LOUISIANA WATER RESOURCES RESEARCH INSTITUTE

BULLETIN 12B SEPTEMBER 1980

A CHANGE IN THE COURSE OF THE LOWER MISSISSIPPI RIVER : DESCRIPTION AND ANALYSIS OF SOME ECONOMIC CONSEQUENCES

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NOTE:

AN UNUSUALLY LARGE NUMBER OF INDIVIDUALS EMPLOYED BY THE DIVISION OF RESEARCH WORKED ON VARIOUS PARTS OF THIS REPORT. RONALD GILBERT, TERRY ROBERTSON, AND JOHN METCALF DIRECTED AND PREPARED MATERIALS FOR PORTIONS OF THE REPORT. GRADUATE ASSISTANTS EDWARD KING, MARK MILLER AND ALTHEA GRUDEM DESERVE SPECIAL MENTION FOR THEIR WORK IN GATHERING AND ASSIMILATING THE DATA, AND VERY HELPFUL SECRETARIAL ASSISTANCE WAS GIVEN BY JANE MITCHEN, DORA LEBLANC, AND LAURA TOLAR.

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DESCRIPTORS: Water Policy, Louisiana, Atchafalaya Diversion, Economic Impacts, Floods, Disaster Planning

IDENTIFIERS: Old River Control Structure, Highway Disruption, Gas Pipeline Breaks, Low Sill Structure, New Orleans Water Supply

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I

INTRODUCTION

The Economic and Physical Attributes of the Mississippi River

Since the colonial period the Mississippi River has been a major artery of transportation for the United States and has played a significant role in the agriculture and fishing industries. More recently, the Mississippi River has been the predominant source of fresh water for many municipalities and industries and it has served to remove their waste products.

In the colonial and ante-bellum United States, the Mississippi River was vital to agriculture because some of the most fertile soil found on the newly developed continent was located in the Mississippi valley. Farmers shipped their products via the river from Illinois and other midwestern states to Louisiana. In New Orleans the products were transported by clipper ship to northeastern population centers and to foreign markets. The paucity of overland transportation facilities made this route, long and tedious as it was, the only economically feasible method of moving large quantities of commodities to their markets.

The Mississippi River still plays a major role in the north-south transportation of commodities and also provides fresh water to municipalities and industry located along its course. Principal cities obtaining water from the Mississippi include St. Louis, Missouri; and New Orleans, Louisiana. Finally, the river delivers millions of tons of organic nutrients to the Gulf of Mexico, thereby creating one of the most productive fishing grounds in the world.

The Mississippi River, which drains over 1 1/4 million square miles located between the Appalachians and the Rocky Mountains, is the largest body of flowing water on the North American Continent. Hundreds of millions of tons of sediment, produced by the erosion process, are brought towards the mouth of the river on the Gulf of Mexico. These deposits are continually expanding the Mississippi delta. As additional layers of sediment are deposited by the river, the channel lengthens and the stream gradient approaches the horizontal. When this situation occurs, the river seeks to alter its course, searching for a shorter path with a steeper gradient. The geologic record shows that the Mississippi has reached the Gulf of Mexico via at least four separate channels including Bayous Teche and Lafourche, the Sabine River, and its present channel.

The river is now trying to change its course once again. The existing delta now extends to the edge of the continental shelf and the lower Mississippi River has a stream gradient that approaches the horizontal. In effect, there are strong physical forces acting upon the river which are causing it to seek a more direct access to the Gulf. These forces are focussed at a place about 45 miles northeast of Baton Rouge, Louisiana, where the Old River meets the Mississippi River. This location is the site of the Old River Control Structure (ORCS) which controls the distribution of the flow of the Mississippi between the lower Mississippi River and the Atchafalaya River. Below this point the Mississippi River flows approximately 300 miles in a southeasterly direction to the Gulf of Mexico. By way of comparison, the distance to the Gulf via the Old River and the Atchafalaya River is only about 150 miles and the Mississippi River has shown a tendency to use this shorter route to the Gulf of Mexico (see Figure 1.1).

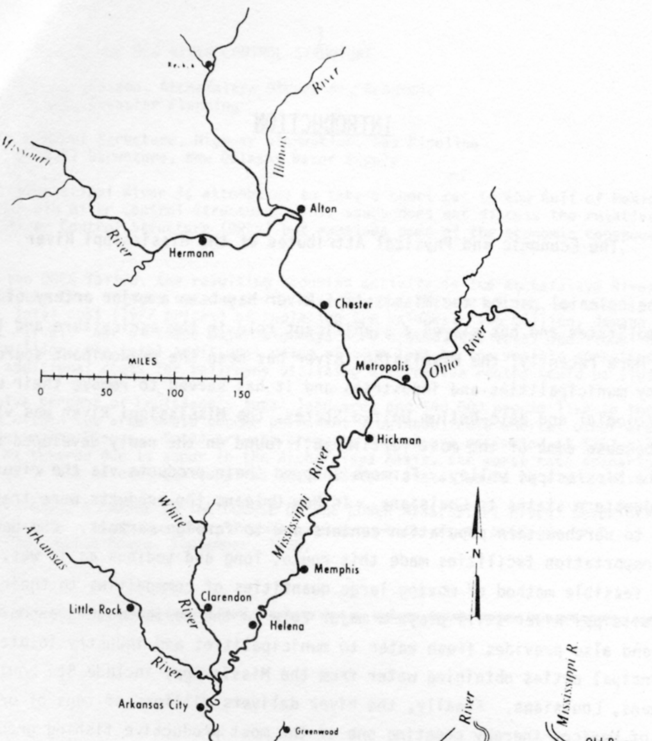

FIGURE 1.1 The Mississippi River System and the Relationship Between the Mississippi River, the Atchafalaya River and the Old River Control Structure.

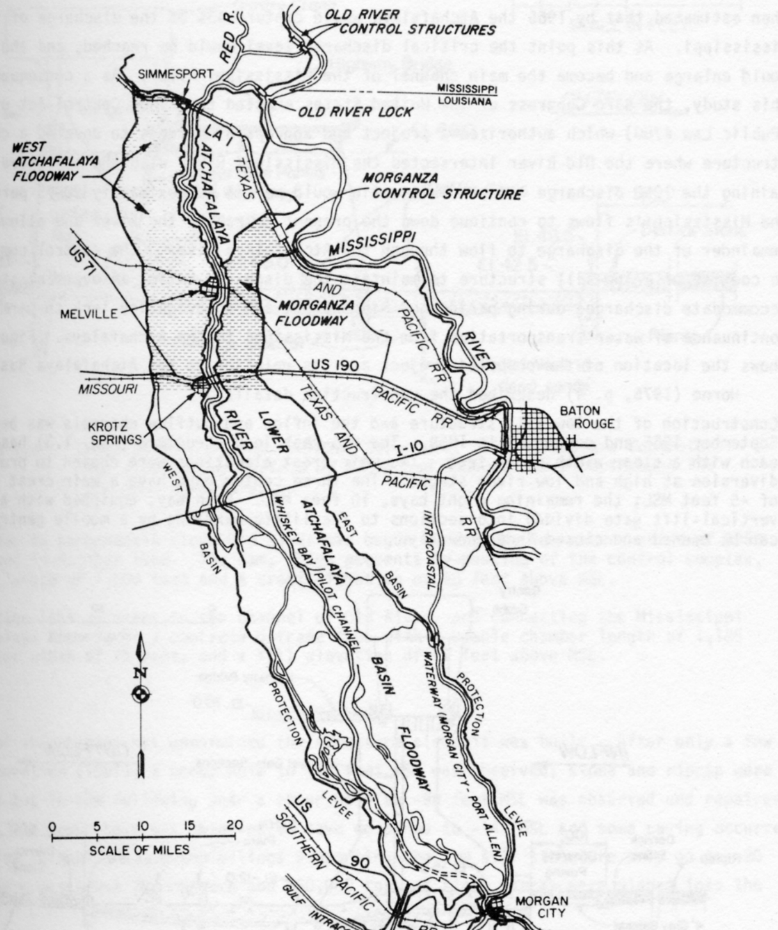

FIGURE 1.2 *Map of the Atchafalaya Basin Showing the Highways and Railroads, the Intracoastal Waterway, and the Protection Levees. Note the Relative Postions of Morgan City and the Wax Lake Outlet.*

The Old River Control Structure: Background and Significance

The origins of the Old River Control Structure date back to 1950 when Latimer and Schweizer conducted a survey for the Mississippi River Commission (MRC) and concluded that the Mississippi's flows were increasingly being diverted into the Atchafalaya River. It was then estimated that by 1965 the Atchafalaya would capture 43% of the discharge of the Mississippi. At this point the critical discharge level would be reached, and the Atchafalaya would enlarge and become the main channel of the Mississippi River. As a consequence of this study, the 83rd Congress of the United States enacted the Flood Control Act of 1954 (Public Law #780) which authorized a project and appropriated funds to develop a control structure where the Old River intersected the Mississippi River with the objective of maintaining the 1950 discharge ratio. This ratio would permit approximately 70-75 percent of the Mississippi's flows to continue down the present course of the river and allow the remainder of the discharge to flow through the Atchafalaya River. The control complex was to consist of a low-sill structure to maintain the discharge ratio, an overbank structure to accommodate discharges during periods of high water, and a navigation lock to permit the continuance of water transportation from the Mississippi to the Atchafalaya. Figure 1.2 shows the location of the proposed project and its relation to the Atchafalaya Basin.

Horne (1976, p. 4) described the construction details:

> Construction of the low-sill structure and the inflow and outflow channels was begun in September 1955 and completed in 1959. The 566-feet long structure (Fig. 1.3) has 11 bays, each with a clear width of 44 feet. Two weir crest elevations were chosen to provide diversion at high and low river stages. The three center bays have a weir crest elevation of -5 feet MSL; the remaining eight bays, 10 feet MSL. Each bay, equipped with a steel vertical-lift gate divided into sections to facilitate handling by a mobile gentry crane, can be opened and closed independently.

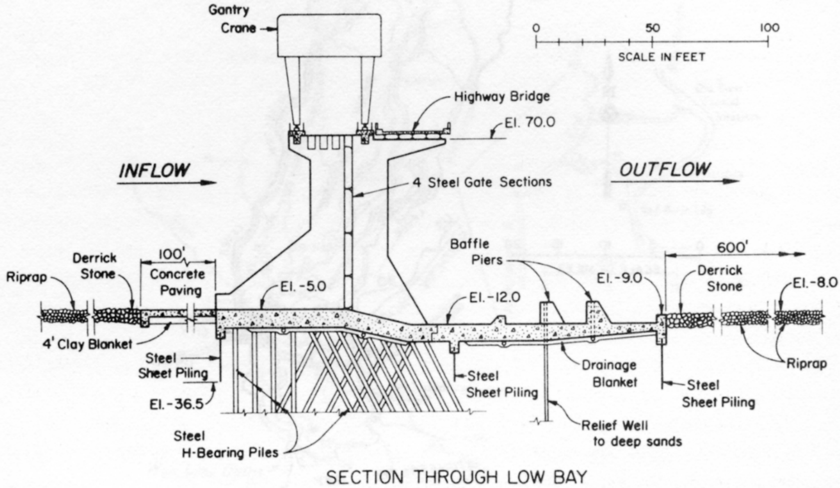

FIGURE 1.3 *Cross Section of the Low Sill Structure.*

> The inflow channel from the Mississippi River and an outflow channel joining the Red River at mile 12 above its mouth were excavated. River water is directed into the structure by curved wing walls on each end. Steel H bearing piles driven into deep sand to an elevation of -90 feet MSL support the structure. Steel sheel piling, driven to elevation -36 feet MSL, was used as cut-off walls to minimize erosion and seepage under the structure.
>
> No piles were used under the guide wells on the inflow channel because stability studies showed pile supports to be unnecessary.

The overbank structure, begun in 1956 and completed in 1959 consists of 73 gated bays, each with a clear width of 44 feet between piers (Fig. 1.4). The total length is 3,358 feet. The weir crest elevation in all bays is 52 feet MSL. Flow is controlled by hinged timber panels operated by a gentry crane.

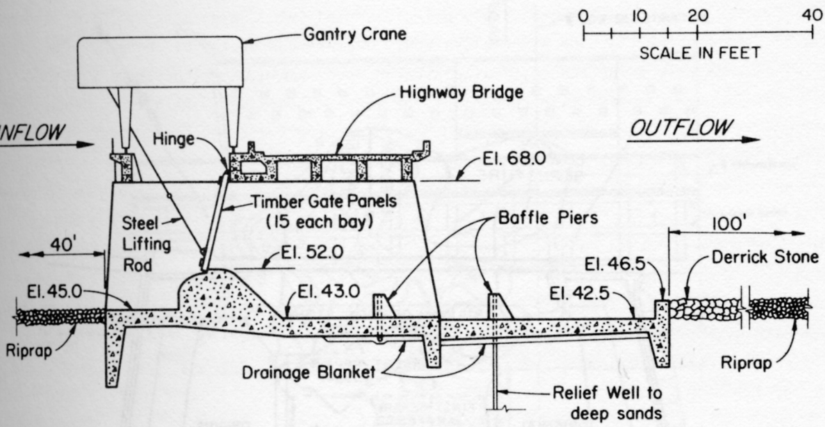

FIGURE 1.4 Cross Section of the Overbank Structure. This Structure Controls the Flow During Periods of Flood and Reduces the Flow Through the Low Sill Structure.

The earth dam to permanently close Old River was begun during the low-water period of 1962 and completed in October 1963. The dam, which prevents by-passing of the control complex, has a base length of 1,500 feet and a crest elevation of 68 feet above MSL.

The navigation lock adjacent to the channel of Old River, and connecting the Mississippi and Atchafalaya Rivers, is a concrete U-frame type with a usable chamber length of 1,185 feet, a clear width of 75 feet, and a sill elevation of 11 feet above MSL.

Scour Problems

Scour of the channel has undermined the structure since it was built. After only a few months of operation (1961), a scour hole to -40 feet MSL was observed; stone and riprap were placed in it but in the following year a scour hole to -90 feet MSL was observed and repaired. During 1964, the scour hole was observed to have deepened to -140 MSL and some caving occurred in the outflow channel. Since the pilings supporting the low sill structure only go to -90 feet MSL, there was cause for concern and 150,000 tons of stone riprap were placed into the scour hole.

The first major test of the ORCS came during the flood of 1973. Three separate factors were responsible for the flood: 1) the melting of the heavy snow cover in the midwest, 2) abnormally large amounts of rainfall in the lower Mississippi Valley, and 3) sustained southerly winds for about two weeks during May, 1973 which retarded the movement of flood waters downstream in the Basin and hindered normal drainage into the Gulf.

Shortly after the onset of the Spring flood of 1973, it was discovered that a large scour hole had been created in the bed of the inflow channel of the ORCS which not only undermined the left wing wall of the Low Sill Structure but exposed the supporting pilings of the Low Sill Structure down to -50 feet MSL. On April 14, 1973, the wall collapsed and it became apparent to the Corps that emergency actions were needed. The Overbank Structure and the Morganza floodway were opened for the first time to reduce the flow through the Low Sill Structure. Despite these measures the Corps of Engineers reported a maximum discharge of 500,000 cfs through the Low Sill Structure, as compared with the expected maximum of

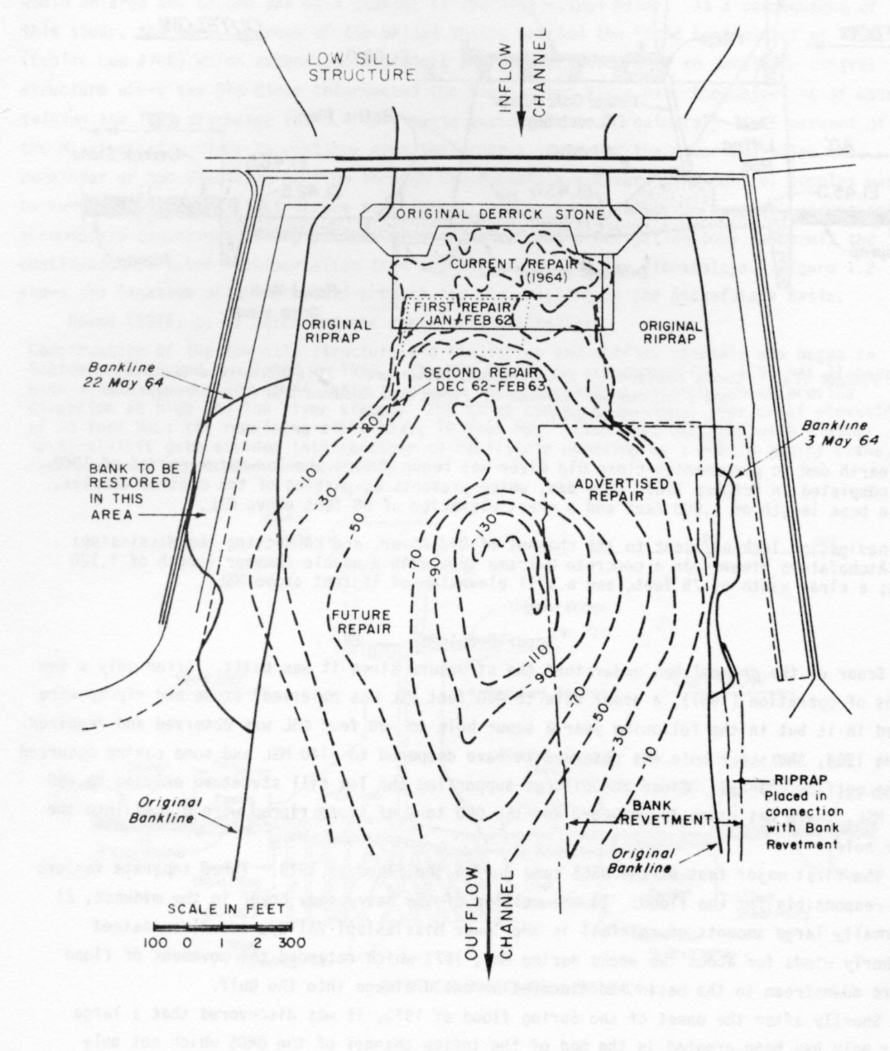

FIGURE 1.5 Scour Hole Just Downstream of the Low Sill Structure in 1963. In 1973 this Hole Was Undoubtedly Scoured Deeper Than Shown Here.

325,000 - 350,000 cfs. After the flood had subsided, the Corps surveyed the riverbed to determine the extent of the scour activity and found that in addition to the -50 MSL hole in the inflow channel there was a scourhole in the outflow channel at -130 ft.

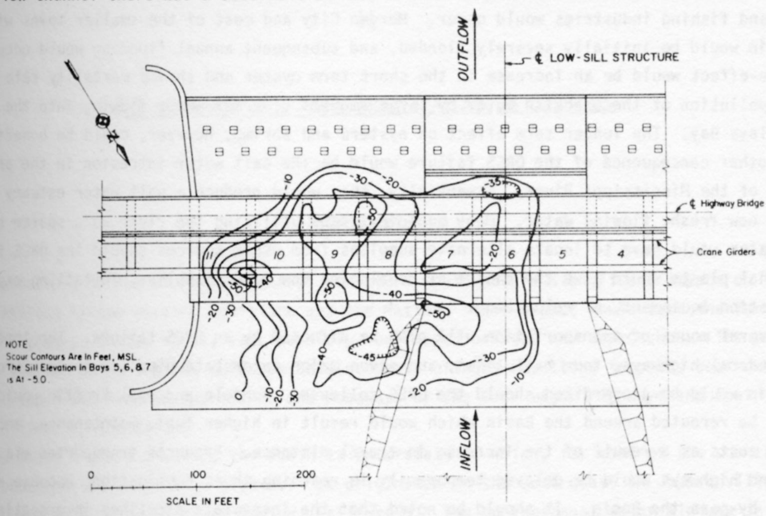

FIGURE 1.6 *Scour Hole Upstream from and under the Low Sill Structure During the Flood of 1973. This Figure Should Be Studied in Conjunction with 1.5.*

Since 1973, the Corps has rebuilt the wing wall and has continued to drop concrete and granite boulders into the scour holes. The approximate extent and location of the scour activity in the inflow and outflow channels is depicted in Figures 1.5 and 1.6 respectively.

Resource Allocation Effects

The conditions which have created the scouring activities are very likely to become more severe in the future. For any given set of flood conditions in the watershed, the water levels of the lower Mississippi River are higher. The Atchafalaya River is in the process of deeping and widening, with a resulting lowering of the water level in the upper reaches of the river for the same discharge. This means the water level differences between the two rivers at and near the ORCS are becoming greater. This increasing differential between the respective levels of the two rivers will increase discharge and velocity through the ORCS which, in turn, will increase scouring.

This paper does not discuss the probability of ORCS failure, nor the time frame in which failure is most likely to occur. Its purpose is to examine some of the economic consequences which would result from an ORCS failure if it occurred. Most of the cost estimates are very approximate and not all of the consequences are examined in detail.

Relatively little has been done to correct the underlying deficiencies of the ORCS. Many engineers believe that the structure has been weakened to such an extent that, were another flood similar to that of 1973 to occur, the ORCS could not successfully withstand it. Other engineers speculate it would take a flood at least 1.5 times as large as the Spring, 1973 flood to cause the structure to fail. If the structure does fail, the Atchafalaya would probably capture most of the Mississippi within three months: the discharge ratio might become 70% down the Atchafalaya and 30% down the present main-stem Mississippi. Once a complete failure of the ORCS occurred, it would be very expensive, if not technically impossible, to restore the previous discharge ratio.

The extent of the first year flooding in Louisiana could, as a minimum, reach from Bayou Teche in the west to Bayou Lafourche in the east. This area constitutes almost 11% of

Louisiana's total land area, and the entire Atchafalaya Basin would be subject to severe inundation each spring until new flood protection works could be built. The Basin would be essentially uninhabitable and serious disruptions of production in the oil and gas, agricultural, and fishing industries would occur. Morgan City and most of the smaller towns within the Basin would be initially severely flooded, and subsequent annual flooding would occur. One side-effect would be an increase in the short term oyster and shrimp mortality rate due to the pollution of the brackish water by large amounts of fresh water flowing into the Atchafalaya Bay. The longer term effect on oysters and shrimp, however, could be beneficial.

Another consequence of the ORCS failure would be the salt water intrusion in the present channel of the Mississippi River. Essentially, this would produce a salt water estuary in what is now fresh, flowing water. Many municipalities utilizing the river as a source of fresh water would have to locate alternate supplies from other sources should the ORCS fail. Industrial plants would have the choice of developing new water supplies, installing expensive desalination equipment, or relocating.

Several modes of transportation will also be affected by an ORCS failure. The three major federal highways, four rail lines, and seven major interstate pipeline systems crossing the basin would be jeopardized should the ORCS collapse. Vehicle and rail traffic would have to be rerouted around the Basin which would result in higher fuel, maintenance, and capital costs as a result of the increase in travel distance. Products transported via the rails and highways would be delayed temporarily in reaching their destinations because of need to by-pass the Basin. It should be noted that the interstate pipelines intersecting the Basin transport about 15% of the total natural gas consumed in 28 eastern and southern states each year. If all or most of the pipelines fail, many communities and industries in the north-east portion of the United States might be without supplies of natural gas for some period of time.

Another anticipated effect is that as the Atchafalaya continued to capture an ever larger portion of the Mississippi, the Mississippi River channel below the ORCS structure would fill with silt and barge navigation on the river would be imperiled. If this occurred there are three options which could be pursued. River traffic could be routed down the Atchafalaya River, then east on the intercoastal waterway to New Orleans; a lock and dam, accompanied by some dredging, could be built south of the ORCS to by-pass the shoal; or extensive and continual dredging operations could be conducted in the silted area south of the ORCS.

II

THE HIGHWAY AND RAIL TRANSPORTATION SECTORS

Introduction

The failure of the Old River Control Structure would have a significant impact on the transportation system serving Louisiana and the Nation. This impact would take the form of flooded highways, eroded banks, and, possibly, collapsed bridges and approaches. The purpose of this chapter is to examine some possible economic effects resulting from the destruction of key bridges and related approaches and roadways of the four major highways and four railroad lines in the Basin.

The major highway crossing the Basin is Interstate 10 which, for most of the country, is the southernmost interstate highway. It originates on the east coast in Jacksonville, Florida, and terminates in Santa Monica, California. The southernmost major highway in Louisiana is U.S. 90 which crosses the Basin at Morgan City and follows a route through New Orleans, Houma, Lafayette, and Lake Charles. Both I-10 and U.S. 90 serve as major east-west transportation routes. U.S. 190 which runs parallel to I-10 and about 15 miles north of it connects Covington, Baton Rouge, and Eunice and crosses the Atchafalaya Basin at Krotz Springs.

The northernmost rail line, owned by the Texas and Pacific Railroad crosses the Atchafalaya River at Simmesport. The two central railroad lines which cross the Basin at Melville and Krotz Springs are owned by the Texas and Pacific and Missouri Pacific railroads, respectively. The southernmost line is operated by the Southern Pacific Company and passes through Morgan City - Berwick area. If the ORCS were to fail, the bridges serving these highways and railroads would be subject to increased scour activity which might undermine the supporting piers and cause the bridges to collapse. Loss of these commercial arteries would virtually disrupt all rail and highway transportation across the basin. In Figure 1.2, a map of the four major highway and four rail line bridges transversing the basin is presented.

Estimate of Economic Costs Resulting From Highway Disruption

Highways and Bridges

Although the failure of the ORCS could result in flood and erosion damage to the highways and their roadbeds, the most significant impact would be the destruction of the bridges. In discussions with bridge design consultants at the Louisiana Department of Transportation and Development, it was apparent that the bridges were designed to operate safely during average and high water levels and that the bridge super-structure could withstand severe stresses. Even if the ORCS should fail and most of the waters of the Mississippi River were to flow under the affected bridges, it is very unlikely that the bridges would be destroyed as a direct result of the impact of water. The most probable cause of destruction would be the undermining of the supporting piers by scouring activity. During the 1973 flood a scour hole deeper than the depth of the centerline pier (-155 ft.) was observed approximately 600 downstream of the I-10 bridge over Whiskey Bay and, although that hole has been filled in by loose sediment it will scour very quickly in the next flood.

As shown in Table 2.1 the total costs of replacing the five bridges across the Atchafalaya are approximately $65 million in 1977 dollars. These estimates are made by adjusting the bridge construction costs in the year in which they were incurred by the Federal Highway Administration's construction cost index for 1977.

TABLE 2.1

PUBLIC EXPENDITURES ON HIGHWAY BRIDGES AND ESTIMATED REPLACEMENT COSTS

Highway	Location	Substructure Year	Substructure Cost	Superstructure Year	Superstructure Cost	1977 Dollar Cost[1] Sub-	1977 Dollar Cost[1] Super-	Estimated Replacement Costs
I-10	Atch. River	--	--	1972	$ 6,590,350	--	$ 9,693,346	$ 9,693,346[2]
I-10	Whiskey Bay	--	--	1972	13,340,047	--	19,621,065	19,621,065[2]
U.S. 190	Krotz Springs	1972	$3,265,244	1973	4,371,590	$ 4,802,649	5,772,955	10,575,604
La. 1	Simmesport	1967	2,861,938	1971	2,838,043	5,918,488	4,237,598	10,156,086
U.S. 90	Morgan City	1972	4,790,457	1975	7,847,902	7,045,992	7,709,958	14,755,950
Total			$10,917,639		$34,987,932	$17,767,129	$47,034,922	$64,802,051

1 Costs of structure in the year it was completed were inflated by the Federal Highway Administration Construction Cost Index.

2 Costs for that portion of the project directly over the Atchafalaya River and Whiskey Bay.

Source: Louisiana Department of Transportation and Development, Bridge Design Section.

The cost estimates for the bridges do not include the elevated approaches to the bridges. It is possible that a failure of the bridges would also cause partial failure of the approaches. Because I-10 and U.S. 90 are elevated on both sides of the bridges, there are no identifiable approaches. The costs of the bridge approaches for U.S. 190 and La. 1 are shown in Table 2.2. These replacement costs, which are estimated to be $5.9 million, are adjusted to reflect 1977 prices.

TABLE 2.2

REPLACEMENT COSTS FOR BRIDGE APPROACHES

Highway	Location	Approach Length (ft.)	Departure Length (ft.)	Total Length (ft.)	Replacement Cost
U.S. 190	Krotz Springs	970	915	1,885	$2,525,900
La. 1	Simmesport	1,171	1,311	2,482	3,325,880
Total					$5,851,780

Flood waters in the Basin could also erode and damage the roadways within the Basin but I-10, which is elevated throughout the Basin, is unlikely to suffer extensive roadway damage. The Louisiana Department of Transportation and Development's 1977 estimate of the costs of replacing, or extensively repairing, one mile of high-grade road surface is about $250,000. Total cost (1977) of replacing all roadways excluding I-10 which is elevated in the Basin, are estimated to be approximately $14 million as shown in Table 2.3. Not all of the roadways would suffer damages, however, so it assumed that only 20 percent would require extensive repairing at a cost of approximately $2.8 million.

TABLE 2.3

REPLACEMENT AND REPAIR COSTS OF MAJOR ROADWAYS IN THE ATCHAFALAYA BASIN (Excluding Bridges and Approaches)

Highway	No. of Miles	Total Cost at $250,000/mile	Estimated Damages at 20%
190	25	$ 6,250,000	$1,250,000
1	29	7,250,000	1,450,000
90	3	750,000	150,000
TOTAL		$14,250,000	$2,850,000

Table 2.4 presents total replacement costs estimates for the major highways in the Basin including roadways, approaches, and bridges. Total estimated replacement costs (1977 prices) are $72 million. This estimate does not include the damages to rural access raods, municipal streets or secondary highways. These losses are included in the estimate of the losses to the public sector in Chapter IV of this study.

TABLE 2.4
Total Replacement Costs:
Highways, Approaches, and Bridges

Highway	Roadways	Approaches	Bridges	Total
I-10	--	--	$29,314,411	$29,314,411
U.S. 190	$1,250,000	$2,525,900	10,575,604	14,351,504
LA 1	1,450,000	3,325,900	10,156,086	14,931,966
U.S. 90	150,000	--	14,755,950	14,905,950
TOTAL	$2,850,000	$5,851,780	$64,802,051	$73,503,831

a. Operating Costs: If one or more of the major highways crossing the Basin should be closed for any period of time, highway users would have to use alternative routes which would result in increased costs for fuel, tire wear, maintenance, and other "wear and tear" on automobiles and trucks. In addition, individuals and employers will suffer a significant loss for the value of additional time spent on alternative routes.

The vehicle counts listed in Table 2.5 were taken at the Atchafalaya crossings in 1977. These vehicle counts are listed by automobiles and trucks for each crossing.

U.S. 90, whose bridges are the least vulnerable of all four bridges, carried the most traffic each day in 1977. The I-10 bridge, the structure most likely to collapse, had the second highest traffic count per day. Although the other two bridges carried lesser amounts of traffic, these roadways play an important part in the Louisiana transportation network.

Cost per mile data for automobiles were obtained from the United States Department of Transportation. Only variable costs are included in the total figure inasmuch as fixed costs would not be affected by the increased usage of the vehicles. The variable costs included in the cost per mile data include: maintenance, tires, gasoline, and motor oil. A breakdown of these pertinent costs is presented in Table 2.6.

TABLE 2.5

Average Traffic Counts for Bridges Crossing the Atchafalaya Basin (vehicles/day, 1977)[1]

Bridge	Automobiles[2]	Trucks[3]	Total
US I-10	10,185	3,395	13,580
US 190	6,040	1,510	7,550
LA 1	3,348	372	3,720
US 90	14,339	3,811	18,150

[1] Louisiana Department of Transportation and Development, Traffic Planning Division

[2] Pickup and panel trucks, automobiles, all other vehicles

[3] 18-wheeler and medium trucks

TABLE 2.6

Variable Costs Per Mile for Automobiles (1977)

Type	Cost (cents)
Maintenance	2.9
Fuel	3.3
Tires and Oil	5.7
Total	12.2

SOURCE: United States Department of Transportation

The federal government has not conducted a survey of operating costs for trucks on a per mile basis so private sources were used for these estimates. In 1975, the Hertz Corporation produced a survey of operating expenses for both automobiles and trucks. The costs for automobiles were higher than those reported in the Federal publications so the relative ratios were utilized. Variable expenses for trucks were roughly twice as high as those for cars in 1975; and if the ratio of variable expenses for trucks to cars is the same in 1977 as in 1975, the estimated variable costs for trucks are almost 25 cents per mile.

The amount of variable costs imposed on individuals and business firms will be affected by the number and types of highway closed. Since U.S. I-10 and U.S. 190 bridges are the most vulnerable to failure, Case I assumes that these will fail. In the second, and worst, case it is assumed that all four bridges are undermined and transportation through the Basin is impossible.

If the two bridges in Case I were to fail, vehicular transportation would be able to cross the Basin via the Highway 1 bridge to the north and the Highway 90 bridge to the south. Travelers from Lafayette to Baton Rouge could be rerouted through Morgan City via U.S. 90, La. 20 from Morgan City to Thibodaux, and La. 1 from Thibodaux to Baton Rouge. As a result of the I-10 and U.S. 190 bridge failures there would be a 96 mile detour at a daily total cost of $119,266 for automobiles and $79,511 for trucks (Table 2.7). Similarly, travelers from Alexandria to Baton Rouge would use La. Highway 1 and U.S. 190 through Simmesport rather than La. 71 and U.S. 190 through Krotz Springs. The detour would total 6 miles and represent a daily cost of $4,400 for automobiles and $2,200 for trucks should the U.S. 190 bridge collapse. It is assumed in the calculations that all U.S. 190 traffic is traveling from Alexandria to Baton Rouge, which is a very conservative assumption. The breakdown of the costs per vehicle produced by the detours, and total cost, is shown in Table 2.7. Total cost for a one year detour would be $45 million for automobiles and $30 million for trucks for a total of $75 million.

TABLE 2.7

COSTS OF DETOURS ASSUMING FAILURES OF
U.S. I-10 AND U.S. 190 BRIDGES

Variable Operating Costs for Automobiles

Highway	No. Miles Detour	Cents Per[1] Mile	Cost Per Vehicle	No. Veh.[3] Per Day	Total Cost Per Day
US I-10	96	12.2	$ 11.71	10,185	$119,266
LA 1/US 190	6	12.2	.73	6,040	4,409
Total Daily Cost for Automobiles					$123,675
Annual Cost					$45,141,375

Variable Operating Costs for Trucks

Highway	No. Miles Detour	Cents Per[2] Mile	Cost Per Vehicle	No. Veh. Per Day	Total Cost Per Day
US I-10	96	.244	$23.42	3,395	$79,511
US 190	6	.244	1.46	1,510	2,205
Total Daily Cost for Trucks					$81,716
Annual Cost					$29,826,340
Total Daily Costs for Automobiles and Trucks					$ 205,391
Total Annual Costs for Automobiles and Trucks					$74,967,715

Sources: 1. U.S. Department of Transportation
2. The Hertz Corporation, 1975, adjusted to 1977 prices
3. Louisiana Department of Transportation and Development

Case II depicts a situation in which all four bridges across the Basin have been undermined. In this instance all traffic will have to be rerouted north of the Basin through Natchez, Mississippi. This route, of course, involves many more miles of detour than the previous case.

West bound I-10 traffic would be detoured from Baton Rouge northward along U.S. 61 to Natchez, then southwest to Alexandria along U.S. 54 and La. 28, and finally back to I-10 via U.S. 71 and La. 13. The total detour necessitates 221 additional travel miles. Vehicles traveling on U.S. 190 should take the same route as above, but the detour for Highway 190 traffic is 18 miles less for a net 203 additional miles. Traffic utilizing La. 1 will also use the same route to Natchez, but will be able to rejoin La. 1 at Alexandria for a total of 159 detour miles.

Finally, U.S. 90 runs parallel to I-10 to the west of the Basin. Most west bound traffic using this highway passes through New Orleans and would be forced to take U.S. 61 to Natchez and then the same southwesterly route to U.S. 90 as described above. This additional distance would require a detour of approximately 300 miles.

Total variable operating costs of automobiles and trucks assuming failure of all bridges are shown in Table 2.8. The daily costs for automobiles making the detour are $1 million and for trucks it is $550,000. The total costs of detouring for one year would be approximately $573 million.

TABLE 2.8

COSTS OF DETOURS ASSUMING FAILURE OF ALL BRIDGES CROSSING BASIN

Variable Operating Costs for Automobiles

Highway	No. Miles in Detour	Costs Per[1] Mile	Cost Per Vehicle	No. Veh.[3] Per Day	Total Cost Per Day
US I-10	221	12.2	$26.96	10,185	$ 274,588
US 190	203	12.2	24.76	6,040	149,550
LA 1	159	12.2	19.40	3,348	64,951
US 90	302	12.2	36.84	14,339	528,249
TOTAL Daily Cost					$ 1,017,338
Annual Cost					$371,328,370

Variable Operating Costs for Trucks

Highway	No. Miles in Detour	Costs Per[2] Mile	Cost Per Vehicle	No. Veh. Per Day	Total Cost Per Day
US I-10	221	.244	$53.92	3,395	$ 183,058
US 190	203	.244	49.53	1,510	74,790
LA 1	159	.244	38.79	372	14,430
US 90	302	.244	73.69	3,811	280,833
TOTAL Daily Cost					$ 553,111
Annual Cost					$201,885,515

TOTAL Daily Costs for Automobiles and Trucks	$ 1,570,449
TOTAL Costs of a one year detour for Automobiles and Trucks	$573,213,885

Sources:
1. U. S. Department of Transportation
2. The Hertz Corporation, 1975
3. Louisiana Department of Transportation and Development

b. Value of Time Loss: In addition to the operating costs which would be incurred by highway users, the failure of the bridges and the resulting detours would result in additional time utilized by the travelers. This additional time has a value both to those engaged in economic pursuits and to those who are traveling for leisure. The average wage rate of drivers of semi-trucks and medium trucks, obtained from the U.S. Department of Labor, was

TABLE 2.9

VALUE OF TIME LOSSES PER DAY ASSUMING FAILURES OF U.S. I-10 and U.S. 190 BRIDGES

Vehicle	Vehicles/ Day Crossing Basin	Ave. No. Occupants/ Vehicle	Ave. Wage Rate/ Occupants	No. of Miles Detoured	Hours Required to Detour	Total Time Value Loss
U.S. I-10						
Semi-truck	2,580	1.0	$9.90	96	2.13	$ 54,404
Medium truck	815	1.0	5.30	96	2.13	9,200
Automobiles and Other	10,185	1.5	2.65	96	2.13	86,234
Total	13,580					$149,838
U.S. 190/LA 2						
Semi-truck	981	1.0	$9.90	6	0.13	$ 1,262
Medium truck	529	1.0	5.30	6	0.13	364
Automobiles and Other	6,040	1.5	2.65	6	0.13	3,121
Total U.S. 190	7,550					$ 4,747
Total Cost Per Day						$154,585
Total Costs Assuming a one year detour						$56,423,525

(1) Department of Labor, 1977
(2) Data from Table 2.8
(3) Calculated at 45 mph.
(4) Cols. 1 x 2 x 3 x 5

TABLE 2.10

VALUE OF TIME LOSSES PER DAY ASSUMING FAILURES OF U.S. I-10, U.S. 190, LA 1, and U.S. 90 BRIDGES

Vehicle	Vehicles/ Day Crossing Basin	Ave. No. Occupants/ Vehicle	Ave. Wage Rate/ Occupant	No. of Miles Detoured	Hours Required to Detour	Total Time Value Loss
U.S. I-10						
Semi-truck	2,580	1.0	$9.90	221	4.91	$ 125,411
Medium truck	815	1.0	5.30	221	4.91	21,209
Automobiles and Other	10,185	1.5	2.65	221	4.91	198,783
Total	13,580					$ 345,403
U.S. 190/LA 2						
Semi-truck	981	1.0	$9.90	203	4.51	$ 43,801
Medium truck	529	1.0	5.30	203	4.51	12,645
Automobiles and Other	6,040	1.5	2.65	203	4.51	108,281
Total	7,550					$ 164,727
LA 1						
Semi-truck	149	1.0	$9.90	159	3.53	$ 5,207
Medium truck	223	1.0	5.30	159	3.53	4,172
Automobiles and Other	3,720					46,978
Total	3,720					$ 56,359
U.S. 90						
Semi-truck	1,996	1.0	$9.90	302	6.71	$ 132,592
Medium truck	1,815	1.0	5.30	302	6.71	64,657
Automobiles and Other	14,339	1.5	2.65	302	6.71	382,453
Total	18,150					$ 579,591
TOTAL DAILY COST FOR ALL HIGHWAYS						$ 1,146,078
TOTAL COSTS, ASSUMING A ONE YEAR DETOUR						$418,318,470

(1) Department of Labor, 1977
(2) Data from Table 2.8
(3) Calculated at 45 mph.
(4) Cols. 1 x 2 x 3 x 5

applied to the number of similarly classed vehicles crossing the Atchafalaya highways. These are good wage estimates but they are conservative because they do not include many fringe benefits.

Estimating the value of time of the occupants of automobiles is more complicated. If individuals were free to adjust their hours, the value of their leisure time, at the margin, would equal their wage rate, less an income tax adjustment. We utilized the minimum wage rate of $2.65 which, before income taxes, would be approximately equal to an hourly wage rate of $3.53.

The daily costs of lost time in Case I, in which only I-10 and U.S. 190 bridges were closed, would be $154,585 with an annual cost of $56 million (Table 2.9). The daily cost in Case II, in which all bridges were closed, would be $1.1 million with an annual cost of $418 million (Table 2.10).

Table 2.11 presents estimates of the total operating and time costs involved in the detours. In Case I, the total daily costs of the detours are $360 thousand and in Case II they are approximately $2.7 million. Generally the construction of major bridges would take two to three years, but because part of the bridges would remain intact and because of the emergency nature of the situation the bridges would be reconstructed in less time. If the time period from the moment of failure to the reopening of the bridge were one year, the total time and operating costs imposed by the detours would be $130 million in Case I and approximately $1 billion in Case II.

TABLE 2.11

TOTAL ESTIMATED COSTS OF BRIDGE FAILURES

Case 1: Assumes Failure of I-10 and U.S. 190 Bridges	Daily	One Year
Additional operating costs	$205,391	$ 74,967,715
Value of time losses	154,585	56,423,525
	$359,976	$131,391,240

Case 2: Assumes Failure of All Bridges Across the Basin	Daily	One Year
Additional operating costs	$1,570,449	$573,213,885
Value of time losses	1,146,078	418,318,470
	$2,716,527	$991,532,355

Losses to Rail Carriers

Currently there are four rail bridges spanning the Atchafalaya River, but the only two which remain in service are the Southern Pacific's bridge near Morgan City and the Missouri Pacific Railway crossing at Krotz Springs. Both lines were originally constructed in the early part of this century, and both are probably vulnerable should the ORCS fail.

If the Southern Pacific bridge at Morgan City collapsed as a result of ORCS failure, the six trains per day that cross the Basin on this line would have to be rerouted from New Orleans through Natchez and finally reconnect at the main line west of the Atchafalaya. The total detour mileage necessitated by the failure of the Southern Pacific bridge would be approximately 300 miles. The four daily trains passing through the Basin on the Missouri Pacific tracks would follow virtually the same route; but their line lies roughly 20 miles north of the Southern Pacific's. Therefore, the Missouri Pacific trains would have to detour approximately 280 miles.

Table 2.12 presents the operating losses per day for the rail industry caused by an ORCS failure. The figure for cost per mile of $35.25, was obtained from the Economics and Finance Department of the Association of American Railroads. The loss of the two bridges would cost Southern Pacific about $63,000 per day and Missouri Pacific just under $40,000 per day in additional expenses. The total cost per day would be almost $103,000. Again, if it is assumed that it would take one year to rebuild the two bridges, the total cost to these two railroads, alone, would be more than $37 million dollars.

TABLE 2.12

POTENTIAL COSTS TO THE RAIL INDUSTRY DUE TO DETOURS

Line	Cost per mile per train	# Miles in Detour	Cost per Train	# Trains per day	Total Cost per day
So. Pac.	$ 35.25	300	10,575	6	$ 63,450
Mo. Pac.	35.25	280	90,870	4	39,480
TOTAL PER DAY					$ 102,930
ANNUAL COSTS					$37,539,450

Source: Division of Research and the Economics and Finance Department of the Association of American Railroads, 1977

In addition to the operating losses, the railroads would suffer the capital loss of replacing the bridges. We were unable to obtain any information on the costs of replacing the bridges, primarily because no similar major railroad bridges have been built recently. There is also some doubt about the financial ability of the railroads to replace these bridges. They might continue the detour routes indefinitely.

III

EFFECTS OF A LOSS OF THE OLD RIVER CONTROL STRUCTURE ON NATURAL GAS PIPELINES

Introduction

Seven major interstate gas pipeline systems cross the Atchafalaya Basin and would be vulnerable to damage by flood waters if the ORCS should fail. The seven systems include pipelines owned by the Columbia Gulf Transmission Compnay (CGT), the Florida Gas Transmission Company (FGTC), the Southern Natural Gas Transmission Company (SNG), the Texas-Eastern Transmission Company (TET), the Texas Gas Tramsmission Company (TGT), the Transcontinental Company, (TRANSCO), and the United Gas Transmission Company (UGT). Collectively the pipelines of these companies which cross the Basin carry about 15 percent of the natural gas consumption east of the Mississippi River. Although even a 15 percent decrease in natural gas availability which occured suddenly and without time to make adjustments for other energy sources would be a cause for concern, some states would have a much larger percentage of their natural gas curtailed.

The purpose of this chapter is to describe the situation and to analyze some alternative scenarios. The analysis is presented in three scenarios: The first scenario assumes the failure of only one or two lines crossing the Atchafalaya Basin. The second scenario is a situation in which five of the seven lines in the Basin are ruptured. In this instance there could be some curtailments of gas deliveries to most of the states served by natural gas lines crossing the Atchafalaya. Finally, the third scenario is the worst case situation: a failure of the ORCS which has ruptured all the lines in the Basin would most likely cause some curtailments of natural gas deliveries.

The Probability of Failure of Natural Gas Pipelines

A general overview of the major natural gas pipeline systems crossing the Atchafalaya River Basin is presented here. Variables such as the age of the system, the type of crossing (i.e., under river or aerial), subsoil characteristics at crossings, discharge of the river at the point of crossing, and the number of lines contained within each system have been evaluated and the various pipelines ranked in order of their probability of failure. The probabilities assigned are ordinal rankings of likelihood of failure because precise numerical values could not be assigned. For example, it is impossible to state that an ORCS failure would result in a seventy percent chance of a rupture in the United Gas pipeline. It is a matter of judgement to conclude that should the ORCS fail, United Gas pipeline would be more likely to fail than, say, the Transco line, but less likely than the Columbia Gulf line. The ordinal ranking of the likelihood of failure has been based upon detailed analyses of the five variables mentioned above. Although there are no generally accepted criteria which can be used to assess the probability of a pipeline failure, the pipeline companies generally agreed with the analysis.

The age of the system is one variable which must be considered in the ordinal ranking. Some pipelines constructed as early as 1942 have been inspected recently and have shown no evidence of deterioration while other lines constructed as recently as 1960 are already showing signs of wear.

The type of pipeline crossing the waterway, whether under river or aerial, plays a major role in the probability of line destruction. Subriver crossings are occasionally exposed on a river bed through the process of bottom scour or erosion. Major floods can increase the rate of erosion and uncover the buried lines, thus exposing them to swift currents and to impacts from large pieces of debris. It was precisely this situation which produced the rupture of one major and four minor pipelines during the 1973 flooding in the Atchafalaya Basin. Such pipeline ruptures are virtually impossible to correct during a period of flooding.

As a result of the 1973 experience, aerial crossings were constructed by two firms to eliminate the possibility of pipeline rupture due to underwater exposure. The aerial design is more capable of withstanding high water, high discharge velocities, and the movement of debris. The pilings or piers that support the aerial crossing are usually driven to an elevation of between -15 to -30 feet msl. This means that if a river overtopped its levees, the erosion process would have to be sustained for long periods in order for the structure to be undermined to the point of collapse. However, while this type of crossing is satisfactory for minor floods, it is not designed to survive a major disaster such as a failure of the ORCS. Under such conditions it is possible that the piers which support the pipeline could be undercut and washed away. The probability that the piers which support an aerial crossing would be undermined depends on several major factors: the depth to which the piers are driven, the distance from the river banks to the piers, and the expected duration of exposure should the river leave its banks. If the ORCS collapsed, the flooding and subsequent erosion would be significant since the reach of the river in which most aerial crossings have been made is degrading (cutting) and there is some probability that the aerial crossings of the Atchafalaya would also fail. An engineering firm involved in the design of these piers stated that it is conceivable that a major flood which is worse than the 1973 flood could undermine the supporting piers for the aerial crossings. In the final analysis, however, the aerial crossings are much less vulnerable than the existing sub-river crossings.

The third variable affecting the probability of failure of a river crossing is the velocity of the discharge at the crossing. The velocity of discharge varies at different locations along the river. In the area from Simmesport southward to the I-10 bridge, the guide levees direct the river into a relatively narrow channel which means that during high water the flow velocity is high and the bottom is more quickly scoured and degraded. Pipelines located in this area would, other things being equal, have a greater chance of being disrupted. In the area south of I-10 the absence of guide levees allows flood discharge to fan out through the entire Basin area, thus resulting in lower discharges and volume at any location. Erosion is less likely to be a serious problem in the area immediately south of I-10. As the water in the Atchafalaya River moves further south, however, the discharge of the river is once again directed into narrow channels. There are two potential trouble spots in the extreme southern portion of the Basin. The first is the Morgan City-Berwick area where seventy percent of the Atchafalaya's discharge (under normal low water circumstances) moves through a narrow channel into Atchafalaya Bay. The other potential trouble spot is the Wax Lake outlet. During times of normal water level, only about thirty percent of the river's discharge passes through Wax Lake. However, during flood stages, about fifty percent goes through the Wax Lake outlet into the Gulf. Both of these areas are subject to serious scour activity during flood stages.

Soil type and stratigraphic history also play an important role in the determination of the probability of pipeline failure. In the area between Simmesport and I-10, and also in the region near US 90 at the origin of the Wax Lake Channel, scour is prevalent not only because of high discharge velocity, but also as a result of the existence of numerous unconsolidated sandy-silty formations in the area. The coupling of these two conditions causes serious problems of scour on the river bottom. A survey in the Basin made after the 1973 flooding revealed that the channel bottom was at -125 msl. During the 1973 flooding, at least three pipelines were ruptured in this specific area.

Finally, the area bounded by US I-10 in the north and US 90 in the south is not subject to unusual erosion for the following reasons: 1) the subsoil in this area consists of numerous pleistocene clay formations which are consolidated and tough and 2) the river in this area loses its identity among the several lakes, bayous, and swamps contained within the Basin. As a result, the discharge in this area is neither concentrated nor strong enough to cause serious scour problems; instead, it is an area of sediment deposition.

Major Interstate Gas Pipelines Crossing the Basin

The ordinal rankings of failure probabilities are discussed below by grouping the pipelines into three ordinal categories: the pipelines of Transco and Florida Gas Transmission comprise the group considered least likely to fail. Pipelines operated by companies in the second group - Southern Natural Gas, Texas Eastern, and United Gas, have a greater chance of being ruptured in the aftermath of a failure of the ORCS. Pipelines operated by members of Texas Gas and Columbia Gulf are considered most likely to experience pipeline failure.

Category I.

a) Transco: This system consists of a total of four natural gas pipelines (two 18-inch and two 30-inch lines) originating in the offshore waters of Louisiana and Texas. It crosses the Basin just north of the town of Melville, Louisiana. The lines serve the states of Alabama, Delaware, District of Columbia, Georgia, Kentucky, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Virginia, and West Virginia and terminate in New York City. The predominant sector served by Transco is the gas and electric utility industry, including Consolidated Edison of New York and Atlanta Gas and Light.

The two 30-inch lines, built in 1974, cross the river on a bridge. The piers of the crossing are not in the river and would not readily be subject to river scour. A senior official of Transco has indicated that the loss of the Low Sill Control Structure, with the increased possibility of bottom scour due to increased flow, would only affect the two 18-inch underwater crossings and not the two 30-inch lines. Because the river near Melville contains the reach which is eroding and scouring, there is an increased probability that the two 18-inch lines (built in 1966) would fail. Company officials have indicated, however, that the excess capacity generally available in the aerial crossings would enable near normal throughput to be maintained. The Transco system would most likely be able to function at or near normal levels should the ORCS fail.

b) The Florida Transmission System: The system owned by Florida Gas Transmission (FGTC) consists of one 24-inch aerial crossing of the Atchafalaya. This line was constructed in 1974 after the submerged river line was ruptured during the 1973 flooding. The FGTC system originates in south Texas and terminates in Miami, Florida. Virtually all gas transmitted by FGTC is delivered to Florida. The dominant industry group served by FGTC is the gas and electric utility industry in Florida.

The aerial crossing is located approximately one mile north of Krotz Springs, Louisiana and is in a reach of river where the bed is cutting. Since bed erosion plays no direct part in the rupture of an aerial crossing, there is a very small probability that a failure of the ORCS would cause a failure of FGTC's pipeline. There is, of course, the possibility that the banks could be undercut sufficiently to wash out the supporting piers; but the probability of a failure of this line is much less that that of the pipelines in Categories II and III.

Category II.

The second category consists of three underwater crossing systems between US 190 at Krotz Springs and US 90 directly north of the Wax Lake outlet. Continuing the ranking from the least to the most likely to fail, the systems in this group are: Southern Natural Gas, Texas Eastern Transmission System and United Gas Pipeline.

a) Southern Natural Gas: The pipeline system which Southern Natural Gas operates within and across the Basin consists of one 20-inch line crossing the central portion of the Basin and two parallel lines, one 20-inch and one 30-inch crossing in the south near the Franklin, Louisiana area. From its point of origin in southeastern Louisiana, the system continues through Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, Tennessee, Pennsylvania, New Jersey, Rhode Island, Massachusetts, and Connecticut. This system delivers natural gas to industrial, utility, commercial, and residential customers along its route.

The system serves municipally-owned and investor-owned public utilities and a number of industrial customers such as petrochemicals, rubber, clay products, canneries, aero-space (Martin-Marietta), and rail yards. In addition, the Corps of Engineers and Naval Auxiliary air bases in Mississippi have direct connections with Southern. Because Southern's system traverses the Basin in the area between US 190 in the north and US 90 in the south, the system falls entirely in that portion of the Basin in which the river loses its identity among the various lakes, bayous, and swamps. Thus, a rupture caused by scour is not very likely to occur. Southern lost no lines during the flood of 1973, and it might not be adversely affected by a similar flood in the future.

b) The Texas Eastern Transmission System: This system originates in south-central Texas near the Mexican border and terminates on Manhattan Island. It provides natural gas to public utilities in the states of Alabama, Arkansas, Connecticut, District of Columbia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Missouri, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, Texas, Virginia and West Virginia. Most of TET's system consists of several lateral lines which join together at St. Francisville, Louisiana and proceed to the northeastern part of the country. In addition, Texas Eastern also operates a northern line which cuts diagonally across Texas and Arkansas, and connects with the main system in southern Ohio. The portion of the system crossing the Atchafalaya, consists of one 36-inch line at St. Francisville. This crossing built in 1950 is in an area of potentially serious scour where the main channel levees contain the waters within the narrow confines of the present course of the river.

c) United Gas Pipeline: The United Gas Pipeline Company operates an intricate web of pipeline systems serving much of Louisiana and Mississippi as well as isolated areas in Texas, Alabama, and the Florida panhandle. One line which does not cross the Basin originates near Corpus Christi, Texas, enters Louisiana south of Shreveport, passes through Monroe, and terminates in Kosciusko, Mississippi.

The second line, which does go through the Basin, originates in southeastern Louisiana, crosses the Basin at Wax Lake, joins another lateral line to the northwest, and again goes through Monroe in route to Central Mississippi. The third line in the system originates south of New Orleans, crosses Lake Ponchartrain, cuts across southern Mississippi, Alabama, and terminates in the Florida panhandle.

An 18-inch line crosses the Wax Lake outlet which is very narrow and constrained by levees on both sides. During high water this small outlet discharges about fifty percent of all flood waters passing through the Basin. United's line at Wax Lake is an underwater crossing and, therefore, subject to exposure resulting from bottom scour. On the other hand, available subsoil data indicates that the line crosses the outlet in an area of Pleistocene clay which is somewhat resistant to erosion. This may be the reason that United was one of the few lines in the Wax Lake area to have escaped rupture in 1973. However, the tremendous volume of water projected to pass through the Atchafalaya Basin should the ORCS fail might be sufficient to cause a rupture.

United's customers are primarily public utilities and some industries are connected directly to the system. Specific customers listed in the FPC flow diagram include firms in the following industries: brick and tile, petrochemical, paper products, aluminum and chemical, cement manufacture, steel, canneries, packing, poultry, agriculture, and sugar refining.

Category III.

The third category consists of those pipelines which are located south of US 90, in the Wax Lake area (the area where failure is considered most likely to occur). The two systems located here are operated by Texas Gas Transmission Company and Columbia Gulf Transmission Company.

a) Texas Gas Transmission: TGT's main system originates at Eunice, Louisiana and terminates in Lebanon, Ohio. The system consists of three parallel lines: one 20-inch, one 26-inch, and one 36-inch serving the states of Louisiana, Arkansas, Mississippi, Tennessee, Kentucky, Indiana, and Ohio. The western line originates southwest of Eunice and does not cross the Basin. However, the eastern line, consisting of one 20-inch and one 26-inch line, does cross the Basin in the vicinity of the Wax Lake outlet. This would be the only part of the TGT system that would be affected by a failure of the ORCS.

This system, which serves only public utilities and gas distribution systems, crosses the Atchafalaya Basin in the Wax Lake area. In addition, the lines cross the Atchafalaya River main channel just south of Morgan City. Both of these crossings, which are in narrow leveed channels, would be vulnerable to sustained scour activity should the ORCS collapse. Taking into account the age, depth of cover, discharge and width of the river, this part of the T G T system is one of the most likely to fail should the ORCS collapse.

b) Columbia Gulf Transmission: Columbia Gulf's system west of Lafayette, Louisiana consists of three parallel lines: two 30-inch and one 36-inch, that traverse Louisiana, Mississippi, Tennessee, and Kentucky.

Delivery points, as listed on the FPC flow diagram, are located in Louisiana and Kentucky. In Louisiana, the delivered natural gas is used in the agricultural and refining sectors of the state's economy. In Kentucky, much of the natural gas delivered is interconnected with other gas transmission lines and transported out of the state into West Virginia, Virginia, Pennsylvania, and Maryland. The portion of the delivered gas retained in Kentucky is used in the public utilities and natural gas distribution sectors.

Three lateral lines cross the Atchafalaya Basin southwest of Morgan City, in the Wax Lake Outlet, of which one is aerial. During the 1973 flooding, the southernmost line was ruptured and had to be replaced, while the northern line remained intact. The outflow channel at Wax Lake is subject to scour so Columbia's system is classified as one of the systems more likely to fail if the ORCS were lost.

Summary.

The major systems within the Basin fall into three categories: 1) those that are least likely to fail because they operate aerial lines crossing the Basin, 2) those that might fail because their lines are underwater crossings between Simmesport and US 90, and 3) those that are most likely to fail because they are located in the troublesome area below US 90 and the Wax Lake Outlet. The categories and their respective systems are classified as follows:

I. Least Likely to Fail
   1) Transco
   2) Florida Gas

II. Intermediate Likelihood of Failure

3) Southern

4) Texas Eastern

5) United

III. Most Likely to Fail

6) Texas Gas

7) Columbia Gulf

The Volume of Gas Crossing the Basin

Not all of the natural gas delivered by the seven major pipeline systems described above cross the Atchafalaya Basin. Some natural gas is imported into the system east of the Basin and some gas from west of the Basin is routed north of the Basin. After unsuccessfully trying to piece together data from numerous sources in order to determine the amount of natural gas which traveled across the Basin, the writer had to rely on estimates made by officials in the various pipeline companies. The quantity estimates of the natural gas passing through the Basin are 1979 data. Tables 3.1 through 3.7 present the quantities of natural gas passing through the Basin. The total quantity of natural gas traversing the Basin is shown in the total of column (1). Other data in that column show the allocation of this quantity of natural gas to the various market areas. The allocation formulae for Tables 3.1-3.9 were derived from FPC/FERC flow charts and other sources. These allocations relate to the entire system and are crude approximations. The relative distributions of natural gas in the various markets of each system were applied to the quantity of natural gas crossing the Basin. For example, in Table 3.1, a total of 438,000 mmcf delivered by Transcontinental crossed the Basin in 1979. Of that amount 24 percent, or 107,063 mmcf was delivered to New York. This amount was equal to 15.79 percent of the total natural gas consumption in New York. The latest state consumption data available are for 1977, whereas the quantities delivered are for 1979 but the consumption quantities have not changed very much in the two year interval. Tables 3.8 and 3.9 present summary data on the relative impact of natural gas disruption in each of the affected states. The data in Table 3.8 are based on the assumption that all of the pipelines crossing the Basin are disrupted. This is a worst case scenario which is highly unlikely to occur but which presents an extreme order of magnitude.

Approximately 15 percent of the natural gas in 28 eastern states would be disrupted if all of the pipelines should fail. The more seriously affected states and their percentage of natural gas shortfall are: New Jersey (46.7), South Carolina (42.1), Delaware (40.9), and Georgia (39.4).

Table 3.9 is constructed on the assumption that only the pipelines in Categories II and III fail. In this case, 10 percent of the natural gas in 28 eastern states could be disrupted. The states which would suffer the most significant losses would be Georgia (33.5), Alabama (27.7) South Carolina (26.7), Rhode Island (24.8), and Connecticut (23.0). Table 3.10 presents the relative impact on the various states if only the two pipelines in Category III should fail. It appears that Kentucky with a loss of 13 percent of its natural gas would suffer the most significant impact.

Tables 3.8, 3.9 and 3.10 present data on the relative quantities of natural gas which would be disrupted if the relevant pipelines in the Basin should fail. They do not provide any estimates of the economic costs of such failures. Tables 3.11, 3.12 and 3.13 provide data on estimated economic and social costs. An example might clarify the information presented in the tables.

In table 3.11, column (1) shows that Alabama could lose 226,701 mcf per day if all pipelines were ruptured. At a cost of 92.38¢ per mcf, the value of the natural gas in this daily shortage is $209,426. This is not the only effect which will be experienced in Alabama

TABLE 3.1

TRANSCONTINENTAL GAS PIPE LINE CORPORATION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	5,010	280,100	1.79
Delaware	7,983	19,546	40.84
Dist. of Col.	2,287	28,873	7.92
Georgia	20,261	340,630	5.95
Kentucky	628	236,043	.27
Louisiana	2,667	345,280	.77
Maryland	7,522	179,113	4.20
Mississippi	2,167	250,990	.86
New Jersey	87,743	277,103	31.66
New York	107,063	677,930	15.79
N. Carolina	71,612	137,609	52.04
Ohio	7,290	1,048,448	.70
Pennsylvania	72,202	763,322	9.46
S. Carolina	22,038	143,017	15.41
Virginia	20,582	148,330	13.88
W. Virginia	946	101,950	.93
Total	438,000	4,983,294	8.79

TABLE 3.2

FLORIDA GAS TRANSMISSION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	65	280,100	0.00
Florida	51,135	271,994	37.65
Louisiana	194	345,280	.001
Mississippi	71	250,990	.028
Total	51,465	1,148,364	4.48

TABLE 3.3

SOUTHERN NATURAL GAS COMPANY
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	65,140	280,100	.232
Connecticut	27	68,932	.00039
Florida	12,349	271,994	.0045
Georgia	107,887	340,630	.0317
Louisiana	1,911	345,280	.00055
Massachusetts	508	167,457	.003
Mississippi	13,020	250,990	.518
New Jersey	696	277,103	.0025
Pennsylvania	1,352	763,322	.00177
Rhode Island	13	18,927	.000816
S. Carolina	36,205	143,017	.25
Tennessee	5,442	270,115	.02
Total	244,550	3,197,867	.0763

TABLE 3.4

TEXAS EASTERN TRANSMISSION CORPORATION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	1,072	280,100	.38
Arkansas	995	253,792	.39
Connecticut	12,858	68,932	18.65
Dist. of Col.	579	28,873	2.01
Illinois	1,866	1,193,012	.16
Indiana	2,211	543,530	.41
Kentucky	4,219	236,043	1.79
Louisiana	1,508	345,280	.44
Maryland	3,980	179,113	2.22
Massachusetts	24,385	167,457	14.56
Mississippi	1,356	250,990	.54
Missouri	1,472	383,452	.38
New Jersey	33,451	277,103	12.07
New York	45,681	677,930	6.74
Ohio	59,006	1,048,448	5.63
Pennsylvania	64,377	763,322	8.43
Rhode Island	3,228	18,927	17.06
Tennessee	2,402	270,115	.89
Virginia	2,375	148,330	1.60
W. Virginia	3,092	101,950	3.03
Total	270,113	7,236,699	3.73

TABLE 3.5

UNITED GAS TRANSMISSION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	11,443	280,100	4.09
Arkansas	2,252	253,792	.89
Connecticut	1,853	68,932	2.69
Dist. of Col.	147	28,873	.51
Florida	6,428	271,994	2.36
Georgia	6,184	340,630	1.82
Illinois	6,730	1,193,012	.56
Indiana	4,297	543,530	.79
Kentucky	4,851	236,043	2.06
Louisiana	45,787	345,280	13.26
Maine	9	1,970	.46
Maryland	997	179,113	.56
Massachusetts	3,635	167,457	2.17
Mississippi	19,108	250,990	7.61
Missouri	24,382	383,452	6.90
New Hamshire	38	8,648	.44
New Jersey	4,507	277,103	1.63
New York	8,176	677,930	1.21
Ohio	12,800	1,048,448	1.22
Pennsylvania	10,543	763,322	1.38
Rhode Island	880	18,927	4.65
S. Carolina	1,964	143,017	1.37
Tennessee	4,168	270,115	1.54
Virginia	642	148,330	.43
W. Virginia	673	101,950	.66
Total	182,494	8,002,958	2.28

TABLE 3.6

TEXAS GAS TRANSMISSION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumptic Delivered
Alabama	16	280,100	.01
Arkansas	1,067	253,792	.42
Connecticut	1,116	68,932	1.62
Delaware	15	19,546	.08
Dist. of Col.	494	28,873	1.71
Georgia	30	340,630	.01
Illinois	2,042	1,193,012	.17
Indiana	21,299	543,530	3.92
Kentucky	28,553	236,043	12.10
Louisiana	3,222	345,280	.93
Maryland	3,317	179,113	1.85
Massachusetts	2,116	167,457	1.26
Michigan	3,143	839,266	.37
Mississippi	5,536	250,990	2.21
New Jersey	2,919	277,103	1.05
New York	12,145	677,930	1.79
North Carolina	108	137,609	.08
Ohio	2,819	1,048,448	.27
Pennsylvania	13,595	763,322	1.78
Rhode Island	576	18,927	3.04
Tennessee	19,703	270,115	7.29
Virginia	2,029	148,330	1.37
W. Virginia	1,889	101,950	1.85
Total	127,750	8,190,298	1.56

TABLE 3.7

COLUMBIA GULF TRANSMISSION
DISTRIBUTION OF NATURAL GAS CROSSING THE BASIN

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Dist. of Col.	1,253	28,873	4.340
Kentucky	3,176	236,043	1.346
Louisiana	696	345,280	.202
Maryland	8,411	179,113	4.696
Mississippi	579	250,990	.231
New York	2,237	677,930	.330
Ohio	24,520	1,048,448	2.339
Pennsylvania	11,219	763,322	1.470
Tennessee	379	270,115	.140
Virginia	5,157	148,330	3.477
W. Virginia	4,415	101,950	4.331
Total	62,042	4,112,436	1.51

TABLE 3.8

RELATIVE IMPACT IF ALL PIPELINES FAIL

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	82,746	280,100	29.5
Arkansas	4,314	253,792	1.7
Connecticut	15,854	68,932	23.0
Delaware	7,998	19,546	40.9
Dist. of Col.	4,760	28,873	16.5
Florida	69,912	271,994	25.7
Georgia	134,362	340,630	39.4
Illinois	10,638	1,193,012	0.9
Indiana	27,807	543,530	5.1
Kentucky	41,427	236,043	17.6
Louisiana	55,985	345,280	16.2
Maine	9	1,970	0.5
Maryland	24,227	179,113	13.5
Massachusetts	30,644	167,457	18.3
Michigan	3,143	839,266	0.4
Mississippi	41,837	250,990	16.7
Missouri	25,854	383,452	6.7
New Hampshire	38	8,648	0.4
New Jersey	129,316	277,103	46.7
New York	175,302	677,930	25.9
N. Carolina	71,720	137,609	52.1
Ohio	106,435	1,048,448	10.2
Pennsylvania	173,288	763,322	22.7
Rhode Island	4,697	18,927	24.8
S. Carolina	60,207	143,017	42.1
Tennessee	32,094	270,115	11.9
Virginia	30,785	148,330	20.8
W. Virginia	11,015	101,950	10.8
Total	1,376,414	8,999,379	15.3

TABLE 3.9

RELATIVE IMPACT IF PIPELINES IN CATEGORIES II AND III SHOULD FAIL

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption Delivered
Alabama	77,671	280,100	27.7
Arkansas	4,314	253,792	1.7
Connecticut	15,854	68,932	23.0
Delaware	15	19,546	0.1
Dist. of Col.	2,473	28,873	8.6
Florida	18,777	271,994	6.9
Georgia	114,101	340,630	33.5
Illinois	10,638	1,193,012	0.9
Indiana	27,807	543,530	5.1
Kentucky	40,799	236,043	17.3
Louisiana	53,124	345,280	15.4
Maine	9	1,970	0.5
Maryland	16,705	179,113	9.3
Massachusetts	30,644	167,457	18.3
Michigan	3,143	839,266	0.4
Mississippi	39,599	250,990	15.8
Missouri	25,854	383,452	6.7
New Hampshire	38	8,648	0.4
New Jersey	41,573	277,103	15.0
New York	68,239	677,930	10.1
N. Carolina	108	137,609	0.1
Ohio	99,145	1,048,448	9.5
Pennsylvania	101,086	763,322	13.2
Rhode Island	4,697	18,927	24.8
S. Carolina	38,169	143,017	26.7
Tennessee	32,094	270,115	11.9
Virginia	10,203	148,330	6.9
W. Virginia	10,069	101,950	9.9

TABLE 3.10

RELATIVE IMPACT ASSUMING FAILURE OF PIPELINES IN CATEGORY III

State	(1) Natural Gas Delivered mmcf/yr	(2) State Consumption of Natural Gas mmcf/yr	(3) Percentage of State Consumption mmcf/yr
Alabama	16	280,100	.01
Arkansas	1,067	253,792	.42
Connecticut	1,116	68,932	1.62
Delware	15	19,546	.08
Dist. of Col.	1,747	28,873	6.05
Georgia	30	340,630	.01
Illinois	2,042	1,193,012	.17
Indiana	21,299	543,530	3.92
Kentucky	31,729	236,043	13.44
Louisiana	3,918	345,280	1.13
Maryland	11,728	179,113	6.55
Massachusetts	2,116	167,457	1.26
Michigan	3,143	839,266	.37
Mississippi	6,115	250,990	2.44
New Jersey	2,919	277,103	1.05
New York	14,382	677,930	2.12
North Carolina	108	137,609	.08
Ohio	27,339	1,048,448	2.61
Pennsylvania	24,814	763,322	3.25
Rhode Island	576	18,927	3.04
Tennessee	20,082	270,115	7.43
Virginia	7,186	148,330	4.84
W. Virginia	6,304	101,950	6.18
TOTAL	189,791	8,190,298	2.32

Table 3.11

ESTIMATES OF ECONOMIC COSTS
ASSUMING FAILURE OF ALL MAJOR PIPELINES

	Estimated Shortages mcf per day	1977 Value Per Day of Shortage	Estimated Reduction in Gross State Output Per Day	Estimated Reductions in State Income Per Day	Estimated Reductions in Employment
Alabama	226,701	$ 209,426	$ 418,852	$ 502,622	5,272
Arkansas	11,819	10,918	21,836	26,203	276
Conneticut	43,436	40,126	80,252	96,302	1,007
Delaware	21,912	20,242	40,484	48,581	511
Dist. of Col.	13,041	12,047	24,094	28,913	304
Florida	191,540	176,945	353,890	424,668	4,457
Georgia	368,115	340,065	680,130	816,156	8,563
Illinois	29,145	26,924	53,848	64,618	676
Indiana	76,184	70,379	140,758	168,910	1,773
Kentucky	113,499	104,850	209,700	251,640	2,643
Louisiana	153,384	141,696	283,392	340,070	3,567
Maine	25	23	46	55	1
Maryland	66,375	61,317	122,634	147,161	1,546
Massachusetts	83,956	77,559	155,118	186,142	1,953
Michigan	8,611	7,955	15,910	19,092	200
Mississippi	114,622	105,888	211,776	254,131	2,663
Missouri	70,833	65,436	130,872	157,046	1,649
New Hampshire	104	96	192	230	2
New Jersey	354,290	327,293	654,586	785,503	8,245
New York	480,279	443,682	887,364	1,064,837	11,171
N. Carolina	196,493	181,520	363,040	435,648	4,575
Ohio	291,603	269,383	538,766	646,519	6,783
Pennsylvania	474,762	438,585	877,170	1,052,604	11,047
Rhode Island	12,868	11,887	23,774	28,529	297
S. Carolina	164,951	152,382	304,764	365,717	3,836
Tennessee	87,929	81,229	162,458	194,950	2,042
Virginia	84,342	77,915	155,830	186,996	1,960
W. Virginia	30,178	27,878	55,756	66,907	704
Total	3,770,997	$3,483,646	$6,967,292	$8,360,750	87,723

<u>Sources</u>:
1. Table 3.8 column 1 multiplied by a 1000 and divided by 365 days
2. Column 1 times the price of natural gas which was calculated as the 1976 will lead price of 58.0¢/mcf adjusted by 23.9% inflation factor, plus 20.52¢/mcf which is the average cost of transporting one mcf. (58.0) (1.239) + 20.52 = 92.38¢/mcf.
3. Column 2 times the average of State gross output multiplier of 2.0
4. Column 2 times the average State income multiplier of 2.4
5. Employment data were calculated as follows: Average output per employer in the utility sector, was divided into a million dollars to determine the number of utility employees necessary to produce $1 million of output. This number of employees per million dollar of output was multiplied by the average state utilities employment multplier to obtain total primary and secondary employment reduction per million dollar of decrease in output. This total employment reduction multiplied by the reduction in output of the gas utility sector equals total estimated reduction in employment.

Example:
a) Average dollar output per employee in the utilities sector = $33,764.
b) $1 million ÷ $33,764 = 30
c) 30 employees multiplied by the average utilities employment multiplier of 2.3 equals 69 employees
d) Alabama's decrease in natural gas value of $209,426 per day equals a reduction of $76.4 million per year. The reduction of 69 employees per million dollars of annual output multiplied by 76.4 will yield an annual reduction in employment of 5272.

Table 3.12

RELATIVE IMPACT IF PIPELINES IN CATEGORIES II AND III SHOULD FAIL

	Estimated Shortages mcf per day	1977 Value Per Day of Shortage	Estimated Reduction in Gross State Output Per Day	Estimated Reduction in State Income Per Day	Estimated Reduction in Employment
Alabama	212,797	$ 196,582	$ 393,164	$ 471,797	4,954
Arkansas	11,819	10,918	21,836	26,203	276
Connecticut	43,436	40,126	80,252	96,302	1,007
Delaware	41	38	76	91	1
Dist. of Col.	6,775	6,259	12,518	15,022	159
Florida	51,444	47,524	95,048	114,058	1,194
Georgia	312,605	288,784	577,568	693,082	7,273
Illinois	29,145	26,924	53,848	64,618	676
Indiana	76,184	70,379	140,758	168,910	1,773
Kentucky	111,778	103,261	206,522	247,826	2,601
Louisiana	145,545	134,454	268,908	322,690	3,381
Maine	25	23	46	55	1
Maryland	45,767	42,280	84,560	101,472	1,063
Massachusetts	83,956	77,559	155,118	186,142	1,953
Michigan	8,611	7,955	15,910	19,092	200
Mississippi	108,490	100,223	200,446	240,535	2,525
Missouri	70,833	65,436	130,872	157,046	1,649
New Hampshire	104	96	192	230	3
New Jersey	113,899	105,220	210,440	252,528	2,650
New York	186,956	172,710	345,420	414,504	4,347
N. Carolina	296	273	546	655	7
Ohio	271,630	250,932	501,864	602,237	6,320
Pennsylvania	276,948	255,845	511,690	614,028	6,445
Rhode Island	12,868	11,887	23,774	28,529	297
S. Carolina	104,573	96,605	193,210	231,852	2,436
Tennessee	87,929	81,229	162,458	194,950	2,042
Virginia	27,953	25,823	51,646	61,975	649
W. Virginia	27,586	25,484	50,968	61,162	642
Total	2,429,993	$ 2,244,829	$ 4,489,658	$ 5,387,591	56,524

TABLE 3.13

ESTIMATES OF ECONOMIC COSTS
ASSUMING FAILURE OF PIPELINES IN CATEGORY III

	Estimated Shortages mcf per day	1977 Value Per Day of Shortage	Estimated Reduction in Gross State Output Per Day	Estimated Reductions in State Income Per Day	Estimated Reductions in Employment
Alabama	44	$ 41	$ 82	$ 98	1
Arkansas	2,923	2,700	5,400	6,480	68
Connecticut	3,058	2,825	5,650	6,780	69
Delaware	41	38	76	91	1
Dist. of Col.	4,786	4,421	8,842	10,610	110
Georgia	82	76	152	182	2
Illinois	5,595	5,169	10,338	12,406	131
Indiana	58,353	53,906	107,812	129,374	1,359
Kentucky	86,929	80,305	160,610	192,732	2,022
Louisiana	10,734	9,916	19,832	23,798	248
Maryland	32,132	29,684	59,368	71,242	745
Massachusetts	5,797	5,355	10,710	12,852	138
Michigan	8,611	7,955	15,910	19,092	200
Mississippi	16,753	15,476	30,952	37,142	386
New Jersey	7,997	7,388	14,776	17,731	186
New York	39,403	36,400	72,800	87,360	918
North Carolina	296	273	546	655	7
Ohio	74,901	69,194	138,388	166,066	1,746
Pennsylvania	67,984	62,804	125,608	150,730	1,580
Rhode Island	1,578	1,458	2,916	3,499	37
Tennessee	55,019	50,827	101,654	121,985	1,283
Virginia	19,688	18,188	36,376	43,651	455
W. Virginia	17,271	15,955	31,910	38,292	400
Total	519,975	$ 480,354	$ 960,708	$ 1,152,848	12,092

TABLE 3.14

PERCENTAGE OF ELECTRICITY GENERATED BY NATURAL GAS, 1978

STATE	ELEC. GENERATED BY NATURAL GAS, MEGAWATT HOURS	TOTAL ELECTRIC POWER GENERATED, MEGAWATT HOURS	GAS GENERATED ELECTRICITY AS % OF TOTAL GENERATION
Alabama	671,979	69,268,379	0.97
Arkansas	486,000	17,669,319	2.75
Conneticut	0	25,820,043	0.00
Delaware	154,164	7,047,603	2.19
Dist. of Col.	0	1,780,295	0.00
Florida	14,304,153	92,023,566	15.54
Georgia	462,401	52,525,337	0.88
Illinois	1,908,319	106,830,507	1.79
Indiana	298,047	62,196,223	0.48
Kentucky	105,468	55,615,853	0.19
Louisiana	36,935,279	51,504,383	71.71
Maine	0	8,207,727	0.00
Maryland	45,578	35,132,853	0.13
Massachusetts	122,390	36,262,800	0.34
Michigan	1,974,623	74,534,338	2.65
Mississippi	3,508,886	19,009,395	18.45
Missouri	2,130,108	45,873,468	4.64
New Hampshire	0	4,811,560	0.00
New Jersey	73,070	30,363,579	0.24
New York	100,438	113,121,167	0.09
N. Carolina	168	63,332,705	0.00
Ohio	164,566	109,217,425	0.15
Pennsylvania	31,941	122,579,577	0.03
Rhode Island	0	559,249	0.00
S. Carolina	454,215	42,348,208	1.07
Tennessee	0	58,939,242	0.00
Virginia	82,692	41,211,628	0.20
W. Virginia	1,304	61,981,781	0.00
TOTAL	64,015,789	1,409,768,210	4.54

Source: Edison Electric Institute

because utilities and industry will have to decrease their damand for other goods and so forth. After these secondary and tertiary effects have worked themselves through the state economy the total reduction in state output per day will be $419 thousand. The estimated reduction in state income will be $503 thousand. Total employment will be reduced by 5272. If the pipelines remain ruptured for 180 days, the reduction in gross state output and personal income for Alabama would be $75 million and $90 million dollars respectively. Total employment would be reduced by 5272. Total reductions in gross state output per day for all of the states is $7 million, state income is reduced by $8 million and total employment will decrease by 88 thousand.

If the pipelines in Categories II and III should fail (Table 3.12) gross output would be reduced by $4 million, income by $5 million and employment reduced by 57 thousand. If only the pipelines in Category III should fail (Table 3.13), output would be reduced by $1 million dollars, and income would be reduced by $1 million. Twelve thousand individuals would become unemployed. As explained in footnotes to Table 3.11, input-output analyses were utilized in deriving these estimates. While this is the most appropriate method available for making these estimates in view of our constraints in time, they are subject to numerous analytical and data limitations. The results should be interpreted with caution.

Southeastern Louisiana and part of Southern Mississippi might be two regions most severely affected by a disruption of natural gas deliveries. Data pertaining solely to the substate regions could not be disaggregated from state data for this study. The petrochemical firms located along the Mississippi River between New Orleans and Baton Rouge, rely heavily upon natural gas as feedstock and boiler fuel. Based on a cursory analysis, it is possible that the disruption of one or two major natural gas pipelines could have a significant effect on this area.

An original concern that severe shortages of electricity could occur in several eastern states as a result of the potential disruption in natural gas deliveries appears to be unwarranted. After obtaining data on the use of natural gas in the affected states it appears that those states likely to suffer the most significant decreases in natural gas generate only a small proportion of their electricity by natural gas (Table 3.14). The only state in which the disruption of natural gas could have a very noticeable effect is Louisiana, particularly southeastern Louisiana. Sufficient alternative sources exist through the interconnect system to provide electricity for Louisiana alone, but providing electricity for all of the affected area might prove more difficult. The interconnect system should be able to replace the generation lost by the disruption of natural gas deliveries if the disruption occurs during the Spring. However, if the pipelines cannot be repaired, or substitute routing put into place, by July and August, which are the peak periods of electricity consumption in the southern and southeastern portions of the country, there could be a shortage of generating capacity.

Another concern related to electricity was that the high voltage electric lines which cross the Basin could be undermined by the action of flood waters. Gulf States Utilities, which services southern Louisiana and southeastern Texas, has two 138 KV lines and one 500 KV line crossing the Basin. The lines cross the Basin south of Krotz Springs, Louisiana where scouring within the channel is most likely to occur. The towers, however are located outside the channel but they would be subject to scouring in the event of a major flood or failure of the ORCS. (GSU engineers have stated that they do not believe the ORCS structure is in danger of failure.) The 500 KV line is looped through Arkansas and Mississippi so that a break in the line in the Basin would not result in an interruption of service. If another break would occur, however, there could be an interruption in service.

GSU officials have stated that it would cost between $500,000 and $1 million to replace one transmission line tower.

Substitute Routing and Pipeline Replacement Costs

The various economic and social costs that would result from a disruption depend not only upon the failure of the Old River Control Structure and/or the channeling of excess flood waters down the Basin, and the probability of one or more pipelines being severed, but also upon the availability of feasible rerouting possibilities and the time interval involved in making the necessary interconnections and replacing or repairing the severed pipeline.

Based on the information we have obtained, the pipeline companies have made no plans nor identified a set of specific options which would be available should one or more pipelines fail. If a particular pipeline fails during a flood period, repairs or replacement could take as long as six months to a year. During this time, the pipeline company could reroute the gas if it could find a pipeline with available excess capacity which crossed, or was located near, its pipeline on the west side of the Basin and which crossed, or was located near its pipeline on the east side of the Basin. Generally pipelines do have interconnections with some other pipelines but few, if any, pipelines have interconnections with the same pipelines on both sides of the Basin. Interconnections can be constructed but - especially if compressors are involved - the purchase of a compressor and the necessary construction could take 6 months to a year.

Prospective companies and some of their customers do hold reserves of natural gas but such reserves are at a seasonal low during the months of March and April, which is when an ORCS failure or an extensive flood are likely to occur.

IV

FLOOD DAMAGE EXPECTED

Introduction

Although one inevitable consequence of a failure of the Old River Control Structure would be the flooding of lands in and adjacent to the Basin, there is no general agreement among engineers about the extent of the area which would be flooded. The Louisiana Department of Public Works suggests that the failure of the ORCS would inundate most of southeastern Louisiana -- from the Bayou Teche ridge in the west to the Mississippi River in the east. This area would include the heavily populated areas near New Orleans which are situated along the west bank of the Mississippi River, including the towns of Gretna, Harvey, and Marrero.

Based on the extent of the inundation caused by the 1927 flood, the U.S. Corps of Engineers estimates that flooding might occur in the entire Atchafalaya Basin, as well as in areas extending westward to the Bayou Teche ridge and eastward to the Bayou Lafourche ridge. The Atchafalaya project guide levees could be expected to be overtopped, or to fail from other causes, south of I-10. During the 1973 and 1975 floods the levees around Ramah and Henderson were approaching failure and the levee system was found to be honeycombed with armadillo holes. Approximately 12 percent of Louisiana's total land area -- or approximately three million acres with a population of approximately 140 thousand -- is in the flood prone area. Principal towns which would be affected include Morgan City, Berwick, Patterson, Melville, Krotz Springs, and portions of Franklin, Houma, and Thibodaux.

Moderate to serious flood damage was sustained in Morgan City during the 1973 flood and much emergency work was required to protect the city from more serious losses. If the ORCS had failed in 1973, 70 percent of the discharge of the Mississippi River -- or 1.5 million cfs -- might have been diverted down the Atchafalaya Basin. In addition, approximately 50,000 cfs from the Red River would also have been discharged into the Atchafalaya. Given these flows, it can be stated with a fairly high degree of certainty, that the channel would enlarge and deepen, the existing levees would be washed away in parts, and the Morgan City/Berwick area would be very seriously flooded. Even after the first flood receded, Morgan City, as well as the entire Basin, would be under constant threat of serious flooding annually which would tend to make the Basin uninhabitable.

Our study includes four distinct sectors of economic activity within and outside the Basin area: estimates of private property losses within and outside of the Basin, public sector losses and expenditures, and some impacts on the fishing inductry.

Private Property Losses

Introduction

One of the consequences of extensive flooding in the Atchafalaya Basin would be the damage to private homes, commercial establishments and other private property. A number of problems were encountered in estimating the value of these property losses. One immediate problem confronting the research team was that property value estimates were available only on a parish-wide basis, whereas only portions of some parishes would be flooded. In order to adjust for this problem, the assessed value of real property in each parish was divided by the 1976 estimated population within the parish. This estimate of per capita value was then multiplied by the population in each voting ward in order to obtain the property loss in each ward. The property values* in those voting wards in the projected flood plain were aggregated to obtain the estimates of the value of property which has a probability of being flooded.

Losses Within the Basin.

Table 4.1 presents the estimates of the total real estate values of those parishes that would be affected by flooding and Table 4.2 shows the estimated growth in parish population between 1970 and 1976. Both of these tables were employed in calculating the losses within and outside the Basin. Since entire parishes do not lie within the Basin, the voting wards which are expected to be flooded are shown in Table 4.3. Even some of the voting wards do not lie entirely in the Basin, so an estimate was made of the percentage of population within each ward that would be affected. Because current 1976 ward population data do not exist it was assumed that the population in each ward changed proportionately to the change in parish population between 1970 and 1976 (Table 4.2).

TABLE 4.1

ESTIMATED 1976 PRIVATE PROPERTY VALUES (BY PARISH)

PARISH	TOTAL 1976 REAL ESTATE ASSESSMENT	ASSESS RATIO %	VALUE OF REAL ESTATE	EXEMPTED PROPERTY	ESTIMATED ACTUAL VALUE OF REAL ESTATE
ASSUMPTION	$ 10,289,790	10.12	$ 101,677,766	$ 17,374,818	$ 119,052,584
AVOYELLES	21,880,390	9.73	224,875,539	3,338,909	228,214,448
IBERIA	39,377,320	17.21	228,804,881	7,124,106	235,928,987
IBERVILLE	14,490,986	7.38	196,354,823	N/A	196,354,823
LAFOURCHE	34,115,964	9.96	342,529,759	9,511,413	352,041,172
POINTE COUPEE	14,606,741	9.11	160,337,442	40,790,876	201,128,318
ST. LANDRY	64,869,080	13.76	471,432,267	32,222,334	503,654,601
ST. MARTIN	7,129,140	7.98	89,337,594	20,703,092	110,040,686
ST. MARY	58,258,650	16.72	348,436,901	110,485,782	458,922,683
TERREBONNE	36,956,480	7.01	527,196,576	20,243,265	547,439,841
TOTAL	$301,974,541		$2,690,983,548	$261,794,595	$2,952,778,143

Source: Division of Business and Economic Research, Louisiana State University.

Table 4.4 utilizes data presented in Tables 4.1, 4.2 and 4.3 to produce an estimated value of lost private property for those areas of each parish located within the Basin.

The estimates of property losses within the Basin are based on the assumption that the portions of Avoyelles, Iberville, Point Coupee, St. Landry, St. Martin and St. Mary which are located within the Basin would most probably be subject to permanent inundation, thus making these areas virtually uninhabitable. As shown in Table 4.4, the Basin contains approximately 60,000 residents and private real wealth of nearly $380 million. Although, the buildings and other construction situated on the land would lose virtually all value,

* The assessed values were taken from the Eighteenth Biennial Report (1976-1977) published by the Louisiana Tax Commission. The assessed valuations were revised upward on the basis of the parish assessment ratios made by Dr. Terry Robertson, Division of Research at LSU. Estimates of the value of tax exempt property was obtained and added to the totals for each parish.

TABLE 4.2

PERCENT CHANGE IN PARISH

POPULATIONS FROM 1970 to 1976

PARISH	1970 CENSUS	1976 ESTIMATES	PERCENT CHANGE IN POPULATION 1970 - 1976
ASSUMPTION	19,654	20,499	+4.2
AVOYELLES	37,751	38,516	+2.0
IBERIA	57,397	62,747	+9.3
IBERVILLE	30,746	30,835	+0.3
LAFOURCHE	68,941	74,783	+8.5
POINTE COUPEE	22,002	22,100	+0.4
ST. LANDRY	80,346	81,970	+1.9
ST. MARTIN	32,453	34,994	+7.8
ST. MARY	60,752	61,590	+1.3
TERREBONNE	76,049	85,784	+12.8

Source: Division of Business Research, Louisiana Tech University and U.S. Census Bureau.

the land itself would most probably retain some value for grazing cattle and hunting and fishing and some buildings could be inhabited on a periodic basis. A conservative estimate of the property value loss would approximate 60%. Thus applying 60% to $380 million yields as an estimated loss of $228 million.

TABLE 4.4

1976 ESTIMATES OF PRIVATE PROPERTY LOSSES WITHIN THE BASIN

PARISH	ESTIMATED PROPERTY VALUE	1976 POP. ESTIMATE	PER CAPITA PROPERTY VALUE	ESTIMATED POPULATION AFFECTED	ESTIMATED VALUE OF PROPERTY	ESTIMATED LOS AT 6% OF VAL
AVOYELLES	$ 228,214,448	38,156	$5,925	2,931	$ 17,366,175	$ 10,419,70
IBERVILLE	196,354,823	30,835	6,368	87	544,009	326,40
POINTE COUPEE	201,128,318	22,100	9,101	2,934	26,702,334	16,021,40
ST. LANDRY	503,054,601	81,970	6,137	4,026	24,707,562	14,824,53
ST. MARTIN	110,040,686	34,994	3,145	10,725	33,730,125	20,238,27
ST. MARY	458,922,683	61,590	7,451	37,005	275,724,255	165,434,55
TOTALS	$1,697,715,559	269,645		57,708	$ 378,784,460	$ 227,264,67

Source: Division of Research, Louisiana State University.

St. Mary Parish, which contains 65 percent of the affected population and 73 percent of the private sector wealth of the ten parishes, would be most seriously damaged. 37,000 people would be affected and at least $165 million in private property would be lost. If St. Mary Parish were inundated, the effectiveness of the oil industry both onshore and offshore could be impaired due to the large number of oil industry employees and equipment centered in the Morgan City area. The Avondale, Brown and Root, and J. Ray McDermott companies each have huge offshore platform construction facilities in the immediate area and many of the support facilities are located within the Basin. It is doubtful that these firms would be able to resume immediate operations in this area and these construction and

TABLE 4.3

ESTIMATED 1976 POPULATION
WITHIN THE BASIN, BY PARISH

PARISH	WARDS AFFECTED	1970 WARD POP.	ESTIMATED PERCENT OF POPULATION AFFECTED	1970 POP. AFFECTED	PERCENT CHANGE	1976 POPULATION AFFECTED
AVOYELLES	#7	2812	100%	2812		
	#8	2497	2.5	62		
TOTAL				2874	+2.0	2931
IBERVILLE	#8	3480	2.5	87		
TOTAL				87	+0.3	87
POINTE COUPEE	#1	1289	100	1289		
	#2	1633	100	1633		
TOTAL				2922	+0.4	2934
ST. LANDRY	#3	5483	0.3	16		
	#4	10,367	37.8	3919		
TOTAL				3951	+1.9	4026
ST. MARTIN	#1	9728	100	9728		
	#4	8856	2.5	221		
TOTAL				9949	+7.8	10,725
ST. MARY	#4	18,870	100	18,870		
	#5	7,736	100	7,736		
	#6	7,213	100	7,213		
	#8	2,711	100	2,711		
TOTAL				36,530	+1.3	37,005
TOTAL AFFECTED POPULATION IN BASIN						57,708

Source: Division of Business and Economic Research, Louisiana State University.

support services could be disrupted for a considerable period of time. We have made no estimates of the losses resulting from delays on disrupted operations in the oil industry.

St. Martin Parish would also sustain serious damage. While there are no large towns in this parish, there are rural communities interspersed throughout the Basin with an affected population of about 11,000 people. Additionally, the greatest amount of oil and natural gas production in the Basin is concentrated in St. Martin Parish. Many of these areas are heavily endowed with fossil fuels but are located in swampy areas which makes current access difficult and expensive. However, should the ORCS fail, access to these fields would be made more difficult, which might disrupt exploration, production, and maintenance of facilities in the parish.

Outside the Basin.

Approximately 81,000 people live in the affected area outside of the Basin and the private reality value is approximately $480 million. Although the affected areas outside the Basin would suffer an initial flooding, the waters would eventually recede and the population could move back into their homes and places of employment. During the 1973 flood many areas remained underwater for two months. A further problem is that, until the Corps of Engineers upgrade the present flood protection systems along the Atchafalaya River, the area outside the Basin would suffer periodic flooding but to a lesser extent than would be experienced within the Basin. Until the levee projects are completed, some areas outside of the Basin would not be suitable for permanent residence or, in many instances, for permanent employment.

Utilizing the same methodology employed in the previous section, Tables 4.5 and 4.6 show that the total value of real property in the area outside the Basin which could be affected by flooding is $480 million. During the 1973 flood, the areas between Bayous Teche and Lafourche sustained capital losses of approximately $24 million. Excluding the heavily populated areas of Thibodaux, Houma, New Iberia and Franklin, which were not seriously flooded in 1973, the capital value of real property in the area that was flooded is approximately $330 million. Thus, flood damages in 1973 amounted to 7.2 percent of the value of real property in the area. Applying this percentage to the entire potentially affected area outside the Basin yields a conservative estimate of future losses. This estimate is a conservative one because it does not include repetitive losses from periodic floods subsequent to the first one. Until the appropriate levees are constructed, there will be periodic floods outside the Basin. Table 4.7 presents an estimate of these losses. Total property losses outside the Basin would approximate $34 million.

Terrebonne Parish, which is the fastest growing parish in this area, would sustain the greatest losses. Approximately 28,000 people in eight voting wards (about one-third of the parish's population) could be forced to take refuge on higher ground should the ORCS fail. Private property losses would be approximately $813 million. The western portion of Houma would probably sustain serious flooding, but the eastern part of that city is built on the Bayou Lafourche alluvial ridge and is on higher ground. Therefore, the probability of flooding in this area is somewhat reduced. Other parishes which would probably sustain heavy initial flooding are Assumption, Iberville, and Lafourche.

As shown in Tables 4.8 and 4.9 the total flood losses inside and outside Basin are estimated to be $262 million affecting 139 thousand people. The most significantly impacted parish is St. Mary with total potential losses of $168 million.

TABLE 4.5

ESTIMATED AFFECTED
POPULATION BY PARISH OUTSIDE
THE BASIN
1976

PARISH	WARDS AFFECTED	1970 WARD POP.	ESTIMATED PERCENT POP. AFFECTED	1970 POP. AFFECTED	PERCENT CHANGE	1976 POPULATION AFFECTED
	#5	3758	1.000	3758		
	#6	3135	1.000	3135		
	#7	2232	1.000	2232		
	#8	3035	1.000	3035		
	#9	3236	1.000	3236		
ASSUMPTION				15,396	+4.2	16,043
	#1	1073	0.667	716		
	#2	3165	0.210	665		
	#4	3388	0.290	983		
IBERIA				2364	+9.3	2,584
	#1	5454	1.850	4636		
	#2	8280	1.200	1656		
	#7	2203	0.950	2093		
	#8	3480	1.000	3480		
	#9	2530	1.000	2530		
IBERVILLE				14,395	+0.3	14,438
	#5	1821	0.550	1002		
	#6	4323	1.000	4323		
	#7	3063	0.350	1072		
	#11	3033	0.750	2275		
LAFOURCHE				8672	+8.5	9,409
	#4	3530	0.400	1412		
	#10	1683	0.050	84		
POINTE COUPEE				1496	+0.4	1,502

TABLE 4.5 (Continued)

PARISH	WARDS AFFECTED	1970 WARD POP.	ESTIMATED PERCENT POP. AFFECTED	1970 POP. AFFECTED	PERCENT CHANGE	1976 POPULATION AFFECTED
	#3	5,483	0.025	137		
	#4	10,367	0.050	518		
ST. LANDRY	Total			653	+1.9	665
	#1	9,728	0.050	486		
	#3	4,772	0.250	1,193		
	#4	1,578	0.200	316		
	#5	3,945	0.500	1,973		
ST. MARTIN	Total			3,968	+7.8	4,278
	#2	957	1.000	957		
	#4	2,711	0.500	1,356		
	#7	1,555	1.000	1,555		
ST. MARY	Total			3,868	+1.3	3,984
	#2	1,344	0.900	1,210		
	#4	4,739	1.000	4,739		
	#5	2,053	1.000	2,053		
	#6	3,139	1.000	3.139		
	#7	6,573	1.000	6,573		
	#8	2,390	1.000	2,390		
	#9	1,934	1.000	1,934		
	#10	2,998	1.000	2,998		
TERREBONNE	1			25,048	+12.8	28,254

Source: Division of Research, Louisiana State University

TABLE 4.6

ESTIMATES OF PRIVATE
PROPERTY LOSSES OUTSIDE THE BASIN

PARISH	ESTIMATED PROPERTY VALUE	1976 POP. ESTIMATE	PER CAPITA PROPERTY VALUE	ESTIMATED POP. AFFECTED	ESTIMATED VALUE OF AFFECTED REAL PROPERTY OUTSIDE BASIN
ASSUMPTION	$ 119,052,584	20,499	$ 5807	16,043	$ 93,161,701
IBERIA	235,928,987	62,747	3760	2,584	9,715,840
IBERVILLE	196,354,823	30,835	6368	14,438	91,941,184
LAFOURCHE	352,041,172	74,783	4708	9,409	44,297,572
POINTE COUPEE	201,128,318	22,100	9101	1,502	13,669,702
ST. LANDRY	503,654,601	81,970	6144	665	4,085,760
ST. MARTIN	110,040,686	34,994	3144	4,278	13,450,032
ST. MARY	458,922,683	61,590	7451	3,984	29,684,784
TERREBONNE	547,439,841	85,784	6381	28,254	180,317,028
TOTAL	$2,724,563,695			$81,157	$ 480,323,603

TABLE 4.7

ESTIMATED REAL PROPERTY
LOSSES OUTSIDE THE BASIN *

PARISH	ESTIMATED CAPITAL LOSSES
Assumption	$ 6,708,482
Iberia	698,852
Iberville	6,619,683
Lafourche	3,067,070
Pointe Coupee	948,200
St. Landry	249,193
St. Martin	968,574
St. Mary	2,137,377
Terrebonne	12,982,028
TOTAL	$ 34,379,459

* Source: Division of Research,
Louisiana State University

TABLE 4.8

TOTAL POPULATION AFFECTED
INSIDE AND OUTSIDE THE BASIN

PARISH	POPULATION AFFECTED
ASSUMPTION	16,043
AVOYELLES	2,931
IBERIA	2,584
IBERVILLE	14,525
LAFOURCHE	9,409
POINTE COUPEE	4,436
ST. LANDRY	4,691
ST. MARTIN	15,003
ST. MARY	40,989
TERREBONNE	28,254
TOTAL	138,865

TABLE 4.9

TOTAL PRIVATE PROPERTY LOSSES
INSIDE AND OUTSIDE THE BASIN
1977 Prices

PARISH	PRIVATE PROPERTY LOSSES
ASSUMPTION	$ 6,708,482
AVOYELLES	10,419,705
IBERIA	698,852
IBERVILLE	6,946,083
LAFOURCHE	3,067,070
POINTE COUPEE	16,969,600
ST. LANDRY	15,073,730
ST. MARTIN	21,206,649
ST. MARY	167,571,930
TERREBONNE	12,982,028
TOTAL	$ 261,644,129

Public Sector Losses and Expenditures

During the flooding of 1973 losses and expenditures were incurred by local, state, and federal governments. According to the 1973 Post Flood Report of the Corps of Engineers, principal categories of expenditures for flood-related activities in the Atchafalaya and Mississippi-Atchafalaya Basins included strengthening of levees and floodwalls, raising of the Atchafalaya Basin guide levees, sand bagging, plugging cluverts, emergency pumping operations, and patrolling. Additionally, governmental units expended funds to repair damaged roads and highways, to provide flood relief to refugees, and to issue emergency food stamps in the affected areas.

The most extensive governmental losses and expenditures in 1973 occurred in the Atchafalaya Basin where the inundation was the most severe and extensive. Total damages sustained in this area were almost $37 million and government damages and expenditures were $11.5 million, or about 31 percent of the total. Losses in the Mississippi-Atchafalaya Basin to the east were only about $2 million, or 12 percent of the total.

If the ORCS fails, the Atchafalaya Basin will essentially be an area where little can be done to mitigate the effects of the flooding. In other words, much of the land will be perennially or permanently inundated. The estimated loss of public sector capital is conservatively estimated to be $60 million. Thus, the major additional explicit expenditures in this area would be funds used to evacuate the population as quickly as possible and to repair levees around Morgan City and other inhabited areas in the Basin. No estimates have been made of these costs. Other losses to the federal government would include the capital loss involved in the ORCS itself as well as the navigational locks in the area. A conservative estimate, in 1977 dollars, of the value of the entire complex would be approximately $200 million.

The areas in the greatest need of emergency governmental services would be outside the Basin itself. Here, the land would be submerged for a period of a few months, and as the waters receded, flood control systems would have to be rebuilt, roads and highways repaired, and displaced persons sheltered and fed. In short, these areas would require the same services that the Atchafalaya Basin needed after the 1973 flood. A very conservative estimat of $11 million would be spent by governmental units in addition to the more than $200 million replacement cost of the ORCS, if such reconstruction is possible. This amount excludes government expenditures on levees, additional dredging, or federal disaster relief and makes an allowance for inflation.

TABLE 4.10

ESTIMATED GOVERNMENTAL DAMAGES AND EXPENDITURES

ORCS COMPLEX	$ 200,000,000
GOVERNMENTAL LOSSES OUTSIDE THE BASIN	11,000,000
CONSERVATIVE ESTIMATE OF CAPITAL LOSSES IN THE BASIN	60,000,000
TOTAL	$ 271,000,000

Fishing Industry Losses

The oil and gas industries and commercial fishing are the two major sources of income to residents of the lower Atchafalaya Basin. The effect of the failure of the ORCS on the oil and gas industries was discussed very briefly above. The purpose of this section is to discuss the impact of the failure on the fishing industry.

Apart from flooding the homes of some fisherman, disrupting their vehicular transportation, and damaging structures in the Basin, the ORCS failure will have relatively little impact on fishing except for oyster dredging and shrimp trawling, which are the most economically important portions of the fishing industry in this area. The total value of fish and shellfish landings in Louisiana in 1977 was $139 million of which 63% were shrimp landings and 7.5% were oyster landings. Approximately $69 million in landing value was reported for the central Louisiana area which includes the coastal and bay areas extending from Bayou Lafourche to Bayou Teche. Forty-six million dollars of shrimp landings and $4 million of oysters landings were reported for the central district. The total value of shrimp and oyster landings in the central district constitute 36% of total state landings. These figures are based on the National Marine and Fishery Service publication "Current Fisheries Statistics #7520: Louisiana Landings, Annual Summary, 1977.

The oyster mortality rate is affected by both water salinity and temperature; as salinity and water temperature decrease the oyster mortality rate increases. If the ORCS should fail, the greatly increased flow of water in the Atchafalaya Basin would significantly decrease the salinity and temperature of the waters and, thus, destroy the oyster beds in portions of the Atchafalaya Basin and areas adjacent to it.

During the flood of 1973, the Morganza and Atchafalaya flood control structures were opened during the third week of April. During the months of May and June oyster harvesting in the central district surged far above the levels of the same months in previous years. This increase was due to the efforts of the oystermen to salvage as many oysters as possible in anticipation of high oyster mortality rates in the area. By the end of June, however, the stations around the Atchafalaya Bay were reporting close to one hundred percent mortality and during September only a few thousand pounds of oysters were harvested.

Because the flood waters receded and the salinity level returned to its previous level, the 1974 oyster populations and harvests were higher than in previous years. The reason for the apparent growth in population and harvest is that the previous year's flooding deposited an increased amount of nutrients in the affected areas and eliminated many of the oyster's natural enemies. In the event of a failure of the ORCS, however, the salinity level, while fluctuating during periods of high and low water, would be permanently higher in that immediate vicinity and many of the current oyster beds around the Atchafalaya Bay would be permanently destroyed. However, the estuarine area would expand and the oyster beds would, in a couple of years, be thriving in new areas. The additional sediment and nutrients which would be discharged in the lower Basin would have a very beneficial impact on oyster yields in future years.

The major difficulty with the relocation of the oyster beds is that those individuals who had leases on the beds which were destroyed would suffer economic losses. Some oystermen would gain but those who had their leased oyster beds destroyed would seek compensation for some or all of these losses.

The marshy wetlands which constitute Louisiana's coast line are one of the world's largest shrimp nurseries. The major reasons for the existence of these nurseries are the estuarine areas of southern Louisiana and the Mississippi and Atchafalaya Rivers which deliver nutrients, sediments, and fresh water without which the shrimp could not survive.

Shrimp require an average water temperature of 68 degrees or warmer and a salinity level of the range of 10 - 20 parts per thousand during the months of their maturation period (March, April and May) in the estuaries before they begin their movement to the offshore waters. During periods of floods, such as that which occurred in 1973, the water discharge rate of the rivers increase, and the water temperature decreases as does the salinity of the waters in the estuaries. The result is a high mortality rate among the juvenile shrimp. If the ORCS structure should fail in the months of March through May, the young shrimp located in the estuaries fed by the Atchafalaya River would have a very high mortality rate and the harvest of shrimp during that spring would most likely be decreased as compared with normal years. If the structure should fail, and the waters of the Mississippi are diverted down the Atchafalaya, the fresh water discharge into the estuaries would be permanently increased and at least the northern portions of these estuaries would become permanently unsuitable for shrimp nursuries.

Although, there would be a short run (1-2 years) decrease in the number of shrimp harvested and some shrimp nursery grounds would be permanently destroyed, the long run consequences of this diversion are likely to be positive because the additional nutrients and sediments deposited by the Atchafalaya would help abet the settling of the marshland area and would actually increase the area in which nurseries could be established. One of the problems associated with the Mississippi levee system is that the sediments are channeled down the Mississippi where most of them are deposited in very deep waters located adjacent to the Mississippi outlet. Because the Atchafalaya River is not leveed and the waters distributed over a wide area, the sediments would be deposited in shallow waters where shrimp nurseries and oyster beds could be established.

A positive benefit of the ORCS failure might be a significant increase in the production of both shrimp and oysters, but it must be recognized that this increase would occur in different areas and certain shrimpers and oystermen would be damaged.