

ECONOMICS OF THE INDUSTRY

The United States agriculture industry includes farmers, local grain elevators, regional grain companies, international grain companies, livestock producers, wheat millers, corn processors, soybean processors, and a variety of other feed and food-processing companies.

Farming and production of livestock approach pure competition in character, given the large number of growers and producers and the ease of market entry. Even some of the largest producers of broilers and cattle exert only limited, if any, influence over prices and output.

Studies of the price elasticity of demand for grain by USDA indicate that the demand is inelastic with respect to price. This inelasticity makes it difficult for farmers to raise their income in times of rising production. During the past 50 years, United States agricultural production has increased faster than the growth in the general United States population and, thus, exports play an important role in counterbalancing this long-term trend. In order to circumvent the problems associated with large production, various measures have been taken including:

1. Advanced contract sales of crops to processors or grain companies.

2. Use of futures markets to hedge the sale of crops prior to harvest.

3. Vertical integration of farming and processing. This practice is common in cane sugar, citrus fruits, and selected vegetables.

4. Government programs that set price supports or restrict acreage.

Since there are a large number of local grain elevators and regional grain companies in the United States, the business of drying, storing, and shipping grain is extremely price-competitive. An estimated 15 regional grain companies operate one or more export elevators on the Great Lakes or the other coasts. Another 40 to 50 regional grain companies compete for the bulk of United States grain produced for commerical sale. There are hundreds of local evelators scattered through the major grain-growing areas.

Large international grain companies account for the bulk of United States export sales. Although the number of these firms is limited to 10 or 11 principal firms, the competition among them for business is substantial.

The relative maturity of the food-processing businesses has led to extensive vertical integration. Large integrated food processors (several with large grain processing divisions) with 1978 sales over $2 billion include Beatrice Foods; Borden, Inc.; CPC International; Consolidated Foods; General Foods; General Mills; H. J. Heins Co.; Kraft, Inc.; Norton Simon; Ralston Purina; and Standard Brands. These firms earned an average 4.3% on sales 17.1% on equity in 1977. These firms, however, had substantial operations other than grain exporting or processing. Four grain processing companies, namely American Maize, Archer-Daniels-Midland, Central Soya, and A. E. Staley Manufacturing, had an average, a lower net income to sales ratio (1.9%) and return on equity (11.2%) in 1978 than the other companies mentioned above.

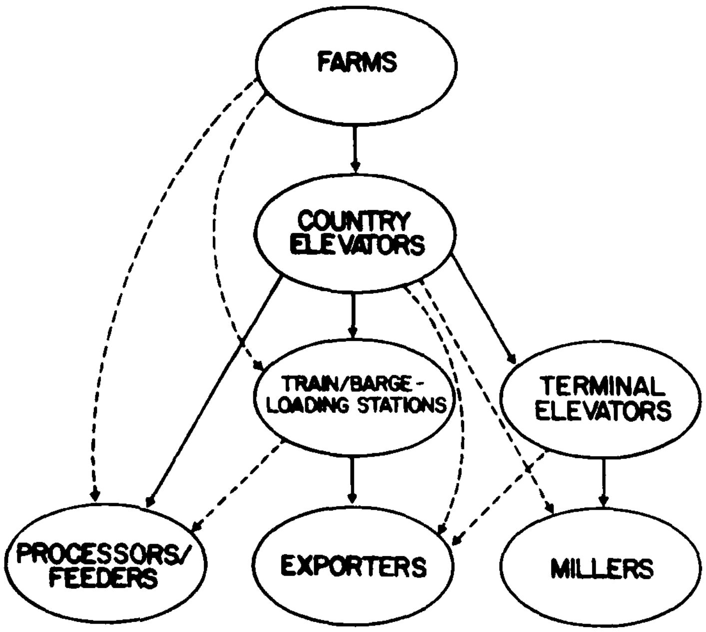
DESCRIPTION OF LOGISTICS SYSTEM

Well over 200 million tons of grain are moved each year from farms to domestic and export markets. The logistics system is complex and has evolved to gather grain for the most efficient means of transportation and storage to domestic and export markets.

A simplified flow chart of the grain and soybean distribution system is shown in Figure II-A.

Figure II-A

Grain Distribution System



Very little grain moves directly from the farm to the processors, millers, feeders (except, of course, on-farm feeding of livestock), and exporters. Instead, several intermediate storage, handling, and transportation steps are involved.

The components of this grain distribution system are described under separate headings.

(a) Farms

The process of moving grain to markets begins at the farms. As grain is harvested, the farmers must decide whether to: 1) keep it on-farm for storage or feed or 2) move it off-farm for storage or sale. Since farmers are interested in increasing their revenue net of storage, transportation, and grain drying costs, they base their decisions on a number of factors. These factors include changes in harvesting techniques, the benefits and costs of constructing on-farm storage, and the potential for increasing net income by feeding grain to livestock produced on the farm.

Since the early 1900's, tremendous progress has been made in designing equipment to harvest grain and soybeans quickly. For example, in the past, most corn was picked and stored on the ear. Farmers would allow this corn to "dry" in the fields as long as possible before picking it. As corn matures in the field, the moisture content in the kernels declines. Grain that has been properly dried to 14 or 15-1/2% moisture will keep almost indefinitely. If the corn was picked before it had dried properly, it was stored on the ear in corn cribs that were open to the air to permit further drying.

With the advent of combines or picker shellers, the corn is picked and shelled in one operation. This combining is usually done as early as possible to avoid field losses from any bad weather, such as snow, that might develop later in the crop-year. As a result of these changes, corn that has a high moisture content must be dried and shipped to markets or dried and stored in a much shorter time period.

The farmers have responded to these new demands by either building more sophisticated storage and drying facilities on-farm or shipping the moist corn to local elevators for drying and storage. A common means of storing corn on-farm is the construction of corrugated metal bins which rest on concrete foundations and include aeration and handling equipment.

These are at least two advantages to on-farm storage and drying of grain. First, by storing grain on the farm, farmers have not given up any options for the final disposition of their crop including on-farm feeding to livestock. Second, farmers have the option of selling their grain at the most advantageous time for them to do so. If domestic and export markets have more than adequate supplies of grain in the "pipeline" to handle 30 to 60 day needs, then carrying charges will develop in cash grain and grain futures markets to encourage the farmer to hold grain off the market for a period of time. If carrying charges develop, then farmers will compare their cost of storing grain with the additional income that they could receive by selling their grain later in the crop-year. By constructing farm storage, the farmers are assured of adequate capacity to store their grain at harvest time if it becomes attractive to do so.

There are some disadvantages to on-farm storage as well. In particular, local elevators may be in a position to offer storage at rates that are lower than the costs of constructing and maintaining on-farm storage and drying facilities. Furthermore, local elevators are more skilled at drying corn and soybeans without damaging them in the process. Heat-damaged corn and soybeans must be sold at a discount of anywhere from 1/4 to 5 cents a bushel for each percentage point of damage above a minimum standard.

In recent years, the USDA had conducted surveys of on-farm storage. The surveys indicate that new construction of on-farm storge for corn and soybeans has been growing rapidly. This construction has been encouraged by federal programs that have made long-term credit at attractive rates available to farmers.

An important implication of this additional farm storage for the grain and soybean logistics system is that shipments of grain from farms will coincide more closely with changes in market demand for these commodities. Whereas in the past grain was forced to move to intermediate or end markets during harvest time regardless of the level of demand; farmers at the present time are capable of storing much more grain for shipment later in the crop-year.

As discussed previously, farmers also make this decision to keep grain on-farm or ship it to market based in part upon the attractiveness of feeding livestock. Corn farmers, for example, can choose either to sell their corn either to local elevator operators who, in turn, may sell to corn processors or train-loading stations, or to sell their corn by feeding hogs and marketing these animals at a later date. USDA statistics for the 1977 crop-year, indicate that farmers kept 39% of corn for grain on-farm.

The role that improvements in transportation services and costs play in this decision is often not understood. One shipper noted, in particular, that farmers in western Iowa had little choice in the late 1960's but to feed their corn on-farm. Single car rates to export facilities were so high that other sources of grain with cheaper means of transportation dominated the export market. However, with the introduction of unit-train rates from western Iowa origins to export facilities located at the Gulf and Great Lakes, these farmers were in a much better position to take advantage of the increased opportunities made possible by the sharply higher export sales to such countries as Russia in the early 1970's. In effect, the combination of lower rail rates and increased foreign sales "pulled" Iowa corn off the farm.

It should also be noted that the brunt of reductions in transportation services and increased costs is ultimately borne by farmers. If adequate capacity is not available for the transportation of grain, soybeans, and processed products to a particular market, then farmers are forced to settle for the next best alternative.

(b) Country Elevators

From the farm, grain is typically moved to country elevators. This is a small trip, averaging 10 miles or less, and is usually made by a small farm truck or a tractor hauling a farm wagon or gravity box. The farmer often has a choice of two or more elevators to patronize, so competition among country elevators for this business is keen.

The facilities of country elevators typically include storage elevators ranging from 50,000 to several million bushels, truck receiving pits and dumps, rail and truck shipping legs capable of shipping from 1,000 to 20,000 bushels an hour, and grain driers.

The country-elevator operators will either purchase the farmers' grain outright or they will store the grain for the farmers at a specified charge per bushel per month. If country elevators are unable to offer all the storage their farmers need, then they may seek to secure additional storage for their farmers' accounts at major terminal elevators. This practice is common in the wheat growing areas of the Southwest where terminal elevators reserve much of their storage capacity for the accounts of local elevators.

If the elevator operators buy the grain, they either can choose to resell it immediately and pass the risk of owning the grain onto the next buyer or can "hedge" the purchases by selling an equivalent amount of grain futures contracts. Futures are contracts to deliver a specified quantity and grade of a commodity during a designated month at a price determined by public auction. Thus, elevator operators usually do not speculate in the futures market or hold grain in storage on speculation.

The prices that country-elevator operators offer farmers are based on four factors: 1) storage charges (assuming that farmers are selling their grain that has been in storge with the country elevators); 2) transportation rates or costs to various market outlets including local grain and soybean processors, train or barge-loading stations, and terminal elevators; 3) net purchase prices being offered by these various market outlets on a delivered basis; and 4) operating margins that the elevators charge for performing these marketing services.

Country elevators have little control over the third and fourth factors. Competition among country elevators keeps operating margins to a few cents per bushel plus any gains from blending (blending is the activity of mixing different grades of grain in such a way to produce a more uniform grade that can be sold at a higher price net of any discounts by the country elevators). Country elevators also have little control over the delivered bids that other market outlets can offer.

Since country elevators have little control over delivered bids or operating margins, they can increase their market shares only by offering more storage at a lower net price to surrounding farmers or by securing truck or rail transportation of better service and lower cost. Without distinctive advantages for reducing these costs, individual country elevators, can not hope to expand beyond their immediate service areas. In contrast to country elevators, both train or barge-loading stations and terminal elevators have a much wider grain "draw" (i.e., grain gathering area) based on lower transportation costs, in the former case, and lower storage costs and more opportunities for blending in the latter case.

(c) Train/Barge-Loading Stations

Some general characteristics of these stations are discussed before descriptions of each type of station are presented. Train or barge-loading stations are strategically located in the grain or soybean-producing areas to take advantage of unit-train rates and/or barge transportation on the inland waterways. They are specifically designed to "feed" export facilities on the Gulf coasts, or Lakes.

Although these stations may offer grain-storage and drying services to farmers and local elevators, these are not their competitive strengths. Their competitive strengths lie in their ability to handle large volumes of grain at low margins. Their ability to attract large volumes of grain is directly related to their ability to secure reliable transportation at low costs.

Train and barge-loading facilities have several things in common. First, they are often affiliated with or owned by the companies operating export terminals on the coasts, Gulf and Great Lakes. Second, the owners or operators of these loading stations have often invested substantial capital providing adequate transportation equipment and, in the case of barge transportation, power to keep the stations open and running, even when grain is "moving" from the country. A train-loading station may keep two trains of privately owned, hopper-car equipment running, while some grain companies have actually started or purchased their own barges or barge lines to service their barge-loading stations. Third, these facilities typically buy most of their grain from country elevators not farmers. Country elevators perform the initial tasks of gathering grain from farm-wagon lots; drying, cleaning, and blending this grain; and shipping it in truck, single car, or multiple-car-load lots. Fourth, since these loading stations often have limited storage capacity. They must work closely with the export terminals to which they ship in order to prevent shut-downs for lack of storage space or purchased grain. Fifth, these loading stations typically must have strong financial backing since they purchase anywhere from 6 to 30 million bushels a year, valued at $2 to $3 per bushel for corn and $6 to $8 per bushel for soybeans. Finally, these stations are designed to transload grain and soybeans from trucks or rail cars to trains or barges at very low margins. Some loading stations can operate with as few as 4 to 12 men. Private stations may be able to require and ship grain or soybeans for the parent company at a variable cost of 50 to 70¢ per ton.

1. <u>Barge-Loading Stations</u>. Barge-loading stations have at least one truck dump that is capable of receiving 7,000 to 9,000 bushels per hour. These stations usually have enough storage to hold the equivalent of two barge-loads or 100,000 bushels, so that grain can be transloaded directly to barges or to storage for later loading.

The relatively low storage requirements of barge-loading stations are due in part to the flexibility with which tows are assembled on the Upper Mississippi and Illinois Rivers. Grain barges move in tows as large as 15 on these rivers, but barge lines may distribute the empties or assemble the loads for a single tow across three or more stations. In this way, grain companies can keep a barge under the shipping spout of their stations much of the time, so that grain received by truck can bypass storage and be conveyed directly to the river. Barge-loading stations typically have dock space for two or more barges and shipping leg capacity of at least 10,000 bushels per hour.

Barge-loading stations on the Upper Mississippi and Illinois Rivers typically receive most of their grain by truck from country elevators. The market share captured by barge terminals in a particular grain-growing area is determined by both the relative rates for barge, rail, and truck transportation to export markets and the strength of the alternative markets for the grain and soybeans as reflected in the bids of domestic processors, millers, and feeders.

A hypothetical example can illustrate the importance of transportation rates. Consider an area 100 miles wide stretching from a waterway barge terminal to an inland point that has both a train-loading station and a corn-processing plant. Both stations ship to Gulf export facilities where the export price for corn is $3.00/bushel. The barge and train rates to the Gulf are assumed to be 30 and 33 cents per bushel, respectively. Thus, the barge terminal can offer a bid three cents per bushel higher than the rail terminal and maintain an equal margin for handling and profit. If the local truck rate is seven cents per bushel for the first ten miles and one cent for every additional ten miles, then the three cents per bushel premium that barge-loading stations can bid for grain covers the cost of trucking grain an additional 30 miles. Thus, country elevators up to 65 miles away find it more profitable to sell the barge terminal, while elevators further from the river ship to the train-loading station.

The example is, of course, complicated by consideration of alternative markets, such as the corn-processing plant located next to the train-loading station. The processor competes with both the barge-loading and train-loading stations for corn. Since processors are interested in maintaining steady flows of corn deliveries to their plants; they set their bids high enough to attract sufficient grain to maintain such orderly shipments.

The example also shows why competition between barge and train-loading stations is influenced strongly by changes in barge or train rates, but has shown little sensitivity to increases in trucking costs. A 10% increase in barge rates to 33 cents per bushel (or a similar decrease in rail rates) leads to a 23% reduction in the area that ships by barge.

In contrast, truck rate increases have had little effect on the barge-train split, because, at least in central Illinois, these rate increases have taken the form of increases for the first ten-mile block only. The incremental price for handling grain an additional ten miles has remained constant.

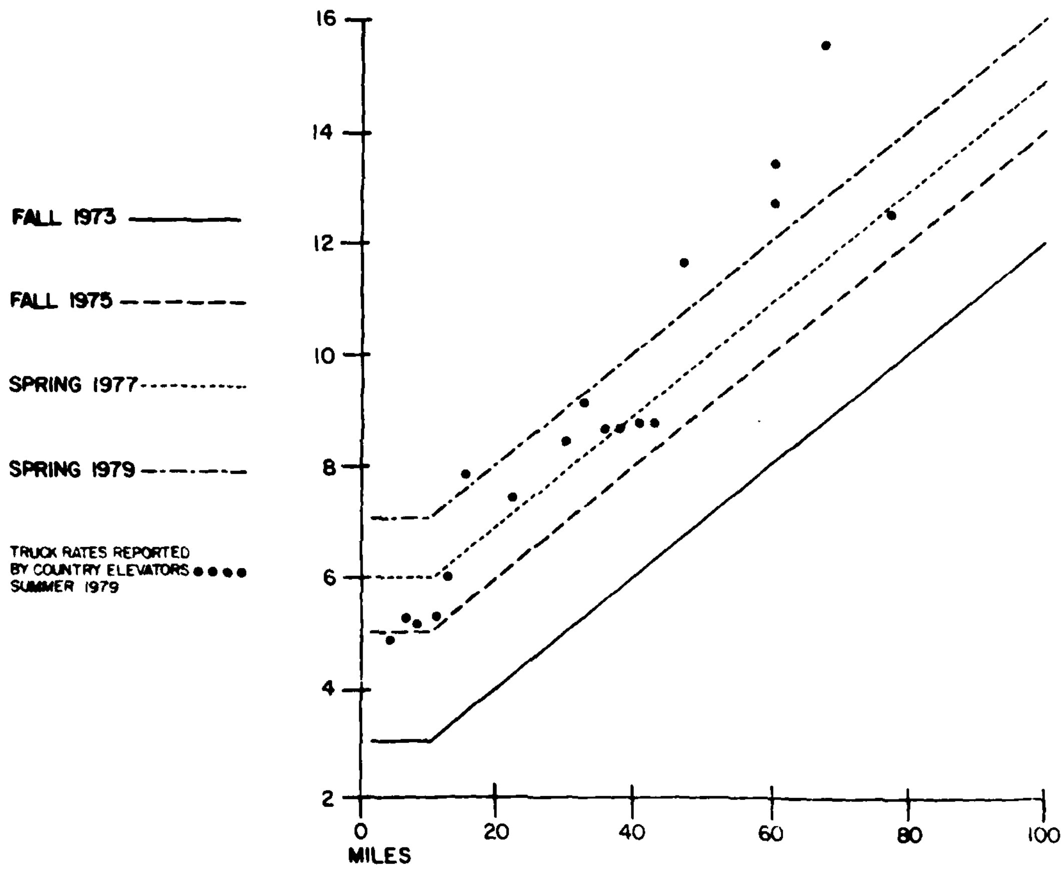
Figure II-B presents truck-rate data for Illinois obtained from two sources: 1) tariffs published by the Mid-West Truckers Association that give the rates charged by members in Illinois and 2) rates quoted by Illinois country elevator operators during telephone interviews conducted in August and September 1979 for the Element B Report. Since 1973, truck rate increases have been concentrated in the first block, while charges for additional mileage have remained constant. This finding is surprising in light of the rapid increases in fuel costs and, as variable costs (especially fuel costs) continue to grow faster than fixed costs, there may be increased pressure to alter the current rate structure.

In contrast to rail rates, barge rates for grain are not regulated by the Interstate Commerce Commission and fluctuate according to market conditions. There is an active barge-trading market and spot rates in that market vary sharply over the course of a year. Although many grain companies negotiate long-term contracts with barge lines, operate their own barge lines, or own their own barges, they also participate in the barge-trading market.

Figure II-B

Illinois Truck Rates For Corn

Cents Per Bushel



SOURCE: Mid-West Truckers Association and Interviews.

A measure of barge rates is the differential between the bid at Gulf export terminals for barge-delivered grain and the bid at an inland barge-loading station for truck-delivered grain. This differential includes elevating margins at the barge-loading station as well as the barge transportation costs; thus; it is not strictly a measure of only barge cost differences.

Exhibit II-12 presents the end-of-month differential between Gulf corn bids and river bids at Hennopin, Illinois for 1977 and 1978. As can be seen, this differential has varied substantially. In mid-1977, this differential was as narrow as 13-1/2 cents per bushel. At that time, there was more than an adequate number of barges to handle downbound shipments of corn and barge rates fell. The barge fleet is often fully utilized even during slack times, because operators cut rates to keep their equipment under load. If rates fall below variable costs of operation or operators expect rates to rise substantially in the near future, than operators may decide to keep equipment temporarily idle rather than commit themselves to shipments at unattractive rates.

By way of contrast, this differential had widened to just over 50 cents per bushel in the spring of 1978. The 1977-1978 winter had been especially severe and traffic on the Illinois River had been brought to a virtual standstill for down-bound traffic originating north of Peoria. As the river condition improved, barge freight was in great demand to move grain that had been purchased from country elevators for delivery earlier in the year.

Barge-loading stations are often located near major highways. For stretches of river running east-west, the barge-loading stations are often located near major north-south highways. For example, there are approximately 20 barge-loading stations on a 100-mile stretch of the Illinois River from Spring Valley to Lockport, Illinois. These terminals are located at such bridge crossings as highways 51 at Peru-LaSalle, 23 at Ottawa, and 47 at Morris. The grain-gathering area of these terminals, of course, varies with changes in river conditions and barge/rail rate differentials. Figure II-C depicts the grain-gathering areas for these Illinois River ports under conditions considered normal by shippers.

Figure II-C

Grain-Gathering Areas for Selected Illinois River Ports

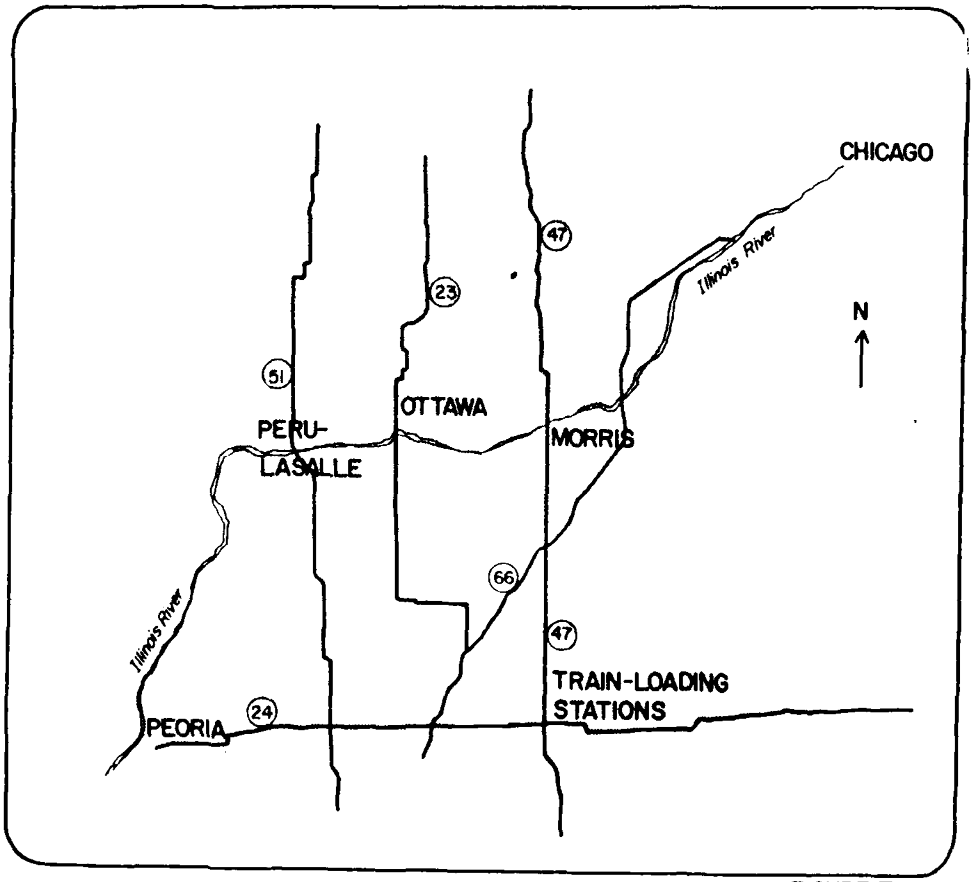


FIGURE II-C

SOURCE: Shipper Interviews.

Figure II-C also depicts the grain-gathering areas of both barge-loading stations located near Peoria and train-loading stations in Central Illinois. Since the river is running north-south at Peoria, the draw of the Peoria terminals is largely from west and east to the river.

The grain-gathering area of barge-loading stations can be extended by the "feeder" service provided by certain rail lines. A good example of this is the service provided in recent years by the Milwaukee Road on its east-west line running across northern Iowa and terminating at the Upper Mississippi near McGregor, Iowa. Whereas Upper Mississippi stations in Iowa may receive truck-delivered grain from as far away as 100 miles to the west, good rail service on an east-west line may nearly double the gathering area of an individual station. (It should be noted that rail-barge tonnage has not grown as quickly as anticipated. The Iowa Department of Transportation reports that the rail share of grain shipments to Iowa barge terminals slipped from 20% to 19% between 1974 and 1977, although tonnage increased from 840,000 to 920,000 tons.)

2. Train-Loading Stations. Train-loading stations typically have two or more truck dumps that are each capable of receiving 7,000 to 9,000 bushels. The incoming grain is dumped from the truck or rail car into a pit from which it is elevated into storage. Train-loading stations must have adequate yard capacity to receive multiple hopper cars at one switch. (Usually 25 cars with one switch is adequate for Iowa or Illinois terminals, but some facilities are capable of receiving all 125 cars of an Illinois Central Gulf train with one switch). And they must have adequate shipping leg capacity to load 7 to 12 hopper cars per hour (this is equivalent to anywhere from 21,000 bushels of soybeans to 42,000 bushels of corn).

Train-loading stations usually have sufficient storage to hold the equivalent of two train-load shipments of grain or soybeans. In Central Illinois, this minimum storage capacity is approximately 900,000 bushels, but stations may have storage capacities of six million bushels or more.

The higher storage requirements for typical train-loading stations (relative to barge-loading terminals) is due to several reasons. First, rail tariffs generally require that trains be loaded at one station within a 24-hour period. Although grain delivered by truck during this 24-hour period can be transferred directly to rail cars, operators of trainloading stations are unwilling to ask their customers to limit deliveries to those days for which trains are available for loading.

Second, unlike barge and truck rates, rail rates for grain are regulated by the Interstate Commerce Commission and are not free to vary with changes in the demand for rail transportation. (The 4-R Act of 1976 provided rail carriers with the opportunity to file for seasonal rate increases or decreases, however such provisions have not been used significantly by rail carriers on export rates.) Because railroads have been trying to improve hopper car utilization and have been unwilling to invest in equipment that would be used only part of a crop-year, they have offered rates that encourage shippers to spread shipments evenly throughout the year. This in turn has forced shippers to build more storage.

Exhibit II-13 presents East Coast export rates offered under tariff TEA-4043 unit-train shipments of corn and soybeans. Using railroad equipment, shippers in Columbus, Ohio can reduce their shipping rate per ton from $10.43 to $9.45 by loading a 100-car train 45 consecutive times during a crop-year. To qualify for the lower rates, shippers must make a commitment to ship a minimum number of 100-car trains and post an indemnity bond sufficient to cover the difference between the standard, single-car rate and the volume discount rate.

Although the rate savings from shipping multiple trains are attractive, shippers must often increase their storage capacity in order to purchase sufficient grain for multiple shipments. When grain is "moving" from the country, train-loading stations seek to fill their storage. As market conditions change or barge rates fall, train-loading stations are often forced to draw on their grain stocks in order to meet shipping schedules.

Exhibit II-13 also presents East Coast export rates for unit-train shipments in privately-owned shipper equipment. Rates decrease if shippers provide their own cars. If additional trips are made, shippers enjoy lower rates and, thus, they have a strong incentive to improve turn-time on their own trains. Since the average round trip from Illinois to Norfolk using a single carrier takes 12 days, a railroad car on this route can make a maximum of 30 trips per year.

Train-loading stations are often located just off or near major interstate highways, such as highways I-55, I-57, and I-74 in Central Illinois or highway I-80 in Nebraska. They are not only located to take advantage of good highways, but also to take advantage of good rail transportation services and rates. In some cases, these stations are located where they can ship directly to both Gulf and East Coast ports or Gulf and West Coast ports. Train-loading stations are located throughout the cornbelt in such places as Champaign, Gilman, Tuscola, and Gibson City, Illinois; Logansport, Kokomo, and Delphi, Indiana; and Hastings, Kearney, and Grand Island, Nebraska.

The grain-gathering area of train-loading stations is related both to the difference in rates between competing barge and train-loading stations and to the difference between single or multiple-car rates and train rates. Whereas country elevators typically have a draw of no more than 10 to 20 miles, train-loading stations may receive grain as far away as 100 miles. The grain-gathering area of stations competing with barge-loading stations is extended during navigation.

(d) Terminal Elevators

Terminal elevators are strategically located in the major wheat-producing and flour-milling areas to take advantage of certain features of rail rates. These features include:

1. Transit privileges, which provide rail shippers with the privilege of stopping cars at transit points for either storage or processing. (These privileges are included in the rate structure and, thus, no additional cost for exercising these privileges is incurred by shippers.)

2. In-transit inspection, which permit rail shippers to stop cars at points along rail routings for grain inspection.

Transit privileges permit terminal elevators to extend their grain-gathering area in a much different manner than barge or train-loading stations. In sharp contrast to these stations, terminal operators do not earn the bulk of their income from transloading truck-delivered grain to unit trains or barges. Rather they earn their income (and increase their grain-gathering area) by offering a variety of other services to country elevators and flour millers.

One of the principal services that terminal elevators offer to country elevators is storage. Storage capacity for terminal elevators range anywhere from 1 to 18 million bushels. At harvest time, farmers usually fill their own storage first and then secure storage at their country elevators. As country elevators run out of space, they secure storage space with terminal elevators for the account of their farmers. The terminal elevator operators are able to offer storage to farmers as far away as 500 miles by moving the grain into the terminals under transit rates. In effect, the farmers are able to store their grain at some distance from their farms without incurring any additional transportation costs.

Another important service offered by terminal elevators to country elevators is providing a market for wheat of different grades and varying protein content. Country elevators may have premiums, high-protein wheat, but, at the time they purchase the wheat from their farmers, millers may have adequate supplies of such wheat. Terminal elevators may nonetheless offer a premium for such wheat. They can do this by storing it for their own accounts until market conditions are more favorable. Terminal elevators may also provide markets for off-grade wheat. Since country elevators in wheat-processing areas often can not get grades at origin, they ship their wheat on a transit rate to inspection points. If the wheat is not of standard grade for export or milling markets, terminal elevators stand ready to buy this wheat. This can be done by blending the wheat with other wheat in store.

Terminal operators ship any purchased wheat to other export or domestic markets. Since these markets typically call for different types of grades and protein content, wheat exporters and millers will often rely on terminal operators to ship them the bulk of their needs. Although additional wheat can be purchased by exporters or millers directly from country elevators, terminal elevators are better suited to ship large quantities of wheat with a uniform quality.

Terminal elevators are often located on railroads with major wheat-originating capabilities, such as the Santa Fe, Union Pacific, and Burlington Northern. Terminal elevators are located in such places as Kansas City, Salina, Hutchinson, and Wichita, Kansas; Enid, Okalahoma; Fort Worth, Texas; and Minneapolis-St. Paul. Terminals in Minneapolis-St. Paul, Kansas City, and Chicago have the additional opportunity of delivering wheat in store against future contracts.

(e) Corn and Soybean Processors

As a general comment, processors seek to reduce their total transportation costs; total costs include inbound charges for delivery of corn and soybeans as well as outbound charges for shipment of processed products.

The key factor influencing the distribution systems is plant location. Plants either are located in major crop-producing areas, in which case processed products are distributed throughout the United States, or are located away from major crop-producing areas, in which case processed products are distributed in a regional area surrounding the plant.

The first corn and soybean processing plants were built in the major corn and soybean-producting states of Iowa, Illinois, and Indiana. With the exception of Mississippi, these states still have the largest number of wet corn milling and soybean processing plants (see Exhibit II-10 and II-11).

Originally, these plants were designed to receive the majority of their corn and soybeans by rail. Even though receipts typically came from nearby locations, rail transportation was attractive because of its transit privileges. Outbound shipments were made throughout the United States, predominantly by single car.

In recent years, several changes in this distribution system have taken place. First, additional soybean processing plants have been built in the South to serve the growing broiler market with meal and the increasing population with oil. The southern states of Mississippi, Arkansas, Tennessee, and North Carolina each have five or more soybean processing plants. Soybean processors locating plants in the South have increased their share of this market at the expense of midwestern processors for two reasons. They have been able to purchase locally grown soybeans for some of their needs. In addition, they have been able to reduce their overall transportation costs by shipping the processed products a shorter distance.

A new wet corn processing plant is also being built outside the cornbelt in California. One of the reasons for the construction of this plant is that shipments from midwestern plants to users in the West were as large as any inter-regional movement of wet corn milling products. (See Exhibit II-14 for 1977 rail flows of wet corn milling products.) As interregional shipments increase, processors find it cost effective to locate new plants near the consuming area even if it means transporting the corn by rail long distances.

This location of new plant capacity in the South and West have caused midwestern processors to concentrate more fully on export markets. As noted earlier, the trade and price-support policies of Western Europe have encouraged foreign feeders to use corn gluten feed and soybean meal produced in the United States

With the change in market, midwestern processors have made several changes in their distribution. First, corn gluten feed is being pelletized in order to ship it to overseas markets more easily. Second, processors have begun to ship more of their products to transloading facilities on the inland waterways. Muti-car, non-transit rail rates are used to ship the products from plants to terminals on the waterways. Barge transportation is used to move the products down to the Gulf. Third, processors have used floating rigs at the Gulf to transfer much of the soybean meal and corn gluten feed pellets to vessels. Floating rigs have been necessary to handle this business, because many grain companies have not had extra elevating capacity at the Gulf. Since soybean meal and corn gluten feed are uniform manufactured products, there has been no need to "blend" these products at Gulf export facilities.

(f) Feeders

The logistics systems of livestock feeding operations in the corn belt should be distinguished from those in the Southeast, Southwest, West, and Northwest. (See Exhibit II-6, II-7, II-8, and II-9 for the location of livestock feeding operations in the United States)

The feeding operations in the Midwest rely almost exclusively on truck delivery of grain and soybean meal. With the short haul of these shipments and ready access to farmer-stored grain, feeders in the Midwest have not had to make large investments in distribution.

Feeders in other locations have had to draw on corn, grain sorghum, or other feedgrains from outside regions to meet their needs. Multi-car shipments have been common in the Southwest, Southeast, and Northeast for a number of years. Such shipments have offered savings to rail carriers over single-car shipments and they have effectively competed with truck shipments in states such as Louisiana, Mississippi, and Arkansas. Railroads in the West began offering multi-car or volume discount rates in 1976 and these rates have virtually displaced single-car traffic. Feeders in the West have been willing to increase their storage and unloading facilities to handle the multi-car shipments.

(g) Millers

Just as in the case of corn and soybean processors, some wheat millers have decided to locate new mills closer to major consuming areas. The decision process in nearly identical to that of the processors. Millers are able to reduce overall transportation costs by using multi-car or, for a few mills on the Tennessee River, barge transportation for the delivery of wheat and truck or rail for the shipment of flour to local or regional areas.

It should also be noted that millers often rely on terminal elevators to provide them with an adequate supply of wheat that has been blended to certain specifications. This has allowed mills located outside the wheat producing areas to avoid the costly investment in large storage and blending facilities.

(h) Exporters

Over 100 million tons of grains, oilseeds, and grain products were exported from the United States in 1977. This figure is nearly double the estimate of United States agricultural exports for 1970.

Exporters have played a key role in the growth of United States agricultural exports. Their primary function is to originate the cheapest grain, oilseeds, or grain products in grain producing areas for the dearest sale in other parts of the world. Just as the sale of agricultural products is international in scope, the origination of these products is also international. The United States must compete with Australia, Canada, France, and Argentina for the sale of wheat to Japan, Korea, Brazil, and India.

For example, an international grain exporting firm may negotiate a wheat sale to China. This sale will specify the grade and protein content of the wheat, the delivery schedule, and the port(s) to which the wheat is to be shipped. The contract will also specify a delivered price. This price reflects the cost of shipping the wheat to the Chinese destination(s) from the cheapest source of acceptable wheat at the time of the sale. Thus, this particular sale may or may not be based on the export price of wheat at a United States port.

This process of buying and selling establishes the export prices of grain, oilseeds, and grain products at United States ports. Export prices at United States port vary over time and vary from coast to coast at any given time. Exhibit II-15 presents monthly export bids for high-protein, hard wheat. These bids are for the Gulf Coast, Duluth, and Pacific Northwest during 1977 and 1978.

As can be seen, the export bids at Gulf Coast elevators during the first two months of 1977 were 15 to 17 cents a bushel more than the same bids at Pacific Northwest elevators. These differences could be explained by a number of factors; a possible explanation is that customers who are best served from the Gulf ports, such as Brazil, were actively seeking high protein wheat.

In late 1977 and early 1978, the export bids for this same type of wheat at Pacific Northwest elevators exceeded Gulf Coast bids. A change in shipment of wheat from Brazil to a customer who is best served from the West Coast, such as China, is only one possible explanation. Another possible explanation is that there has been a change in the availability of vessels suitable for loading grain on the West Coast. Increased imports of such things as cars from Japan may have resulted in a change in the cost of shipping to Asian markets. Operators of these vessels may have been willing to have their vessels cleaned and loaded with grain rather than have them return empty to Asian ports.

Bids at Great Lake ports are less than the Gulf or Pacific Northwest, because of the cost of navigating the St. Lawrence Seaway.

Other factors that might explain differences in export prices for United States ports at any time include:

1. The size of the ship that the export elevator can accommodate.

2. The speed with which the ship can be cleaned and loaded.

3. The quantity of grain, oilseeds, and products available for shipment.

Exporters who originate grain, oilseeds, and products from the United States seek to design a logistics system that is responsive to changes in market demand. This system must be capable of supplying grain of acceptable grade for vessel shipment during a certain period of time.

Export elevators are designed to receive, blend, and ship large volumes of grain, oilseeds, and products. Gulf Coast elevators may have as little as 2 million bushels of storage space, yet some of the most efficient of these elevators may load as much as 18 to 20 million bushels a month.

Export elevators receive grain by rail, barge, and truck. The grain is dumped (in the case of trucks or hopper cars) into pits and then elevated into storage or a vessel being loaded at the elevator's dock. Some export facilities now have a loop track for the continuous unloading of a train. Barge-delivered grain is discharged by using clamshells and power shovels. The grain is shoved to the center of the barge and then lifted out with clamshells. The grain is then conveyed into storage or a vessel.

In order to "feed" an export elevator, grain exporting companies have made substantial investments in an inland distribution system that includes train-loading stations, barge-loading stations, and the equipment to keep these stations open. In recent years, a good example of this investment has been the construction of train-loading stations in Nebraska for the shipment of corn and grain sorghum to Pacific Coast ports.

The major grain exporters operate export elevators on the Great Lakes, Atlantic Coast, Pacific Coast, and Gulf Coast. The share of total grain exports that is obtained by any one port area reflects in part the cost of moving grain from the interior to the port. As the capacity of the least-cost port areas is reached (either in terms of the export elevator capacity or the interior distribution system), grain companies may rely more heavily on other port areas to meet unusually large sales commitments. For example, several shippers commented that the Great Lakes ports serve the role as a residual supplier of export elevating capacity.

If the increase in export sales activity is considered to be permanent, grain companies then must make long-term investment decisions as to where they will add capacity. Of course, any increase in elevator capacity at a particular port must be accompanied by an increase in capacity at appropriate interior points. Thus, consideration of the cost and capacity of barge, rail, and truck transportation to a particular port plays a key role in deciding where new investments in export elevating capacity will take place.

PRINCIPAL TRANSPORTATION FLOWS

This subsection is divided into two parts. The first part contains a disussion of each of the principal transportation flows of grain, soybeans, and products. In the second part, selected waterway flows are discussed in more detail.

(a) Transportation Flow by Individual Markets

In 1977 an estimated 53 million tons of grain, oilseeds, and products were shipped by barge. Another 4 million tons were shipped by lake and coastal vessels to domestic destinations in the United States rail shipments of farm products by Class I railroads totaled 121.9 million tons in 1977. No national summary of truck shipments are available for recent years.

Table II-12 presents the principal origin and destination pairs for rail, barge, and truck shipments of grain, oilseeds, and products. Crop-producing areas have been divided into five areas: the Midwest (this region corresponds to the corn belt); the Southwest (Louisiana, Texas, Oklahoma, Kansas, Nebraska, and Arkansas); the Southeast (Mississippi and Tennessee); the Upper Plains (North Dakota and Montana); and the Pacific Northwest (Washington and Idaho). The principal ports have been divided into seven areas. (See Appendix B for definition of regions for NWS.) Domestic destinations for livestock feeding, corn and soybean processing, and wheat milling operations are divided into five areas. Although reliable estimates of rail and truck traffic are not available for each of these origin and destination pairs, it is possible to discuss the principal transportation options available to domestic and export shippers. This discussion is presented by major destination.

Table II-12

Principal Rail, Barge and Truck Movements of Wheat, Corn, Soybeans and Processed Products

DESTINATIONS	Mid-west	South-west	South-east	Upper Plains	North-west
EXPORT					
Baton Rouge to Gulf	X	X		X	
Gulf Coast West	X	X			
Gulf Coast East/ South Atlantic	X		X		
Middle Atlantic/ North Atlantic	X		X		
Great Lakes/SLS	X			X	
Washington/Oregon		X		X	X
California		X		X	
DOMESTIC					
Midwest	X			X	
Southwest	X	X			
Southeast	X		X		
West		X		X	X
Northeast	X				

SOURCE: Exhibits II-1 through II-11; Shipper Interviews; and One Percent Waybill Sample of 1977 Interstate Rail Traffic.

1. Export Elevators at Baton Rouge to Gulf. Export elevators in this area receive grain, oilseeds, and products by barge, rail, and truck. Barge receipts typically average 50 to 70% of the total. Rail receipts are almost exclusively train-load shipments. Truck shipments account for no more 10 to 20% of receipts and are largely soybeans.

2. Export Elevators at Gulf Coast West. These export elevators receive wheat, corn, soybeans, and sorghum by rail and truck from country and terminal elevators in the Southwest. In addition, corn and soybeans are received by unit train from the Midwest. Truck receipts come from as far as Southern Kansas.

3. Export Elevators at Gulf Coast East and South Atlantic. These elevators receive soybeans by truck from country elevators in the Southeast. Corn and soybeans are shipped by unit train from the Midwest.

4. Export Elevators at Middle and North Atlantic Coasts. Export elevators on the Middle and North Atlantic Coasts receive corn, soybeans, and some wheat by unit train from the Midwest. Middle Atlantic elevators receive soybeans by truck from the Southeast as well.

5. Export Elevators on the Great Lakes and St. Lawrence Seaway. Terminals on the Great Lakes receive corn, soybeans, wheat, and some products by truck and rail from country elevators, train-loading stations and processors in the Midwest. Duluth-Superior elevators receive wheat by single-car from the Upper Plains; and some barge grain is delivered in Chicago terminals from points on the Illinois River. Since vessels are limited to a draft of 27 feet in the Great Lakes, there are elevators at the end of the St. Lawrence Seaway that top off ocean-going vessels before they leave for foreign destinations.

6. Export Elevators on the Washington/Oregon Coasts. These elevators receive wheat by barge, rail, and truck from origins in the Northwest. In addition, they receive corn, grain sorghum, and wheat from Nebraska by unit train or multiple-cars. Finally, wheat is shipped by rail from the Upper Plains.

7. Export Elevators in California. Export elevators in California receive corn and grain sorghum by unit-train from the Southwest. Some wheat is also shipped from California's Central Valley, Upper Plains, and Southwest to California ports.

8. Domestic Users in the Midwest. Grain, oilseeds, and products are shipped by either truck or rail to domestic users in the Midwest.

9. Domestic Users in the Southwest. Broiler-producers receive most of their corn by multi-car shipments from the Midwest and Southwest, although truck shipments of corn and grain sorghum provide competition to rail. Cattle producers rely primarily on truck delivery of grains from the Southwest. Millers and soybean processors receive wheat and soybeans by truck and rail. Outbound shipments are split between rail and truck.

10. Domestic Users in the Southeast. Domestic feeders in the Southeast receive corn in multi-car shipments from the Midwest. Truck shipments of locally grown corn are also received and some limited use of barge transportation is made by feeders located on the Upper Tennessee River. Millers receive wheat by rail and barge from the Southwest. Some wheat is also received by rail from the Midwest. Finally, soybean processors receive locally grown beans by truck as well as soybeans from the Midwest by rail.

11. Domestic Users in the West. Domestic users in the West receive grain and processed products from the Southwest by multi-car and unit-train. Users in the Pacific Northwest receive wheat and barley by rail and truck from country elevators in the Upper Plains and Northwest.

12. Domestic Users in Northeast. Feeders rely on multi-car shipments of corn from the Midwest. Corn processors receive corn from the Midwest by unit trains and some locally grown corn by truck. Millers receive wheat by truck, rail, and lake vessels from the Midwest.

(b) Principal
Waterborne Flows

The primary waterborne flows of grains, oilseeds, and products are discussed below. They include the:

- Illinois River.
- Upper Mississippi River.
- Ohio River.
- Other Rivers.
- Coastal and Great Lakes Ports.

1. Illinois River. Illinois River barge terminals originated 15 million tons of grains and oilseeds in 1977. Corn accounted for four fifths of the total with soybeans accounting for much of the remainder.

Total corn tonnage has risen sharply from the seven million tons shipped in 1969. Shipments to export elevators located on the Lower Mississippi from Baton Rouge and south grew from five million tons (72% of all corn loaded on the Illinois River) in 1969 to 11 million tons (94%) in 1977.

Declines in domestic market traffic accompanied this increase in export market tonnage. Illinois River terminals shipped over one million tons of corn to the Upper Tennnessee River in 1969 for distribution to the Southeast feed market, but the introduction of multiple-car rates and the replacement of boxcars with 100-ton covered hoppers increased the competitiveness of rail. Barge shipments from the Illinois River to the Southeast have fallen to 292,000 tons in 1977.

Barge loadings of soybeans on the Illinois River grew by over 50% from 1969 to 1970 but averaged only a 3.5% annual growth from 1970 to 1977. The percentage of Illinois River soybean loadings shipped to points around Baton Rouge and south has increased from 69% in 1969 to 89% in 1977. Shipments to processing plants in the Southeast and Southwest has declined as production of soybeans in these areas has increased.

2. Upper Mississippi River. Upper Mississippi barge terminals shipped 12 million tons of grains and oilseeds in 1977. Corn shipments accounted for over half of total shipments with the balance being split evenly between wheat and soybeans.

Shipments of corn rose sharply in 1972 and again in 1973 to a peak of 9.7 million tons and then declined unevenly through 1977. This uneven pattern is due in part to differences between shipments from Minnesota, on the one hand, and shipments from Iowa and Illinois, on the other hand. During the strong export markets of 1973 and 1974, Minnesota terminals shipped 4.4 and 4 million tons of corn, respectively. This represented nearly a doubling of prior year shipments. The higher prices made possible by increased export sales and a poor 1974 crop induced Minnesota farmers to ship more corn to export markets at the expense of local feed markets. Since 1974, shipments from Minnesota terminals have declined to just over two million tons. In contrast to Minnesota terminals, Iowa and Illinois loadings of corn on the Upper Mississippi have increased steadily from 1.9 million tons in 1969 to 4.6 million tons in 1977.

Soybean shipments on the Upper Mississippi doubled from 1969 to 1970, but during the next seven years, shipments fluctuated between 2 and 2.9 million tons.

Wheat shipments on the Upper Mississippi have grown from one million tons in 1969 to 2.3 million tons in 1977. Over three quarters of the wheat shipped in 1977 was sent to Baton Rouge and points south. The remainder was shipped to Lower Upper Mississippi (primarily St. Louis) and Tennessee River (primarily Chattanooga) ports.

3. Ohio River. Corn, wheat, and soybean originations on the Ohio River grew from 729,000 tons in 1969 to 4.3 million tons in 1977. Corn accounted for almost two-thirds of total shipments in 1977.

Corn shipments on the Ohio River have grown from 254,000 tons in 1969 to 2.8 million tons in 1977. Over 90% of Ohio River corn is shipped to Lower Mississippi ports for export.

Operating problems on the Illinois River have been a major factor contributing to the growth of Ohio River corn traffic. From 1969 to 1976, Illinois River corn traffic was heaviest during the first quarter when ice closed the Upper Mississippi and a large number of barges were transferred to the Illinois. (The first quarter is also a good time for farmers to sell grain for tax purposes.) However, during the winters of 1977-1979, ice and high water hindered Illinois River operations. In contrast, the Lower Ohio River remained open and record first quarter shipments were made from Ohio River terminals. From 439,000 tons in the first quarter of 1976, Ohio River corn shipments grew to 1.8 million tons for the first quarter of 1979.

Soybean shipments have increased from 395,000 tons in 1959 to 884,000 tons in 1977. Wheat shipments have also increased, growing from 80,000 tons in 1969 to 476,000 tons in 1977.

4. Other Rivers. Wheat shipments on the Columbia-Snake Waterway have increased from 1.0 million tons in 1969 to 3.4 million tons in 1977. This growth was aided by the completion of projects on the Snake River. These projects have made the river navigable as far as Lewiston, Idaho. In addition, rail car shortages have encouraged truck shipments to the Waterway.

Shallow channels and strong current make it necessary to light-load barges and operate smaller tows on the Missouri River. As a result, this has limited the growth of grain traffic. From 1969 to 1977, tonnage grew from 693,000 to 1.2 million tons. Wheat accounted for three-fourths of this traffic in 1977. Just under half the wheat is shipped to mills located on the Tennessee River. The remainder of the wheat is shipped to Lower Mississippi ports for export.

Grain and oilseed shipments from Lower Upper Mississippi terminals grew from 1.3 to 3 million tons between 1969 and 1977. 1977 shipments were equally divided among corn, soybeans, and wheat.

Grain shipments to points on the the Tennessee River fell between 1969 and 1977 as a result of increases in local grain production and stronger rail competition. Whereas wheat shipments were fairly steady, corn and soybean shipments declined sharply from 1.8 million tons in 1969 to 645,000 tons in 1977.

5. Coastal and Great Lakes Ports. As noted earlier, over 100 million tons of grain, oilseeds, and products were exported from coastal and Great Lakes ports in 1977. Table II-13 presents estimates of 1974-1979 export shipments of grain and oilseeds for the Great Lakes, Atlantic, Gulf, and Pacific ports.

Since 1974, there has been a modest increase in the share of exports by Great Lakes and Pacific ports. The Gulf Coast share declined both in 1978 and 1979, however, with the exception of 1977, there have been continual increases in tonnage. The Atlantic Coast share has remained virtually constant throughout this period.

Table II-13

Port Share of Grain and Oilseed Exports 1/

	1974	1975	1976	1977	1978	1979
Great Lakes	9%	10%	9%	11%	13%	11%
Atlantic Coast	13	14	15	14	12	13
Gulf Coast	65	65	65	66	63	61
Pacific Coast	13	11	11	9	12	15
TOTAL	100%	100%	100%	100%	100%	100%

NOTE: 1/ Includes wheat, corn, soybeans, oats, sorghum, barley, and rye.

SOURCE: USDA, Grain Market News, 1974-1979.

The increase in Pacific Coast activity is due in large part to increased corn shipments. Both the Union Pacific and Burlington Northern have established unit-train rates from Nebraska origins to Pacific ports and shippers have responded by upgrading existing facilities to load trains, constructing new facilities, and acquiring more hopper cars. Pacific ports are also favored by shorter vessel-transit times to growing feed-grain markets in Asia and higher Panama Canal tolls.

FACTORS INFLUENCING FLOWS IN THE FUTURE

There are two key factors that may influence the grain industry and change the nature and amount of waterborne grain flows in the future. These factors are:

1. Waterway capacity on the Illinois and Upper Mississippi Rivers,

2. Rail deregulation.

Each of these factors is discussed, below.

(a) Waterway Capacity on the Illinois and Upper Mississippi Rivers

Although shipper constraints to use of the waterways are the subject of Section X, a discussion of the factors affecting future grain flows cannot be complete without at least mentioning this subject.

Gulf ports accounted for an estimated 66% of total grain and oilseed exports in 1977. Barge deliveries to Gulf ports were estimated by USDA to be 57% of this total in 1977. The predominant grain-originating waterways are the Upper Mississippi and Illinois Rivers.

In the past, grain exporters have looked to barge transportation for providing a reliable, low cost means of moving grain from Iowa, Illinois, Minnesota, and Wisconsin to the Gulf. As Lock and Dam 26 has reached its practical capacity and objections have been raised to construction of a replacement lock, grain companies have incurred higher real costs of transportation and, more importantly, have determined that waterway transportation from these rivers may simply not be available at any reasonable cost in the future.

Although grain companies have few options in the short run to deal with transportation bottlenecks, there are options available in the long run. In particular, grain companies can rely on rail transportation for shipment to the Pacific, Atlantic, and Gulf Coasts. In addition, they can rely more heavily on the Great Lakes than they have done in the past to supply needed capacity. Such changes in the export of grain require companies to make long-term investments in both export elevators and "feeder" stations in the interior. These investments are costly and can be expected to alter the nature of grain flows for a significant period of time.

Whereas recognizing that such investments may be necessary, grain companies note that farmers in Minnesota, Iowa, Illinois, and Wisconsin may ultimately pay the higher costs associated with this change in grain distribution. These farmers may well pay for these higher costs by having to accept a lower export bid for their grain. In some areas, this may mean that farmers will be encouraged to "feed" their crops to livestock on-farm.

(b) Rail Deregulation

Grain waterborne flows are likely to be affected by changes in the rail industry over the next ten years. Partial or complete deregulation of rail carriers may be expected to change the rail industry and how it competes with water carriers for grain. In contrast to truck and water carriers, rail carriers have been subject to both rate regulation and entry or exit restrictions.

Some form of rail deregulation is expected in the future, but informed sources at the Interstate Commerce Commission (ICC) and in industry differ among themselves as to the exact form that this deregulation might take. Possible components of rail deregulation might include.

1. Complete deregulation of rail rates for rail tonnage that is truck competitive (Grain processors and some millers argue that this has in effect taken place already. The continual shortage of rail cars for short-haul, inbound shipments of grain and oilseeds to midwestern processing and some milling plants has forced them to rely more heavily on truck transportation.)

2. Limited rate regulation that allows carriers to raise rates (within a zone of reasonableness) with provisions for only limited shipper protection.

3. Increased rate-making flexibility for traffic that is subject to periodic demand variation (The Southern Freight Association has taken advantage of provisions under the 4-R Act to apply a 20% surcharge on multi-car traffic moving from midwestern origins to destinations in the southeast. This seasonal rate increase applied to domestic feed grain and soybean traffic only. Since the demand for rail transporation by southeastern feeders was strong in the fall of 1977 and winter of 1978, the initial impact of the seasonal rate increase was to increase rail revenues. In the long run, there may be some diversion of rail traffic to truck or barge.

4. Establishment of negotiated contract rates subject to little regulation provided that these rates are made available to other shippers in similar circumstances.

5. More timely and favorable review of carrier proposals to abandon lines (The final report of the Rural Transportation Advisory Task Force, entitled Agricultural Transportation Services: Needs, Problems, Opportunities, noted that, in the opinion of many country elevators, numerous branchlines have effectively been abandoned for years. With infrequent and unreliable switching service and a continual shortage of cars that are suitable for loading, some carriers have effectively abandoned lines and side-stepped legal niceties regarding abandonment proceedings.)

6. More timely and favorable review of proposals for selected railroad mergers.

Several implications of rail deregulation for water-borne grain, oilseed, and product traffic can be made. First, as rail rates are increased to pay for improved mainline track, more power, and more rolling stock, some diversion of grain traffic to water and truck carriers can be expected in the short term. Such diversion is only possible if shippers have alternatives to rail service.

Truck transportation is an alternative to rail for short-haul shipments of 50 to 200 miles. Water transportation is an alternative to rail for some major grain flows, provided that there is a adequate waterway capacity for the relevant waterway segments. Of the principal movements of grain, oilseeds, and products listed in Table II-12, the following origin/destination pairs have a water transportation alternative:

Origins	Destinations
1. Midwest	Baton Rouge to Gulf for export (Water transportation is currently limited by Lock and Dam 26. Some diversion to Lower Upper Mississippi, Ohio River, or Great Lakes is feasible.)
2. Upper Plains	Baton Rouge to Gulf for export (Water transportation is currently limited by Lock and Dam 26. Some diversion to Great Lakes is feasible.)
3. Midwest	Middle Atlantic/North Atlantic for export (Diversion to a Great Lakes/SLS move is feasible)
4. Upper Plains	Washington/Oregon for export (Diversion to the Columbia-Snake Waterway is feasible, provided adequate feeder service is available by truck)
5. Northwest	Washington/Oregon for export (Diversion to the Columbia-Snake Waterway)
6. Midwest	Southeast for Domestic Use (Lock & Dam 26 limits wheat from Upper Plains and Corn from Midwest. Some diversion of wheat to the Missouri River for barge shipment to domestic millers located on the Tennessee River is feasible. Some diversion of corn to Ohio River for barge shipment to feeders near the Tennessee River is feasible.)

On the basis of this analysis, some diversion to the Lower Upper Mississippi, Ohio River, Great Lakes, Columbia-Snake, and Missouri River might be expected in the short-term if rail carriers were to increase rates significantly.

In the long-term, such rate increase might improve the financial position of rail carriers and permit them to invest additional resources to handle grain traffic. As a result, some loss of grain traffic from truck and, especially, water carriers can be expected.

The high-volume, long-haul barge shipments of grain, oilseeds, and products from the Midwest to Gulf ports are especially attractive business for rail carriers. In seeking to handle this bussiness, barge carriers face significant competition from train-loading stations at the present time. (It should be noted that this competition is not only limited to carriers that serve the Gulf; train shipments to the Atlantic and Pacific Coasts are also competing for export business.)

With financially stronger rail carriers, the competition could be expected to be more severe. Furthermore, if rail carriers can effectively use contract rates to market their services, grain shippers that would normally use the Upper Mississippi (and Illinois) River during open navigation season may be induced to ship grain by unit-train for the entire 12 months of any given year.

Shippers in Minnesota, Iowa, and Illinois view contract rates quite favorably due in part to the attractive margin that can be earned by operating unit trains during the close of navigation on the Upper Mississippi River. The increased distribution costs associated with storing grain three to four months during close of navigation on the Great Lakes and the Upper Mississippi also make negotiated contract rates attractive to grain shippers.

EXHIBIT II-1

U.S. WHEAT PRODUCTION BY STATE 1/
(1976-78 Three-Year Average 2/)

	Millions of Bushels	Percent of U.S. Total
Kansas	330	17%
North Dakota	268	13
Oklahoma	158	8
Montana	148	7
Washington	126	6
Minnesota	119	6
Nebraska	93	5
Texas	92	5
Idaho	65	3
Ohio	60	3
Other States	533	27
United States TOTAL	1,992	100%

NOTE: 1/ Preliminary data for 1978.

NOTE: 2/ Year begins June 1.

SOURCE: USDA, Crop Production, 1976-1978.

EXHIBIT II-2

U.S. CORN PRODUCTION BY STATE 1/
(1976-78 Three-Year Average 2/)

	Millions of Bushels	Percent of U.S. Total
Iowa	1,243	19%
Illinois	1,198	18
Indiana	654	10
Nebraska	635	10
Minnesota	525	8
Ohio	384	6
Wisconsin	237	4
Missouri	189	3
Michigan	178	3
Texas	164	2
Other States	1,184	17
United States TOTAL	6,591	100%

NOTE: 1/ Preliminary data for 1978.

NOTE: 2/ Year begins October 1.

SOURCE: USDA, Crop Production, 1976-1978.

EXHIBIT II-3

U.S. SOYBEAN PRODUCTION BY STATE 1/
(1976-78 Three-Year Average 2/)

	Millions of Bushels	Percent of U.S. Total
Illinois	296	18%
Iowa	246	15
Indiana	132	8
Missouri	129	8
Minnesota	114	7
Ohio	113	7
Arkansas	100	6
Mississippi	77	5
Louisiana	66	4
Tennessee	50	3
Other States	308	19
United States Total	1,631	100%

NOTE: 1/ Preliminary data for 1978.

NOTE: 2/ Year begins September 1.

SOURCE: USDA, Crop Production, 1976-1978.

EXHIBIT II-4

U.S. DOMESTIC PRODUCTION OF FACTS AND OILS IN 1977 1/

Category	Million Pounds	Percent of Total
Soybean Oil	10,291	66%
Cottonseed Oil	1,453	9
Butter	1,040	7
Lard	999	6
Edible Tallow	795	5
Corn Oil	695	4
Other Fats and Oils	436	3
TOTAL	15,709	100%

NOTE: 1/ Excludes oil equivalent of United States exports to foreign processors. Year begins October 1.

SOURCE: USDA, Fats and Oils Situation, FOS-294.

EXHIBIT II-5

WHEAT FLOUR MILLING CAPACITY BY STATE 1/

State	Active Capacity in Thousands of Cost	Percent of U.S. Total
Kansas	120	11%
Minnesota	119	11
New York	114	10
Missouri	82	7
Ohio	70	6
Illinois	60	5
California	47	4
Tennessee	39	4
Pennsylvania	34	3
Oklahoma	31	3
Other States	379	35
United States TOTAL	1,092	100%

NOTE: 1/ Includes soft wheat, whole wheat, and durum wheat flour.

SOURCE: Millings Baking News, Milling Directory/Buyer's Guide, 1978.

EXHIBIT II-6

U.S. BROILER PRODUCTION IN 1977

	Millions of Birds	Percent of Total
Arkansas	570	17%
Georgia	486	14
Alabama	428	13
North Carolina	339	10
Mississippi	256	8
Maryland	199	6
Texas	185	5
Delaware	156	5
California	113	3
Virginia	98	3
Other States	570	17
United States TOTAL	3,400	100%

SOURCE: USDA, Agricultural Statistics, 1979.

EXHIBIT II-7

CATTLE AND CALVES OF FEED
(As of January 1, 1978

	Thousands of Heads	Percent of Total
Texas	1,850	14%
Nebraska	1,700	13
Iowa	1,690	13
Kansas	1,400	10
Colorado	1,020	8
California	845	6
Illinois	650	5
Arizona	422	3
Minnesota	400	3
South Dakota	365	3
Other States	3,108	23
United States TOTAL	13,450	100%

SOURCE: USDA, Argicultural Statistics, 1979.

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EXHIBIT II-8

NUMBER OF MILK COWS FOR 1977

	Thousands of Heads	Percent of Total
Wisconsin	1,802	16%
New York	914	8
Minnesota	866	8
California	827	8
Pennsylvania	703	6
Michigan	403	4
Ohio	400	4
Iowa	386	4
Texas	315	3
Missouri	298	3
Other States	4,070	37
United States TOTAL	10,984	100%

SOURCE: USDA, Agricultural Statistics, 1979.

EXHIBIT II-9

PIG CROP FOR 1977

	Thousands of Pigs	Percent of Total
Iowa	21,339	25%
Illinois	9,430	11
Missouri	6,531	8
Minnesota	6,498	8
Indiana	5,587	6
Nebraska	4,970	6
Kansas	3,176	4
North Carolina	3,175	4
South Dakota	2,744	3
Wisconsin	2,730	3
Other States	20,011	23
United States TOTAL	86,191	100%

SOURCE: USDA, Agricultural Statistics, 1979.

EXHIBIT II-10

NUMBER OF WET CORN PROCESSING PLANTS BY STATE

	Number
Iowa	5
Indiana	4
Illinois	3
Texas	2
Missouri	1
Ohio	1
Pennsylvania	1
Tennessee	1
TOTAL	18

SOURCE: Milling & Baking News, Milling Director/Buyer's Guide, 1978.

EXHIBIT II-11

NUMBER OF SOYBEAN PROCESSING PLANTS 1/

	Number
Iowa	15
Indiana	14
Mississippi	13
Arkansas	7
Indiana	6
Tennessee	6
Minnesota	5
North Carolina	5

NOTE: 1/ There are another 15 states with one to four soybean processing plants.

SOURCE: American Soybean Association, Soybean Digest Blue Book, June 1977.

EXHIBIT II-12

GULF CORN BIDS AND RIVER BIDS
AT HENNEDIN, ILLINOIS (1)
(cents per Bushel)

	1977	1978
January	26.0	28.8
February	20.8	31.8
March	18.5	37.5
April	18.0	51.8
May	14.5	38.5
June	13.5	29.3
July	17.5	20.8
August	23.0	22.8
September	20.0	25.0
October	21.0	34.3
November	19.5	23.8
December	21.0	53.0

NOTE: 1/ End-of-month bids have been used in this analysis.

SOURCE: Interviews.

EXHIBIT II-13

100-CAR TRAIN EXPORT RATES TO EAST COAST PORTS 1/
(Dollars per Ton)

		From East Pearia, Ill.	From Kokoma, Ind.	From Columbus, Oh.
5 trip -	Railroad Equipment	11.97 1/2	11.36 1/2	10.43
	Shipper Equipment	10.37 1/2	9.78 1/2	8.83
20 trip -	Railroad Equipment	11.57	11.00	10.00 1/2
	Shipper Equipment	10.00	9.42 1/2	8.50 1/2
30 trip -	Railroad Equipment	11.24 1/2	10.72	9.79 1/2
	Shipper Equipment	9.67 1/2	9.13	8.20
40 trip -	Railroad Equipment	11.00	10.47 1/2	9.61
	Shipper Equipment	9.42	8.88	8.00 1/2
45 trip -	Railroad Equipment	10.82	10.34 1/2	9.45
	Shipper Equipment	9.24	8.75	7.88 1/2

NOTE: 1/ Rates as of September 1979 and subject to 3.5% surcharge. Rates apply to Albany, Philadelphia, Baltimore, and Norfolk.

SOURCE: Tariff TEA 4043.

EXHIBIT II-14

UNEXPANDED ONE PERCENT WAYBILL SAMPLE --
WET CORN MILL PRODUCTS SHIPMENTS FOR 1977

(Tons)

Origin Territory	Destination Territory					
	Official	Southern	Western Trunk Line	Southwest	Transcontinental	Total
Official	11,896	3,494	--	235	483	16,108
Southern	284	534	--	111	288	1,217
Western Trunk Line	3,533	987	5,024	2,118	4,060	15,722
Southwest	--	155	131	1,083	680	2,049
Transcontinental	--	--	--	--	--	--

SOURCE: One Percent Waybill Sample for 1977.

EXHIBIT II-15

EXPORT BIDS FOR NO. 1 HEAVY NORTHERN SPRING WHEAT, 14% PROTEIN
(Cents Per Bushel)

	1977			1978		
	Gulf	Duluth	Pac. NW	Gulf	Duluth	Pac. NW
January	364	--	347	349	--	360
February	375	--	360	344	--	353
March	--	--	350	371	--	372
April	--	303	353	360	321	382
May	--	275	331	377	336	395
June	--	265	318	--	315	379
July	--	249	310	336	312	371
August	--	259	315	353	327	384
September	--	287	327	361	333	398
October	--	294	334	389	359	403
November	--	--	344	394	346	--
December	350	--	356	398	326	405

SOURCE: USDA, Grain Market News, 1977-1978.

III - FERTILIZER

This industry is comprised of producers and distributors of phosphate rock and phosphatic fertilizers, such as superphosphates; nitrogenous fertilizers, such as anhydrous ammonia, aqua ammonia, urea, ammonium nitrate fertilizer, ammonium sulfate, and nitrogen solutions; potassic fertilizers; and mixed fertilizers.

Approximately 24 million tons of phosphate rock, two million tons of phosphatic chemical fertilizers, five million tons of nitrogencus chemical fertilizers, two million tons of potassic chemical fertilizers, and nine million tons of mixed fertilizers moved on the nation's waterways in 1977. Fertilizer shippers use water transportation for both foreign trade and domestic distribution. The principal domestic flows are coastal and inland shipments. Water shipments offer fertilizer shippers an alternative to rail transportation, thus adequate waterway capacity is of concern to them.

This section is divided into the following subsections:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.
- Description of Logistics System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

COMMODITY CHARACTERISTICS

A fertilizer is any material, organic or inorganic, natural or synthetic, that furnishes plants one or more of the chemical elements necessary for normal growth. The list of elements recognized as being necessary for plant growth has increased over the years and now totals 16. Table III-1 shows the elements essential for plant growth.

Table III-1

Elements Essential for Plant Growth

1. Primary Nutrients	a. Phosphorous b. Potassium c. Nitrogen
2. Secondary Nutrients	a. Calcium b. Magnesium c. Sulfur
3. Other Macronutrients	a. Carbon b. Hydrogen c. Oxygen
4. Micronutrients	a. Boron b. Chlorine c. Copper d. Iron e. Manganese f. Molybdenum g. Zinc

SOURCE: United Nations, Food and Agricultural Organization Yearbook, 1972

The first nine elements in Table III-1 are required in relatively large amounts and are called macronutrients. Of these, carbon, hydrogen and oxygen are supplied by air and water, and are, therefore, not dealt with as nutrients by the fertilizer industry. The other macronutrients are subdivided into primary elements and secondary elements. The remaining seven elements are required in much smaller amounts and are known as micronutrients or trace elements. It is the primary elements of phosphorous (for root development, seed formation and development, and a component of protein), nigrogen (for plant growth, photosynthesis, and formation of protein building blocks), and potassium (for stalk strength and a catalyst for plant metabolism) that form the basis of the fertilizer industry.

(a) Phosphate Products

Phosphate rock contains one or more phosphate minerals, mainly calcium phosphate. Phosphate rock supplies almost all the phosphorous used in fertilizers. Production of phosphate rock is highly concentrated in the Bone Valley of Florida, an area approximately 30 miles east of Tampa. In recent years, Florida has produced over 80% of the total United States production. The percent of 1977 production by state was as follows: Florida and North Carolina 86%; Idaho, Alabama, Montana, and Utah 10%; and Tennessee four percent. Exhibit III-1 shows where the primary phosphate reserves in the United States are located.

Major raw materials for the production of phosphate are phosphate rock and sulfuric acid (sulfur and sulfuric acid are discussed in Section VII). The phosphate rock is processed into phosphoric acid from which several fertilizers are produced. The traditional and dominant method of making phosphoric acid is the wet process, whereby phosphate rock is treated with sulfuric acid. The furnace method calls for elemental phosphorous (produced from phosphate rock in electric furnaces) to be burned into phosphorous pentoxide, which is hydrated into the phosphoric acid. The phosphate fertilizers include: anhydrous superphosphate, triple superphosphate, enriched superphosphate, and ordinary superphosphate. Although, the phosphorous supplied by superphosphates has increased sharply, the substitution of concentrated (i.e., anhydrous and triple superphosphate) for ordinary superphosphates has meant that the tons of superphosphate material shipped have decreased in recent years.

Mixtures, such as diammonium phosphate, that contain nitrogen and phosphate nutrients are popular alternatives to superphosphates as a source of phosphorous.

(b) Nitrogen Products

Nitrogen is an essential component of most fertilizers. Although, an adequate supply of this material is available in the atmosphere, it must be converted into a fixed form for plant use. Synthetic anhydrous ammonia (NH_3) is the basis for almost all nitrogenous fertilizers materials. Approximately 95% of this NH_3 was produced by combining hydrogen from natural gas with atmospheric nitrogen. Prior to 1945, coal or coke was the major raw material used for the production of hydrogen required for ammonia systhesis. Since then, most plants have been designed for the use of natural gas, heavy oil, or naphtha as feedstocks.

Ammonia can be applied directly to the soil or used in the manufacture of other nitrogenous fertilizers. Table III-2 presents the characteristics of major nitrogenous fertilizers.

Figure III-A shows the amount of nitrogen nutrients applied by major fertilizer type from 1960 to 1978. (Ammoniated phosphates are also manufactured with ammonia but they are not included in Figure III-A.)

Table III-2

Characteristics of Major Nitrogenous Fertilizers

Product	Chemical composition	Physical form	Major inputs	Approximate percentage of nitrogen
				Percent
Anhydrous ammonia............	NH_3	Gas	Natural gas, air	82.0
Urea.................	CO(NH2)2	Solid	Anhydrous ammonia, carbon dioxide	46.0
Ammonium nitrate............	NH4NO3	Solid	Anhydrous ammonia, nitric acid	33.5
Nitrogen solutions..........	Mixture	Liquid	Anhydrous ammonia, urea, ammonium nitrate, water	29.0
Ammonium sulfate, synthetic..........	(NH4)2SO4	Solid	Anhydrous ammonia, sulfuric acid	21.0

SOURCE: USDA, The Changing U.S. Fertilizer Industry, 1977.

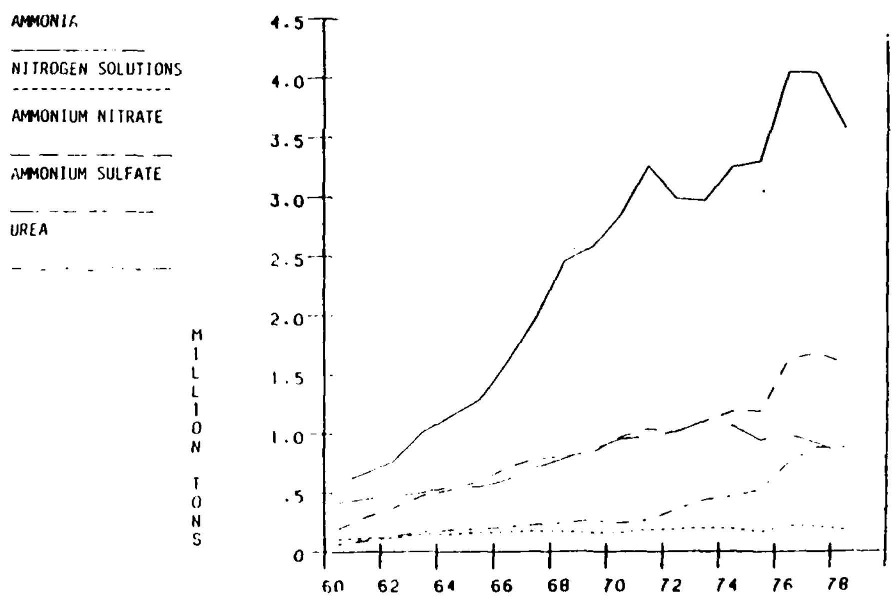
Ammonia is by far the highest analysis nitrogen fertilizer, containing 82% nitrogen by weight. Because of its high analysis, it offers savings in transportation and application costs, although some of these savings are offset by the need for refrigerated or pressurized tanks for transportation and storage. Ammonia can be applied directly to the soil with equipment that inserts the gas several inches into the ground.

The growth in the direct application of ammonia from 580,000 tons in 1960 to 4.4 million tons in 1978 (see Figure III-A) is the major reason for the increase in average analysis of total fertilizer materials consumed during this period.

Urea, ammonium nitrate, and ammonium sulfate are solids and can be applied directly to the soil with spreaders. Urea has the highest percentage of nitrogen by weight of these three products and the amount of nitrogen supplied by urea grew an estimated 33% a year from 1970 to 1978 (see Figure III-A).

Figure III-A

United States Consumption of Nitrogen Nutrients by Fertilizer Type 1/



1/ Excludes mixtures such as ammoniated phosphates.

SOURCE: USDA, Commercial Fertilizers, 1970-1978.

In contrast, nitrogen shipped by solid ammonium nitrate fell from a peak of 1.1 millions tons in 1973 to 820,000 tons in 1978. Ammonium nitrate has several disadvantages relative to urea. Its relatively low analysis, susceptibility to caking, and tendency to decompose and become explosive have all contributed to the decline in the popularity of ammonium nitrate. The amount of nitrogen supplied by ammonium sulfate has remained relatively constant. (see Figure III-A).

Nitrogen solutions are mixtures of water and any of the other four nitrogen fertilizers. Nitrogen solutions containing ammonia require pressurized storage, whereas solutions containing only urea and ammonium nitrate do not. Nitrogen solutions have been increasingly popular with farmers, because there are no dust or caking problems associated with the solid fertilizers. The solution can be easily mixed with herbicides and insecticides, and, since they are applied on top of the soil, it is not necessary to cut or knife the soil in the way that ammonia is applied.

Although the demand for fertilizer is generally expressed in terms of tons of nutrient (as in Figure III-A), this is not useful for transportation analysis. A more useful presentation for transportation purposes is the number of tons ot fertilizer material consumed. Table III-3 presents 1978 estimates of nitrogen fertilizer consumption by product.

Table III-3

Nitrogen Fertilizer Consumed in the U.S. for Year Ended June 30, 1978

Product	Millions of Tons
Anhydrous Ammonia	4.5
Urea	1.9
Ammonium Nitrate	2.4
Nitrogen Solutions	5.5
Ammonium Sulfate	0.9
Other	1.3
TOTAL	16.5

SOURCE: USDA, Commercial Fertilizers, November 1978.

As can be seen, nitrogen solutions were the single largest type of nitrogen fertilizer consumed for the year ended June 30, 1978. Even though ammonia supplies the most nutrient (see Figure III-A), it was only the second largest type of fertilizer consumed in the United States

Figure III-B presents the consumption of nitrogen fertilizers in the United States from 1960 to 1978. As can be seen, ammonia and nitrogen solutions have been the fastest growing fertilizers and, in recent years, the use of urea has increased sharply.

(c) Potassium Products

Potash (K_2O) supplies almost all the potassium used in the United States. United States production of potash is centered in eastern New Mexico, where over 80% of United States production has been mined in recent years. Potash is also mined in Utah and California. Canada supplies much of the United States potash needs from its reserves in Saskatchewan. Potassium fertilizers can be applied directly to the soil or mixed with other fertilizers.

MARKETS

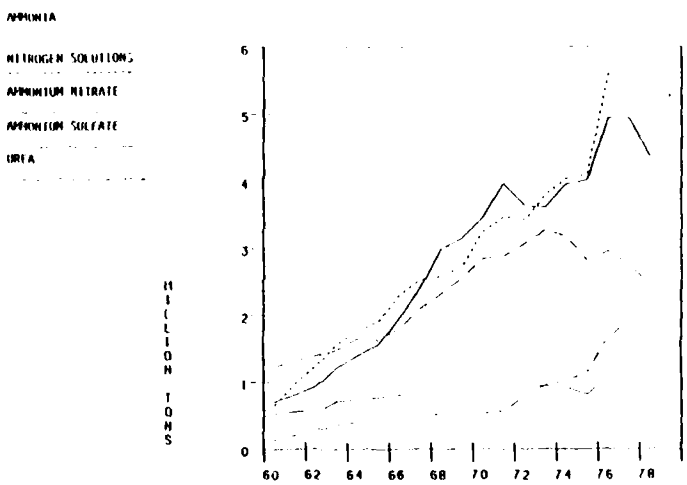
This subsection is divided into four parts. The first part is a discussion of general topics regarding fertilizer use. The remaining three parts discuss issues of interest for each major nutrient.

(a) General

During the 1960's, the United States consumption of fertilizer grew at a steady rate. Nitrogen consumption grew at an average annual rate of 10.5%, while the rate for phosphate and potash fertilizers were 6.0 and 6.5%, respectively. (See Figure III-C for a presentation of nutrient consumption from 1960 to 1978.) During the 1970's, this consumption pattern changed. First, the average annual increase in fertilizer consumption dropped substantially. Nitrogen and potash use increased only 5.5% annually. Phosphate use increased only three percent. Second, the increases have been eratic, with one or more years seeing a decreased use in each of the major fertilizers.

Figure III-B

U.S. Consumption of Nitrogen Products[1]

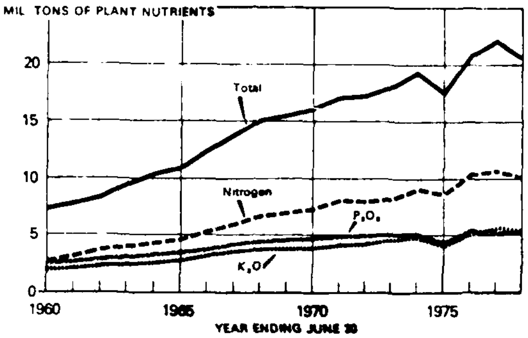


1 Excludes mixtures such as ammoniated phosphates.

SOURCE: USDA, Commercial Fertilizers, 1970-1978.

Figure III-C

Plant Nutrient Consumption



SOURCE: USDA Commercial Fertilizers, Nov. 1978.

Exhibit III-2 presents fertilizers use by major crop for 1965 and 1977. The four major crops for which fertilizer is used are corn, wheat, soybeans, and cotton. These four crops accounted for 56, 58, and 57% of nitrogen, phosphate, and potash use in 1977 respectively. Other crops and uses of fertilizer account for the remainder of fertilizer consumption. These other uses include fertilizers used on hay and pastures, fruits and vegetables, all other field crops, forestry and home gardens and lawns.

Corn is the crop accounting for the largest single use of fertilizers. Almost all corn harvested for grain receives nitrogen, phosphate, and potash fertilizers. In 1977, approximately 96, 88, and 82% of corn harvested for grain received nitrogen, phosphate, and potash fertilizers. Application rates of fertilizer for corn vary from one state to another and have increased dramatically from 1965 levels. Exhibit III-3 presents application rates in 1965 and 1977 for the four major crops. In 1977, an estimated 128, 68, and 82 pounds of nitrogen, phosphate, and potash fertilizer were applied to each acre of corn receiving at least some fertilizer.

Wheat is the crop accounting for the second largest use of fertilizer. However, less than one-fourth as much fertilizer is used on wheat as on corn. Not only has a smaller percentage of the wheat crop been fertilized in the past, but also the application rates for wheat have been substantially lower than those for corn.

Since soybean plants fix nitrogen from the atmosphere, little nitrogen fertilizer has been applied in the past. The fertilizer application rates for phosphate and potash have increased since 1965 (see Exhibit III-3), but remain below those for corn.

Fertilizer use for cotton has actually declined since 1965 (see Exhibit III-2). John Douglas of the Tennessee Valley Authority has noted in an article, entitled Musings on the U.S. Fertilizer Industry, 1990 that the geographic location of cotton has changed so rapidly from areas which need fertilizers to areas where less or no fertilizer is needed. As a result, fertilizer use for cotton in 1977 was actually lower than it was in 1965.

The farmer demand for fertilizers depends on a number of factors, including local soil conditions, prices, and availability. Availability is a key factor, because the demand for fertilizers is highly seasonal. Fertilizer application in the spring generally takes place over a two to four week period, and the timing varies from year-to-year according to the weather. Shippers estimated that as much as 40% of anhydrous ammonia production may be shipped in April and May. Fertilizer companies have encouraged fall application by offering price discounts. For example, solid nitrogen fertilizers can be applied at the time of fall plowing with little risk of leaching during the winter. Despite such inducements, spring and early summer remain the prime consumption periods.

Before discussing the market for each of the three major fertilizers, it should also be noted that these fertilizers can be either applied directly as is or mixed before application. In recent years, nearly equal amounts of mixed fertilizer and direct application fertilizer have been used. Fertilizer companies have developed granular solid fertilizers for easier blending.

(b) Phosphate Products

As noted earlier, United States production of phosphate rock is concentrated in Florida. United States production and consumptior figures for 1977 are presented in Table III-4.

Table III-4

U.S. Phosphate Rock Production and Use for 1977
(Millions of Metric Tons)

Beginning Stocks	13.8
Production	47.3
Imports	0.2
TOTAL SUPPLY	61.3
Consumption	34.4
Exports	13.2
TOTAL USE	47.6
Ending Stocks	13.7

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

As can be seen, the United States was a net exporter of phosphate rock. Exports accounted for approximately 28% of 1977 production.

Exhibit III-4 presents statistics on phosphate rock production and reserves for selected countries. Whereas the United States accounted for over 40% of the estimated world production in 1977, the United States share of world reserves was less than seven percent. Morocco and other countries in the Sahara region, as well as central economy countries, were major producers of phosphate rock and have extensive reserves.

Some geogolists expect that Florida is beginning to exhaust its economically recoverable phosphate desposits, while others believe that deposits can support competitive production for a century or longer. Chemical and fertilizer companies are trying to develop ways of beneficiating low-grade phosphate rock of which there are more reserves. In either case, Florida should continue to dominate domestic production through the year 2000, and any constraints on production are likely to result in a decrease of phosphate rock exports rather than a major change in domestic use.

Exhibit III-5 lists the 10 states with the largest consumption of phosphate fertilizers during 1970-1978. Consumption was widespread throughout the United States The top 10 states accounted for just over half of the total consumption. The single largest markets are Illinois, Iowa, and Minnesota.

(c) Nitrogen Products

Nitrogen fertilizer is produced in a number of states, but production has been concentrated in the Gulf, where natural gas has been available. About three-fourths of ammonia is used as a fertilizer; remaining uses include organic chemicals, explosives, plastics, and animal food supplements. Table III-5 presents estimates of United States production and consumption of fixed nitrogen or ammonia for 1977.

In 1977, the United States was a net importer of ammonia. The United States began importing ammonia in 1974 and 1975 for the first time since the mid-60s. In recent years, the imports to the United States from such countries as Russia, Canada, Mexico, Trinidad, and Tobago have increased sharply. In particular, Russian imports jumped from zero in 1977 to 305,000 tons in 1978 as reported by an ad hoc committee of United States fertilizer companies.

Exhibit III-6 presents estimates of 1977 production of ammonia by country. The United States produced approximately 23% of total world production. Other leading producers include central economy countries, Japan, Canada, The Netherlands, and India.

Table III-5

Fixed Nitrogen Production and Use for 1977
(Millions of Short Tons)

Beginning Stocks	1.8
Production	14.6
Imports	0.9
TOTAL SUPPLY	17.3
Consumption	14.7
Exports	0.3
TOTAL USE	15.0
Ending Stocks	2.3

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

Nitrogen fertilizer consumption in the United States is very similar to the patterns of phosphate consumption. Distribution is widespread. The 10 states using the largest amounts of nitrogen fertilizer were identical to those for phosphate. These states accounted for 60% of total use during 1970-1978 (see Exhibit III-7).

(d) Potassium Products

United States production of potash is centered in eastern New Mexico near Carlsbad. Table III-6 presents 1977 estimates of United States production and use of potash.

Table III-6

U.S. Potash Production and Use for 1977
(Millions of Metric Tons)

Beginning Stocks		0.5
Production		2.2
Imports		4.6
	TOTAL SUPPLY	7.3
Exports		0.8
Consumption		6.0
	TOTAL USE	6.8
Ending Stocks		0.5

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980

In sharp contrast to phosphate rock and ammonia, a substantial portion of United States needs for potash are met through imports. Much of the United States import needs have been met from mines in Saskatchewan, Canada. Canada accounted for 94% of all potash imports from 1975 to 1978. Saskatchewan mines have captured a significant share of the United States market, because their ores have a higher potash content, the rail rate structure is favorable for Canadian mines, and the Government of the Province of Saskatchewan countines to expand its three wholly-owned potash mine/mill complexes.

In 1977, the United States was the fourth largest potash producer and produced an estimated seven percent of the world's production of potash (see Exhibit III-8 for world production and reserves by country). United States reserves of potash are estimated to be three percent of the world's reserves. Other major producers of potash include central economy countries, Canada, West Germany, France, and Israel.

The predominant use of potash is for fertilizer and potassium fertilizer consumption. Just as with nitrogen and phosphate, is distributed throughout the United States The 10 states accounting for the largest consumption of potash were somewhat different from those of the other two fertilizers. Whereas the cornbelt states continue to be the largest market, southeastern states were also an important market for potash (see Exhibit III-9).

ECONOMICS OF THE INDUSTRY

Agricultural chemicals (principally fertilizers, but some other chemical products, such as insecticides and herbicides) represent about one-fifth of total United States chemical industry sales and are produced by both diversified chemical companies and specialized fertilizer companies or cooperatives.

The production of phosphate fertilizers is highly concentrated and integrated. The Bureau of Mines estimates that 10 to 15 firms produce over 95% of domestic phosphate rock and most of these firms are part of major chemical companies or agricultural cooperatives that manufacture ammonia and nitrogenous fertilizers as well.

A larger number of firms are involved in the production of ammonia. In a survey of North American production capacity taken in 1977, the Tennessee Valley Authority listed over 50 companies with plants in operation or under construction.

The large production scale of typical phosphate or nitrogen fertilizer plants (new phosphate plants typically have an annual capacity of 500,000 tons) has contributed to the boom-and-bust cycles that have characterized the fertilizer industry during the 1960s and 1970s. When it is attractive for one company to expand it is attractive to others. As a result, fertilizer capacity has often been built in large "chunks", with 8 or 10 companies deciding independently to build new plants. In recent years, there has been excess United States production capacity of ammonia. In its 1979 survey of the chemical industry, Standard and Poor has stated that more than 30 major ammonia plants have been shut down or temporarily closed. The closings are due to over capacity, escalating operating costs (natural gas is the feedstock for ammonia production and price increases have sharply affected production costs), and increased imports.

Selected financial ratios for five fertilizer companies are presented in Table III-7.

Table III-7

Financial Results for Selected Fertilizer Companies 1/

	Net Income/ Sales (%)	Return on Equity (%)
1973	12.0	17.8
1974	18.6	52.2
1975	16.4	39.6
1976	10.3	16.8
1977	7.4	12.5
1978	5.6	8.8

NOTE: 1/ Companies include Beker Industries, First Mississippi, Freeport Minerals, International Minerals and Chemicals, and Williams Co. Since Beker Industries had a net loss for 1976-1978, data for these years have been excluded from the analysis.

SOURCE: Standard and Poor, Industry Surveys: Chemicals Basic Analysis, August 1979.

Although based on a limited number of companies, the financial data in Table III-7 indicate that these fertilizer companies were subject to sharp changes in profitability from one year to the next. In particular, the highly profitable years of 1974 and 1975 were followed by the lean years of 1977 and 1978 as increased domestic production came on stream and increased foreign imports of fertilizer began to provide significant price competition.

Although the production of fertilizer is concentrated, over 5,000 firms are involved in the business of mixing and blending fertilizers to the specific needs of the farm and non-farm customers in their sales territories. These firms include bulk blending plants, liquid mix or suspension plants, and distributors. These outlets are subject to substantial price competition and have a more limited number of options to respond to changing market conditions.

DESCRIPTION OF LOGISTICS SYSTEM

The distribution system for each of the three primary nutrients is different due to the fact that, in contrast to nitrogen, potash and phosphate rock are mined and to the fact that these mineral deposits are in such different parts of the country. However, some generalization about the distribution process of all three fertilizers can be made from a discussion of phosphate fertilizer.

(a) Phosphate Fertilizer Logistics System

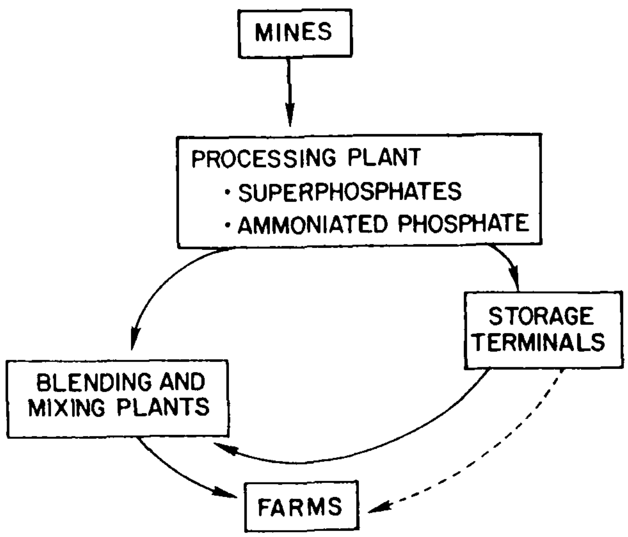
Figure III-D is a simplified scheme for the domestic distribution of phosphate fertilizers.

For domestic use, phosphate rock is shipped from the mine to the processing plant. The plant may be located at the mouth of the mine or at some point closer to the consuming markets. Processing can involve both the production of phosphates from the rock and the treatment of the phosphate with ammonia. The finished products are then shipped directly to local blending and mixing plants or into storage at strategically located terminals. Farmers receive fertilizer from local distributors who either pick up phosphate products for direct application from storage terminals or blend and mix these products with other fertilizers at their own plants.

In a sense the distribution of fertilizer is the opposite process of gathering grain, and fertilizer companies take advantage of the natural backhaul opportunities provided by the barge and truck movement of grain. For example, barges hauling grain southbound on the Upper Mississippi are cleaned and used for upbound shipment of nitrogen fertilizers and ammoniated phosphates. Trucks making grain deliveries to barge-loading stations on the Upper Mississippi and Illinois Rivers in the spring can be loaded with fertilizer for the return trip. Along the same lines, the Santa Fe Railway uses covered hoppers to ship potash in December to May. Then the cars are used to ship winter wheat harvested in May, June, and July.

Figure III-D

Domestic Distribution System for Phosphate Fertilizers



Source: Shipper Interviews

There are at least two key decisions to be made in the design of this distribution system. One is the use of storage terminals and the other is the location of the processing plant.

The decision to establish storage terminals is related to the seasonal demand for fertilizer. As was discussed earlier, the demand for fertilizer is highly seasonal. Farmers apply fertilizer in the spring during a two to four week period and the timing varies from year to year according to the weather. To meet this concentrated and somewhat unpredictable demand, producers and local distributors must stockpile fertilizer near the points of consumption. If stockpiling is not done in the consuming areas, producers only aggravate the serious problems that they have had with securing transportation equipment and power. Carriers have been reluctant to supply equipment for the seasonal use of fertilizer as well as grain shippers. Just as farmers have built on-farm storage to better match supply with changes in market demand, fertilizer producers and distributors have had to provide more storage and/or encourage farmers to apply fertilizer in the fall.

Producers can encourage local distributors to stockpile fertilizer during the off-season by discounting the delivered price. Such discounts are often necessary to compensate local distributors for the cost of carrying fertilizer for an extended period of time. However, there are at least three disadvantages with relying exclusively on storage at local distributors. First, by giving up ownership of the product early in the season, fertilizer producers have given up opportunities to make additional merchandising gains from the redistribution of product to those areas of greatest demand. Second, fertilizer producers lose control over how the product is stored. Nitrogen solutions, in particular, require careful storage to prevent contamination and, in some midwestern states, producers can be held legally liable for failing to deliver products of specified nutrient content. Third, and perhaps most importantly, local distributors do not handle sufficient volume to merit use of the low-cost, efficient transportation provided by pipelines, barges and coastal vessels, or unit trains. As a result of these disadvantages, the largest fertilizer producers have established their own storage terminals to which shipments of product are made on a regular basis and from which truck delivery to blending and mixing plants or farms is easily done. Provided that shipments are large enough, fertilizer companies may operate their own terminals rather than use public terminals.

Another key decision to be made in the design of the phosphate fertilizer distribution process is the location of the processing plant. Fertilizer companies have located processing plants near: 1) end markets, 2) ready sources of natural gas, and 3) mines. There are advantages and disadvantages associated with each location.

Locating processing plants near the end markets permit the use of bulk transportation for the shipment of the rock and the use of short-haul truck transportation for the final delivery of the product. Phosphate rock is a dense commodity, weighing 92 to 102 pounds per cubic foot. The rock is moved from mines in Florida to Tampa by covered hopper cars (if it is dry rock) or open hopper cars (if it is wet rock). The rock is then transloaded at Tampa from rail cars to ocean-going barges for shipment principally to ports in the Baton Rouge to Gulf region. At these ports, the phosphate rock is transloaded again to shallow draft barges for upbound shipment. Plants are located on the Ohio, Upper Mississippi and Illinois Rivers and typically can receive rock by rail and water.

Locating plants near sources of natural gas, such as Houston in the Gulf Coast West region or New Orleans in the Baton Rouge to the Gulf Region, permit the producer to receive both natural gas and phosphate rock by means of low-cost, bulk transportation. (For a description of the regions of the national waterways used in this report, see Appendix B.) A significant precentage of phsophate fertilizers are actually mixtures of nitrogen and phosphate. The phosphate rock is moved from the mine to the processing plant as outline in the previous discussion. The natural gas is often received by pipelines running along the Gulf Coast. The rock is the processed into phosphoric acid and the natural gas is processed into ammonia. The ammoniated phosphate fertilizers are then produced from the reaction of the phosphoric acid with the ammonia. The finished products can be shipped by barge or rail to end markets.

The location of processing plants near the mines provides opportunities for producers to achieve some savings in distribution and storage costs over the other two options. These savings are most easily realized for rail shipments of the finished products to certain markets, such as Ohio, Illinois, and Indiana, where rail service to terminals and local distributors compete effectively with water transportation.

Rail shipments of finished products to these aeas compete effectively with water, because the water route for the shipment of rock to processing plants near these end markets or the shipment of finished products is circuitous.

These savings can also be obtained if the processors are able to manufacture products of higher nutrient content. The higher nutrient contents permits the processor to ship less tonnage than they would do so if they were shipping the rock to plants located at some intermediate points. Although the finished product may move at higher costs per ton, the reduction in tonnage may offset the higher per unit costs.

There is some evidence that, in recent years, producers have decided to process a greater share of the rock at the mines. Shippers mentioned that there are lower production costs associated with large scale processing plants. Large scale plants are typically built at the mine, because these plants have the options of serving both the domestic and export markets. Satellite processing plants located near end markets are not as large, because their production is limited to a smaller domestic market. In addition, certain trace elements from the rock, such as uranium, are being recovered by capital-intensive techniques. The recovery of these trace elements is less costly with the use of high-production plants at mines.

Table III-8 presents information on the share of phosphate fertilizer production for plants located in Florida. Although the share of production declined somewhat from 1972 to 1975, this share has increased to over 59% of United States total production in 1978.

There is also evidence that phosphate fertilizers produced in recent years have on average a higher nutrient content. From 1965 to 1978, the production of normal and enriched super phosphates, containing less than 40% phosphate (P_2O_5), fell over seven percent per year. In contrast, concentrated super phosphate production rose 3.8% per year.

Table III-8

Share of Phosphate Fertilizer Production in Florida

Year	Percent of U.S. Total
1972	52.1%
1973	49.5
1974	50.7
1975	48.0
1976	56.6
1977	56.9
1978	59.2

SOURCE: Bureau of Mines.

The discussion of phosphate-fertilizer distribution would not be complete without mentioning the export of phosphate rock. As shown in Table III-4, approximately 28% of phosphate-rock production in 1977 was exported. The majority of this rock is shipped to Tampa by rail where it is transloaded to deep-draft vessels.

(b) Logistics System for Other Fertilizers

The logistics system for potash is nearly identical to that of phosphate fertilizers, except potash is almost always milled at the mine. Potash producers in Canada supply the bulk of United States needs. Extensive use of storage terminals is made and shipments to these terminals are made by single car and unit train. Some unit train shipments originate from Northgate, North Dakota (some Canadian potash is trucked to Northgate) for shipment to Ohio, Indiana, Minnesota, Iowa, Wisconsin, and Illinois. Some use of the Great Lakes is also made for the distribution of potash.

The logistics system for nitrogen fertilizers in also similar to phosphates, except for the obvious fact that ammonia is manufactured from natural gas rather than mined. The location of ammonia plants has been based in large part upon the availability of natural gas. According to the 1977 survey of production in capacity made by TVA, an estimated 46% of active ammonia plant capacity in the United States was located at points near the Gulf Coast West, Gulf Coast East, and Baton Rouge to Gulf regions. Other plants were located in Oklahoma, Kansas, Nebraska, and inland Texas where natural gas was also available. Less than ten percent of ammonia plant capacity was located in the cornbelt states of Iowa, Illinois, Ohio, and Indiana.

In order to meet the seasonal demand for nitrogen fertilizers, producers make extensive use of storage terminals. Barge delivery of the finished products to terminals on the Upper Mississippi and Illinois Rivers competes with rail and some pipeline deliveries of products. The two major pipelines for delivery of anhydrous ammonia are: 1) the Gulf Central Pipeline from Louisiana to Missouri and 2) the Mapco Pipeline from Texas and Oklahoma to Kansas, Nebraska, and Iowa. Rail movements of nitrogen fertilizers are made to both terminals and local distributors.

PRINCIPAL TRANSPORTATION FLOWS

Whereas federal agencies collect and publish extensive data on the production and consumption of fertilizer, analyzing fertilizer transportation flows is difficult. One reason for this difficulty is that the commodity classification systems used for water and rail shipments do not have comparable categories for fertilizer. The system for waterborne shipments classifies fertilizers by the three primary nutrients and a separate category for mixed fertilizers; some rail shipments classify fertilizers containing different nutrients within the same STCC five digit category.

Despite this problem, a discussion of the principal rail, pipe and water transportation flows for the three major nutrients and mixed fertilizers is presented under separate subheadings.

(a) Nitrogenous Fertilizer

Exhibit III-10 presents estimates of inland water shipments of nitrogen fertilizers for 1969-1977. The principal commodities include nitrogen solutions, urea, and ammonium sulfate. Ammonium nitrate is subject to strict Coast Guard regulations and few, if any, barge shipments are made. Ammonia is not included in Exhibit III-10, because these water shipments are classified under a general category for various chemicals.

Total internal shipments of nitrogenous fertilizers more than tripled from 1969 to 1977 and receipts on major waterway regions showed strong and fairly steady growth. The major origin of internal traffic is the Baton Rouge to Gulf region.

Exports of nitrogenous fertilizers were relatively constant at roughly 1.1 million tons per year from 1970 through 1977. One major internal flow within the Middle Atlantic Coast region is closely linked to exports; most of this traffic moves down the James River from Hopewell, Virginia to export facilities at Hampton Roads.

One other major source of nitrogenous fertilizer materials in the Alaskan Peninsula. Between 1970 and 1977, producers in this area shipped 200,000 to 350,000 tons per year to foreign markets, deep water ports on the Columbia River, or the Port of Sacramento.

Only a few nitrogen products that are shipped by rail can be identified. Ammonia shipments of rail have increased from 2.5 million tons in 1972 to 3.7 million tons in 1977. Shipments from Louisiana and Mississippi to Florida accounted for much of this increase and confirm the growing importance of ammoniated phosphate production in Florida. Nitrogen solutions are the only other rail flows that can be identified. Shipments actually declined from 1.4 million tons in 1972 to 1.3 million tons in 1977. The majority of the flows were relatively short-haul, intrastate shipments of 100,000 tons or less. Barge and pipeline provide most of the long-haul transportation of nitrogen solutions, with rail providing only limited distribution from major production points.

(b) Phosphate Fertilizers and Mixtures

Almost all Florida phosphate rock is used at the mine site to produce phosphate fertilizer or transported by rail to Florida fertilizer plants and coastal terminals. The terminals load freighters for export and barges for domestic traffic. Exhibit II-11 presents estimates of Florida phosphate rock shipments. As can be seen, over 32 million tons of rock were shipped by rail to points within Florida. Of this 32 million tons, 9 million tons were shipped by barge or coastal vessel across the Gulf (predominantly to the Baton Rouge to Gulf region) and 14 million tons were exported.

Exhibit III-12 presents estimates of phosphate fertilizer shipments. Aside from exports, there has been little growth in water shipments. Shipments of product from Florida by rail have also shown little growth. Although the phosphorous supplied by superphosphates has increased sharply over this period, the substitution of concentrated for ordinary superphosphates has held total product shipments nearly constant.

Mixtures containing two or more nutrients are the most popular alternative to superphosphates as a source of phosphorous. Exhibit III-13 presents traffic estimates for ammoniated phosphates and other mixtures. Florida exports and shipments from the Baton Rouge to Gulf region have increased during this period. Barge shipments from the Baton Rouge to Gulf region are predominatly made to the Upper Mississippi and Illinois Rivers. Shippers noted that rail shipments of phosphate fertilizers and mixtures are very competitive with water for destinations in southern Illinois and all of Indiana and Ohio. Rail shipments include aqua ammonia and ammonium sulfate as well as ammoniated phosphates. However, the relatively slow growth in ammonium sulfate consumption (see Figure III-B) and the decline in aqua ammonia consumption indicate that most of the rail shipment growth was in mixtures.

(c) Potassium Products

Domestic waterborne shipments of potash and potassium fertilizers are small, because no potash is produced near the waterways. Most shipments are by rail from Canada.

The only major domestic waterborne flows are from Houston to Tampa by coastwise freight, and to Pascagoula (by barge). There are some export shipments from Houston, San Diego, and Long Beach. There are also some import shipments of Canadian potash and potassium fertilizers through the Lakes. Rail shipments include those from Canada; those from transloading points on the Canadian-United States border, such as Northgate, Nebraska; and those from western mines in the United States.

FACTORS INFLUENCING FLOWS IN THE FUTURE

There are at least five factors that might be expected to influence the fertilizer industry in the future. These are:

1. Increased imports of ammonia and other nitrogen fertilizers from countries such as Russia, Canada, Mexico, Trinidad, and Tobago. OPEC countries could also become significant exporters of nitrogen fertilizers, because they have considerable flexibility to price products produced from gas.

2. Reduced applications of ammonia in favor of other forms of nitrogen fertilizers.

3. Lower nutrient content in ammoniated phosphate fertilizers. The acid being produced from the lower quality of phosphate rock mined in Florida will not react as well with the ammonia.

4. Possible merger of the Seaboard Coast Line and the Chesapeake and Ohio.

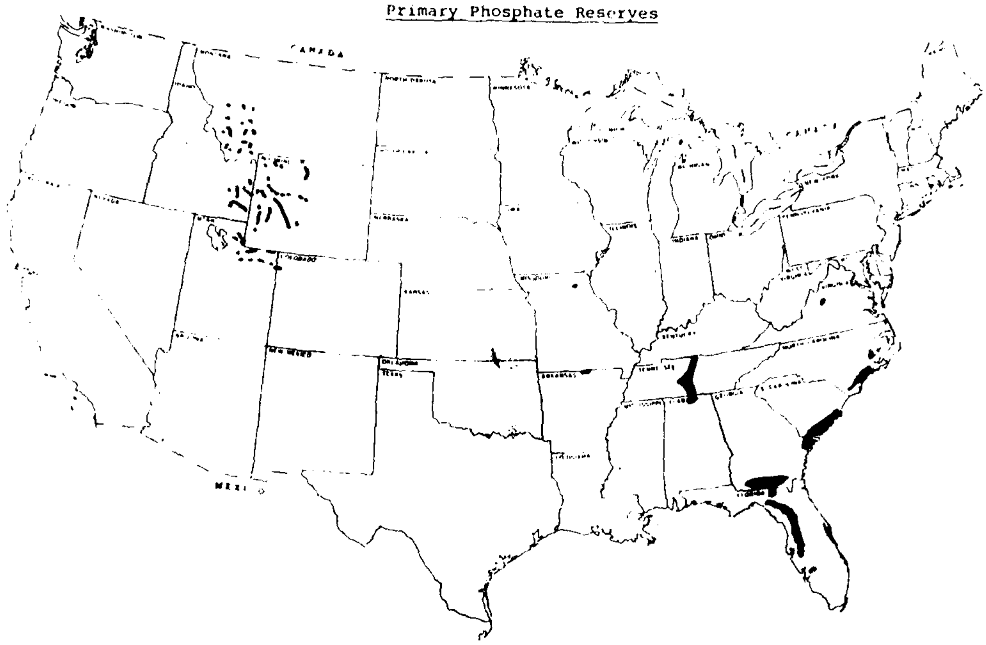
5. Possible production of ammonia from gasified coal.

Whereas these five factors might be expected to change the fertilizer industry, only one factor, namely the production of ammonia from coal, would be expected to change waterborne fertilizer flows. Increased imports of fertilizers would be distributed through existing channels. Reduced applications of ammonia in favor of nitrogen fertilizers with lower nutrient contents would increase the amount of materials being shipped, but would not change the pattern of flows. Along the same lines, the possible mining of lower quality rock in Florida may increase the amount of materials being shipped, but would not change the pattern of flows. The merger of the SCL and C&O may increase the rail share of shipments of phosphate and ammoniated phosphate fertilizers. However, as can be seen by Exhibits III-12 and III-13, the rail share of this traffic is already quite high.

The production of ammonia from coal, on the other hand, could be expected to change the nature of flows in the future. It must be emphasized that production of ammonia from coal could not be expected to take place at any significant commercial level until the mid-1990s. If such a conversion from gas to coal were to take place, then new ammonia plants might be constructed on midwestern coal fields in Illinois, Indiana, and Ohio. Coal would be transported by conveyor or truck to the plant. Fertilizer would in all probability be distributed locally by truck. As a result, waterborne shipments of nitrogen fertilizers from the Baton Rouge to Gulf region might be expected to decline late in the study period as new ammonia plants were brought on-stream in the Midwest.

EXHIBIT III-1

Primary Phosphate Reserves



SOURCE: United States Department of the Interior.

EXHIBIT III-2

FERTILIZER USE BY MAJOR CROPS
(thousands of tons)

	1965	1977
Corn		
Nitrogen	1,826	4,274
Phosphate	1,134	2,080
Potash	1,024	2,337
Wheat		
Nitrogen	369	1,130
Phosphate	282	573
Potash	131	260
Soybeans		
Nitrogen	19	110
Phosphate	88	433
Potash	114	593
Cotton		
Nitrogen	436	401
Phosphate	221	178
Potash	171	106
Other Crops and Uses		
Nitrogen	1,989	4,727
Phosphate	1,787	2,358
Potash	1,395	2,537
Grand Total		
Nitrogen	4,639	10,642
Phosphate	3,512	5,622
Potash	2,835	5,833

SOURCE: John Douglas, Musings on the U.S. Fertilizer Industry, 1990, September 1978.

EXHIBIT III-3

APPLICATION RATES PER ACRE ON CROPS FERTILIZED
(Pounds of nutrient per acre fertilized)

	1965	1977
Corn		
Nitrogen	75	128
Phosphate	50	68
Potash	48	82
Wheat		
Nitrogen	31	53
Phosphate	30	39
Potash	35	41
Soybeans		
Nitrogen	10	16
Phosphate	32	45
Potash	39	60
Cotton		
Nitrogen	81	78
Phosphate	55	53
Potash	57	52

SOURCE: John Douglas, Musings on the U.S. Fertilizer Industry, 1990, September 1978.

EXHIBIT III-4

WORLD PHOSPHATE ROCK PRODUCTION AND RESERVE BASE
(millions of metric tons)

	1977 Production	Reserve Base[1/]
United States	49	8,500
Central Economy Countries	33	22,000
Morocco/Sahara	17	42,000
Tunisia	4	280
Republic of South Africa	2	60
Togo	2	50
Senegal	2	200
Other Market Economy Countries	10	57,500
WORLD TOTAL	119	130,590

NOTE: 1/ Reserve base is that part of an identified resource that meets minimum physical and chemical requirements related to current mining and production practices, including those for grade, quality, thickness and depth, regardless of current economic requirements related to extraction and marketing methods. Estimates are as of 1979.

SOURCE: Bureau of Mines, Mineral Commodity Statistics, 1979-1980.

EXHIBIT III-5

PHOSPOROUS FERTILIZER CONSUMPTION BY STATE[1/]
(average use for 1970-1978)

	Thousands of Tons	Percent of Total
Illinois	477	10%
Iowa	416	8
Minnesota	279	6
Indiana	275	5
Texas	268	5
Ohio	253	5
Missouri	182	4
California	180	4
Kansas	178	4
Nebraska	149	3
Other States	2,324	46
United States TOTAL	4,981	100%

NOTE: 1/ Phosphate equivalent consumption.

SOURCE: USDA, Commercial Fertilizers, 1970-1978.

EXHIBIT III-6

WORLD AMMONIA PRODUCTION FOR 1977
(millions of short tons)

United States	14
Central Economy Countries	24
Japan	3
Canada	3
Netherlands	2
India	2
France	2
West Germany	2
Other Countries	9
WORLD TOTAL	61

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

EXHIBIT III-7

NITROGEN FERTILIZER CONSUMPTION BY STATE
(average use for 1970-1978)

	Thousands of Tons	Percent of Total
Iowa	776	9
Illinois	743	8
Texas	708	8
Nebraska	596	7
Kansas	535	6
California	516	6
Minnesota	437	5
Indiana	391	4
Missouri	332	4
Ohio	291	3
Other States	3,616	40
United States TOTAL	8,941	100%

SOURCE: USDA, Commercial Fertilizers, 1970-1978.

EXHIBIT III-8

WORLD POTASH PRODUCTION AND RESERVE BASE
(millions of metric tons)

	1977 Production	Reserve Base 1/
Central Economy Countries	14	4,900
Canada	6	2,700
West Germany	3	500
United States	2	300
France	2	50
Israel	1	300
Other Countries	1	350
WORLD TOTAL	29	9,100

NOTE: 1/ See footnote 1 to Exhibit III-4.

SOURCE: Bureau of Mines, Mineral Commodity Statistics, 1980.

EXHIBIT III-9

POTASSIUM FERTILIZER CONSUMPTION BY STATE 1/
(average use for 1970-1978)

	Thousands of Tons	Percent of Total
Illinois	575	12%
Iowa	422	9
Indiana	376	8
Minnesota	306	6
Ohio	294	6
Wisconsin	266	6
Florida	230	5
Georgia	229	5
Missouri	215	4
North Carolina	196	4
Other States	1,693	35
United States TOTAL	4,802	100%

1/ Potash equivalent comsumption.

SOURCE: USDA, Commercial Fertilizers, 1970-1978.

EXHIBIT III-10

INLAND WATERBORNE RECEIPTS
OF NITROGEN FERTILIZERS 1/
(thousands of short tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Ohio	118	101	172	144	204	265	305	353	615
Illinois	169	188	219	258	292	283	395	640	598
Upper Miss.	40	120	150	130	224	172	349	496	487
Other	567	887	897	1,054	879	867	1,023	1,010	1,238
TOTAL	894	1,296	1,438	1,586	1,599	1,587	2,072	2,499	2,938

NOTE: 1/ Excludes ammonia and mixtures.

SOURCE: United States Corps of Engineers, Waterborne Commerce Statistics, 1969-1977.

EXHIBIT III-11

FLORIDA PHOSPHATE ROCK SHIPMENT
(millions of short tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Rail 1/									
Intrastate	-	-	-	25.3	25.1	30.9	29.5	30.3	32.1
Interstate	-	-	-	0.6	1.0	1.2	0.7	0.7	0.6
TOTAL				25.9	26.1	32.1	30.2	31.0	32.7
Exports	9.7	10.4	11.3	12.8	12.2	12.4	10.4	9.3	13.5
Barge/Coastal Vessel 2/									
Baton Rouge to Gulf	3.0	3.3	4.6	5.6	5.6	5.1	6.2	6.1	6.9
Gulf Coast West	0.8	1.0	0.9	1.1	1.0	1.0	0.9	0.8	0.9
Gulf Coast East 3/	0.8	0.7	0.9	0.8	0.8	1.1	0.8	0.9	0.8
TOTAL	4.6	5.0	6.4	7.5	7.4	7.2	7.9	7.8	8.6

NOTE: 1/ Not available prior to 1971.

NOTE: 2/ Florida Gulf Coast shipments to the destinations of Baton Rouge to Gulf; Gulf Coast West; Gulf Coast East and other waterways.

NOTE: 3/ Include other destinations.

SOURCES: United States Corps of Engineers, Waterborne Commerce Statistics, and One Percent Waybill Sample.

EXHIBIT III-12

SHIPMENTS OF PHOSPHATE FERTILIZERS 1/
(thousands of tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Water 2/									
Florida Exports	-	501	566	679	813	708	867	1,049	1,007
Shipments from Baton Rouge to Gulf Region	274	882	1,154	466	596	540	453	376	452
Rail 3/									
Florida Intra-State	-	-	-	2,277	2,874	2,033	3,393	3,654	2,613
Florida Intra-State	-	-	-	2,688	2,983	2,964	2,835	2,609	2,362

NOTE: 1/ Excludes mixtures.

NOTE: 2/ Excludes other small water shipments.

NOTE: 3/ Not available prior to 1972.

SOURCES: United States Corps of Engineers, Waterborne Commerce Statistics, 1969-1977 and One Percent Wayhill Sample.

EXHIBIT III-13

SHIPMENTS OF PHOSPHATE FERTILIZERS 1/
(thousands of tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Water 1/									
Florida Exports	1,304	858	962	922	1,251	813	1,535	1,661	2,054
Shipments from the Baton Rouge to Gulf Region 2/	1,073	980	1,250	1,610	1,449	1,808	1,582	2,029	2,411
Rail 3/	-	-	-	1,256	2,356	2,439	3,456	6,051	6,852

NOTE: 1/ Includes other mixtures.

NOTE: 2/ Includes exports and shipments to Upper Mississippi, Illinois, Ohio, and Missouri Rivers.

NOTE: 3/ Total United States shipments of ammoniated phosphates, aqua ammonia and ammonium suflate. Not available prior to 1972.

SOURCES: United States Corps of Engineers, Waterborne Commerce Statistics and One Percent Waybill Sample.

IV - STEEL

This section discusses both the major inputs, such as iron ore, limestone, iron and steel scrap, coke, and ferroalloys and the principal outputs, namely semifinished and finished steel products, of the steel industry.

The steel industry is a major user of the waterways. Table IV-1 presents the 1977 waterborne flows for the steel industry.

Table IV-1

1977 Waterborne Flows for the Steel Industry[1]
(Millions of Tons)

Raw Materials[1]	Domestic	Foreign	Total
Iron Ore	50.0	42.3	92.3
Limestone	28.7	10.4	39.1
Coke[2]	2.8	19.4	22.2
Scrap	2.0	5.4	7.4
Nonmetallic Ores	1.4	4.0	5.4
Ferroalloys	0.8	1.0	1.8
Lime	0.9	-	0.9
SUBTOTAL	86.6	82.5	169.1
Iron and Steel			
Plates	2.9	10.8	13.7
Shapes	1.2	4.2	5.4
Pipe and Tube	1.4	2.7	4.1
Primary Forms	0.6	0.5	1.1
Products, NEC	0.2	0.8	1.0
SUBTOTAL	6.3	19.0	25.3
TOTAL	92.9	101.5	194.4

NOTE: 1/ Other raw materials such as energy products are excluded.

NOTE: 2/ Includes petroleum coke, petroleum asphalts, and solvents.

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

As can be seen, the steel industry uses the waterways for both domestic and foreign traffic. Iron ore and limestone are two commodities shipped in large volumes on the Great Lakes. Significant amounts of ore are imported as well. Coke is imported, exported, and shipped on the inland waterways. Waterway shipments of steel products, on the other hand, are predominantly foreign imports. Thus, steel companies consider water transportation to be an integral part of much of their operations and they are concerned about the adequacy of waterway capacity.

The section is divided into the following major headings:

- Commodity Characteristics
- Markets
- Economics of the Industry
- Description of the Logistics System
- Principal Transportation Flows
- Factors Influencing Flows in the Future

COMMODITY CHARACTERISTICS

The characteristics of the major commodities for the steel industry are discussed below.

(a) Iron Ore

Iron and other ores constitute the basic resources used in creating finished metals, the most important of which is steel. Iron comprises over five percent of the earth's crust and is mined on every continent. It is recovered in the form of an ore consisting of iron-oxygen compound mixed with silica and other impurities.

Traditionally, the minimum iron content required to economically mine ore has been 50%, however, recent technological advances have lowered this threshold to 20%. Ore beneficiation is one of these advances; it is a process to extract the iron from iron ore. This process makes it feasible to mine taconite or crude iron ore with an iron content of as little as 20% by weight.

The beneficiating process involves crushing and grinding the iron-bearing ore, extracting the iron by either magnetic or floatation techniques and then concentrating the iron-rich extract. In recent years, the average iron content of United States crude iron ore has been between 30 to 35%. After the crude iron ore has been processed, its average iron content is close to 60 to 65%.

Since beneficiation plants are typically located near crude iron ore production mines, the process has greatly reduced the amount of tonnage that must be transported long distances. In 1979, 98% of all crude iron ore produced on the United States was shipped first to beneficiation plants and approximately 91% of all beneficiated iron ore was also pelletized to improve storage and loading qualities. Whereas crude iron ore is a powdery, rocky mixture and is subject to dusting and freezing, iron ore pellets, which are approximately 1/4 inch in diameter, are a gravel-like commodity that handle and store more easily.

Steel is manufactured in several ways. Each method involves a series of steps. First, pig iron or direct reduced iron is produced. Pig iron is produced in blast furnaces; in this process, the raw materials, namely iron bearing materials (iron ore, sinter, pellets, iron or steel scrap), flux (limestone), and fuel (coke) are charged into the top of the furnace while heated air is blown in the bottom. The blast air burns part of the fuel to produce heat for the required chemical reactions and for the melting of the iron. The iron is typically shipped in a molten state to steel furnaces, although some ingots (called pigs) are also produced for shipment to steel furnaces and iron foundries.

Direct reduced iron, on the other hand, are iron units that are made in other ways than through the use of blast furnaces. Typically, direct reduced iron is produced by heating iron ore or pellets with a solid reductant such as coke to temperatures as high as 1900°F. Although the iron is not melted as in the case of blast furnaces, the iron is heated high enough to force much of the oxygen in the ore out. Direct reduced iron is approximately 86 to 93% iron by weight. Direct reduced iron, often called sponge iron, is also discussed in Section IX, because it represents a potentially new waterborne commodity.

Once the pig iron or direct reduced iron is produced, steel is manufactured in one of three furnace types - open hearth, basic oxygen or electric. These three types of melt furnaces use varying proportions of pig iron (or, in the case of electric furnaces, directed reduced iron) and iron and steel scrap to produce steel.

Basic oxygen furnaces in the United States were charged with approximately 73% pig iron and 27% scrap in 1978 and 1979, according to the Bureau of Mines. Of total steel production in 1978, basic oxygen furnaces accounted for 61% of aggregate raw steel production of 136.7 million tons.

Electric furnaces were charged with nearly 100% iron and steel scrap and accounted for an estimated 23% of steel production in 1978. In the future, it is expected that electric furnaces will be charged with some direct reduced iron as well as iron and steel scrap.

Open hearths in the United States were charged with an estimated 45 to 46% scrap and the balance pig iron during 1978 and 1979. This method of steel production has been declining for a number of years. As recently as 1967, open-hearth furnaces accounted for over one half of United States steel production; in 1978, open-hearth furnaces accounted for only 16% of United States production.

The steel produced by any of these methods is then cast into ingot molds, which are rough milled while hot. Finally, the semi-finished steel is milled into a marketable product.

It should be noted that the predominant use of pig iron is, of course, for steel, but some pig iron is used in foundries to produce iron castings.

(b) Limestone

Limestone is found at or near the earth's surface in about 10% of the continental area and is used in the steel industry as a flux in blast and open hearth furnaces. Flux helps to remove impurities from the molten metal. In a basic oxygen furnace, with its quicker cycle time (steel production takes less than one hour in a basic oxygen furnace, whereas it takes eight hours in an open hearth furnace), lime is preferred. Since lime is a perishable commodity, limestone is often transported to the steel-making site, crushed, and processed into lime. There are many other uses of limestone aside from steel-making. These uses include road and highway construction, concrete aggregate, and cement to name just a few.

(c) Iron and Steel Scrap

The graphical presentation in Figure IV-A shows the flow of ferrous material through the economy.

There are three types of scrap: home scrap, prompt industrial scrap, and obsolete scrap. Home scrap accounted for an estimated one half of all iron and steel scrap consumed in the United States during 1979. Home scrap is generated in steel mills from worn out ingot molds and mill machinery, trim from product manufacturing, etc. Most of this home scrap is consumed in iron and steel furnaces at the point of production, but a small percentage of home scrap is also shipped to scrap dealers, other industries, or for export.

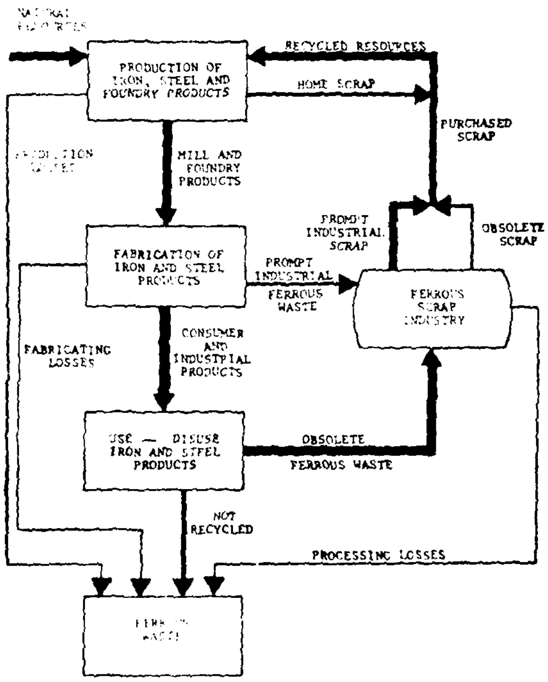
Prompt industrial scrap is generated from the consumers of steel mill products and foundries. As such, this type of waste is generally of known analysis and requires minimal sorting for use. It is typically recycled within a short period of time after leaving the mill.

Obsolete scrap is made available by the discontinued use of any material containing iron or steel. This type of waste is metallurgically heterogenous (there are approximately 20 major grades of scrap), can be of poor quality, and is geographically widely dispersed. Obsolete waste must be collected and processed before it can be sold as scrap. An estimated 27% of reported iron and steel scrap consumption for 1979 was obsolete scrap.

Iron and steel scrap is part of the basic charge for all three types of steel production. At the present time electric furnaces rely almost exclusively on scrap. Scrap is also used in the production of iron. In 1979, the steel industry accounted for about 77% of domestic scrap consumption. The foundry industry consumed about 23% of total scrap to produce cast iron and steel products.

Figure IV-A

The Flow of Ferrous Material Through the Economy



SOURCE: Shipper Interviews.

(d) Coke

Coke is produced from metallurgical coal in coke ovens. Metallurgical coal will produce coke when heated in the absence of air. Once coke is produced, it is charged into blast furnaces where it serves various roles in making molten iron from iron ore.

Typically, a blend of different types of coals is used to make coke. Metallurgical coals contain varying amount of volatile matter that is released as gas in the coking process. The lower the content of volatile matter in the coal, the greater will be the yield of coke. However, the coal must produce coke of sufficient strength and must not expand or exert pressure on the walls sufficient to damage the oven during the coking process. Since low-volatile coal (14 to 22% volatile matter) tends to expand and exert considerable pressure on the oven walls, it is often necessary to blend low-volatile along with high-volatile (over 31% volatile matter) and sometimes medium-volatile coal to produce an acceptable metallurgical coal.

The coal used in coke ovens must also have relatively small quantities of ash and sulfur, since all of the ash and most of the sulfur will stay in the coke and contaminate metals. Thus, the bituminous coal used for coking purposes is of a higher grade than most coals and commands a higher price (For a further discussion of the characteristics of coal, see Section VI).

(e) Manganese and Ferroalloys

Non-ferrous metallic matter is used by the steel making and iron foundry processes to alter the properties of the raw steel. Such metals include manganes ore, ferromanganese, ferrosilicon, ferrochromium, and silicomanganese.

Some manganese ore is used in the production of pig iron and is charged directly to blast furnaces. Much of the manganese ore is used to produce ferromanganese, the chief form in which the manganese is ultimately used in the production of steel.

Silicon is also another material used in the steel and iron industry. Other uses for silicon include the aluminum and silicone chemical industries.

Chromium is used in the iron and steel industry (in particular for the production of stainless steel), chemical industry and refractory industry.

(f) Steel Products

Steel is defined as an iron-base alloy, malleable in some temperature range as initially cast, containing manganese, usually carbon, and often other alloying elements.

All steels ore classified as either carbon or alloy steel. Carbon steels ore those containing very small amounts of alloying elements (not more than 1.65% manganese, 0.6% silicon, and 0.6% copper) and having a carbon content of 0.08 to 1.7%. Carbon steels comprise over 85% of raw steel production in the United States (See Exhibit IV-1 for a summary of United States raw steel production by grade for 1974 - 1978). Lowcarbon steels are used primarily for flat-rolled products, because they can be formed and welded easily. Machines, auto bodies, most structural steel for buildings, and ship hulls are among the products made from carbon steels.

Alloy steels, in contrast to carbon steels, contain specific percentages of certain elements, such as vanadium and molybdenum, and larger amounts of manganese, silicon, and copper. The major alloy grades include full alloys, stainless, tool, and high-strength, low-alloy (HSLA) steels. Stainless steels are used in the aerospace, petrochemical, and medical industries. Tool steels are used in tools and in the cutting and shaping parts of power-driven machinery. HSLA steels are used in automobiles, railroad freight cars, and commercial buildings.

Steel is produced in many forms and products; the steel industry uses the following classification of products:

- Semifinished (ingots, castings, slabs, etc.).
- Shapes, pilings, and plates.
- Rails and accessories.
- Bars and tool steel.
- Pipe and tubing.
- Wire products.
- Tin mill products.
- Sheets and strip.

Exhibit IV-2 presents a summary of both the domestic shipments and net imports of steel products in 1978. Domestic steel producers shipped 97.9 million tons of steel products in 1978. Sheets and strip steel is the largest category of steel product shipments. The next largest product categories are shapes, pilings, and plates; and bars and tool steel.

MARKETS

The production, consumption, and foreign trade patterns for the major commodities of the steel industry are discussed briefly below.

(a) Iron Ore

In 1979, iron ore was produced in the United States by 29 companies operating 54 mines, 41 concentration plants, and 20 pelletizing plants. Open pit mines accounted for 97% of all output. United States iron ore production was concentrated in the Mesabi Range of Minnesota (this state accounted for 70% of total 1979 output) and Michigan (another 20% of output). The remaining domestic production came from western and southern states. These latter areas have declined marketly as uneconomical operations are shutdown. Table IV-2 presents domestic production and consumption estimates of iron ore for 1977 - 1979.

Since the 1940's, the United States has been a net importer of iron ore; an estimated 29 to 36% of total consumption has come from imports in recent years. Canada, Venezuela, Brazil, and Liberia have provided our 90% of the iron ore imported into the United States

The United States was the third largest producer of iron ore in the world. Exhibit IV-3 presents estimates of world production and reserves of recoverable iron by country. As can be seen, the largest producers of iron ore are the Soviet Union and Brazil. Although the United States has ample reserves of recoverable iron for foreseeable future, its level of reserves rank well behind those of the Soviet Union, Brazil, Canada, and Australia.

Almost all of the iron ore produced in the United States is consumed by blast furnaces in the production of primary iron (pig iron). The consumption of iron ore in the United States is concentrated in the Great Lakes states of Illinois, Indiana, and Michigan, (these states accounted for 37% of apparent consumption in 1979); Maryland, Pennsylvania, and New York (another 30%); and Ohio and West Virginia (another 19%).

(b) Limestone

The United States produces sufficient limestone for its needs. Crushed limestone is produced in virtually every state. However, less than five percent of all crushed limestone sold or used by producers in recent years was actually used for steel-making.

Table IV-2

United States Production and Consumption of Iron Ore (Millions of Long Tons)

	1977	1978	1979 1/
Beginning Stocks	75.0	60.1	55.2
Production	55.8	81.5	84.0
Imports	37.9	33.6	35.0
TOTAL SUPPLY	168.7	175.2	174.2
Consumption 2/	106.5	115.8	116.4
Exports	2.1	4.2	4.4
TOTAL USE	108.6	120.0	120.8
Ending Stocks	60.1	55.2	53.4

NOTE: 1/ Preliminary estimates.

NOTE: 2/ Apparent consumption rather than reported consumption has been used.

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

As noted earlier, lime is preferred to limestone for use in basic oxygen furnaces. Table IV-3 presents estimates of lime production and use for 1977 - 1979.

Table IV-3

U.S. Lime Production and Consumption
(Millions of Short Tons)

	1977	1978	1979 1/
Production	19.9	20.4	20.4
Imports	0.4	0.6	0.7
TOTAL SUPPLY	20.3	21.1	21.1
TOTAL USE	20.3	21.0	21.0

1/ Preliminary estimates.

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

Virtually all United States consumption has been met through domestic production of lime. The Bureau of Mines estimates that ten companies, operating 29 plants, accounted for almost half of the 1979 production. Leading producing states were Ohio, Pennsylvania, Texas, Missouri, Michigan, and Alabama. The primary uses for lime were steel-making, alkalies, water treatment, and pulp and paper. The Bureau of Mines also estimates that domestic and world resources of limestone suitable for lime manufacture are adequate.

(c) Iron and Steel Scrap

As noted earlier, pig iron and scrap are used in varying proportions as feed for all three types of steel-making furnaces. Direct-reduced iron is a potential substitute for iron and steel scrap, but domestic production of such iron has been limited by the favorable price relationship that scrap still enjoys.

Table IV-4 presents estimates of United States consumption of both iron and steel scrap and pig iron for 1977 - 1979.

Table IV-4

U.S. Consumption of Scrap and Pig Iron
(Million of Short Tons)

	1977	1978	1979
Iron and Steel Scrap1/	92.5	99.7	101.9
Pig Iron2/	82.0	88.4	87.4

NOTE: 1/ Apparent.

NOTE: 2/ Reported.

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

In recent years, iron and steel scrap has accounted for 46 to 47% of total United States consumption of pig iron and scrap. Domestic use of scrap has been entirely attributable to steel and iron-making. The Bureau of Mines estimates that the steel industry has accounted for just over three quarters of scrap use. The foundry industry accounts for rest of the United States domestic consumption.

Exports of scrap ranged from 5.9 million tons in 1977 to an estimated 11.5 million tons in 1979. The United States has imported less than a million tons of scrap over this same period.

The Bureau of Mines estimates that home scrap has accounted for half of United States production. Purchased scrap has been evenly split between prompt industrial scrap and obsolete scrap in recent years. Production is concentrated in the Great Lake states of Illinois, Indiana, Ohio, Michigan, Minnesota, and Wisconsin. This area generated and consumed just over half of the scrap supply available for consumption in recent years.

(d) Coke

An estimated 71 million tons of domestic coal were used in the production of coke in 1978. This tonnage was one of the lowest in recent history due to a decline in domestic coking activity (domestic coke ovens have in some cases been closed rather than modified to meet environmental regulations regarding air emissions), increased use of electric furnaces (these furnaces do not use coke), and the gradual phase-out of open-hearth furnaces. Blast furnaces account for over 90% of coke use. Table IV-5 presents estimates of domestic coal consumption for coke production.

Table IV-5

Domestic Use of Coal for Coke Production

	Millions of Short Tons	Percent of Total Coal Use
1973	100	16.4
1974	90	14.8
1975	83	13.4
1976	84	12.8
1977	77	11.4
1978	71[1]	10.8[1/]

NOTE: 1/ Preliminary estimates.

SOURCE: Department of Energy

Over the past six years, coal use for coke has steadily declined, both in terms of tons consumed and as a percent of total coal use.

Although domestic coal use for coke has been declining, United States imports of coke have been increasing in recent years. In the early 1970's the United States became a net importer of coke and United States imports in 1975 reached 1.8 million tons. In 1976, coke imports of 1.3 million tons were equal to coke exports. The increased imports of coke are surprizing in view of the large reserves of premium bituminous coal suitable for coke production in the United States (See Exhibit VI-3 for a presentation of United States reserves.)

Of the coals received by domestic oven-coke plants, the majority came from West Virginia, eastern Kentucky, and Pennsylvania.

(e) Manganese and Ferroalloys

In addition to a small amount of manganese ore directly charged to the blast furnace, the iron and steel industry consumed about 900,000 tons of ferromanganese, 1,000,000 tons of ferroscilicon, 425,000 tons of ferrochromium, 190,000 tons of silico manganese, and more than 400,000 tons of other miscellaneous alloys in recent years.

The United States has no domestic production of manganese ore containing 35% or more manganese; as a result, the United States must rely on imports and shipments from government reserves to meet current needs. Gabon, Brazil, Australia, and the Republic of South Africa have supplied much of the imports of ore in recent years. Manganese alloy production, which consumes about 75% of all manganese ore in a normal year, is concentrated in West Virginia, Pennsylvania, Ohio, Kentucky, and Tennessee.

In recent years, there has been a trend toward importation of manganese alloys rather than ores and a corresponding decline in the importation of ore. Ferromanganese imports have come from the Republic of South Africa, France, and Japan.

In contrast to ferromanganese, the United States produces most of its needs for ferrosilicon. In recent years, approximately 85% of United States silicon consumption has been met by domestic production. Most of the ferrosilicon plants are located east of the Mississippi River or in the Pacific Northwest.

(f) Steel Products

In 1979, approximately 80 companies in the United States were producing raw steel in 160 plants. Pennsylvania, Indiana, Ohio, Illinois, and Michigan accounted for 70% of total raw steel production.

Exhibit IV-4 presents estimates of United States production and consumption of steel products from 1973 to 1979. In 1973 and 1974, industry shipments and consumption peaked as the economy reached a cyclical peak in activity as well. In 1975, domestic shipments declined sharply, falling approximately 27% from the average shipments for 1973-1974. Since 1975, industry shipments have increased gradually. Imports of steel have increased from 1975 as well. As the United States economy recovered at a faster pace than Europe or Japan's economies, the United States provided an outlet for these countries' excess production.

More recently, the trigger-pricing system, which is designed to prevent sales of imported steel at prices below those at which the same products are --ld in the domestic market of the exporter, was partially successful in reducing imports in 1979 below those of the two previous years. The trigger price is determined by the Japanese cost of production (Japan is the world's lowest-cost producer). Overhead and a profit margin, plus shipping, insurance, and handling costs to each particular

American market are then added to this cost. Countries exporting to the United States are not permitted to sell below these prices. Japan, Europe, and Canada have been the principal exporters of iron and steel to the United States From 1975 to 1978, these countries accounted for 43, 37, and 10% respectively of United States imports.

Exhibit IV-5 presents estimates of raw steel production by country. The United States continues to be one by the leading producers of raw steel in the world. In recent years, U.S.S.R. has produced more raw steel than the United States Japan has been the third largest producer of steel.

In 1979, the Bureau of Mines estimates that the end use of iron and steel products in the United States was as follows:

- Transportation (31%).
- Construction (27%).
- Machinery (20%).
- Oil and Gas Industries (7%).
- Cans and Containers (6%).

The highly cyclical nature of the steel industry is directly related to the changes in demand for the key markets of transportation and construction. The remaining use was provided by appliances, equipment, and other consumer and military goods.

ECONOMICS OF THE INDUSTRY

There are four levels of production in the steel industry: iron-ore mining; pig-iron production; steel making; and steel rolling. Vertically integrated companies operate in all four areas, while semi-integrated or non-integrated firms provide given segments of the production process.

Although an estimated 80 companies produced raw steel in 1979, the large, integrated producers predominate and the steel industry can be described as oligopolist. Table IV-6 shows the percentage of shipments accounted by the 4, 8, and 20 largest steel companies from 1963 to 1972.

Table IV-6

Concentration Ratios for the Steel Industry

	4 Largest	8 Largest	20 Largest
1963	51%	70%	86%
1967	48%	66%	83%
1972	45%	65%	84%

SOURCE: United States Bureau of the Census, Census of Manufacturers, 1972.

These concentration ratios indicate that, whereas the steel industry is highly concentrated, there has been a gradual decline in the share of production accounted by the largest steel companies.

The extraordinary capital requirements (including environmental control equipment) of the steel industry and the inverse relation between unit costs and volume over a significant production level have contributed to the relative concentration of the steel industry in the United States since the late 1800s. The recent movement from the concentration that typified the first two-thirds of this century has been brought about by several factors:

1. The major steel companies have not earned sufficient income to maintain adequate levels of investment in new techniques and plant. (Exhibit IV-6 presents historical financial data for 9 steel companies from 1970 to 1978. In only one year, namely 1974, did the return on equity exceed that of the average for all manufacturers. In the other years, return on equity was well below that of many other manufacturing concerns.)

2. Capital intensity and vertical integration have been made unnecessary for participation in the steel business due to new technology. Investment in electric furnaces requires for less capital than open hearth furnaces. These mills are smaller and do not require corresponding investments in iron-ore mining and coke production.

3. Importation of steel has increased significantly in the last 20 years. A trigger price system was established to set minimum prices for imported steel and it has been successful in reducing imports during 1979. However, the steel industry is generally considered to lag foreign competition (especially Japanese) in technological innovation.

4. The use of substitute materials such as aluminum and plastics for iron and steel has provided stiff competition in such markets as automobiles.

DESCRIPTION OF THE LOGISTICS SYSTEM

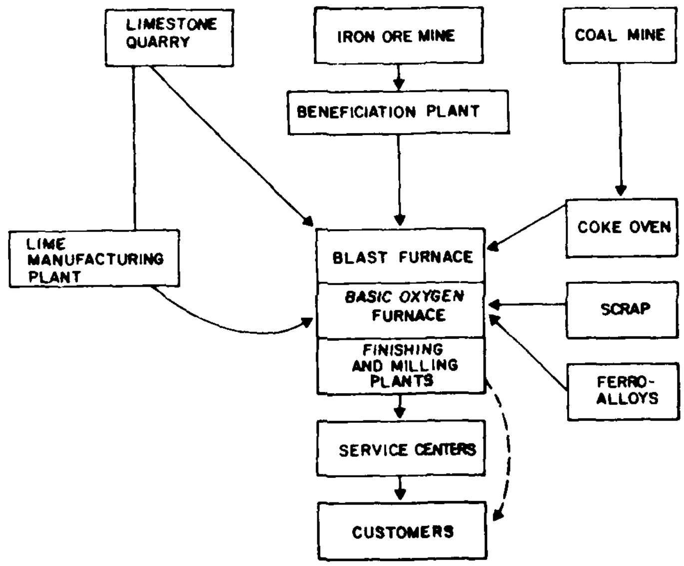
As noted earlier; there are at least three different methods of steel making. The logistics system of the basic oxygen and open hearth methods must be clearly distinguished from the logistics system of the electric furnace method. The distribution system for basic oxygen furnaces is discussed first.

(a) Basic Oxygen Furnaces

Figure IV-B depicts the distribution system of the basic oxygen method.

Figure IV-B

Distribution System for Steel Production Using Basic Oxygen Furnaces



SOURCE: Shipper Interviews

The distribution system for the basic oxygen method of steel production begins with raw material movements from mines and quarries to the blast furnaces and continues with the movement of steel products from the basic oxygen furnaces or finishing and milling plants to service centers and major customers. The discussion of the distribution system for the basic oxygen method is divided into three parts; the blast furnace, basic oxygen furnace, and customers.

1. Blast Furnace. Iron ore, coal, and limestone are the major raw materials used in pig iron production. The iron ore is typically shipped by rail from the mines to the beneficiation plants. This is a short-haul and typically involves a private railroad. The concentrated ore is then pelletized and shipped by lake vessel, rail, or barge to the blast furnaces. The predominant method of shipment is by lake vessel. These movements are high-volume movements and involve large shipments, thus, the reliable, low cost transportation of lake carriers is ideal for them. The close of navigation on the Lakes forces steel companies to stockpile iron ore during the winter. Coke must be produced from coal at coke ovens and limestone is mined and shipped to the blast furnaces for use as is or for use in the production of lime. Coal typically moves by rail or water, whereas limestone is almost exclusively lake transportation.

There are several key factors that influence the design of this stage of the steel-making distribution system. These are:

(a) The large volume of raw material shipments to the blast furnaces (In 1978, the steel industry reported that it consumed 67.5 million tons of coal, 28.7 million tons of fluxes, and over 125 million tons of iron ore and agglomerates.)

(b) Long-term commitments to raw material sources (Most steel companies operating basic oxygen furnaces have either long-term commitments for the purchase of raw materials or vertically integrated operations.)

(c) Long-term commitments to means of transportation (Some of the large steel mill operators operate their own fleets of lake vessels. In addition, they own Class II linehaul railroads. These lines have been built or acquired to move ore from the mine to the pellet plant to the port and, in some instances, to the blast furnace from the vessel receiving port. These railroads are in effect a part of the marine delivery network.)

(d) Automated transloading operation (Operations for the transfer of iron ore from rail to vessel and from vessel to port terminal have been automated by both the pelletizing of iron ore pellets and capital investment. In particular, self unloading vessels, are in common use on the Great Lakes. They can carry as much as 62,000 tons of cargo and are replacing bulkers, which require land-side cranes to discharge the iron ore.)

In addition to these considerations, steel companies recognize the need to locate blast furnaces near coastal, lake or river ports with good rail service. Although these companies seek to secure long-term supplies of raw materials before constructing new blast furnaces, markets can change. In order to take advantage of changing markets, these companies locate their blast furnaces in spots where operators have several options for receiving the large quantities of raw materials necessary to keep the furnaces running.

Exhibit IV-7 lists the principal iron and steel-making facilities in the United States by region. As can be seen, the greatest number of blast furnaces are included in the Pittsburgh, Chicago, Youngstown, and Southern districts. In each of these four districts, the blast furnaces (with only one exception) are located either within 40 miles or directly on a coastal area, river, or one of the Great Lakes. The location of plants at points with good rail service and near navigable waterways permits pig iron producers to take advantage of changing markets.

2. Basic Oxygen Furnace. The next major stage of steel-making is the basic oxygen furnace itself. The pig iron is usually transferred in a molten state from the blast furnaces to the basic oxygen furnaces. The distance travelled is typically very short and, in integrated operations, it is simply a matter of intraplant transfers. Additional inputs to the basic oxygen furnaces include lime or limestone, scrap, and ferroalloys.

The basic oxygen furnaces are typically located near the blast furnaces. Of the 42 basic oxygen furnaces listed in Exhibit IV-7, only six are located away from company-owned blast furnaces. Thus, by and large the location of basic oxygen furnaces is dictated by the location of blast furnaces. The access of basic oxygen furnaces to rail and water transportation increases the options for delivery of scrap, ferroalloys and lime.

3. Customers. Semi-finished and finished steel products move outbound from basic oxygen furnaces and steel mills to service centers and end users, such as the automotive industry, oil and gas industry, appliance manufacturers, construction industry, and manufacturers of industrial machinery and equipment. These products move out bound by truck, rail, and barge.

The design of the logistics system and choice of mode are influenced by a number of factors. As a general comment, a dominant transportation characteristic of these products is that consumers, seeking to minimize inventory carrying costs, are ordering smaller quantities in greater frequency.

Table IV-7 presents estimates of the modal share of steel product shipments for 1955 to 1974.

Table IV-7

Modal Share of Steel Product Shipments[1]

Year	Rail	Truck	Water	Total
1955	61.9%	29.6%	8.5%	100.0%
1960	55.3	36.6	8.1	100.0
1965	51.5	42.5	6.0	100.0
1970	47.3	43.6	9.1	100.0
1974	44.1	48.9	7.0	100.0

NOTE: 1/ Based on a survey of 12 companies, which shipped 60% of total industry shipments in 1974.

SOURCE: American Iron and Steel Institute

Rail and truck transportation have accounted for over 90% of all shipments in each year. Rail has consistently lost share to truck transportation.

There are several factors that explain why the waterborne share is so low and why truck transportation appears to be so well suited for steel product distribution. First, although the steel-producing facilities are located on the waterways, steel markets are often located away from the water. The entire manufacturing complex in the Northeast and East North Central regions is surrounded by water-served steel manufacturers located on the Atlantic Coast, Great Lakes, and the Ohio and Mississippi Rivers. Shipments in this area therefore tend to be away from rather than along waterways.

Second, the overwhelming majority of a mill's customers are locaterd under 500 miles from the mill. Long-haul movements, which favor the use of barge or rail, are not common. In fact, finished steel fabricators, the major users of steel products, have traditionally located their plants near mills.

Third, the relatively large shipment sizes required for water transportation limit its usefulness even for long-haul shipments. For example, the growing steel demand in the Gulf states has provided a continuous outlet for steel products from Chicago, Pittsburgh, and the Ohio River Valley. The location of much oil and shipbuilding activity at waterfront sites encourages the use of water transportation in the Gulf. Water transportation is also favored by the substantial line-haul rate advantage it has over rail. The water and rail rates from the middle of the Ohio River to Houston are $17.79 and $27.43 per ton, respectively, for wrought iron pipe. Despite this rate advantage, as much as 75% of domestic pipe and tube moving into Texas, Louisiana, Oklahoma, and Arkansas from midwestern and eastern producers is by rail. The minimum shipment size was given as the major reason for a low barge share by steel traffic managers contacted during this study. The barge rate quoted previously requires minimum shipment sizes of 1,350 tons; this is in sharp contrast to the minimum shipment size of rail of 50 to 70 tons.

Fourth, the longer transit times associated with barge transportation work against its use. The typical transit time for barge shipment from Chicago or Pittsburgh to

Houston is three or four weeks. The comparable transit time for rail shipment is one week or less. Increased transit times mean higher inventory costs, either because more of a firm's product is in transit at any one time or because larger inventories must be carried at service centers to insure against stockouts. At 15% to 18% commerical interest rates, a shipper faces a cost penalty of 0.29 to 0.34% per week for each additional dollar of inventories carried. At $400 to $500 per ton, this amount adds up to $2.60 to $3.00 per ton, further reducing the barge line-haul rate advantage.

Fifth, the increased transit time of barge transportation has a second, less tangible impact on business profitability. Each of the major steel producers competes in market areas by offering a full range of steel products. These producers must compete on the basis of price and availability. Since specialized products are typically not carried in regional inventories, the increased transit time for barge delivery might prevent such a sale.

Finally, the last reason given for the choice of rail over barge in a water-competitive market is the additional handling costs associated with barge. Rail cars are usually loaded at the steel plants and unloaded at the at the receivers' sidings, whereas barge shipments must often be transferred to trucks or rail cars for final delivery to purchasers. This transfer cost is currently $3.50 to $4.00 per ton in Houston. Subsequent delivery to receivers located 100 miles from the port can add another $10 per ton for iron and steel products and $13 per ton for pipe.

Recognizing these disadvantages, barge carriers and steel shippers have developed several means of reducing the costs of barge transportation. These include:

1. Using steel service centers, which receive large shipments of product, for the distribution of small shipments to local customers.

2. Pooling orders of two or more customers in a bargeload.

Whereas it is clear that such innovations have helped encourage waterway steel shipments, no evidence was found that they are sufficient to augment waterway traffic shares significantly.

(b) Electric Furnaces

The logistics system for electric furnaces in far less complex than that of the basic oxygen or open hearth furnaces.

The principal input to electric furnaces is scrap. (At the present time, there are only three major direct-reduced iron plants in the United States, as noted in Exhibit IV-7). The scrap industry has traditionally been a heavy rail user. The reliance on rail is attributable in part to the physical characteristics of iron and steel scrap. Scrap metal is dense, frequently over sized, and sharp-edged. In addition, the distribution of scrap is regional. Although long-haul shipments of scrap occur, shippers indicate that the average distance of scrap shipments is approximately 175 miles, a relatively short haul. The location of many electric furnaces away from water sites also limits the use of barge transportation.

The distribution of products from electric furnaces is limited by and large to rail and truck, due to the relatively small capacity of most "mini-mills". Whereas the range of the annual capacity of basic oxygen furnaces is anywhere from 150,000 to 10,400,000 tons, the range for electric furnaces listed in Exhibit IV-7 is only 20,000 to 2,000,000 tons. Electric furnaces typically produce high-value products, such as high-alloy, specialty products, or serve localized markets, such as a market for reinforcing bars.

PRINCIPAL TRANSPORTATION FLOWS

The principal transportation flows for each of the major commodities of the steel industry are discussed below.

(a) Iron Ore

Iron ore is the most heavily water-oriented of all the steel industry raw materials and products, although only a small fraction of this commodity moves on the inland waterways.

Of the reported consumption of 125 million short tons of iron ore received at United States iron and steel plants in 1978, an estimated 87 million tons originated at domestic mines. (These estimates differ from those in Table IV-1. These estimates are based on consumption as reported by steel companies and are more useful for traffic analysis purposes.) The remainder was imported from Canada (21.1 million tons) and various overseas destinations (16.9 million tons).

Ores from the United States and Canadian Great Lakes ore-producing regions move predominantly by lake vessels to ports on the lower Lakes. At these ports, the ore is consumed at lakefront plants or transloaded by rail or truck to steel plants in the interior. The close of navigation on the Great Lakes forces steel companies to maintain significant inventories of iron ore pellets at the blast furnaces during the winter months. Great Lakes ore provides the overwhelming share of ore consumed in the Great Lakes and Ohio River Valley steel regions, but seldom moves south of the Ohio River or west of the Mississippi River. Ore from the other domestic mining districts moves by rail.

About two thirds of eastern Canadian iron ore enters the Great Lakes via the St. Lawrence Seaway and serves the same consuming area as the Lake Superior ore. The remainder of the eastern Canadian ore and all of the overseas foreign ores enter the United States at coastal parts.

Ore imported at coastal parts is generally consumed at plants located in the port area or within a short distance of the port (e.g., 50 miles from Philadelphia to the Bethlehem, Pa. facility). There are several exceptions to this pattern, however. First, the ICC One Percent Waybill

Sample indicates that 4 to 5 million tons of ore per year move from eastern Pennsylvania and Maryland to Western Pennsylvania and the Ohio River Valley, with very small amounts going as far as Chicago. Although some of this ore is certainly imported, as much as half may historically have come from the now-defunct iron ore mines in eastern Pennsylvania. Second, the ore imported at Wilmington, North Carolina moves down the Atlantic Intracoastal Waterway to South Carolina. Third, Alabama iron and steel production takes place in the Birmingham-Gadsden belt, near metallurgical coal sources, and requires rail or barge transportation beyond the Port of Mobile. Finally, less than 1 million tons of specialty ore is imported at the Baton Rouge to Gulf Region for movement by barge to inland plants.

(b) Limestone

In 1978, 28.7 million tons of flux were consumed in iron and steel production. Limestone accounted for 18.6 million tons (including 9.7 million tons used directly in pig iron production). Other fluxes included lime (8.3 million tons) and flourspar (0.7 million tons).

The Great Lakes play a significant in the delivery of limestone to the northern steel producing areas. Michigan is the principal origin of this limestone. Ohio River producers are the only steel makers who depend in any significant way on inland water transportation of limestone and lime and, in this case, the movements are short.

(c) Iron and Steel Scrap

In 1978, 76.2 million tons of scrap were consumed by the steel industry. Of this total, approximately 36 million tons were received from outside the plants.

The waterways are a minor source of scrap for the most part. No more than 1.5 to 2.3 million tons of scrap have moved annually in domestic waterborn commerce from 1969 to

1977. The Houston Ship Channel is the largest scrap destination on the waterway system and much of this scrap is originated on the Warrior River.

As noted earlier, scrap exports have ranged from 5.9 to 11.5 million tons in recent years.

Exhibit IV-8 provides a summary of 1977 rail traffic flows. As can be seen, the principal rail flow originates and terminates within the Official territory. The other major flows are also intraregional.

(d) Coke

Most coke is produced at furnace-plants and consumed on site. Due to coding problems, domestic waterborne shipments of coal coke are difficult to measure. Shippers contacted for this study indicate, however, that very little coke is received by water at any of their facilities. Rail is the dominant mode.

The decline in domestic coking activity has resulted in an increase in coke imports above historical levels. In the event of a strong steel market in the mid-1980s, it is possible that coke imports could rise substantially. Whereas the Baton Rouge to Gulf region would appear to be the logical port for these imports (given the large coke demand at barge-served plants on the Ohio River), such a boon in waterway coke activity is not likely. Normally the coke plants in the Ohio River Valley have excess production and make shipments to blast furnaces located on the Atlantic and Gulf Coasts. In periods of strong demand, blast furnaces in the Ohio River Valley will draw on this surplus and coastal blast furnaces will be forced to rely on foreign imports to a greater degree.

(e) Manganese and Ferroalloys

As noted previously, the iron and steel industry consumes ferromanganese, ferrosilicon, ferrochromium, silicomanganese, and other miscellaneous alloys.

Manganese alloy production from the ore is concentrated in West Virginia, Pennsylvania, Ohio, Kentucky, and Tennessee. This ore has been imported through the Baton Rouge to Gulf region and has moved by barge into the Ohio, Kanawha, Tennessee, and Monongahela Rivers. Other ports of entry include Mobile and selected Atlantic Coast ports.

In recent years, there has been an increase in the imports of manganese alloys at the expense of manganese ore. Tables IV-8 presents estimates of United States imports for the ore and alloy.

Table IV-8

U.S. Imports of Manganese Ore and Ferromanganese
(Millions of Tons)

	1973	1974	1975	1976	1977	1978
Manganese Ore	1.5	1.2	1.6	1.3	0.9	0.5
Ferromanganese	0.4	0.4	0.4	0.5	0.5	0.7

SOURCE: Bureau of Mines, Mineral Commodity Summarties, 1980

If this trend continues, a growing share of the industry's needs for ferroalloys will be met by importation at the Baton Rouge to Gulf region with subsequent barge movement as far as Chicago and Pittsburgh. Reduced domestic production will lead to continued declines in barge shipments of manganese ore to Ohio River destinations.

(f) Steel Products

Domestic steel producers shipped 97.9 million tons of steel products to be rest of the economy in 1978. Inclusion of shipments to other steel companies and among plants of the same company increases the total transportation requirements by another 20-25 million tons. In addition, 22.3 million tons of steel products were imported, more than 85% of these imports entered the country by vessel and required transportation beyond the dock.

Annual domestic waterborne steel product shipments from 1965 to 1977 varied between 6.3 and 9.0 million tons. The bulk of this traffic has been on the inland waterways. River steel traffic has been boosted by strong demand in the Gulf states. Thus, steel has moved by barge from Chicago, Pittsburgh, and points on the Ohio River to the Gulf.

The imported steel products were nearly evenly divided among the four coasts in 1978. Table IV-9 presents estimates of each coast's share of foreign imports.

Table IV-9

U.S. Imports of Steel Products

	1977	1978	
	(Millions of tons)	Millions of tons)	Percent of Total
Atlantic Coast	3.7	4.2	20%
Gulf Coast and Mexican Border	5.0	6.3	30
Pacific Coast	3.3	4.3	20
Great Lakes and Canadian Border	7.1	6.0	29
Offshore	0.2	0.3	1
TOTAL	19.3	21.1	100%

Receipts of some imported steel did originate in the Baton Rouge to Gulf region for subsequent shipment by barge to points on the Lower Upper Mississippi, Tennessee, Ohio, and Illinois Rivers. In 1977, for example, over 2.5 million tons of steel products were imported between New

Orleans and the Mouth of Passes. More than 1.7 million tons of barge traffic resulted from these imports. However, most steel imports move by truck or rail from ports of entry.

As discussed previously, rail and truck transportation have accounted for over 90% of steel product shipments (see Table IV-7). Exhibit IV-9 presents a summary of rail traffic flows for semi-finished and basic steel products. The principal flows are within the Official territory and within the transcontinental territory. The dominance of traffic within the Official territory underscores the fact that many producers and users are located in the Great Lakes area.

FACTORS INFLUENCING FLOWS IN THE FUTURE

There are at least four factors that might be expected to influence the steel industry in the future. These factors are:

1. Federal assistance to the United States steel industry.

2. Increased imports of steel.

3. Increased imports of coke.

4. Construction of additional electric furnace capacity.

Each of these factors is discussed below.

The financial performance of the United States steel industry has been poor in recent years. For eight of the last nine years, the return on equity for the steel industry has lagged well behind that of all United States manufacturers (see Exhibit IV-6). The below average profits of the industry have led to a deterioration in its financial position. Standards & Poor reports in its October 11, 1979 Steel-Coal Basic Analysis that the debt to equity ratio of the steel industry had worsened to 0.44

in 1978 from 0.37 at year-end 1969. Since the industry has not been able to generate sufficient funds from operations, it has been forced to borrow in order to finance much of its new investment.

In view of this relatively poor financial performance, the United States steel industry is hoping for increased assistance from the federal government during the 1980s. On the basis of a survey of domestic steel leaders, Business Week reports in its January 14, 1980 issue that this help could come in several ways:

- Tax relief.
- Easing of some environmental regulations.
- More protection from steel imports.

In 1979, the steel industry was helped in at least two ways. First, the United States Treasury accelerated the depreciation rate at which the steel industry could write off its assets for tax purposes. Steel producers can write off plant and equipment purchased after August 17, 1979 over a 12-year period rather than a 14-1/2-year period. In December 1979, the Environmental Protection Agency approved a policy whereby steel makers will be able to meet air-quality standards by controlling gaseous emissions on a plant-wide basis, rather than stack by stack. This change could save the steel industry considerable investment costs for new pollution equipment.

In addition to changes in tax and environmental regulations, some change in steel import restrictions can be expected. Recently, a major steel company in the United States filed dumping suits against Japanese and European steel-makers under the Trade Act of 1979. The Act permits speedier handling of such cases and is more specific about the methods of giving relief to complainants. A possible compromise as reported by Business Week in its January 14, 1980 issue is negotiated quotas.

The exact form of assistance to the United States steel industry will influence the level of steel and coke imports to the United States over the next 10 to 20 years. With increased federal assistance, it is quite possible that steel and coke imports will not increase over 1977 - 1979 levels. Without such assitance, imports are likely to capture much of the growth in United States steel demand over 1977 - 1979 levels.

Although it is not possible to draw inferences about waterborne flows of raw materials and products of the steel industry from changes in federal assistance, it is possible to discuss the impact of increased steel and coke imports on waterborne flows.

Increased steel imports will result, of course, in increased receipts at coastal and Great Lakes ports. In addition, some increase in inland waterway transportation can be expected. This increase in traffic will originate in the Baton Rouge to Gulf region (for shipment to destinations on the Lower Upper Mississippi, Tennessee, Ohio, and Illinois Rivers) and possibly Lake Michigan from Canadian ports (for shipment to points on the Illinois and Mississippi Rivers). These flows would not represent a change in the nature of waterborne flows; rather, they would represent an increase in existing flows.

Increased imports of coke are also possible without some form of assistance to the United States steel industry. However, such imports are not likely to result in a basic change of waterborne flows. As discussed earlier, the coke plants in the Ohio River Valley have some surplus coke capacity and make shipments of coke to users on the Atlantic and Gulf coasts during periods of low demand. In periods of strong demand, this "surplus" capacity in the Ohio River Valley would meet much of the needs of steel producers in that area; thus, no internal waterborne shipments to these plants would be necessary. Increased imports of coke would be necessary for users on the Atlantic and Gulf Coasts to meet their needs.

Increased construction of electric furnace capacity could be expected to change waterborne flows in at least two ways. First, some of this increased capacity will replace existing open hearth furnaces. The effect will be lower shipments of iron ore, limestone, and coke to areas with large amounts of open hearth furnaces. Second, increased steel-making capacity in net deficit steel areas, such as Texas, will reduce waterborne flows of finished products.

There are three districts listed in Exhibit IV-7 with significant amounts of active open hearth capacity. These are the Pittsburgh, Northest Coast, and Chicago districts. As this open hearth capacity is gradually retired, some of it will be replaced with electric furnaces. Since the feed of electric furnaces is almost exclusively scrap at the present time, a reduction of iron ore, coke, and limestone shipments to plants in these districts is possible. This could be expected to affect iron ore and limestone shipments on the Great Lakes more than any other waterborne movement. It should be emphasized that not all the open hearth capacity that is retired will be replaced by electric furnaces. On the contrary, some increase in basic oxygen furnaces can be expected.

According to an Institute for Iron and Steel Study entitled Steel In Texas -- Working Into The Mainstream, the raw steelmaking capacity in Texas is expected to reach 9.5 million tons by 1990 (from 3.7 million tons in 1970). This new capacity coupled with steel imports to the Gulf will reduce downbound flows of steel from Chicago, Pittsburgh, and other points on the Ohio River to Houston.

EXHIBIT IV-1

U.S. RAW STEEL PRODUCTION BY TYPE (MILLIONS OF SHORT TONS)

Year	Carbon	Alloy	Stainless Steel	Total
1974	126.6	17.0	2.2	145.7
1975	100.4	15.2	1.1	116.6
1976	112.0	14.3	1.7	128.0
1977	108.1	15.3	1.9	125.3
1978	116.9	18.2	2.0	137.0

SOURCE: American Iron & Steel Institute

EXHIBIT IV-2

NET INDUSTRY SHIPMENTS AND NET IMPORTS
OF STEEL PRODUCTS IN 1978
(MILLIONS OF TONS)

Product	Shipments from Domestic Mills	Net 1/ Imports	Total	Percent of Total
Semi-finished	5.1	1.4	6.5	6%
Shapes, Pilings, and Plates	13.6	4.6	18.2	16
Rails and Accessories	1.7	0.2	1.9	2
Bars and Tool Steel	16.9	1.0	17.9	15
Pipe and Tubing	8.4	2.5	10.9	9
Wire Products	2.5	1.0	3.5	3
Tin Mill Products	6.1	-	6.1	5
Sheets and Strip	43.6	8.0	51.6	44
TOTAL	97.9	18.7	116.6	100%

NOTE: 1/ Preliminary estimates.

SOURCE: American Iron & Steel Institute.

EXHIBIT IV-3

WORLD IRON ORE PRODUCTION AND RECOVERABLE IRON RESERVES

Country	Iron Ore Production[1] (Millions of Long Tons) 1978	1979	Reserve Base of Recoverable Iron[2] (Millions of Short Tons)
U.S.S.R	237	240	31,000
Brazil	84	86	18,000
United States	82	84	5,800
Australia	82	84	11,800
Mainland China	69	69	3,000
Canada	41	53	12,000
India	38	40	6,200
All Others	201	208	17,200
WORLD TOTAL	834	864	105,000

NOTE: 1/ Preliminary estimates.

NOTE: 2/ That part of an identified resource that meets minimum physical and chemical requirements related to current mining and production practices, including those for grade, quality thickness and depth, regardless of current economic requirements related to extraction and marketing methods.

SOURCE: Bureau of Mines, Mineral Commodity Statistics, 1980.

EXHIBIT IV-4

UNITED STATES PRODUCTION AND USE OF STEEL PRODUCTS
(Millions of Short Tons)

	Net Industry Shipments	Net Imports	Apparent Consumption
1973	111.4	11.1	122.5
1974	109.4	10.2	119.6
1975	80.0	9.0	89.0
1976	89.5	11.6	101.1
1977	91.2	17.3	108.5
1978	97.9	18.7	116.6
1979 1/	100.5	14.6	115.1

NOTE: 1/ Preliminary estimates from Standard & Poor's Industry Surveys: Steel-Coal Basic Analysis.

SOURCE: American Iron & Steel Institute.

EXHIBIT IV-5

WORLD RAW STEEL PRODUCTION
(MILLIONS OF SHORT TONS)

	1978	1979 1/
Central Economy Contries	270.2	283.0
United States	137.0	136.1
Japan	112.6	123.0
West Germany	45.5	51.4
France	25.2	25.3
United Kingdom	22.3	24.1
Other Countries	171.9	176.4
TOTAL	784.7	819.3

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

EXHIBIT IV-6

FINANCIAL DATA FOR MINE
SELECTED STEEL COMPANIES[1]

	Net Income/ Sales	Return on Equity
1970	3.0%	4.5%
1971	2.8	4.4
1972	3.3	5.4
1973	4.3	8.6
1974	6.5	15.4
1975	4.7	9.2
1976	.5	7.1
1977	0.7	1.6
1978	3.1	7.8

NOTE: 1/ Companies included in the analysis are Armco Steel, Bethlehem Steel, Inland Steel, Interlake, Inc., National Steel, Republic Steel, United States Steel, Wheeling-Pittsburgh Steel, and Lykes Corp. (Through 1978).

SOURCE: Standard & Poor's, Industry Surveys: Steel-Coal Basic Analysis, 1979.

EXHIBIT IV-7

U.S. IRON AND STEEL - MAKING FACILITIES

District	Number of Facilities[1]			Annual Raw Steel Capacity[2] (Millions of Tons)		
	Coke Ovens	Blast Furnaces	Steel Furnaces	Open Hearth	Basic Oxygen	Electric Furnaces
Northeast Coast	5	5[3]	23	6.8	7.2	6.5
Buffalo	4	2	9	0.0	3.8	0.7
Pittsburgh	11	14	29	9.0	16.6	4.9
Youngstown	4	6	10	NA[4]	7.0	3.6
Cleveland	2	3	7	0.0	20.4	1.7
Detroit	2	3	9	0.0	10.1	2.7
Chicago	8	7	28	4.2	30.1	7.7
Cincinnati	5	4	7	0.0	6.3	1.1
St. Louis	2	1	4	0.0	2.5	3.0
Southern	7	6[3]	29	0.0	6.5	8.8
Western	4	5[3]	20	0.9	7.3	3.6
Carribean	0	0	1	0.1	0.0	0.0
TOTAL	54	56	176	21.0	117.8	44.3

NOTE: 1/ This exhibit lists the major iron and steel facilities in the United States as of the end of 1979.

NOTE: 2/ Estimated capacity.

NOTE: 3/ Includes one direct reduction plant.

NOTE: 4/ No estimate of the annual capacity for one plant was available.

SOURCE: Institute for Iron and Steel Studies and Shipper Interviews.

EXHIBIT IV-8

UNEXPANDED ONE PERCENT WAYBILL SAMPLE --
IRON AND STEEL SCRAP SHIPMENTS FOR 1977
(TONS)

Origin Territory	Destination Territory: Official	Southern	Western Trunk Line	Southwest	Transcontinential	Total
Official	64,399	1,466	414	324	724	67,327
Southern	3,044	14,158	--	577	--	17,779
Western Truck Line	257	--	10,335	1,087	911	12,590
Southwest	285	460	648	4,815	36	6,244
Transcontinental	30	--	150	--	4,589	4,769

SOURCE: One Percent Waybill Sample for 1977.

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UNEXPANDED ONE PERCENT WAYBILL SAMPLE --
SEMI-FINISHED AND BASIC STEEL PRODUCTS SHIPMENTS FOR 1977
(TONS)

Origin Territory	Destination Territory: Official	Southern	Western Trunk Line	Southwest	Transcontinental	Total
Official	39,579	2,737	51	946	521	43,834
Southern	4,159	203	--	221	--	4,583
Western Truck Line	--	--	323	--	--	323
Southwest	--	92	--	681	--	773
Transcontinental	--	--	--	--	6,597	6,597

SOURCE: One Percent Waybill Sample for 1977.

V - PETROLEUM AND PETROLEUM PRODUCTS

The petroleum and petroleum products industry is comprised of both crude oil and a number of derived petroleum products. The principal petroleum products for waterborne commerce include residual fuel oil, distillate fuel oil, gasoline, jet fuel, kerosene, and asphalt, lubricating oils and greases, naphtha, petroleum coke, and liquefied gases.

The extreme importance of petroleum flow is evidenced by the near paralysis in the United States during the Arab oil embargo of 1973-1974. The United States was, at one time, self-sufficient in crude oil and a major net exporter. However, due to increasing domestic demand, decreasing domestic production, and the inelasticity (lack of substitutability) of demand for many uses, the United States now receives about 42% of its crude oil from foreign sources.

For now and the immediate future, petroleum will be the principal United States waterborne commodity. Approximately one-half of all marine commodity flows arise from the shipment of crude oil and petroleum products. Given the dependence of the United States on foreign oil, this activity is unlikely to diminish to any appreciable extent.

Table V-1 on the following page, presents estimates of 1977 waterborne flows of petroleum and products.

As can be seen, petroleum traffic is almost evenly divided between foreign and domestic traffic. Petroleum and its products represent the single category with the largest amount of both domestic and foreign waterborne commerce.

The foreign traffic is predominantly crude oil imports, although residual fuel is also imported in large volumes.

By way of contrast, domestic flows are predominantly petroleum products. These flows are primarily inland, coastal, and intraharbor shipments. The tonnage of petroleum and products shipped on the inland waterways even exceeds the tonnage of inland coal shipments.

Table V-1

1977 Waterborne Flows of Petroleum and Products
(Millions of Tons)

	Domestic	Foreign	Total
Crude Petroleum	84.8	403.9	488.7
Residual Fuel Oil	134.0	68.5	202.5
Gasoline	94.9	3.6	98.5
Distillate Fuel Oil	89.7	7.8	97.5
Jet Fuel	12.7	-	12.7
Asphalt	9.5	-	9.5
Kerosene	5.4	3.2	8.6
Lubricating Oils and Greases	5.8	1.3	7.1
Naphtha	5.9	-	5.9
Liquefied Gases	1.3	3.5	4.8
Other	5.4	1.2	6.6
TOTAL	449.4	493.0	942.4

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1979.

The material on petroleum is divided with the following headings:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.
- Description of the Logistics System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

COMMODITY CHARACTERISTICS

Crude petroleum and its refined products play a significant role in the United States energy economy. Oil competes with other sources of energy, including coal, natural gas, and nuclear power, to provide energy for utility, industrial, commerical, residential and transportation demands.

Crude petroleum is generally thought to have been formed as the end product of the organic decay of prehistoric plant and animal life. Such crude is a bundle of compounds which must be separated to produce products. The process used to separate the constituent compounds is called refining. The three principal refining processes are separation, conversion, and treating. Each of these processes is discussed below.

Three methods of separation are used to physically fractionate and recover the components of crude oil: distillation, solvent extraction, and refigeration. Distillation separates components by heating crude oil in pipes running through a furnace; this breaks the crude into liquids and gases that are discharged into a fractioning tower. The liquid residues (heavy oil, wax or asphalt) are drawn directly off the bottom of the tower, while the crude oil vapor moves upward through the tower and compounds condense at increasingly lower temperatures.

Solvent extraction is the process of separating compounds by using solvents. Refrigeration is the process of solidifying certain compounds in crude oil.

In contrast to separation, conversion refining refers to changing the chemical structure of certain compounds, primarily to recover lighter fuels. Thermal cracking is the use of high temperatures and pressure to break the large hydrocarbon molecules into smaller molecules. Catalytic cracking is a similar process, except that catalysts rather than high pressure are used to break the large molecules. Finally, polymerization is the process of squeezing small gaseous hydrocarbon molecules at high temperatures to build larger and heavier compounds. (This process is discussed further in Section VII.)

The third and final process of refining crude oil is called treating. Treating removes impurities from crude oil. Crude oil is not a uniform commodity from one part of the world to another; crude oil is distinguished by its specific gravity, chemical structure of its base after complete distillation (wax, asphalt, or mixed), its sulfur content ("sourness"), and its content of physical contaminants (sand). Copper sweetening, doctor treating, acid treatment, and desulfurizing are some of the treating methods.

Gasoline, kerosene, light and heavy fuel oils, jet fuel, and heavy products (asphalt, coke, and waxes) are major refinery outputs. Table V-2 presents estimates of the yield from crude oil refined in the United States during 1978.

Table V-2

Yield of Crude Oil Refined by 1978

Gasoline	48.5%
Distillate Fuel Oil	20.9
Residual Fuel Oil	11.1
Jet Fuel	6.5
Lubricants	1.3
Kerosene	1.0
Other Products	10.7
TOTAL	100.0%

SOURCE: Department of Energy

Gasoline and distallate fuels were the most important petroleum products; the latter are used in diesel engines and domestic heating units. Residual fuel oils are heavy, complex compounds used in large power plants and boilers. It should be noted that the output from a refinery can be changed to adapt to the varying requirements of the market and, as a result, the end-product yield from the refining of crude oil does change from one year to the next.

Table V-3 presents a list of petroluem products by end use application.

Table V-3

Petroleum Products and Applications

Product Name	Pipeable Product	Applications for Product
Aviation Gasoline	Yes	Used for fueling gasoline fuel aircraft. Less than 2% of total gasoline consumption.
Motor Gasoline	Yes	Used for fueling gasoline automobiles, trucks, and boats.
Jet Fuel (Kerosene)	Yes	Kerosene based jet fuels. Used predominatly for commercial jet engines.
Jet Fuel (Naptha)	Yes	Naptha based jet fuels. Used predominantly for commercial jet engines.
Kerosene	Yes	Used for industrial and residential space heating and lighting applications.
Diesel Fuel	Yes	Used for fueling truck, automotive, marine and rail diesel engines.
Distillate Fuels	Yes	Residential, industrial, commerical heating, utility generation, marine applications other than diesel.
Residual Fuels	No	Utility generation, industrial heating, some marine fuels.
Lubricants	No	Used in transportation and industry for lubrication.

Table V-3 (Cont'd)

Petroleum Products and Applications

Product Name	Pipeable Product	Applications for Product
Naptha and Solvents	Yes	Generic name for petroleum product and natural gas liquids with a specific range of boiling points. Some are particularly suited for use in cleaning and other industrial applications as solvents.
Asphalt, Tar, and Pitches	No	Comprised of coal coking and refinery by-products, which yield petrochemicals and heavy petroleum residuals upon further processing.
Coke	No	A relatively pure carbon solid residue remaining after high temperature distillation of heavy petroleum oils. Used primarily as an in-refinery fuel.
Liquified Gases	Yes	Natural gas and petroleum gases recovered in processing. Used as petrochemical feedstock, in refinery fuel.
Asphalt Building Materials	No	Used in construction as binder for aggregates, and as roofing materials.

SOURCE: Shipper Interview

MARKETS

This subsection is divided into three parts: world, United States, and regional markets.

(a) World Markets

The importance of crude oil and petroleum flows can best be understood in the context of the worldwide and United States energy situation. World energy consumption has increased at an annual rate of 4.2% since 1960, with total consumption in 1977 estimated at 8,541 billion metric tons. The United States share of total consumption declined from 34.7% to 29.4% during that period.

Total world production of crude oil, natural gas, and coal, increased since 1960 at annual rates of 6.4%, 6.8% and 1.6% respectively. However, the U.S experienced significantly smaller rates of growth for two of these three energy sorces, namely crude oil (0.9%) and natural gas (2.7%).

Worldwide production of oil in 1977 was an estimated 60 million barrels a day. Table V-4 presents crude oil production by region for, 1960 through 1977.

Table V-4

World Production of Crude Oil
(Millions of Barrels per Day)

	1960	1970	1975	1976	1977
Middle east	5.3	14.0	19.6	22.2	22.4
U.S.S.R., China and Cuba	3.3	7.9	11.9	12.6	13.1
United States	7.1	9.6	8.4	8.1	8.2
Other Countries	5.3	14.3	13.5	15.2	16.3
WORLD TOTAL	21.0	45.8	53.4	58.1	60.0

SOURCE: Department of Energy.

After increasing production significantly throughout the 1960s and early 1970s, Middle East countries have stabilized their output. Although U.S.S.R. and China have been successful in increasing their oil production throughout the 1970s, several experts suggest that U.S.S.R. output will decline in coming years.

Overseas oil reserves are ample for decades, with Saudi Arabia holding by far the largest reserves of any country. OPEC countries hold some 70% of the world's proven crude reserves, and produce about half of the world's crude oil at the present time. With currently proven world oil reserves placed at around 650 billion barrels, additions to reserves have not been keeping pace with production. Since 1975, world reserves of crude have been declining about 6 billion barrels per year.

During the 1980s, there will be at least a few countries where increased production is likely. The North Sea fields should double output of crude oil, to about four million barrels a day. Mexico will increase its production from 1.7 million to at least three million barrels a day. China is also expected to increase its production to three million barrels per day.

It should also be noted that ther is substantial oil above and beyond that which is considered proven reserves. Since proven reserves are defined as being recoverable under existing economic conditions, they exclude oil that can be recovered at prices above present world markets. On the basis of a poll of oil companies, consultants, and government agencies, the Standard & Poor's Industry Surveys of Oil (dated June 7, 1979) concluded that the oil remaining to be discovered and developed is about triple present proven reserves.

(b) United States Markets

United States energy production and consumption patterns are shown in Exhibit V-1. It can be seen that total production has steadied at some 60 quad Btus, while consumption continues at about 75 quad Btus, on an annual basis. Particularly distressing is the shortfall in petroleum production, which translated into 2.4 billion barrels of imported oil in 1977. The distribution of oil imports by country of origin is shown in Table V-5.

Table V-5

United States Crude Oil Imports for 1977

	Millions/of Barrels	Percent of Total
Non-OPEC		
Canada	102	4.2
Mexico	65	2.7
Trinidad	49	2.0
Britain	36	1.4
Other	104	4.4
Subtotal	356	14.7
OPEC		
Algeria	198	8.2
Indonesia	185	7.7
Iran	193	8.0
Libya	257	10.6
Nigeria	412	17.1
Saudi Arabia	501	20.8
Un. Arab Emir.	122	5.1
Venezuela	91	3.8
Other	99	4.0
Subtotal	2,058	85.3
TOTAL	2,414	100.0

SOURCES: United States Bureau of Mines, Minerals Yearbook; and United States Dept. of Energy, Energy Data Report

As can be seen, the United States has relied on oil from OPEC countries for well over 80% of its crude oil imports.

The recent loss of Iran's nearly 200 million barrels of crude oil, representing about eight percent of total imports, has been managed in part through pricing strategies to reduce domestic consumption. In fact, this strategy has succeeded in producing a temporary glut of oil on world markets, to be likely handled through further price increases and production restrictions.

Table V-6 contains data on United States, fossil fuel prices. The sharp escalation in the price of crude oil in 1978-1980 is not reflected in these figures.

Table V-6

United States Fossil Fuel Prices
(¢ per million Btus)

	1960	1965	1970	1974	1977	Compound Annual Growth Rate '60-77
Crude Oil	49.7	47.6	52.1	118.5	147.8	6.6%
Natural Gas	55.2	48.1	50.7	124.9	173.9	7.0
Bituminons Coal	18.3	17.5	25.5	66.4	89.5	9.8
Weighted Composite 1/	30.0	28.5	32.5	72.4	107.3	7.8

NOTE: 1/ Includes dry natural gas and anthracite as well as crude oil, natural gas, and bituminous coal.

SOURCE: United States Dept. of Energy, Annual Report to Congress

As can be seen, all prices of fossil fuels have increased sharply in recent years. The largest increases in absolute terms have been in crude oil and natural gas prices. While coal prices have increased, the absolute level of increase has been more moderate. These higher prices have encouraged users in the United States to conserve on all forms of energy. The sharp increases in natural gas and crude oil prices have encouraged United States users to convert to coal where feasible.

United States oil consumption has moderated in recent years, with a two percent decline to 18,372,000 barrels of oil per day experienced in 1979. This level reflects current economic conditions and efforts at conservation. Consumption of oil in other developed industrial countries have risen, however, reflecting in part the general inefficiency of past United States oil use (see Table V-7).

Table V-7

Oil Consumption in Selected Industrial Nations
(Thousands of Barrels Per Day)

	1978	1979	Per Cent Change
United States	18,745	18,372	-2.0
Japan	5,021	5,114	+1.9
West Germany	2,598	2,681	+3.2
France	2,010	2,074	+3.2
Canada	1,681	1,760	+4.7
Great Britian	1,668	1,700	+1.9
Italy	1,520	1,588	+4.5

SOURCE: American Petroleum Institute.

(c) Regional and State Markets

Within the United States, crude oil is produced in a number of states. Exhibit V-2 presents estimates of daily production and proven reserves by state for 1970 and 1977.

As can be seen by Exhibit V-2, United States production of crude oil is concentrated in such states as Texas, Louisiana, Alaska, and California. From 1970 to 1978, daily production of crude oil remained constant or actually declined in all major oil-producing states with the exception of Alaska. The discovery and development of the oil reserves on the North Slope have been responsible for the recent increases in Alaskan crude oil production.

As can also be seen by this exhibit, proven reserves of crude oil have declined in every major oil-producing state from 1970 to 1978.

A more complete picture of the nature of United States regional markets for crude petroleum can be obtained by examining petroleum activity by Petroleum Administration for Defense Districts (PADD). Exhibit V-3 presents a map of the five PAD Districts. The 50 states have been divided into five Districts. Alaska and Hawaii have been included in PADD 5.

Table V-8 presents estimates of annual crude oil production by PADD for 1970, 1977, and 1978.

Table V-8

Annual Crude Oil Production by PADD
(Millions of Barrels)

	1970	1977	1978
PADD 1	11.4	52.7	53.5
PADD 2	426.9	325.6	321.1
PADD 3	2,375.2	1,869.8	1,770.7
PADD 4	246.3	241.8	234.1
PADD 5	457.8	519.4	795.8

SOURCE: Energy Information Adminstration of the United States Department of Energy.

As can be seen, crude oil production has declined since 1970 in three of the five PADDS, including the district with the largest crude oil production. Crude oil production in PADD has declined throughout most of the 1970s, but, with the Alaskan 5 North Slope production, production has increased dramatically.

Table V-9 presents estimates of annual crude oil imports by PADD for 1970, 1977, and 1978.

Table V-9

Annual Crude Oil Imports by PADD
(Millions of Barrels)

	1970	1977	1978
PADD 1	211.4	548.6	530.5
PADD 2	115.6	516.9	496.3
PADD 3	0.0	919.0	1,022.2
PADD 4	17.6	15.4	18.8
PADD 5	138.7	397.6	206.9

SOURCE: Energy Information Administration of the United States Department of Energy.

As can be seen, crude oil imports have increased since 1970 in all PADDs, except for PADD 4. (Oil producers located in PADD 4 are able to meet the demand for crude oil in their district). The largest increase in crude oil imports has taken place in PADD 3. Alaskan oil has reduced the need for crude oil imports on the West Coast.

Table V-10 presents estimates of crude oil refined by PADD for 1970, 1977, and 1978.

Table V-10

Annual Crude Oil Refined by PADD
(Millions by Barrels)

	1970	1977	1978
PADD 1	470.9	611.3	626.8
PADD 2	1,151.3	1,379.3	1,389.7
PADD 3	1,590.2	2,321.9	2,351.2
PADD 4	143.3	171.1	176.3
PADD 5	611.8	848.2	832.7

SOURCE: Energy Information Administration For Department of Energy.

Since there are crude oil transfers from one region to another (principally from PADD 3 to PADDs 1 and 2), the amount of crude oil refined in a district will not necessarily equal the sum of its production and imports.

As can be seen by Table V-10, the greatest increase in oil refining has taken place in PADD 3. PADD 3 accounts for over 50% of the total increase from 1970 to 1978 in oil refined.

Table V-11 presents estimates of net demand for crude oil by region. Net demand refers to the additional demand for crude oil or equivalent products after taking into account district production and imports.

Table V-11

Net Demands (Supplies) of Crude Oil or Equivalent Proudcts by PADD (Millions of Barrels)

	1970	1977	1978
PADD 1	248.1	10.0	42.7
PADD 2	608.8	536.9	572.3
PADD 3	785.0	466.9	441.8
PADD 4	120.6	86.1	76.6
PADD 5	15.4	68.8	170.0

SOURCE: Energy Information Administration for Department of Energy.

As can be seen by Table V-11, PADDs 1 and 2 have had to obtain additional supplies of petroleum and petroleum products from other United States regions. PADD 3 with its relatively large production, imports, and refining capacity has met much of this residual demand.

The imbalance among regions creates a need for the domestic transportation of products and crude to satisfy net demand. The actual behavor of the regions may involve the simultaneous import and export of petroleum and products from region-to-region, thus making the specification of logistics flows somewhat difficult.

ECONOMICS OF THE INDUSTRY

The United States petroleum industry encompasses crude oil and natural gas producers, specialty companies, domestic integrated companies, and international integrated companies. Producers locate and extract oil and gas from underground formations. In 1978, there were an estimated 516,000 active oil wells producing on average of 16.8 barrels per day. Over 47,000 new wells were drilled in 1978 and, of these, 18,000 and 13,000 wells produced either oil or gas, respectively.

There are a host of specialty companies in the oil industry providing a number of services, including refining, marketing, transportation, equipment manufacturing, and so on. Domestic integrated companies are involved in crude oil production and refining, as well as product marketing and distribution. The operations of these firms are by and large limited to the United States.

International integrated companies are involved in all phases of the oil industry, and their operations are worldwide. The integrated international oil companies, the so-called "Seven Sisters", are Exxon, Texaco, Mobil, Gulf, Standard Oil of California, British Petroleum, and the Royal Dutch-Shell Group.

Exhibit V-4 presents estimates of return on equity for five crude and gas producers, 18 domestic integrated companies, and the seven international companies. For comparison, the Standard and Poor's return on equity for 400 industrial firms has also been included.

The producers achieved returns on equity consistently above those of the 400 industrials, but it should be noted that these five companies include some of the best managed in the world. The integrated companies, on the other hand, had returns consistent with those of the 400 industrials, except for 1974, when oil earnings were affected favorably by the Arab oil embargo and the sharp increase in OPEC prices.

A number of factors have changed the nature of the oil industry in recent years. First, OPEC countries nationalized most of their oil-producing interests in their areas during 1972-1976. Prior to 1972, the discovery and production of much of these reserves had been handled by the international integrated companies. At the present time, remaining oil company equity holdings include a 40% stake by five oil companies in original concession interests in Saudi Arabia, and some minority production interests in Libya and Nigeria.

Second, domestic crude oil prices are to be decontrolled through the period ending October 1981. The decontrol plan establishes separate prices for newly discovered oil (after June 1979, this oil is priced at the world market), upper tier oil (oil discovered after the initial OPEC price increase but before June 1979), lower tier oil (oil discovered before the initial OPEC price hike) and stripper oil (oil from wells producing only a few barrels per day).

Gas prices are also to be decontrolled, but over a much longer period of time. The oil and gas industries have been subject to extensive price regulation over a number of years. The purpose of decontrol is to encourage producers and integrated companies to increase outlays for exploration and development.

DESCRIPTION OF LOGISTICS SYSTEM

The subsection discusses the logistics system of the petroleum industry. It is divided into the following parts:

- Logistics system movements.
- Transportation modes for petroleum.
- Transportation rates.
- Regulatory issues.

(a) Logistics System Movements

The petroleum logistics system can be described as four district movements and each of these movements is discussed below.

1. Movement from the Well Head. There are a variety of ways in which crude oil moves from the well head to the tank farm, depending on the production level of the well, the location of the well in relation to other wells in the field, the production level of the entire field, whether the field is land-based or offshore, and the distance of the move. An isolated or low production land well is generally served by tanker truck or a gathering pipeline, whereas high production, densely located wells are served by trunk pipeline.

Off-shore wells may utilize barges for both temporary storage and shipment to the task farm. However, undersea gathering pipelines are also used for this purpose. Swampy or wetland conditions usually require the use of barge transport to the pipeline for transportation to the tank farm.

2. Movement from the Crude Tank Farm. Crude oil initially is stockpiled at the tank farm for distribution to refineries. Tank farms adjacent to refineries employ pipelines; tank farms located some distance from refineries use pipeline. barge, or tanker. Pipeline would be used when the flows are large and stable in volume.

Tankers are most frequently used to transverse long ocean distances, although coastal tanker moves do occur. Barge movements occur in coastal and inland waterways for both linehaul moves and local repositioning moves.

3. Movement from the Refiner. Following the refining process, the petroleum products are moved to a product tank farm/distribution center. The distribution of petroleum products is similar to that of crude oil, except that some products are not pipeable due to their viscosity or consistency. For example, residual fuel oil must be heated to reach a pipeable state, an uneconomic procedure. Non-pipeable products, which also include lubricating greases and road asphalt, are handled by barge, tank truck, tanker, or rail. The pipeable product group includes gasoline, diesel fuel, kerosene, jet fuel, and light distillates.

4. Movement from the Product Tank Farm. Tanker, barge, pipeline, rail and truck modes are all used in movement from the product tank farm/distribution center to the site of final consumption. The typical means of distribution for some petroleum products are shown below:

- Gasoline and diesel fuel: truck.
- Jet fuel and kerosene: truck, pipe, barge.
- Distillate fuels: barge, pipeline, truck.
- Residual fuel: barge, tanker.

(b) Transportation Modes For Petroleum

As previously noted, petroleum commodities are normally carried by three modes of transportation -- pipeline, barge, and tanker, supplemented by two secondary (normally for final delivery) modes of transportation -- truck and rail. The characteristics of the five modes are such that they can be both complementary and competitive with each other, depending upon the specifics of the move.

1. Pipeline. Pipeline transportation of petroleum commodities is usually the least expensive of the modes, given that a large volume is routinely moved between the origin and the destination of the line. Pipelines are characterized by a large initial investment for construction, followed by low operating costs and debt service costs to retire construction loans. A careful

consideration of the expected demand for a flow between the origin and destination of a proposed pipeline is actually constructed.

A pipe of the proper size can offer lower unit costs per barrel of transported commodity than a smaller pipe that is not large enough to handle all the demand or a pipe that is too large and has excess capacity. To this extent, pipelines are built to handle the high density flows, leaving the low density, erratic flows to other modes of transportation. Historically, most pipelines have operated at close to capacity.

A large diameter pipeline can have tremendous throughput. The Colonial Pipeline system, a major products pipeline running from the Gulf Coast region up to the New York/New Jersey area, is a paired set of 36" pipelines (to Mitchell Junction, Virginia, from Houston) with a single smaller line running north to Linden, New Jersey. The Colonial has a design capacity of 2,100,000 and 2,300,000 barrels per day in the #1 and #2 lines respectively. However, linehaul trunk pipelines are also built as small as a single six inch pipe.

The capacity of a pipeline is dependent upon the cross-sectional area of the pipe, the product mix flowing through the pipe, the topology of the terrain the pipe traverses, the design pressure that the pipe system can safely handle, the horsepower of the pumping stations, and other factors. Assuming that demand exists to utilize the capacity, the larger the pipe, the lower is the unit cost of a petroleum movement. However, the number of locations able to provide the amount of demand needed to justify a large diameter pipeline system is small.

Pipelines are owned by a single oil company as a distribution and transportation subsidiary, a group of oil companies joining together into a consortium, or as separate financial and corporate entities not related to the major oil companies.

2. Barges and Tankers. A typical loading for a petroleum tow is approximately 2,500 tons per barge and about four barges per tow. Integrated tows (a set of barges linked together and designed to be operated as a unit) are also used to haul petroleum, with six to eight barges per tow (15,000 to 20,000 tons per tow) as a typical configuration.

Tankers have a range of capacities depending upon both the design of the vessel and allowable draft. The range varies from 400,000 deadweight tons (dwt.) for a VLCC (Very Large Crude Carrier), to 35,000 dwt. for small coastal tankers. The draft in channels and harbors in the Gulf Coast and the Atlantic Coast is generally limited, preventing tankers of the magnitude of a VLCC from entering. Some islands in the Carribean (particularly Puerto Rico and Bermuda) can receive crude oil by VLCC. United States domestic ports generally have insufficient draft to allow vessels over 80,000 dwt. from navigating channels. The proposed Louisiana offshore oil port will allow VLCCs to drop cargos destined for the United States in the Gulf of Mexico off the United States shore, with the crude being piped to shore for distribution to refineries.

In general, costs of operation for tankers decline as the dwt. of the vessels increase, assuming the vessel makes fully laden trips. Ocean-going petroleum barges are essentially huge oil tanks shaped like tanker hulls and powered by ocean tugs fitted to notches in the rear of the barges. Ocean-going barges can transport petroleum for slightly less than the cost of an equivalent sized tanker for coastal movements of 500 miles or less.

3. Rail and Truck. Rail cars carry less than 100 tons of petroleum commodity per trip, with the national average near 60 tons/car. Rail petroleum flows generally consist of less than four or five cars at a time, for a combined shipment size of 250-300 tons. Some western railroads have experimented with unit oil trains, with up to 100 cars per movement. However, such operations still have difficulty competing on a cost per barrel basis with pipeline and barge, and have been used only in specialized movements where the other modes were not available. Tank trucks carry less than 25 tons of petroleum per trip.

(c) Transportation Rates

Rates per ton mile vary across the five modes, with pipeline offering the lowest rates. In general, if there is sufficient demand to merit constructing a pipeline, then oil companies prefer to use pipeline to other modes. Pipeline rates per 100 barrel miles currently range from 2.0 cents to 12.0 cents.

Coastal tankers operate either in private service or in spot markets. The imputed rate for private operations is difficult to obtain and the spot market price varies considerably, with changes of 100% within the period of one year not unusual. The tanker rate is generally considered by oil companies to be higher than pipeline.

As there is no major pipeline for crude or products running along the West Coast, pipeline does not compete with tankers in this market. The Colonial Pipeline directly competes with coastal tanker for products movements to the East Coast, the average 1978 spot tanker rate to the New York and New Jersey area from the Texas Gulf Coast area was some-2 1/2 times the average Colonial Pipeline price. As a result, coastal tanker flows of products on the East Coast are generally product flows in excess of the joint capacity of the Colonial, the Dixie, and Plantation Pipeline Systems, the three major pipelines running from the Gulf to the East Coast.

Barge rates are generally 1.2 to 3 times the pipe rates. At the present time, barge rates per 100 barrel miles range from 5 cents to 17 cents. Barges and towboats are owned, leased, or contracted on a spot or long term basis for petroleum commodity movements. The larger the amount of petroleum commodities moved by a shipper, the greater is the likelihood of direct ownership of barges. The major oil companies can usually secure better credit terms for financing equipment acquisitions than leasing companies; leased equipment does not therefore play a large role in petroleum commodity distribution.

Rail rates are generally about seven times point-to-point pipeline rates. Rail is used for small shipments to locations not served by water or pipeline. Most rail petroleum flows occur in leased or privately owned tank cars. Truck rates are generally about 10 times pipe rates. Because of this rate differential, truck is rarely used for line haul distribution of petroleum commodities. Instead, truck is used as a means of final distribution from barge, tanker, and pipeline served distribution centers.

(d) Regulatory Issues

The safe transportation of hazardous commodities and the regulations associated with achieving this objective are playing an increasingly important role in the transport of petroleum and products. This regulation has and will continue to affect modal costs and modal choice.

The distribution of petroleum and petroleum products is regulated by the Department of Transportation, Environmental Protection Agency, and Occupational Safety and Health Administration. The principal issues regarding petroleum distribution are discussed under separate headings for each agency.

1. Department of Transportation. Regulations under Department of Transportation (DOT) jurisdictions, as administered primarily by the Coast Guard, govern waterborne commerce activity. Under the Port and Tanker Safety Act of 1978 (33 U.S.C., Sections 1221 et seq.), tankers are required to install various types of equipment designed for accident prevention and pollution control. Specific minimum standards include:

(a) Require installation of a cargo tank protection system, segregated ballast tanks, and a crude oil washing system for new crude oil tankers of 20,000 dead-weight tons (dwt) or more.

(b) Require installation of segregated ballasts or a crude oil washing system in existing crude oil tankers of 40,000 dwt or more by June 1, 1981.

(c) Require installation by 1986 of segregated ballasts or crude oil washing systems in tankers between 20,000 to 40,000 dwt, if they were at least 15 years old.

(d) Require installation of inert gas systems by 1983 in existing crude oil tankers of 20,000 dwt or more.

(e) Require all "self-propelled" vessels of 10,000 gross tons or more -- a definition that excludes most barges -- to have a dual radar system, a computerized relative motion analyzer to warn of impending collisions, an electronic position fixing device, adequate communications equipment, a sonic depth finder, a gyrocompass and up-to-date charts.

The cost of complying with these regulations is forcing oil companies to re-examine their use of coastal tankers for petroleum and product distribution. If possible, some oil companies hope to retire older vessels and forego these conversion costs by distributing more product by pipeline, the principal competition to coastal movements along the Gulf and Atlantic Coasts. Where pipeline transportation is not feasibile, oil companies will bring existing vessels into compliance or construct new vessels rather than divert shipments to rail.

DOT has also issued some proposed regulations regarding petroleum distribution by shallow-draft vessel. These proposals include construction of double-skin barges and early retirement of barges after 20 years of petroleum service. Once again, oil companies can be expected to examine other alternatives to compliance, such as increased use of pipelines, if these proposals become law.

2. Environmental Protection Agency. Regulations under EPA jurisdiction govern the responsibilities associated with spills and discharges of hazardous materials into the water, as mandated in the Clean Water Act (33 U.S.C. Sections 1151 et seq; 1251 et seq). The costs associated with these regulations involve both penalties for discharges (including fines for negligence and malfeasance) and the costs of materials handling equipment less prone to spillage and discharge.

Certain provisions of the Clean Air Act also affect petroleum distribution systems. These provisions require transloading terminals to have vapor recovery systems. (Hydrocarbon vapor emissions occur when transferring various products.) These provisions were established to reduce the risk of accidents, spills, and vapor emissions.

In 1979, the Carter administration proposed the creation of a "Superfund" of $1.625 billion. The purpose of this fund was to clean up oil and chemical spills as well as hazardous waste sites. This proposed legislation (Senate 1341 and H.R. 4571) would have provided 80% of the funding through fees on oil refiners and chemical manufacturers. If legislation of a similar nature were to become law, oil companies would have an inducement to reduce their shipments of petroleum and products by water, where feasible. Pipeline operators could be expected to be the principal beneficiaries of any modal change.

3. Occupational Safety and Health Administration. Regulations under OSHA jurisdiction cover the safety of employees in workplace environments, including the permissable exposure to hazardous substances and some work safety rules. The costs associated with these regulations include compliance with hazardous substance exposure regulations, involving vapor recovery and materials handling equipment, and such other items as earplugs and safety shoes.

PRINCIPAL TRANSPORTATION FLOWS

The following subsection presents an analysis of petroleum commodity flows by PADD for 1977. The subsection draws upon the Department of Energy (DOE) PADD-to-PADD pipeline flows by commodity classification and the DOE waterborne flows by coastal region and commodity classification. These two sets of data do not contain information relating to intra-PADD movements of petroleum commodities.

To provide some understanding of intra-PADD commodity flows, the Corps of Engineers flows were also examined.

Since the major oil companies are few in number and have terminals and refineries in only a limited number of locations, it was necessary to present information on transportation flows at an aggregated level. The analysis is presented by PADD for both crude oil and petroleum products. Petroleum products include a wide variety of commodities, but the distribution pattern across commodities does not vary greatly. The most important distinctions are pipeable versus non-pipeable products and the special end use of some petroleum products, such as jet fuel. Table V-3 presents information on product characteristics (regarding pipeline use) and end use for petroleum products.

The primary products that cannot be transferred by pipe include residual fuels, coke, asphalt, and lubricants. These products are typically distributed by water or rail. Other products are distributed primarily by water and pipeline. This discussion concentrates on water and pipe shipments, since these are the dominant movements.

(a) PADD 1 -- Traffic

PADD 1 corresponds to the eastern seaboard of the United States, including New England, the Middle Atlantic states and the South Atlantic states including Florida. The eastern seaboard is a large net user of both crude and petroleum products, crude because it produces little crude of its own, and products because its refineries have insufficient capacity to produce the quantity of products that its industry and population consume.

The primary crude petroleum flows to PADD 1 were tanker imports to both the Middle Atlantic states of 93 million tons and Puerto Rico and the Virgin Islands of about 44 million tons. Pipelines from PADD 2 delivered about 2.6 million tons of crude, while pipelines from PADD 3 delivered another 3.8 million tons. Pipeline deliveries of crude to PADD 1 are relatively insignificant, because tanker deliveries of imported crude have replaced shipments of domestic crude from the Gulf Coast. Domestic flows by tanker from the Gulf Coast about 2.0 million tons in 1977.

Redistribution of crude by water occurs in PADD 1. Crude oil is moved from large tanker-served terminals to refineries located on the Chesapeake and Delaware Bays (in 1977, approximately 11.3 million tons of crude were shipped within these areas) and on the New Jersey and New York Coast (in 1977, approximately 2.7 million tons were shipped along this coast). Small amounts of crude are shipped by barge from the Gulf Coast to the Pittsburgh area and by tanker from Puerto Rico to the refinery complexes near Philadelphia and New Jersey.

PADD 1 product flows occur primarily by water and pipeline. The principal product flows are from PADD 3. The Colonial, Dixie, and Plantation pipeline systems run from the Gulf Coast and east of the Appalachians. The Texas Eastern and Allegheny pipelines run from the Gulf Coast along the Mississippi Valley to Pennsylvania and New York. Larger tanker shipments of products also are made to PADD 1 from PADD 3. As a general comment, waterborne flows from PADD 3 to PADD 1 serve the coastal regions whereas pipeline flows serve the inland regions.

PADD 1 also receives some tanker imports of products, but with the exception of residual fuel, these imports are small.

Finally, PADD 1 receives some products by pipe from PADD 2. These pipeline shipments are, however, overshadowed by the volume of PADD 1 shipments to PADD 2 by pipe. These pipelines distribute product in New Jersey and Pennsylvania before continuing on to PADD 2. The pipelines include Buckeye, Laurel, Sun, Mobil, and Arco. Product for shipment in these pipelines originates from refineries in the Philadelphia and New Jersey areas.

Aside from the shipments made within PADD 1 that were discussed above, there are some additional shipments distributed by other pipelines in New England. These smaller pipelines receive imported product by tanker and domestic product from Gulf and Atlantic Coast refineries.

Products are also shipped by barge to upstate New York and Vermont on the New York State Waterway.

Although western Pennsylvania receives some products by pipe, it also receives products by barge primarily from refineries located on the Ohio River, the Lower Mississippi, and the Gulf Coast.

Finally, there are some small shipments by barge of products on the Apalachicola, Flint, and Chattahoochee Rivers from Gulf Coast refineries.

Although rail and truck transportation is used extensively throughout PADD 1, it is primarily for final distribution to customers from storage terminals.

(b) PADD 2 -- Traffic

PADD 2 is the region from Ohio, Kentucky, and Tennessee at the eastern end and North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma at the western end. PADD 2 must receive large amounts of crude and equivalent products from PADDs 1, 3, and 4. With the expected construction of a pipeline to transfer Alaskan crude to the Midwest, PADD 5 will provide additional supplies of crude oil to refiners in PADD 2.

Crude oil in PADD 2 moves predominantly by barge and pipeline. Great Lake movements of crude are minimal, but small amounts of imported crude from Canada have moved on the Detroit River in the past.

Pipeline shipments of crude originate in PADDs 3, 4, and 2. PADD 3 shipments are made in a number of crude pipelines including the Amoco, Mid-Valley Capline, and Mobil lines. Pipelines run from wells in PADD 4 to Kansas, Chicago, and St. Louis. Pipelines also, connect wells in PADD 2 with refineries located throughout PADD 2. Pipelines run from wells in Kansas and Oklahoma to St. Louis, Chicago, Detroit, Toledo, and Cincinnati. Pipelines also run from North Dakota and Canada to Minnesota, Wisconsin, Illinois, and Michigan.

Due to the network of crude pipelines serving PADD 2, waterborne movements of crude are not large. The largest flows are from the Gulf Coast to the Upper Mississippi, Lower Upper Mississippi, and Ohio Rivers. (For a definition of the waterways used in NWS, see Appendix B). Local movements from storage terminals served by pipelines to refineries located on the inland waterways also take place.

Product flows within PADD 2 also occur by both barge and pipeline. Product pipelines enter PADD 2 from the East and include the Laurel, Arco, Buckeye, and Sun pipelines. Pipelines also enter PADD 2 from the Gulf Coast and the Oklahoma/Kansas region. Some of these pipelines are the Explorer, Texas Eastern, Williams, Amoco, Mapco, and Arco lines. Almost all major urban areas in PADD 2 are pipeline served.

River movement of products is both competitive and complementary with pipelines. River movements include long-haul shipments from the Gulf and short-haul shipments from pipeline terminals and refineries in PADD 2. Refineries and pipeline terminals are located in such places as St. Louis, Chicago, Detroit, Toledo, Minneapolis, Kansas City, Cleveland, Cincinnati, and Tulsa. Small volumes of products move within Lake Michigan and Lake Erie.

(c) PADD 3 -- Traffic

PADD 3 is the Gulf Coast region of the country. PADD 3 is a net supplier of petroleum commodities. It contains crude producing regions in all of its states and a large refinery capacity.

Crude oil in PADD 3 moves by both water and pipeline. In 1977, foreign crude was delivered to Gulf Coast ports in large amounts, about 78 million tons for Louisiana, 118 million tons for the Texas Gulf Coast, and 8.6 million tons for the Alabama and Mississippi coasts. Crude is also barged along the coasts from isolated wells to tank farms and from tank farms to refineries.

Crude pipelines are widely distributed throughout PADD 3, due to the diverse locations at which crude is produced. Pipelines run along the coast, within and across Texas through north and coastal Louisiana and southern Arkansas, and from New Mexico to Texas. The trunk linehaul pipelines run north from Louisiana and Texas to PADD 2, and from Texas, Oklahoma, and Kansas to other parts of PADD 2. Crude from PADD 3 is also shipped by tanker to PADD 1.

PADD 3 is also a net supplier of petroleum products. Products are produced in PADD 3 in many locations, but products produced for reshipment to other PADDs are principally refined along the coast at Corpus Christi, Houston, Beaumont, Lake Charles, Baton Rouge, New Orleans, and Pascagoula. Inland refineries tend to be smaller and oriented to serving the immediate area.

(d) PADD 4 -- Traffic

PADD 4, consisting of the northern Rocky Mountain states, receives or distributes little crude or products by water. Crude pipelines run from the "four corners" region to both Texas and California and from Montana and Wyoming to local refineries and refineries in PADD 2.

PADD 4 product shipments are predominantly internal movements. Small shipments are made to PADDs 2 and 5. The head of navigation for the Snake River lies in PADD 4, and small amounts of products are received and shipped by barge.

(e) PADD 5 -- Traffic

PADD 5 consists of the Pacific Coast states, Nevada, Arizona, Hawaii and Alaska.

Crude pipelines run from producing fields in the Bakersfield area to San Francisco and Los Angeles and from the southern California offshore wells to the Los Angeles area. The Alaskan pipeline carries crude from Prudhoe Bay to Valdez, where it is transported by tanker to Puget Sound, California, and Gulf Coast refineries. During 1977, substantial amounts of foreign crude were imported to PADD 5, at Puget Sound (10.8 million tons), San Francisco (19.4 million tons), and Los Angeles (27.3 million tons).

Petroleum product flows in PADD 5 occur by both water and pipe. Pipelines run from Puget Sound refineries south to Oregon paralleling the coastline; the San Francisco Bay area into the surrounding inland area; from Los Angeles to the surrounding area, Nevada, and Arizona. Phoneix also receives some product by pipe from PADD 3 refineries. Oregon and Washington receive product by pipe from PADD 4.

Domestic and foreign waterborne shipments of products to PADD 5 are very small.

FACTORS AFFECTING FLOWS IN THE FUTURE

At least two major factors are expected to reduce the rate of growth in waterborne shipments of petroleum and petroleum products. These factors are:

- Increased energy conservation.
- Increases in pipeline capacity.

In addition, there are two factors that can be expected to prevent any radical change from taking place in the nature of waterborne flows. These factors are:

- Refinery capacity in the United States
- Petroleum distribution network.

Each of these four factors is discussed under separate headings.

(a) Increased Energy Conservation

As discussed previously, natural gas and crude oil prices are being decontrolled gradually in the United States Two of the purposes of price decontrol are to encourage users of petroleum products to reduce their overall consumption of energy products and to rely more heavily on other sources of energy, such as coal. Oil companies contacted for the NWS expect that higher real prices of petroleum products will encourage users to conserve oil and will result in lower growth in overall United States demand.

Consumption of gasoline and diesel fuel is also expected to be lower than it would have been, as a result of the passage of the Energy Policy and Conservation Act of 1975 (42 U.S.C., Section 6301 et seq.). This act mandates that United States car companies must build cars, which obtain an average more miles per gallon. Vehicle miles traveled on a per capita basis are also expected to stabilize in the future.

Thus, for both legislated and economic reasons, United States consumption of petroleum and petroleum products can be expected to grow at levels below those of prior periods. All shipments of these commodities can therefore be expected to grow at lower rates in the future.

(b) Increases in Pipeline Capacity

As a general comment, the oil and pipeline industies expect to see little extensive investment in new crude oil pipeline systems. The major exception is the possible construction of a transcontinental pipeline to transport Alaskan crude from landings in the Puget Sound area or southern Alaskan Coast to points in the Upper Midwest. The Northern Tier Pipeline is considered to be the most likely candidate for construction of the various pipelines proposed to handle Alaskan crude oil. Construction of this pipeline can be expected to reduce watrborne and possibly pipeline shipments from the Gulf Coast (PADD 3) to the Midwest (PADD 2).

The oil and pipeline industries also expect to see little extensive investment in new product pipeline systems. However, some replacement of pipeline mileage with larger diameter pipe is envisioned. Increases in pipeline capacity from additional pumping capacity and new stations are also expected to occur. Some new spurs are expected to be built to service new locations. The conversion of a natural gas pipeline along the Gulf Coast to petroleum products may also take place in the future.

Since the oil industry expects to see a relatively low growth rate in petroleum product demand, it is not likely to make major investments in new distribution systems. However, the increased regulation of tanker transportation and, more generally, hazardous materials transportation (including some petroleum products) is encouraging oil companies to shift to pipeline wherever feasible. Thus, the possible conversion of natural gas pipelines and the increase in pipeline capacity can be expected to reduce the waterborne share of product shipments from Gulf Coast origins to Gulf Coast East, South Atlantic Coast and Middle Atlantic Coast destinations.

(c) Refinery Capacity In The United States

Oil companies contacted for the NWS do not expect to see a major increase in United States refinery capacity. The lower rate of growth in United States petroleum demand and the possibility that major oil-producing contries, such as Saudi Arabia, will ship more refined products as new foreign refining capacity is brought on-stream are two reasons why oil companies are reluctant to construct new refining capacity in the United States

Any additional refining capacity constructed in the United States is likely to be made in line with the present distribution of refining capacity as indicated in Table V-10. This is due to the difficulty in successfully negotiating environmental regulations for new facilities and the comparative ease with which existing facilities can be expanded. The stringent environmental restrictions associated with air and water regulations on the East coast and certain other locations (such as Los Angeles) may tend to restrict some expansion at these sites.

In view of these findings, it is reasonable to expect little change in the nature of waterborne flows to and from oil refineries.

(d) Petroleum Distribution Network

With the exception of possible investments in off-shore oil ports located in the Gulf Coast, oil companies do not expect to see a change in the location of petroleum distribution facilities. Oil companies cited the high costs of new construction and relatively slow growth of United States demand as two reasons to expect little change in the distribution network. In fact, in contrast to other industries such as coal and grain, petroleum companies expect to see a consolidation in the number of terminals served by water as a result of the high costs of complying with new air and water quality regulations.

The construction of off-shore oil ports, such as the proposed Louisiana Off-shore Oil Port (LOOP) would represent of course new investment, but would not result in a change in the nature of waterborne flows. Such a port could handle vessels up to 400,000 dwt. (At the present time, only 125,000 dwt. tankers can be unloaded at the Gulf.) The oil off-loaded from these ports would be moved by underwater pipeline to on-shore storage terminals at refineries. Such ports or similar lighering activities involving VLCCs can be expected to be undertaken at major refining locations in the United States, and would not require any change in the location of refineries or petroleum distribution facilities.

EXHIBIT V-1

UNITED STATES PRODUCTION AND CONSUMPTION OF ENERGY

YEAR	Total production (Quad. Btu)	PERCENT OF PRODUCTION				Total consumption (Quad. Btu)	PERCENT OF CONSUMPTION			
		Coal	Crud petroleum	Natural gas.	Electricity		Coal	Crud petroleum	Natural gas	Electricity
1940	25.1	53.3	31.3	11.9	3.5	23.9	52.4	31.4	11.4	3.8
1950	34.5	42.7	33.4	20.0	3.9	33.6	38.1	39.8	18.1	4.0
1955	39.1	32.6	37.0	27.0	3.4	39.2	29.1	44.2	23.3	3.5
1960	41.8	26.7	35.7	33.8	3.8	44.1	22.8	45.1	28.5	3.6
1965	49.7	27.0	33.3	35.6	4.2	53.0	22.3	43.6	30.2	3.9
1970	62.5	24.3	32.6	38.6	4.5	66.8	18.9	44.0	32.8	4.3
1971	62.0	22.1	32.5	40.2	5.2	68.3	17.6	44.7	32.9	4.7
1972	62.8	23.1	31.9	39.5	5.5	71.6	17.3	46.0	31.7	4.9
1973	62.5	23.1	31.2	39.7	6.0	74.6	17.8	46.7	30.2	5.2
1974	61.2	23.7	30.4	38.7	7.2	72.4	17.7	46.1	29.9	6.3
1975	60.1	25.6	29.5	36.6	8.4	70.7	18.2	46.4	28.3	7.2
1976	60.1	26.5	28.7	36.3	8.5	74.2	18.5	47.0	27.4	7.1
1977	60.4	26.3	28.9	36.3	8.5	76.6	18.5	48.6	26.0	6.9
1978 1/	61.0	24.8	30.1	35.3	9.8	78.0	16.1	48.4	25.4	8.1

1/ Preliminary.

SOURCE: United States Bureau of Mines, Minerals Yearbook; United States Energy Information Administration, Annual Report to Congress, Vol. II.

EXHIBIT V-2

UNITED STATES CRUDE OIL PRODUCTION
AND PROVEN RESERVES
(Millions of Barrels 1/)

	Daily Production		Proven Reserves 2/	
	1970	1978	1970	1978
Texas	3.4	3.1	13,195	7,690
Louisiana	2.5	1.5	5,710	2,893
Alaska	0.2	1.2	10,149	9,247
California	1.0	1.0	3,984	3,471
Oklahoma	0.6	0.4	1,351	1,073
Wyoming	0.4	0.4	1,017	805
New Mexico	0.4	0.2	761	486
Kansas	0.2	0.2	539	350
Other States	0.9	0.8	2,295	1,789
U.S. TOTAL	9.6	8.8	39,001	27,804

NOTE: 1/ Barrles of 42 gallons.

NOTE: 2/ Proved reserves are reserves that can be recovered with reasonable certainty from known reservoirs under existing economic and operating conditions.

SOURCES: Department of Energy and American Petroleum Institute.

EXHIBIT V-3

Petroleum Administration for Defense
(PAD) Districts

PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS

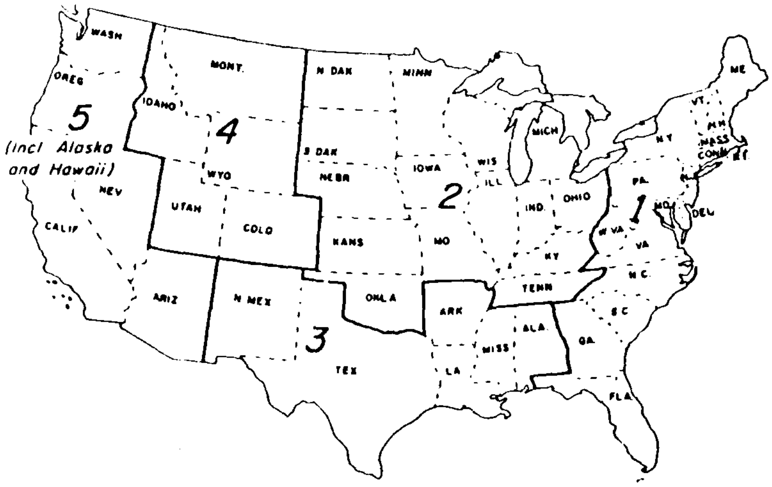


EXHIBIT V-4

RETURN ON EQUITY FOR SELECTED OIL COMPANIES

	S&P 400 Industrials	Crude and[1] Gas Producers	Domestic Integrated[2] Cos.	International Integrated[3] Cos.
1970	10.3	15.7	11.3	10.6
1971	10.8	17.6	10.2	11.4
1972	11.7	32.9	10.5	9.7
1973	14.2	19.4	15.4	16.6
1974	14.2	30.5	23.6	19.2
1975	12.1	21.0	14.7	11.5
1976	14.0	22.7	15.7	12.6
1977	14.0	21.9	15.1	13.2
1978	14.8	15.4	14.9	12.3

NOTES: (1) Includes General American Oil, Houston Oil Minerals, Louisiana Land, Mesa Petroleum, and Superior.

(2) Includes Amerada Hess, Ashland, Atlantic Richfield, Cities Service, Clark Oil & Refining, Continental, Getty, Kerr-McGee, Marathon, Murphy Oil, Phillips Petroleum, Quaker State, Shell Oil, Standard Oil of Ind., Standard Oil of Ohio, Sun, Union Oil, and United Refining.

(3) Includes British Petroleum, Exxon, Gulf, Mobil, Royal Dutch, Standard Oil of California, and Texaco.

SOURCE: Standard & Poor's Industry Surveys: Oil Basic Analysis, June 7, 1979.

VI - COAL

Coal and its uses for electric utilities, industrial firms, and export markets are the principal topics of this section. Coking or metallurgical coal is discussed under the section entitled IV - Steel.

In 1977, 212 million tons of coal were shipped by water. One quarter of this total represented export shipments from such ports as Norfolk. Much of the balance was inland traffic. Approximately 10% of waterborne coal shipments was traffic on the Great Lakes.

The large shipments of coal in the United States make coal a key commodity for both rail and water carriers. Water transportation provides an alternative to rail or truck for many utilities that are located on the Ohio, Illinois, and Mississippi Rivers and burn eastern coal. Western coal is originated by rail, but some of this coal is transloaded at points along the Mississippi and Illinois Rivers as well as the Great Lakes for final shipment to users.

Coal shippers are especially concerned about the adequacy of waterway capacity to meet projected increases in coal traffic. Conversion of utilities and industrial power plants from oil and gas to coal will undoubtedly change the nature of coal flows in the future. In particular, the Lower Mississippi River, the Gulf Intracoastal Waterway, and the Atlantic Coast should see large increases in coal traffic in the future.

This section is divided into the following subsections:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.

- Description of Logistic System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

COMMODITY CHARACTERISTICS

Coal is the compressed remains of accumulated plant life that has been turned into peat and later coal through various chemical reactions and compression from sedimentary rock. Coal is classified into four types as presented in Table VI-1.

Table VI-1

Typical Coal Characteristics

Type	Average Heat Value (Bts per Pound)	Percentages by Weight: Moisture	Volatiles	Fixed Carbon	Ash	Sulfur
Anthracite	13,540	2.3%	3.1%	87.7%	6.9%	0.5%
Bituminous	12,950	7.2	39.8	48.8	4.2	2.6
Sub-Bituminous	9,420	23.3	33.3	39.7	3.8	0.4
Lignite	7,210	34.8	28.2	30.8	6.2	0.7

SOURCE: J.H. Perry, Chemical Engineers' Handbook

Anthracite coal typically has the highest average heat value and the lowest levels of such undesirable elements as moisture and sulfur. Anthracite is processed primarily in northeastern Pennsylvania and is used for both home or industrial heating and electricity generation. However, the production of anthracite is very limited (less than one percent of all coal produced in the United States during 1977 was anthracite) and, as a result, the remainder of this report addresses only the other three types of coal.

Bituminous and sub-bituminous coal is in widest usage and is greatest supply throughout the United States An estimated 95% (659.7 million tons) of all coal produced in the United States during 1977 was either bituminous or sub-bituminous. Typical origins of bituminous coal include Kentucky in the east and Illinois in the Midwest. Sub-bituminous coal is produced in such western states as Wyoming and Montana.

Lignite contains the lowest average heat value of all types of coal. It also has the highest levels of moisture. Lignite is produced in Texas and North Dakota and accounted for an estimated four percent (28.9 million tons) of 1977 production.

Coal is classified by grade as well as type. The higher grade coals contain fewer undesirable elements, such as sulfur, moisture, and ash. The most important of these undesirable elements is sulfur. When burned in power plants, sulfur dioxide is a major air pollutant. Table VI-2 presents the distribution of sulfur content by type of coal for identified United States coal resources.

Table VI-2

Sulfur Content of U.S. Coal Resources
(Percent)

Type	Sulfur Content 0 to 1%	1 to 3%	Over 3%
Anthracite	97.1%	2.9%	--
Bituminous	29.8%	26.8	43.4%
Sub-Bituminous	99.6%	0.4	--
Lignite	90.7%	9.3	--
All Types	65.0%	15.0%	20.0

SOURCE: United States Mineral Resources, Geological Survey Paper 820.

Sulfur dioxide emissions are a particular problem for bituminous coal as over 40% of United States bituminous coal reserves contain sulfur levels of three percent or more. In sharp contrast, the deposits of sub-bituminous coal and lignite are generally low-sulfur coal.

Over half the coal mined in the United States is produced by surface mining. In this process, earth and rock above the coal (referred to as the overburden) are removed and placed to one side. The exposed coal is broken up, loaded into trucks, and hauled away. The machines used in surface mining range in size from ordinary bulldozers and front-end loaders to giant power shovels and draglines. The smaller, more mobile equipment is generally used in the East, while the power shovels and draglines are used in the Midwest and West, where coal seams at strippable depths may run for miles. These power shovels and draglines do not remove the coal; rather, they lay the seam base so it can be pick-up by smaller shovels or front-end loaders. After the coal has been mined, the overburden is then regraded to the desired shape and planted with vegetation or young trees.

In 1977, an estimated 39% of all bituminous, sub-bituminous or lignite coal produced in the United States was mined underground. Most underground mines in the United States follow a room-and pillar plan, resulting in intersecting tunnels 14 to 20 feet wide. The pillars are columns of coal left standing to help support the roof until a particular area is mined. Miners working underground move forward until as much coal as possible has been removed from a seam. Then as miners move back toward the main entry of the mine, they often remove the coal from pillars and permit the roof to cave.

There are two predominant methods of underground mining: conventional and continuous mining. Conventional mining accounts for just over 30% of all underground mining. It involves using a cutting machine that cuts a deep slot in the face of a coal seam (the slot allows the solid coal to shatter more easily when it is blasted), a mobile drill that bores holes in the coal, and explosives or cylinders of compressed air that shatter a section of the seam. A loading machine then sweeps the coal onto mobile conveyor belts or shuttle cars, which carry the coal to a larger conveyor system or underground rail cars.

Continuous mining machines accounted for an estimated 63% of all coal mined underground in the United States These machines can cut coal from the face at 4 to 15 tons per minute. In one operation, these machines tear the coal from the seam with revolving teeth and load it for movement out of the mine.

As might be expected, the output per man-day at United States mines differs dramatically for underground and strip mines. Table VI-3 presents estimates of output per man-day for bituminous mines in the United States

Table VI-3

Output Per Man-Day at U.S. Coal Mines 1/
(Tons)

	Underground	Strip
1970	13.8	36.0
1971	12.0	35.7
1972	11.9	36.0
1973	11.7	36.7
1974	11.3	33.2
1975	9.5	26.7
1976	9.1	26.4

NOTE: 1/Excludes anthracite mines.

SOURCE: Department of Energy

As can be seen, average output has been declining since the latter 1960s and early 1970s for both underground and strip mines. Productivity has declined for a variety of reasons, including changes in reclamation and mine safety laws. Nonetheless, output for strip mining remains substantially higher than that of underground mining and, as a result, coal prices for strip-mined coal are usually cheaper than those for underground coal.

MARKETS

United States coal production was estimated to be 689 million tons (this excludes 6 million tons of anthracite coal) in 1977. Table VI-4 presents coal production in the United States from 1970 to 1977.

Coal production did not grow at all from 1970 to 1974 and it even declined sharply in 1971. Since 1973, coal production has shown small but steady increases.

Exhibit VI-1 presents United States coal production and reserves by state. Kentucky, West Virginia, and Pennsylvania in the East were the three largest coal-producing states in 1977. Illinois and Ohio were the next largest coal producers, while Wyoming and Montana in the West were the sixth and eighth largest producers, respectively.

Table VI-4

U.S. Coal Production 1/
(Million of Tons)

1970	602.9
1971	552.2
1972	595.4
1973	591.7
1974	603.4
1975	648.4
1976	678.7
1977	688.6

NOTE: 1/Excludes anthracite coal.

SOURCE: Department of Energy.

Montana has the largest demonstrated coal reserves of any single state. As is true of Wyoming, the overwhelming proportion of coal reserves in Montana is the low-sulfur deposits of sub-bituminous coal. During the 1970's, coal production from these two states has increased dramatically. Illinois has the second largest coal reserves in the United States These reserves are high-sulfur bituminous coal (approximately half of these reserves are known to exceed three percent sulfur by weight). Other states with major coal reserves are West Virginia, Kentucky, Pennsylvania and Ohio. With the exception of Ohio (where the reserves are predominantly high-sulfur), these other states have reserves with low, medium, and high-sulfur contents.

As can be seen by Exhibit VI-1, the United States has ample reserves of coal. Regarding demonstrated coal reserves (i.e., known or indicated deposits that are economically recoverable with present technology), the United States has sufficient coal to last for over 600 years at present levels of use. Remaining identified reserves (i.e., identified deposits that may or may not be economically recoverable) exceed demonstrated reserves of coal by a four to one margin. Thus, coal can be expected to play a major role in meeting United States energy needs throughout the time period of the NWS.

Exhibit VI-2 presents estimates of world coal production and reserves by country. The Soviet Union was the single largest producer of coal followed by the United States and People's Republic of China. While the United States is not the world's largest producer of coal, it does have the largest coal reserves. It was estimated by the World Energy Conference Survey of Energy Resources that United States reserves were over 25% of the world's total reserves. This survey was taken in 1974.

Coal must compete with other energy sources and Table VI-5 presents estimates of the principal sources of energy in the United States for 1970 and 1978.

Table VI-5

Sources of Energy in the U.S. for 1970 and 1978

	1970	1976
Natural Gas	39%	35%
Crude Petroleum	32	30
Coal	24	25
Water, Nuclear Power	5	10 1/
TOTAL	100%	100%

NOTE: 1/ Includes geothermal.

SOURCES: Standard & Poor's, Industry Surveys: Steel-Coal Basic Analysis, October 1979.

For both years coal has accounted for an estimated one quarter of all United States energy needs. The share of energy provided by natural gas and crude petroleum has declined during the 1970's due in large part to the increased reliance in nuclear power by electric utilities.

The principal markets for coal in the United States include electric utilities, coking coal, manufacturing and mining, and exports. Table VI-6 presents estimate of coal consumption by major market for 1971 and 1977.

Table VI-6

Consumption of Coal for 1971 and 1977
(Millions of Tons)

Major Use	1971	1977
Electric Utilities	326	476
Coking Coal	98	77
Manufacturing and Mining	69	60
Retail	11	7
Exports	57	54
United States TOTAL	551	674

SOURCE: Department of Energy

The principal market for coal, namely electric utilities, has also been the fastest growing market. Each of these markets except coking coal (see Section IV) is discussed briefly below.

(a) Electric Utilities

Electric utilities use coal, oil, gas, nuclear fuels, and hydropower to generate electricity. Table VI-7 presents estimates of electricity generation by energy source for 1977.

Table VI-7

Generation Mix of Electric Utility Plants for 1977

Coal	47%
Oil	17
Gas	14
Nuclear	12
Hydro	10
TOTAL	100%

SOURCE: Standard & Poor's Steel-Coal Basic Analysis, October 1979.

Coal accounted for almost half of the electricity generated by utilities in 1977. Oil and gas were the next largest sources of fuel. Utilities are expected to increase their reliance on coal in the future at the expense of oil and gas. Virturally all new power plants (with the exception of small peakload units) to be constructed in the United States will be powered by either coal or nuclear power.

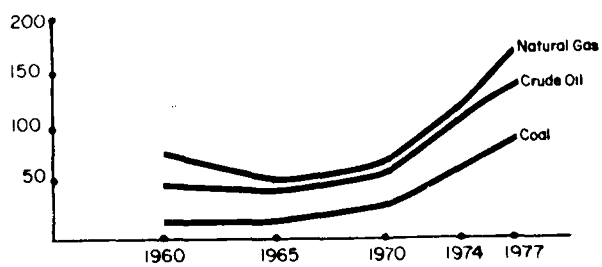
Whereas energy experts are nearly unanimous in their belief that coal use will increas in the United States, there are both positive and negative factors regarding the future use of coal. Utilities and coal-mining companies contacted for the NWS noted, in particular, that, whereas the official United States policy is one of encouraging coal use, certain laws passed in the 1970s have discouraged the use of coal and increased coal production costs (in some cases dramatically). With some degree of overstatement, several shippers noted that these laws "won't let you mine coal, ship coal, or burn coal!"

Clearly, there are a number of key government policies and economic factors that will influence the use of coal in the future. Some of the positive and negative factors affecting coal use are discussed below under separate headings.

1. Positive Factors. Utilities that have relied on oil and gas in the past are being encouraged to convert to coal by the ever-widening spread between coal prices, on the one hand, and oil and gas prices, on the other hand. Figure VI-A presents fuel prices as measured in cents per million Btu.

Figure VI-A

Fossil Fuel Prices
(Average Cents per Million Btu)



SOURCE: U. S. Department of Energy, Annual Report to Congress.

As can be seen, all fuel prices as measured in cents per million Btu have been increasing, but the amount of increase in oil and gas prices has been sharper than that for coal.

Increased use of coal by utilities has also been encouraged by the government via a number of new programs. Two major programs are the President's Commission on Coal and the Federal Coal Management Program. The President's Commission on Coal has reviewed the state of the utility industry and has initially recommended reconversion of a number of oil-burning plants back to coal in the Northeast, especially in New York and New Jersey. The Commission has identified 11 oil-fired units in New York (accounting for approximately 12,460 kilowatt hours (kwh) or 19% of New York's total kwh production in 1977) and 10 units in New Jersey (accounting for approximately 8,123 kwh or 37% of New Jersey's total kwh production in 1977) as initial reconversion candidates. Most of these units formerly burned coal, but switched to oil because it was cheaper and cleaner.

The second program, namely the Federal Coal Management Program is the leasing of mineral rights to federally-owned coal reserves. There has been a moratorium or leasing since 1973, but the program has been redesigned and is expected to begin in 1981. Specific plans call for leasing 1.5 billion tons of coal reserves. Broken down by lease sales, the reserves are distributed as follows: 531 million tons of reserves in the Green River-Hams Fork region (Idaho, Wyoming, Utah, and Colorado); 109 million tons in the Uinta-Southwestern Utah region (extending into western Colorado); and 776 million tons in the Powder River region (Montana and Wyoming). If these leasing plans would take place, coal production in these western states could be increased 80 million tons as indicated by the Department of Interior.

Coal use by utilities will also be affected by future reliance on nuclear power. In light of the Three Mile Island and other nuclear accidents, the cost of constructing and operating a nuclear power plant has increased due to more intensive government and private review. A moratorium on building such plants is a possibility.

2. <u>Negative Factors</u>. Coal use in the United States has been made more costly by a number of different environmental statutes and regulations. The cost of using coal for a utility includes all costs associated with

meeting the standards as established by the Clear Air Act of 1970 and the Clean Air Act Amendments of 1977. As required by the Clean Air Act of 1970, the Environmental Protection Agency (EPA) established standards for six classes of pollutants:

- Particulates.
- Sulfur oxides.
- Hydrocarbons.
- Carbon monoxide.
- Nitrogen oxides.
- Photochemical oxidants.

The 1977 amendment require EPA to review all National Ambient Air Quality Standards by December 1980 and every five years thereafter. In 1979, EPA issued the final version of the revised New Source Performance Standards (NSPS). NSPS are established to provide standards for a number of specific sources emitting these pollutants. The revised NSPS call for: (1) a ceiling of 1.2 pounds of sulfur dioxide per million Btu of heat input, averaged monthly; (2) 70-90% reduction of SO_2, averaged monthly; (3) partial scrubbing for coal with controlled potential emissions below 0.6 lb SO_2 per million Btu; and (4) coal-washing (to remove sulfur) "credits" against these other standards.

Three of these four changes in the NSPS increase the cost of burning coal. The fourth, namely the provision of credits for coal washing, is clearly not an inducement to burn coal.

However, the impact of the NSPS on utilities is not likely to be less burning of coal. Most utilities have little choice but to continue to burn coal at existing plants. New plants can be powered by nuclear fuel, but, as discussed previously, nuclear accidents have made even this option less attractive.

A possible impact of the NSPS on coal-burning utilities is increased use of low-sulfur coal in the near future at the expense of high-sulfur coal. This trend toward low-sulfur coal will not take place if lawsuits that are expectd to challenge the new regulations are successful. And some utilities are located in areas under more stringent requirements from other provisions of the Clean Air Act. As a result, these utilities have already swithched to low-sulfur coal or installed scrubbers.

Whereas the NSPS may encourage the use of western coal and low-sulfur eastern coal in the near future, this trend may be short-lived if utilities develop improved technology to scrub all sulfur content levels in coal. The removal of sulfur oxides before and after combustion has been the subject of intense research by utilities. An improvement in technology will most likely encourage utilities to consume coal from nearby local or regional sources.

Current sulfur dioxide removal systems (referred to as scrubbers) treat stack gases with an absorbent, either lime or limestone in a watery solution that reacts with the sulfur dioxide in the stack gases to produce a sludge of sulfite and sulfate salts or a magnesium or sodium solution to absorb the sulfur dioxide. Another process now being tested is fluidized-bed combustion. In a fluidized-bed boiler, whirling particles of limestone and coal are suspended in a stream of air whooshing upward through a bed of ash and limestone heated to about 1,600 degrees. Crushed coal injected into the combustion zone burns very rapidly as a suitable amount of limestone is added continuously. Calcium in the limestone reacts with sulfur dioxide released from the burning coal. This produces calcium sulfate, an inert substance that is discharged with the coal ash and eliminated from the combustion gas going up the stack.

Although the NSPS are significant provisions affecting the use of coal, there are other environmental statutes. Other provisions of the Clean Air Act as amended include the Prevention of Significant Deterioration regulations and Nonattainment Policy. Each of these provisions are discussed under the next subheading "Mining and Manufacturing". Other environmental statutes that are not related to the Clean Air Act but do affect the use of coal by utilities include the Toxic Substances Control Act (this act restricts the disposal of certain chemical substances contained in coal or scrubber sludge wastes) and the Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act of 1977, and the Safe Drinking Water Act of 1974 (this act as amended establishes regulations regarding water effluents from coal facilities). It should also be noted that the Surface-Mining Control and Reclamation Act affects the production cost of coal. The impact of this legislation is discussed under the major heading "Economics of the Industry."

(b) Manufacturing And Mining

Coal use by manufacturing and mining concerns was the second largest coal market in 1977, but, since the early 1970s, its use has been declining. Industrial firms can choose to generate their own power or purchase electricity from a local utility. Just as with electric utilities, industrial firms can choose from coal, oil, or gas to fire their boilers (industrial firms rarely consider nuclear power).

Although this market has been declining during the 1970s, it may well increase in the future as industrial concerns are encouraged or forced to convert from oil and gas to coal. Many of the same reasons that apply to utilities for coal conversion also are relevant for industrial firms. However, several additional topics affecting the industrial use of coal need to be addressed, including two provisions of the Clean Air Act as amended, namely the Prevention of Significant Deterioration (PSD) regulations and Nonattainment Policy.

The PSD regulations specify that any major, new or modified stationary source emitting over 100 tons per year of any pollutant in a "clean air" area is subject to a preconstruction review. This new or modified source review is to ensure that such a source employs the best available control technology for all pollutants covered in the Clean Air Act.

The Nonattainment Policy of the Clean Air Act as amended further restricts the construction or modification of major stationary sources of pollutant emissions. For those areas in each state that has not attained the air quality standards by February 1978 as established by the Act and its amendments, no new construction or modification can be undertaken without an accompanying reduction in emissions from existing sources in the area. This policy is referred to as an emissions trade-off policy. Industrial concerns wishing to construct new facilities or modify existing facilities must in effect reduce or eliminate emissions from existing plants before they can secure the approval for any new construction. Clearly, industrial users of coal will be forced to explore coal-scrubbing techniques in detail before making any change in fuel use at existing plants or constructing new coal-fired plants in the future.

(c) Retail

A small amount of anthracite and bituminous coal continues to be sold in the retail market. This coal is used primarily for residential and commercial space heating. Consumption of coal for this purpose is expected to continue to decrease.

(d) Exports

The United States shipped an estimated 54 million tons of coal to overseas markets in 1977. Table VI-8 presents estimates of coal shipments to foreign countries.

Table VI-8

United States Exports of Coal for 1977 1/
(Millions of Tons)

Canada	17.2
Japan	15.9
Italy	4.1
Brazil	2.3
France	2.1
Netherlands	2.0
Other Countries	10.1
United States TOTAL	53.7

NOTE: 1/Excludes Anthracite Coal.

SOURCE: Department of Energy

The largest customers of United States coal were Canada and Japan. The predominant coal shipped overseas has been metallurgical coal, since the United States has significant reserves of premium bituminous coal reserves suitable suitable for coke production (see Exhibit VI-3 for a presentation of coal reserves for coke production by state).

Some exports of lower quality steam coal have been made to Canadian utilities in the past and it is possible that such exports to Europe and Japan may grow in the future. Poland, Australia, and South Africa have been traditional suppliers of coal to Europe but increased bunker fuel costs are making coal from Australia and South Africa less competitive and the Soviet Union is taking an increasing share of Poland's exports. Australia, South Africa, and China have supplied Japan in the past and higher bunker fuel costs may limit the shipment of United States coal to Japan. However, if Japan would need large amounts of coal,it may have to import United States coal.

ECONOMICS OF THE INDUSTRY

The coal industry includes both coal mining companies and the major users of coal, namely electric utilities. Both of these companies are discussed below.

(a) Coal Companies

Over 6,000 mines were active in 1977. Over half of these mines are located in Kentucky and West Virginia. As a general comment, eastern-coal mines produce less coal than typical western coal mines. (Although it should be noted that the top 50 producing mines, which account for almost one quarter of United States coal production, are evenly divided among western, midwestern, and eastern regions.) Western coal mines are often strip mines that resemble huge construction sites. As noted earlier, these mines are not labor-intensive; instead, operators of these mines rely on large power shovels and draglines.

Although there are a large number of coal mining companies operating in the United States, the majority of coal production has been accounted for by the top 50 coal operating groups. With the exception of 1978 when a coal strike temporarily reduced the share of production for these companies, their share has been almost two thirds of coal production according to the Keystone News Bulletin. Exhibit VI-4 presents the top 15 coal-producing companies in 1978. The majority of these 15 producers are affiliated with corporations involved principally in noncoal businesses. Of the 15 companies, five are affiliated with oil firms, three with electric utilities, two with steel companies, and one with a natural resources concern.

A recent article in Business Week entitled "The Oil Majors Bet on Coal" outlined some of the key factors that have changed the nature of the coal industry in recent years. First, major oil companies have been acquiring coal-mining companies over the past 15 years as part of a deliberate strategy to acquire more control over the major energy source in the United States. Such mergers are a natural reaction to the loss of oil reserves in the Mideast. Exhibit VI-5 lists some recent mergers among coal and oil companies.

Second, by and large, these oil companies favor the development of the western coal reserves. Not only do these reserves contain less sulfur, but the cost of production is substantially lower than many eastern coal mines. Exhibit VI-6 presents estimates of average coal values (f.o.b. mines) by state for 1976. Although these prices are not derived production costs, there is sufficient price competition among mines in each region such that these prices provide some insight into the varying costs of production from one area of the country to another.

Third, a variety of factors have forced many smaller mines out of business. An estimated 500 mines have been closed since 1977. These smaller mines have had to face several problems:

1. Slumping spot market prices for coal. (Since many smaller companies rely on spot markets for the sale of their coal, this development has hurt them more than others.)

2. Surplus production capacity in the United States. (With the large-scale development of strip mines in the West, coal-production capacity has tended to increase more rapidly than coal consumption. This surplus capacity has made it especially difficult for smaller, less efficient mines in the East.)

3. Increased production costs associated with the Surface-Mining Control and Reclamation Act. (This act has required coal producers to return land that has been strip-mined to its original form. Such costs are particularly expensive for strip mines in the East. Exhibit VI-7 presents regional reclamation costs for surface mining by region.)

4. Demand for ever-larger quantities of coal by operators of big electric generating plants. (This factor is discussed in detail in the next major heading. Briefly, utilities operating large power plants are interested in locking up dependable coal supplies over a long period of time. Smaller mines are at a disadvantage in servicing these customers.)

Financial results for five leading coal companies are provided in Exhibit VI-8. Of particular interest is the sharp decline in profitability in 1977 and 1978. This decline is due not only to the "soft" coal markets of recent years as production has increased faster than consumption, but also to the coal miners' strike in 1978. The 1978 return on equity for these coal companies of 4.0% is far below that of 4.0% for industry in general.

(b) Electric Utilities

As natural monopolies, utilities are subject to extensive state and federal regulation of service rates, service levels, safety, purchase and sale of assets, accounting systems, and rate of return on investment. Because most utilities operate on an intrastate basis, state regulation is usually more important than federal regulation in setting rates. To protect the consumer against the abuses of monopolistic pricing and, at the same time, enable the utility to attract capital when required and provide adequate service, regulatory bodies allow the company to charge "just and reasonable rates." Just and reasonable rates have been determined by the United States Supreme Court to provide for a return to the equity owner that both is commensurate with returns on investment in other enterprises having corresponding risks and is sufficient to ensure confidence in the financial integrity of the enterprise.

As a practical matter, regulatory agencies use varying methods to determine service rates. Commissions differ over what expenses will be recognized or what the proper rate base should be. For example, in some states, the original cost of properties is used to determine the rate base, while in offer rates fair-value methods are employed that take replacement cost into account. In inflationary times, it is necessary for regulated utilities to file for governmental approval to obtain rate increases on a timely basis so that higher costs can be passed on quickly.

There are over 90 major investor-owned utilities in the United States; these companies include both electric power holding companies that operate utility plants in more than one service area and electric power operating companies. In addition, there are numerous government plants and rural cooperatives that supply electricity. Annual capital expenditures for the electric utility industry are large and were estimated to be over $30 billion by Electric World in 1978.

DESCRIPTION OF LOGISTICS SYSTEM

This subsection describes the logistics system for electric utilities. As part of the description, the decision process for modal choice and the distribution network design is outlined. It should be emphasized that it is proper to focus on the electric utility rather than a coal-mining company. A coal-mining company is in the business of mining coal as cheaply as possible to offer as low an f.o.b. minemouth price as possible to prospective buyers. Although some coal companies are directly involved in the transportation of coal, the final decision about delivery mode is usually made by the utility not the coal-mine operator. Although emphasis is placed on the electric utility's logistics system, significant differences for industrial coal users and coal exporters are discussed briefly at the end of this subsection.

(a) Electric Utilities

Electric utilities are in the business of producing electricity as cheaply as possible to meet the needs of a given service area. The initial planning process involves forecasting the demand for electricity by service area. Once demand is forecast, utilities are in a position to determine their needs for new plants. If demand is not sufficient to justify new construction, utilities may choose to purchase electricity from generating plants owned and operated by others or to increase electricity generation at existing plants in or near the service areas.

If demand is sufficient to justify new construction, electric utilities determine the generating capacity of the new plant based on at least two considerations. On the one hand, utilities seek to build larger units (1,300 megawatt plants) to take advantage of economies of scale. On the other hand, utilities seek to build units small enough (150 megawatt unit) such that they will be efficiently utilized within a reasonable period of time following construction. In order to meet peak demand and utilize generating capacity effectively, many utilities have constructed peaking units that can be fired quickly to meet a small percentage of total system needs during peak demand periods.

Once the generating capacity of proposed plants has been established, utilities determine their cheapest source of energy. Alternative sources include coal, oil, gas, nuclear power, geothermal power, and hydropower. The evaluation of alternative fuel sources must consider both initial capital costs and continuing operating costs over the life of the plant.

All capital costs are considered, including plant, transportation equipment, terminal, transmission, and environmental compliance costs. Significant operating costs are considered as well, including minemouth and transportation costs, plant maintenance and operating costs, transmission costs, and continuing environmental compliance costs; these operating costs are then discounted by the appropriate cost of capital so that financial comparison of feasible alternatives can be made. By comparing both capital and operating costs on a discounted cash flow basis, utilities can determine the "cheapest" source of energy.

The final decision regarding choice of energy is made on considerations of safety (nuclear power may appear to be the cheapest source of energy, but, in view of the Three Mile Nuclear Island accident, utilities may decide to use a more costly, less risky energy source) and long-term availability of fuel (natural gas may be available at regulated prices for several years, but, with declining oil and gas production in the United States, utilities may wish to forego the use of energy sources that are likely to be priced much higher in the long run).

Assuming that coal has been selected as the best energy source, utilities begin a detailed look at their options with regard to purchasing, transporting, and burning coal. Where feasible, utilities may consider constructing minemouth plants. Such plants have been constructed in Texas over lignite deposits in recent years, but are not attractive if the electricity must be transmitted over long distances, since line losses sharply increase overall system costs.

Where minemouth plants are not feasible, utilities evaluate their options by identifying the following constraints or alternatives:

1. Environmental regulations regarding emissions from coal-fired plants.

2. Technology available for coal-scrubbing and associated costs.

3. Mines that produce acceptable types and grades of coal.

4. Equivalent coal prices expressed on a Btu basis either f.o.b. the mine or delivered the plant.

5. Transportation alternatives for each mine and associated costs.

6. Ancillary costs associated with each type and grade of coal (need for washing or sizing).

7. Plant operating and capital costs for each type and grade of coal.

With this information, utilities are in a position to identify the most attractive origins for purchasing coal and the most attractive means for transporting this coal. Once these decisions are made, utilities establish a timetable for beginning negotiations with coal mine operators and carriers.

Typically, utilities constructing large coal-fired plants enter into long-term contracts (20 to 25 years) with coal suppliers. Not only do such long-term contracts protect the buyer from sudden, sharp price increases, but also from sudden curtailments of coal production. In some instances, utilities will not negotiate long-term contracts, but will rather rely on spot purchases or purchases for periods of one to five years.

Utilities consider a number of factors when negotiating for transportation services. There are at least three primary considerations and a host of secondary considerations. Each of the three primary considerations are discussed below. This is followed by a brief discussion of other considerations. The three primary considerations are:

- Matching purchase and transportation agreements.
- Costs.
- Reliability.

1. Matching Purchase and Transportation Agreements. Utilities seek to match their transportation arrangements with the terms of the coal-supply contracts. In the case of longterm coal contracts, utilities seek either to negotiate long-term agreements with carriers or to arrange for the the purchase of their own transportation equipment needs.

In the past, either option was available to utilities for securing water transportation. Barge, lake, and coastal carriers have not been subject to rate regulation, but have been free to offer long-term contracts calling for periodic rate adjustments for fuel and other costs subject to inflation. In addition, since the waterways are a public right-of-way, utilities have been free to purchase or lease their own power and equipment needs where it has been to their advantage to do so.

In sharp contrast, rail carriers have been subject to rate regulation and have not been free to offer contract rates, specifically tailored to the needs of individual utilities. While many utilities have obtained unit-train rates that have some features of a contract-rate agreement, the rates have not been performance agreements. Several utilities mentioned in particular that previous unit-train rates were subject to substantial rate increases not specifically tied to the escalation of specific cost factors. Furthermore, these rates have provided for neither performance incentives on the part of rail carriers nor formulas for sharing savings due to operating efficiencies or losses due to operating inefficiencies.

In the opinion of the utilities contacted, the inability to secure long-term contract rates that called for performance standards has increased the risk associated with purchasing coal originated and terminated by rail. By the same token, some utilities may be more susceptible to rail transportation now that rail carriers can negotiate contract rates. Contract rates may be most effective in securing the business of utilities located on waterways that have 9 to 10 month navigation seasons; these utilities have higher overall costs for water transportation than they would otherwise have with year round navigation.

Securing long-term transportation agreements with motor carriers or pipeline operators has not been an issue with utilities in the past. Since utilities are free to secure their own truck transportation, they have considerable bargaining leverage with independent truck operators. Truck transportation is usually limited to short distances of less than 100-150 miles. And as will be seen in the next major heading entitled "Principal Transportation Flows," pipeline transportation of coal has not been significant in the past.

2. Costs. Clearly, the costs of alternatives for tranporting the coal from mine-mouth to the plant play a crucial role in the negotiation for transportation services. These costs include all components of the distribution logistics system, such as linehaul, storage, transloading costs at a terminal, and plant receiving costs to name just a few.

In the case of barge or vessel transportation, these costs include the costs of any prior or subsequent moves by other modes, transloading, terminal storage, fleeting, linehaul, and plant receiving costs. Coal that moves by water is typically originated by either truck or rail and, in some cases, water transportation may not provide the final delivery to the plant. These other modal and transloading costs (shippers estimated that terminal charges varied from $0.75 to $2.00 per ton) are part of the overall distribution costs. Since use of more than one mode requires that operators have the flexibility to receive more coal than they ship or vice versa, storage and fleeting costs are also incurred. With regard to linehaul costs, many utilities have found that dedicated tows and vessels provide the cheapest means of transportation. Dedicated shipments require that the operator handle only coal in one direction and return empty for the next coal movement. The improved transit time offsets any potential gain from seeking backhaul traffic. Finally, costs are incurred at the plant for receiving and storing the coal. Without exception, utilities have some stockpile of coal on hand at the plant to assure them of an adequate supply even if serious disruptions caused by a strike or bad weather disrupt coal shipments to the plant. Stockpiles are made for 30 to 90 days of coal use and, in the special case of utilities that rely on water delivery of coal to plants with a 9 to 10 month open navigation season, addi- tional stockpiling is necessary.

At each point in the distribution of coal by water, utilities have the option of providing the services on their own or arranging for the services on a contract or spot basis. For example, one utility noted that private ownership of terminals is attractive if shipment volumes are high (such as 25,000 to 40,000 tons per day). A large terminal capable of handling 10 million tons per year may cost as much as $30 million to contsruct (a significant portion of this cost is associated with the large amount of land to store coal on the ground and the capital equipment to stack and reclaim this coal).

Some of the same costs must be calculated for rail transportation of coal. Utilities have found unit-train shipments of coal to be most cost effective; however, this has required the utilities to have adequate land at the plant for both a loop track and ground storage of the coal. Turn-time for these trains is often measured in hours and utilities will make substantial investments at the plant to discharge the coal quickly so that the dedicated trains can return quickly for the next coal shipment. Although utilities have not been able to secure their own power, they have determined whether it is in their best interests to purchase or lease their own hopper cars or gondolos. Linehaul costs are also affected by the amount of interlining that is required among rail carriers. Typically, utilities seek to ship their coal in a single-line movement, but, when choosing a site for a new utility plant, utilities prefer to have rail service from more than one carrier.

As the preceding comments suggest, it is difficult to generalize about rail and water transportation costs without considering numerous factors that can change the linehaul cost differences between water transportation and rail transportation rates.

Rail line-haul costs have historically been higher than barge rates, due partly to the large investments necessary to operate a railroad as compared to barge operations. However, as the following samples suggest, recent unit-train rates for coal from selected western mines were no different from recent barge rates on the Ohio River. As of July 15, 1979, a sample of unit-train rates for origins in North Appalachia with an average length of haul of 404 miles averaged $8.41/ton. South Appalachian origins averaged $8.13/ton for a movement of 452 miles. Originations in the Midwest were a good deal lower at $4.03/ton with an average length of haul of 217 miles. Montana-Wyoming originations cost more per ton ($11.84) but also traveled further (1,050 miles). The eastern and midwestern rates averaged 1.91¢ per ton mile while western rates averaged 1.13¢ per ton mile.

Although less information is available for barge rates, a sample of eastern coal traffic with an average length of haul of 208 miles was available. The average rate per ton was $2.31, or 1.11¢ per ton mile. This rate was 60% of the average rate for eastern and midwestern rail traffic and nearly identical to the western rail rate per ton mile.

From this limited sample of rates, it is not appropriate to draw many conclusions. It can be stated, however, that when barge transportation does offer a cost advantage, this advantage is often realized only if the utility has unloading facilities directly on the water.

The utility considering the use of truck transportation costs must also consider the impact of the traffic on public roads. Although roads are maintained by local, state, and federal governments, the large volume of coal traffic has a decided impact upon road maintenance requirements.

Pipeline transportation costs are a function primarily of the amount of tonnage. To make pipeline transportation feasible, minimum tonnages of 15 million tons are required for distances of 750 to 800 miles as indicated by one utility.

3. Reliability. Once a plant has been constructed and a distribution network established, utilities concentrate on achieving the highest plant utilization possible, given service area demands and alternative sources of purchased electricity. Shipment disruptions or inadequate transportation service can be very costly to utilities. Such incidents may prevent the utility from selling electricity to other utilities and may even force the utility to purchase higher-priced electricity from others.

Thus, the reliability of service and the adequacy of capacity to transport the coal over the 20 to 30 year life of coal-burning plants are key factors influencing modal choices. Without assurances of this reliability or capacity, utilities may be forced to select a next best alternative that may be more costly in the short run, but may be less expensive overall considering the additional capital costs associated with changing the logistics system from one method to another at some later point before the plant is scheduled for retirement. It is the large costs associated with making a change in the logistics system that make utilities relatively insensitive to increases in modal costs in the short run.

4. Other Considerations. Although utilities may attempt to plan for their fuel needs over the entire life of a plant, unforeseen events such as the OPEC price hikes, do occur that force utilities to convert existing boilers from one fossil fuel to another or from one type or grade of coal to another. When this happens, utilities must make a decision to retire a unit or pay for both the conversion of the unit and the logistics system to a new source of fuel. The conversion costs are substantial and, in all cases, utilities have less options when converting exiting units than they do when constructing new units.

A good example of this conversion process has been the conversion from eastern or midwestern coal to western coal by utilities located on the Upper Mississippi. Originally, these plants were designed to receive eastern or midwestern coal by barge. With the advent of the Clean Air Act and Amendments, these utilities have switched to western coal. Normally utilities constructing new plants in this area would plan to receive western coal by rail; however, existing plants without good rail service are forced to use rail-to-water terminals at places such as East St. Louis; Keokuk, Iowa; and Minneapolis-St. Paul in order to receive western coal. Although this arrangement is not optimal, it is cheaper than other alternatives, including the retirement of the plant.

Another good example of this conversion process may well be the conversion of utilities located in the Northeast and central Southwest from oil and gas to coal. This development is discussed further under the major heading entitled "Factors Influencing Flows in the Future".

(b) Industrial Users

Industrial users of coal must make similar investment decisions that the electric utility industry makes with regard to the purchase and transportation of coal. Furthermore, as noted earlier, industrial users face similar economic, environmental, and energy directives that are forcing them to burn more coal in an acceptable manner. However, it should be noted that energy costs are only part of the costs of producing manufactured goods. As a result, decisions with regard to the coal logistics system are made within the overall company's plans for industrial production.

(c) Coal Exporters

As noted earlier, over 50 million tons of coal were exported in 1977. The overwhelming share of this coal was high-quality coking coal. Since West Virginia and Kentucky have the largest reserves of coal suitable for coke production, East Coast ports such as Norfolk and Baltimore, that have good rail service from these eastern mines are well suited to handle this traffic. Aside from good single-line rail service from mine to port, an important factor for securing this traffic is the presence of a good export terminal located on a channel with adequate draft for large ocean-going vessels. Terminal requirements also include substantial yard capacity and fast rail-to-vessel transloading systems. It should also be noted that some coal exports move to Canada by rail or by a rail-to-water shipment. Great Lake ports on Lake Erie are well suited for this business.

PRINCIPAL TRANSPORTATION FLOWS

This subsection outlines the key transportation flows of coal. In 1976, the Department of Energy estimated that water shipments accounted for 10% of all coal shipments from United States mines. Table VI-9 presents 1976 coal shipments by mode.

Since a portion of the coal loaded at mines for shipment by rail is involved in a subsequent water move, these figures should not be interpreted strictly as the modal shares of all coal shipments. Although rail and water are often considered the dominant modes for coal transportation, a substantial amount of coal traffic moves by truck or is consumed at mine-mouth.

Table VI-9

1976 Shipments of Coal from the Mine

	Millions of Tons	Percent of Total
Rail	431.1	63.5
Water	69.6	10.3
Truck	89.8	13.2
Mine-Mouth	79.2	11.7
Other 1/	9.0	1.3
	678.7	100.0%

NOTE: 1/ Includes coal used at mine for power, heat, and coke production, as well as coal shipped by slurry pipeline.

SOURCE: Department of Energy.

Exhibit VI-9 presents estimates of total coal flows for 1977 by six principal origins and seven principal destinations. The major coal flows for all modes are:

1. South Appalachia to South Atlantic (116.8 million tons).

2. North Appalachia to East North Central (80.8).

3. North Appalachia to New England and Northeast (71.7).

4. Midwest to East North Central (66.5).

5. South Appalachia to East North Central (46.5).

6. South Appalachia to East South Central (44.0).

7. Midwest to East South Central (42.0).

8. Montana and Wyoming to East North Central (30.9).

9. Montana and Wyoming to West North Central (27.6).

As can be seen, shipments from eastern mines continue to dominate United States coal flows. However, unlike historical coal movements that were characterized by utilities using the nearest coal supplies, there are significant coal movements from Montana and Wyoming to utilities in the East North Central (ENC) and West North Central (WNC) regions. As noted earlier, utilities in the ENC region have been forced to burn low-sulfur coal from the West to meet air pollution standards. As coal scrubbing techniques improve, high-sulfur eastern coal may again replace the western coal. Utilities in the WNC region have been using more western coal due to both air pollution standards and the favorable price relationship of this coal to midwestern coal. The sharply lower mining costs of Montana and Wyoming allow shipments to be competitive with Midwestern coal, despite longer hauls (in this case, well over 500 miles).

Before discussing water transportation flows in more detail, a brief comment should be made about coal-slurry pipelines. Coal-slurry pipelines transport finely ground coal mixed with water. Pumping or compressor stations located at regular intervals throughout the pipeline move the slurry from origin to destination.

At the present time, there are two such pipelines in the United States, but only one of these pipelines, the Black Mesa Pipeline, is in operation. The Black Mesa Pipeline connects a strip mine in Kayenta, Arizona to the Mohave Power Plant in southern Nevada. The pipeline is 273 miles long; it was considered to be a less costly transportation alternative than the construction of 150 miles of new track for rail service. The line has an annual capacity of 4.8 million tons and total transit time is approximately three days. The other pipeline, Consolidation Coal Ohio Pipeline, is 108 miles long and connects a mine at Cadiz, Ohio with East Lake Power System in Cleveland. The pipeline was built in 1957 and was in operation for six years, until rail rates were reduced low enough to make continued operation of the pipeline uneconomical. The capacity of the line is 1.25 million tons per year.

A number of new coal-slurry pipelines are being proposed primarily for the transportation of western coal. These pipelines are discussed further in the next major heading.

A brief description of some of the water transportation used by utilities and coal exporters is presented below. The description is presented by major waterway regions as defined for the NWS in Appendix B.

(a) Ohio River

The discussion of the Ohio River inclues the Monongahela, Allegheny, Kanawha, Green, and Cumberland Rivers as well.

There are presently 22 utilities on the Ohio River that receive some coal by water.[1] These utilities accounted for 27% of the 1977 net kwh production in Illinois, Indiana, Kentucky, Ohio, Pennsylvania and West Virginia. The largest coal source is Kentucky (supplying an estimated 32% of coal deliveries to these utilities) with Ohio and West Virginia supplying most of the remainder (25% and 16%, respectively). The total coal burn by these utilities in 1977 was 58 million tons.

The average waterborne trip for the utilities on the Ohio is less than 100 miles and the coal is generally moved to the river by truck. Major barge-loading areas include Cincinnati and Huntington-Ashland. The majority of coal which is not moved by barge to the utilities is delivered by truck.

Western coal has made little enroads to these utilities; however, some of the plants have begun to use low-sulfur coal from East Kentucky.

The eight utilities on the Monongahela, Allegheny and Kanawha Rivers provided 27% of the Kwh production in West Virginia and Pennsylvania in 1977.[2] The 1977 burn was 18 million tons. The majority of this coal comes from Pennsylvania and West Virginia with the average barge-haul between 25 to 100 miles. Because of the short distances involved, any movement not by barge is generally by truck. In order to meet air-quality standards, these utilities have been burning low-sulfur, eastern coals in recent years.

There are two plants on the Green River and one plant on the Cumberland River that receive some coal by barge.[3] These three utilities produced 13% of the total electricity generated in Kentucky and Tennessee during 1977 and their total burn was 6 million tons. The two plants on the Green River receive their coal from West Kentucky. The West Kentucky Coal is received by truck and barge. Barge coal is loaded either on the Green River or on the Ohio River.

The plant on the Cumberland receives its coal from West Virginia. This coal is moved by conveyer to the Ohio River for downstream shipment to the Cumberland.

(b) Upper Mississippi River

There are presently thirteen utilities in Minnesota, Wisconsin, and Iowa that receive some coal by water.4/ The two predominant sources of coal for these utilities were Illinois and Montana/Wyoming. These sources accounted for an estimated 82% of all coal deliveries. The total burn in 1977 for these utilities was 9 million tons.

The majority of western coal is delivered by rail to St. Paul, where it is transloaded onto barges for downstream movements of 20 to 350 miles. Illinois coal is typically moved by rail to transloading facilities in East St. Louis and barged upstream anywhere from 10 to 675 miles.

(c) Illinois River

There are presently five plants on the the Illinois River that receive some coal by water.5/ Two other plants can receive barge-delivered coal, but they are not doing so at the present time. These seven utilities generated 22% of Illinois' Kwh production in 1977 and their total coal burn was over 8 million tons. Over 55% of the coal delivered to these utilities originated in the West. This western coal is moved to Havana, Illinois where it moves by barge upstream. Some midwestern coal is also loaded in Havana for shipment downstream.

(d) Tennessee River

There are four plants on the Tennessee River that receive some coal by barge.6/. These plants generated 25% of the electric power output of Tennessee and Alabama in 1977 and their total burn was 11 million tons. West Kentucky coal is the predominant source of coal for these utilities. Additional coal is received by both truck and rail.

(e) Lower Mississippi River

There are two utilities on the Lower Mississippi River that receive their coal by water[7]. The 1977 burn was four million tons for these utilities. The majority of coal on the Lower Mississippi originates in Illinois and West Kentucky. The West Kentucky coal is loaded on the Ohio River at points such as Uniontown, Kentucky and barged downstream to the Mississippi. The Illinois coal is also loaded on the Ohio River near its confluence with the Mississippi.

(f) Tombigbee - Alabama - Coosa - Black Warrior Rivers

There is one utility located on the Tombigbee River and another located on the Black Warrior River[8]. Their 1977 burn was four million tons. The coal burned at these utilities typically comes from Alabama. This Alabama coal is trucked and conveyed to the Black Warrior River and then barged downstream to points on the Black Warrior and Tombigbee Rivers.

(g) Great Lakes/St. Lawrence Seaway/New York State Waterway

There are 16 utilities that receive some coal by the Great Lakes[9]. All but one of these utilities are located in either Michigan or Wisconsin and they generated 60% of kwh production in these states during 1977. The total burn of all 16 utilities in 1977 was 21 million tons. The principal sources of coal were West Virginia (this state accounted for an estimated 25% of all coal receipts to these plants in 1977), East Kentucky (20%), and Ohio (17%). Secondary, sources were Montana (13%), Pennsylvania (12%), and West Kentucky (8%).

Most of the waterborne coal destined for Lake Erie, Lake Huron, Lake Michigan, and Lake Superior is loaded at Lake Erie ports and moved by lake bulkers to the utilities. Lake Erie ports include Conneaut, Lorain, Toledo, Sandusky, and Ashtabula, Ohio. The Duluth - Superior port is expected to handle increasing amounts of western coal. Some coal is also shipped by lake vessel from Chicago.

It should also be noted that some coal exports move by rail to Lake Erie ports and then by vessel to Canadian ports on Lake Erie, Lake Huron, and Lake Ontario.

(h) Gulf Coast East

Five utilities in Florida receive some domestic coal via the Gulf of Mexico and small quantities of imported coal. These utilities produced 29% of Florida's total electricity output in 1977[10/]. The total burn of these utilities in 1977 was seven million tons. West Kentucky supplied 59% of total coal deliveries, while Illinois and East Kentucky supplied the remainder. The typical transportation pattern's for the West Kentucky and Illinois coal to be loaded on the Mississippi and barged down to New Orleans where the coal is transferred into ocean-going barges for final shipment to the utilities. East Kentucky coal is typically shipped by rail. One of the utilities also receives some imported coal from Poland.

There is one utility that receives coal on the Biloxi River[11/]. Approximately one million tons of coal were burned at this plant in 1977. The major sources of this coal were Illinois and East Kentucky. The coal is shipped to the Ohio River, loaded on barges, moved down the Mississippi and then shipped along the Gulf Intracoastal Waterway to the Biloxi River.

(i) Middle Atlantic Coast

There are two New Jersey utilities that receive their coal by water[12/]. These plants accounted for 32% of kwh production in New Jersey during 1977 and their total burn was two million tons. The principal sources of this coal were West Virginia, Pennsylvania, and New Jersey. One of the plants receives its coal from Norfolk where it is transloaded from rail cars. The other plant receives its coal by river barge, after the coal has been transloaded from rail.

In addition to these domestic shipments, there are export shipments of coal from such ports as Norfolk and Baltimore to Japan. The coal moves to these ports by rail and is transloaded to vessels with capacities of 55,000 to 60,000 dwt. The ships then travel either through the Panama Canal and on to Japan or to Western Europe.

FACTORS INFLUENCING FLOWS IN THE FUTURE

There are a number of factors that may influence the coal and electric utility industries in the future and some of these factors may be expected to change the nature and amount of waterborne coal flows. Nine factors are discussed under separate headings below. These factors include:

1. New electric utility plants.

2. Conversion of existing oil and gas-fired plants to coal.

3. Increased use of high-sulfur coal.

4. Nuclear moratorium.

5. Coal-slurry pipelines.

6. Rail deregulation.

7. Synfuel.

8. Increased leasing of mineral rights to federally owned coal reserves.

9. Increased steam coal exports.

(a) New Electric Utility Plants

Utilities regularly review their needs for additional megawatt capacity by forecasting growth in base load and peak load demand. The demand for electricity has been especially difficult to forecast in recent years, because the sharply higher service rates have generally slowed the annual growth in base load demand below the historical increases characteristic of the 1960s and early 1970s. Although, consumers in many service areas have reacted to higher rates by reducing their use of electricity, it is still early to tell whether a significant change in the demand for electricity will take place as a response to higher rates.

Nonetheless, there are some electric utilities that have plans for new megawatt construction. Exhibit VI-10 presents the units known to be planned by utilities for the 1980s and early 1990s. These units are planned to be coal-burning and will in most cases receive coal by water. An estimated 29 to 30 units are expected to be constructed in the 1980s. The largest increase in units (10) and megawatt capacity (8,625) is expected to occur on the Ohio River. This would represent a 33% increase in megawatt capacity for the Ohio River utilities.

The Gulf Coast East is the waterway with the next largest increase in units (seven or eight) and megawatt capacity (4,125-4,775). If this new construction would take place, it would increase megawatt capacity in Florida along the Gulf of Meixco by over 67%.

Although, many of the utilities listed in Exhibit VI-10 do not have final transportation contracts, it is expected that these units will receive most of their coal by water due partly to the fact that much of the construction represents additions to existing plants with established logistics systems.

(b) Conversion of Existing Oil and Gas-Fired Plants to Coal

As noted earlier in the major heading entitled "Markets", conversion of existing oil gas-fired plants has been recommended and, in some cases, directed by the federal government. The President's Commission on coal has recommended that 11 units in New York and 10 units in New Jersey be reconverted to coal. In view of the limited number of units receiving coal in these areas at the present time, it is not possible to state to what degree these utilities will rely on water transportation for their needs. However, some increase in Atlantic coastal traffic can be expected.

Other areas of the country can also be expected to convert existing oil or gas-fired plants. Table VI-10 presents estimates of coal's share of total fossil fuel use by steam electric utility plants in 1976. (It should be noted that nuclear power is excluded from this analysis.)

Aside from the Middle Atlantic region (which includes New York and New Jersey), there are three principal regions that might be expected to increase their use of coal to fire existing steam plants. These regions are: New England, West South Central, and Pacific.

In the case of New England, there are several utilities in Massachusetts that might be expected to receive coal by water. In 1976, fully 99% of fossil fuel use by Massachusetts' utilities was oil. Possible movements include shipment from eastern coal mines to coastal ports, such as Norfolk or Baltimore, for subsequent water delivery by ocean-going barge. In any event, waterborne coal terminations for Upper Atlantic ports can be expected to increase if these utilities convert to coal.

Table VI-10

Coal's Share of the 1976 Fossil Fuel Market[1] for Steam Electric Utilities

Region	Coal's Share
New England	4%
Middle Atlantic	60%
South Atlantic	67%
East North Central	94%
East South Central	93%
West North Central	82%
West South Central	7%
Mountain	79%
Pacific	7%

NOTE: 1/ Oil, gas, and coal use are compared on an equivalent Btu basis.

SOURCE: National Coal Association, Coal Facts, 1978-1979.

In the case of the West South Central region, states, such as Texas, Louisiana, and Arkansas have relied on oil and natural gas for a substantial share of their utility fuel needs. Arkansas used oil for 77% of its plant's needs in 1976, while gas represented more than 80% of plant consumption in Lousiana and Texas. Conversion of some of these utilities can be expected; however, the waterborne share of potentially new coal flows to these plants is difficult to predict. Unit train shipments of western coal to such cities as Houston have captured much of the new coal business of recent years. Furthermore, utilities in Arkansas, Texas, and Louisiana have been supporting the construction of new coal-slurry pipelines. (This factor is discussed further under a separate heading.) At the present time, those two utilities located on the Lower Mississippi receive most of their coal from West Kentucky and Illinois by truck and barge or rail and barge. Another possible method of shipment is rail delivery of western coal to St. Louis, Cora, Illinois and other Mississippi River points for subsequent shipment by barge. With the conversion of existing oil and gas-fired plants to coal, some increase in barge terminations can be expected, provided the converted plants are at or near navigable waterways.

Although the Pacific region also has a low share of coal use at existing steam plants, it is not expected that any possible conversion of these plants would use significant amounts of water-delivered coal. Since western coal is the predominant source of coal for this region, unit-train shipments or possibly coal-slurry pipelines are the expected methods of shipment.

Finally, there are some individual states in other regions where some conversion to coal can be expected. These states include Florida, Mississippi, and Michigan.

In 1976, over 60% of fossil fuel consumption by Florida utilities was oil. Gas accounted for another 17% of fuel use. The division of this potentially new business between rail and waterborne carries is difficult to judge, because these utilities have a number of options.

These options include the present water movement down the Mississippi and across the Gulf; possible rail shipments to East Coast ports, such as Norfolk, for shipment by barge down the Coast; unit train shipments from eastern coal mines; and possible barge shipments down the Tennessee - Tombigbee Waterway once it is completed.

Mississippi utilities relied on oil for other half of their fossil fuel use in 1976. Just as with Louisiana and Arkanasas, Mississippi utilities may increase their use of coal and rely on water transportation (either from the Mississippi or Tombigbee Rivers) for some of their transportation needs.

Michigan utilities rely primarily on coal for fossil fuel use, but, in 1976, an estimated 15% of this use was oil. If selected Michigan utilities are encouraged to convert, rail transportation would be expected to obtain much of the new business.

(c) Increased Use of High-Sulfur Coal

Increased use of high-sulfur coal by electric utilities and industrial users located in the East and Midwest is possible for two different reasons:

1. Improved technology resulting in lower-cost methods of removing pollutants from the coal or the combustion gas going up the stack.

2. Relaxation of air quality standards on a selective, case-by-case basis.

Improved technology to remove sulfur from the coal as stack gas could reduce the costs of burning high-sulfur coal in areas restricted by present air quality standards. As discussed earlier under the heading "Markets," fluidized bed combustion is one approach being taken to reduce sulfur emissions. A relaxation of air quality standards, such as the recent decision by EPA to permit a utility in Ohio to continue using high-sulfur coal despite the fact that emissions would exceed previously estimated limits, would also encourage the use of high-sulfur coal.

If either of these two factors would become important in the future, a relatively small, but growing waterborne movement of western coal on the Great Lakes might be curtailed. At the present time, the majority of the utilities on the Great Lakes only have precipitators and tall stacks for pollution control. Thus, it is a real possibility that these utilities may be forced to switch to low-sulfur, western coal as one Michigan utility has done recently. A change in the costs of removing sulfur or a relaxation of air quality standards would permit these utilities to continue burning midwestern and eastern coal.

(d) Nuclear Power Moratorium

In light of the Three Mile Island and other nuclear accidents, a moratorium on building nuclear power plants is a possibility for the 1980s and beyond. This moratorium could result in the termination of over 40 nuclear facilities currently under planning or construction in states where water transportation of coal is important. Exhibit VI-11 presents the number of nuclear plants under planning or construction in states bordering major waterways. The greatest increase in planned megawatt capacity for nuclear power is in those states bordering the Ohio and Tennessee Rivers.

A nuclear moratorium would in nearly all cases force utilities in the areas bordering the Ohio and Tennessee Rivers to rely exclusively on coal-fired plants for additional megawatt capacity. Since the location of these coal-fired plants would be determined by utilities on a case by case basis, it is difficult to determine the impact on waterway flows. If utilities located new coal plants such that the modal share of coal shipments was representative of present conditions (see Table VI-11), then water transportation might be expected to capture anywhere from 15 to 43% of the additional coal business.

Table VI-11

1977 Coal Shipments by Mode and State of Destination (Percent)

	Rail	Water	Truck 1/
Alabama	51%	15%	34%
Indiana	70%	15%	15%
Kentucky	51%	17%	32%
Ohio	37%	35%	28%
Tennessee	45%	43%	12%

NOTE: 1/ Includes trainway, conveyor, and private railroad.

SOURCE: National Coal Association, Coal Traffic Annual: 1977.

(e) Coal-Slurry Pipelines

There are presently six coal-slurry pipelines that the Coal-Slurry Transport Association considers active or semi-active. Coal-slurry pipelines face a number of obstacles, such as securing right of way and water supply. However, some utilities receiving western coal from origins as far as 1,000 and 1,600 miles away are strong advocates of these pipelines. One utility in the Southwest estimated potential transportation savings of $2 billion over a 20 to 25 year period. Exhibit VI-12 lists the names, origins and destinations, length, capacity, and proposed completion dates for each of these six pipelines.

The principal impact of the completion of these coal-slurry pipelines would be a reduction in rail traffic. The two lines that would pose the most substantial competition of existing waterborne flows are the ETSI and Florida Gas pipelines. The ETSI pipeline would have little effect on waterborne flows at the first principal destination of the line in Arkansas. (The Arkansas units are using western coal and must rely on unit-train shipments of coal at the present time.) As the line is extended further south to Baton Rouge, Louisana and other Mississippi destinations, the line would reduce the amount of new coal business that would otherwise be available to rail and marine carriers from both the conversion to coal of southern utilities and increased synthetic fuel production from coal. The principal alternative to this line for serving this new coal business is a combined rail and water move requiring the use of transloading facilities at ports, such as St. Louis or Cora, Missouri.

The Florida Gas Pipeline would also reduce waterborne coal flows below what they would otherwise be. The principal water movements affected would be the Lower Mississippi and cross gulf route to Florida and the Tombigbee, Black Warrior, and Gulf Intracoastal Waterway route to Florida.

(f) Rail Deregulation

Another factor that may change the nature or amount of waterborne coal flows in the future is the partial or complete deregulation of rail carriers. In contrast to truck and water carriers, rail carriers have been subject to both rate regulation and entry or exit restrictions.

Some form of rail deregulation is expected in the future, but informed sources at the Interstate Commerce Commission (ICC) and in industry differ among themselves as to the exact form that this deregulation might take. Possible components of rail deregulation might include:

1. Complete deregulation of rail rates for rail tonnage that is truck competitive. (The interim report entitled A Study to Perform an In-Depth Analysis of Market Dominance and Its Relationship to Other Provisions of the 4-R Act prepared by A.T. Kearney for the ICC found that 30% of the 1977 interstate rail tonnage could be considered truck-competitive.)

2. Limited rate regulation that allows carriers to raise rates (within a zone of reasonableness) with provisions for only limited shipper protection.

3. Increased rate-making flexibility for traffic that is subject to periodic demand variation.

4. Establishment of negotiated contract rates subject to little regulation provided that these rates are made available to other shippers in similar circumstances.

5. More timely and favorable review of carrier proposals to abandon lines. (However, lines actually abandoned could be purchased from other carriers or shippers.)

6. More timely and favorable review of proposals for selected railroad mergers.

Regardless of the exact form that rail deregulation may take in the future, the intent of such changes is to improve the ability of railroads to raise capital for the maintenance and upgrading of track, yard facilities, locomotive power, and rolling stock. This issue is of special importance to coal traffic because rail carriers are expecting to handle additional coal traffic in the future and their ability to compete for this traffic may be influenced by the form that deregulation takes.

Several implications of rail deregulation for waterborne coal traffic can be made. First, as rail rates are increased to pay for improved mainline track, more power, and more rolling stock, some diversion of coal traffic to water and truck carriers can be expected in the short term. Such diversion is, of course, only possible if shippers have alternatives to rail service. Truck transportation is an alternative to rail for short-haul shipments of 50 to 150 miles. Water transportation is an alternative to rail if the mine and/or utility are located near navigable waterways. Utilities relying on eastern coal and located on the rivers, Great Lakes, or coasts would be in a better position to make more use of water transportation in the short run.

Second, as rail carriers begin to improve their financial positions and invest additional resources to handle coal traffic, some loss of coal traffic from water and truck carriers can be expected. Such loss is even more likely if either rail carriers can effectively use contract rates to market their services or selected end-to-end railroad mergers, such as the BN-Frisco, SCL-C&O, or UP-MOP, are permitted. The waterborne coal traffic that is most susceptible to increased rail competition might include:

1. Waterborne traffic on waterways with only 9 to 10 month navigation seasons. (The increased distribution costs associated with stockpiling coal for three to four months of use make utilities located on the Illinois River, Upper Mississippi River, or Great Lakes susceptible to negotiated contract rates that provide dependable year round service.)

2. Short-haul waterborne traffic that has a prior, long-haul rail movement. (A long-haul, such as the shipment of coal from western mines to St. Louis, provides rail carriers with considerable rate-making flexibility. Thus, these carriers can price through rates in such a way that shippers located on water will be encouraged to use rail for the entire movement.)

(g) Synfuel

The production of synthetic fuels from coal could have widespread impacts on the future distribution of coal. President Carter has recently suggested a production split of approximately 1.0 to 1.5 million barrels per day of coal synthetics and another 1.0 to 1.5 million barrels per day of shale oil, biomass, and unconventional natural gas. (The implications of fuel production from biomass are discussed further in Section IX.) Since substantial amounts of coal will have to be used in the synthetic fuel process, the location of plants will establish a new set of logistics systems.

In the opinions of shippers, synthetic-fuel plants would most likely be located near coal sources or complementary facilities (such as chemical and fertilizer plants or refineries). Plants located near coal sources would be mine mouth operations and water transportation would play little role except for the possible distribution of the refined products. Plants located near complementary facilities, however, would require transportation of the coal from mine to the plant. Since many chemical plants and refineries are located on the Gulf Coast, new coal flows such as rail shipments to the Mississippi River and barge shipments to the Gulf of Mexico would be likely. The principal waterways experiencing an increase in coal traffic would be the Lower Mississippi, Gulf Coast West, and Gulf Coast East. (Further discussion of this factor is provided in Sections III and VII.)

(h) Increased Leasing of Mineral Rights to Federally Owned Coal Reserves

As discussed above, there has been a moratorium on leasing mineral rights to federally owned coal reserves since 1973. However, the Federal Coal Management Program has been redesigned and is expected to begin in 1981. The increased availability of western coal provided by this program could be expected to change existing waterborne coal flows.

The increased coal production is not expected to be a factor until 1985 or 1990 because planning and developing coal mines take a considerable amount of time. When production does begin, there will be large amounts of new low-sulfur coal requiring transportation to southern and midwestern markets. The markets will most likely be utilities that operate in urban areas where environmental standards are fairly strict. This western coal would compete directly with midwestern and eastern coal for this business. Since western coal moving eastward by rail and water has been shipped either by rail to the Great Lakes or by rail to the Mississippi River, some increase in this traffic could be expected.

(i) Increased Steam Coal Exports

As discussed previously, several coal experts (see the Wall Street Journal article entitled "Growing Market Overseas for Steam Coal Begins to Draw on Big Supply in the United States" in February 7, 1980) expect to see a sharp increase in coal exports for foreign utilities. Of particular promise is Western Europe. (An unpublished DOE study suggests that a substantial coal export market will develop in Japan by 1990 or 2000. If this happens, some coal may move from western mines to the Columbia-Snake Waterway, assuming that western railroads are willing to give this traffic up at river points.) The United States has some competitive advantages in serving this market, because South Africa and Australia are further away and Poland's coal is increasingly going to the Soviet Union. The Middle Atlantic and South Atlantic Coasts as well as Gulf Coasts would be expected to see increases in activity if this new business develops.

EXHIBIT VI-2

WORLD COAL PRODUCTION AND RESERVES 1/
(Millions of Tons)

1976 Total	Production	Reserves 2/
U.S.S.R.	702	301,151
United States	679	400,758 3/
People's Republic of China	510	330,693
East Germany	273	N/A
Poland	241	42,851
West Germany	239	109,702
England	134	108,993
Czechoslovakia	130	N/A
India	116	25,529
Australia	110	81,946
Other Countries	381	163,959
World TOTAL	3,515	1,565,582

NOTE: 1/ Excludes anthracite.

NOTE: 2/ That portion of total resources that have been carefully measured and assessed as being exploitable under local economic conditions and available technology. The estimate of reserves is based on a 1974 survey.

NOTE: 3/ Estimates of United States coal reserves in this survey do not agree with other domestic data.

SOURCE: Bureau of Mines, Minerals Yearbook, 1975, and World Energy Conference Survey of Energy Resources, 1974.

EXHIBIT VI-3

PREMIUM BITUMINOUS COAL RESERVES
SUITABLE FOR COKE PRODUCTION 1/
(Millions of Tons)

West Virginia	10,461
Kentucky 2/	4,977
Virginia	1,628
Utah	782
Colorado	612
Other States	1,093
UNITED STATES TOTAL	19,553

NOTE: 1/ The reserve base includes only those coals greater than 28 inches in thickness, less than 1,000 feet in depth, and in reliability categories as defined by high, medium, and low-volatile content.

NOTE: 2/ Includes East Kentucky only.

SOURCE: National Coal Association, Coal Facts, 1978-1979, Washington, D.C., 1979.

EXHIBIT VI-4

LARGEST COAL - PRODUCING COMPANIES IN THE U.S. FOR 1978

Group or Company	Millions of Tons
Peabody Coal Co.	52.5
Consolidated Coal Co.	41.8
AMAX Coal Co.	29.8
Island Creek Coal Co.	13.6
Arch Mineral Corp.	12.9
NERCO Group	11.4
Pittston Group	11.0
Western Energy Co.	10.6
United States Steel Corp.	10.4
Peter Kiewit Group	10.2
Bethlehem Mines	9.5
American Electric Power	9.3
Pittsburg & Midway	7.9
Old Ben Coal Co.	7.7
North American Group	7.6
TOTAL	246.1

SOURCE: Keystone Coal Industry Manual.

EXHIBIT VI-5

MAJOR OIL AND COAL MERGERS SINCE 1976

Year	Buyer	Company Acquired
1976	Barber Oil	Paramount Coal
	Ashland Oil	Kentucky Highland River Coal
1977	Prudential Group	Cumberland River Coal
	Shell Oil	Seaway Coal
	Tosco	Sonner Brothers Coal
	Hamilton Bros. Group	Carbon Coal
	Mobil	Mount Olive & Staunton Coal
	Gulf Oil	Kewanee Industries
1978	Patrick Petroleum	Belibe Coal, Black Nugget Coal
	Transcontinental Oil	Diamond Coal
1979	Diamond Shamrock	Falcon Seaboard
	Standard Oil (Ohio)	Dahlgren-Moores Prairie Coal Assn.
	Sun	Elk River Resources

SOURCE: "The Oil Majors Bet on Coal," Business Week, Sept. 24, 1979.

EXHIBIT VI-6

AVERAGE VALUE F.O.B. MINES
BY STATE FOR 1976
(Dollars per Ton)

East	
Kentucky	$19.79
Pennsylvania	25.33
Virginia	24.12
West Virginia	30.12
Alabama	28.37
Midwest	
Illinois	$15.90
Indiana	12.34
Ohio	16.61
West	
Montana	$ 4.90
North Dakota (Lignite)	3.74
Wyoming	7.00
United States Average	$19.43

SOURCE: Deptartment of Energy.

EXHIBIT VI-7

REGIONAL RECLAMATION COSTS FOR 1977

Region	Dollars per Ton
North Appalachia	$7.04
South Appalachia	7.04
Midwest	5.70
Montana/Wyoming	0.77
Colorado/Utah	0.96
Arizona/New Mexico	0.74

SOURCE: Deptartment of Energy.

EXHIBIT VI-8

FINANCIAL PERFORMANCE FOR SELECTED COAL COMPANIES 1/

	Net Income Sales	Return on Equity
1970	6.7	15.6%
1971	5.6	12.8
1972	4.1	10.0
1973	4.1	10.6
1974	10.9	25.2
1975	13.3	29.4
1976	9.5	22.7
1977	5.2	11.2
1978	1.9	4.0

NOTE: 1/ Companies include Eastern Gas and Fuel, North American Coal, Pittston Company, Westmoreland Coal, and Utah International (through 1976 only).

SOURCE: Standard & Poor's, Industry Surveys: Steel-Coal Basic Analysis, October, 1979.

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NATIONAL WATERWAYS STUDY. COMMERCIAL WATER TRANSPORTATION USERS--ETC(U)
AUG 81   V CHURCHWARD, D REITZ   DACW72-79-C-0003

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EXHIBIT VI-9

1977 TOTAL COAL FLOWS
(MILLIONS OF TONS)

Destinations	North Appalachia(1)	South Appalachia(2)	Midwest(3)	Montana/ Wyoming	Colorado/ Utah	Arizona/ New Mexico	Total
New England/ Middle Atlantic	71.7	10.3					82.0
South Atlantic	21.5	116.8	10.0				148.3
East North Central	80.8	46.5	66.5	30.9	5.3		230.0
East South Central	0.6	44.0	42.0				86.6
West North Central	0.2	1.1	17.5	27.6	0.5		46.9
West South Central		1.9		4.3	1.4	1.2	8.8
Mountain/Pacific				22.3	15.5	21.8	59.6
TOTAL	174.8	220.6	136.0	85.1	22.7	23.0	662.2

(1) Includes Md., Oh., YA., and North WV.

(2) Includes AL., East KY., TN., VA., and South WV.

(3) Includes IL., IN., and West KY.

SOURCE: Department of Energy, Energy Data Reports on Bituminous, Sub-Bituminous, and Lignite Distribution for 1977, 1978.
National Coal Association, Steam Electric Plant Factors, 1978.

EXHIBIT VI-10

FUTURE COAL-BURNING UNITS TO BE WATER-SERVED

Waterway	Company	No. of Units	Increase in Megawatt Cap.
Ohio River	Dayton Power Co.	1	1,200
	Kentucky Utilities	2	1,000
	East Kentucky Power Corp.	1	500
	Pennsylvania Power	1	825
	Cincinnati Gas & Electric	2	1,200
	American Electric Power	3 2/	3,900
Mononyahela River	Monongahela Power	2	1,252
Green River	Big Rivers Electric Corp.	4	1,250
Upper Mississippi River	Muscatine Power & Water	1	150
Illinois River	Central Illinois Light Co.	1	400
Lake Erie	Niagara Mohawk Power	2	1,700
Lake Michigan	Wisconsin Electric Power	1	600
Lake Superior	Marquette Board of Light and Power	1	44
Gulf Coast East	Tampa Electric	5-6	3,025-3,675
	Florida Power	2	1,100

NOTE: 1/ Plants that are planned to be built in 1979-1991.

NOTE: 2/ The dates for two of these plants are not determined.

SOURCE: National Coal Association, Steam Electric Plant Factors, 1978, and Interviews.

EXHIBIT VI-11

NUCLEAR PLANTS CURRENTLY UNDER PLANNING FOR 1980 TO 1987 OR CONSTRUCTION

Waterway	Number of Plants	Megawatt Capacity
Ohio River	20	20,000
Monongahela, Allegheny, and Kanawha River	4	4,200
Upper Mississippi River	2	2,000
Illinois River	7	6,700
Tennessee River	11	13,000

SOURCE: National Coal Association, Steam Electric Plant Factors, 1978, and Interviews.

EXHIBIT VI-12

ACTIVE AND SEMI-ACTIVE
COAL-SLURRY PIPELINE PROPOSALS

Name	Origin, Destination	Length (Miles)	Capacity (Million Tons	Proposed Completion Date
1. Boeing **Florida Gas Pipeline**	Southern Illinois, **Southern Indiana**, East Kentucky, and West Virginia to Tennessee, Georgia, and Florida	1,500	40	1990
2. Energy Transportation Systems, Inc.	Wyoming to Penton, Mississippi	1,355	25	1983-1985
3. Texan Eastern	Montana to Houston	1,260	22-26	1985-1988
4. Houston Natural Gas (San Marco Pipeline Co.)	Colorado to Texas	900	15	1990
5. Nevada Power (Alton Pipeline)	Utah to Nevada	183	10-11.6	1983-1984
6. Gulf Interstate	Wyoming to Oregon	1,100	10	1990 or later

SOURCE: Coal Slurry Transport Association.

EXHIBIT VI-13

U.S. COAL PRODUCTION AND DEMONSTRATED COAL RESERVE BASE 1/
(Millions of Short Tons)

State	1977 Production	Demonstrated Coal Reserve, January 1976 2/			
		Bituminous	Sub Bituminous	Lignite	Total
Kentucky	142.9	25,951	-	-	25,951
W. Virginia	95.4	38,607	-	-	38,607
Pennsylvania	83.2	23,728	-	-	23,728
Illinois	53.9	67,969	-	-	67,969
Ohio	46.2	19,230	-	-	19,230
Wyoming	44.5	4,003	51,370	-	55,373
Virginia	37.9	4,166	-	-	4,166
Montana	29.3	1,385	103,417	15,767	120,569
Indiana	28.0	10,714	-	-	10,714
Alabama	21.2	2,009	-	1,083	3,092
Texas	16.8	-	-	3,182	3,182
Other States	89.3	31,163	13,638	13,585	58,386
U.S. TOTAL	688.6	228,925	168,425	33,617	430,967

NOTE: 1/ Excludes anthracite coal.

NOTE: 2/ Known or indicated deposits that are economically recoverable with present technology.

SOURCE: National Coal Association, Coal Facts 1978-1979, 1979.

VII - CHEMICALS

This sections discusses a variety of basic and intermediate chemicals as well as selected chemical products. It does not discuss fertilizer; for a discussion of fertilizer, see Section III.

Although there are a number of chemicals and chemical products produced in the United States (see Exhibit VII-1 for a listing of the top 49 chemicals produced in the United States during 1977 along with estimates of waterborne shipments), the number of chemicals and chemical products moving on the national waterways in significant volume is much smaller. Table VII-1 presents estimates of 1977 waterborne traffic for chemicals and chemical products.

Ignoring for the moment that the categories of chemicals and products not elsewhere classified and miscellaneous chemical products contain 52% of the traffic, it is possible to see that the organic and inorganic chemicals account for much of the remaining traffic, namely 44% of the remaining 48%. These organic and inorganic chemicals represent the basic and intermediate chemicals from which many chemical products are derived.

In general, as commodities move from raw materials to basic industrial chemicals to intermediates to final products, the values per ton of the commodities increase. This is due to the value added by each step in the manufacturing process. As the values of the products increase, the shipment sizes that can be reasonably and economically handled at each step in the logistics system tend to decrease. This is due to the increased use of modes with a higher level of service, quicker response, smaller shipment size, and higher rates. As a result, the role of the waterways in transporting chemicals is much more important for basic chemicals and intermediates than it is for intermediates and finished products. Water transportation is better suited for moving large shipments of commodities to or from selected locations, rather than small shipments to or from widespread locations.

Table VII-1

1977 Waterborne Shipments of Chemicals and Allied Products

	Millions of Tons	Percent of Total
Organic Chemicals		
Crude Tar, Oil, and Gas Products	2.8	4%
Alcohols	4.2	6
Benzene and Toluene	4.6	6
Gum and Wood Chemicals	0.6	1
Inorganic Chemicals		
Sulfur (Dry and Liquid)	10.7	15
Sulfuric Acid	2.6	4
Sodium Hydroxide	5.4	8
Products		
Dyes, Pigment and Tanning Mats	0.1	-
Plastic Materials	1.7	2
Synthetic Rubber	0.4	1
Synthetic Fibers	0.2	-
Drugs	0.1	-
Soap	0.4	1
Paints	0.1	-
Other		
Basic Chemicals and Products, NEC	34.8	49
Miscellaneous Chemical Products	2.1	3
TOTAL	70.8	100%

SOURCE: Corps of Engineers, *Waterborne Commerce of the United States*, 1977.

This generalization about waterborne chemical flows is true even when the "not elsewhere classified" and "miscellaneous chemical products" categories are considered, since these categories are dominated by shipments of basic and intermediate chemicals as well.

This section is divided into the following subsections:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.
- Description of the Logistics System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

A numerous of sources were used in this section, but several should be explicitly mentioned. These are Impact Study of Chemical Barge Traffic on Inland Waterway System by R. J. Bigda & Associates; Kline Guide to the Chemical Industry by Charles H. Kline & Co., Inc.; 1979 Directory of Chemical Procedures by SRI International; Industrial Chemicals by Faith, Keyes, and Clarkes; and Industry Surveys: Chemicals Basic Analysis by Standard & Poor's.

COMMODITY CHARACTERISTICS

The chemical industry processes raw and intermediate materials and produces a variety of synthetic and formulated products for other industries and consumers. Figure VII-A presents the production process of the chemical industry in a highly simplified form.

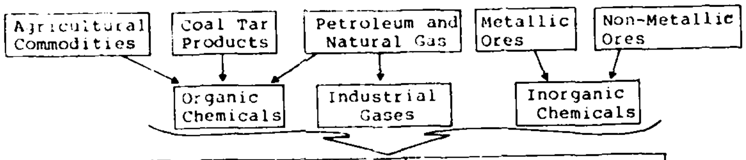
There are five types of raw materials that are used in the production of chemicals and products. The three raw materials that produce organic chemicals are agricultural commodities, coal tar products, and petroleum and natural gas. Organic chemicals are compounds that contain the element carbon. In general, they are combustible, insoluble in water, and either liquids or low-melting solids. Based on figures reported by the United States International Trade Commission, there are approximately 7,000 organic compounds in commercial production. Of all organic chemicals produced, nearly three-fourths can be classified as basic and intermediate compounds. Of these basic and intermediate compounds, nearly 98% are petrochemicals. Petrochemicals are hydrocarbons obtained from petroleum, natural gas and coal feedstocks. Some basic petrochemicals include ethylene, propylene, benzene, toluene, methanol, and xylene (see Exhibit VII-1 for the 1977 production of these chemicals).

Other organic chemicals are produced from natural plant products consisting essentially of oil and resin, carbonized wood products (these are primarily charcoal and charcoal briquettes made by distilling or partially burning wood), and fatty acids (these acids are obtained from the hydrolysis of animal fats and vegetable oils).

The organic chemicals and petrochemicals in particular are used to manufacture a number of intermediate chemicals and finished products. These products include some plastic materials and synthetic resins, such as polyvinyl chloride and polyurethane foam; synthetic fibers, such as polyester, nylon, acrylics, and polypropylene; synthetic elastomers (elastomers are elastic, rubber-like substances that are used as substitutes for natural rubber in such products as tires); pesticides, such as DDT (dichlorodiphenyltrichloroethane) and automotive chemicals, such as antifreeze.

Figure VII-A

Production Process of the Chemical Industry



Chemical Products	Chemical Additives and Processing Aids
Plastics	Colors
Synthetic Fibers	Surface-active agents
Elastomers	Processing aids
Medicinals	Flavors and Fragrances
Adhesives	Carbon black
Cleaners	Biocides
Water-treatment chemicals	Thickening agents
Automotive chemicals	Flame retardants
Diagnostic aids	Corrosion inhibitors
Refrigerants	Petroleum additives
Catalysts	Food additives
Explosives	Paint chemicals
Oil-field chemicals	Metal finishing
Others	Others

SOURCE: C. H. Kline & Co., Kline Guide to the Chemical Industry, 1977.

Inorganic chemicals are large tonnage compounds that, with certain minor exceptions, do not contain the element carbon. These chemicals are typically produced from metallic or non-metallic minerals. Generally, they are solid, non-combustible, and often soluble in water. They include such products as sulfuric acid, lime (for a discussion of the use of lime in the steel industry see Section IV), sodium hydroxide or caustic soda, chlorine, sodium carbonate or soda ash, and hydrochloric acid (see Exhibit VII-1 for the 1977 production of these chemicals). Inorganic chemicals for the most part are employed in long-established end uses, primarily as processing aids in the manufacture of products rather than as building blocks for the production of other chemicals. In sharp contrast to organic chemicals, they are not extensively used in synthetic products such as plastics and fibers. A limited number of high-volume commodities account for much of the tonnage.

Industrial gases are produced from the liquification and subsequent fractionation of air or from natural gas. The major industrial gases are oxygen, nitrogen, hydrogen, acetylene, carbon dioxide, argon, and helium.

It should be emphasized that this characterization of the chemical industry is highly simplified. In practice, the flow of commodities in the chemical industry is very complex and involved. This is particularly true of organic chemicals. There often exist two or more economically competitive processes to produce an organic compound and nearly all basic and intermediate organic chemicals are interchangeable with other products in some uses. The choice of one particular organic compound as a raw material or component of an end product depends upon its cost and, in recent years, long-term availability. Thus, the United States petrochemical industry exhibits a high degree of vertical and horizontal integration. Manufacturers control the production process from raw materials to the processing products. This high degree of integration is due in part to the economies of scale in integrated chemical complexes that turn out a broad mix of products from hydrocarbon feedstocks using the output of a previous step as the input to the next process.

Before discussing the markets for chemicals and allied products, the characteristics of the major waterborne commodities should be noted. Table VII-2 presents the physical characteristics of those chemicals listed in Exhibit VII-1 with estimated waterborne shipments in 1977 of one million tons or more.

Table VII-2

Physical Characteristics and Hazard Ratings of Major Waterborne Industrial Chemicals

Organic Compounds	Physical Form	Color	Liquid Specific Gravity	Soluble in Water	Toxicity	Flammability	Corrosiveness
Benzene	Liquid	Yellow	0.88	No	High	High	None
Toluene	Liquid	None	0.87	No	Moderate	High	None
Styrene	Liquid	None	0.90	No	Moderate	High	None
Methanol	Liquid	None	0.79	Yes	High	High	None
Xylenes	Liquid	None	0.86	No	Moderate	High	None
Ethylene Glycol	Liquid	None	1.12	Yes	Moderate	Low	None
Cyclohexane	Liquid	None	0.78	No	Moderate	High	None
Inorganic Compounds							
Sulfuric Acid	Liquid	Brown	1.84	Yes	High	None	High
Sodium Hydroxide	Solid	White	2.13	Yes	High	None	High
Chlorine	Gas	Amber	1.56	Slightly	High	Moderate	None
Sodium Carbonate	Solid	White	2.26	Yes	None	None	None

SOURCE: Condensed Chemical Dictionary and Exhibit VII-1.

While the natural form of these compounds may be either a solid, liquid, or gas, most industrial chemicals are transported in the liquid state. In the case of sodium hydroxide, it is frequently moved in a water solution, while chlorine is normally moved in a liquid state under pressure. Most of the organic compounds have a clear, water-like appearance, but they usually have a specific gravity less than one and are not soluble in water. Thus, in the event of an accident or spill, these materials will float on the surface of the water as a distinct layer. The inorganic chemicals, in contrast, have color and a specific gravity greater than one. They are also soluble in water so containment of a spill is much more complicated.

Typically, industrial chemicals must be handled with more care than is required for more bulk commodities. Organic chemicals are highly flammable and moderately to highly toxic. Inorganic chemicals are also highly toxic in addition to being corrosive.

MARKETS

Sales of basic and intermediate chemicals are almost exclusively made up of organic and inorganic chemicals. The Kline Guide to the Chemical Industry estimates that organic chemicals accounted for almost two-thirds of basic and intermediate chemical sales and inorganic chemicals accounted for another 31% of sales. (Industrial gases make up the remaining production - see Figure VII-A.) As a result this discussion is limited to the markets for organic and inorganic chemicals.

(a) Organic Chemicals

Six basic organic chemicals and their derivatives are discussed. These chemicals are

- Ethylene.
- Propylene.
- Butadiene.
- Benzene.
- Xylene.
- Methanol.

1. Ethylene. Ethylene, both in number of pounds produced and in dollar value, is the world's most important petrochemical building block. Like other large volume petrochemicals, ethylene is primarily a raw material for polymeric materials such as plastics and resins, fibers, and elastomers (synthetic rubber). The major end uses of ethylene are presented in Exhibit VII-2 and production estimated of ethylene and derivatives are presented in Table VII-3.

The key derivatives are the three major plastics, low-density polyethylene, high-density polyethylene, and polyvinylchloride (PVC). Vinyl chloride monomer (VCM) is the raw material for PVC plastic. Ethylene oxide is used in the production of ethylene glycol, a product used in antifreeze, synthetic fibers, and film. Ethylbenzene is one of the intermediates for the production of styrene.

Table VII-3

1977 Production of Ethylene and Derivatives 1/
(Billions of Pounds)

Ethylene	25.4
Ethylbenzene	8.3
LDPE	6.5
VCM	6.0
PVC	5.3
Ethylene Oxide	4.4
HDPE	3.7
Ethylene Glycol	3.7
Vinyl Acetate	1.6
Ethanol	1.3

NOTE: 1/ Other building blocks besides ethylene are used for the production of some of these chemicals.

SOURCES: Chemical & Engineering News; Standard & Poor's Industry Surveys: Chemical Basic Analysis; and United States International Trade Commission.

In the early 1970s almost half of United States ethylene was made by chemical companies from ethane, a light hydrocarbon distilled from natural gas. As gas supplies tightened, producers turned to heavier feedstocks, such as various fractions of crude oil, principally naphtha.

Ethylene is not exported and the United States produces all of its needs. Ethylene demand growth averaged about 11.5% annually during the 1960 to 1973 period. Due to the Arab oil embargo and the subsequent recession, ethylene was particularly impacted and demand growth averaged 4.4% in the 1973-1978 period.

In recent years anywhere from five to 12% of ethylene derivatives such as low-density polyethylene, high-density polyethylene, PVC, and VCM have been exported. These exports have been due to the lower petroleum costs in the United States (relative to world prices) and surplus plant capacity.

2. Propylene. Propylene is the second most important member of the ethylene series used as a petrochemical building block. Most of the propylene consumed in the United States for chemicals is used in the form of polymeric materials (plastics, fibers, and elastomers). Exhibit VII-3 presents the major end uses of propylene and Table VII-4 presents the production estimates for propylene and derivatives.

Table VII-4

1977 Production of Propylene and Derivatives
(Billions of Pounds)

Propylene	13.3
Polypropylene	2.7
Acetone	2.2
Isopropyl Alcohol	1.9
Propylene Oxide	1.9
Acrylonitrile	1.6
N-Butanol	0.8
Acrylic Fiber	0.7
Propylene	0.5
Acrylic Acid	0.3

SOURCES: Chemical and Engineering News; Standard & Poor's Industry Surveys: Chemical Basic Analysis; and United States International Trade Commission.

Propylene consumption in the manufacture of polypropylene (an intermediate used in plastics and fibers), acrylonitrile (used to make acrylic fibers, resins, and elastomers), and propylene oxide (used in the production of polyurethane and resins) accounts for almost 50% of total propylene consumption.

Propylene is recovered from cracked gas streams of oil refineries and, to an increasing degree, from steam-cracking ethylene plants as an ethylene coproduct. Propylene consumption has grown at an average annual rate of over 10% from 1960-1978. Much of this growth is attributed to the rapid initial growth of the relatively new polymer, polypropylene. In recent years, anywhere from two to 14% of the domestic production of propylene derivatives has been exported.

3. Butadiene. Butadiene is the primary building blocks for elastomers. Exhibit VII-4 presents the major end uses of butadiene and Table VII-5 presents production estimates of butadiene and derivatives.

Table VII-5

1977 Production of Butadiene and Derivatives 1/
(Billions of Pounds)

Butadiene	3.3
SBR	3.1
ABS	1.1
Polybutadiene	0.8
SBL	0.6
Neoprene	0.4
Nitrile	0.2

NOTE: 1/ Other building blocks besides butadiene are used for the production of some of these chemicals.

SOURCES: Chemical and Engineering News; Standard & Poor's Chemical Industry Survey; and United States International Trade Commission.

Butadiene consumption in the manufacture of major elastomers (styrene butadiene rubber, polybutadiene, neoprene, and nitrile rubber) accounts for approximately 75% of total use. Tires are the principal end market.

Butadiene is produced as an ethylene coproduct and from butylenes and butane (these are in turn produced from either cracking crude oil or natural gas). In addition, the United States imported 17% of its butadiene needs.

Butadiene consumption has grown at an average annual rate of about 6.1% from 1960 to 1973. However, between 1973 and 1978, demand has stagnated at about four billion pounds. The stagnating demand is due to feedstock shortages, the economic recession of 1974, the 141-day rubber workers' strike in 1976, and the changing profile of the tire industry (smaller cars, longer lasting radial tires, and fewer miles driven).

4. Benzene. Benzene is the largest volume aromatic used as a petrochemical building block. (Aromatization is the conversion of a hydrocarbon containing no aromatic rings to a hydrocarbon with at least one benzene ring.) Toluene is another important aromatic hydrocarbon. Exhibit VII-5 presents the major end uses of benzene and Table VII-6 presents the production estimates of benzene and derivatives.

Table VII-6

1977 Production of Benzene and Derivatives 1/
(Billions of Pounds)

Benzene	11.2
Ethylbenze	8.3
Styrene	6.9
Polystyrene	3.4
Cumene	2.6
Nylon 6/Nylon 66	2.5
Phenol	2.3
Cyclohexane	2.2
Phenolics	1.5
Adipic Acid	1.5
Unsaturated Polyester	1.1
Caprolactane	0.9
Epoxy Resins	0.3

NOTE: 1/ Other building blocks besides benzene are used for the production of some of these chemicals.

SOURCES: Chemical and Engineering News; Standard and Poor's Industry Surveys: Chemical Basic Analysis; and United States International Trade Commission.

Ultimately over 60% of the benzene produced is used in synthetic plastics and resins. Styrene is produced from ethylbenze and is used in the production of plastics, resins, and elastomers. Man-made fibers, such as nylon, account for about 15% of benzene use (cyclohexane is one of the intermediate chemicals from which nylon is made); elastomers use just under 10%; and the remaining 15% is used in diverse applications, including insecticides and detergents.

Benzene is derived primarily from petroleum and minor quantities from coke. Historically, coke oven byproducts were the first source of benzene supply. Now, refinery streams are the major source of benzene. However, these streams that produce benzene have high octane values and the phasedown of two octane boosters (tetra ethyl lead and MMT) by the federal government has put pressure on refiners to increase the use of aromatics in gasoline. Another source of benzene is pyrolysis gasoline, a by-product in the manufacture of ethylene.

Benzene consumption averaged 9.2% growth from 1960 to 1973, but this growth has slowed to approximately 6% in recent years due to the higher energy and raw material costs. The United States produces virtually all of its needs for benzene. Approximately 15% of styrene and cyclohexane domestic production is exported.

Benzene, toluene, styrene, and cyclohexane are organic compounds that do move in significant volumes on the waterways.

5. Xylene. Several molecular forms of xylenes are important chemical building blocks. The most important of these forms are para-xylene and ortho-xylene. Exhibit VII-6 shows the major uses of xylenes and Table VII-7 presents the production estimates of xylenes and derivatives.

Table VII-7

1977 Production of Xylenes and Derivatives 1/
(Billions of Pounds)

P-Xylene	3.2
O-Xylene	1.0
Polyester Polymer	4.4
Polyester Fiber	3.6
Dimethyl Terephthalate	3.0
Terephthalic Acid	1.4
Phthalic Anhydride	0.9

NOTE: 1/ Other building blocks besides P-Xylene and O-Xylene are used for the production of some of these chemicals.

SOURCES: Chemical and Engineering News; Standard and Poor's Industry Surveys: Chemical Basic Analysis; and United States International Trade Commission.

As can be seen by Exhibit VII-6, para-xylene is used in the production of polyester fibers, film, and resin for the manufacture of bottles. Similarly, the main use of ortho-xylene is in the manufacture of phthalic anhydride, which goes into a variety of plastics. Mixed xylenes, from which both ortho and para-xylene are produced, are also in high demand as a high-octane blending component for gasoline.

Xylene is produced from those petroleum fractions that also yield benzene and toluene. And, just as in the case of benzene, chemical producers of xylene must compete with the use of these fractions as a high-octane blending component for gasoline.

From 1960 to 1973 of cheap energy, demand for xylene rose sharply, spurred primarily by the phenomenal growth in polyester fibers. The demand for polyester fibers grew at a compound annual rate of close to 20%. Following the sharp rise in energy prices caused by the Arab oil embargo, demand has been growing at a slower rate

These developments have come through a relatively high investment in research and development (C. H. Kline & Co. notes that the chemical industry spends more of its own money on research and development than any other industry except electrical and communication equipment) and a high capital investment in new, low-cost manufacturing processes. In fact, the high rate of innovation in both products and processes have caused a high rate of captial obsolescence and forced leading chemical companies to continually reinvest much of their earnings.

Sales of the chemical industry are relatively concentrated with a small number of firms accounting for a large part of total shipments. C. H. Kline & Co. estimates that the top four companies accounted for about 35% of total United States industry sales in the mid-1970's and the top ten nearly 50%. (It should be noted that these figures do not distinguish between agricultural and industrial chemical sales.) However, chemical manufacturing has been undertaken by many types of companies largely because of its central role in industry.

In particular, petroleum companies have increasingly obtained leading positions in the chemical industry. This has been particularly true of the production of certain petrochemicals such as ethylene. In the early 1970s, almost half of the ethylene produced in the United States was made by chemical companies from ethane, a light hydrocarbon distilled from natural gas. As natural gas prices increased rapidly and supplies became difficult to find, these chemical companies began to use various fractions of crude oil as basic feedstocks. Oil refiners supplied much of these feedstocks to chemical companies and have sought to upgrade their hydrocarbon feedstocks to profitable chemical products. Of the leading ten United States chemical producers in 1976 as listed by C. H. Kline and Co., four are oil companies.

of 10% per year. Recent relatively strong export demand has contributed to the slower, but still strong performance of these components.

6. Methanol. Methanol is an important chemical building block, which, up until 1979, was produced entirely from natural gas. A new methanol plant to be brought on-stream in 1980 is the first commercial plant in the United States to be designed for the use of heavy oil feedstocks. This plant may be the bellwether for future domestic methanol production.

Exhibit VII-7 presents the major uses of methanol and Table VII-8 presents the production estimates for methanol and derivatives. As can be seen in both Exhibit VII-7 and Table VII-8, a key use for methanol is the manufacture of formaldehyde. Formaldehyde is in turn used in resins for the building and construction industries. Other major derivatives of methanol are dimethyl terephthalate (for polyesters) and acetic acid (used in the coatings, textile, and solvents industries). There are many other uses for methanol, including a fast-growing new use, methyl tertiary butyl ether (MTBE), as a gasoline additive.

Table VII-8

1977 Production of Methanol and Derivatives 1/
(Billions of Pounds)

Methanol	6.5
Formalen 2/	6.0
Acetic Acid	2.6
Vinyl Acetate	1.6
Urea and Melamine Formaldehyde Resins	1.2
Methyl Methacrylate	0.7
Acetic Anhydride	0.6

NOTE: 1/ Other building blocks besides methanol are used for the production of some of these chemicals.

NOTE: 2/ Formalen is the common name of 37% formaldehyde (gas) solution in water.

SOURCES: Chemical and Engineering News, Standard and Poor's Industry Surveys: Chemical Basic Analysis; and United States International Trade Commission.

Historically methanol demand grew at an average rate of more than 10% per year during the pre-embargo period from 1960 to 1973. During that period, demand was spurred by strong housing markets as well as strong growth in polyester fiber. In the post embargo period from 1976-1978, methanol has again shown strong growth (annual compound rates of 7.5%), in spite of the fact that intrastate gas prices had risen by a factor of three or more.

A serious problem for companies considering the construction of new methanol plants has been the lack of assured supplies of natural gas. Several companies tried to get gas for new methanol units but were unsuccessful. As a result, companies turned to alternate sources, such as crude oil, for domestic production of methanol or sought joint ventures in the Middle East, where abundant supplies of natural gas were being flared.

(b) Inorganic Chemicals

The markets of four basic inorganic chemicals that are also shipped in significant volumes on the national waterways are discussed in this part. These include:

- Sulfuric Acid.
- Sodium Hydroxide.
- Chlorine.
- Sodium Carbonate.

1. Sulfuric Acid. Sulfur is the basis for the production of sulfuric acid. Sulfur is primarily produced by the Frasch process from naturally occurring deposits along the Gulf Coast. This process accounts for approximately 40% of current needs. Approximately 30% of needs are met by recovered elemental sulfur produced as a co-product at petroleum refineries, natural gas operations, and coal-burning power plants. Another 18% of needs have been met by imports of sulfur from Canada and Mexico. The gas from Alberta, Canada, is quite sour and represents a large potential source for United States domestic needs.

Since the principal application of sulfur is sulfuric acid (approximately 85% of sulfur use is for sulfuric acid), sulfur demands are tied to the competitiveness of sulfuric acid in acid markets. Sulfuric acid's major attributes have been low cost and good acid performance. Sulfuric acid is an excellent drying agent in chemical applications and an effective catalyst for many organic reactions. However, there has been a substitution over time to other acids for some uses, such as steel pickling, due to increases in the cost of sulfuric acid, decreases in the cost of other acids, and problems associated with the disposal of spent sulfuric acid. In particular, Frasch production costs are increasing as high quality deposits are exhausted.

It is expected that sulfuric acid production from regenerated acid and recovered stack gas emissions of sulfur dioxide at utilities and ore-smelting plants could supply much of the future sulfur needs of the United States However, utility sulfur is often not located well for marketing as sulfuric acid and recovery of the sulfur from the sulfur oxides is not yet economically competitive for many plants.

Sulfuric acid is used in a variety of ways. The production of phosphate and ammonium fertilizers accounts for approximately half of domestic use. Other major uses include petroleum refining, industrial chemical production, and metal mining.

2. Sodium Hydroxide. Sodium hydroxide or caustic soda is a strong base used widely through the chemical and pulp and paper industries. Other smaller users of caustic soda include the aluminum, petroleum refining and textiles industries.

Approximately 10.9 million tons of caustic soda were produced in 1977. The economics of caustic soda are closely linked with those of chlorine, since the two are primarily derived by electrolysis of salt and are produced in a fixed ratio of 1.3 tons of caustic soda to a ton of chlorine. Depending upon which product is in greater demand, the other product is considered a by-product. Over the years, chlorine has been outpacing the demand for caustic soda with the result that causcic soda producers are aggresively looking for new markets.

3. Chlorine. Chlorine is primarily produced from salt by electrolysis to yield chlorine gas and caustic soda. Chlorine demand has grown more rapidly than caustic soda demand and there has been a trend to produce chlorine from other processes. The share of these processes is small but may grow if the chlorine and caustic soda markets continue to be out of balance.

The principal considerations in industry location used to be the availability of cheap salt and cheap power. However, considerations of hazardous material transportation (see Table VII-2 for product characteristics) have led to the location of new plant capacity closer to end markets.

The chemical and pulp and paper industries account for approximately 90% of chlorine demand. The use of chlorine in the production of chlorinated hydrocarbons accounts for over half of its use and much of this use is met by captive production.

4. Sodium Carbonate. Sodium carbonate or soda ash has been produced from both the Solvay process of production and the mining of the principal raw materials, trona ore and brine. However, the high costs of energy, equipment maintenance and compliance with environmental protection legislation are forcing the closing of Solvay plants in the United States. These plants synthesize soda ash from salt and limestone using ammonia, but they are energy-intensive and the calcium chloride by-product poses pollution problems.

In contrast, the large deposits of trona ore in the Green River basin of Wyoming (the United States has an estimated 51% of the world's reserves of natural soda ash and the largest deposit of trona is in the Green River basin) and dry lake brines in California make production of soda ash from natural ore or brine attractive. In general, about half the weight of mined trona can be converted into high-purity soda ash.

With the closing of all but one of the Solvay plants in the United States during the 1970's, the center of production has moved from the Midwest and South to the Rockies and Far West.

The Bureau of Mines estimates that over half of the soda ash consumed in recent years was used in the manufacture of glass. Chemicals, detergents, pulp and paper, and water treatment are the other uses of soda ash.

ECONOMICS OF THE INDUSTRY

Since the 1930's, the chemical industry has experienced rapid growth mainly through a working knowledge of polymerization, the science of joining simple molecules into giant ones to form plastics, fibers, elastomers, and non-structural resins. The industry has developed in this period such synthetic products as pesticides, drugs, and aerosol propellants to name just a few.

Whereas the entry of the oil companies in the chemical industry has been ongoing for a number of years, leading chemical companies continue to emphasize the development of new technology as a means of maintaining market share. At least two chemical companies are constructing advanced crude oil processing plants. These plants will permit the companies to produce basic chemical feedstocks from crude oil while producing a minimum of fuel by-products.

One company's unit will recover up to 70% of the contents of a barrel of crude oil as ethylene and other chemical intermediaries, in contrast to conventional cracking operations, which have a maximum chemical yield of only 40%.

The chemical industry has traditionally exhibited an above average rate of profitability as compared to the average for all manufacturing industries. From the period of 1966 to 1972, C. H. Kline and Co. note that the return on equity fell below the average due in part to the inabiity of the chemical indsutry to attain productivity improvements that were large enough to offset the impact of falling prices of chemical products. Since 1972, the return on equity for chemical companies has improved. Exhibit VII-8 presents estimates of net income to sales and net income to stockholders' equity for selected chemical companies.

As can be seen from Exhibit VII-8, return on equity improved considerably after 1972. This improvement is attributable to: (a) sharply higher prices of basic and intermediate chemicals as well as chemical products (the prices for some of these products, especially differentiated products, more than kept pace with increases in raw material costs) and (b) individual company strategies to eliminate unprofitable product lines, concentrate on profitable lines, and integrate operations from feedstocks to consumer products. In recent years, the United States chemical industry has benefited from lower United States energy prices (relative to world prices) and this has increased exports of key petrochemicals and products to such foreign markets as Western Europe.

The chemical industry is subject to a number of government regulations. The principal agencies responsible for this enforcement are the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and Department of Transportation (DOT). In 1976, the Toxic Substances Control Act was passed, with the Environmental Protection Agency (EPA) responsible for establishing standards on the use of toxic chemicals. This act is intended to prevent unreasonable risks of injury to health or to the environment associated with the manufacture, processing, distribution, use or disposal of chemical substances.

The chemical and allied industries are the second largest industrial users of water as measured by water intake and the industry has been clearly affected by water control legislation. The 1972 Admendments to the Federal Water Pollution Control Act are intended to reduce or eliminate the discharge of pollutants, achieve high water quality by 1983, and eliminate the discharge of toxic pollutants. The 1977 Amendments to the Federal Water Pollution Control Act (the amendments are commonly referred to as the Clean Water Act) provide among other things for the control of the discharge of hazardous substances. In 1978, EPA issued regulations designating 271 substances to be hazardous, requiring industry to have in place by 1983 the best technology available to remove toxics from the water, determining the harmful quantity of these substances, and establishing units of measurement and penalty rates for discharges of each hazardous substance. One of several industry lawsuits overturned most of these regulations, except for those designating certain wastes as hazardous. In November, 1978, Congress enacted new Amendments to the Clean Water Act. These amendments dealt with the court's objections to EPA's spill regulations. In 1979, EPA proposed its new hazardous substances spill program, which set forth reporting requirements and penalties for spills of hazardous substances. EPA also finalized a rule establishing another 28 substances as hazardous. These substances are listed in Exhibit VII-9.

As can be seen by Exhibit VII-9, most of the chemicals discussed in the previous subsection are classified as hazardous substances by EPA.

The chemical industry is also affected by certain provisions of the Clean Air Act. Air pollution is a problem in much chemical processing. The offending emissions are of four types: (a) particulates such as fly ash, sand, and char; (b) highly corrosive sulfur dioxide; (c) organic sulfur compounds having highly persistent odors; and (d) various other chemicals such as nitrogen compounds, hydrocarbons, carbon dioxide and lead compounds.

Finally, the DOT regulations govern the transportation and packaging of DOT defined hazardous substances. The OSHA regulations govern the exposure of workers to workspace hazards.

DESCRIPTIONS OF LOGISTICS SYSTEM

The design of the logistics system for a chemical company is based on a number of factors. In general, the aim of chemical shippers is to reduce the total distribution costs for their products to the lowest point while, at the same time, meeting the service requirements of each of the markets in which they compete. Total distribution costs are in this case broadly defined. They include line-haul transportation costs and terminal operating and capital costs. These costs are in turn influenced by the physical characteristics of the products and a number of safety considerations.

The chemical industry produces a wide range of chemicals and products. The characteristics of some of these products have led to the need for specialized rail cars, barges, tank trucks, and cleaning systems. The large number of hazardous products in the chemical industry has forced companies to take a number of safety precautions in advance of government regulations, such as barges with double skins and emergency centers. Product purity is of special concern to chemical companies since many products are carefully formulated for specific industrial uses. This concern for product purity has encouraged chemical companies to operate their own transportation, equipment and terminals or to design product stewardship programs for contract carriers and terminal operators.

In view of the wide range of chemical products and markets, it is most useful to discuss the logistics system of the chemical industry by discussing under what conditions each of the transportation modes is used. Rail, truck, water and pipeline transportation are used by chemical shippers. As might be expected, the modal mix for one chemical company may differ markedly from another. For example, one chemical company contracted for the NWS relies on water and rail transportation for 33% and 30%, respectively, of its total shipments, whereas another company ships over 50% of its total tonnage in less-than-truckload quantities.

Some appreciation of the wide range of modal mix for chemical shipments can be obtained by examining the 1972 Census of Transportation. Exhibit VII-10 presents the share of total shipments by mode for selected chemicals. Shipments of basic and intermediate chemicals were made predominantly by rail and truck in 1972. However, the water share of basic and intermediate organic chemicals was estimated to be 25% of all shipments. The mix of modes for selected chemical products differed markedly from one product to the next in 1972, but, in general, truck transportation was the dominant mode.

The description of the logistics system for the chemical industry is divided into separate parts for each of the transportation modes in use: water, rail, truck, and pipeline.

(a) Water
Transportation

Barge transportation has provided chemical shippers with relatively low cost transportation for high volume shipments from waterside production plants to other production plants on distribution terminals located on water.

A key factor in the use of barge transportation is the location of the chemical plant. Barge transportation is most competitive with rail if the production plant is located directly on the water. Since natural gas and crude oil are the major sources of raw materials for the petrochemical industry and since these raw materials are available in the Gulf States, many large organic-chemical plants have been located on the waterways in the Gulf Coast West and Baton Rouge to Gulf regions. (See Appendix B for a description of the regions of the National waterways used in this study.) The location of these plants in these regions has enabled chemical manufacturers to purchase more easily: 1) crude oil fractions from petroleum refineries; 2) crude oil for use in cracking operations; or 3) natural gas (see Section V for a discussion of United States refinery locations).

Another key factor in the use of barge transportation is adequate volume to make barge transportation cost effective. Dry bulk shipments are typically made in covered hoppers of 1,500 tons and liquid bulk shipments are made in tank barges with capacities as large as 3,000 tons.

Whereas large customers located on water are logical candidates to receive barge shipments of chemical products, many customers are too small to receive a barge load of chemicals at any one time. As a result, chemical companies have sought to increase their market share in major consuming areas on the inland waterways by constructing terminals that are capable of receiving large volumes of chemicals by barge and shipping these chemicals by rail and truck to a variety of customers on an "as needed" basis. These distribution terminals are located in such places as Chicago, Louisville, Cincinnati, Pittsburgh, St. Louis, and St. Paul.

These terminals are not built for the benefit of one or two customers. On the contrary, these terminals are only built if there is a broad level of demand for a company's products in a given area. A chemical company may ship products to one or two large customers by barge if there is a suitable public terminal or customer's private dock that can be used in the area. However, without this broad level of demand, a chemical company is not likely to construct a distribution terminal.

There are a number of reasons why chemical companies have been reluctant to construct their own distribution terminals in areas without a broad level of demand. First, the chemical industry is capital intensive and distribution projects must compete with other marketing or production projects for capital. As was discussed earlier, the chemical industry has had many opportunities for investing capital in processes that reduce manufacturing costs or develop new products. Second, whereas barge transportation offers line-haul transportation cost savings relative to rail transportation, every chemical company contacted for the NWS indicated that a 20% cost increase in water transportation or 20% cost decrease in the appropriate rail rates would cause them to reexamine their modal mix and would result in some diversion to rail over a one to three year period. (Diversion is less likely to take place if the shipper has invested in private equipment and terminals, but every company stated that they would reexamine their modal mix.) Rail transportation does offer service advantages over barge transportation and a relatively small change in the ratio of line-haul costs would cause more diversion.

Recent changes in environmental regulations regarding air and water quality provide chemical companies with yet another reason to carefully consider whether they wish to construct distribution terminals in areas without a broad level of demand. Vapor recovery systems for liquids and dust control systems for dry chemicals have resulted in higher capital costs at landside facilities for more sophisticated receiving and shipping equipment. EPA regulations regarding the containment and treatment of product spills or discharges into waterways have also increased capital and operating costs at terminals. An elaborate system of overflow lines and signals, catch basins, alarms, holding and treatment ponds, and discharge lines to water sources are necessary for the containment and treatment of product spills or discharges. Part of this increased capital cost is attributable to greater land requirements for waste treatment at distribution terminals.

Once it is determined that there is a broad level of demand in a market that could be served by barge, chemical companies compare the costs associated with constructing their own terminals to that of using public terminals. Public terminals are used by chemical companies, but the operations of these terminals are closely monitored. Operations of public terminals must be able to: 1) control and contain air and water emissions; 2) deal with emergencies; 3) receive and ship product efficiently (due to the high cost of specialized barge equipment, fast turnaround at terminals is essential); and 4) collect and analyze water runnoff. Since inexperienced or poor management at these terminals can result in spills or discharges, chemical companies have adopted terminal stewardship programs as a means of reducing the probability and severity of accidents.

Whereas barge transportation does offer cost savings over rail for certain large-volume shipments, there are some important disadvantages. First, the freezing of the Upper Mississippi River and, in recent winters, the Illinois River, have a forced chemical companies to build additional storage at water-served distribution terminals. This storage increases the capital costs of a water distribution system. In addition, chemical companies have had to meet some of this winter demand by shipping some product by rail. Securing cars, whether railroad or privately owned equipment, for seasonal use is difficult and this has resulted at times in reduced service levels for some customers.

Another disadvantage of barge transportation is the issue of hazardous materials transportation. The chemical companies contacted for the NWS felt that the probability of an accident and possible spill was less for barge than it would be for rail. However, the large shipment size of the typical barge makes the severity of the accident far greater. And the containment of certain chemicals in a free-flowing waterway is more difficult than it would be if the accident were to take place on land.

In view of these safety problems, the chemical industry has taken a number of steps to reduce the probability and severity of spills. These steps include the construction of double-skin barges, crew training, and sophisticated absorption systems. A special industry insurance pool, the Water Quality Insurance Syndicate, has been established to provide coverage for movements of hazardous chemicals as well.

Ocean-going vessels are also used for bulk shipment of chemicals. Aside from import and export shipments, which, of course, rely on dry bulkers or liquid tankers, there are some coastal shipments from the Gulf Coast West region to the Middle Atlantic Coast. Chemical tankers are relatively small for tankers, usually under 40,000 dwt., and often constructed of stainless or some other alloy steel to resist corrosion and to provide a contamination-free environment. They are divided into a number of small tanks, as small as 1000 tons, to haul a number of different bulk liquid chemicals per trip. Bulkers are primarily used to haul solid sulfur.

Coastal movements of chemicals offer considerable cost savings to shippers if, of course, there is sufficient volume to justify such movements. In contrast to petroleum products, chemicals are rarely shipped in pipelines and, thus, these coastal shipments do not compete with pipelines. Rail transportation does offer some competition, but major end markets served by coastal terminals and located some distance from the production plants are well suited to water transportation.

(b) Rail Transportation

Rail transportation has provided chemical shippers with somewhat higher costs but greater flexibility relative to water transportation.

In a manner analogous to water transportation, multiple car shipments from production plants to other production plants, large customers, or distribution terminals are made by chemical shippers. (Unit-train shipments of industrial chemicals are not common.) These distribution terminals are then used to ship the products by truck to the final customers. The chemical companies contacted for the NWS noted that these terminals are not subject to the extensive review and regulation of water-served terminals. The lower shipment volumes associated with these rail terminals and lack of water quality problems make the process of securing the necessary construction permits an easier task.

Single-car shipments are extensively made by chemical companies. For several reasons these shipments are often made in privately owned equipment and chemical companies do have large fleets of cars. Tank cars have never been supplied by carriers. Chemical shippers also have greater control over the cleaning of private equipment and this results in fewer losses due to product contamination.

Private equipment also offers advantages to chemical companies as a marketing tool. In many instances, shippers will permit their customers to use the cars as temporary storage. The customers may have little or no private storage facilities at their plants and they may keep the cars on their sidings for as long as a week before completely emptying the cars. Of course, this distribution method results in poor equipment utilization (tank cars in single car service may get as few trips as 10 per year) and chemical shippers have begun to use multiple-car shipments, where improved turnaround times can be expected, more frequently than in the past.

Chemical companies have also taken steps to reduce the frequency and severity of accidents involving the transportation of hazardous materials in rail cars. In conjunction with the Manufacturing Chemists Association, chemical companies have developed a means of notifying knowledgeable personnel within minutes of an accident so that these personnel can in turn provide information about the properties of the substance to those who are at the site. In addition, chemical companies have made a number of modifications to tank cars, including head shields, specially designed couplers, and recessed valves on the bottom of the cars.

(c) Truck Transportation

Truck transportation is characterized by high rates, small shipment sizes, and good service. Truck transportation is widely used in the chemical industry either as a means of directly serving customers within a 200 to 400 mile radius of a production plant or as a means of supplying customers with product from water or rail-served distribution terminals.

Bulk liquid shipments are made in tank trailers. Smaller shipments are made in 55 gallon drums (or smaller containers) at LTL rates. Shippers also utilize trailer on flat car or container on flat car rates to ship chemical products. Bulk solids are moved in either specially designed trailers or standard truck trailers. These standard trailers can be loaded with a plastic liner for shipment of low density bulk solids such as plastic pellets.

Just as in the case of barge or rail equipment, trailers are often placed in dedicated service to avoid cleaning and contamination problems. The 1972 Census of Transportation indicates that chemical companies rely more heavily on motor carriers than private fleets.

(d) Pipeline Transportation

Pipeline flows of chemicals account for only a small proportion of total chemical traffic. Although the chemical industry is closely allied with the oil industry in some respects, the distribution patterns of the two industries are decidely different, especially with respect to pipeline transportation.

In general, chemical flows in pipelines are shipped in smaller volumes (than petroleum and petroleum products) and shorter distances. Pipelines are appropriate for the shipment of olefins (ethylene or propylene) from cracking plants or refineries located on the Texas and Louisiana Gulf Coasts to petrochemical plants located in the same general area. Some naphthas are also currently used as feedstocks by petrochemical plants and can be shipped via the extensive pipeline network for petroleum products along the Gulf Coast. It should also be noted that pipelines for natural gas are extensive, particularly throughout the states bordering the Gulf Coast, Oklahoma, and Kansas, and these pipelines can be used to supply petrochemical plants with natural gas as feedstocks.

PRINCIPAL TRANSPORTATION FLOWS

In this subsection, the waterborne flows of chemicals and chemical products are discussed. This discussion is based on the following commodity groups:

- Crude tar, oil, and gas products.
- Alcohols.
- Benzene and toluene.
- Basic industrial chemicals.
- Sulfur.
- Sulfuric acid.
- Sodium hydroxide.
- Plastic materials.
- Miscellaneous chemical products.

These commodity groups are the principal commodity classifications used by the Corps to record chemical traffic flows. (Some of the smaller waterborne flows of chemical products are not discussed. See Table VII-1 for a list of all of the Corps chemical waterborne categories.) In addition to a description of waterborne flows, this subsection discusses the other transportation modes used to move these chemicals.

(a) Crude, Tar, Oil
and Gas Products

As can be seen by Table VII-1, approximately 2.8 million tons of chemicals and products that were classified as crude, tar, oil, and gas products moved on the national waterways in 1977. Of this total, approximately 2.2 million tons were domestic traffic and, of this traffic, movements on the inland waterways accounted for the largest number of tons (an estimated 1.4 million tons in 1977).

This category consists of a broad mix of chemicals derived from by-products from the coal coking and crude petroleum cracking and refining industries. These can be further processed to yield aromatics (benzene, toluene, and xylenes) as well as cresols, cresylic acid, naphthas, naphthalene, phenols, and other compounds. Although benzene and toluene are classified under a separate heading, some of the tonnage in this category is a mix of benzene, toluene, and xylene fractions derived from petroleum industry catalytic cracking or stream cracking of naphthalene and other aromatics-rich feedstocks. These mixtures can be shipped to other refineries lacking sufficient refining capacity for use in octane upgrading of gasoline or sent to chemical companies for further separation and use in chemical feedstocks for benzene, toluene, and xylene-based products. (These mixtures are discussed further under the heading "Benzene and Toluene".)

Other commodities in this category include cresols, cresylic acids, phenols, and naphthalene as well as the tars and oil from which they are derived. Coal when coked yields 35 to 50 liters of coal tars per ton of coal. These tars can be distilled to yield light oil from which benzene, toluene, and xylene can be produced; middle oil from which naphthalene, phenols, cresols, and cresylic acids are produced; heavy oil; and pitch. The heavy oil and pitch are often used as fuels. It is these crude tars and oils that constitute the bulk of the remaining tonnage in this category.

An estimated three million tons of crude tar and oil were produced by United States coke ovens in 1977. Approximately one-half of these products were used in-house as fuel or distilled on site by coke oven operators. An estimated 1.2 million tons were shipped to distillers by truck, rail, and barge. Barge shipments are estimated to be 25 to 40% of total shipments. As might be expected, these flows are concentrated on the Ohio River.

Other flows in this category (consisting primarily of petroleum tars and benzene, toluene, and xylene mixtures) originated along the Gulf Coast (predominantly Gulf Coast West) and terminated at other locations on the Gulf Coast and Lower Mississippi River.

(b) Alcohols

As can be seen by Table VII-1, approximately 4.2 million tons of alcohols moved on the waterways in 1977. This tonnage was evenly split between coastal and inland traffic. There was very little foreign traffic.

This category consists of a variety of alcohols. The alcohols comprise approximately 140 chemicals, of which only a few such as methanol, ethylene glycol, isopropyl alcohol, ethanol and, to a lesser extent, butanol and the oxoalcohols move on the waterways.

The methanol used for formaldehyde production is usually produced in-house. Much of the remaining amount moves to terminals by water for final delivery by truck and rail. Movements of ethylene glycol for anti-freeze are often made by water. Isopropyl alcohol production is limited to a small number of plants, of which the major plants are on water. In contrast, ethanol production plants are relatively small and located off water. The large amount of ethanol in toiletries and cosmetics tends to promote truck shipments.

Approximately 6.6 to 6.8 million tons of alcohols were produced in the United States in 1977. Waterborne flows were 4.2 million tons or over 60% of total production. The principal waterborne flows were:

1. Gulf Coast West to the Middle, North and South Atlantic Coasts.

2. Gulf Coast West to other points on the Gulf Coast Coast West.

3. Gulf Coast West to the Ohio and Illinois Rivers.

4. Baton Rouge to Gulf region to the North and Middle Atlantic Coasts.

5. Baton Rouge to Gulf region to the Illinois and Ohio Rivers.

There were also some coastal shipments from the Caribbean to the North, Middle, and South Atlantic Coasts.

(c) Benzene and Toluene

As can be seen by Table VII-1, approximately 4.6 million tons of benzene and toluene moved on the waterways in 1977. Nearly three quarters of this tonnage was in-land traffic. The remaining traffic was coastal.

Benzene and toluene are aromatic hydrocarbons primarily produced from petroleum fractions rich in naphthalenes via catalytic dehydrogenation or steam reforming (hyrdocracking). Xylenes are also typically produced by these processes. A typical output from the reforming process produces about 10% benzene, 40% toluene, and 50% xylene mixtures. As was discussed earlier, a small percentage (two percent to five percent) of these chemicals is produced as coking coal by-products.

Approximatley 9.5 million tons of benzene and toluene were produced in the United States in 1977. Of this total, 4.6 million tons were moved by water. Other shipments of benzene are made by truck and rail and by truck for toluene. The predominant waterborne flows were nearly identical to those of the alcohols. The largest flow (accounting for 40% of 1977 traffic) was from points on the Gulf Coast West to other points on the same waterway. Smaller shipments from the Gulf Coast West region were made to the Baton Rouge to Gulf area, the Ohio River, and the Middle and North Atlantic Coasts. Coastal shipments were made from the Caribbean to the Gulf Coast West region.

(d) Basic Industrial Chemicals

This category consists of a very diverse mix of chemicals and accounted for half of the 1977 waterborne traffic (see Table VII-1). The principal waterborne chemicals included in this category are acetic acid, acetone, acrylonitrile, ammonia (ammonia is not discussed here, but it is the chemical with the largest waterborne tonnage in this category), butadienes, cumene, cyclohexane, ethylbenzene, ethylene dichloride, hydrochloric acid, phenol, styrene, vinyl acetate, vinyl chloride, and xylenes. Each of these chemicals was one of the top 50 chemicals produced in the United States and was shipped on the waterways in quantities of 250,000 tons or more (see Exhibit VII-1). From the basis of shipper interviews, it was determined that rail and truck shipments of these chemicals were also common. In addition to these chemicals, there were another 21 chemicals that moved on the waterways in small to moderate volumes during 1977.

In 1977, approximately 34.8 million tons of chemical traffic in this category moved on the waterways. Of this total, just over half was foreign traffic with exports accounting for 10.0 million tons and imports accounting for 7.5 million tons. The domestic traffic totalled 17.3 million tons. Inland traffic accounted for three-quarters of this traffic with coastal traffic accounting for much of the remainder.

The principal origins of export shipments were the Gulf Coast West and Baton Rouge to Gulf areas. Smaller export shipments were made from the Atlantic Coasts, Caribbean, and California Coast. Imports were received in the Washington/Oregon Coast, the Atlantic Coasts, and the Gulf Coasts.

The domestic waterborne flows follow similar patterns of the alcohols and aromatics. The largest flows are from Gulf Coast points to other points on the Gulf Coast. Coastal shipments are made from the Gulf Coast West to the Middle and North Atlantic Coasts. Inland shipments from both the Gulf Coast West and Baton Rouge to Gulf areas are made to the Lower Mississippi, Ohio, and Illinois Rivers. There are also some inland shipments to and from points on the Ohio River.

(e) Sulfur

Dry and molten sulfur shipments on the national waterways were approximately 10.7 million tons in 1977, making sulfur the chemical with the single largest waterborne shipments of any chemical. Molten sulfur represented nearly four-fifths of this traffic and was exclusively domestic traffic. Domestic shipments of molten sulfur were divided nearly equally between in-land and coastal shipments. Dry sulfur, in contrast to molten sulfur, was almost exclusively foreign traffic. Exports of 1.3 million tons were somewhat greater than imports of 1.0 million tons.

Domestic shipments are primarily molten sulfur, because it is less expensive to ship molten sulfur by heated and insulated tank cars, barges or vessels than it is to ship dry sulfur to domestic destinations. The principal domestic flows are from the Baton Rouge to Gulf and Gulf Coast West regions to phosphate fertilizer producers located on the Florida Coast. Another major domestic flow is to and from points in the Baton Rouge to Gulf region. (The use of sulfuric acid in the production of phosphate fertilizers is discussed in Section III.)

Export shipments of dry sulfur are made predominantly from the Gulf Coast West, Baton Rouge to Gulf, and Caribbean regions. Import shipments are received predominantly by phosphate fertilizer producers located on the Florida Coast.

(f) Sulfuric Acid

As can be seen by Table VII-1, 2.6 million tons of sulfuric acid were shipped by water in 1977. All of this tonnage was domestic and it moved predominantly on the inland waterways, although there were local shipments within ports on the Atlantic and Gulf Coasts.

Approximately 34.4 million tons of sulfuric acid were produced in the United States during 1977. Due to the economics of sulfur transportation and sulfuric acid production, sulfuric acid shipments tend to be local in nature. Typically, sulfur is shipped long distances and the conversion to acid is done locally. Thus, the major sulfuric acid movements take place within the following waterway regions: the Middle and North Atlantic Coasts; the Baton Rouge to Gulf area; and the Gulf Coast West area. Smaller shipments take place to and from points on the Ohio River.

(g) Sodium Hydroxide

Sodium hydroxide or caustic soda is a strong base used widely throughout the chemical and industrial markets. In 1977, an estimated 5.4 million tons of sodium hydroxide were shipped by water (see Table VII-1). Of this total, nearly 70% was shipped on the inland waterways. Another 1.4 million tons or 26% of the total were shipped in coastal waters.

Sodium hydroxide can be shipped as either a solid or an aqueous solution. Barge, vessel, rail, and truck shipments are made. Shippers indicated that shipments of aqueous solutions have been increasing over time as a percentage of total shipments.

Approximately 10.9 million tons of caustic soda were produced in the United States during 1977. Water shipments were approximately 50% of total production. Since United States production of caustic soda is concentrated along the Gulf Coast West and Baton Rouge to Gulf areas, the principal transportation flows originate from these areas. Shipments are made to and from points in both of these areas by barge. Barge shipments are also made to the Lower Mississippi, Middle Mississippi, Upper Mississippi, Illinois, and Ohio Rivers. Barge shipments are also made to and from points on the Ohio River.

Coastal shipments of sodium hydroxide also originate for the most part from the Gulf Coast West and Baton Rouge to Gulf regions. These shipments are made to the Atlantic and California Coasts. Smaller coastal shipments take place to and from points on the North and Middle Atlantic Coasts as well as the Oregon/Washington Coast.

(h) Plastic Materials

Of the seven chemical product categories listed in Table VII-1, only one category, namely plastic materials, had waterborne shipments of any significant amount. Approximately 1.7 million tons of plastic materials moved on the waterways in 1977. Of this total, over 1.3 million tons represented foreign traffic. The United States exported more plastic materials in 1977 (an estimated 1.1 million tons) than it imported (an estimated 230,000 tons).

Plastic materials consist of a wide variety of plastics, resins, and cellulose items. Waterborne flows represent only a small fraction of total shipments (see the modal mix for 1972 polymer shipments in Exhibit VII-10). The waterborne share of these shipments is low, because the value of the items are relatively high and the items are demanded in smaller lots.

Exports of plastic materials originated from the Atlantic Coasts, Gulf Coasts, and California Coast. Imports were received primarily at ports along the North and Middle Atlantic Coasts. Ports on the California Coast also received some imports in 1977.

Domestic shipments were small and were primarily coastal shipments to the North and Middle Atlantic Coasts.

(i) Miscellaneous Chemical Products

Miscellaneous chemical products is the final industrial chemical category with significant waterborne traffic in 1977, but, as might be expected, this category consists of a wide variety of chemicals. The principal waterborne commodities in this category are ethylene glycol (this commodity has already been discussed in the part entitled "Alcohols") and chlorine. Other commodities include activated carbon, which is shipped predominantly by rail and truck, and tetraelroethyl lead, which accounts for some of the exports in this category.

In 1977, approximately 2.1 million tons of miscellaneous chemical products were shipped by water. Of this total, just over 60% represented foreign traffic. Exports out numbered imports three to one. Domestic traffic was predominantly inland and coastal traffic.

Chlorine production was approximately 10 million tons in 1977, so water shipments represent only a relatively small share of total shipments.

Export flows originated from the Atlantic Coasts and Gulf Coasts. Imports were received from the Middle and North Atlantic Coasts and the Gulf Coasts.

Domestic shipments were small and no major origin to destination flows dominate this traffic. The single largest flow was to and from points on the Great Lakes. Other water shipments originated from points on the Gulf Coasts.

FACTORS INFLUENCING FLOWS IN THE FUTURE

There are five principal factors that might be expected to affect the chemical industry over the next 10 to 20 years. These are:

1. Shift from natural gas to crude oil and coal as chemical feedstocks.

2. Conversion of chemical power plants to coal.

3. Reduced United States net exports of chemicals.

4. Increased regulation of hazardous material transportation.

5. Rail deregulation.

Four of these five factors can be expected to change the nature or amount of chemical waterborne flows in the future and each of these five factors is discussed under separate headings.

(a) Change in Chemical Feedstocks

The chemical industry is a major user of energy both as feedstocks for organic chemicals and power to operate production plants. The Standard & Poor's Industry Survey: Chemical Basic Analysis dated August 30, 1979 notes that approximately 60% of domestic hydrocarbon feedstock requirements are met by natural gas and gas liquids. Crude oil and its fractions account for most of the remaining feedstock needs. Chemical shippers expect to see crude oil account for a higher percentage of total feedstock needs in the future. The sharply higher prices of natural gas and, most importantly, the inability to secure long-term contracts of natural gas are encouraging chemical companies to develop processes to utilize other feedstocks for the production of such important chemicals as ethylene.

Crude oil is the feedstock that chemical companies expect to rely on to a greater degree in the near future. As discussed previously, at least two chemical companies are contracting new production plants that will use crude oil as a basic feedstock in the manufacture of ethylene and other chemical intermediates.

Although conversion to crude oil as a feedstock requires large capital investment in new plants and newly improved cracking processes, it will not necessarily result in a change in waterborne flows. Organic chemical production has traditionally been concentrated along the Gulf Coast and much of the new plant construction is expected to be made in this same area. Instead of receiving natural gas by pipeline, these plants will receive domestic crude oil by pipeline or imported crude oil by vessel. The distribution of products from these plants can be expected to follow the pattern of transportation flows outlined in the previous subsection for organic chemicals and allied products.

Other chemical producing areas, which include the Philadelphia/New Jersey area, selected plant locations along the southern Atlantic Coast, the Upper Ohio River Valley, the Chicago and St. Louis areas, southern California, and the Puget Sound area, may also be expected to see some shift toward the use of crude oil as a feedstock. For plants located near coastal ports, increased reliance on crude oil is a good possibility. For plants located on inland waterways, such a conversion is not nearly as likely. Some of these plants were at one time using coal coking products and gas from coal fields as feedstocks for their production. More recently, they have relied on Gulf Coast facilities to supply them with basic and intermediate chemicals, which in turn were processed into finished products for local or regional distribution. A conversion to crude oil at Gulf Coast plants would not be expected to change these patterns.

Some chemical shippers expect that coal may play a more important role as a chemical feedstock in the late 1980s and early 1990s. It should be emphasized that the future role of coal as a major hydrocarbon feedstock is decidely more controversial than that of crude oil. If coal does become a major hydrocarbon feedstock, then a change in waterborne coal and chemical flows can be expected. To the extent that plants located along the Gulf Coast use coal as a feedstock, increased barge shipments of coal down the Lower Mississippi to points along the Baton Rouge to Gulf area and the Gulf Intracoastal Waterway can be expected. Plants located on the Middle Atlantic Coast may also receive coal by rail or a rail-water movement.

Another possible development is the relocation of the production capacity for certain chemicals near western, midwestern, or appalachian coal mines. These plants would receive much of their coal requirements by conveyor or track and ship their products to local or regional markets by truck and rail. As a result, some of the major northbound flows on the Mississippi River and tributaries from the Gulf Coast may be lower than they would otherwise be. Once again, this factor would be expected to change waterborne flows only late in the NWS period.

(b) Conversion of Chemical Power Plants to Coal

The chemical industry is also a major user of energy for power plant operation. In particular, the production of inorganic chemicals such as chlorine and caustic soda consume large amounts of energy. The conversion of selected chemical power plants from natural gas and oil to coal can be expected in the future.

Gulf Coast plants powered by gas or oil are especially good candidates for eventual conversion to coal. Chemical shippers located along the Gulf Coast have several options for receiving coal at their plants. These include all rail and combined rail-water movements. Some increase in barge movements down the Lower Mississippi to Gulf Coast points can be expected.

In addition, some conversion of chemical power plants located along the Atlantic Coast can be expected. Some of these chemical shippers also have the options of choosing an all-rail movement or a combined rail and water movement and increased coal flows along the Atlantic Coast can be expected.

(c) Reduced United States Net Exports of Chemicals

There are at least two reasons why chemical shippers expect to see a reduction in United States chemical exports in the future. First, countries such as Mexico, Canada, and Saudi Arabia have domestic reserves of natural gas and crude oil that may in the future be processed into refined petroleum products and manufactured chemical products to a greater degree than they have been in the past. In addition, United States net exports of chemicals and chemical products have surged in recent years due to excess plant capacity in the United States and raw material cost advantages that some United States chemical companies have enjoyed as a result of the domestic control of natural gas and crude oil prices.

As increased foreign plant capacity is brought onstream and natural gas and crude oil prices are decontrolled in the United States, chemical shippers expect to see a reduction in chemical exports to certain markets, such as Western Europe, and an increase in foreign imports of such chemicals as methanol, ethylene dichloride, styrene, ethyl alcohol, and ammonia to the United States

No major changes in waterborne flows of chemicals and products are expected as a result of these factors. Much of these chemical imports can be expected to be handled at existing plants or terminals located along the Gulf Coast. Distribution to interior terminals, plants, and end users would be expected to use existing rail, barge and truck logistics systems.

(d) Increased Regulation of Hazardous Material Transportation

Hazardous materials transportation is regulated by both DOT and EPA. Increased regulation of these movements will have a major impact on the flows of certain chemicals.

The primary impact of such increased regulation may be a reduction in the shipment of certain chemicals by all modes. Increased regulation can be expected to increase both the transportation costs and the liability costs associated with accidents. Transportation costs are increased by mandatory changes in equipment design. Some of these changes can be expected to further reduce the average shipment size of hazardous materials for all modes. Liability costs are increased by the assignment of increased rights to parties who are injured or who suffer damages as a result of accidents.

Legislation has been proposed by the Carter Administration to create a multi-million dollar fund to clean up hazardous waste pollution sites. This legislation was proposed in 1979 and would apply to oil and chemical spills regulated under the Clean Water Act as well. This so called "superfund" legislation would further increase the costs associated with hazardous materials transportation, because industry would be subject to a tax to finance some of these expenditures.

The increased costs of hazardous material transportation can be expected to encourage shippers to consume certain chemicals at the point of production. This will result in lower shipments of certain chemicals by rail, water, and truck. (Pipeline transportation is not expected to be affected by increased regulation.) If such changes in use are not possible, it is feasible that the demand for certain chemicals will be reduced as higher transportation costs make competing products or materials more attractive. Once again, the number of water, rail, and truck shipments can be expected to decline.

Increased regulation of hazardous material transportation may also be expected to encourage shippers to use one mode rather than another. However, chemical shippers are divided over the relative safety of such competing modes as rail and water. Safety is a function of both the frequency and the severity of accidents. Although some shippers consider the frequency of chemical spills to be less for water transportation, they also recognize that the severity of the accident may be greater with water transportation. As a result, no clear cut inference can be drawn about the impact of increased hazardous material regulation on the use of rail or water by chemical shippers.

(e) Rail Deregulation

The deregulation of rail carriers might also be expected to change the amount of chemical waterborne flows in the future. Some chemical shippers share the view that rail carriers have kept business from shifting to water transportation by publishing "water compelled or competitive" rates. With increased rate-making freedom and increased freedom to exit or enter markets, rail carriers will be in a better position to pursue attractive business at the expense of less profitable business.

Revenue cost ratios published by A. T. Kearney in an interim study for the ICC entitled A Study to Perform an In-Depth Analysis of Market Dominance and Its Relaionship to Other Provisions of the 4-R Act indicate that by and large rail shipments of chemical traffic have contributed to rail revenues above and beyond the variable costs of operations. Table VII-9 presents estimate of revenue to variable cost ratios for 1977 rail shipments of chemicals.

As can be seen, industrial chemical shipments have been relatively attractive business for rail carriers. Revenue has exceeded average variable costs for all categories and, with one exception, the revenue received has been more than 150% of variable costs. To the extent that increased rate-making and entry or exit freedoms permit rail carriers to earn more revenue by concentrating their efforts on attractive business and shedding less profitable business, then increased rail competition for certain types of chemical traffic can be expected. In particular, long-haul shipments of organic and inorganic chemicals from the Gulf Coast to interior markets located on or near the inland waterways represent attractive business. The increased use of contract rates may permit rail carriers to obtain a greater share of these markets, especially to destinations such as Chicago where the recent freezing of the Illinois River has placed chemical shippers who rely on barge transportation in a less competitive position during the winter months.

Table VII-9

Revenue to Variable Cost Ratios for 1977 Rail Shipments of Industrial Chemicals

Product	Ratio
Industrial Inorganic Chemicals	1.8
Barium or Calcium	1.7
Sodium Alkalies	1.8
Soda Ash	1.8
Industrial Gases	2.0
Industrial Organic Gases	1.7
Sulfuric Acid	1.8
Agriculural Chemicals 1/	1.6
Plastic Materials	1.9
Rubber	1.6
Detergents	1.2

NOTE: 1/ Excludes fertilizers, such as anhydrous ammonia and superphosphates.

SOURCE: A. T. Kearney, A Study to Perform an In-Depth Analysis of Market Dominance and Its Relationship to Other Provisions of the 4-R Act, 1979.

It should be emphasized that this factor is not likely to affect waterborne flows until the late 1980s. It will take rail carriers some time to readjust their operations to take advantage of some of the increased freedom that may be available to them. Furthermore, rail carriers are not likely to capture traffic that is presently moving on the waterways. This traffic is often especially difficult to obtain, because chemical shippers have purchased specialized floating equipment or entered into long-term agreements with carriers who operate such specialized equipment. It is more likely to expect rail carriers to secure a greater portion of any net increase in future chemical shipments from plants located along the Gulf Coast to various destinations located near the waterways.

EXHIBIT VII-1

TOP 49 CHEMICALS PRODUCED
IN THE UNITED STATES DURING 1977

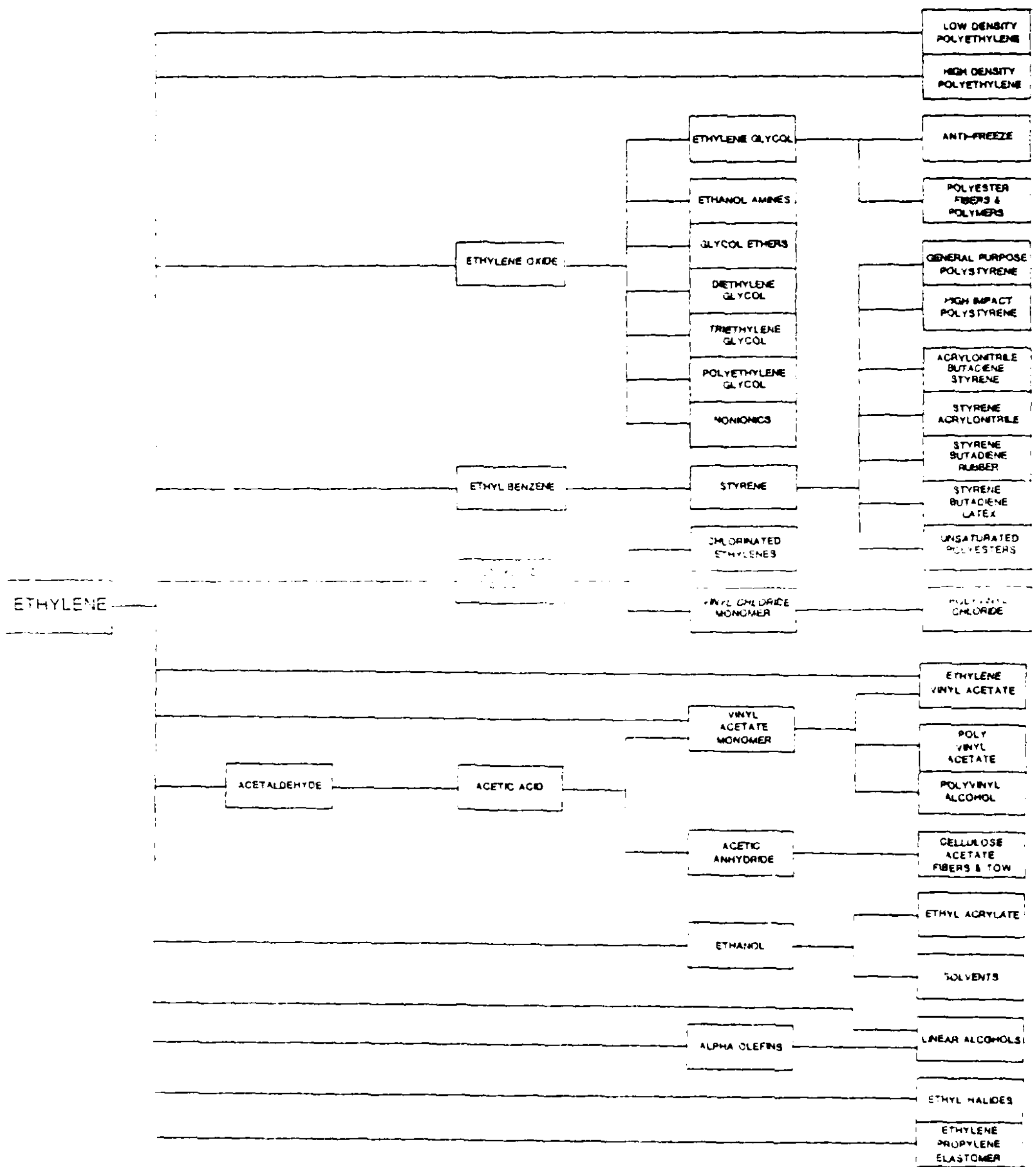
Production Rank-1977	Chemical Name	Production Billions of Pounds	Approximate Waterborne Tonnage (tons)
1	Sulfuric Acid	[illegible]	2,588,298 1/
2	Lime	[illegible]	888,396 1/
3	Ammonia	[illegible]	7,000,000
4	Oxygen	[illegible]	Small
5	Ethylene	[illegible]	Small
6	Nitrogen	[illegible]	Small
7	Sodium Hydroxide	[illegible]	5,370,214 1/
8	Chlorine	21.15	1,250,000
9	Phosphoric Acid	[illegible]	Small
10	Sodium Carbonate	16.18	1,000,000
11	Nitric Acid	15.9[illegible]	Small
12	Ammonia Nitrate	14.35	Small
13	Propylene	13.33	Small
14	Benzene	[illegible]	[illegible]
15	Ethylene Dichloride	11.00	320,000
16	Urea	8.89	[illegible]
17	Ethylbenzene	8.31	350,000
18	Toluene	7.73	[illegible]
19	Styrene	6.87	1,450,000
20	Methanol	6.45	[illegible]
21	Formaldehyde	6.05	Small
22	Xylenes (All Grades)	6.05	2,500,000
23	Vinyl Chloride	5.99	268,000
24	Hydrochloric Acid	5.44	535,000
25	Terephthalic Acid	5.41	500,000
26	Carbon Dioxide	4.51	Small
27	Ethylene Oxide	4.36	Small
28	Ammonium Sulfate	4.36	Small
29	Ethylene Glycol	3.68	1,370,000
30	Carbon Black	3.48	Small
31	Butadiene (1,3-)	3.26	560,000
32	P-Xylene	3.17	1,300,000
33	Cumene	2.64	650,000
34	Acetic Acid	2.57	385,000
35	Aluminum Sulfate	2.51	Small
36	Calcium Chloride	2.42	Small
37	Sodium Sulfate	2.40	Small
38	Phenol	2.34	295,000
39	Cyclohexane	2.24	1,065,000
40	Acetone	2.22	665,000
41	Isopropyl Alcohol	1.89	800,000
42	Propylene Oxide	1.87	19,000
43	Acrylonitrile	1.65	495,000
44	Vinyl Acetate	1.59	395,000
45	Adipic Acid	1.54	Small
46	Sodium Silicate	1.52	Small
47	Sodium Tripolyphosphate	1.43	Small
48	Titanium Dioxide	1.37	Small
49	Ethanol (Synthetic)	1.34	250,000

NOTE: 1/ Actual waterborne tonnage

SOURCES: Chemical and Engineering News, May, 1979; R.J. Brida & Associates, Impact Study of Chemical Barge Traffic [illegible] Inland Waterway System, 1978; Corps of Engineers, Waterborne Commerce of the United States, 1977; and Shipper Interviews.

EXHIBIT VII-2

MAJOR END USES OF ETHYLENE [1/]

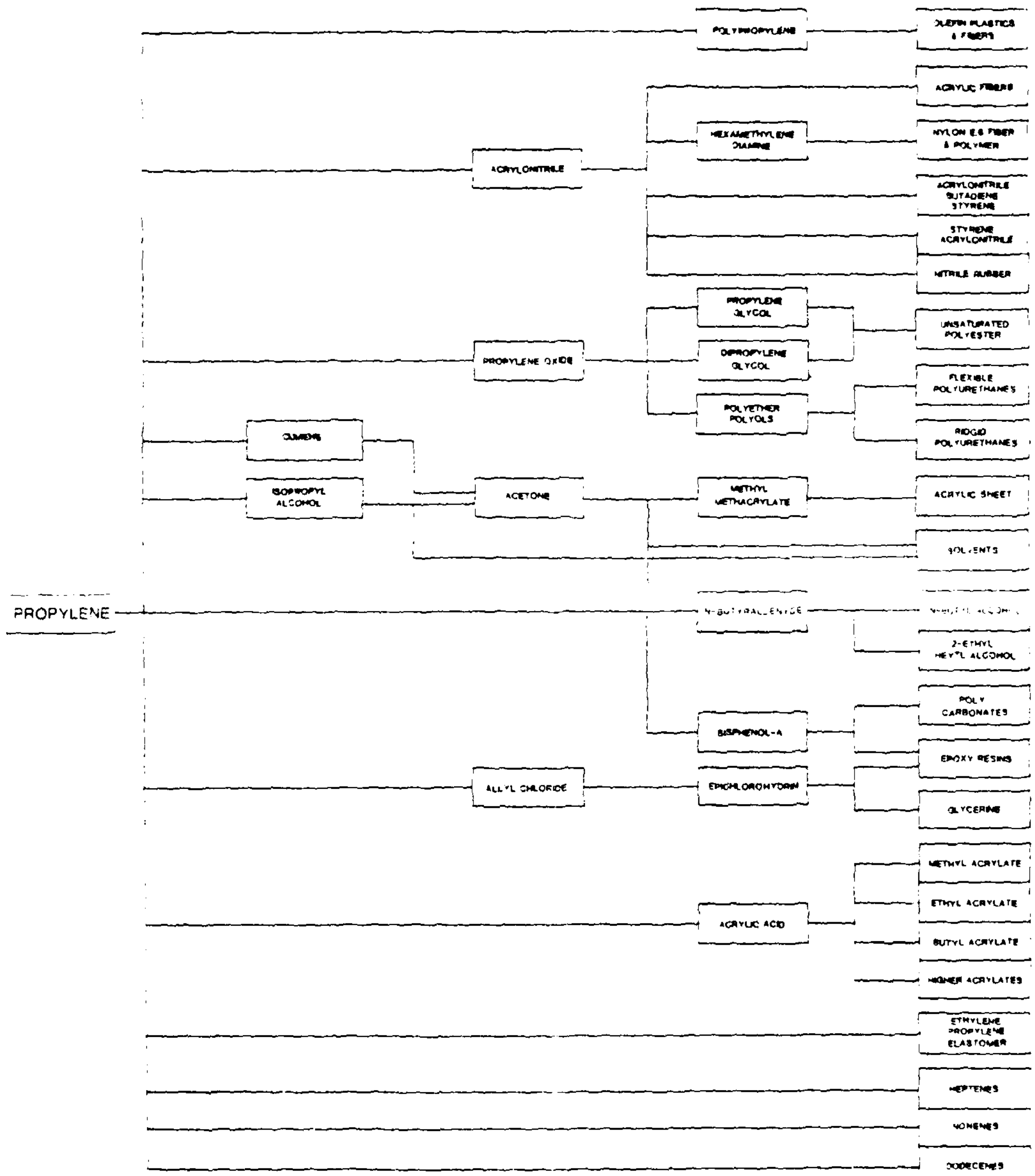


NOTE: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting materials.

SOURCE: Data Resources, Inc.

EXHIBIT VII-3

MAJOR END USES OF PROPYLENE 1/

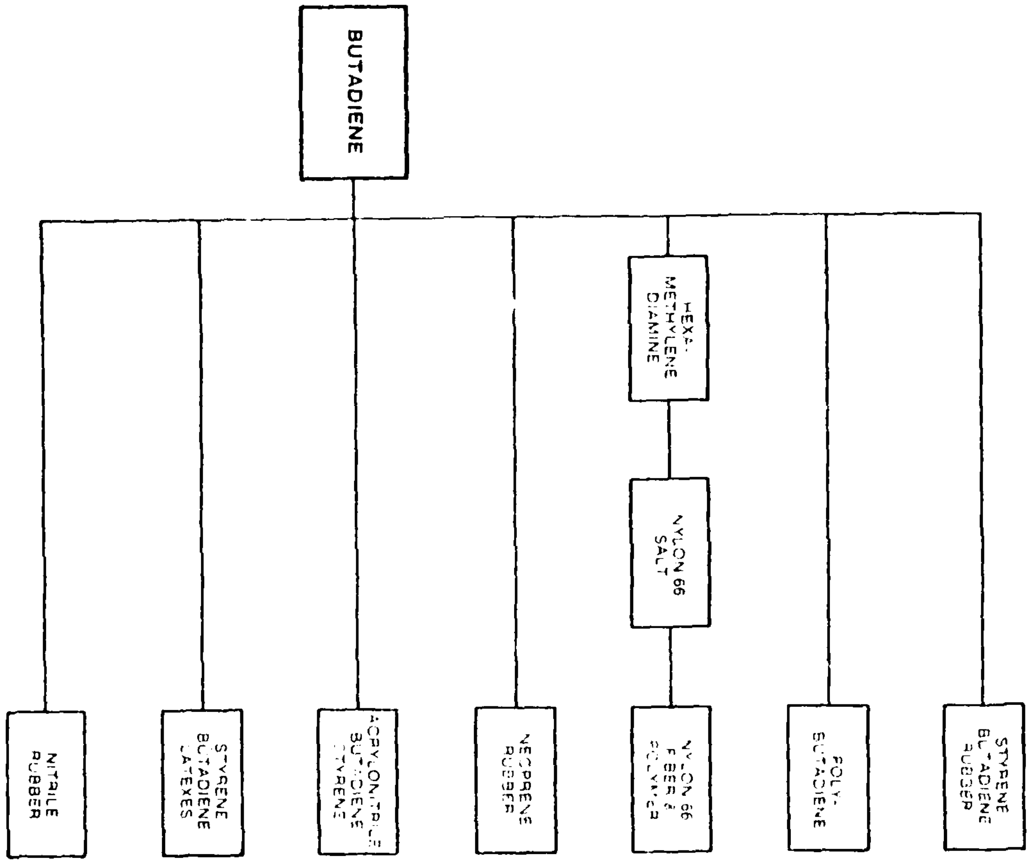


NOTE: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting materials.

SOURCE: Data Resources, Inc.

EXHIBIT VII-4

MAJOR END USES OF BUTADIENE 1/

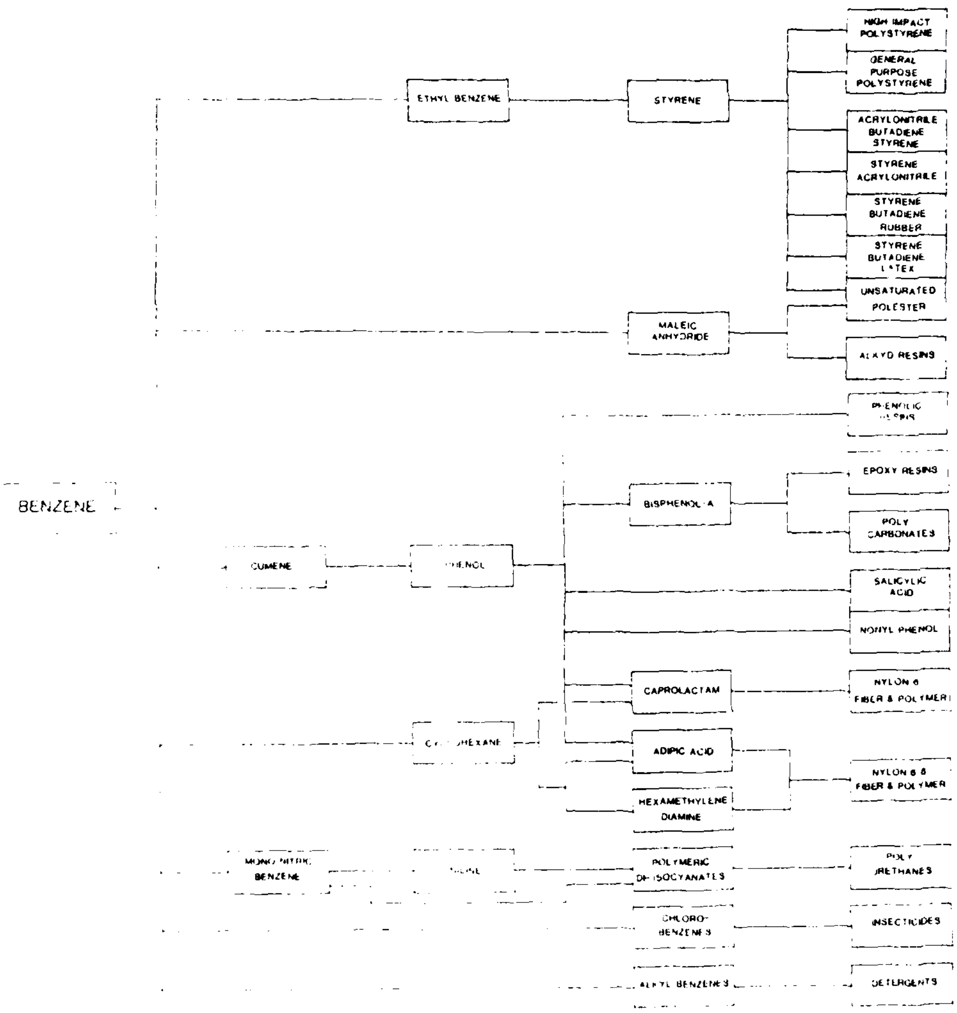


NOTE: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting points.

SOURCE: Data Resources, Inc.

EXHIBIT VII-5

MAJOR END USES OF BENZENE[1/]

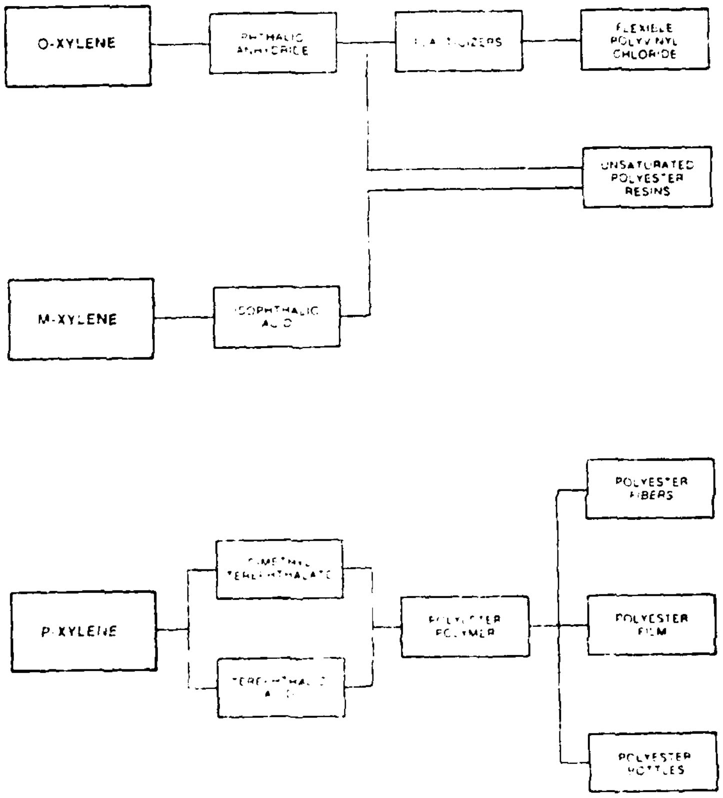


Note: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting materials.

Source: Data Resources, Inc.

EXHIBIT VII-6

MAJOR END USES OF XYLENES 1/

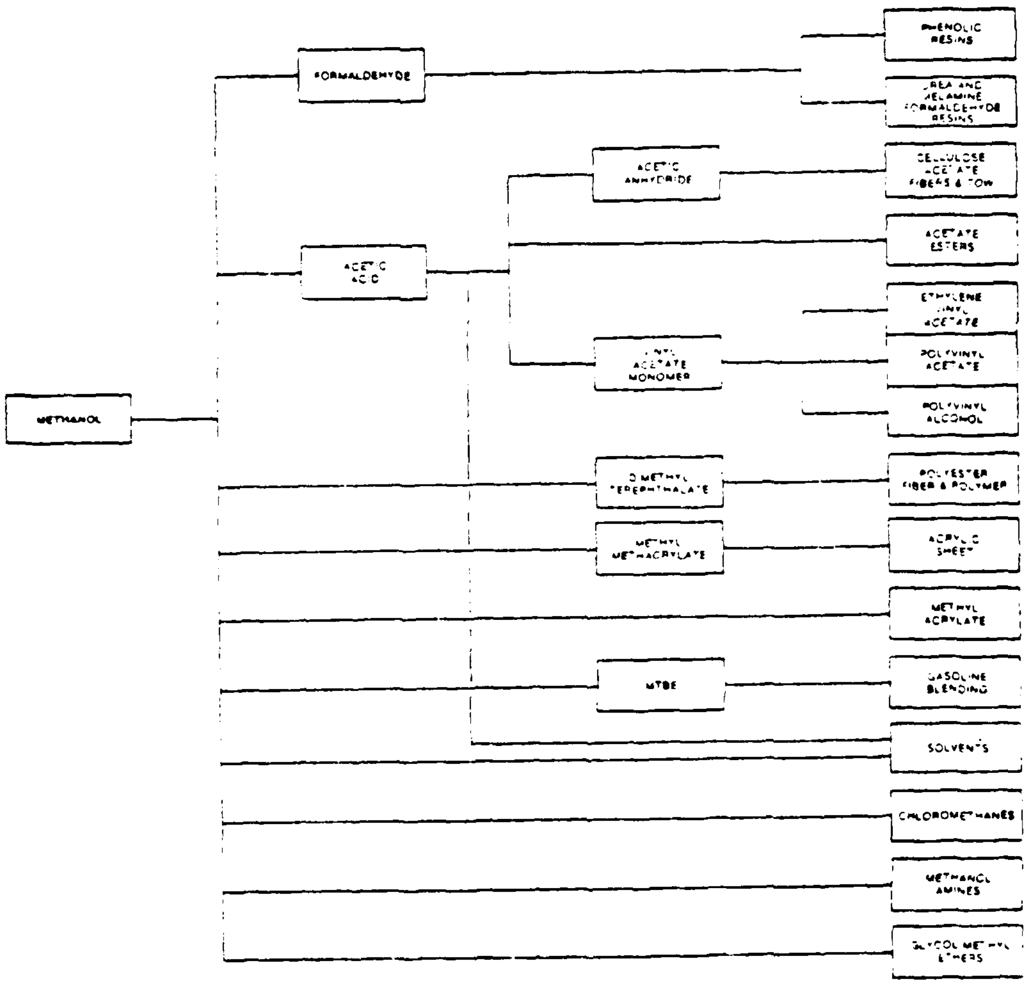


NOTE: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting points.

SOURCE: Data Resources, Inc.

EXHIBIT VII-7

MAJOR END USES OF METHANOL 1/



NOTE: 1/ This exhibit must be used with caution. It does not indicate the existing opportunities for producing some chemicals from two or more primary starting materials.

SOURCE: Data Resources, Inc.

EXHIBIT VII-8

FINANCIAL DATA FOR SELECTED CHEMICAL COMPANIES 1/

	Net Income/ Sales	Net Income/ Equity
1971	5.9%	9.9%
1972	6.7	11.8
1973	8.0	15.0
1974	7.9	17.7
1975	6.9	14.0
1976	7.2	15.2
1977	6.1	13.2
1978	6.4	14.1

NOTE: 1/ Companies include: Allied Chemical, American Cyanamid, Dow Chemical, Du Pont, Hercules, Monsanto and Union Carbide. Airco, Chemetron, GAF, and Olin were excluded in 1971 to 1974.

SOURCE: Standard & Poor's, Industry Survey: Chemicals Basic Analysis, 1979.

EXHIBIT VII-9
Page 1 of 2

HAZARDOUS SUBSTANCES REGULATED IN SECTION 311 OF THE CLEAN WATER ACT

50000	Formaldehyde
50293	DDT
51285	2 4 Dinitrophenol
52686	Trichlorfon
56382	Parathion
56724	Coumaphos
57249	Strychnine
57749	Chlordane
58899	Lindane
60004	Ethylenediaminetetraacetic acid (EDTA)
60571	Dieldrin
62533	Aniline
62737	Dichlorvos
63252	Carbaryl
64186	Formic acid
64197	Acetic acid
65850	Benzoic acid
67663	Chloroform
71432	Benzene
72208	Endrin
72435	Methoxychlor
72548	TDE
74895	Monomethylamine
74908	Hydrogen cyanide
74931	Methyl mercaptan
75047	Monoethylamine
75070	Acetaldehyde
75150	Carbon disulfide
75207	Calcium carbide
75445	Phosgene
75503	Trimethylamine
75649	tert Butylamine
75865	Acetone cyanohydrin
75990	2 2 Dichloropropionic acid
76448	Heptachlor
78002	Tetraethyl lead
78795	Isoprene
78819	iso Butylamine
79094	Propionic acid
79312	iso Butyric acid
79367	[illegible]
80626	Methyl methacrylate
85007	Diquat
86500	Guthion
87865	Pentachlorophenol
88755	o Nitrophenol
91203	Naphthalene
91225	Quinoline
93765	2 4 5 T acid
93798	2 4 5 T ester
94111	2 4 D ester
94757	2 4 D acid
94791	2 4 D ester
94804	2 4 D Butyl ester
95476	o Xylene
95487	o Cresol
98011	Furfural
98884	Benzoyl chloride
98953	Nitrobenzene
99650	m Dinitrobenzene
100027	p Nitrophenol
100254	p Dinitrobenzene
100414	Ethylbenzene
100425	Styrene
100447	Benzyl chloride
100470	Benzonitrile
105464	sec Butyl acetate
106423	p Xylene
106445	p Cresol
107028	Acrolein
107051	Allyl chloride
107131	Acrylonitrile
107153	Ethylenediamine
107186	Allyl alcohol
107493	Tetraethyl pyrophosphate
107926	n Butyric acid
108054	Vinyl acetate
108247	Acetic anhydride
108316	Maleic anhydride
108383	m Xylene
108394	m Cresol
108463	Resorcinol
108883	Toluene
108907	Chlorobenzene
108952	Phenol
109739	n Butylamine
109897	Diethylamine
110167	Maleic acid
110178	Fumaric acid
110190	iso Butyl acetate
110827	Cyclohexane
115297	Endosulfan
115322	Kelthane
117806	Dichlone
121211	Pyrethrins
121299	Pyrethrin
121448	Triethylamine
121755	Malathion
123626	Propionic anhydride
123864	n Butyl acetate
123922	iso Amyl acetate
124403	Dimethylamine
124414	Sodium methylate
127822	Zinc phenolsulfonate
133062	Captan
142712	Cupric acetate
143339	Sodium cyanide
151508	Potassium cyanide
298000	Methyl parathion
298044	Disulfoton
300765	Naled
301042	Lead acetate
309002	Aldrin
315184	Mexacarbate
329715	2 5 Dinitrophenol
330541	Diuron
333415	Diazinon
506774	Cyanogen chloride
506876	Ammonium carbonate
506967	Acetyl bromide
513495	sec Butylamine
528290	o Dinitrobenzene
540885	tert Butyl acetate
541093	Uranyl acetate
542621	Barium cyanide
543908	Cadmium acetate
544183	Cobaltous formate
554847	m Nitrophenol
557211	Zinc cyanide
557346	Zinc acetate
557415	Zinc formate
563122	Ethion
573568	2 6 Dinitrophenol
592018	Calcium cyanide
592041	Mercuric cyanide
592858	Mercuric thiocyanate
592870	Lead thiocyanate
625161	tert Amyl acetate
626380	sec Amyl acetate
628637	n Amyl acetate
631618	Ammonium acetate
815827	Cupric tartrate
1066304	Chromic acetate
1066337	Ammonium bicarbonate
1072351	Lead stearate
1111780	Ammonium carbamate
1185575	Ferric ammonium citrate
1194656	Dichlobenil
1300716	Xylenol
1303282	Arsenic pentoxide
1303328	Arsenic disulfide
1303339	Arsenic trisulfide
1309644	Antimony trioxide
1310583	Potassium hydroxide
1310732	Sodium hydroxide
1314621	Vanadium pentoxide
1314803	Phosphorus pentasulfide
1314847	Zinc phosphide
1314870	Lead sulfide
1319773	Cresol (mixed)
1320189	2 4 D ester
1327533	Arsenic trioxide
1330207	Xylene
1332076	Zinc borate
1333831	Sodium bifluoride
1336216	Ammonium hydroxide
1336363	Polychlorinated biphenyls
1338245	Naphthenic acid
1341497	Ammonium bifluoride
1762954	Ammonium thiocyanate
1863634	Ammonium benzoate
1918009	Dicamba
1928387	2 4 D esters
1928478	2 4 5 T ester
1928616	2 4 D ester
1929733	2 4 D ester
2545597	2 4 5 T ester
2764729	Diquat
2921882	Chlorpyrifos
2944674	Ferric ammonium oxalate
2971382	2 4 D ester
3012655	Ammonium citrate, dibasic
3164292	Ammonium tartrate
3251238	Cupric nitrate
3486359	Zinc carbonate
5893663	Cupric oxalate
5972736	Ammonium oxalate
6009707	Ammonium oxalate
6369966	2 4,5 T ester
7428480	Lead stearate
7440235	Sodium
7446084	Selenium oxide
7446142	Lead sulfate
7447394	Cupric chloride
7558794	Sodium phosphate, dibasic
7601549	Sodium phosphate, tribasic
7631892	Sodium arsenate
7631905	Sodium bisulfite
7632000	Sodium nitrite
7645252	Lead arsenate
7646857	Zinc chloride
7647010	Hydrochloric acid
7647189	Antimony pentachloride
7664382	Phosphoric acid
7664393	Hydrofluoric acid
7664417	Ammonia
7664939	Sulfuric acid
7681494	Sodium fluoride
7681529	Sodium hypochlorite
7697372	Nitric acid
7699458	Zinc bromide
7705080	Ferric chloride
7718549	Nickel chloride
7719122	Phosphorus trichloride
7720787	Ferrous sulfate
7722647	Potassium permanganate
7723140	Phosphorus
7733020	Zinc sulfate
7758294	Sodium phosphate, tribasic
7758943	Ferrous chloride
7758954	Lead chloride
7758987	Cupric sulfate
7773060	Ammonium sulfamate
7775113	Sodium chromate
7778441	Calcium arsenate
7778509	Potassium bichromate
7778543	Calcium hypochlorite
7779864	Zinc hydrosulfite
7779886	Zinc nitrate
7782505	Chlorine
7782630	Ferrous sulfate
7782823	Sodium selenite
7782867	Mercurous nitrate
7783188	Ammonium thiosulfate
7783359	Mercuric sulfate
7783462	Lead fluoride
7783495	Zinc fluoride
7783508	Ferric fluoride
7783564	Antimony trifluoride
7784341	Arsenic trichloride
7784409	Lead arsenate
7784410	Potassium arsenate
7784465	Sodium arsenite
7785844	Sodium phosphate, tribasic
7786347	Mevinphos
7786814	Nickel sulfate
7787475	Beryllium chloride
7787497	Beryllium fluoride

SOURCE: Federal Register, November 13, 1979

HAZARDOUS SUBSTANCES REGULATED IN SECTION 311 OF THE CLEAN WATER ACT (CONT.)

[illegible]	Beryllium nitrate
[illegible]8989	Ammonium chromate
[illegible]	Potassium chromate
[illegible]89062	Strontium chromate
[illegible]	Ammonium bichromate
[illegible]89428	Cadmium bromide
[illegible]	Cobaltous bromide
[illegible]89619	Antimony tribromide
[illegible]945	Chlorosulfonic acid
8001352	Toxaphene
[illegible]	Sodium hypochlorite
[illegible]25873	Phosphorus oxychloride
[illegible]	Antimony trichloride
[illegible]	Zirconium tetrachloride
[illegible]	Ferric sulfate
[illegible]	Sodium phosphate, dibasic
[illegible]	Sodium phosphate, dibasic
[illegible]	Aluminum sulfate
[illegible]	Ferrous ammonium sulfate
[illegible]	[illegible] nitrate
[illegible]	[illegible]
[illegible]	Lead nitrate
[illegible]	[illegible] sulfate
[illegible]	Lead sulfide
[illegible]	Sodium phosphate, tribasic
[illegible]	[illegible]
[illegible]	[illegible] selenite
[illegible]	[illegible]
[illegible]	Lead arsenate
[illegible]	Cadmium [illegible]
10124502	Potassium arsenite
10124568	Sodium phosphate, tribasic
10140655	Sodium phosphate, dibasic
10192300	Ammonium bisulfite
10196040	Ammonium sulfite
10361894	Sodium phosphate, tribasic
[illegible]	Cupric sulfate, ammoniated
10415755	Mercurous nitrate
10421484	Ferric nitrate
10588019	Sodium bichromate
11115745	Chromic acid
12002038	Cupric acetoarsenite
12054487	Nickel hydroxide
12125018	Ammonium fluoride
12125029	Ammonium chloride
12135761	Ammonium sulfide
12771083	Sulfur chloride
13597994	Beryllium nitrate
13746899	Zirconium nitrate
13765190	Calcium chromate
[illegible]14965	Lead fluoborate
13826830	Ammonium fluoborate
13952846	sec-Butylamine
[illegible]	Cobaltous sulfamate
14216752	Nickel nitrate
14258492	Ammonium oxalate
14307358	Lithium chromate
14307438	Ammonium tartrate
14639975	Zinc ammonium chloride
14639986	Zinc ammonium chloride
16844612	Zirconium sulfate
15699180	Nickel ammonium sulfate
16721805	Sodium hydrosulfide
16871719	Zinc silicofluoride
16919190	Ammonium silicofluoride
16923958	Zirconium potassium fluoride
25154545	Dinitrobenzene
25154556	Nitrophenol
25155300	Sodium dodecylbenzenesulfonate
25167822	Trichlorophenol
25168154	2,4,5-T ester
25168267	2,4-D ester
26264062	Calcium dodecylbenzenesulfonate
27176870	Dodecylbenzenesulfonic acid
27323417	Triethanolamine dodecylbenzenesulfonate
27774136	Vanadyl sulfate
28300745	Antimony potassium tartrate
30525894	Paraformaldehyde
36478769	Uranyl nitrate
37211055	Nickel chloride
42504461	Dodecylbenzenesulfonate isopropanolamine
52628258	Zinc ammonium chloride
52740166	Calcium arsenite
53467111	2,4-D ester
55488874	Ferric ammonium oxalate
61792072	2,4,5-T ester

SOURCE: Federal Register, November 13, 1979

EXHIBIT VII-10

MODAL SHARE OF SELECTED CHEMICALS FOR 1972

	Rail	Truck	Water	Other	Total
Inorganic Chemicals 1/	51%	37%	12%	0%	100%
Organic Chemicals 2/	42	31	25	2	100
Selected Chemical Products:					
Polymers	45	52	3	0	100
Industrial gases	30	69	1	0	100
Pesticides	32	66	1	1	100
Inorganic pigments	33	65	2	0	100
Adhesives	6	93	0	1	100
Surface-active agents	16	84	0	0	100
Explosives	34	65	0	0	100
Organic colors	6	93	1	0	100
Miscellaneous chemicals	32	34	34	0	100

NOTE: 1/ Includes basic and intermediates.

NOTE: 2/ Includes basic, cyclic intermediates, gum and wood, fatty acids, and other organic chemicals.

SOURCE: U. S. Bureau of the Census, 1972 Census of Transportation.

VIII - FOREST PRODUCTS

This section discusses the principal forest products transported on the national waterways. It includes a discussion of both lumber and wood products as well as selected pulp and paper products.

Table VIII-1 on the next page presents a summary of the principal forest products transported on the waterways in 1977.

Lumber and wood products accounted for the bulk of waterway traffic in 1977. And two of these products, logs and rafted logs, accounted for well over half of the lumber and wood products tonnage. Logs were predominantly exported (principally from the West Coast to Japan), whereas rafted logs moved on inland waterways in the Pacific Northwest.

Less than 12 million tons of paper, pulp, and allied products moved on the waterways in 1977. Much of this traffic was foreign exports and, to a lesser degree, imports.

Since rail and truck transportation handle most of the shipments of these products, water transportation plays a limited role in the distribution of forest products for many shippers. The use of the waterways for the shipment of forest products is concentrated in the Pacific Northwest.

This section is divided into the following headings:

- Commodity Characteristics.
- Markets.
- Economics of the Industry.

- Description of the Logistics System.
- Principal Transportation Flows.
- Factors Influencing Flows in the Future.

Table VIII-1

1977 Waterborne Shipments of Forest Products
(Millions of Tons)

	Domestic	Foreign	Total
Lumber and Wood Products			
Rafted logs	16.3	0.0	16.3
Logs	0.7	12.7	13.4
Wood chips, staves and moldings	2.2	9.4	11.6
Lumber	1.5	4.9	6.4
Veneer, plywood and worked wood	0.3	1.5	1.8
Pulpwood logs	1.4	0.1	1.5
Fuel wood, charcoal and wastes	0.5	0.4	0.9
Timber, posts, poles, and pilings	0.1	0.1	0.2
Wood manufactures, not elsewhere classified	0.2	0.3	0.5
Subtotal	23.2	29.4	52.6
Pulp, Paper, and Allied Products			
Pulp	1.0	3.0	4.0
Paper and paperboard	1.1	2.7	3.8
Standard newsprint paper	0.2	1.8	2.0
Pulp and paper products, not elsewhere classified	1.7	0.2	1.9
Subtotal	4.0	7.7	11.7
TOTAL	27.2	37.1	64.3

SOURCE: Corps of Engineers, *Waterborne Commerce of the United States*, 1977.

COMMODITY CHARACTERISTICS

The commodity characteristics of logs, lumber, plywood, pulp, paper and paperboard, and standard newsprint paper are discussed in this subsection.

Forest products are produced from trees and trees are divided into broad classes, referred to as hardwoods and softwoods. United States softwoods have needlelike or scalelike leaves that remain on the trees throughout the year. The hardwoods, with a few exceptions, lose their leaves in fall or winter.

Roundwood logs are shipped to sawmills, plywood plants, pulp and paper mills and export markets. One means of moving these logs to market is to raft them. Typically, logs are dumped along river banks into the water. In the Pacific Northwest dumping logs has been common, but environmental concerns over debarking and soil erosion, which occur when logs are dumped over a river bank, has made it necessary in some places to lift and lower the logs into the water or ship them by truck or rail.

Lumber and plywood are basic building materials used for construction and manufactured products, such as furniture. Lumber is solid wood cut from the tree, whereas plywood is a glued wood panel made up of relatively thin layers, or plies, with the grain of adjacent layers at an angle, usually 90 degrees. Both softwood and hardwood lumber and plywood are distributed throughout the United States, but softwood lumber and plywood are the dominant materials for the construction industry. In recent years, softwood lumber has accounted for over 80% of United States lumber production. Softwood lumber is produced primarily from douglas fir timber in Washington, Oregon, and California and from pine in the West and South. Hardwood lumber is used for the remanufacture and finished wood markets and hardwood plywood is used for the construction (when appearance is more important than strength) and remanufacture markets.

Pulpwood logs and chips are the major sources of wood fiber used to make paper. Pulpwood logs are harvested in the harvest, cut to prescribed lengths of five to eight feet (there are some instances where tree length logs are moved to the pulp mills), and transported to the pulp mill. Pulpwood chips, on the other hand, are a waste material from sawmills and plywood plants. Chips are accumulated at these plants and transported to the pulp mill for processing.

There are two kinds of wood pulp. Groundwood or mechanical pulp is made by grinding wood to break down the fiber structure. Lignin, which binds the fibers together, remains in the pulp. Groundwood pulp is used to produce low grade paper products such as newsprint, chipboard, and tissue. Chemical pulp is prepared by boiling wood chips under pressure in soda, sulfite or sulfate to remove the lignin. The resulting pulp is almost pure cellulose fiber. It is washed, bleached, screened, beaten, and blended to specification. If the pulp is to be shipped to another mill for paper making, it is dried, folded and compressed into large bales or bundles. Otherwise, the pulp moves directly to the paper making machine in an integrated mill. About 90% of United States pulp and paper production comes from integrated manufacturing facilities, those which combine the two processes of pulp making and paper machining.

The paper making process begins by passing the pulp/water solution over a wire screen. As water drains through the screen, the fibers form in a layer. A wet fan belt picks up the fibers and passes through a series of rollers for drying. The compressed, dried layer of fibers then passes through a series of finishing rollers (calendars) and is wound in a roll.

Standard newsprint paper is a relatively low grade paper made from groundwood pulp. Newsprint paper is produced in large rolls weighing up to two tons. Book paper is any printing paper except newsprint. Writing paper is sized (coated with resin) to prevent ink spreading. Wrapping and packing papers are made from kraft paper (a product of the sulfate pulping process). Paperboard is similar in shape and composition to paper, but it is thicker, stronger, and more rigid. Paper and paperboard stock are generally produced in roll form for shipment to converters or printers. However, either commodity may be "sheeted" at the mill and stacked on pallets or skids.

MARKETS

The principal producing areas and markets for lumber and plywood as well as paper are discussed below.

(a) Lumber and Plywood

United States lumber production has shown little growth in recent years. Table VIII-2 presents estimates of United States lumber production by region.

Table VIII-2

United States Lumber Production
(Billion Board Feet)

	1970	1973	1974	1975	1976	1977 1/
Pacific	15.3	18.0	15.8	14.8	16.6	17.1
Mountain	4.2	4.6	3.9	3.9	4.6	4.7
South Atlantic	5.2	5.5	5.1	4.7	5.2	5.3
East South Central	3.4	3.6	3.4	3.0	3.3	3.5
West South Central	3.2	3.3	2.9	3.0	3.1	3.6
Other	3.4	3.6	3.5	3.2	3.5	3.6
TOTAL	34.7	38.6	34.6	32.6	36.3	37.8

NOTE: 1/ Preliminary

SOURCE: United States Bureau of the Census, Current Industrial Reports, series MA-247, annual.

Lumber production declined during the recession of 1974 and 1975, but began to recover in 1976. Production in 1977 was nearly equal to that of 1973. As can be seen, there are three primary producing regions for lumber in the United States, namely the Pacific Coast, Inland West, and South.

The region accounting for the largest portion of total production is the Pacific Coast, which includes California, Washington, and Oregon. In contrast to the South, over half of commercial timber land in this area is owned by the federal government. Thus, lumber production in this region is strongly influenced by the supplies made available from United States National Forests. These forests carry much old-growth timber suitable for lumber production, but these supplies are often restricted as a result of the reclassification of this land to wilderness areas under federal programs such as RARE I and II.

The Inland West includes such states as Idaho, Montana, Arizona, and New Mexico. This area is also a major lumber producing area and, like the Pacific Coast, a significant amount of commercial timberland is owned by the federal government.

The South is the third major lumber producing area in the United States This area includes South Atlantic states such as the Carolinas, East South Central states such as Alabama and Mississippi, and West South Central states such as Arkansas, Oklahoma, and Texas. In this region, industry and private ownership account for nearly 90% of commercial timberland. The net effect is that the volume of timber available for commercial uses in this area is known with much more certainty at any point in time.

As can be seen by Table VIII-2, lumber production by region has changed very little from 1970 to 1977. All regions showed some increase, but no single region captured the predominant share of the increase. If the attention is focused on softwood lumber and historical data are provided for the 1960's, a different picture emerges.

Exhibit VIII-1 presents estimates of United States consumption of softwood lumber by region of origin. It should be noted that the Western Pine region corresponds to the Inland West and parts of the Pacific Coast, while the Douglas Fir and California Redwood regions correspond to the Coast region.

As can be seen, lumber producers in the western regions have lost considerable market share to the Southern Pine region and foreign (almost exclusively Canadian) producers. Much of this decline in market share took place from 1960 to 1970. But forest product shippers noted that this trend may well continue in the 1980's, due to the restrictions placed on timber sales of government owned land and the fact that producers in the Pacific Northwest are harvesting more timber than is being replenished.

While United States production of lumber has remained relatively constant over the past 20 years. United States consumption of lumber has increased. Table VIII-3 presents estimates of lumber production and consumption for selected years beginning with 1960.

Table VIII-3

United States Lumber Production and Consumption
(Billions of Board Feet)

Year	Production	Consumption	Net Imports[1]
1960	32.9	35.2	2.3
1965	36.8	40.8	4.0
1970	34.7	38.1	3.4
1973	38.6	45.6	7.0
1974	34.6	38.9	4.3
1975	29.6	36.1	6.5
1976	36.3	42.2	5.9
1977[2]	37.8	46.8	9.0

NOTE: 1/ Imports less exports.

NOTE: 2/ Preliminary.

SOURCE: United States Bureau of the Census, Current Industrial Reports, series MA-24T, annual and Mackay-Shields Economics, Inc.

As can be seen, consumption of lumber has varied markedly from year to year, but in the 1970s it has been higher than the 1960 estimate of consumption. Net imports of lumber have increased from 2.3 billion board feet in 1960 to a range of 3.4 to 9.0 billion board feet during the 1970s.

As previously noted, Canada accounts for the bulk of United States lumber imports. And, in recent years, British Columbia has produced approximately 80% of the Canadian lumber exported to the United States.

Plywood is produced in the same regions that account for the bulk of lumber production. Table VIII-4 presents estimates of United States plywood production by region.

Table VIII-4

United States Domestic Production of Softwood Plywood
(Billions of Square Feet - 3/8" Basis)

	Pacific Coast	Inland West	South	Total
1960	7.7	0.1	--	7.8
1965	11.3	0.7	0.4	12.4
1970	10.1	0.9	3.3	14.3
1973	11.7	1.0	5.6	18.3
1974	9.8	1.0	5.1	15.9
1975	9.3	1.1	5.7	16.1
1976	10.4	1.2	6.5	18.1

SOURCE: American Plywood Association, Regional Production and Distribution Patterns of the Softwood Plywood Industry.

Since 1965, the production of plywood in the Pacific Coast and Inland West has shown little change. However, production in the South has increased sharply from 400 million square feet in 1965 to 6.5 billion square feet in 1976. This southern production has captured virtually all of the growth in the United States plywood market since 1965. In contrast to lumber, there is little importing of plywood into the United States

The major end markets for lumber are residential construction, other new construction, repair and modeling, and materials handling. Residential construction includes single-family, multi-family, and mobile homes. In recent years, residential construction has accounted for approximately 40% of softwood lumber consumption. However, as discussed previously, lumber consumption has been volatile and the major contributor to these dramatic shifts in consumption has been the residential construction market. Lumber use for this market amounted to 20 billion board feet in 1972, but tumbled to 11 billion in 1975 when the housing market collapsed.

The nonresidential construction and repair and modeling markets have each accounted for approximately 20% of soft lumber consumption in recent years. The remaining 20% of lumber consumption has been divided nearly equally between materials handling, on the one hand, and other markets, on the other hand. In contrast to residential construction, volumes consumed in these market have been much more state during the 1970's. For example, nonresidential construction consumption has ranged from a low of 4.4 billion board feet in 1975 to a high of 5.4 billion board feet in 1970.

Lumber is consumed throughout the United States, but, during the past 10 years, there has been increased demand in both the South and West. Table VIII-5 presents estimates of increases in lumber shipments to different regions of the United States.

Table VIII-5

Changes in Lumber Consumption Patterns by Region

Region	Percent of Increase in Shipments 1968-1977
New England	14%
Middle Atlantic	20
East North Central	8
West North Central	43
East South Central	4
South Atlantic	28
West South Central	45
Mountain	118
Pacific	106

SOURCE: Western Wood Products Association, Southern Forest Products Association, and Canadian shipment analysis.

As can be seen, all regions have shown an increase in receipts of lumber during this period. But, the largest percentage increases have been in the Mountain, Pacific, and West South Central regions. The more rapid population growth and increase in industrial activity in these areas are largely responsible for these market shifts.

Along with regional shifts in demand for lumber, there have been changes in the distribution of lumber from the four principal lumber producing areas of the Pacific Coast, Inland West, South, and Canada. Exhibit VIII-2 shows the major geographical markets for these producing areas. As can be seen in this exhibit, the coastal region has lost market share in all markets except the Mountain and Pacific markets. In both of these markets, the Coastal regions market share from 1968 to 1977 has remained constant.

The only market area in which producers in the Inland West have enjoyed an increase in market share has been in their own local market.

In contrast to the Pacific and Inland West, the South has had little change in the markets that it serves. The data show that this area has increased or held its market share constant in the following areas: Middle Atlantic, East North Central, and East South Central.

The Canadian contribution to the increase in United States lumber demand from 1970 to 1977 has been substantial. Canada has increased its market share in all United States market areas.

In summary, the lumber market has become more regionalized during the 1970s. A higher percentage of lumber production in the West is consumed in local markets. The South has produced enough lumber to maintain or increase its shares in local markets, while Canada has been a major residual supplier of lumber to the United States

The primary plywood markets in order of their importance are as follows:

- Residential construction.
- Homeowner use.
- Industrial use.
- Nonresidential construction.

The residential construction and homeowner markets account for more than 60% of plywood consumption. Homeowner use includes repairs, remodeling, additions, and alterations. In recent years, the industrial and nonresidential construction markets have accounted for approximately 16% and 12%, respectively, of United States plywood consumption. Other markets including exports account for the remainder of plywood consumption.

(b) Paper

As discussed earlier, pulp is the raw commodity from which paper is produced. The United States imports only small amounts of pulpwood logs and chips as well as pulp. A feasible source of imports for the United States is Canada, but Canadian law prohibits the exporting of unprocessed wood fiber.

The United States does export pulpwood chips to Scandanavia and Europe. There are substantial pulping capacities located overseas and these operations require large amounts of wood fiber. The United States has accommodated some of this demand by exporting pulpwood chips from facilities located on the Gulf Coast and South Atlantic Coast.

In general, United States wood pulp is produced close to timber sources without reference to final consumer markets, while converted paper products are made in or near areas of high personal income. Table VIII-6 presents estimates of the geographic location of the United States pulp and paper industry.

Table VIII-6

1976 Geographic Location of the United States Paper and Pulp Industry

	Woodpulp	Paper and Board	Converted Products	Personal Income
New England	5%	8%	6%	6%
Middle Atlantic	3	9	21	19
North Central	8	18	35	27
South	67	50	26	29
West	17	15	12	19
TOTAL	100%	100%	100%	100%

SOURCES: United States Bureau of the Census, Current Industrial Reports, series MA-26; Annual Survey of Manufacturers; Survey of Current Business; and C. H. Kline & Co., Kline Guide to the Paper Indusry.

As can be seen, the United States woodpulp industry is heavily concentrated in the South. A smaller but sizeable share of United States paper production is also concentrated in the South. The South serves both midwestern and eastern paper and pulp markets. The West supplies much of its own pulp and paper needs.

Although the United States imports only small amounts of pulpwood logs, pulpwood chips, and woodpulp, it does import significant amounts of paper. Newsprint paper is the commodity with the single largest amount of imported tonnage. The United States imported approximately 6.6 million tons of newsprint in 1977, primarily from Canada. Thus, as in the case of lumber, Canada is a significant supplier of paper to United States markets.

Production of paper and paperboard is highly correlated to the overall level of domestic economic activity, especially expenditures for nondurable goods. Table VIII-7 presents estimates of United States per capita consumption of paper and paperboard.

Table VIII-7

United States Per Capita Consumption of Paper and Paperboard (Pounds)

	Newsprint	Printing & Writing Papers	Other Paper	Paperboard	Total
1970	96	113	127	228	564
1971	97	113	136	229	575
1972	100	118	148	251	617
1973	102	128	148	261	639
1974	100	127	142	248	617
1975	86	103	126	209	524
1976	92	123	140	239	594
1977	94	130	155	236	615

SOURCE: Department of Commerce and American Paper Institute, The Statistics of Paper and Paperboard, annual.

As can be seen, United States per capita consumption of paper and paperboard rose steadily from 1970 to 1973. After the strong, steady growth of the 1960's and early 1970's, the 1974 recession severely affected the business confidence in the pulp and paper section. Consumption in the United States and Western Europe declined sharply in 1974 and 1975. The recovery since 1975 has been slow and arduous, especially in Western Europe. However, a good recovery in 1976 U.S demand for paper and paperboard as well as subsequent annual increases have brought demand more in line with production capacity.

Exhibit VIII-3 presents estimates of world paper and paperboard production and consumption for 1978. As can be seen by this exhibit, United States production accounts for over one third of world production. Despite this large production, the United States is also the world's largest net importer of paper and paperboard. As discussed previously, these imports are predominantly newsprint from Canada.

Canada, Sweden, and Finland are the largest exporters of paper and paperboard. Sweden and Finland supply much of the residual needs of Western European countries.

Major producers such as Japan, Russia, and China are largely self-sufficient with regard to paper and paperboard production.

There is considerable potential for growth in demand for paper and paperboard in the developing countries of Africa, Asia, and Latin America. These countries consume far less paper on a per capita basis than the more advanced countries of the world, such as the United States, Canada, Sweden, West Germany, Japan, and Great Britian.

Paper companies in the United States and Canada are well positioned to take advantage of the world's growing demand for paper and paperboard goods, since they are the world's foremost producers of pulp. Exhibit VIII-4 presents estimates of 1978 world production of pulp. As can be seen, the United States is by far the largest producer of pulp and, in contrast to paper and paperboard, the United States is nearly self-sufficient with regard to pulp production.

Canada and Sweden are major exporters of pulp, primarily to Western European countries. Japan and Russia are largely self-sufficient with regard to pulp production.

ECONOMICS OF THE INDUSTRY

This discussion includes both the solid wood products industry and the pulp and paper industry.

The solid wood products industry operates in a competitive atmosphere. It is often viewed as the classic example of pure competition since there are a large number of relatively small producers and entry and exit from the market is common. However, it should be noted that lumber production is relatively concentrated. The top ten companies produce an estimated 30% of United States output. These companies have large integrated operations and are involved in both solid wood products and paper products.

Not only is there a competitive price structure for solid wood products, but there is also a shifting mix and location of producers over time. Lumber mills can be built with considerably less capital than pulp operations. Thus, lumber mills follow timber resources with relative ease. Forest product shippers noted that there is a continuing trend to the production of southern timber due in part to the uncertainty associated with the amount of timber sales from federally owned land in the West. A move to southern production of lumber, plywood, pulp and paper is also a necessary outcome of the move to increased harvesting of southern timber. As might be expected, lumber mill operators are the first to respond to this change in the mix of timber production.

By way of contrast to the solid wood products industry, the pulp and paper industry is capital intensive. C. H. Kline & Co. reports that 1978 and 1979 capital expenditures as a percent of the total value of shipments by pulp and paper companies were comparable to the rate of expenditures in the chemical industry and higher than the rate for all manufacturing. Required pollution control expenditures have hit the pulp and paper industry hard during the 1970s and have added another 10% to 20% to the total cost of a new mill. The required filing of a detailed environmental impact statement before a new plant can be built has also discouraged new firms from entering the industry.

Because of this relatively high capital investment, the pulp and paper industry tends to be production oriented rather than marketing oriented. Producers seek to maintain good production levels even when demand is poor. Thus, at times, pulp and paper producers will move products into storage facilities near major consuming areas rather than shut their mills down.

The pulp and paper industry includes the production of pulp and its by-products; primary paper and paperboard; and converted paper and paperboard products. Most woodpulp is made by integrated companies and consumed captively without moving through the marketplace. Furthermore, some paper and paperboard production moves directly from mills to such users as newspapers and book publishers, printers, and builders. However, most paper and paperboard production is further processed by the converting segment of the industry into such products as containers, bags, sanitary tissue products, and stationery before sale to end users.

Exhibit VIII-5 presents financial data for both 9 forest product companies (with solid wood and paper operations) and 18 paper companies. As can be seen, the return on equity of forest product companies has fluctuated markedly throughout the 1970s along with the general economy. For example, return on equity for these companies averaged 23% in 1973, but fell to less than 10% in 1975.

By way of contrast, the return on equity of paper companies was somewhat less cyclical. Although return on equity averaged 19% in 1974, it fell to just under 13% in 1975 and 1976. This somewhat different performance may be due in part to the high capital intensive nature of the paper industry and the fact that its activity is more closely related to expenditures on nondurable goods rather than residential construction, the principal factor affecting solid wood product activity.

The above considerations point to a fairly stable pulp and paper industry and a fluctuating solid wood product industry, both of which can be affected by environmental concerns, United States federal timber sales, and regional shifts in production and consumption.

DESCRIPTION OF LOGISTICS SYSTEM

The forest products industry is highly competitive. As discussed previously, this is particularly true of the solid wood products market, but it is also true of the pulp and paper industry. Producers of forest products in one region compete with producers in other regions. Many United States producers must compete with Canadian producers in the sale of finished products to United States market.

The ability of any one forest product company to compete in a market is influenced by several factors, only one of which is distribution factors. These other factors include timber supply and production costs. These two factors are discussed briefly before shipper choice of transportation modes is discussed.

(a) Other Factors Affecting Ability to Compete

The availability of timber is one of the key factors affecting the ability of a producer to compete. Western producers in the United States have been at a disadvantage to other producers, because pressure from environment-alists and inadequate budgets for the Forest Service have resulted in a decline in the available timber. The pres-sures to create large wilderness (roadless) areas have been substantial (RARE I and RARE II) with millions of acres taken from the commercial timberland and placed into a wilderness classification. This reduced timber supply in the West has encouraged the location of new mills in the South and has encouraged western mills to concentrate on local markets or seek other export markets.

Production costs also influence the ability of producers to compete and these costs vary substantially from region to region for both timber and manufacturing costs. Although manufacturing cost is an important component of total production costs, such cost estimates are not available on a regional basis. The cost of uncut marketable timber, referred to as stumpage costs, is available from government sales, and industry sources indicate that this measure is indicative of variations in regional cost.

Table VIII-8 presents estimates of stumpage prices for both douglas fir and southern pine.

Table VIII-8

Stumpage Price Comparisons
(Dollars per Thousand Board Feet)

	Douglas Fir	Southern Pine
1972	$ 71.70	65.60
1973	138.10	93.40
1974	202.40	76.20
1975	169.50	57.00
1976	176.20	87.00

SOURCE: United States Forest Service, The Demand and Price Situation for Forest Products.

These prices must be interpreted with caution, because (1) timber from private and industry lands accounts for much of the timber used or sold nationwide and (2) stumpage prices in the West reflect in part the premium paid for old growth timber. Despite these qualifications, it can be seen that the South has a cost advantage with regard to timber.

Just as in the case of reduced supplies in the West, higher timber costs have encouraged producers to relocate operations in the South and this has changed the nature of demand for transportation.

(b) Shipper Choice of Transportation Modes

The result of the trend toward sourthern timber is that the production of forest products is becoming regional in nature. Markets are being served by those producers that are located closest, thereby reducing transportation costs and improving transportation service.

This trend favors the use of truck transportation because of its high service levels and relatively low cost for short hauls. Long-haul shipment of products by rail from the Pacific Coast to eastern markets will continue to be an important factor and United States shippers have little choice but to rely on rail transportation. Truck transportation is costly for long-haul shipments and, in the past, motor carriers have been prevented from seeking backhauls to offset some of the cost of these shipments. Waterborne shipments from the Pacific Coast to the East Coast have historically been important, but the retirement of vessels (new vessels are not being replaced due in part to the Jones Act) and increased tolls through the Panama Canal have made water transportation costly.

Rail and truck transportation are well suited for the movement of forest products for several reasons. Rail and truck carriers can serve both the mills and the consumer outlets. No expensive transloading operation is required to complete these moves as it often is with the case of water transportation. Rail and truck shipments are also relatively small in size. The purchasers of forest products have become more sophisticated in controlling their total logistics costs including any inventory costs. In order to reduce these inventory costs, customers have demanded and producers have supplied smaller, more regular shipments of products. This also tends to place the regions that are closer to end markets at a significant advantage over other producers.

During periods of strong demand for forest products (especially solid wood products), this distribution pattern is changed. The deficit areas of the Northeast, North Central, and even the South draw not only from regional producers but also from other producers that traditionally ship products only at higher total costs. Rail transportation is well suited to handle much of this long-haul business, because it provides relatively good door-to-door service at a lower cost than truck transportation. Since some of this demand is cyclical, both carriers and shippers are reluctant to make substantial investments in distribution. The buyers must as a result pay a higher transportation cost at times of peak demand than they would otherwise pay if demand were steady.

Given these needs, shippers of forest products rely primarily on rail and truck transportation. Exhibit VIII-6 and VIII-7 present estimates of rail and truck shipments as a percent of total lumber shipments from western and southern states. Since 1968, the use of trucks in western states has increased from 35% to 41%, largely at the expense of rail. Rail and truck transportation accounted for over 90% of all shipments throughout this period. Since 1970, the use of trucks in southern states has also increased.

Exhibit VIII-8 presents estimates of plywood shipments by transportation mode for each of the three United States producing areas. As can be seen, truck and rail transportation accounted for 98% or more of all shipments during 1974 to 1976.

Exhibit VIII-9 presents estimates of pulp and paper shipments by transportation mode for 1972. Once again, truck and rail shipments dominate total activity.

PRINCIPAL TRANSPORTATION FLOWS

The principal transportation flows of forest products are rail and truck shipments from the four principal areas (including Canada) to local or regional markets. Large rail shipments are also made from western producers to customers in the Midwest and East. For example, the second and third largest rail flows of lumber in 1977 were from origins in the Transcontinental rate territory to destinations in the Official and Western Truck Line territories. (See Exhibit VIII-10 for a presentation of 1977 rail flows of lumber.) The single largest rail flow of lumber was to and from points in the Transcontinental territory.

Water shipments of solid wood products and pulp and paper products play a significant role only in selected regions. These regions are the Columbia-Snake Waterway/ Willamette River; and the Washington/Oregon Coast. (See Appendix B for a listing of the waterway regions used in the NWS.)

One of the major waterborne flows is shipments of rafted logs. Table VIII-9 presents estimates of 1977 shipments of rafted logs.

Table VIII-9

1977 Shipments of Rafted Logs

Tons	Millions of
Lower Columbia-Snake/Williamette River	7.0
Puget Sound	4.3
Oregon/Washington Coast	2.6
Southeast Alaska	1.2
Upper Columbia-Snake	1.1
TOTAL	16.2

All of these shipments were local movements within each of the waterays listed in Table VIII-9. Logs are loaded into the water, tied together, and towed by tug to mill sites or one of three major export ports, namely Astoria and Portland, Oregon and Vancouver, Washington.

Rafting is preferred to truck transportation because of its lower costs. A log raft can move between 750 and 1,000 tons. This is far greater than the typical truck-load of 50 to 75 tons. Truck operations are also subject a relatively high tax in Oregon. As previously discussed, this advantage may disapper if environmental restrictions on dumping increase in the future.

Aside from foreign traffic, lumber shipments by water in 1977 were small and no single shipment exceeded 600,000 tons. The single largest shipments were from points on the Oregon/Washington Coast and Lower Columbia to points on the California Coast. Lumber shipments from the West Coast to the East Coast were insignificant in 1977. The principal foreign shipments of lumber are imports from Canada to selected United States ports, including several East Coast points.

As can be seen by Table VIII-1, plywood shipments by water are predominantly foreign traffic and, of this, imports from Canada are the largest flows.

The principal waterborne flows of wood chips are export shipments from the Gulf and South Atlantic coasts to Western Europe, but several million tons of wood chips are currently being shipped to Japan from the West Coast.

Domestic pulp and paper shipments by water were very small in 1977. Total inland and coastal movements were less than one percent of United States production. The single largest flow was to and from points on the Lower Columbia-Snake. Domestic paper and paperboard shipments were less than three percent of United States production. The single largest flow was to and from points on Lake Michigan.

Although less than ten percent of the total production of each of the major forest products moves on the waterways, this tonnage does represent a major portion of the total flows on the Columbia River and the Oregon/Washington Coast. In 1977, waterborne shipments of forest products represented over 30% of tonnage moving on the Columbia and over 50% of total tonnage along the Oregon/Washington Coast.

FACTORS INFLUENCING
FLOWS IN THE FUTURE

There are a number of factors that can be expected to change the forest products industry in the future. These factors include increased production of southern timber, a possible increase in pulp and paper exports from the South, and increased environmental regulations. A major issue affecting both the solid products and pulp and paper products industries is the sale of timber on federally-owned land.

While there are a number of factors that can be expected to change the industry, no major conclusions can be drawn regarding their impact on waterborne flows. Shipments of these products by water are small and limited primarily to the Pacific Northwest.

Shippers in the Pacific Northwest did mention that they were dissatisfied with the service of rail carriers. This dissatisfaction coupled with the declining importance of eastern markets may result in increased water shipments of products along the West Coast. Transloading costs at either or both ends can be expected to limit water carriers ability to compete, however.

Shippers in the South mentioned that several new plants are being constructed on or near inland waterways. This trend may also result in increased shipments. Market considerations including the large shipment size and slow transit time of water transportation have limited the growth of this traffic in the past.

Estimated United States Consumption of Softwood Lumber by Region of Origin

Year	Southern Pine Region	Douglas Fir Region	Western Pine Region	California Redwood Region	Other U.S. Regions	U.S. Imports	Total
	Producing Region						
1960	18.0%	26.1%	30.8%	7.8%	4.8%	12.5%	100.0
1961	18.9	24.6	30.1	7.4	4.8	13.5	100.0
1962	18.2	24.7	30.7	7.3	4.4	14.7	100.0
1963	19.1	24.0	29.7	7.3	4.0	15.9	100.0
1964	19.5	24.5	30.2	6.8	3.8	14.7	100.0
1965	20.8	24.4	30.2	6.2	3.7	15.0	100.0
1966	20.0	23.4	31.8	6.1	3.7	15.0	100.0
1967	20.4	22.5	31.5	6.4	3.8	15.4	100.0
1968	20.6	21.8	30.4	6.9	3.2	17.1	100.0
1969	21.4	21.1	28.7	6.8	4.1	17.9	100.0
1970	21.8	20.6	28.5	6.8	4.2	18.1	100.0
1971	21.4	21.1	27.7	6.3	3.7	19.8	100.0
1972	20.1	21.0	26.1	6.5	3.7	22.6	100.0
1973	20.0	19.6	26.7	6.4	3.9	23.4	100.0
1974	20.5	20.1	26.9	6.9	4.7	20.9	100.0
1975	22.5	20.2	27.2	6.8	4.6	18.7	100.0
1976	21.2	19.0	26.7	6.8	4.6	21.7	100.0

SOURCES: National Forest Products Association and Council of Forest Industries of British Columbia.

EXHIBIT VIII-2

Estimated United States Consumption of Softwood Lumber by Region of Origin

Producing Region

Year	Southern Pine Region	Douglas Fir Region	Western Pine Region	California Redwood Region	Other U.S. Regions	U.S. Imports	Total
1960	18.0%	26.1%	30.8%	7.8%	4.8%	12.5%	100.0
1961	18.9	24.6	30.1	7.4	4.5	13.5	100.0
1962	18.2	24.7	30.7	7.3	4.4	14.7	100.0
1963	19.1	24.0	29.7	7.3	4.0	15.9	100.0
1964	19.5	24.5	30.2	6.8	3.8	14.7	100.0
1965	20.8	24.4	30.2	6.2	3.7	[illegible]	100.0
1966	20.0	23.4	31.8	6.1	3.7	15.0	100.0
1967	20.4	22.5	31.5	6.4	3.8	15.4	100.0
1968	20.6	21.8	30.4	6.9	3.2	17.1	100.0
1969	21.4	21.1	28.7	6.8	4.1	17.9	100.0
1970	21.8	20.6	28.5	6.8	4.2	18.1	100.0
1971	22.4	21.1	27.7	6.3	3.7	19.6	100.0
1972	20.1	21.0	26.1	6.5	3.7	22.6	100.0
1973	20.0	19.6	26.7	6.4	3.9	23.4	100.0
1974	20.5	20.1	26.9	6.9	4.7	20.9	100.0
1975	22.5	20.2	27.2	6.8	4.6	18.7	100.0
1976	21.2	19.0	26.7	6.8	4.6	21.7	100.0

SOURCES: National Forest Products Association and Council of Forest Industries of British Columbia.

EXHIBIT VIII-3

1978 World Production and
Consumption of Paper And Paperboard
(Millions of Metric Tons)

Country	Production	Consumption	Net Exports & (Imports)
United States	57.8	63.6	(5.8)
Japan	16.5	16.3	0.2
Canada	13.6	4.5	9.1
USSR	9.4	8.9	0.5
China	8.1	8.1	0.0
West Germany	6.8	8.7	(1.9)
Sweden	5.7	1.5	4.2
Finland	5.1	0.9	4.2
France	5.0	5.9	(0.9)
Italy	4.6	4.6	0.0
United Kingdom	4.2	7.3	(3.1)
Brazil	2.5	2.7	(0.2)
Spain	2.2	2.2	0.0
Other Countries	26.0	32.1	(6.1)
TOTAL	167.5	167.3	0.2

SOURCE: *Pulp and Paper International.*

EXHIBIT VIII-4

World Production and Consumption of Pulp in 1978 1/
(Millions of Metric Tons)

Country	Production	Consumption	Net Exports & (Imports)
United States	45.8	47.1	(1.3)
Canada	19.6	13.1	6.5
USSR	9.5	9.1	0.4
Japan	9.4	11.0	(1.6)
Sweden	8.6	4.8	3.8
Finland	6.1	4.6	1.5
China	5.2	5.4	(0.2) 2/
Brazil	2.0	1.8	0.2
France	1.9	3.3	(1.4)
West Germany	1.8	3.9	(2.1)
Other Countries	17.9	23.7	(5.8)
TOTAL	127.8	127.8	0.0

NOTE: 1/ Producing countries only

NOTE: 2/ Estimates

SOURCE: Pulp and Paper International.

EXHIBIT VIII-5

Financial Data for Selected Forest Product and Paper Companies

	Forest Product Companies 1/		Paper Product Companies 2/	
	Net Income Sales	Return on Equity	Net Income Sales	Return on Equity
1970	3.4%	7.7%	5.2%	8.2%
1971	5.5	10.0	4.0	6.0
1972	5.8	12.4	5.2	9.0
1973	8.2	23.1	7.3	14.4
1974	8.0	17.9	8.3	19.1
1975	5.2	9.5	6.7	12.8
1976	5.5	13.0	6.1	12.7
1977	6.8	15.9	6.5	13.0
1978	7.3	18.0	6.8	14.8

NOTE: 1/ Includes Boise Cascade, Champion International, Evans Products, Georgia-Pacific, Louisiana- Pacific, MacMillan Bloedel, Pope & Talbot, Potlatch, and Weyerhauser.

NOTE: 2/ Includes Abitibi-Price, Chesapeake, Consolidated Paper, Crown Zellerbach, Domtar, Fort Howard Paper, Great Northern Nekoosa, Hammermill Paper, International Paper, Kimberly-Clark, Longview Fibre, MacMillan Bloedel, Mead, St. Regis, Scott Paper, Union Camp, Westvaco, and Industry Surveys of Building Material, Williamhouse Regency.

SOURCE: Company data as reported by Standard & Poor's in Industry Surveys of the Building Material and Paper Industries.

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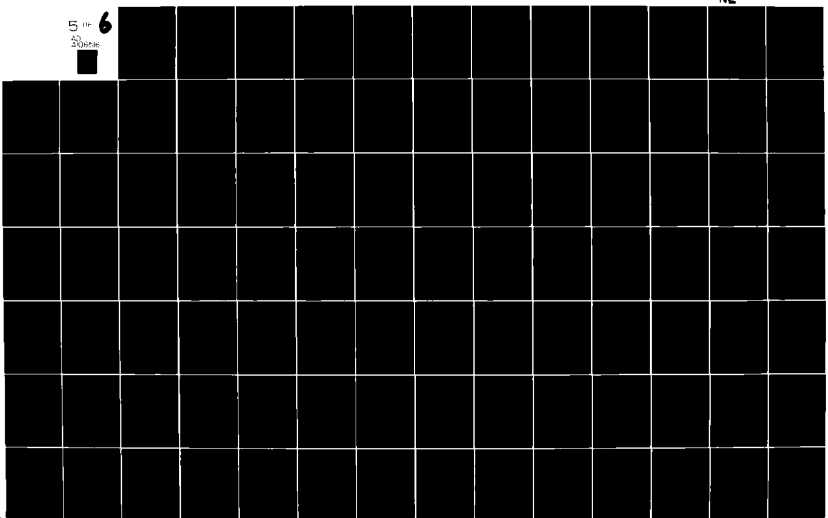


EXHIBIT VIII-6

Lumber Shipments Originating in Western States by Rail and Truck 1/ (Percent of Total Shipped)

	1968		1972		1976	
	Rail	Truck	Rail	Truck	Rail	Truck
Arizona	28.8	71.2	21.5	78.5	20.5	79.5
California	42.7	54.7	46.8	51.4	42.4	56.5
Colorado	44.6	55.4	29.1	70.9	9.6	90.4
Idaho	81.9	18.1	81.8	18.2	67.5	32.5
Montana	69.6	30.4	67.2	32.8	56.4	43.6
New Mexico	15.0	85.0	8.5	91.5	4.1	95.9
Oregon	71.4	14.9	68.5	19.1	59.9	29.2
South Dakota	26.6	73.4	13.2	86.8	0.7	99.3
Utah	--	100.0	13.4	86.8	1.3	98.7
Washington	66.1	23.2	62.4	28.8	52.9	38.3
Wyoming	62.8	37.2	35.9	64.1	7.4	92.6
TOTAL	64.5	35.0	61.0	32.5	53.1	41.1

NOTE: 1/ Percentages do not always add to 100.0 because of the availability of water transportation.

SOURCE: Western Wood Products Association Statistical Yearbook

EXHIBIT VIII-7

Lumber Shipments Originating in Southern States by Rail and Truck

	1970		1974		1976	
	Rail	Truck	Rail	Truck	Rail	Truck
Alabama	26.3	73.7	29.3	70.7	30.0	70.0
Arkansas & Oklahoma	42.8	57.2	38.7	61.3	27.5	72.5
Florida	19.1	80.9	.2	99.8	--	--
Georgia	8.5	91.5	21.2	78.8	37.4	62.6
Louisiana	26.7	73.3	13.8	86.2	12.1	87.9
Mississippi	40.9	57.1	34.5	65.6	37.4	62.6
North Carolina	16.8	83.2	.1	99.9	14.3	85.7
South Carolina	17.3	82.7	21.0	79.0	23.2	76.8
Tennessee	--	100.0	--	100.0	--	100.0
Texas	20.3	79.7	5.8	94.2	3.0	97.0
Virginia	18.0	82.0	6.6	93.4	12.5	87.5
TOTAL	64.5	35.0	61.0	32.5	53.1	41.1

SOURCE: Southern Forest Products Association *Distribution of Southern Pine Shipments*

EXHIBIT VIII-8

U.S. Plywood Shipments by Mode

Region	Year	Percentage		
		Rail	Truck	Other
Pacific Coast	1974	77.0	20.0	3.0
	1975	71.4	25.7	2.9
	1976	73.8	23.3	2.9
Inland	1974	71.0	29.0	--
	1975	60.0	40.0	--
	1976	60.1	39.9	--
Southern	1974	69.0	30.0	1.0
	1975	67.8	32.1	.1
	1976	66.5	33.4	.1
Total U.S.	1974	74.0	25.0	1.0
	1975	68.5	30.1	1.4
	1976	69.1	29.6	1.3

SOURCE: American Plywood Association

EXHIBIT VIII-9

1972 Shipments of Pulp and Paper by Type of Carrier 1/

	Rail	Truck	Water	Total
Pulp and Pulp Mill Products	78%	8%	14%	100%
Paper	59	40	1	100
Paper board	72	26	2	100
Other Converted Products	51	48	1	100
Paperboard Containers	7	93	0	100

NOTE: 1/ Percent of total tons shipped.

SOURCE: United States Bureau of the Census, 1972 Census of Transportation.

EXHIBIT VIII-10

Unexpanded One Percent Waybill
Sample Lumber Shipments for 1977
(Tons)

Origin Territory	Destination Territory					
	Official	Southern	Western Truck Line	Southwest	Transcontinental	Total
Official	1,760	963	97	272	246	3,338
Southern	6,490	8,639	475	1,540	238	17,382
Western Trunk Line	522	120	689	99	182	1,611
Southwest	1,281	560	791	2,532	312	5,476
Transcontinental	17,765	4,418	17,957	11,187	35,303	86,629

SOURCE: One Percent Waybill Sample for 1977.

IX - OTHER WATERBORNE COMMODITIES AND NEW WATERBORNE COMMODITY FLOWS

This section discusses the commodity characteristics and waterborne flows of other waterborne commodities that are not included in the seven NWS primary waterway industries. These commodities are:

- Sand, gravel, and crushed rock.
- Aluminum ores and concentrates.
- Cement.
- Marine shells.
- Salt.

In addition, this section discusses new commodities that might be expected to move on the waterways in the future. Analysis of this kind of subject is necessarily speculative, relying very much on judgment as well as on hard information. Since the time horizon of the overall study extends only to the year 2000, it is necessary to focus upon those commodities that are likely to begin moving in significant quantities in the more immediate future so as to achieve a significant impact by the year 2000. Historically, new commodities have achieved only slow acceptance and wide use.

It is also important to keep in mind the characteristics of waterway transportation that are relevant to the modal selection process. Waterway transportation is most useful for the transportation of bulk commodities in high volumes over relatively long distances. Therefore, new commodities which are shipped in very small volumes during the time frame of the study are less likely to use water transportation. Similarly, the proper focus is not upon manufactured products, of which new ones are introduced everyday, but rather raw materials or semifinished goods. The distances which goods might travel are more difficult to identify. Where general patterns of production and consumption can be predicted that generate long hauls, these goods in turn may be more likely to use water transportation.

During the course of the analysis of new commodities, the focus was also on the major on-going trends in the economy as a whole. In particular, the most significant trend is the increasing cost of energy and the consequent search for substitutes and means of conservation. Another important trend is the increasing pressure on industries to reduce or eliminate pollution problems. This in turn may lead to substitution of processes and products.

The new commodities discussed in this section are:

- Biomass derived liquid fuels.
- Composite materials.
- Ocean bed modules.
- Direct reduced iron.

The section is divided into ten subsections. Nine subsections are devoted to the commodities listed previously. The tenth summarizes the prospects for charges in waterborne flows.

SAND, GRAVEL, AND CRUSHED ROCK

The waterborne shipments of sand, gravel, and crushed rock are classified together by the Corps of Engineers. Table IX-1 presents estimates of 1977 waterborne shipments of sand, gravel and crushed rock.

Table IX-1

Waterborne Shipment of Sand,
Gravel and Crushed Rock for 1977
(Millions of Tons)

Domestic	
Internal	48.8
Local	6.6
Coastwise	3.0
Lakewise	0.6
SUBTOTAL	59.0
Foreign	
Imports	2.8
Exports	1.5
SUBTOTAL	4.3
TOTAL	63.3

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

These shipments are over five percent of all 1977 waterborne traffic. These commodities move on every region of the waterways, but the single largest number of tons moves on the inland wateways. Movements of sand, gravel, and crushed rock within the confines of ports represent the next largest number of tons. It should be emphasized that these movements do not include limestone (39.1 million tons in 1977) or phosphate rock (23.9 million tons in 1977). Limestone is discussed in Section IV and phosphate rock is discussed in Section III.

The term "sand" is used to represent material within a size range of 0.0625 to 2 millimeters and consisting primarily of silica oxide. Gravel consists of naturally occurring rock particles larger than about 4 millimeters but less than 64 millimeters in diameter. Although silica usually predominates in gravel, varying amounts of other rock constituents such as mica, shale, and feldspar are often present. Crushed rock is available in a wide variety of sizes and grades. The principal crushed rocks are limestone, granite, basalt, and quartzite.

Table IX-2 presents estimates of the production of sand, gravel, and crushed rock for 1977-1979.

Table IX-2

United States Production of Sand, Gravel and Crushed Rock
(Millions of tons)

	1977	1978	1979 1/
Sand and Gravel	929	992	1,000
Crushed rock	955	1,057	1,037

NOTE: 1/ Preliminary estimates

SOURCE: Bureau of Mines, Mineral Commodity Summaries, 1980.

Just over one billion tons of sand and gravel were produced in 1979. Of the one billion tons of crushed rock produced in 1979, the Bureau of Mines estimates that 74% was limestone, 12% was granite, and 8% was traprock.

Reserves of sand and gravel are not systematically estimated. Although reserves may seem unlimited, local shortages of sand and gravel are common due to an uneven distribution of deposits, urban encroachment, and increased land prices. The primary sources of sand and gravel are rivers, lakes, coastal areas, and glaciated terrain. Much of the sand and gravel that moves on the waterways is produced from dredging operations. Any curtailment of dredging activity along a given segment of the waterways forces producers to look for other sources. Reserves of rock are also not estimated, but are considered adequate. Most of the largest stone producers have been mining the same quarries for over 25 years and are still expanding their operations on the same sites.

The major uses of sand and gravel are concrete aggregates for all types of construction (buildings, highways, bridges, dams, waterworks, and airports); road bases and coverings; and fill. Industrial sand and gravel should be distinguished from construction sand and gravel. In recent years, no more than three percent of all sand and gravel production was for industrial uses, such as foundries, glass, and ceramics. The major uses of crushed rock are road bases, concrete aggregates roadstone, cement, bitumious aggregate, and agricultural soil.

Table IX-3 lists the modal shares of sand, gravel, and crushed rock shipments for 1976.

Table IX-3

Sand, Gravel, and Crushed Rock Shipments by Mode for 1976

	Truck	Rail	Water	Other 1/
Sand and Gravel	86%	4%	4%	6%
Crushed Rock	80	9	7	4

NOTE: 1/ Includes used at site and unspecified

SOURCE: Bureau of Mines, Minerals Yearbook 1976.

The majority of shipments are by truck. Since the primary users of these commodities are widely scattered throughout any given region, most of them require the versatile delivery system of truck transportation. For larger volumes originating and terminating at fixed points, rail and water transportation can play a major role.

The principal factor that could change the level of waterborne shipments of sand and gravel in the future is a curtailment of dredging activity. Permit restrictions on dredging to protect aquatic life has reduced dredging in many waterway regions.

ALUMINUM ORES AND CONCENTRATE

The waterborne shipments of bauxite and alumina in 1977 were estimated to be 17.4 million tons. Nearly 95% of this traffic represented imports at coastal ports. Less than one million tons of bauxite and alumina moved on the inland waterways and virtually no tonnage moves on the Great Lakes.

Aluminum is a silvery white, ductile, lightweight metal with efficient electrical conductivity and resistance to oxidation. Bauxite is processed electrolytically into alumina, which, in turn, is chemically reduced to calcined aluminum metal. The calcined alumina is reduced to molten aluminum (99.0 to 99.5 pure). The molten aluminum is then cast into ingots and billets, which are fabricated into wrought products (chiefly sheets and extruded shapes) and castings.

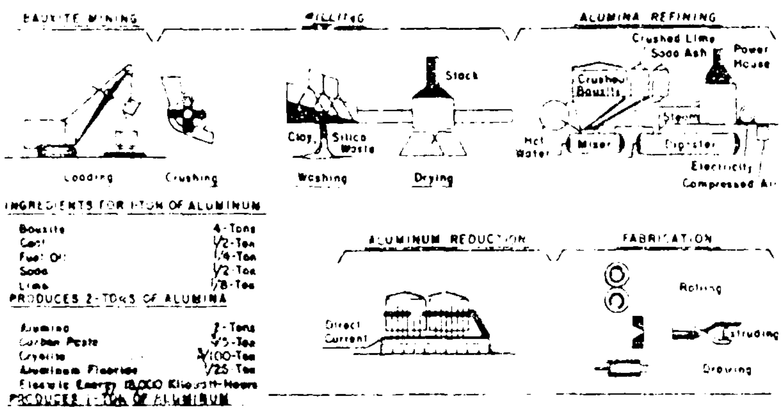
The United States produced two million metric tons of bauxite ore in 1977. Over 80% of this bauxite was mined in Arkansas. In recent years, the United States ha. produced little more than percent of the world's production of bauxite. Domestic reserves are estimated to be 40 million metric tons, which are less than 0.2 of the world's reserve base. The countries with the largest production and reserves are Australia, Guinea, Jamaica, Brazil, and Surinam. And these countries supplied the United States with nearly all of its 13.6 million tons of bauxite and 3.7 million tons of alumina imported in 1977.

Although the United States is not a large producer of bauxite, it is the largest producer of aluminum. In 1977, United States produced an estimated 4.5 million tons of primary aluminum and another 500,000 tons of secondary aluminum from scrap. The United States continues to be a net importer of aluminum and consumption of aluminum was estimated to be 5.5 million tons in 1977.

Figure IX-A illustrates the process of primary aluminum production. This process involves four steps in different locations: 1) bauxite mining and milling, 2) alumina refining (known as the Bayer process), 3) aluminum reduction, and 4) fabrication or converting aluminum shapes into wrought products and castings.

Figure IX-A

Primary aluminum Production Processes



SOURCE: Federal Reserve Bank of San Francisco, Alumin[illegible].

Whereas most of the bauxite mines and alumina plants are located outside the United States, the reduction and fabricating plants for United States aluminum production are all located in the United States. The reduction plants are located near sources of low-cost electical power, because of the large amount of power required (7-1/2 to 10 kilowatt hours per pound of metal). These plants are located in the Arkansas River Valley, Pacific Northest, Ohio River Valley, Tennessee River Valley, and the Gulf Coast. The fabricating plants, on the other hand, are located near major end markets.

Aluminum consumption is concentrated in the East Central region. The principal markets for aluminum are building, packaging, transportation, electrical, and consumer durables.

Raw bauxite is primarily shipped to Gulf ports from the Caribbean area. At these ports, the bauxite is refined to alumina in plants along the coast. The alumina is shipped primarily by rail to reduction centers in the Pacific Northwest, Ohio River Valley, and the Gulf Coast. Reduction plants in Arkansas rely on domestic bauxite. Rail transportation is also the principal mode for shipments of aluminum to fabricating plants.

The principal factor that could change the number of tons of bauxite and alumina moving on the waterways in the future is an increase in alumina imports at the expense of bauxite ore. It requires approximately two tons of bauxite ore to produce one ton of alumina. Major bauxite exporting countries may build additional bauxite-processing plants in order to capture a large margin for processing the ore in addition to mining it.

CEMENT

Approximately 12.6 million tons of cement moved on the water-ways in 1977. Table IX-4 presents 1977 waterborne traffic. Waterborne shipments of cement take place on the inland waterways, Great Lakes, and coastal waters in relatively small volumes.

Table IX-4

Waterborne Shipments of Cement
(Millions of Tons)

Domestic	
Internal	4.4
Lakewise	3.6
Coastwise	1.6
Other	0.1
SUBTOTAL	9.7
Foreign	
Imports	2.8
Exports	0.1
SUBTOTAL	2.9
TOTAL	12.6

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977

Approximately 95 of the hydraulic (water activated) cement produced in the United States is portland cement. Portland cement is made from the following raw materials (in order of use), limestone, cement rock, clay, gypsum and anhydrate, shale, oystershell, and sand.

The cement industry in recent years has been the sixth largest consumer of energy. Estimated energy requirements per ton of portland cement are 7.6 million Btu. Thus, energy conservation has been a major focus for cement producers. The dominant recourse for cement producers to reduce energy costs has been to covert from natural gas to coal and coke. Coal-burning facilities of cement plants increased from 41 of industry capacity in 1972 to about 75 in 1979.

In 1977, the United States produced approximately 75 million tons of portland cement. Six states, namely California in the West, Texas in the Southwest, Pennsylvania and New York in the East, and Missouri and Michigan in the Midwest, have accounted for just over 40% of United States cement production in recent years. The cement industry is reasonably concentrated with the 10 largest companies accounting for just under half of active production capacity.

Construction uses account for virtually all of cement consumption. These uses are ready-mixed concrete (distributed by mixer trucks directly to job sites); concrete products, such as block, pipe, and prestressed precast concrete; building material; highways; and other contracting uses. The principal use is ready mix concrete, and in recent years, this has accounted for two-thirds of United States consumption.

Cement is shipped either directly to customers or to distribution terminals. Table IX-5 presents the distribution pattern of portland cement shipments in 1976. Large-volume, plant-to-terminal shipments move principally by water and rail. Facilities are often located along a waterway and efficient pneumatic cargo handling and storage equipment are available. Final distribution of cement is almost exclusively accomplished by truck. Over 87% of customer shipments were made by truck in 1976. Since cement production is spread throughout the United States, plants typically serve a local area by truck. This marketing area can be extended by using distribution terminals, which are fed by the relatively low-cost means of water or rail transportation.

Table IX-5

U.S. Shipments of Portland Cement for 1976 1/
(Thousands of Tons)

Mode	Plant to Terminal	Plant and Terminal To Customer
Truck	1,433	62,251
Rail	8,258	8,281
Water	7,348	1,073
TOTAL	17,039	71,605

NOTE: 1/ Excludes unspecified shipments accounting for less than two percent of total.

SOURCE: Bureau of Mines, Minerals Yearbook, 1975.

Little change in the nature of waterborne cement flows is expected in the future.

MARINE SHELLS

An estimated 12 millions tons of marine shells moved on the inland waterways in 1977. Most of these shipments take place on the Gulf Coast West, Gulf Coast East, the Lower Mississippi River, and the Baton Rouge to Gulf regions (for a description of these regions, see Appendix B).

Marine shells are used as aggregates foi paving, fiber for concrete and cement, and as a substitute for other construction materials, and additives in poultry feed.

SALT

The waterborne shipments of salt are classified under salt and non-metallic minerals, not elsewhere classified. This classification into two categories is necessary to avoid disclosure of individual company operations. Table IX-6 presents the waterborne shipments of salt and non-metallic minerals.

Table IX-6

Waterborne Shipments of Salt and Non-Metallic Minerals for 1977
(Millions of Tons)

		Domestic		
	Foreign	Internal	Lakewise	Coastwise
Salt 1/	4.7	-	-	-
Non-metallic Minerals NEC	-	5.1	1.0	0.2
TOTAL	4.7	5.1	1.0	0.2

NOTE: 1/ Includes foreign traffic only.

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, 1977.

In 1977, just over four million tons of salt were imported, primarily from Canada, Mexico, and the Bahamas. Although the domestic shipments of salt are grouped together with other non-metallic minerals, the general pattern is consistent with the numbers shown in Table IX-6. The dominant movement of salt is on the inland waterways. Salt moves from the rock mines in Louisiana and Texas along the Gulf Intracoastal Waterway and up the Mississippi River to destinations on the Upper Mississippi, Illinois, and Ohio Rivers. Salt is also produced along the Great Lakes and moves from mines or evaporating plants in Michigan and Ohio to a variety of destinations including Chicago, Milwaukee, and Duluth-Superior.

Salt or sodium chloride is recoverd from bedded and dome-type underground deposits and by evaporating lake and sea brine. The primary types of salt are: a) salt in brine (brine is a solution of salt in water); b) rock salt (rock salt is produced by drilling and blasting natural salt deposits and then cleaning and sorting the salt for different commercial uses); c) vacuum-pan and open-pan evaporate salt (fine crystals of salt are produced by evaporating brines in covered, steam-heated kettles or pans under vacuum); and d) solar evaporated salt. In recent years, salt in brine has accounted for over half of all salt sold or used. Rock salt has accounted for one-third of all salt use.

United States production of salt in 1977 was just over 43 million tons, making the United States far and away the largest producer of salt in the world. However, as noted earlier, the United States did import another million tons of salt in 1977.

The United States has vast reserves of commercially recoverable salt. The reserves of rock salt alone have been estimated at 24 trillion tons. The reserves of rock salt occur in the following areas:

1. The Permian Basin deposit lies underneath parts of Kansas, Colorado, Oklahoma, Texas, and New Mexico.

2. The Salina reserve stretches for more than 100,000 square miles under New York, Pennsylvania, West Virginia, Ohio, and Michigan.

3. The Gulf Coast embayment lies below Texas, Louisiana, and the Gulf of Mexico.

4. The Williston Basin lies under North Dakota, South Dakota, and Montana.

The largest consumer of salt is the chemical industry, which utilizes well over half of the salt sold or used by producers. Most of the salt consumption in the chemical industry is used in the manufacture of chlorine and caustic soda. Some chemical plants are located directly over major salt deposits, thus, no transportation of salt is required. The next major use of salt is for highway ice control and, in recent years, about one-fifth of all salt used was for this purpose. Salt is also used in soda ash production.

Salt produced in Louisiana and Texas is shipped by barge, rail, and truck. Highway ice-control salt is often shipped by barge to terminals on the Upper Mississippi, Illinois, and Ohio Rivers for distribution by truck during the winter months. This salt is usually stockpiled on the ground and covered with Tarps. Since this salt is moving in the opposite direction of the waterborne grain flows, shippers are often able to move salt in covered hopper barges at lower, backhaul rates. Salt from Louisiana and Texas is also shipped directly to customers, such as chemical companies, by rail and truck.

Salt produced in Ohio and Michigan is shipped by lake vessel, rail, and truck. Kansas and New York salt is shipped by rail and truck.

Two factors are expected to limit the growth of shipments of salt in the future. These are the completion of the interstate highway system and the possible negative effects of excessive highway salt applications on ground water quality. While these factors may be expected to reduce overall shipments, there is at least one factor that might increase water shipments of salt. This trend is the construction of new mining capacity in the Gulf states. These mines rely on barge shipments for a greater portion of their highway ice-control shipments.

BIOMASS DERIVED LIQUID FUELS

The economy of the United States is likely to rely upon liquid fuels into the far distant future. This is true if only because so much of the existing stock or capital is based upon liquid petroleum fuel technology. The existing capital stock may be adapted to other liquid fuels. This will facilitate the introduction of such new fuels. Also, liquid fuels have many advantages over other sources of energy for many applications. For example, liquid fuels used in transportation are easier to store than electricity and provide more rapid acceleration.

A significant new source of liquid fuels which is likely to be developed before the year 2000 is biomass derived fuels. Biomass derived fuels are used generically in this context to designate any energy source that is derived from a living organism. For example, ordinary firewood is a biomass fuel. Methane gas produced from animal wastes is another example. However, useful energy products are seldom produced by biomass in a liquid form. Some processing is almost always required.

The "energy balance" of such processses is at the present time a major constraint to large scale production. The energy balance is the difference between energy produced and energy consumed in feedstock production and gathering, and processing and distributing energy products.

The problem for biomass is the relative inefficiency of production and processing. For example, ethanol produced from corn provides a gain of only percent more energy (a form of alcohol) produced over what is consumed in corn production and processing.

Despite this relatively unfavorable energy balance, ethanol has been produced on a large scale in the past. Germany used ethanol produced from potatoes as a fuel in World War II. It was also produced in Brazil from sugar cane before World War II. In both instances, however, production was undertaken for reasons other than economic profitability. Germany had to develop alternative fuels to support its war effort and Brazil wanted to provide a market for surplus sugar cane production. Brazil today is undertaking a crash program to utilize domestically produced alcohol as a fuel to replace imported petroleum fuels. This can be done more economically today since the world price of petroleum is so high.

Ethanol can be derived from a variety of biomass sources. These include corn, sugar cane, and trees. Recent studies indicate that tree crops would be less costly to produce and process, but lead times for large scale production are longer.

In all cases feedstock costs and processing costs are high. For example, a bushel of corn selling for $2.50 yields 2-1/2 gallons of ethanol with feedstock cost of $1.00 per gallon not considering gathering, processing, and delivery costs. Nevertheless, assuming that the relative price of petroleum derived fuels continues to escalate, biomass fuels will become more attractive. If incentives and subsidies (such as the state of Iowa foregoing the retail fuel tax of 6-1/2 cent/gallon for gasohol purchases) are introduced, then biomass fuels will become even more attractive.

A grain based ethanol industry in the United States is most likely to develop in the Midwestern grain surplus producing states. Biomass liquid fuels are also likely to be produced in the southeastern part of the United States which has a good growing climate and a long growing season. These climatic conditions favor the production of biomass fuels in that part of the country over other parts of the country.

It is likely that such fuels will have an impact on waterborne commerce. Ethanol produced from petroleum is shipped even now by barge, but this ethanol is used entirely as a chemical feedstock (see Section VII for a discussion of ethanol). This ethanol generally originates along the Gulf Coast and is distributed inland. One possible outcome is that ethanol produced from grain in the Midwest may be used as a substitute chemical feedstock, thus reducing total water shipments or changing the movement patterns. If production of biomass fuels takes place in the Southeast, some large shipments are likely to originate in this area as well. Such movements can use existing water transportation technology and facilities, and the movement pattern is likely to duplicate that of existing petroleum products movements (see Section V for a discussion of petroleum product movements).

Barring a crash program similar to Brazil's in both scope and objectives, total annual production of biomass liquid fuels will range from one to ten million tons by the year 2000. Of this only a small fraction is likely to move by barge. The areas most affected will be the grain surplus states of the Midwest and those areas of the Southeast with access to the Mississippi River, the Tennessee River, and the Tennessee-Tombigbee Waterway.

COMPOSITE MATERIALS

Composite materials are materials which are manufactured by layering or combining different materials in order to combine multiple characteristics. Such materials have high strength in relation to their weight. Recent examples of products include body panels made of acrylic, fiber glass, and polyester used on GMC buses and well casings made of polyester, fiber glass, and sand filler. The ability of these materials to resist corrosion is another factor in their favor.

Historically, manufacturing costs have been high relative to metals. Thus, the most common applications have been in the aerospace industries where weight is a paramount consideration. Automotive manufacturers are also increasingly concerned about weight. Reducing the weight of automobiles is a major means of increasing fuel efficiency. Therefore the demand by this manufacturing sector for light weight materials of all kinds is likely to increase.

Major barriers to increased utilization of composites have been consumer acceptance and manufacturing costs. As the technology has evolved acceptance has increased. Greater volumes of production have lowered manufacturing costs in turn. In some applications manufacturing costs are lower than comparable metal products. This is due to several factors. Since many composite products are built up by layering and wrapping of fibers, little or no waste of material occurs. When dies are used to form sheets into a product, fewer stampings are typically required for composites than for metal. The lives of dies used for forming composite products are also longer. Thus composite products are expected to continue to be become more cost competitive.

The key to volume production is wider use in the automotive industry. A decision by a major automotive company to start using composite materials for a high percentage of its inputs, could result in several million tons of additional feedstock shipments. Shipments are likely to originate from chemical producing areas along the Gulf coast. Truck, rail, and barge transportation are all likely to be used for some movements, depending on volume, distance and access to waterways. Such movements can use existing waterway transportation equipment. Waterborne shipments of finished products are likely to be minor since most potential users of composites rely heavily on other modes (see Section IV for a discussion of the modal share of finished steel products).

OCEAN BED NODULES

For several years speculation about the availability of mineral deposits on the ocean floor has wavered from optimism to pessimism. Several obstacles, both institutional and economic, have prevented large scale exploitation of these sources.

Since the nodules are located on the deep ocean floor beyond the effective control of a single nation, the question of property rights and legal jurisdiction arises. Although Congress could authorize American firms to mine this resource, the government as a whole has been reluctant to offend world opinion by taking this step. The issue has been before the ongoing International Law of the Sea Conference for several years. While this negotiating process has resolved some issues, the deep undersea mining issue remains unsettled and is likely to remain so for the forseeable future.

The basic conflict is between the industrialized nations, which want the resource now, and the less developed nations (LDCs), which see the resource as a common property of all to be conserved. The LDCs see little benefit for themselves in immediate exploitation. Some LDCs also see the resource as a competitor for their own dry land minerals industries. These countries have promoted the idea of a mining authority under the control of the United Nations. This idea has been resisted by the industrialized nations and the issue remains deadlocked.

While the technology of retrieving the nodules is well developed and cost competitive, processing costs are high compared to conventional sources. Furthermore the composition of the nodules themselves is primarily of metals with limited uses.

The chemical analysis of typical nodules is shown in Table IX-7.

Table IX-7

Illustrative Chemical Composition of Nodules

Element	Maximum	Minimum	Average
		Percent Composition	
		Pacific Ocean	
Manganese	41.1	8.2	24.2
Iron	26.6	2.4	14.0
Cobalt	2.3	0.0	0.4
Nickel	2.0	0.2	1.0
Copper	1.6	0.3	0.5
		Atlantic Ocean	
Manganese	21.5	12.0	16.3
Iron	25.9	9.1	17.5
Cobalt	0.7	0.1	0.3
Nickel	0.5	0.3	0.4
Copper	0.4	0.1	0.2

SOURCE: Nyhart, et al, A Cost Model of Deep Ocean Mining and Associated Regulatory Issues

As can be seen in this table the two predominant metals are manganese and iron. Manganese is a brittle metal with limited uses. Iron is a relatively abundant metal available from many sources (see Section IV for a discussion of these metals).

Nodules from the ocean do represent an alternative source of manganese, but the market for manganese is not large enough to sustain truly large scale recovery and processing. Lacking a large market for the manganese, it is unlikely that ocean mining for the other metals in the nodules would be profitable enough to sustain large operations by themselves. For example, United States consumption of nickel has ranged from 100,000 to 200,000 tons annually. Assuming a nickel content of one percent, the corresponding tonnages of nodules would range from 1,000,000 to 2,000,000 tons. This would produce 200,000 to 400,000 tons of manganese assuming an average analysis of 20%. This would be enough to seriously impact the manganese market, probably resulting in a glut and reduced profitability.

Should the deep ocean nodules become a commercially mined source it is likely that some of the processed concentrates would be shipped inland by water. This would not require any new barge technology. However, nodule landings in the United States are not likely to exceed a few million tons annually by the year 2000, generating relatively small increments in waterborne tonnage.

The key factor influencing waterborne commerce of nodule derived products will be the location of processing plants for the nodules. Plants on the Pacific Coast and Atlantic Coast can be expected to ship the bulk of their products to inland users by truck and rail. Processing plants located on the Gulf Coast would probably use barges for a high percentage of inland shipments similar to existing tonnages and movement patterns.

DIRECT REDUCED IRON

The iron and steel industry of the United States is expected to undergo a great deal of change by the year 2000. Pressures to reduce pollution, foreign competition, declining markets, increasing energy costs, escalating capital costs, and increased competition from substitute materials have all combined to create a very difficult economic environment for this industry. (See Section IV for a discussion of the steel industry.) This in turn will influence the selection of processes, energy sources, raw materials, and plant sites by firms in the industry. It is expected that trends in the industry will result in greater use of a particular intermediate product known as direct reduced iron or "sponge iron".

Iron and steel products are the results of many production steps. Many individual technologies are available and these may be combined in different ways to respond to changing circumstances. The basic sequence of production includes: 1) reduction of iron ore to remove impurities and 2) processing the reduced ore into iron or steel products. Reduction can include mechanical, chemical, and thermal processes. The result of reduction of virgin ore is hot metal, pig iron, or sponge iron. Hot metal may be transferred directly to further processes with considerable savings in energy. Pig iron and sponge iron are intermediate products which require re-melting for further processing.

Pig iron is produced in a blast furnice. The iron "pigs" are ingots of iron. About 95% of blast furnace production goes directly in to steel production as hot metal. Sponge iron is the result of "direct reduction". In this type of process the ore is heated to a temperature below the melting point and a reductant is used. Sponge iron technology is quite old and was quite important before the invention of the blast furnace. Several processes are in use today throughout the world using various reductants including natural gas and coal. The most successful processes rely on gas and require an abundant supply of gas at favorable prices to be competitive in the United States sponge iron processes have been most successful in countries lacking a good resource base of coal. Direct reduction processes using coal have been developed but have not been fully proven in commercial operations.

Nevertheless, two trends in the iron and steel industry in the United States favor increased production and use of sponge iron. The first of these is the future availability and cost of coke for pig iron production. The production of coke with conventional ovens creates serious air pollution problems. Even if the technology is improved, production costs will increase, making direct reduction more attractive.

A second major trend in the industry is the ongoing switch to electric furnaces for steel production. Most new steel capacity is expected to use this technology. Electric furnaces rely on scrap for a high percentage of their charges. This in turn will put upward pressure on scrap prices. Since sponge iron is a substitute for scrap in electric furnace steel making, increased demand for sponge is likely to occur. Production costs for sponge iron in the United States are currently estimated to be about $110 per ton. Scrap prices are volatile but have occasionally reached this level.

The anticipated increased use of sponge iron in the United States may not result in a corresponding increase in domestic production. It is possible that some sponge iron may be imported from countries where the technology is well established.

United States consumption of direct reduced iron is difficult to project. Whereas aggregate steel and iron production can be reasonably projected a number of factors can influence the use of direct reduced iron. These are:

1. Improvements in coke technology.

2. Energy costs from different sources, particularly direct use of coal versus electricity.

3. Environmental constraints.

4. The availability and cost of scrap.

Projected consumption of sponge iron by regions will be correlated with the regional increases in electric furnace capacity. Since some of the expected increase in electric furnace capacity may be built in net deficit areas like Texas (see Section IV) shipments of sponge iron may be concentrated there. Shipments of sponge iron are expected to be similar to existing commodity flow patterns for iron ore and scrap. As discussed in Section IV, little quantities of scrap are moved on the waterways relative to rail and truck. However, large shipments of iron ore take place on the Great Lakes. Limited movements of domestic sponge iron may take place and some additional barge movements of imported sponge iron up the Mississippi to steel districts may also occur.

SUMMARY

One of the principal factors that could change waterborne flows of sand and gravel (both products move on the waterways in large volumes) is increased restrictions on dredging activity. Lower levels of dredging will force sand and gravel producers to look for other sources of these commodities.

Few factors are expected to change the nature of waterborne flows for bauxite, alumina, cement, and marine shells.

The increase in salt production capacity along the Gulf Coast may be expected to increase the waterborne share of total shipments, although location of chemical plants near mines, the completion of the interstate highway system, and environment problems with salt and highway ice control may be expected to limit the growth of total salt shipments in the future.

New commodities are not likely to result in major waterborne flows by the year 2,000. Limited shipments of biomass derived fuel from the Southeast is a possibility. The product characteristics of composite materials are expected to limit the use of water transportation. The recovery of minerals from ocean bed nodules face a number of institutional, technical, and economic problems. Finally, producers of direct reduced iron can be expected to use water transportaton in ways that iron ore and scrap ore presently transported.

X - SHIPPER CONSTRAINTS TO WATERWAY USE

INTRODUCTION

This section examines potential constraints and concerns, as perceived by waterway users, to the present or future use of the national waterways system for transportation.

Constraints are defined as shortfalls in the physical capacity of a channel lock, or port in the present waterway system to meet present or projected waterway transportation use. Potential constraints include any number of factors that determine waterway capability. Some of these factors include:

1. Channel depth and width.
2. Lock chamber size and processing time.
3. Navigation conditions such as bends, bridges, and navigation aids.
4. Port depth.
5. Conflicts with other uses of the waterways.
6. Length of navigation season.

Concerns are defined as problems or issues that have increased or can be expected to increase the real costs of water transportation.

The basis for this examination is field interviews conducted with the shippers, carriers, port authorities, and trade associations listed in Appendix A.

Shippers were selected after contacting appropriate trade associations. Generally, three or more interviews were conducted with major companies of each of the seven primary waterway industries. Carriers were selected such that inland, Great Lakes, and coastal views would be represented. Since the comments in this section include the judgments of individuals revealed in confidential interviews, no direct attribution to source is made.

The principal categories of potential constraints identified in these interviews provide the basic organization for this section and are as follows:

- Locks.
- Seacoast and Great Lakes port constraints.
- Channel maintenance on inland waterways.
- Terminals and fleeting.

Lock capacity was the single most important concern of inland waterway users. Channel maintenance and regulations restricting the development of waterfront property for terminals and fleeting areas were also important concerns. Coastal shippers and carriers were primarily concerned with channel maintenance and depth at harbors. Waterway users of the Great Lakes were concerned about channel maintenance and project depth as well as the length of the navigation season.

Although carriers and shippers were explictly asked about conflicts with other waterway uses, such as recreation, irrigation, and power plant cooling, only recreational activity was mentioned as a problem around selected metropolitan areas. This conflict is discussed briefly as well.

Aside from concerns of safety, carriers, shippers, and port authorities did not consider bends or bridges to be potentially significant constraints to waterway use.

Before preceding, it should be noted that the purpose of this section is not to fully catalogue, by location or severity, constraints to waterway use. Other NWS reports present findings and conclusions from rigorous, analytic assessments of the capability of the present waterway system to meet present and future water transportation needs. The purpose of this section is to present the perspective of water transportation users on the relative importance of addressing different categories of potential constraints.

LOCKS

Inadequate lock capacity was the single most important concern of inland waterway users.

Lock chambers are located at dams to permit vessels and/or tows to pass from one pool to another. The size of the lock chamber determines the vessel and/or tow size that can be accommodated during each locking event. If the lock chamber can handle only nine barges at a time, as in the case of many locks on the Upper Mississippi and Illinois Rivers, then two lockages are required to process a 15 barge tow. Thus, the size of the lock chamber is one component of lock capacity.

Another component of lock capacity is service or processing time. Once a lock chamber has been made ready to receive a tow or vessel, the tow or vessel must approach the chamber, enter the chamber, wait until the chamber is "filled" or "spilled," and then leave the chamber. When a tow must be broken up in order to fit within the chamber, additional time is required for the breaking-up and making-up of the tow. The time required for chamber approach, entry, fill or spill, and exit is also a key determinant of lock capacity.

Table X-1 presents estimates of the time required to process different types of lockages at Lock and Dam 22 on the Upper Mississippi. These estimates are average times for 1977.

As can be seen, the type of lockage corresponds to a certain range of tow size. The definitions of these lockage types are provided in Exhibit X-1. It can also be seen that different lockage types have markedly different processing times. The longer time required to process a double lockage is due to the break-up and make-up of the tow as well as the additional time required for the processing of the second cut.

Additional components of lock capacity are length of season and use by recreational vessels. Length of season is limited on the Upper Mississippi, Great Lakes, and, on occasion, the Illinois and Ohio Rivers. This, of course, reduces lock capacity. Recreational vessels seeking lockages also reduce lock capacity. This can be a problem on the Upper Mississippi, Ohio, and Illinois Rivers.

Table X-1

Comparison of Average Tow Size and Processing Time 1/ by Type of Lockage (1977 Data for Lock 22)

Type of Lockage2/	Average Tow Size (Barges)	Average Processing Time (Minutes)
Straight	2.9	42
Double	13.0	124
Setover	3.8	73
Knockout	4.3	60
Other Commercial	0.3	33
Recreational	-	17

NOTE: 1/ Processing time includes time for approach, entry, chambering, and exit.

NOTE: 2/ For a definition of lockage type, see Exhibit X-1.

SOURCE: United States Corps of Engineers, 1977 Performance Monitoring System Data.

As the traffic levels at locks increase, delays at locks begin to increase as well and, as the practical capacity of the locks is reached, delays can become very long. At some point, there simply may not be enough time during the navigation season to service all the traffic seeking to pass these locks. When these traffic levels are reached, shippers incur higher costs due to the lengthy delays and may be unable to ship additional traffic by water. Congestion in the vicinity of the constraining locks poses safety problems as tows and/or vessels must wait in line on both sides of the locks.

Locks mentioned as actual or potential constraints to waterway use are listed in Table X-2.

As can be seen, the single largest number of actual or potential constraining locks are on the Illinois and Ohio Rivers. However, another seven waterway regions had at least one actual or potential lock constraint.

Table X-2

Lock Constraints

Waterway Region [1/]	Lock
Upper Mississippi	22
Lower Upper Mississippi	26, 27
Lower Mississippi	Old River
Gulf Coast West	Algiers, Vermillion
Gulf Coast East	Industrial Canal
Illinois River	Chicago Harbor
	Lockport
	Brandon Road
	Marseilles
	Starved Rock
Columbia-Snake Waterway	Bonneville
Ohio River	Emsworth
	Dashields
	Montgomery
	Gallipolis
	#50, 51, 52, 53
	Winfield (Kanawha)
	#7, 8 (Monongahela)
Tennessee River	Kentucky

NOTE: 1/ For a definition of the waterway regions used in the NWS, see Appendix B.

SOURCE: Interviews.

While other locks may at times have lengthy delays, the locks listed in Table X-2 were the ones of greatest concern to shippers and carriers. And three of these locks were recognized as special problems. These locks include locks and Dam 26 on the Upper Mississippi, Gallipolis Lock on the Ohio River, and the Inner Harbor Navigation Canal Lock in the Port of New Orleans. Each of these locks is discussed under separate headings.

(a) Lock and Dam 26

Locks and Dam 26 consisting of a main lock (600' by 110') and an auxilliary lock (360' by 110') are located at Alton, Illinois, 203 river miles above Cario on the Mississippi River.

Locks and Dam 26 are very important to waterway transportation, because traffic moving to or from both the Upper Mississippi and Illinois Rivers must pass through either lock.

Shippers report that in 1979 southbound delays have reached as much as two and a half days. The data collected by the Corps of Engineers at the locks indicate that the average delay in 1977 was approximately 10 hours per tow.

All the primary waterway industries are affected by long delays at Locks and Dam 26, but the lack of lock capacity is a special problem for the agriculture and coal industries. The predominant south bound tonnage at Lock and Dam 26 is grain, oilseeds, and grain products. The predominant northbound tonnage at Lock and Dam 26 is coal.

As discussed in Section II, the Illinois and Upper Mississippi Rivers are far and away the dominant inland waterway regions for the origination of agricultural exports. In the past, these waterways have supplied much of the tonnage for export elevators located in the Baton Rouge to Gulf region.

As was also discussed in Section II, the states of Illinois, Iowa, Minnesota, and Wisconsin will continue to grow large amounts of corn, wheat, and soybeans throughout the NWS time period.

If lock capacity is not increased at Locks and Dam 26, farmers, country elevators, operators of barge-loading stations, and grain exporters will have to rely on other means of shipment for additional traffic. These other means might include shipment by rail and truck to Great Lakes ports and shipment by train to Gulf, West, and East Coast ports. Other means also include truck or rail shipments to barge-loading stations on lock-free water south of St. Louis.

If such a change in the logistics system is required, grain exporters will need to make additional investments in interior and export facilities to handle the traffic that would have moved on the Illinois and Upper Mississippi Rivers.

Coal shippers are also affected by the lack of capacity at Locks and Dam 26 as large amounts of eastern coal are shipped to destinations on the Illinois and Upper Mississippi Rivers from origins on the Ohio and Lower Upper Mississippi Rivers (see Section VI for a discussion of these flows).

Since utilities often make their coal purchases for long periods of time and seek to match their transportation arrangements with their purchase agreements, a key factor in the choice of coal source and transportation mode is the availability and cost of water transportation. Utilities on the Illinois and Upper Mississippi Rivers are naturally reluctant to commit to barge delivery of eastern coal if they do not expect to see additional capacity at Locks and Dam 26 in the future.

(b) Gallipolis Lock

Gallipolis Lock, consisting of a 600' by 110' lock chamber, is located at Gallipolis Ferry, West Virginia, about 279 river miles below Pittsburgh on the Ohio River.

The data collected by the Corps of Engineers at the lock indicates that average delays of three hours per tow were experienced in 1976.

As discussed in Section VI, this is a major coal-producing area for electric utilities, industrial power plants, and coke ovens. Thus, the lock is considered a key constraint for the coal, electric utility, and steel industries.

Without capacity increases, shippers will be forced to move additional traffic by other, more costly means.

(c) Inner Harbor Navigation Canal Lock

This lock, commonly called the Industrial Lock, consists of a 640' by 75' lock chamber. It is located at the entrance to the Inner Harbor Navigation Canal East in the Port of New Orleans and connects the Mississippi River with the canal and the Mississippi River Gulf Outlet.

This lock is a special problem for two separate reasons. First, it restricts the movement of through traffic to or from the Mississippi River Gulf Outlet and the Inner Harbor Navigation Canal. It also restricts local New Orleans and Baton Rouge traffic moving to and from these waterways. For example, terminals located on these waterways receive or ship barges to points on the Mississippi River only by passing through this lock. Since the lock has a depth over sill of only 31.5 feet, deeper-draft vessels cannot pass from these waterways to the Mississippi River in any event.

Second, the lock makes land that would be available for terminal development in the New Orleans area (provided certain environmental regulations are met) less attractive. With respect to land availability, New Orleans may be viewed as consisting of two major zones, joined by the Inner Harbor Industrial Lock and Canal. These zones are:

1. The Mississippi River, which, in turn, includes both the east and west banks.

2. The tidewater area which includes the Industrial Canal, the Mississippi River Gulf Outlet, and Lake Ponachartrain.

Historically, the port developed primarily along the Mississippi River in order to take advantage of the existing highway and rail network. However, as New Orleans grew, less land was available for new development in this traditional port area and interest grew in the tidewater area.

The traffic congestion and lack of additional land for development at the Port of New Orleans are major problems and the congestion at the Industrial Lock only makes matters worse.

The Baton Rouge to Gulf region is a major port area for many bulk commodities, including grain, oilseeds, and grain products; fertilizer; iron and non-metallic ores; petroleum and petroleum products; and chemicals. In addition, as discussed in Section VI, the possible conversion of many electric utility and industrial power plants to coal may greatly increase coal shipments through this area. As a result, the Industrial Lock is a serious constraint to many waterway users.

SEACOAST AND GREAT LAKES PORT CONSTRAINTS

Authorities were contacted at twelve different seacoast and Great Lakes ports to identify any actual or potential constraints to the growth of bulk traffic. Once again, it must be emphasized that this section does not attempt to catalogue the concerns and potential constraints of all major United States ports. On the contrary, the purpose of this section is to present the views of port officials and waterway users regarding the type of constraints that might be expected to limit port growth.

The principal potential constraints to the port growth are:

- Land availability for terminal development.

- Dredge disposal site availability.

The lack of land for terminal development was considered to be a potential constraint among most East, West, and Gulf Coast ports. The lack of disposal sites for the placement of dredge materials was a potential constraint for most Gulf Coast and East Coast ports. Both of these potential constraints are due in part to increased environmental concerns and regulations.

A major concern of each and every port authority contacted for the NWS is port depth. Except for Puget Sound, all seacoast ports had either recommendations, proposals, or active projects that involved substantial channel deepening efforts.

Increasing port depth is a key action for improving the competitiveness of a port vis a vis other United States ports. Such actions permit a port to handle larger vessels, which, in turn, offer cost savings to importers and exporters. Increasing port depth is also a key action toward reducing port congestion, since a smaller number of deeper-draft vessels would be required to ship or receive the same amount of tonnage. Thus, in major ports with substantial traffic congestion and serious safety problems, channel depth may become a constraint to future waterway use.

Another concern of some port authorities was the lack of rail capacity to meet the needs of exporting facilities (primarily grain facilities). This concern once again affects the competitiveness of one port vis a vis other ports, but it is not a factor that directly affects the capability of the waterway system.

Decisions to reduce the impact of port constraints involve complex issues of public policy. For example, federal legislation designed to minimize port impact on ocean and coastal environments include:

1. The Clean Air Act with amendments of 1977.

2. Resource Conservation and Recovery Act of 1976.

3. Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977.

4. The Rivers and Harbors Act of 1899.

5. Water Research and Development Act of 1978.

6. Water Resources Planning Act of 1965.

7. Fish and Wildlife Coordination Act with amendments of 1965.

9. Ports and Waterways Safety Act of 1972.

10. Noise Control Act of 1972.

11 .Coastal Zone Management Act of 1972.

12. Endangered Species Act of 1973.

13. Soil and Water Resources Conservation Act of 1977.

14. Deepwater Port Act of 1974.

15. National Ocean Pollution Research and Development Monitoring and Planning Act of 1978.

16. Marine Protection, Research and Sanctuaries Act of 1972.

17. Outer Continental Shelf Lands Act of 1978.

18. Executive Order 11990

Ports must comply with applicable provisions of federal, state, and local government regulations regarding:

1. Dredging effects on marine habitats.

2. Dredged material disposal in off-channel, ocean or land areas.

3. Port facility land use impact on the social and natural environment, including competing water uses.

Table X-3 presents the potential constraints to port growth over the next 20 years as perceived by port authorities.

A short discussion of each of the ports is presented below.

(a) <u>Port of Baltimore</u>

Port officials believe the most significant concern to future bulk traffic growth is the lack of sufficient main channel depth. Although authorization has been received to lower the existing main channel from 42 to 50 feet, major problems relating to the disposal of dredged material may prevent this project from being completed.

The port estimates that the probable quantity of dredged material resulting from annual maintenance requirements and new projects through the year 2000 will amount to 136 million cubic yards. However, port officials maintain that there is only enough disposal site capacity to satisfy several years' worth of dredged material placement. This situation is further aggravated by recent environmental restrictions that ban open water disposal of dredged material in the Chesapeake Bay.

Opposition to the placement of dredged material has come from environmental agencies that advocate preservation of Chesapeake Bay as a haven for shellfish and waterfowl. One example of successful environmental opposition occurred in 1973 when over 20 dredging permits were held in abeyance pending the issuance of a comprehensive port planning study by the Port of Baltimore. As a result of this action, no major dredging activities outside of annual maintenance dredging were performed from 1973 to 1975.

Table X-3

Bulk Port Constraints

Ports	Potential Constraints	Bulk Commodities
Baltimore	Unavailability of land, inadequate channel depths, insufficient disposal sites.	Grain, Coal, Petroleum
Hampton Roads	Unavailability of land at deepwater locations, insufficient disposal sites.	Grain, Coal, Petroleum
Philadelphia	Inadequate channel maintenance, unavailability of land (City of Philadelphia), inadequate channel depths.	Grain, Coal, Petroleum, Ores
Chicago	Project channel depths 8 to 9-month navigation season.	Grain
Galveston	Unavailability of land, inadequate channel depths.	Grain, Coal, Petroleum
Houston	Inadequate channel depths, decreasing land availability (Houston Ship Channel)	Grain, Coal, Petroleum
Mobile	Inadequate channel depths and widths, insufficient disposal sites	Grain, Coal Petroleum, Ores
New Orleans/ Baton Rouge	Unavailability of land, inadequate channel depths, lock constraints, congestion.	Grain, Coal Petroleum, Ores
Long Beach	Unavailability of land, environmental restrictions	Grain, Petroleum
Los Angeles	Inadequate channel depths, unavailability of land, environmental restrictions.	Grain, Petroleum
Puget Sound	Unavailability of land at the Port of Seattle, environemental restrictions at the Port of Tacoma	Grain, Petroleum, Forest Products

SOURCE: Interviews

Another potential constraint relates to the unavailability of land for bulk terminal development. The shortage of waterfront property has caused the city to question the appropriateness of having bulk storage facilities located on increasingly valuable tracts of land. The city appears to be hesitant to relinquish waterfront land for terminal development when it could be utilized for residential or recreational land uses.

(b) Port of Hampton Roads

Hampton Roads is in better position than Baltimore with respect to both channel depth and land availability. However, the port's two 45-foot channels are still inadequate to accommodate the larger coal bulk carriers and land adjacent to deep water (greater than 40 feet) is in limited supply.

According to Hampton Roads port officials, coal terminals at Newport News and Norfolk would like to be able to handle deeper-draft vessels at their coal docks. In response to this demand for deeper water, the port has formulated proposals for deepening the main channel from 45 feet to 50-55 feet. Two factors, however, may prevent this project from ever being completed: lack of available disposal sites and the rising cost of dredge disposal. Craney Island, the major disposal site in the port area, may soon reach capacity within the next eight to ten years. Unless new, satisfactory disposal sites are found, the port may have to postpone certain deepening projects and curtail its annual maintenance dredging program estimated at about three million cubic yards of material.

(c) Port of Philadelphia

The Port of Philadelphia, as it is referred to in this section, encompasses the following ports: Philadelphia, Pennsylvania; Camden, New Jersey; and Wilmington, Delaware. Although the primary dry bulk terminals (grain and coal) are located at the Port of Philadelphia proper, large numbers of petroleum handling facilities are scattered throughout the area.

Port officials identify three potential concerns that could limit the port's future bulk handling capabilities: inadequate main channel depth; lack of suitable dredge disposal sites; and shortage of waterfront property for development.

Although the Delaware River's project depth is 40 feet, port officials state that actual depths along the channel are often less. Shallow spots appear in the main channel periodically and frequently go unnoticed, because of a lack of continuous maintenance dredging.

Port officials believe that 40-foot depths are inadequate for current bulk carrier operations and place the port at a competitive disadvantage with respect to Norfolk. At the present time, the port has no plans for deepening the Delaware River.

One problem confronting the port is the lack of available disposal sites. Annual dredging maintenance for 1979 resulted in 10.7 million cubic yards of material requiring disposal. Given such huge volumes, existing disposal sites will be exhausted in the very near future.

Shortage of available land for development is not a universal problem for the entire port area. Waterfront land in Philadelphia is generally scarce, limited to small non-contiguous tracts of private property. On the other hand, land is available in sufficient quantities on the Camden side of the Delaware River but suffers from marginal rail access. (Only one rail bridge spans the Delaware River to Camden.)

(d) Port of Chicago

Like other Great Lakes ports, the Port of Chicago's ability to compete for foreign traffic with East Coast ports is limited by:

- Project depth of 26 feet.
- Limited navigational season of eight to nine months.
- Lock congestion at the Welland Canal.

(e) Port of Galveston

Two concerns that could impact future bulk handling capabilities are: lack of available land for development and inadequate channel depths.

At the present time, the port has only about 500 acres of vacant land adjacent to deep water that it can use for terminal development. Plans are already formulated to use much of this land for the construction of two new bulk handling facilities, leaving little for other terminal development. Some land, containing old general cargo facilities, could be converted to new bulk terminals, but this land will most likely be used for expanded container marshalling yards.

The present 40-foot channel is inadequate to permit the passage of large bulk carriers and tankers envisioned for use at new terminals. Although the port has formulated plans to deepen the entrance channel to 50 feet and to create a 50-foot turning basin, the costs associated with such a massive dredging effort may be prohibitive.

(f) Port of Houston

Insufficient channel depth and shortage of vacant land available for development are the principal concerns.

The Houston Ship Canal has a project depth of 40 feet. This depth has not prevented terminal development in the past, as evidenced by the large number of facilities situated along the channel. However, if channel depth as expected becomes the primary criterion for future development, bulk terminal development (particularly grain facilities) may occur at those ports on the East or West coasts that have depths in excess of 45 feet rather than at Houston.

Land on both banks of the ship canal is already intensely developed. Although some waterfront land currently occupied can be converted to terminal use, tracts of vacant land are at a minimum.

(g) Port of Mobile

Two concerns that could limit future bulk handling capabilities are insufficient channel depths and widths and lack of adequate dredge disposal sites.

The entrance channel through Mobile Bay has an authorized depth of 42 feet, while the main channel has current depths of 40 feet. The Corps of Engineers has under study a proposal to increase channel depths from 40 feet to 55 feet. The Mobile River channel widths vary from 400 to 700 feet. Such widths are sufficient for current levels of two-way vessel traffic.

The Port of Mobile is prohibited from dumping dredged materials into either the Mobile River or Mobile Bay. As a result, only enough land is available at approved disposal sites to accommodate the material from two complete channel dredging efforts. The major problem concerning the disposal of dredged material is finding sufficient land, in proximity to future dredging projects, that can be developed as a disposal area at a reasonable cost. Potential sites currently proposed by Mobile District the Corps could substantially increase the disposal capacity.

(h) Ports of New Orleans and Baton Rouge

Four potential constraints or concerns exist at the Port of New Orleans. They include: unavailabiltiy of land for development; inadequate channel depths; restrictions imposed by the Industrial Lock; and vessel and barge congestion.

As discussed previously, New Orleans may be viewed as comprising two major zones, joined by the Inner Harbor Navigation Lock and Canal:

1. The Mississippi River, which, in turn, includes both the east and west banks.

2. The tidewater area, including the Industrial Canal, the the Mississippi River Gulf Outlet, and Lake Ponachartrain.

Historically, the port developed primarily along the Mississippi River in order to take advantage of the existing highway and rail network. However, as New Orleans grew, less land was available for new devlopment in this traditional port area.

Major portions of the southern half of Louisiana consist of wetland regions and, as such, are the focus of environmental interests seeking their preservation. Since the land along the Mississippi River Gulf Outlet is wetland area, it is doubtful whether much of the available land can be devoted to new terminal development.

The Mississippi River has a natural depth of over 70 feet from the Head of Passes to the Port of New Orleans. Yet, the authorized project depth of the Southwest Pass is only 40 feet. A study authorized by Congress in 1967, Deep-Draft Access to the Ports of New Orleans and Baton Rouge, indicated that depths to 60 feet were economically justified at the Southwest Pass. At the present time, improvements to the passage are being studied.

Port officials estimate that about one-tenth of the nation's barges are within the port's limits at any one time, and during the peak grain season there are about 3,000 gain barges within the port. Given the high volume of barge traffic, the two-way vessel movements, and the space requirements for fleeting areas, congestion along the Mississippi River at certain times of the year is inevitable. This problem is further compounded by the increasing number of floating rigs appearing on the river. As commerce within the port grows, so will the traffic levels and the need for additional fleeting areas. Although a vessel movement reporting system (utilizing VHF-FM networks) is in operation in the port area, congestion will continue to be a problem.

The long-term constraint foreseen by port officials at Baton Rouge is the diminishing supply of land. Land along both banks of the Mississippi from Baton Rouge to New Orleans has undergone intensive development in recent years. Although the port believes that land will be adequate throughout the remainder of the century, prime waterfront property will become increasingly scarce.

(i) Port of Long Beach

The potential constraints that could limit future bulk handling capabilities are a lack of available land for development and restrictive environmental policies.

In 1979, the port acquired about 128 acres of undeveloped land for future terminal expansion and development. This recent purchase, however, practically exhausts the supply of suitable land that can be obtained by the port. In the long-term, additional land may become available as numerous oil wells located in the port area become depleted. Also, more land could be made available by extending the port seaward, but several proposals suggesting such action have met with stiff environmental opposition.

The Port of Long Beach has been subjected to tight environmental controls that have, in the past, restricted terminal growth and development. For example, plans for a proposed two-berth, deep-water tanker terminal to be constructed by Standard Oil of Ohio were abandoned because of prohibitive environmental research and compliance costs. Authorization of more than 700 permits would have been necessary to initiate the project. Much of the North Slope Alaskan oil that was to be delivered to the proposed terminal now arrives in Long Beach aboard smaller tankers, with the surplus moving to Gulf ports via the Panama Canal.

A new air quality rule, to be monitored by the State of California Air Resources Board, may also affect future terminal construction. Under this rule, vessel emissions are combined with facility emissions to determine a new terminal's overall air quality. According to port officials the rule makes it extremely difficult for new bulk facilities to be in compliance with air quality standards.

(j) Port of Los Angeles

Three concerns that could adversely impact future bulk handling capabilities are: inadequate channel depths; lack of available land for development; and restrictive environmental policy.

Except for the 51-foot depths at Berths 45, 46, 47, 49, and 50, most terminal facilities are situated along 35-foot channels. Since many bulk carriers in use today require more than the current 35-foot depth, such vessels either do not use the port or submit to lightering before entering. However, the port has recently obtained Congressional approval for the Army Corps of Engineers to deepen the Main Channel by 10 feet.

According to port officials, there is little unoccupied land remaining in the port area for future terminal development. Some land could be made available by either converting antiquated facilities to new terminal structures or relocating recreational and fishing activities away from potential deep-water terminal sites.

(k) Port of Seattle

A constraint that can be expected to restrict the port's future bulk handling capabilities is the lack of available land for development. Undeveloped waterfront land is in extremely short supply and costly. Port officials indicated that about 150 acres can be made available by consolidating various facilities, but land obtained in this manner may be used for additional general cargo and container development.

(l) Port of Tacoma

Two concerns are: restrictive environmental policy governing dredging activity and new terminal development and bridge obstruction problems.

In the past, proposed dredging and filling projects have not been approved because of environmental concerns. Industrial growth in the port areas has also been affected by environmental control standards. Since the Tacoma tidal basin industrial region is a nonattainment area for total suspended particulates, new source industrial permits are rarely granted.

The other potential constraint at the port is the 150-foot wide Blair Waterway Bridge. This bridge prevents large vessels from using the waterway.

CHANNEL MAINTENANCE ON INLAND WATERWAYS

Channel maintenance involves dredging and other actions such as river training. These actions are taken to maintain project depths and widths so that safe and cost-effective water transportation is possible.

In recent years, states have been granted additional rights to monitor dredge disposal operations within their boundaries. States such as Minnesota and Wisconsin have exercised these rights by restricting the means by which dredged material can be disposed. Disposal costs per cubic yard of material have risen and, in numerous locations along the Upper Mississippi, appropriate state and federal officials have not agreed upon acceptable sites. (For additional information on this matter, see Barge Traffic Forecasts and Constraint Analysis for GREAT II conducted by A. T. Kearney, Inc. in association with Data Resources, Inc. for the Rock Island District Corps of Engineers.)

At one point in 1978, the state of Wisconsin refused to permit dredging unless an emergency, defined as a grounding, existed. A tow did run aground in 1978 and traffic on the Upper Mississippi at the mouth of the Chippawa River was blocked for five days in both directions.

Table X-4 presents those areas with previous channel maintenance problems. Once again, this list is not meant to be a catalogue.

As can be seen, the Upper Mississippi River was considered to have the largest number of channel maintenance problems. These problems are related to a lack of acceptable disposal sites, but it should be emphasized that changing flow conditions also change the need for maintenance dredging.

To date, inadequate channel maintenance has not been a constraint to present traffic, as defined earlier in this section, however it has increased on occasion the real cost of water transportation to shippers. In extreme cases, it can force shippers to light-load (the loss in carrying capacity results in a proportional increase in ton-mile costs) and reduce speeds (the increase in transit time results in a proportionate increase in ton-mile costs).

As in the case of Locks and Dam 26, the major industries affected by this problem are the grain and coal industries.

TERMINALS AND FLEETING

The problem of securing land for terminal and fleeting facilities has been discussed with regard to seacoast and Great Lakes ports. The conclusion was that, for selected ports, it can be considered a potential constraint to future waterway use.

Securing terminal and fleeting services on the inland waterways is a problem for those industries expecting to make large investments in their inland water distribution systems. These are primarily the coal, grain, and chemical industries. The chemical industry's problem is especially severe, since large amounts of acreage are required to contain, treat, and dispose of waste materials.

Table X-4

Channel Maintenance Problems

Waterway Region	Location
Upper Mississippi River	Pine Bend, Mn. (mile-maker 824) Red Wing, Mn. (791) Mouth of the Chippawa River (763) Island 189 (610) Hurricane Island (599) Gordon's Ferry (566) Savannah, Ill. (538) Dark Slough Foot Light (531) Keithsburg (426) Huron (425) Oquawka (416) Kemp's Landing (398-401)
Curtis (350)	
Illinois River	Principally the southern end
Great Lakes	Sault Ste. Marie and St. Marys River Detroit River and the northern approach to Lake St. Clair.

SOURCES: Interviews and A. T. Kearney, Barge Traffic Forecasts and Constraint Analysis for GREAT II.

Securing terminal and fleeting services on the inland and waterways is not a constraint at the present time, but land use and environmental regulations, and permit processes have greatly increased the cost of purchasing property and constructing new facilities.

A brief discussion of fleeting and terminal services is provided below.

(a) Fleeting

Barge fleeting is an integral part of inland port and terminal operations. Fleeting operators provide two basic services:

1. Make-up and break-up of line-haul tows.

2. Pick-up and delivery of barges at docks with barge storage between use.

Barges are stored in bank fleets (adjacent to the bank and moored to it) or in anchor fleets (in open water, away from the channel, and attached to an anchor secured to the river bottom).

Shortages of fleeting spaces are common around major metropolitan areas and, when possible sites are found, lengthy permit processes may be required. These processes invite the review of federal and state agencies and frequently the general public. These reviews can lead to long delays and eventual disapproval of the application. Once granted, the permit is considered temporary since the right of revocation remains with the issuing authority.

(b) Terminals

Securing terminal services is a problem for inland shippers. Since access to good rail and/or truck transportation is a key requirement for inland terminals, the number of acceptable locations along individual waterway segments is limited. Securing terminal services is further complicated by an extensive review process for any harmful environmental effects of new construction. Several examples of problems associated with terminal construction help illustrate the problem.

One carrier contacted for the NWS was able to purchase land and construct a new grain terminal only after "donating" additional land to an agency as a wilderness area and initiating a costly law suit against another agency. This terminal was the only terminal constructed in the Minneapolis/St. Paul area from 1975 to 1979.

Several coal shippers in the same area were interested in constructing a terminal for handling coal at Pig's Eye Lake on the Upper Mississippi. The terminal was to receive unit-trains of 100 cars and to transload the coal to barges for distribution to water-served utilities on the Upper Mississippi. The St. Paul Port Authority advocated a plan for a unit-train loop track with a one mile conveyor to the river. The proposed site included more than 200 acres with supporting rail service from the Burlington Northern, Chicago and Northwestern, and Milwaukee Road.

Public participation, which included consideration of airborne particle problems, ultimately led to a decision to cancel development plans in 1977. Two years later the Minnesota EPA decided the site was acceptable and indicated interest in site development plans. By this time the shippers had committed themselves to less cost effective coal handling procedures.

OTHER ISSUES

(a) Competing Water Uses

Competing water uses were found to pose no constraint to present or future waterway use, except where large numbers of recreational lockages reduce lock capacity.

Heavy recreational activity at selected ports does, however, pose some safety problems in places such as Minneapolis/St. Paul; Pittsburgh; Cincinnati; San Francisco Bay; Waukegan, Illinois; and Lake St. Clair.

(b) Navigation Conditions

Navigation conditions, such as bends, bridges, and navigation aids, are not constraints to waterway use, but they do pose safety problems and increase the ton-mile costs of water transportation. The reader is referred to NWS Report #10 entitled Defense and Emergency Requirements of Waterways for a review of this subject.

CONCLUSIONS

The principal conclusions regarding shipper constraints to waterway use are:

1. Lock capacity on nine waterway regions is a potential constraint to waterway use.

2. Key constraining locks are Lock and Dam 26 (the grain and coal industries are most affected and diversion to rail or other waterways is likely for grain with diversion to rail likely for coal), Gallipolis Lock (the coal, electric utility and steel industries are most affected and diversion to rail or truck is possible), and Inner Harbor Navigation Canal Lock (the grain, fertilizer, steel, petroleum, coal, and chemical industries are affected with diversion to other ports possible).

3. Lack of suitable land for terminal development and dredge disposal is a potential constraint for many seacoast ports.

4. Increasing port depth is a key concern and competitive factor for United States ports.

5. Inadequte channel maintenance on the Upper Mississippi is not a constraint to waterway use, but it has at times increased the real costs of water transportation.

6. Lack of terminals and fleeting areas on the inland waterways is not a constraint, but land use and environmental regulations as well as lengthy permit processes have greatly increased the cost of new construction (the coal, grain, and chemical industries are expected to be most affected by these higher costs).

7. Competing water uses are not constraints nor do they pose problems for shippers, aside from safety issues in local areas and a small impact on lock capacity.

8. Navigation conditions (bends, bridges, and navigation aids) are not constraints, but the do pose safety problems for shippers, and increase the real costs of water transportation.

EXHIBIT X-1

DESCRIPTION OF LOCKAGE TYPES

1. Straight lockage. A straight lockage occurs when the barges making up the tow and the towboat pushing the tow are able to fit within the lock chamber without any change in the tow configuration. Of course, lockages on the Great Lakes involve lakers and ocean-going vessels and can be considered straight lockages.

2. Double lockage. A double lockage occurs when the tow and towboat require two separate (or single) lockages to be processed. Typically, a dry cargo tow of 15 barges moving through a 600' by 110' lock chamber is broken up into a single lockage of the first nine barges followed by another single lockage of the remaining six barges. The first (unpowered) cut is extracted from the lock chamber by winches or a helper towboat.

3. Setover lockage. A setover lockage occurs when the tow and towboat are able to fit within the lock chamber only after the towboat and one or two barges are broken away from the original configuration and set alongside the other barges in the tow. Typically, a liquid cargo tow of three larger barges and one smaller barge is broken in such a way that the towboat, the smaller barge, and one of the large barges is set alongside the other large barges.

4. Knockout lockage. A knockout lockage occurs when the tow and towboat are able to fit within the lock chamber only after the towboat has been broken away from the original configuration and set alongside the tow.

5. Other commercial lockages. There are at least three other commercial lockages. A light tow lockage occurs when a single towboat is processed. A multi-vessel lockage occurs when two towboats pushing a tow are processed. A barge transfer lockage occurs when a tow is transferred from one towboat on one side of the lock to another towboat on the other side of the lock.

6. Recreational lockages. Recreational lockages occur when one or more recreational vessels are processed.

XI - POSSIBLE ACTIONS AND RECOMMENDATIONS FOR FURTHER INVESTIGATION

INTRODUCTION

This section examines possible actions as suggested by waterway users to address the constraints identified in Section X. In addition, possible actions to address other concerns identified in Section X are discussed.

Potential constraints represent possible shortfalls in the capability of the waterway system to meet present or future waterway transportation use. The shipper constraints identified in Section X are:

1. Lock capacity.

2. Lack of land for terminal development and dredge disposal at seacoat ports.

Other shipper concerns identified in Section X are:

1. Port depth.

2. Channel maintenance on inland waterways.

3. Terminals and fleeting space on inland waterways.

It is recognized that these constraints and concerns are recurring problems that have been and will continue to be addressed by actions. This section focuses on ideas for new or alternative actions. It also discusses the reaction of waterway users to various capacity-rationing schemes.

This section does not attempt to evaluate the effectiveness of alternative actions or strategies to meet water transportation needs. The reader is referred to NWS Reports 4,6, and 15 entitled Findings and Conclusions, The Present Waterways System and Analysis of Waterways System Navigational Capability, respectively, for such an evaluation.

Since the effectiveness of alternative actions is beyond the scope of this section, only conclusions regarding waterway user perceptions of alternative actions are drawn.

The remainder of the section is divided into the following headings:

- Increasing lock capacity.
- Addressing port constraints and concerns.
- Improving channel maintenance.
- Developing terminals and fleeting areas
- Conclusions.

INCREASING LOCK CAPACITY

(a) Possible Actions

This subsection is divided into two parts: possible actions and shipper reaction to capacity-rationing measures. As discussed previously, locks may constrain traffic, because of chamber size (which limits the vessel size or number of barges that can be accommodated at any one time) and time available for processing commercial traffic. The time available for processing traffic is, in turn, determined by the length of the navigation season less time lost for activities other than commercial lockages as well as the process time for each type of lockage.

At key constraining locks, shippers and carriers favored the use of structural actions, such as increasing the number and size of lock chambers. This was particularly true of Locks and Dam 26. Shippers emphasized that building only one 1200' chamber to replace the 600' chamber at Lock and Dam 26 would not double capacity even though the lock chamber size is doubled. Shippers also noted that the long lead times to complete waterway improvements (estimated by the Corps of Engineers to be nearly 18 years for major projects) must be reduced if reasonable capital investment decisions are to be made by industry.

However, many shippers and carriers recognized that a number of relatively new, less costly actions were available to increase capacity and reduce lock delays. Although these actions were not favored as long-term solutions to inadequate lock capacity, coal and grain shippers, in particular, felt that these actions offered substantial benefits as other structural actions were being implemented.

These actions have been implemented by the Corps of Engineers and the barge and towing industry at Locks and Dam 26 and, on occassion, Gallipolis Lock when delays become excessive.

These actions involve changes in locking procedures with a resulting reduction in average processing time. One of these actions is the processing of tows in sequence of four up followed by four down.

Another action is the requirement that double lockages be made up far enough from the chamber to prevent any blockage of the gates. (For a definition of lockage types, see Exhibit X-1). These tows are broken up in the usual manner, but the first (unpowered) cut of barges are pulled out of the chamber by a "helper boat" and moved down a guidewall some distance from the chamber gates. The chamber is immediately turned back for the rest of the tow. When the second locking is completed, the tow is made up along the guidewall and away from the chamber gates. Thus, the chamber can be immediately turned back for the processing of the next tow.

By the same token, setover and knockout lockages are broken up and reconfigured before entering the chamber and then made up at some distance from the chamber.

In order to facilitate the break-up and make-up of tows, the St. Louis District of the Corps of Engineers extended the upper and lower guidewalls running from the lock chamber. In addition, the barge and towing industry initated a self-help program whereby towboats waiting in line would serve as helper boats to pull unpowered cuts out of the chamber.

The impact of this capacity increase is reduced upriver if four upbound tows arrive in close sequence at the next lock utilizing a one up, one down locking policy. Thus, a systemwide approach may be necessary to minimize total delays.

Other actions suggested by inland carriers include improved crew training to expedite locking operations and establishment of traffic information systems like the one in use on the Ohio River. This system permits data subscribers to receive reports on the number of tows waiting at or in transit to individual locks. Such systems provide accurate information on lock congestion and may enable carriers to adjust operaions in ways to prevent aggravating the problem further.

Users of the Great Lakes were concerned about the capacity of the Canadian-operated Welland Canal. Extending the navigation season of the St. Lawrence Seaway has increased lock capacity and further extensions are possible. The use of marine shunters at this canal is also a possible action. These shunters are attached near the bow and stern of vessels and reduce the amount of time required to move vessels in and out of the lock chamber.

Lake carriers also suggested that the lock capacity at Sault Ste. Marie might be increased by deepening the channel approaches to the lock. Project depth is 27 feet and the approach channels are maintained at these depths. But the depth over sill at this lock is 30 to 31 feet. Lakers moving from Lake Superior to points on Lake Huron or Lake Michigan encounter no other point of 27-foot draft; thus, with increased dredging, these lakers could take on 15% more cargo with no increase in locking requirements.

(b) Shipper Reaction to Capacity - Rationing Measures

As noted previously, shippers favored structural improvements to increase lock capacity, but recognized the benefit of undertaking some non-structural actions in the interim.

However, shippers did not favor any means of rationing lock capacity. Rationing capacity on the basis of price was universally condemned. Rationing by coupon was acceptable to some shippers as a means of reducing average delay at congested locks. But, these same shippers noted that designing an equitable allocation system would be so difficult as to make the action impractical.

Practical objections were also raised to any rationing system where lockages would be scheduled in advance or tows would be permitted to move to the head of the line. Scheduling of lockages was not considered practical, because weather or cargo transfer delays could easily cause tows to miss appointed times. Shippers, carriers, and trade associations objected to tows moving ahead of others at congested lock, because such "jockeying" for position greatly increases the risk of accidents.

ADDRESSING PORT CONSTRAINTS AND CONCERNS

The potential constraints to port growth as perceived by port authorities and shippers were a lack of land for terminal development and dredge disposal.

Land is not readily available for terminal development in major port areas for several reasons. Waterfront land is valuable for residential and recreational purpose as well as commercial purposes. At just about all coastal ports, much of the land that is suitable for terminal development is wetlands and, by law, a number of precautions must be taken to limit the adverse impacts of development in these areas.

Shippers emphasized the importance of modifying existing facilities to increase terminal shipping and receiving capabilities. Additional sites are not necessarily needed to handle higher grain exports at New Orleans or coal exports at Hampton Roads, if terminal operators in these areas can modify existing facilities. These shippers emphasized that improvements are continually being made to existing facilities and that any new terminals are designed to provide maximum flexibility for future expansion.

Port authorities emphasized the importance of consolidating little-used facilities, converting autiquated facilities to new terminal structures, and relocating recreational, fishing, or other activities away from potential deep-water sites. Port authorities emphasized the importance of planning, negotiation, and a lot of hard work in successfully completing the construction of new terminals or major additions to existing terminals.

Other actions include forcing regulatory agencies to consider the compliance costs when formulating and enforcing regulations concerning new terminal development in port areas.

With regard to the lack of land for dredge disposal, port authorities and environmentalists agree that it is a matter of finding sites that are both cost-effective and environmentally acceptable. Port authorities ask that more emphasis be placed on the cost of complying with strict environmental regulations since dredge disposal is a necessary action to maintain channel depths.

With regard to increasing port depth, port authorities recognize that there is at least one other alternative for handling VLCCs, the construction of off-shore oil ports. These ports pose fewer environmental problems, because no extensive dredge disposal in wetland areas is required. Lightering of oil vessels is, of course, an action in practice at the present time on all seacoasts.

Finally, it should be noted that self-unloading vessels on the Great Lakes have been successful in dealing with inadequate port depths at some locations.

IMPROVING CHANNEL MAINTENANCE

Inadequate channel maintenance is not a constraint to water users, but it has increased the real costs of water transportation on certain waterway regions, especially the Upper Mississippi. Costs are increased due to slower transit times and increased groundings or spills.

In general, carries on the Upper Mississippi River feel that a minimum depth of 11-1/2 feet to 12 feet and a minimum width of 300 feet are necessary for safe and efficient navigation. Since loaded barges and towboats draw about 9 feet of water, an additional 2-1/2 to 3 feet of channel is necessary to provide adequate control and maneuverability. In addition since a 15 barge tow is typically 105 to 110 feet wide, a channel width of 300 feet is necessary if two oncoming tows are to pass one another without one tow having to wait along one side of the channel. At river bends, the channel width, according to shippers, ought to be greater than 300 feet due to the length of the tow (a typical 15 barge tow is over 1,100 feet in length) and the need for the captain to follow the river's turn.

The problem of inadequate channel maintenance is primarily a problem of the placement of dredged materials. Site selection is governed by cost and environmental considerations. Shippers and carriers emphasized the importance of cost as a criterion for site selection and argued that the cost implications of compliance with environmenal regulations are not understood by regulatory agencies. Actions forcing these agencies to consider the compliance costs of their regulations would change the decisions being made.

In addition, waterway users argued that the process of approving the need for dredging must be based on considerations for safe and cost-efficient navigation, rather than the presence of emergency conditions.

DEVELOPING TERMINALS AND FLEETING AREAS

Securing terminal and fleeting services on the inland waterways are special problems if new facilities must be constructed.

The principal objections that developers have with regulations affecting new construction are:

1. The lack of precision with which federal regulations are interpreted by public agencies from one waterway region to another.

2. The inablility of regulatory agencies to translate possible environmental impacats into measures that can be objectively and quantitatively assessed.

3. The ease with which the approval process can be delayed.

4. The disregard of regulatory agencies for the costs of complying with this approval process and other environmental regulations.

Possible actions include reducing the period of time for which regulatory agencies have to make their objections known and forcing these agencies to consider the costs of compliance when formulating and enforcing regulations.

Of course, a number of actions are available to operators of existing terminals and fleeting areas for increasing the productivity of their property. These include investment in more efficient landside and floating equipment and operation of more than one work-shift.

CONCLUSIONS

The principal conclusions regarding the assessment of actions by waterway users are:

1. In general, waterway users emphasized the importance of maintaining and improving the existing waterway system rather than extending it.

2. Structural actions are favored at key constraining locks.

3. The lead time for completing these structural improvements should be greatly reduced.

4. Non-structural actions do offer cost savings to users by increasing lock capacity and should be implemented on a system-wide basis as appropriate.

5. Further investigation of possible non-structural actions such as marine shunters should be made.

6. Schemes for rationing lock capacity are not considered to be practical and these actions pose safety problems.

7. Modifying existing terminal facilites at seacoast ports is a [illegible] for [illegible], with the potential constraint of a lack of land.

8. With regard to coastal and inland dredged material disposal, increased emphasis on the cost of compliance with environmental standards would result in the selection of more practical disposal sites.

9. The construction of off-shore oil ports would permit the use of VLCCs, while posing fewer environmental problems than increasing project depth at selected seacoast ports.

10. Reducing the period of time for which regulatory agencies have to raise objections to the new construction of terminals and fleeting areas is a key action in reducing the present delays and costs incurred by waterway users.

XII - CONCLUSIONS

A number of factors influence the decision of companies to use water transportation. These factors differ by industry and, to a lesser extent, by companies within the same industry. In order to understand the nature of future water transportation use, it is necessary to identify those factors that can be expected to change waterborne flows in the future.

One of the primary purposes of this report is to identify these factors that can be expected to influence the future use of water transportation by the following industries:

- Agriculture.
- Fertilizer.
- Steel.
- Petroleum and petroleum products.
- Coal.
- Chemicals.
- Forest products.

The principle conclusions regarding future transportation use by these industries are:

1. Numerous factors can be expected to change the nature of waterborne coal flows in the future.

2. One or more changes in the chemical, fertilizer, and steel industries can be expected to change the nature of waterborne flows in the future.

3. Possible changes in the railroads' ability to compete can be expected to change the waterborne share of grain export shipments in the future.

4. Changes in the capacity of existing pipelines and the possible construction of new pipelines can be expected to change the waterborne share of petroleum and petroleum products' shipments in the future.

5. Although one or more changes can be expected to affect the forest products industry, these changes are not expected to affect appreciably the relatively small waterborne share of total shipments.

A more detailed statement of these conclusions are made by industry under separate headings after the other principal conclusions of this report are noted.

Another purpose of this report is to identify factors that might be expected to change the nature and amount of the waterborne flows for other commodities in the future. These commodities include:

- Sand and gravel.
- Bauxite ore and alumina.
- Cement.
- Marine shells.
- Salt.

The principal conclusions regarding the future transportation of these commodities by water are:

1. Changes in the amount of dredging can be expected to dramatically affect the use of the waterways by the sand and gravel industry.

2. Whereas the waterborne share of salt shipments might be expected to increase with the construction of new salt capacity in the Gulf states, other factors such as the location of chemical plants over salt mines, environmental problems with the use of salt for highway ice control, and the completion of the interstate highway system can be expected to hold down the rate of growth of salt shipments.

3. Although one or more changes can be expected to affect the aluminum and cement industries, no single factor is expected to change the nature of waterborne flows of these industries in the future.

Another purpose of this report is to identify new commodities that might be expected to use the waterways in the future. The principal conclusions regarding potentially new waterborne commodity flows are:

1. No new bulk commodities are expected to move on the waterways in large volumes by the year 2000.

2. Biomass derived fuels represent a potentially new waterborne commodity flow. Fuel derived from biomass produced in the Southeast may be shipped on the inland waterways to midwestern destinations, but the tonnages are expected to be small (less than several million tons) even by the year 2000.

3. Direct reduced iron or sponge iron represents a potentially new waterborne flow. This iron may be expected to move in patterns similar to the present distribution of iron ore and scrap.

Another purpose of this report is to present the principal constraints and concerns as perceived by waterway users to the present or future use of the waterways for transportation. The principal conclusions regarding shipper constraints to waterway use are:

1. Inadequate lock capacity on nine waterway regions is a potential constraint to waterway use.

2. The largest numbers of constraining locks are on the Ohio and Illinois Rivers, but the key constraining locks at the present time are Locks and Dam 26 on the Lower Upper Mississippi, Gallipolis Lock on the Ohio River, and the Inner Harbor Navigation Canal Lock in the Port of New Orleans.

3. The grain and coal industries are most affected by the constraint at Locks and Dam 26. Without action, some diversion to rail or other waterways can be expected for the shipment of grain exports, reducing the share of the nation's largest grain exporting ports, New Orleans and Baton Rouge, in the future. Without action, some diversion to rail for the shipment of eastern and midwestern coal to midwestern utilities and industrial power plants can be expected in the future.

4. The coal and steel industries are most affected by the constraint at Gallipolis Lock. Without action, some diversion to rail and truck can be expected.

5. Virtually all of the seven primary waterway industries are affected by the constraint at the Inner Harbor Navigation Canal Lock. Without action, some diversion of foreign traffic to other ports is possible and some diversion of domestic steel, chemical, fertilizer, and petroleum traffic to other modes of transportation is also possible.

6. Lack of suitable land for terminal development and dredged material disposal is a potential constraint for most seacoast ports. Of the ports contacted for NWS, lack of land for dredge disposal is especially serious at the ports of Baltimore, Hampton Roads, Philadelphia, and Mobile.

7. Increasing port depth is a key concern and competitive factor for United States ports.

8. Inadequate channel maintenance (attributable to a lack of acceptable dredged material disposal sites) on the Upper Mississippi is not a constraint to waterway use, but it has at times increased the real cost of water transportation.

9. Lack of terminals and fleeting areas on the inland waterway is not a constraint to waterway use, but land use and environmental regulations as well as lenghty permit processes have greatly increased the cost of new construction. The coal, grain, and chemical industries are expected to be most affected by these problems.

10. Conflicts with competing water uses are not constraints to waterway transportation use, but recreational boating activity does pose some safety problems to shippers in local metropolitan areas.

11. Navigation conditions such as bends, bridges, and navigation aids are not constraints to waterway use, but they do pose safety problems to shippers in local areas.

The final purpose of this report is to present an assessment of actions to address constraints from the perspective of waterway users. The conclusions regarding this assessment are:

1. Waterway users favor actions to maintain and improve the existing waterway system rather than actions to extend the present waterway system.

2. Waterway users favor structural actions such as the construction of larger lock chambers to address constraining locks.

3. The lead time for completing these structural changes should be greatly reduced.

4. Non-structural actions offer cost savings to waterway users by reducing lock processing time and should be implemented on a systemwide basis as appropriate.

5. Further investigation of possible non-structural actions such as marine shunters should be made.

6. Schemes for rationing lock capacity are not considered to be practical and these actions pose safety problems to waterway users.

7. Improving existing terminal facilities at seacoast ports is a key action for dealing with the potential constraints of a lack of land.

8. Increased emphasis on the cost of compliance with environmental standards would result in the selection of more practical means for dredge disposal.

9. The construction of off-shore oil ports would permit the use of VLCCs, while posing fewer environmental problems than increasing project depth at selected seacoast ports.

10. Reducing the time period for which regulatory agencies have to raise objections to waterfront development is a key action in reducing the present delays and costs incurred by waterway users.

The conclusions with regard to factors affecting the use of water transportation by the seven primary industries are discussed below under separate headings.

COAL

Coal is the commodity with the second largest tonnage moving on the national waterways. The major capital expenditures for plant, equipment, and logistics systems in this industry make it essential for coal shippers and receivers to plan far in advance for the choice of transportation mode. A key component in this decision process is the capacity of the transportation system to move large amounts of coal reliably and cheaply over the entire life of the plant.

A number of factors can be expected to influence the nature of coal flows in the future. Factors that can be expected to increase waterborne coal flows include:

1. The construction of new coal-fired electric utility and industrial power plants in the future along the national waterways. The largest numbers of plants (an estimated 10 plants with a total megawatt capacity of 8,625) are to be constructed along the Ohio River in the next ten years. The second largest number of plants (an estimated seven or eight plants with a total megawatt capacity of 4,125 to 4,775) are to be constructed along the Gulf Coast East Region. (See Appendix B for a definition of the waterway regions used in NWS.)

2. The conversion of existing oil or gas-fired electric utility and industrial power plants to coal. Conversions are expected along the Middle Atlantic Coast and North Atlantic Coast. Utilities in these areas can be expected to use coastal vessels or barges for the final delivery of the coal. Other conversions of waterserved plants to coal can be expected in the West South Central area as well as the states of Florida and Mississippi. These conversions will increase coal shipments on the Lower Mississippi and Gulf Coast.

3. A possible moratorium or slowdown in the construction of nuclear power plants. The largest number of nuclear power plants (an estimated 20 plants with a megawatt capacity of 20,000) are planned or under construction in areas served by the Ohio River. Other water-served areas where nuclear power plants are planned or under construction are the Tennessee River Valley (11 plants with 13,000 megawatt capacity) and Illinois (7 plants with 6,700 megawatt capacity).

4. Increased production of synthetic fuels from coal. Synthetic fuels might be produced near chemical plants or refineries located along the Baton Rouge to Gulf region, Gulf Coast West, and Gulf Coast East. If so, waterborne shipments of coal down the Lower Mississippi to these plants can be expected.

5. Increased exports of steam bituminous coal to Western Europe. Increased bunker fuel costs are making American coal more competitive than Australian and South African coal. Poland, a traditional supplier, is shipping more of its coal to Russia.

Increased competition from coal-slurry pipelines and strengthened railroads is also possible in the future and can be expected to reduce waterborne coal flows below what they would have otherwise been.

1. The initial impact of rail deregulation may well be the diversion of some coal to water and truck transportation as carriers seek to increase the profitability of existing coal traffic.

2. The long term impact of rail deregulation may well be reduced waterborne coal flows on waterways that freeze (principally the Upper Mississippi River) as railroads enter into contract rates specifying performance standards. In addition, possible end-to-end railroad mergers may reduce the growth of waterborne coal flows on the Lower Mississippi, the Gulf Coast East, and the Gulf Coast West.

3. Although the possible construction of coal-slurry pipelines can be expected to reduce western rail traffic dramatically, it may also reduce the growth of coal traffic on the Lower Mississippi and Gulf Coast East.

AGRICULTURE

Grain, oilseeds, and grain products comprise the commodity group with the fourth largest waterborne tonnage. The overwhelming proportion of these shipments are exports. As in the case of coal, grain shippers have developed extensive logistics systems.

In contrast to coal, there are few industry factors that are expected to change the nature of waterborne grain flows in the future. The United States is expected to continue to have a dominant position in the international sale of corn and soybeans and a major position in the international sale of wheat. No major shifts in United States crop production by region are expected. In addition, grain export activity can be expected to fluctuate with changes in demand, although increased farm storage is reducing the fluctuations in grain shipments due solely to supply side factors.

The factor that is expected to change the nature of waterborne grain flows in the future is the railroads' ability to compete for the shipment of grain exports. This, in turn, will influence the share of grain exports that each seacoast and Great Lakes port obtains.

1. The initial impact of rail deregulation is expected to cause some diversion to truck and water. The principal waterway regions that might receive additional grain export traffic are the Lower Upper Mississippi, the Great Lakes, the Ohio River, and the Columbia Snake Waterway.

2. The long term impact of rail deregulation is likely to be increased competition between rail and water carriers for the long-haul shipment of midwestern grain, soybeans, and gran products to United States ports.

3. Midwestern shippers located near waterways that freeze (principally the Upper Mississippi) are expected to view contract rates with performance standards favorably and, as a result, a higher proportion of future increases in grain exports from these areas might be expected to move by rail if rail carriers can perform effectively.

4. Key factors influencing the railroads' ability to compete are the nature and timing of actions taken to increase the waterway capacity of the Illinois, Upper Mississippi, and Lower Upper Mississippi Rivers. Without such increases, grain shippers in these areas may be forced to develop new logistic systems for the distribution of grain exports, including increased rail shipments to the West and East Coasts.

PETROLEUM

Petroleum and petroleum products are the category with the single largest tonnage moving on the national waterways. Conservation and substitution of other energy products for petroleum are expected to hold the rate of growth in shipments below historical levels or to use as actual decline of shipments. In view of this low-growth, or declining rate, few major changes in the nature of waterborne flows are expected.

The single most important factor influencing waterborne petroleum flows in the future is the growth in pipeline capacity. Since petroleum shippers consider pipelines to offer lower costs, water transportation will continue to act as a residual supplier of transportation services.

1. Expected increases in the capacity of existing produce pipelines running from the Gulf to the East Coast will keep the rate of growth in competing tanker shipments to a minimum.

2. The possible conversion of a natural gas pipeline to petroleum products will reduce competing coastal shipments of products from the Texas Gulf to Florida destinations.

3. The possible construction of a crude oil pipeline running from the West Coast to midwestern refineries will reduce waterborne shipments from the West to the Gulf and East Coasts.

4. The possible construction of a pipeline from Alaska to the West Coast may also reduce competing tanker movements of Alaskan crude oil.

STEEL

The steel industry is a major user of the national waterways for the receipt of raw materials and imported steel products. Outbound shipments of steel from domestic mills are largely made by truck and rail.

The key factor influencing the nature of waterborne flows for the steel industry is the construction of electric furnace-type, steel-making units. Such furnaces are expected to replace some of the existing open hearth capacity and, as a result, waterborne shipments of iron ore and limestone to open hearth plants will be reduced. This reduction in shipments may be partially offset by an increase in direct reduced iron shipments. Since electric furnaces may also be built in net-deficit areas such as Texas, reduced waterborne steel shipments from the Midwest to Texas can be expected.

CHEMICALS

The chemical industry is also a major user of the National waterways. A number of factors are expected to influence the nature of the chemical industry and waterborne chemical flows in the future. These are:

1. A shift from natural gas to crude oil in the short term and possibly to coal in the long term as a feedstock for the production of organic chemicals. Although the shift to crude oil would not change the nature of flows, a shift to coal would result in a reduction in waterborne shipments from Gulf Coast plants to destinations on the Ohio, Illinois, and Upper Mississippi Rivers as new plants are constructed near midwestern coal mines.

2. The conversion of some chemical power plants located along the Gulf and Atlantic Coasts to coal from natural gas or oil. Such a change is expected within the next five to ten years and will result in increased coal shipments down the Lower Mississippi to Gulf Coast destinations and increased coal shipments along the Atlantic Coast.

3. Increased regulation of hazardous material transportation. The increasing transportation cost of shipping hazardous materials and the increased liability associated with spills may result in lower chemical shipments for all transportation modes.

4. Rail deregulation. By and large, rail carriers consider chemical traffic to be attractive and, as less profitable traffic is diverted to other modes, rail carriers will be able to concentrate on increasing their market share of this business. Shipments to Illinois and Upper Mississippi River destinations are especially susceptible to improved rail service as these waterways have closed or partially closed navigation seasons during the winter.

FERTILIZER

Fertilizer shippers also use the national waterways. The key factors that can be expected to influence the chemical industry also apply to the fertilizer industry. In particular, the relocation of ammonia plants to midwestern areas near coal mines is a possibility late in the NWS time period. Such a relocation would reduce waterborne shipments of product from the Gulf to the Illinois, Upper Mississippi, and Ohio Rivers. In addition, the possible merger of the Seaboard Coast Line and Chesapeake and Ohio railroads may result in increased rail competition for fertilizer shipments from Florida.

FOREST PRODUCTS

Shippers of forest products rely primarily on rail and truck transporation. A number of factors are expected to affect this industry in the future, including increased production of southern timber and a possible increase in exports of pulp and paper from the South. However, water transportation is not expected to account for a large portion of shipments in the future. The increased regional nature of the forest products industry favors the use of rail and truck, since shipments are typically short hauls. Product characteristics and customers service requirements are also expected to limit the use of water transportation in the future.

FOOTNOTES

1. National Coal Association, Steam Electric Plant Factors.

2. Ibid.

3. Ibid.

4. Ibid.

5. Ibid.

6. Ibid.

7. Ibid.

8. Ibid.

9. Ibid.

10. Ibid.

11. Ibid.

12. Ibid.

BIBLIOGRAPHY

American Soybean Association, Soybean Digest Blue Book, June 1977.

Business Week, "The Oil Crisis is Real This Time," July 30, 1979, pp. 44-60.

Business Week, "The Oil Majors Bet on Coal," September 24, 1979, pp. 104-112

Business Week, "Oil's New Power Structure," December 24, 1979, pp. 82-88.

Business Week, "Steel Has High Hopes for More U.S. Aid," January 14, 1980, pp. 93-100.

Charles H. Kline & Co., Inc., Kline Guide to the Chemical Industry, Third Edition; Fairfield, New Jersey; 1977.

Charles H. Kline & Co., Inc., Kline Guide to the Pulp and Paper Industry; Fourth Edition; Fairfield, New Jersey; 1979.

Faith, Keyes and Clarkes, Industrial Chemicals, 1975.

The Fertilizer Institute, Informal Study of Freight Rate Structure: Fertilizer and Fertilizer Products by Edwin M. Wheeler, Washington, D.C., 1977.

G. W. Fauth & Associates, Inc., An Analysis of Revenue and Cost Relationships for Fertilizer Material Rail Shipments to and from Canada and within the United States, Washington, D.C., 1977.

Institute for Iron & Steel Studies, Steel in Texas -- Working Into the Mainstream, IISI Commentary, June, 1978.

Kearney, A. T. & Co., Barge Traffic Forecasts and Constraint Analysis for GREAT II, Chicago, Ill., 1979.

Kearney, A. T. & Co., Commodity Market Analysis Briefing Manual, Chicago, Ill., February 1976.

Kearney, A. T. & Co., A Study to Perform an In-Depth Analysis of Market Dominance and Its Relationship to Other Provisions of the 4-R Act, Chicago, Ill., 1979.

Milling & Baking News: Grain Directory/Buyer's Guide, Kansas City, Mo.: Sosland Publishing Co., 1978.

Milling & Baking News: Milling Directory/Buyer's Guide, Kansas City, Mo.: Sosland Publishing Co., 1978.

National Academy of Sciences, Critical Issues in Coal Transportation Systems, Washington, D.C., 1979

National Coal Association, Coal Facts 1978-1979, Washington, D.C., 1979.

National Coal Association, Coal Traffic Annual: 1977, Washington, D.C., 1978.

National Coal Association, Steam Electric Plant Factors, Washington, D.C., 1979.

Nyhart, J.D.; Antrim, Lance; Capstaff, Arthur; Kohler, Alison D; and Leshaw, Dale; A Cost Model of Deep Ocean Mining and Associated Regulatory Issues, Cambridge, Ma.: Massachusetts Institute of Technology, March 1978.

Petzinger, Jr., Thomas, "Growing Market Overseas for Steam Coal Begins to Draw on Big Supply in the U.S." in Wall Street Journal, February 7, 1980.

R. J. Bigda & Associates, Impact Study of Chemical Barge Traffic on Inland Waterway Systems.

SRI International, 1979 Directory of Chemical Producers.

Standard & Poor's Corporation, Industry Surveys: Chemical Basic Analysis, New York, N.Y., August 30, 1979.

Standard & Poor's Corporation, Industry Surveys: Oil Basic Analysis, New York, N.Y., June 7, 1979.

Standard & Poor's Corporation, Industry Surveys: Paper Basic Analysis, New York, N.Y., November 15, 1979.

Standard & Poor's Corporation, Industry Surveys: Steel-Coal Basic Analysis, New York, N.Y., October 11, 1979.

Standard & Poor's Corporation, Industry Surveys: Utilities-Electric Basic Analysis, New York, N.Y., March 22, 1979.

Tennessee Valley Authority, Fertilizer Trends 1976, Muscle Schoals, Alabama, March 1977.

Tennessee Valley Authority, Musings of the U.S. Fertilizer Industry 1990, Muscle Schoals, Alabama, September 1978.

U.S. Bureau of Mines, Mineral Commodity Summaries, 1980, Washington, D.C.: U.S. Government Printing Office, 1979.

U.S. Bureau of Mines, Minerals Yearbook 1976, Washington, D.C.: U.S. Government Printing Office, 1979.

U.S. Corps of Engineers, Waterborne Commerce of the United States, 1977, 1979.

U.S. Department of Agriculture, *Agricultural Statistics, 1979*, Washington, D.C.: U.S. Government Printing Office, 1979.

U.S. Department of Agriculture, *Fats and Oils Situation*, Washington, D.C., February, 1979.

U.S. Department of Agriculture, *Feed Situtation*, Washington, D.C., February 1979.

U.S. Department of Agriculture, *Wheat Situation*, Washington, D.C., February 1979.

U.S. Department of Agriculture and U.S. Department of Transportation, *Agricultural Transportation Services: Needs, Problems, Opportunities*, Rural Transportation Advisory Task Force, January 1980.

U.S. Department of the Census, *Statistical Abstract of the United States: 1979*, 100th ed. Washington, D.C., 1979.

Uttal, Bro, "Life is Getting Scary in the Oil Markets" in *Fortune*, Vol. 101, January 28, 1980, pp. 54-57.

GLOSSARY

Action: In the context of NWS, an action is defined as a special act taken to maintain, operate, or improve the present waterways system.

Analyses Commodity: An analysis commodity is a grouping of one or more Waterborne Commerce Commodity Codes. These codes are in turn defined by the Corps and form the basis of commodity reporting in the Waterborne Commerce Statistics.

Analysis Segment: An analysis segment is one of 61 geographic areas for which the inland, Great Lakes, and coastal waterways of the United States have been divided for purposes of the NWS.

Bulk Commodities: Bulk commodities are those liquid commodities which are typically shipped in minimum shipment sizes of full truck loads or more without special bagging, packaging, or stacking requirements.

Carrier: A carrier is a business organized to transport its own products or those products of others.

Commercial User. A commercial user of the waterways is any business organization that uses the waterways for transporting freight.

Constraint: A constraint in the context of the NWS refers to any shortfall in the physical capacity of a port, channel or lock in the present waterway system to meet present or projected waterway transportation use.

Ferrous: A ferrous substance is related to or contains iron.

<u>Forecasts</u>: A forecast is a set of projected traffic levels (in tons) that have been developed from regression models incorporating explicit assumptions about industry and traffic growth. Forecasts have been developed for the NWS assuming that adequate waterway transportation capability will be provided as needed.

<u>Lock</u>: A lock is a chamber located at a dam. The chamber has gates at either end to raise or lower vessels and/or tows as they pass from one side of the dam to another.

<u>Logistics</u>: Logistics refers to the business activity involved in storing, handling, and transporting freight.

<u>Market</u>: A market is any number of spheres within which price-making forces operate and in which exchanges in title tend to be followed by actual movement of freight.

<u>Navigation Aid</u>: A navigation aid is any device that assists operators in the passage of their vessels or tows through waterways. Navigation aids include but are not limited to lights, reflectors, and buoys.

<u>PADD</u>: A PADD is an acronym for Petroleum Administration for Defense Districts. There are five such districts and a map of these districts is shown in Exhibit V-3.

<u>Port Authority</u>: A port authority is any organization usually established by a local, state, or regional government to maintain and improve a port.

<u>Primary Metal</u>: A primary metal product is a basic form in which metals such as steel are provided for further fabrication.

Reporting Commodity: A reporting commodity is one of the 14 groupings of waterborne commerce used in the NWS. Reporting commodities are made up of one or more analysis commodities.

Reporting Region: A reporting region is one of 22 geographical areas into which the present waterways system have been divided. A reporting region is made up of one or more analysis segments.

Scenario: A scenario is a set of events or factors that influence the use of the national waterways for transportation of freight.

Shipper: A shipper is any business organization that uses one or more transportation modes to transport freight.

Waterways Improvement Materials: Waterways improvement materials are materials such as pilings or cement used to maintain or improve the waterways for commercial navigation.

Waybill: A waybill is a document that is prepared by a carrier transporting a shipment of goods, that contains such information as the nature of the shipment, and that serves as a means of identification, a guide for routing, and a basis for freight accounting.

NATIONAL WATERWAYS STUDY

SHIPPER INTERVIEWS

1. American Electric Power
2. Armco Steel
3. Archer Daniels Midland
4. Bethlehem Steel
5. Cargill, Inc.
6. CF Industries
7. Chevron
8. Cleveland-Cliffs
9. Continental Grain Co.
10. Crown Zellerback
11. Dow Chemical
12. Exxon Corporation
13. Grain Terminal Association
14. Houston Light and Power
15. Inland Steel
16. Middle South Utilities
17. Mobil Oil Corporation
18. Morton Salt

NATIONAL WATERWAYS STUDY

SHIPPER INTERVIEWS

19. Northern States Power
20. Olin Corporation
21. Peabody Coal
22. PPG Industries, Inc.
23. Shell Oil Co.
24. TVA
25. Union Carbide
26. U.S. Steel Corporation

NATIONAL WATERWAYS STUDY

CARRIER INTERVIEWS

1. American Commercial Barge Lines
2. American Steamship
3. Campbell Barge
4. Canal Barge
5. Crowley Tug and Barge
6. Federal Barge
7. Ingram Barge
8. Kinsman Lines
9. McAllister Brothers
10. McDonough Marine Services
11. M/G Transport
12. National Marine
13. Oglebay Norton
14. Ohio Barge Line
15. Twin City Barge
16. Union Mechling
17. Valley Lines

NATIONAL WATERWAYS STUDY

PORT AUTHORITY INTERVIEWS

1. Chicago Regional Port District
2. Delaware River Port Authority
3. Greater Baton Rouge Commission
4. Maryland Port Administration
5. Philadelphia Port Corporation
6. Port of Galveston
7. Port of Houston Authority
8. Port of Long Beach
9. Port of Los Angeles
10. Port of Mobile
11. Port of New Orleans
12. Port of Seattle
13. Port of Tacoma
14. Virginia Port Authority

NATIONAL WATERWAYS STUDY

TRADE ASSOCIATIONS INTERVIEWS

1. American Iron and Steel Institute
2. American Paper Institute
3. American Petroleum Institute
4. American Sand and Gravel Institute
5. Chlorine Institute
6. The Fertilizer Institute
7. Manufacturer's Chemists Association
8. National Coal Association
9. National Grain and Feed Association
10. The Salt Institute

APPENDIX B

National Waterways Study Reporting Regions

Segment Name	Description
Upper Mississippi	Minneapolis, Minn. to mouth of Illinois River
Lower Upper Mississippi	Illinois River to Cairo, Ill.
Lower Mississippi	Cairo, Ill. to Baton Rouge, La.
Baton Rouge to Gulf	Baton Rouge, La. (including port) to Mouth of Passes
Illinois River	Chicago, Ill. (Guard Lock) to mouth of Illinois River
Missouri River	Head of navigation to mouth
Ohio River	Head of navigation to Mississippi River
Tennessee River	Head of navigation to mouth
Arkansas River	Head of navigation to mouth
Gulf Coast West	New Orleans, La. to Brownsville, Tex.
Gulf Coast East	New Orleans, La to Key West, Fla.
Tombigbee-Alabama Coosa-Black Warrior River	Heads of navigation to mouth including Tennessee-Tombigbee Waterway
South Atlantic Coast	Key West, Fla. to North Carolina/ Virigina Line
Middle Atlantic Coast	North Carolina/Virginia Line to New York/Connecticut Line
North Atlantic Coast	Hudson River: Waterford to mouth: New York/Connecticut Line to St. Croix River, Maine

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Great Lakes/Saint Lawrence Seaway/ New York State Waterways	
Washington/Oregan Coast	Puget Sound to California-Oregon Line
Columbia-Snake Waterway/ Willamette River	Lewiston, Idaho to Mouth
California Coast	California-Oregon Line to Mexican
Alaska	1/
Hawaii and Pacific Territories	2/
Caribbean, including Puerto Rico and Virgin Islands	2/

NOTE: 1/ Includes Alaska mainland and Aleutian ports, Alaska intrastate routes, and routes from Alaska to the CONUS ports.

NOTE: 2/ Includes both intrasegment routes and routes between segment and Continental U.S.

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